BASIC COMBAT ENGINEER OFFICER

JULY 2000

MARINE CORPS ENGINEER SCHOOL
MARINE . CORPS BASE .
CAMP LEJEUNE, NORTH CAROLINA

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STUDENT HANDOUT

ENGINEERING IN THE MAGTF

LEARNING OBJECTIVES: There are no Learning Objectives. This is a Lesson Purpose class developed to assist you in the mastery of all other Learning Objectives throughout the course.

OUTLINE:

1. MILITARY ENGINEERING. Military engineering spans the warfighting continuum from the strategic to the operational to the tactical levels of war. Engineers support the intelligence and operational planning efforts by analyzing the affects of terrain, hydrology and infrastructure, and by identifying potential targets. Engineering in the military speeds force flow by assessing shortfalls and improving needed facilities to include air and sea ports of debarkation, force bed-down sites and lines of communication, as well as providing associated facility operations and maintenance (O&M). It facilitates operational maneuver and force protection by providing bridging, expeditionary airfields, facility war damage repair, explosive ordnance disposal, barriers and defensive fortifications. Engineers play essential roles in Military Operations Other Than War (MOOTW), disaster recovery, humanitarian relief operation and peacekeeping operations, environmental compliance and mitigation. All these efforts fall into two broad categories:

a. Combat Engineering. Combat engineering enhances momentum by physically shaping the battlespace, creating the space and time necessary to generate mass and speed while simultaneously degrading enemy maneuver. By improving the battlespace, combat engineers accelerate the concentration of combat power increasing the tempo of the force necessary to exploit critical enemy vulnerabilities. By reinforcing the natural restrictions of the battlespace, combat engineers limit enemy ability to generate tempo, thereby increasing reaction time while physically and psychologically degrading enemy will. These efforts fall into three types of operations that together shape the battlespace. They are mobility, countermobility, and survivability.

(1) Mobility. Mobility operations physically shape the terrain and space for the maneuver commander to gain freedom of tactical and operational maneuver. These tasks fall under the five functional areas:

(a) Gap Crossing

(b) Assault Breaching

(c) Countermine/Counter-obstacle

(d) Combat roads and trails

(e) Forward Operating Bases (FOBs)

(2) Countermobility. By reinforcing existing (natural) obstacles with man-made obstacles to restrict maneuver, engineers multiply the effects of our forces while denying the enemy the ability to concentrate. These operations are divided into landmine warfare and obstacle development in order to accomplish the following to the enemy:

(a) Turn

(b) Fix

(c) Block

(d) Disrupt

(3) Survivability. Survivability includes all aspects of protecting personnel, weapons, and supplies while simultaneously deceiving the enemy. The lethal battlefield requires commanders to know all survivability tactics available including building a good defense; employing frequent movement; using cover, concealment, deception, and camouflage; and construction of fortified positions for personnel and equipment.

b. General Engineering.

(1) Construction. Construction is the creation or rehabilitation of structures or areas for use by military forces. These efforts fall into 2 categories; horizontal and vertical.

(a) Horizontal. Horizontal construction is the modification of the terrain to aid movement or allow for large assemblies to include building runways, roads, and marshaling areas. Ground level construction.

(b) Vertical. Vertical construction is creating or rehabilitating buildings or other structures. Above ground construction.

(2) Facilities. Encompasses the acquiring of land or facilities, construction, and maintenance of real property

(a) Mobile Electric Power. Portable generators used for everything from powering a COC to powering a hospital during disaster relief operations.

(b) Hygiene Equipment. Portable water purification processing.

c. Engineer Community Military Occupational Specialties (MOSs). The following Marines perform the tasks listed above and are found in Marine Divisions, Air Wings and Force Service Support Groups:

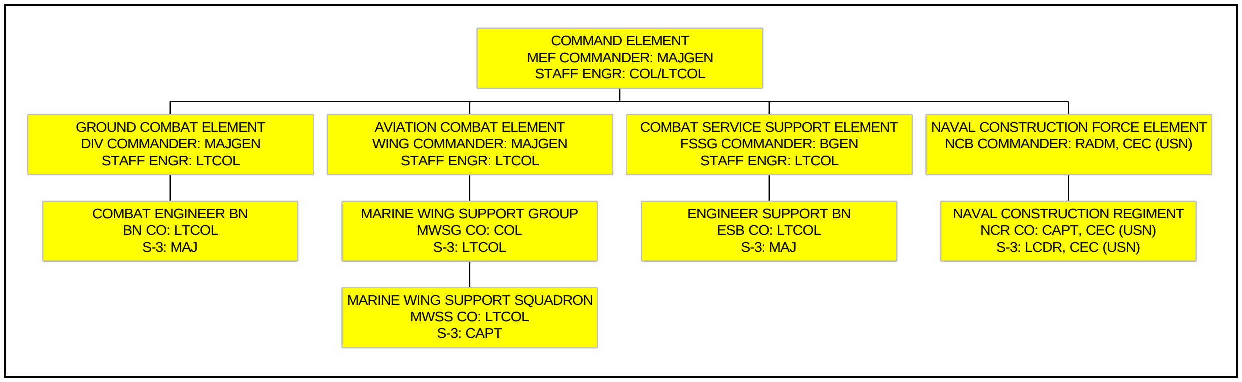
1302	Engineer Officer
1310	Engineer Equipment Officer
1330	Facilities Maintenance Officer
1361	Engineer Assistant (Drafter/Surveyor)
1371	Combat Engineer
1316	Metal Worker/Welder
1341	Engineer Equipment Mechanic
1345	Engineer Equipment Operator
1349	Engineer Equipment Chief
1390	Bulk Fuel Officer
1391	Bulk Fuel Specialist
1120	Utilities Officer
1141	Basic Electrician
1142	Electrical Equipment Specialist

1161	Refrigeration Mechanic
1169	Utilities Chief
1171	Hygiene Equipment Operator
1181	Fabric Repair Specialist

2. ENGINEERS IN THE MAGTF

a. Marine Expeditionary Force (MEF)

(1) Engineers serve as special staff officers at every level of the MEF. It is important to note that staff engineer officers at the MEF and division level are not dual hatted as Battalion and Squadron Commanders. You will see how this changes as we step down the levels of command.



(2) The MEF, largest of the Marine Air-Ground Task Forces, may be formed with many variations in task organization. Variations range from division/wing team to a MEF composed of two reinforced divisions and two aircraft wings, together with the appropriate combat service support organization. MEFs are:

(a) Commanded by a Major General.

(b) Ground Combat Element (GCE) is usually a Marine Division reinforced with appropriate force combat support units.

(c) Aviation Combat Element (ACE) is usually a Marine Aircraft Wing (MAW) task organized to conduct all tactical air operations.

(d) The Combat Service Support Element (CSSE) of the MEF is a Force Service Support Group (FSSG), which is structured to support the entire MAGTF. Combat Service Support Detachments (CSSD) provide supply and maintenance support as far forward as possible in support of maneuver forces. The remaining FSSG assets are staged in forward areas to support operations as required.

(e) The Naval Construction Forces are under the operational control of the MEF Commander to broaden the naval civil engineering spectrum of construction to enhance and sustain MAGTF operations ashore.

(3) MISSIONS:

(a) Combat Engineer Battalion (CEB). Mission: To enhance the mobility, countermobility, and survivability of the Marine Division through close combat engineer support and provide limited general support required for the functioning of the Marine Division. Secondary mission is to act as infantry.

(b) Engineer Support Battalion (ESB). Mission: To increase the combat effectiveness of the MAGTF by accomplishing general engineering missions of a deliberate nature.

(d) Marine Wing Support Squadron (MWSS). Mission: Provide all essential ground support and engineer support requirements to aid designated fixed-wing or rotary wing components of a Marine aviation combat air station.

(e) Naval Construction Regiment (NCR). Mission: To provide responsive military construction support to Navy, Marine Corps, and other forces in military operations; to construct and maintain base facilities; to repair battle damaged facilities and to conduct limited defensive operations as required by the circumstances of the deployment situation and also accomplish disaster control and recovery efforts when required.

b. Marine Expeditionary Force (Fwd).

(1) Engineer company commanders have a dual role as the special staff officer to the GCE, ACE, and CSSE commanders, respectively, and as commanders of their respective engineer companies.

(2) Company(REIN) and Engineer Detachments include organic personnel and equipment from Communications, Heavy Equipment, Motor Transport, and Utilities elements as well as mechanics and Corpsman.

(3) The MEF (Fwd) is a non-standing MAGTF. The force is drawn from the parent MEF for contingency operations requiring capabilities beyond those a Marine Expeditionary Unit (MEU) can provide. The MEF (Fwd) is formed from the division/wing/FSSG team. A MEF (Fwd) is capable of air-ground amphibious operations in low to mid-intensity conflicts. The MEF (Fwd) is normally established to accomplish a mission of limited scope.

(a) Commanded by Brigadier General.

(b) The GCE of the MEF (Fwd) is tailored to accomplish the mission assigned; however, the ground combat capability of the MEF (Fwd) will normally equate to a Regimental Landing Team (RLT).

(c) The normal ACE of the MEF (Fwd) is a Marine Aircraft Group (MAG) Which has substantially more varied aviation capabilities than that of the Marine Expeditionary Unit (MEU).

(d) The Combat Service Support Group (CSSG) includes significant resources from the FSSG task organized to support specific mission requirements. Navy organizations also provide significant resources to establish the Navy Beach Group in support of operations ashore.

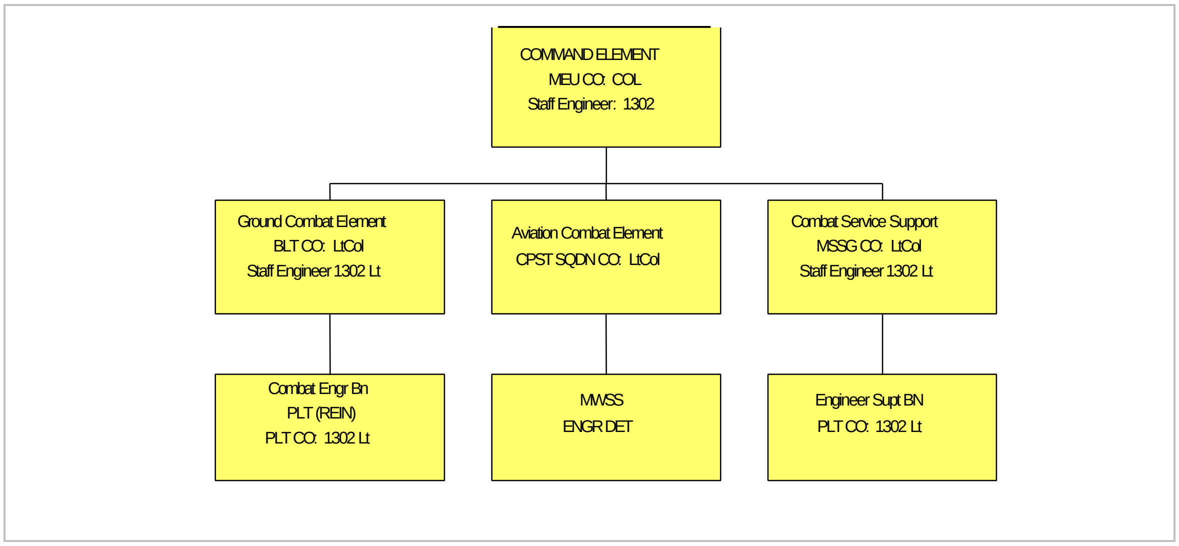
(e) A MEF (Fwd) is capable of sustained operations for thirty (30) days of combat.

c. Marine Expeditionary Unit (MEU).

(1) CEB, PLT (REIN); MWSS ENG DET; and ESB, PLT (REIN)

(a) Engineer platoon commanders have a dual role as the special staff officer to the GCE, ACE, CSSE Commanders, respectively, and as platoon commanders for their engineer platoons.

(b) Platoons (REIN) and Engineer Detachments include organic elements from Corpsmen, Communications, Heavy Equipment, Motor Transport, Utilities, and mechanics.



(2) MEUs possess the basic characteristics of larger MAGTFs, utilizing all the elements of a combined arms team. A MEU is formed from the Division/Wing/FSSG team. It is capable of performing combat operations on a relatively limited scope.

(a) Commanded by Colonel.

(b) The GCE of the MEU is normally a Battalion Landing Team (BLT).

(c) The ACE is normally a composite helicopter squadron with additional AV-8B Harriers.

(d) The CSSE of a MEU is formed primarily from FSSG resources and is designated a MEU Service Support Group (MSSG).

(e) A MEU is capable of sustained combat operations for 15 days.

(3) SPECIAL OPERATIONS CAPABLE (SOC)

(a) Concept. As a global force-in-readiness a MEU (SOC) is organized, trained, and equipped as a self-sustaining, general-purpose expeditionary force possessing the capability to conduct a wide spectrum of conventional and selected maritime special operations, rather than a force which is tailored for a specific operation or area of responsibility (e.g., a Special Purpose MAGTF). The unique immediate-response utility of a MEU (SOC) requires it be capable of mission execution within 6 hours of warning order receipt. This provides all geographic combatant commanders a forward-deployed, rapid crisis response capability that can conduct conventional amphibious and selected maritime special operations under the following conditions: night, adverse weather, over the horizon, under emissions control, from the sea, by surface and/or air.

d. Special Purpose MAGTF. Special Purpose MAGTFs (SPMAGTFs) are task organized to perform specific missions of limited duration. Normally, SPMAGTFs are deployed for humanitarian assistance or noncombatant evacuation operations (NEOs). They are designated by the name of the location to which they deploy, such as SPMAGTF (Liberia), SPMAGTF (Los Angeles), or SPMAGTF (Haiti).

3. THE ROLE OF THE STAFF ENGINEER.

a. The role of the MAGTF engineer is to increase rates of advance, modify terrain, provide critical ground support, increase force survivability and sustainability, and support the efforts of the MAGTF elements in carrying out the commander's intent. The MAGTF engineer carries out these roles by providing support for intelligence, operations, plans, logistics, facilities, real estate, and environmental considerations. The engineer staff develops engineer policy, guidance, and standards for the coordination of engineer efforts throughout the battlespace.

(1) Intelligence. Throughout the intelligence cycle the engineer staff assist the S-2/G-2 in coordinating intelligence requirements. The staff provides technical assistance in identifying, prioritizing and validating engineer intelligence needs, and assists in coordinating the collection of engineer information.

(2) Operations. The engineer staff monitors the deployment, employment and mission status of MAGTF engineer assets with the primary focus on applying engineer capabilities to achieve the commander's intent.

(3) Facilities. Encompasses the acquisition of necessary land or facilities, construction, and the maintenance of real property as described below:

(4) Real Estate. The engineer staff coordinates real estate services to the MAGTF and organizations supporting the MAGTF in the zone of operation.

(5) Construction. The engineer staff monitors construction efforts of MAGTF engineer forces, and based on commander guidance, formulates construction policies, priorities and standards.

(6) Real Property Maintenance. The repair and upkeep of leased or constructed property or facilities in the zone of operation that is utilized by the MAGTF.

(7) Environment Considerations. It is the function of an engineer staff to coordinate the environmental protection effort in the zone of operation.

(8) Logistics. The engineer staff manages the bulk storage of fuel and water throughout the area of operation. Additionally, while remaining a Supply function, the engineer staff also assist in monitoring the inventory and flow of Class IV material in the zone of operations and recommends appropriate reordering points.

REFERENCES:

FM 5-100	Engineer Combat Operations
JP 4-04	Civil Engineering Support
MCWP 3-17	MAGTF Engineer Operations
MCWP 4-25.2	SEABEE Operations in the MAGTF

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STUDENT OUTLINE

SOIL STABILIZATION

LEARNING OBJECTIVES

1. Terminal Learning Objectives:

a. Given a tactical situation and a mission to construct a horizontal or vertical facility, with the aid of references, supervise a soil stabilization operation that satisfies the construction requirements in accordance with FM 5-410. (1302.1.2)

2. Enabling Learning Objectives:

a. Given an unidentified soil sample, perform field identification tests per FM 5-410. (1302.1.2a)

b. Given the results of field identification tests, classify the soil using the Unified Soils Classification System (USCS) per FM 5-410. (1302.1.2b)

c. Given a USCS classification, determine the suitability of the soil for the intended mission per FM 5-410. (1302.1.2c)

d. Given a completed field identification analysis and soil suitability, apply proper soil stabilization techniques per FM 5-410. (1302.1.2d)

e. Given a soil stabilization requirement, determine the appropriate amount of admixture necessary to satisfy the mission per FM 5-410. (1302.1.2e)

f. Given a mission to construct a horizontal or vertical facility requiring soil stabilization, determine compaction requirements per FM 5-410. (1302.1.2f)

g. Given a mission to construct a horizontal or vertical facility and proper compaction equipment, identify the procedure for installing a test strip per FM 5-410. (1302.1.2g)

h. Given the results of a test strip, list procedures to adjust stabilization and/or compaction of the material to meet requirements per FM 5-410. (1302.1.2h)

OUTLINE

1. **SOIL FORMATION**. The term “soil” refers to the entire unconsolidated material that overlies and is distinguishable from bedrock. Soil is composed principally of the disintegrated and decomposed particles of rock. It also contains air and water as well as organic matter derived from the decomposition of plants and animals. Soil is a heterogeneous accumulation of

cemented or weakly cemented mineral grains enclosing voids of varying sizes. These mineral grains range in size from large boulders to single mineral crystals of microscopic size. The process of rock weathering and often the additional process of transportation create soil.

a. Weathering. Weathering is the physical or chemical breakdown of rock. These physical and chemical processes will vary with the environmental conditions present.

(1) Physical Weathering is the disintegration of rock. It breaks rock masses into smaller pieces without altering the chemical composition of the pieces. Processes that produce physical weathering include:

(a) Unloading - Extensive fracturing that results from the relief of pressure on a rock unit due to the removal of overlying material.

(b) Frost Action - The fracturing that occurs when trapped moisture in rocks freezes. This moisture can expand up to one tenth of its original volume, creating pressure of up to 4000 pound per square inch (psi).

(c) Organism Growth - Trees and plants readily grow in the joints of rock masses near the surface. The wedging action caused by root growth hastens the disintegration process.

(d) Abrasion - Sediments suspended in wind or fast-moving water can act as abrasives to physically weather rock masses. Rock particles carried by glacial ice can also be very abrasive.

(2) Chemical Weathering is the decomposition of rock through the chemical reactions that take place between minerals of the rock and the air, water or dissolved chemicals in the atmosphere. Chemical weathering processes include:

(a) Oxidation - The chemical union of a compound with oxygen. An example is rusting, which is the chemical reaction of oxygen, water and the iron mineral pyrite which forms ferrous sulfate.

(b) Hydration - The chemical union of a compound with water.

(c) Carbonation - The chemical process in which carbon dioxide from the air unites with various minerals to form carbonates.

b. Formation Methods

(1) Residual Soils. Where residual soils are formed, the rock material has been weathered in place. While mechanical (physical) weathering may occur, chemical weathering is the dominant factor.

(2) Transported Soils. By far, most soils that we encounter are materials that have been transported and deposited at a new location. Three major forces - glacial ice, water and wind - are the transporting agents; hence, these soils can be divided into glacial deposits, sedimentary (water-laid) deposits and eolian (wind-laid) deposits.

2. **SOIL CHARACTERISTICS**. The physical characteristics of a soil aid in determining the engineering characteristics. These properties form the basis for the system of soil classification used to identify soil types. The physical characteristics of soil particles are size and shape.

a. Grain (Particle) Size. Soils are divided into groups based on the size of the particle grains in the soil mass. Particle size is determined through the use of sieves. A sieve is a screen attached to a metal frame. There are two types of sieves, inch and numbered.

(1) Inch Sieves - These sieves range in size from 3” to 1/4” and are measured by the clear distance between the wires.

(2) Numbered Sieves - These sieves are numbered from #4 to #200 and are measured by the number of openings per linear inch.

If a particle will not pass through a screen of a certain size opening, it is said to be “retained on” that sieve. The following table lists size groups within the Unified Soils Classification System:

Size Groups	Sieve size	
	Passing	**Retained on**
Cobbles	No Maximum Size	3 inch
Gravels	3 inch	Number 4
Sands	Number 4	Number 200
Fines	Number 200	No Minimum Size

b. Particle Shape. Two general shapes are normally recognized: bulky and platy. The bulky shapes include particles which are relatively equal in all three dimensions. In platy shapes, one dimension is very small compared to the other two; for example, a thick book would be considered bulky, but a page of a book would be platy.

(1) Bulky Shapes. Bulky shapes are subdivided depending on the amount of weathering that has acted on them.

(a) Angular particles are particles that have recently been broken up. Jagged projections, sharp ridges and flat surfaces characterize angular particles. The interlocking characteristics of angular gravels and sands generally make them the best materials for construction. These particles are seldom found in nature because the weathering processes normally wear them down in a relatively short time.

(b) Subangular particles have been weathered until the sharper points and ridges of their original angular shape have been worn off. The particles are still very irregular in shape and are excellent for construction.

(c) Subrounded particles are those on which weathering has progressed even further. Still somewhat irregular in shape, they have no sharp corners and few flat areas. They are still adequate for construction.

(d) Rounded particles are those in which all projections have been removed and few irregularities remain. The particles approach spheres of varying sizes. They are not desirable in construction unless crushing can alter the rounded shape.

(2) Platy Shapes. As previously stated, platy particles are extremely thin compared to their length and width. Only fine-grained material

of the clay variety has this characteristic shape. It is generally accepted that platy grains are responsible for the plasticity of clay. Platy particles are highly compressible under static load. Several phenomena are associated with platy shapes.

(a) Clays frequently undergo very large volume changes with variations in moisture content. Evidence of this can be seen in the shrinkage cracks that develop in a lake bed as it dries.

(b) Unpaved clay roads, although often hard when sun baked, lose stability and turn to mud during rainstorms.

(c) In general, the higher the moisture content of a clay or silt, the less its strength and hence its bearing capacity.

c. Gradation. The distribution of particle sizes within a soil mass is known as its gradation. Gradation is described by two main headings.

(1) Well-Graded Soil. A well-graded soil is defined as having a good representation of all particle sizes from the largest to the smallest. Additionally, the shape of the grain size distribution curve is smooth, the coefficient of curvature is between 1-3, and the coefficient of uniformity must be >4 for gravel and >6 for sand.

(2) Poorly-Graded Soil. There are two types of poorly-graded soil.

(a) Uniformly graded soil consists primarily of particles of nearly the same size.

(b) Gap Graded soil contains both large and small particles, but the gradation continuity is broken by the absence of some particle sizes.

d. Bearing Capacity. The above soil characteristics are a measure of the soil's suitability to serve some intended purpose. Generally, a dense soil will withstand greater applied loads (have greater bearing capacity) than a loose soil. Particle size has a definite relation to this capacity. Empirical tests show that well-graded, coarse grained soils generally can be compacted to a greater density than fine grained soils because the smaller particles tend to fill the spaces between the larger ones. The shape of the grains also affects the bearing capacity. Angular particles tend to interlock and form a denser mass, and are more stable than rounded particles, which can roll or slide past one another. Poorly-graded soils, with their lack of one or more sizes, leave more or greater voids and therefore a less dense mass.

3. **UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)**. Soils seldom exist separately as sand, gravel, or any other single component in nature. They are usually mixtures with varying proportions of different sized particles. Each component contributes to the characteristics of the mixture. The USCS is based on the characteristics that indicate how a soil will behave as a construction material. These characteristics include the percent of gravel, sand and fines; gradation; and plasticity. The physical properties determined by field identification techniques are used to classify the soil. Once an accurate classification is obtained, the potential behavior of the soil under traffic or foundation loads can be determined.

a. Categories. In the USCS, all soils are divided into three major categories: Coarse grained, fine grained, and peat. The first two are differentiated by grain size, whereas the third is identified by the presence of large amounts of organic material.

b. Groups. Each of the major categories is further subdivided into groups and a letter symbol is assigned to each group. The primary letter of a classification relates to the soil group, while the secondary letter is descriptive of the soil's characteristics. The following symbols are combined to describe the soil mixture:

SOIL GROUPS	SYMBOL
Gravel	G
Sand	S
Silt	M
Clay	C
Organic	O

SOIL CHARACTERISTICS	SYMBOL
Well Graded	W
Poorly Graded	P
High Compressibility	H
Low Compressibility	L

*M and C are also used as secondary letters of the USCS

4. **FIELD IDENTIFICATION OF SOIL**. The soil types of an area are an important factor in selecting the exact location of airfields and roads. The military engineer, construction foreman, and members of engineer reconnaissance parties must be able to identify soils in the field so that the engineering characteristics of the various soil types encountered can be compared. Several simple field identification tests are described below. Each test may be performed with a minimum of time and equipment, although seldom will all of them be required to identify a given soil. The number of tests required depends on the type of soil and the experience of the individual performing them. By using these tests, soil properties can be estimated and materials can be classified. Such classifications are approximations and should not be used for designing permanent or semipermanent construction.

a. Soil Surveys. The survey of soil conditions at the site of proposed military construction provides information about the nature, extent and condition of soil layers. It is vital to both the planning and execution of military construction operations.

(1) Sources Useful in Planning Soil Surveys

(a) Intelligence Reports. Intelligence reports that include maps and studies of soil conditions usually are available for areas in which military operations have been planned. These reports are a source of information on geology, topography, terrain conditions, climate, and weather conditions.

(b) Local Inhabitants. Local inhabitants may provide information to supplement intelligence reports or provide information about areas for which intelligence reports are unavailable. Data obtained from this source could include possible locations of borrow pits, sand and gravel deposits, and peat or highly organic soils.

(c) Maps and Aerial Photographs. Thorough inspection of maps provide information about topography that can be useful to the trained soils analyst such as locations of hills, mountains, ridges, levees, sand dunes and alluvial fans. Aerial photographs allow the trained observer to identify landforms, slopes, drainage patterns, erosion characteristics and land use.

(2) Soil Exploration. Soil exploration, or soil boring, is nothing more than gathering soil samples for examining, testing and classifying.

Three methods of obtaining samples are available to the military engineer: taking samples from the surface, from excavations already in existence or digging a test hole. Regardless of the method employed, a quantity of soil that will fit in a sandbag is required for analysis. When digging a test hole or conducting a soil boring, the following procedures should be followed:

(a) Locate soil borings at or adjacent to the point of interest.

(b) Ensure that the bore hole is deep enough to penetrate the topsoil layer.

(c) Observe the color, moisture and number of layers exposed within the bore hole.

(d) On large scale horizontal projects (roads or airfields), conduct multiple borings and compare data as required.

b. Procedures. An approximate identification of coarse grained soil can be made by spreading a dry sample on a flat surface and examining it, noting particularly, grain size, gradation, grain shape and particle hardness. All lumps in the sample must be thoroughly pulverized to expose individual grains and to obtain a uniform mixture when water is added to the fine grain portion. A rubber-faced or wooden pestle and a mixing bowl are recommended for pulverizing. Placing a portion of the sample on a firm, smooth surface and using the foot to mash it can also pulverize lumps. If an iron pestle is used for pulverizing, it will break up the mineral grains and change the character of the soil; therefore, using an iron pestle is discouraged. Tests for identification of the fine grained portion of any soil are performed on the portion of the material that passes a Number 40 sieve. This is the same soil fraction used in the laboratory for Atterberg limits tests, such as plasticity. If the sieve is not available, spreading the material on a flat surface and removing the gravel and larger sand particles may make a rough separation. Fine grained soils are examined primarily for characteristics related to plasticity.

c. Equipment. Practically all the tests to be described can be performed with no equipment or accessories other than a small amount of water. However, the accuracy and uniformity of results is greatly increased by the proper use of certain equipment. The following equipment is available in nearly all engineer units (or may be improvised) and is easily transported:

(1) A Number 40 US standard sieve. Any screen with about 40 openings per lineal inch could be used, or sorting the materials by hand. Number 4 and Number 200 sieves are useful for separating gravels, sands, and fines.

(2) A pick and shovel or a set of entrenching tools for obtaining samples. A hand earth auger is useful if samples are desired a few feet below the surface.

(3) A spoon issued as part of mess equipment for obtaining samples and for mixing materials with water to the desired consistency.

(4) A bayonet or pocket knife for obtaining samples and trimming them to the desired size. A small mixing bowl with a rubber faced or wooden pestle for pulverizing the fine grained portion of the soil. Both may be improvised by using a canteen cup and a wooden dowel.

(5) Several sheets of nonabsorbent paper for rolling samples.

(6) A pan and a heating element for drying samples.

d. Testing. The procedures outlined below will result in a USCS classification. Many of the tests listed are not in sequential order. Utilize the wire diagram on page 12 to determine required tests and the order in which they should be performed. This wire diagram is an extract from FM 5-472, Materials Testing.

(1) Select a random but typical sample of soil.

(2) Perform visual examination, noting color, particle shape, maximum size aggregate.

(3) Separate the gravel.

(a) Remove from the sample all particles retained on the #4 sieve.

(b) Estimate the percent of gravel.

(4) Odor test

(a) Heat the sample with a match or open flame.

(b) If the odor is musty or foul smelling, there is a strong indication that organic material is present.

(5) Sedimentation test (**Both methods use -4 material only**)

CANTEEN CUP METHOD

(a) Place the sample in a canteen cup, mark the soil depth, and fill it with water.

(b) Shake the mixture vigorously.

(c) Allow the mixture to stand for 30 seconds to settle out.

(d) Pour the water containing the suspended fines into another container.

(e) Repeat steps (b) through (d) until the water poured off is clear.

(f) Dry the soil left in the cup (sand).

(g) Estimate the percent of sand.

MASON JAR METHOD

(a) Place approximately 1” of soil into a mason jar. Draw a line on the mason jar to represent 100% of material to be tested.

(b) Add water to within 1” from top of jar (about 5” of water).

(c) Shake mixture vigorously for 4 minutes.

(d) Place jar on flat, undisturbed surface and allow to settle for 30 seconds.

(e) Mark settlement line on mason jar. This represents % settled.

(f) Estimate % settled in relation to the original 100% line.

(g) Determine % sand using the following equation:

$$\frac{\%\ \text{settled}}{100} \times \%\ \text{sand \& fines} = \%S$$

(6) Compare the gravels, sands, and fines.

(a) The gravels have been estimated in test (3) step (b).

(b) The sands have been estimated in test (5) step (g).

(c) Estimate the percent of fines. 100 - (%G + %S) = %F

(7) Grit or Bite test.*

(a) Place a pinch of the sample between teeth and bite.

(b) If the sample feels gritty, the sample is silt (ML) or sand (S).

(c) If the sample feels floury, the sample is clay (C).

(8) Feel test.*

(a) Rub a portion of dry soil over a sensitive portion of the skin, such as the inside of the wrist.

(b) If the feel is harsh and irritating, the sample is silt (ML) or sand (S).

(c) If the feel is smooth and floury, the sample is clay (C).

(9) Wet Shaking test.*

(a) Place the pat of moist (not sticky) soil in the palm of the hand (the volume is about ½ inch)

(b) Shake the hand vigorously and strike it against the other hand.

(c) Observe how rapidly water rises to the surface.

(d) If it is fast, the sample is silty (M). If there is no reaction, the sample is clayey (C).

(10) Thread test.*

(a) Form a ball of moist soil (marble size).

(b) Attempt to roll the ball into a thread 1/8 inch in diameter.

(c) If thread is easily obtained, it is clay (C).

(d) If thread cannot be obtained, it is silt (M).

(11) Ribbon test.*

(a) Form a cylinder of soil that is approximately the size and shape of a cigar.

(b) Flatten the cylinder over the index finger with the thumb, attempting to form a ribbon 8 to 9 inches long, 1/8 to ¼ inch thick, and 1 inch wide.

(c) If 8 to 9 inches is obtained, it is (CH); if less than 8 inches is obtained, it is (CL); if there is no ribbon (less than 3”), it is silt (ML).

(12) Shine test.*

(a) Draw a smooth surface, such as a knife blade or thumbnail, over a pat of slightly moist soil.

(b) If the surface becomes shiny and lighter in texture, the sample is a highly plastic compressible clay (CH).

(c) If the surface remains dull, the sample is a low plasticity compressible clay (CL).

(d) If the surface remains very dull or granular, the sample is silt (M).

(13) Dry Strength test.*

(a) Form a moist pat 2 inches in diameter by ½ inch thick.

(b) Allow it to dry with low heat.

(c) Place the dry pat between the thumbs and index fingers only and attempt to break it.

(d) If breakage is easy, it is a slightly plastic silt (ML).

(e) If breakage is difficult, it is a medium plastic and medium compressible clay (CL) or a highly compressible silt (MH).

(f) If breakage is impossible, it is a highly plastic and highly compressible clay (CH).

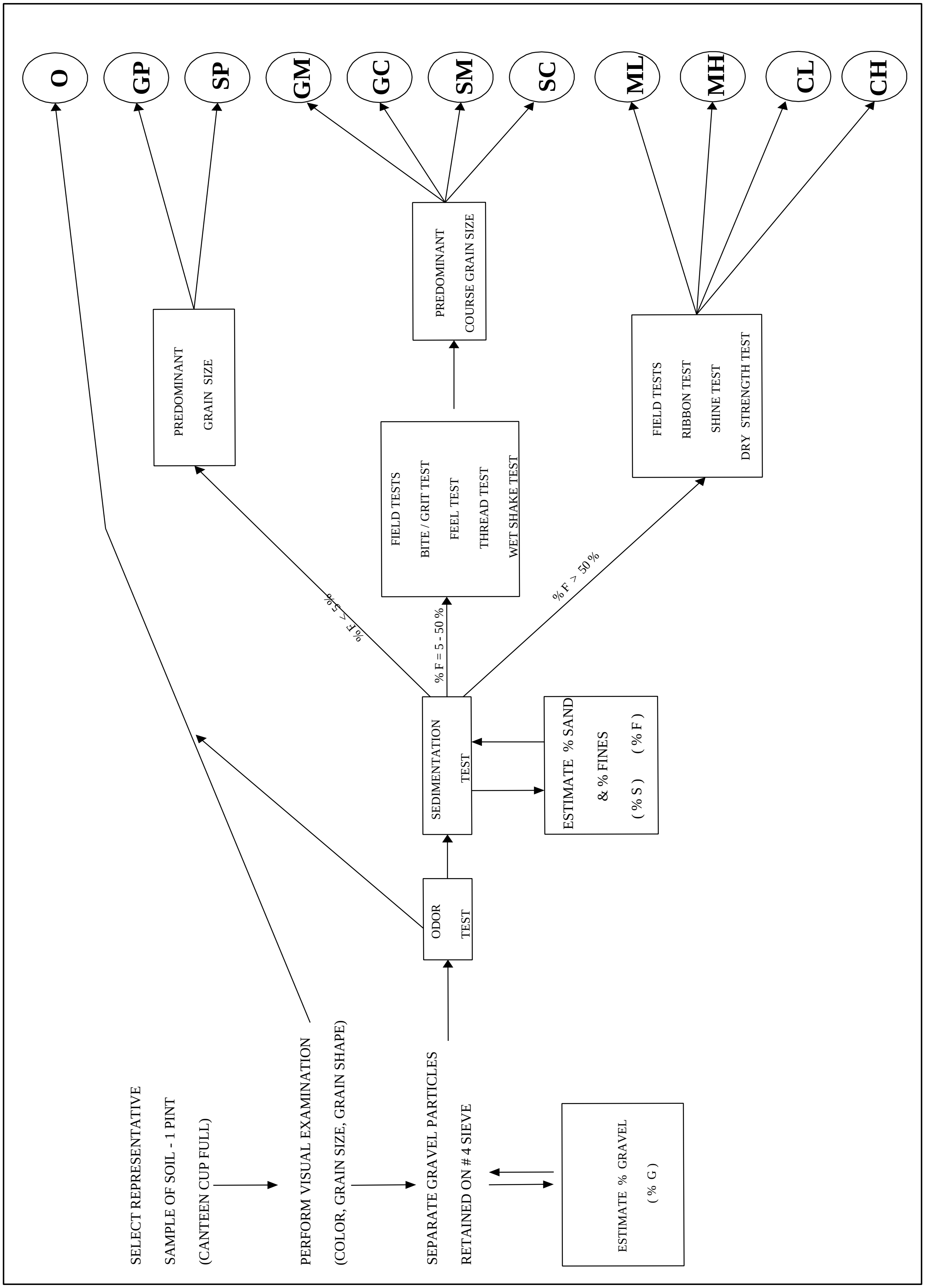
* Tests conducted on material smaller than 1/32 inch in diameter (passes Number 40 sieve).

5. **SOIL STABILIZATION**. Once a soil classification has been obtained the soil’s value, as a construction material must be evaluated. The chart on page 13 is utilized to determine a material’s suitability in relation to its intended purpose. This chart is an extract from FM 5-410, Military Soils Engineering. If a soil has less than desirable attributes as a construction material, it may be necessary to perform soil stabilization. Soil stabilization is the alteration of one or more soil properties, by chemical or mechanical means, to create the desired engineer properties. Soils can be stabilized to increase strength and durability or to prevent erosion and dust generation. Regardless of the purpose, the desired result is the creation of a soil material that will remain in place under the design use conditions for the design life of the project.

a. Chemical Stabilization. Chemical admixtures are manufactured commercial products that, when added to soil in proper quantities, will improve the quality of the soil layer. Lime, bituminous material, fly ash and portland cement are all types of chemical admixtures. Of the four listed, only portland cement will be discussed in depth since it is the only material readily available to us in both garrison and the theater of operations.

(1) Lime. Lime will react with many medium, moderately fine, and fine grained soils to produce decreased plasticity, increased workability, reduced swell and increased strength. Lime gains strength slowly, requiring 14 days in hot weather and 28 days in cool weather to gain significant strength. Unsurfaced lime-stabilized soils abrade rapidly under traffic, so bituminous surface treatment is recommended to prevent surface deterioration.

(2) Bituminous. Bituminous stabilization is generally accomplished using two types of liquid asphalts - cutback asphalts and asphalt emulsions. Both require specialized equipment for application which the USMC does not possess.


SELECT REPRESENTATIVE
SAMPLE OF SOIL - 1 PINT
(CANTEEN CUP FULL)
PERFORM VISUAL EXAMINATION
(COLOR, GRAIN SIZE, GRAIN SHAPE)
SEPARATE GRAVEL PARTICLES
RETAINED ON # 4 SIEVE
ESTIMATE % GRAVEL
(% G)
ODOR TEST
SEDIMENTATION TEST
ESTIMATE % SAND
& % FINES
(% S) (% F)
% F < 5%
% F = 5 - 50 %
% F > 50 %
PREDOMINANT GRAIN SIZE
FIELD TESTS
BITE / GRIT TEST
FEEL TEST
THREAD TEST
WET SHAKE TEST
PREDOMINANT COURSE GRAIN SIZE
FIELD TESTS
RIBBON TEST
SHINE TEST
DRY STRENGTH TEST
O
GP
SP
GM
GC
SM
SC
ML
MH
CL
CH

CHARACTERISTICS PERTINENT TO ROADS, AIRFIELDS, FOUNDATIONS AND EMBANKMENTS

USCS DESIG	VALUE AS A SUBGRADE	VALUE AS A BASE COURSE	VALUE FOR EMBANKMENTS	VALUE FOR FOUNDATIONS	MDD LBS/CF
GP	GOOD TO EXCELLENT	FAIR TO GOOD	REASONABLY STABLE	GOOD BEARING VALUE	110 -140 (R&A) 115 - 125 (F&E)
GM	GOOD	POOR TO NOT SUITABLE	REASONABLY STABLE	GOOD BEARING VALUE	115 - 135 (R&A) 120 - 135 (F&E)
GC	GOOD	POOR TO NOT SUITABLE	FAIRLY STABLE	GOOD BEARING VALUE	130 - 145 (R&A) 115 - 130 (F&E)
SP	FAIR TO GOOD	POOR TO NOT SUITABLE	REASONABLY STABLE	GOOD TO POOR BEARING VALUE	105 - 135 (R&A) 100 - 120 (F&E)
SM	FAIR	NOT SUITABLE	FAIRLY STABLE	GOOD TO POOR BEARING VALUE	100 - 130 (R&A) 110 - 125 (F&E)
SC	POOR TO FAIR	NOT SUITABLE	FAIRLY STABLE	GOOD TO POOR BEARING VALUE	100 - 135 (R&A) 105 - 125 (F&E)
ML	POOR TO FAIR	NOT SUITABLE	POOR STABILITY	VERY POOR	90 - 130 (R&A) 95 - 120 (F&E)
CL	POOR TO FAIR	NOT SUITABLE	STABLE	GOOD TO POOR BEARING VALUE	90 - 130 (R&A) 95 - 120 (F&E)
MH	POOR	NOT SUITABLE	POOR STABILITY	POOR BEARING VALUE	80 - 105 (R&A) 70 - 95 (F&E)
CH	POOR TO FAIR	NOT SUITABLE	FAIR STABILITY	FAIR TO POOR BEARING VALUE	90 - 115 (R&A) 75 - 105 (F&E)
O	POOR TO VERY POOR	NOT SUITABLE	NOT SUITABLE	FAIR TO VERY POOR	80 - 110 (R&A) 65 - 100 (F&E)

(3) Fly Ash. Fly ash, when mixed with lime and water, forms a hardened,cementitious mass capable of obtaining high compressive strengths. It can be used effectively on most coarse and medium grained soils. Fly ash is a byproduct of coal-fired electric power generation facilities. The quality and usefulness of fly ash is dependent upon the type of coal used in power generation.

(4) Portland cement. Cement can be used as an effective stabilizer for a wide range of soil types. It improves the quality of the soil by reducing plasticity and transforming it into a cemented mass, which significantly increases its strength and durability. Soil that has been stabilized with cement lends itself to reduced thickness design criteria when installing a military road or expedient airfield. Procedures to determine the amount of cement required and application techniques follow.

Step 1. Determine soil classification and check chart above to judge suitability.

Step 2. Determine if soil stabilization using portland cement is necessary.

Step 3. Select initial estimated cement content using table below. This table is an extract from FM 5-410, Military Soils Engineering.

ESTIMATED CEMENT REQUIREMENTS BY SOIL TYPE	
SOIL CLASSIFICATION	**INITIAL ESTIMATED CEMENT REQ PERCENT DRY WEIGHT**
GP	6
GM, SM, GC, SC	7
SP, CL, ML, CH	10
MH, O	11

Step 4. Determine quantity of stabilizing agent using the following formula:

Q = A x (T / 12) x D x S x W

Where:

Q = Quantity of additive in pounds
A = Area to be stabilized in square feet (length x width)
t = Thickness of the stabilized lift in inches
D = Desired density in lbs/cf (lowest mdd value from chart on page 13)
S = Percent of stabilizer in decimal form (i.e., .02) taken from chart above
W = Waste factor (use 1.1 or 10%)

Step 5. Scarify the material to be stabilized the entire depth of the loose lift. This prepares the soil for what is known as "in place" mixing. If "off site" mixing is employed, scarification may be omitted. "Off site" mixing is than blending the stabilizing agent with fill material at the borrow site.

Step 6. Spread cement over the scarified lift. Generally, portland cement comes in 94 pound sacks. By dividing the total number of pounds required obtained in step 4 by 94, determine the total number of sacks required. These sacks can be spotted along the loose lift in rows of predetermined spacing. The sacks are then cut and the material cast evenly by hand over the loose lift. If "off site" mixing is employed, this step may be omitted.

Step 7. Blend the portland cement into the loose lift by scarifying or windrowing the material back and forth until a uniform mix is achieved. Sufficient water should be added at this time to bring the soil mass to optimum moisture content. The 130G Motorized Road Grader is ideally suited for steps 5 and 7. **Remember to ensure that the cement and water are blended the entire depth of the loose lift. Failure to do so will result in a stabilized soil-cement crust with little to no compaction underneath. If this happens, the risk of failure is high.**

Step 8. Compact. Compaction should begin immediately after the application and blending of water and cement, as the hydration process acting on the portland cement is immediate. For proper compaction requirements, refer to the chart on page 17.

b. Mechanical Stabilization can be achieved by two methods: mixing/blending two or more poorly graded soils to obtain a well graded material and compaction.

(1) Blending Soil. In order for a true, mechanically stabilized blend to be obtained, a complete laboratory analysis on all material considered must be performed. Once information on percents passing certain sieves is gathered, either graphic or arithmetic proportioning formulas can be employed. Since we do not possess the ability to conduct a complete lab analysis, this method of stabilization is remote in the Fleet. It is not beyond the realm of possibility, however, to perform field identification of two or more different soils and determine if the addition of one or more would yield a more adequate construction material. A field identification test would have to be conducted on the hybrid material and rough proportioning could then be established.

(2) Compaction. Soil compaction is one of the most critical components in the construction of roads, airfields, embankments, and foundations. Structural failure of roads and airfields and the damage caused by foundation settlement can often be traced back to improper soil compaction. Compaction is the process of mechanically densifying a soil by compressing the soil particles together in a close state of contact, with air being expelled from the soil mass in the process. Compaction, as used here, implies dynamic compaction or densification by the application of moving loads to the soil mass. With relation to compaction, the density of a soil is normally expressed in terms of dry density (mdd) and the common unit of measurement is pounds per cubic foot (pcf).

(a) Effects of Proper Compaction

IMPROVEMENT	EFFECT ON SOIL MASS
Higher shear strength	Greater stability
Lower compressibility	Less settlement under static load
Higher CBR value	Less deformation under live load
Lower permeability	Less tendency to absorb water
Lower frost susceptibility	Less likelihood of frost heave

(b) Moisture Content . Nearly all soils exhibit a similar relationship between moisture content and dry density when subjected to a given compactive effort. For each soil, a maximum dry density develops at an optimum moisture content (OMC) for the compactive effort used. The OMC at which maximum dry density is obtained is the moisture content at which the soil becomes sufficiently workable under a given compactive effort to cause the soil particles to become so closely packed that most of the air is expelled (reduction of voids). To determine OMC in the field, we use the Clod Test:

Step 1. Mold a golf ball-sized sample of the soil with your hands.

Step 2. Squeeze the ball between the thumb and forefinger.

Step 3. If the ball shatters into several fragments of rather uniform size, the soil is said to be at or near OMC.

Step 4. If the ball flattens out without breaking, the soil is wetter than OMC; adjust moisture content as required.

Step 5. If the soil is difficult to mold or crumbles under very little pressure, the soil is drier than OMC; adjust moisture content as required.

(c) Application of Water.

In-place Application - Adding the water directly to the loose lift with a water truck. When using in-place application of water, it is crucial to remember that, as with cement, the water must be fully blended to the depth of the loose lift; **otherwise, complete compaction/ mdd cannot be obtained.**

Ponding - If time is available, bulk water can be added to loose fill material at the borrow site. This method is difficult to control since soil can dry out significantly while being hauled from the borrow site to the construction site. Conversely, soil can get so saturated that it remains wetter than OMC even after it has been delivered and placed. Ponding usually requires trial and error to achieve adequate results.

(d) Compaction Equipment. The RAYGO 420C vibratory compactor uses a vibratory action in conjunction with the ballast weight of the drum to rearrange the soil particles into a dense mass. Vibratory compaction is one of the most effective and economical means of attaining maximum density. The 420C comes with a smooth-wheeled drum for compacting coarse, non-cohesive/non-plastic material, and a padded foot drum for compacting fine grained or plastic soils.

(e) Employment Concepts

SCIP (Scarify and Compact in Place). If information on a soil type obtained from the chart on page 13 reveals that a material is marginal (poor to not suitable) for use as a subgrade, it may be necessary to SCIP the material rather than expend time, money and resources to chemically stabilize it. SCIP entails scarifying the subgrade layer to a depth not to exceed lift thickness criteria found in the chart below. This chart is an extract from FM 5-410, Military Soils Engineering. Once the subgrade has been scarified, adjust the moisture content to achieve OMC and then compact, following the guidance provided in the chart pertaining to speed, vibrations per minute and number of passes. If the subgrade is deemed suitable for use, this evolution may be omitted.

Compacting Fill. Once the subgrade has been prepared, loose fill, or lifts, are brought in. The general rule of thumb for the depth of the loose lift is 11/2 to 2 times greater than the desired finished, compacted lift. Finished lift thickness is based on structural design criteria and will be covered under separate lesson. **Remember, minimum lift thickness is governed by the maximum size aggregate found in the soil. Minimum lift thickness must be twice as large as the (MSA).** Maximum lift thickness should not exceed the lift thickness shown in the chart below. Further, use the chart below to determine speed, vibrations per minute, and number of passes. We can reasonably assume that as long as we are at or near OMC, by following the specs in the chart, we will achieve maximum dry density upon completion of compaction.

Test Strip. A test strip should be installed adjacent to the construction site in order to evaluate/validate construction procedures. Things to determine via the test strip are water application rate and optimum depth of lift. The test strip and the information gleaned from it are our only real form of quality control.

COMPACTION REQUIREMENTS FOR RAYGO 420C VIBRATORY COMPACTOR			
USCS DESIG	COMPACTED LIFT THICKNESS (INCHES)	ROLLING SPEED (MPH) (VPM)	NUMBER OF PASSES
GP	18	4 MPH 1,400 VPM	8
GM	12	4 MPH 1,100 VPM	6
GC	12	4 MPH 700 VPM	6
SP	18	4 MPH 1,400 VPM	8
SM	12	4 MPH 1,100 VPM	6
SC	12	3 MPH 700 VPM	7
ML	8	3 MPH 700 VPM	7
CL	8	3 MPH 700 VPM	7
MH, OH, OL CAN'T BE PROPERLY COMPACTED WITH THE 420C			

REFERENCE(S):

FM 5-410 MILITARY SOILS

UNITED STATES MARINE CORPS
COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C-01A06
19 Jun 00
(98 POI)

STUDENT OUTLINE

EXPEDIENT DRAINAGE SYSTEMS

1. Purpose: The purpose of this period of instruction is to teach you the types, purpose, design, construction, and maintenance of drainage systems.

2. LEARNING OBJECTIVES:

a. TERMINAL LEARNING OBJECTIVE (S)

(1) Given a tactical situation, a map and references, design a drainage structure to intercept, collect, and remove surface water flowing toward a designated area from adjacent areas per the references. (1302.1.25)

b. ENABLING LEARNING OBJECTIVES

(1) Given an existing all-weather stream, the requirement for a drainage structure and references, calculate the area of waterway to provide adequate drainage per the references.
(1302.1.25a)

(2) Given a map, an area requiring a drainage structure and references, calculate peak storm water run off to provide adequate drainage per the references. (1302.1.25b)

(3) Given an area of waterway and references, determine the amount of culvert required to provide adequate drainage per the references.
(1302.1.25c)

(4) Given a volume of water to be drained and references, design a drainage ditch to provide adequate drainage per the references. (1302.1.25d)

OUTLINE

1. SOURCES OF WATER/HYRDOLOGIC CYCLE.

a. Precipitation. Rainfall and ground water are the two primary concerns to most military drainage designers. Snowmelt may be of greater concern in wide ranging climates or in the design of reservoirs, but snowmelt estimation and reservoir hydrology is beyond our capabilities.

b. Interception. Vegetation decreases the velocity and amount of water. Rain will not reach the soil until the holding capacity of the vegetation as been exceeded.

c. Infiltration. A significant amount of water is absorbed into the soil. The amount of water absorbed depends on the type of soil, vegetal cover, and the slope of the terrain.

d. Ground water.

(1) Surface water is water that has accumulated on the ground surface.

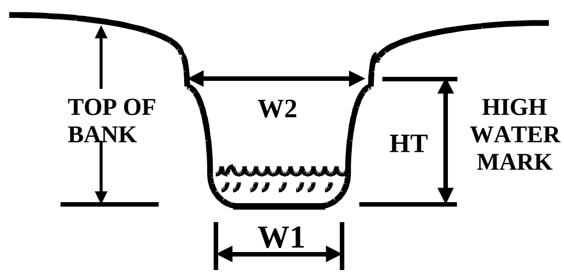
(2) Subsurface water is the water that is in the ground (water table).

(3) Capillary water is water that seeps up to the surface.

2. HASTY METHOD. The hasty method of runoff estimation is used when existing streams with an all-weather flow crosses or interferes with a construction site. This method provides an estimate of the cross-sectional area of water (Aw) to be expected as a result of the maximum annual runoff-producing storm.

a. This method makes the assumption that the cross section of the stream during a high water event approximates the shape of a trapezoid. The formula is:

$$Aw = \frac{W1 + W2}{2} H$$



Where:
Aw = Area of the waterway.

W1 = Width of the channel bottom.

W2 = Width at the high water mark.

H = Height from the bottom to the high w

b. Determining the measurements of the channel is the first step. The bottom width (W1) rarely presents a problem. The upper width (W2) may be more difficult. The upper width must be measured at the high water mark.

c. The high water mark is characterized by water flowing at higher than normal velocity. The high velocity flow tends to cause notable bank erosion and undercutting. The higher flow velocity also tends to retard the growth of vegetation on the banks. Thus the high water mark is that point where bank erosion is present or vegetation ceases.

d. The preferred location for observing the high water mark and for determining height (H) is along a straight run of the stream at, or immediately adjacent to, the construction site.

e. Once the expected cross-sectional area of storm water runoff (Aw) has been determined, since culvert pipes rarely flow full, a safety factor is incorporated so that adequate cross-sectional area is provided. This safety factor is provided in the term Ades, the culvert design cross section. The formula is:

Ades = 2Aw

Ades = design cross section.
2 = Safety factor
Aw = Area of the waterway that was previously computed.

<u>Example #1 Step (1)</u>

$$Aw = \left(\frac{\_\_\_ + \_\_\_}{2}\right) \_\_\_ =$$

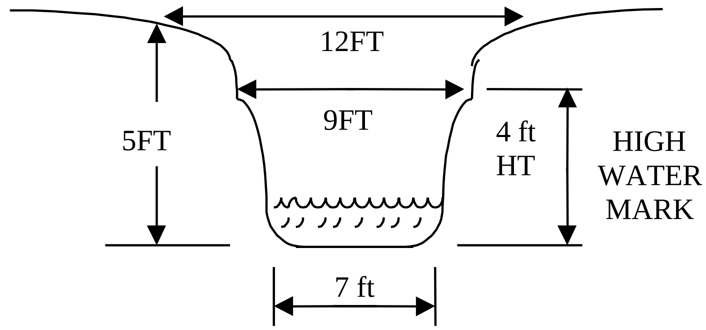
Aw=________ sqft.

<u>Example #1 Step (2)</u>

Ades= _____(sqft) X ___2___ =

Ades= _____(sqft)

(EXAMPLE 1)



<u>Example #2 Step (1)</u>

$$Aw = \left(\frac{\_\_\_ + \_\_\_}{2}\right) \_\_\_ =$$

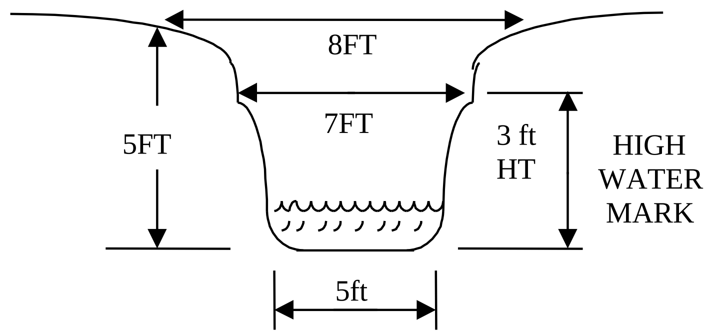
Aw=________ sqft.

<u>Example #2 Step (2)</u>

Ades= _____(sqft) X ___2___ =

Ades= _____(sqft)

(EXAMPLE 2)



3. <u>FIELD ESTIMATE METHOD</u>.

The field estimate method is an abbreviated version of the more deliberate rational method. The field estimate method is used to estimate the peak volume of storm water runoff. The runoff is carried in drainage paths that only carry flow during and immediately following precipitation. Results of the field estimate method are adequate for determining the size of drainage structures for temporary facilities in drainage areas of 100 acres or less. The formula is: **Q = 2 x A x R x C**

<u>Where</u>:

Q = peak volume of storm water runoff, in cubic feet per second.

2 = a constant (safety factor).

A = area of drainage basin, in acres.

R = design rainfall intensity based on the one hour, two year frequency rainstorm, in inches per hour.

C = coefficient representing a ratio of runoff to rainfall.

a. <u>Drainage area.</u> The fastest and most preferred method for determining the size of the drainage area is the stripper method. The first step of the stripper method is called delineation. It is done on a topographic map.

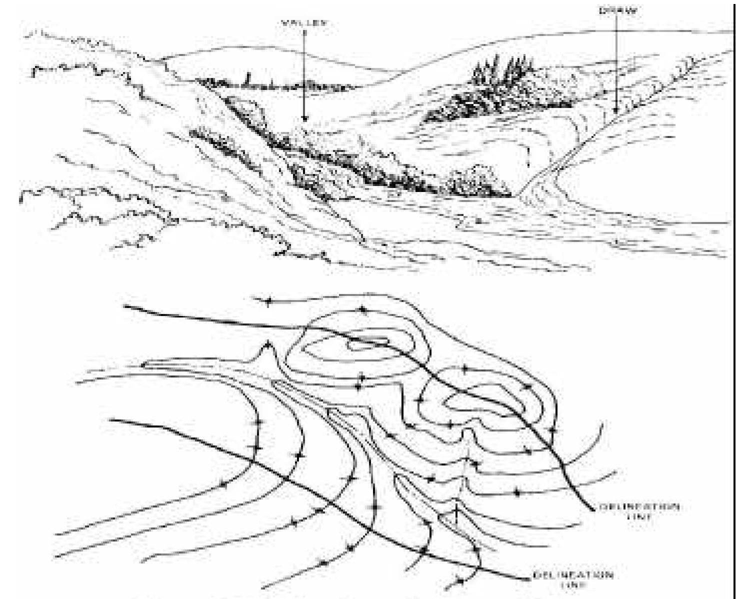


Figure 3-3. Delineation of valleys and draws

(1) Locate all the hilltops within the vicinity of the construction site.

(2) Draw arrows that follow the contour lines from hilltop down, you will then be able to see which area(s) will drain toward the construction site. This is the drainage area.

(3) Draw lines from hilltop to hilltop to delineate or outline an area.

(4) Locate the longest, steepest gradient (based on contour line interval) within the drainage area. This will be the base line.

(5) Now you must determine the area in square inches on the map and then convert to acres. Use a straight edge to draw a series of lines parallel to the base line, **one inch apart**.

(6) Starting with the base line, measure the length of each line within the limits of the drainage area. Add the length of all the lines together. This is the map area in square inches.

(7) Since you are concerned with acres, you must convert square inches on the map, to acres on the ground.

(a) First determine how many square feet are in one square inch on the map. Divide the map scale by twelve and then square the result.

<u>EXAMPLE</u>: If your map had a scale of 1:5000.

5000/12 = 416.67 ft. (Note 1" on map = 416.67 ft. on ground.)
416.67 = 173,613.88 (Notes 1 sq inch on map contains 173,613.88 sq feet on ground.)

(b) Second, determine how many square feet are in the drainage area. Multiply the square inches of the drainage area by the number of square feet per square inch.

EXAMPLE: If the total length of your strips had been 5.25 inches.
5.25" X 173,613.88 = 911,472.87

(c) Now you must convert square feet to acres. Divide the total area in square feet by the number of square feet in one acre, which is 43,560.

EXAMPLE: Your area had 911,472.87 square feet.

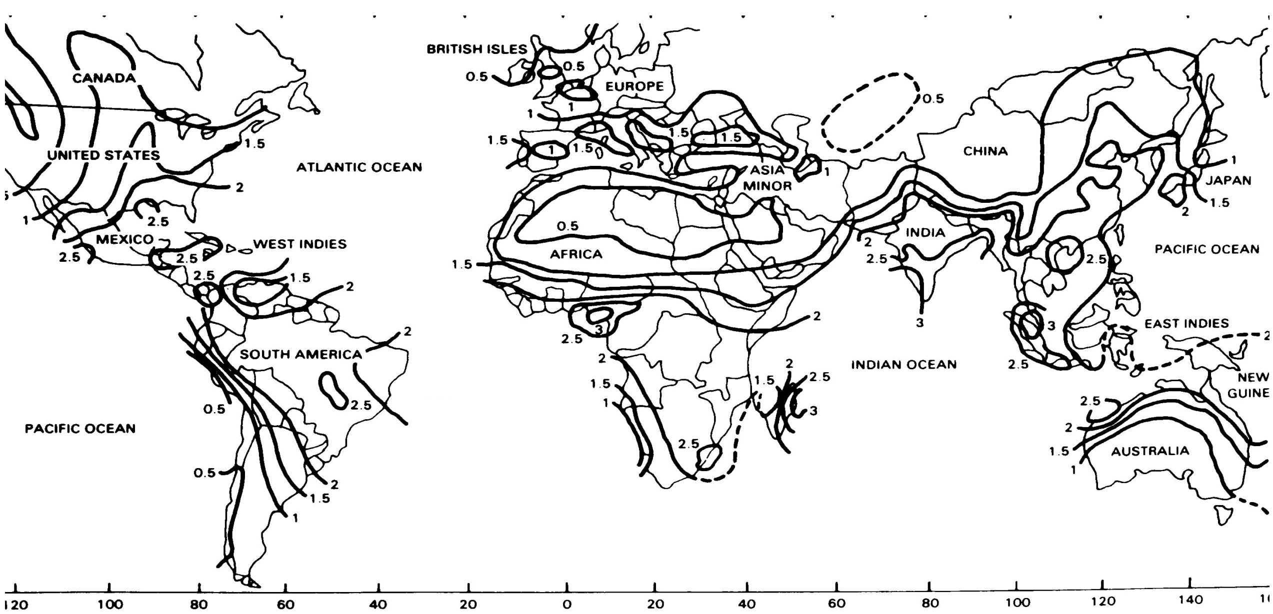
911,472.87 / 43,560 = 20.92 OR 21 ACRES

STUDENT PROBLEM: Using the map provided by the instructor, determine the acres of the drainage area.

b. Rainfall intensity. This is the intensity of the one-hour, two-year frequency rainstorm. This can be determined two different ways.

(1) Local rainfall data may be obtainable through the weather station or the intelligence officer (S-2). This is the preferred method because it is normally more accurate.

(2) The other method is by looking up the value on an isohyetal map. A copy of this map can be found on page 6-7 of FM 5-430, or on page 8-5 of FM 5-34. **Do not interpolate**. If the project location falls on an isohyetal line, read the value of that line. If it falls between two lines, read the larger value. If it falls within an encircling isohyetal line, read the value of the encircling line.



EXAMPLE: If your project location is Eastern North Carolina, you can see that it falls between 1.5 and 2.0. Use the larger value of 2.0.

c. Runoff coefficient. The runoff coefficient is the ratio of runoff to rainfall. It is the amount of water expected to drain from (not infiltrate) an area as the result of a specific amount of rainfall. The runoff coefficient is expressed as a decimal. There are three primary factors that affect the percentage, the soil type, surface cover and slope.

(1) Soil type. If the soil is porous, a large portion of the rain will infiltrate the soil. This condition would translate to a smaller runoff coefficient. On the other hand almost all of the rainfall will pass over surfaces such as asphalt, concrete, and compacted gravel or macadam, thus resulting in a higher runoff coefficient.

(2) Surface cover. It is also important to know the surface cover. If the area is completely bare then it would be without turf. If the area is completely covered with vegetation then it would be with turf. If the area has some vegetation but is not completely covered then use the higher without turf value. If the area is wooded then the coefficient will be 0.20 because of the capability for the root systems to absorb water. **See table below.**

Soil or Cover Classification	C VALUES					
	Slope $\leq$ 2 %		Slope >2 & <7%		Slope $\geq$ 7%	
	w/turf	w/o turf	w/turf	w/o turf	w/turf	w/o turf
GW, GP, SW, SP	.10	.20	.15	.25	.20	.30
GMd, SMd, ML, MH, Pt	.30	.40	.35	.45	.40	.50
GMu, GC, SMu, SC CL, OL, CH, OH	.55	.65	.60	.70	.65	.75
Wooded area	.20	.20	.20	.20	.20	.20
Asphalt Pavement		.95		.95		.95
Concrete Pavement		.90		.90		.90
Gravel/macadam		.70		.70		.70

table 6-1

(3) Slope. As terrain becomes steeper, water flows sooner and more rapidly. This allows less time for infiltration to occur and results in the C value becoming larger for the natural cover or soil categories.

d. <u>Finding (C) the Runoff coefficient</u>

(1) <u>(USCS)</u> Using the soil classification based on the Unified Soil Classification System (USCS), select the <u>predominant</u> soil type located in the left column of **table 6-1**. Be sure to use the value that corresponds to the cover type. If the area is wooded or covered with asphalt, concrete, gravel or macadam simply lookup the C value in the left hand column of the table.

(2) <u>Slope percentage</u>. Identify the slope on the map. The difference between the top and bottom of the slope is found by reading the elevation contours. Then the horizontal distance is measured and converted to the same unit of measure as the vertical distance.

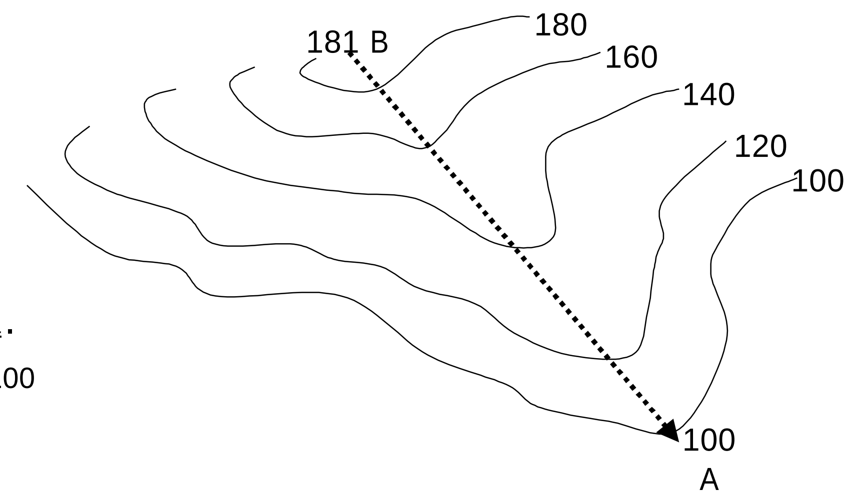
<u>Difference in Elevation</u>
Elevation B =181m
Elevation A =<u>100</u>m
Difference (Vd) **81m**

Horizontal Distance (Given) **=4150m**

<u>Use the percent formula</u>.

$$\frac{Vd}{Hd} X100 = \frac{\mathbf{81}}{\mathbf{4150}} x100$$

=1.9% or 2% Slope



(3) <u>Turf</u>. If the soil is not covered as previously explained then determine whether the area is with or without turf.

(4) <u>Safety</u>. In all cases where you have more than one possible runoff coefficient, use the highest value.

<u>EXAMPLE</u>: Your drainage area is made up of ML soil, with 40% turf and a slope of 2%.

*Since your area is covered with 40% turf you use the highest value which will be without turf.

* Look up the value based on the drainage characteristics. You should obtain a value of 0.40 for your runoff coefficient.

(a) <u>Q = 2ARC</u>

<u>Q = Peak volume "cubic feet per second"</u>

A = Area in acres, previously computed at <u>**31.89**</u> acres. Rounded up to the whole acre would be <u>**32**</u> acres.

R = Rainfall intensity for eastern North Carolina was found to be <u>**2.0**</u>

c = Runoff coefficient which was **<u>0.40</u> ML** soil without turf.

$\underline{Q = 2 \times 32 \times 2 \times 0.40}$

$\underline{Q = 64 \times 2 \times 0.40}$

$\underline{Q = 128 \times 0.40}$

$\underline{Q = 51.2 \text{ CFS}}$

4. <u>WATERWAY AREA</u>. Expedient culvert and ditch design is based on the waterway area. The hasty method produced a result in terms of waterway area, but the field estimate method produced a result in terms of peak volume of storm water runoff (Q). The storm water runoff must now be modified so that it is in terms of waterway area.

a. First look at the equation where Q = VAw.

Q = peak volume of storm water runoff.

V = velocity of water, in feet per second (fps).

Aw = waterway area, in square feet.

b. For expedient purpose you will always use a velocity of 4 fps for design of expedient drainage structures. Using <u>simple</u> algebra, you can rearrange the above equation so that the result will be waterway area.

(1) Q = VAw

(2) Divide both sides of the equation by the velocity (V). The result is Q/V = Aw.

c. The final step would be to substitute the known and previously calculated values for the variables in the equation and solve for the waterway area.

<u>EXAMPLE</u>: You previously calculated a Q of 51.2 cfs, and the velocity is a given of 4 fps.

d. Aw = Q/V

e. As with the hasty method described earlier, you rarely design a drainage system to flow completely full. You must apply a safety factor which is represented by Ades.

Ades = Aw x 2

<u>EXAMPLE</u>: Since your waterway area is 16 sqft., multiplying by the safety factor of two gives a design waterway area (Ades) of 32 sqft.

5. <u>TRIANGULAR (V) DITCHES</u>: Triangular (V) ditches are used to move small quantities of water. Small quantities of water generally means Q < 60 cfs or AW $\leq$ 15 sqft. There are two formulas used to determine how wide and how deep the ditch should be. They are:

a.

$$\boxed{D = \left(\sqrt{\frac{Ades}{X + Y}}\right) + .5}$$

D = Water depth in feet

Ades = Design cross section

X = Slope ratio, or amount of vertical distance to every horizontal distance of the fore slope.

Y = Slope ratio, or the amount of vertical distance to every horizontal distance of the cut slope or back slope.

.5 = Constant as a safety factor.

b. Width = D x (X + Y)

Wt = Width of the top of the ditch
X = Determined by slope ratio.
Y = Determined by slope ratio.

c. X- Slopes less than or equal to 3:1 (H/V) ratio are recommended as safe side slopes for roadside ditches.

d. Y- It is recommended that the slope be a 1:1 (H/V) ratio.

e. The width formula uses the same X and Y as the depth formula. Also, you need the depth (D) to determine the width. To ensure the ditch will be able to move the necessary amount of water at peak periods a freeboard of 1/2 foot will be added to the depth prior to working this equation.

(Example from previous solution) AW = 16 sqft.

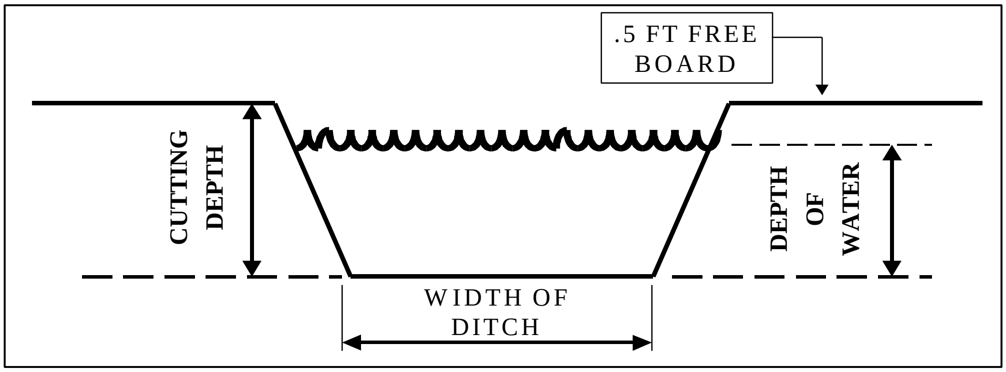
(1) $D=\sqrt{\dfrac{Ades}{X+Y}}$ **(2)** $D=\sqrt{\dfrac{2 \times 16}{3+1}}$ **(3)** $D=\sqrt{\dfrac{32}{4}}$

(4) $D=\sqrt{8}$ **(5)** $D=\sqrt{2.82}$

(5) D= foot of water depth rounded off to 2.8 water depth.

Freeboard 2.8 + 0.5 =3.3 ft. (cutting depth).

6. TRAPEZOIDAL DITCHES. Trapezoidal ditches are installed for larger runoff requirements, generally for Q >60 cfs or Aw >15 sqft. Compute the cross-sectional area of a trapezoidal ditch as if the trapezoid were a rectangle. The slope areas are not considered. Generally the designer selects the width of the bottom of the ditch based upon the width of the cutting edge of the equipment used in constructing the ditch then solves for d, the depth of water. For example, if the ditch is to handle a peak flow rate of 75 cfs and the bottom width is 12 feet, then:



Aw = $\frac{Q}{4\ fps}$ = $\frac{75\ cfs}{4\ fps}$ = 18.75 or 18.8 sqft

D = $\frac{Aw}{bottom\ width}$ = $\frac{18.8\ sqft}{12}$ = 1.56 or 1.6 feet deep

Freeboard = 1.6 ft. deep + 0.5 = 2.1 ft. deep.

7. CUTTING DEPTH. Remember to add 1/2 foot of freeboard to the depth of water to determine the cutting depth (CD). CD may be exceeded, especially if it is less than 1.5 feet, the normal minimum depth. **CD = d + 0.5 ft**

8. CULVERTS A culvert is an enclosed waterway used to pass water through an embankment or fill. There are two classifications of culverts: permanent and expedient. The flow of water depends upon the materials the culvert is constructed of and the down stream conditions.

a. Permanent Culverts. There are different materials culverts may be constructed of such as corrugated metal, concrete, vitrified clay (VC), polyvinyl chloride (PVC), timber, and many other materials.

b. Timber Box Culverts. are used when standard culverts are not available. Timber culverts can be rapidly constructed but require good workmanship. They provide good strength to support superimposed loads and have hydraulic characteristics that compare favorably with other types of culverts. They are made of:

(1) Large timber (treated if possible)

(2) Made strong enough to support the heaviest vehicle that will be crossing.

(3) Must have minimum of 12" of cover.

c. Corrugated Metal; Pipe Culverts (CMP)

(1) 8"-72" Diameter

(2) Shipped in 26" long half sections, with a 24-inch effective length due to 2 inch overlap.

(3) Bolted in every hole, threaded end alternated.

(4) Cradled to prevent pipe shifting during back fill.

(5) Place exhaust end, at the same grade as ditch, 45-90 degrees off centerline.

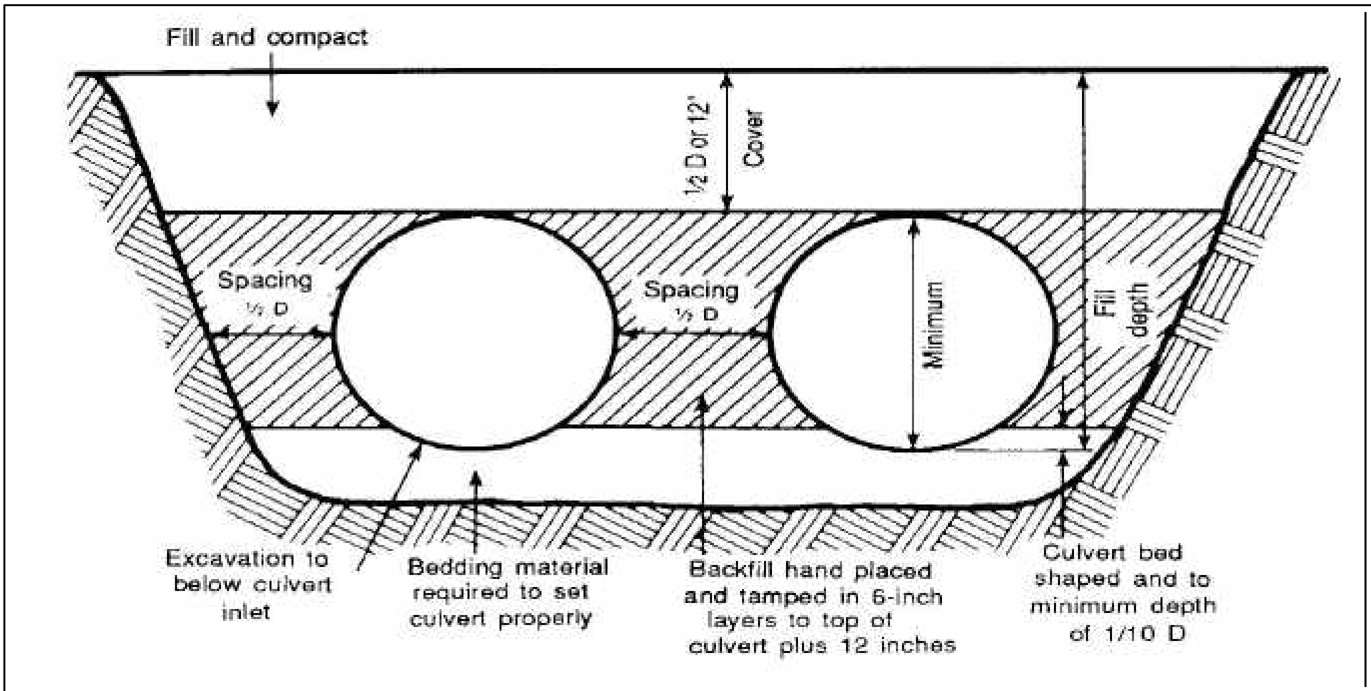
(6) multiple pipes must all be the same diameter.

(7) multiple pipe spacing is half the diameter of the pipe.

9. MAXIMUM ALLOWABLE CULVERT DIAMETER. Permanent culverts are selected based on their diameter. There are two equations for determining the maximum diameter (Dmax) of a culvert. Both methods depend upon the amount of fill used to bury the culvert. Fill (F) is defined as the distance from the inside bottom (the invert) of the culvert to the finished grade of the road. Cover (C) is another term used in culvert design. Cover is measured from the top of the culvert to the finished grade.

a. For fills greater than 36 inches use Dmax = 2/3F.

b. For fill less then 36 inches use Dmax = F-12.



EXAMPLE: From the hasty method example you had a AW of 16 sqft. and a Ades of 32 sqft. The stream itself was five feet deep with a road thickness of one foot. Therefore, you have a six-foot fill.

c. Dmax = 2/3 F
(Step 1.) 6' x 12 = 72"

d. Dmax = 2/3 72 inches $\frac{2 \times 72}{3} = \frac{144}{3}$ or 48"

e. Dmax = 48 inches

10. CULVERT MATERIALS. There are several factors that need to be considered when calculating materials. You will need to know the most economical diameter to be used as well as the total length of culvert necessary.

a. Economical diameter: We want to save material, therefore we want to put in the least number of pipes possible, and still equal or exceed the design area. Economy also dictates that we exceed the design area by the least possible amount. Manpower, too, is a factor that we must consider when thinking of economy, for it takes less time and effort to install 2 pipes than it does to install 3.

b. From the standpoint of economy, then, we cannot simply select the largest pipe that satisfies the fill and cover requirement. To find the most economical size, we must divide the Design Area by the end area of several different pipe sizes. We use the largest pipe that satisfies the fill and cover requirements as a starting point, and work with the next smaller size of pipe until the number of pipes required to provide necessary Design Area increases. When the number of pipes required increases, we have reached and just passed our optimal (or most economical) design, and we are no longer economical.

(1) Select the next smaller diameter culvert. Selecting the next larger diameter would lead to insufficient cover and, possibly, a culvert collapse should vehicles drive over it. Use the table below.

(2) Divide the design cross section (Ades) by the cross-sectional area of the diameter selected. Round up to the next whole number. Repeat using successively smaller pipes.

COMMON CULVERT SIZES

CORRUGATED METAL PIPE

Maximum Diameter (IN)	Cross-sectional area (SqFt)
12	00.79
18	01.77
24	03.14
30	04.91
36	07.07
42	09.62
48	12.57
60	19.64
72	28.27

EXAMPLE:

N48 = Ades/A48

N48 = number of 48 inch pipes.

A48 = cross-sectional area of a 48 inch pipe.

Ades = design waterway area.

N48 =

N48 =

N42 =

N42 =

N42 =

c. Culvert length. Since corrugated metal pipe is manufactured in two-foot sections the calculated length must be rounded up to the even foot. Some other considerations include:

(1) Headwalls protect the soil around the culvert from erosion.

(2) Headwalls are always required at the upstream end of the culvert and are desirable at the downstream end. If a headwall is not constructed on the downstream end of the culvert, the end must be extended an additional two feet to prevent erosion of the fill.

(3) Headwalls need not be built precisely at the toe of the fill slopes. Most often, headwalls are recessed some distance into the fill section. The culvert length will have to be adjusted to this length. The amount of building materials and time will dictate whether the headwalls will be recessed or not.

(4) The length will be determined using road cross sections provided by the surveyor and will include the width of the road plus the length of the fill slopes.

(5) The length of the fill slopes may not be labeled, but can be computed using the slope ratio and the height at the road shoulder. Since the slope ratio is expressed as the horizontal distance to the vertical distance you can multiply the horizontal distance of the slope ratio by the vertical distance. The result will be the length of the fill slope.

(6) Pipe is ordered by length needed, and comes with enough nuts and bolts for assembly. It is recommended that an additional 15 percent be added to allow for damage during shipment and construction. This is obtained by multiplying the length by 1.15. Additionally you must multiply by the number of pipes to determine the total order length.

EXAMPLE: Using the cross section above and the knowledge that you will place headwalls at the toe of both fills.

Road: 22.5 feet wide
Left slope: 2:1 with a 7' depth.
Right slope: 3:1 with a 6' depth.
Gradient: 2%

(7) OL = order length

DL = Depth of fill at left shoulder

SL = Slope on left side slope

DR = Depth of fill at right shoulder

SR = Slope on right side slope

RW = road width including shoulders.

N = number of pipes. (culverts)

1.15 = waste factor.

LS (left shoulder slope) = (7'x 2:1)

RS (right shoulder slope) = (6'x3:1)

W (width of roadway) = 22.5

N = 3 - 48 inch diameter.

OL (order length) = {(DL x SL) + RW +(DR x SR)} N x 1.15

OL = {(7x2)+ 22.5 + (6x3)} 3 x 1.15

OL = {(14) + 22.5 + (18)} 3 x 1.15

OL = (545) 3 x 1.15

OL = 163.5 x 1.15

OL = 188ft. of 48" pipe.

d. Strutting. Because of the stress placed on corrugated metal pipe by large amounts of cover it becomes necessary to support pipes 48 inches in diameter or larger with struts.

(1) The table below gives the length and spacing for struts.

STRUT SPACING FOR NEST ABLE (CMP)

DIAMETER (IN)	LENGTH OF STRUT (IN)	FILL HEIGHTS (FT)		
		5-10	10-20	20-30
		SPACING OF STRUTS (FT)		
48	37.5	6	6	6
54	43.6	6	6	6
60	49.8	6	6	6
66	56.0	6	6	6
72	62.2	6	6	5

(2) The other materials for strutting will be:

(a) One lower sill, 4" X 4" lumber.

(b) Two upper sills, 4" X 4" lumber with joints staggered on alternate struts.

(c) Vertical struts, 4" X 4" lumber.

(d) Jack struts, 4" X 4" lumber shortened to accommodate the length of the jack.

(e) Compression caps, not less than ten inches long to provide enough room for the vertical strut and the jack strut.

(f) Bearing blocks, large enough to support the bottom of the jack being used.

EXAMPLE: You have three 48-inch pipes 76 feet in length.

(g) Lower sill, 3 @ 76' X 4" X 4" = 228' of 4 X 4

(h) Upper sill, 6 @ 76' X 4" X 4" = 456' of 4 X 4

(i) Vertical strut, every 6 feet = 13 X 3 = 39, 39 X 37.5 = 1462.5" = 122' of 4 X 4

(j) Jack strut, 4(37.5" - 18") = 78" = 6'6" of 4 X 4

(k) Compression caps, 4(2 X 10 X 10") = 40" of 2 X 10

(l) Bearing blocks, 4(2 X 10 X 10") = 40" of 2 X 10

(m) Total lumber, 812' 6" of 4 X 4, 6' 7 3/16" of 2 X 10

11. EROSION CONTROL METHODS.

a. Ditches. There are several methods of erosion control used in ditches. The primary concern is to slow the water down. However, water that runs too slow will cause drainage systems to clog and ultimately fail. The desirable gradient for a ditch is between 0.5 percent and 2 percent. Ditches with a gradient greater than 2 percent will require erosion control.

(1) Ditch lining. Ditches may be lined to prevent erosion. The use of concrete, asphalt, rock and mortar will not decrease the velocity of the water by any great degree, but it will protect the soil. The use of grass will not only help to protect the soil but it will also reduce the velocity of the water. Grass seed is cheap, and is normally available at the construction site. Concrete, asphalt, rock and mortar can be rather expensive and will not be readily available.

(2) Check dams. Check dams are nothing more than small dams built from logs or heavy timbers that reduce the gradient of the ditch.

(a) Timbers. The timbers should be six to eight inches in diameter or square. They will be set at least two feet into the sides and bottom of the ditch. In addition, they will be joined with drift pins and held in place by piles. The piles will be on both sides of a notch in the center of the check dam. The notch is called a weir notch.

(b) Weir notch. A weir notch will be cut in the center. Normally the weir notch will be a minimum of six inches deep and twelve inches wide. Naturally a larger dam will have to have a larger weir notch.

(c) Rock apron. A rock apron made of rip-rap will be placed in front of the dam, and should extend four feet in front of the dam for every one-foot of dam height.

(d) Top of dam. The top of the check dam should be placed at the high water mark on an existing ditch. A new ditch will not have a high water mark, so the top of the check dam will be placed one foot below the top of the ditch.

(e) Dam spacing. Check dams will have a minimum spacing of 50 feet. To reduce construction effort the dams should be placed as far apart as possible, while achieving the desired gradient.

S = Spacing in feet.

A = Present ditch gradient.

B = Desired ditch gradient.

H = Height of check dam.

100 = Converts to percentage.

$$S = \frac{100(H)}{A - B}$$

% Gradient = (Rise/Run) 100

(f) Check dams should be checked periodically to allow the free flow of water.

REFERENCE(S):

FM 5-430-00-1
MCRP 3-17A

UNITED STATES MARINE CORPS
COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA 28547-0069

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STUDENT HANDOUT

PRODUCTION ESTIMATION

1. TERMINAL LEARNING OBJECTIVES:

a. Given a horizontal construction scenario and blank production worksheets, plan horizontal construction operation per the reference. (1302.1.34)

2. ENABLING LEARNING OBJECTIVE(S):

a. Given a horizontal construction scenario and blank scraper production worksheets, calculate scraper production per the reference. (1302.1.34 a)

b. Given a horizontal construction scenario and blank dozer production worksheets, calculate dozer production per the reference. (1302.1.34 b)

c. Given a horizontal construction scenario and blank grader production worksheets, calculate grader production per the reference. (1302.1.34 c)

d. Given a horizontal construction scenario and blank scooploader production worksheets, calculate scooploader production per the reference. (1302.1.34 d)

e. Given a horizontal construction scenario and blank excavator production worksheets, calculate excavator production per the reference. (1302.1.34 e)

f. Given a horizontal construction scenario and blank clamshell production worksheets, calculate clamshell production per the reference. (1302.1.34 f)

g. Given a horizontal construction scenario and blank compactor production worksheets, calculate compactor production per the reference. (1302.1.34 g)

h. Given a horizontal construction scenario and blank dump truck production worksheets, calculate dump truck production per the reference. (1302.1.34h)

INDEX

BODY

1. **ESTIMATING**

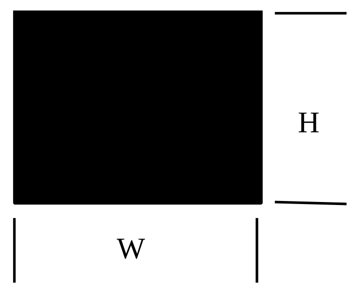
a. Estimating is the art of determining the size of the job, labor and equipment needed to perform the job, and quantities of materials. To do any type of estimation, you need to know some basic formulas to get started.

2. **AREA AND VOLUME**

a. **Area:** To measure area, find how much surface is taken up by a plane figure. Knowing just how much surface there is in a plane becomes important when you wish to cover a surface such as a road. Areas are measured in square units, i.e. square yards, square feet. To compute the area of planes most closely associated with production estimation, use the formulas below. When working with feet, divide your answer by 9 to convert the answer to square yards. Nine is a constant. We use 9 because there are three feet to one yard and nine feet to one square yard.

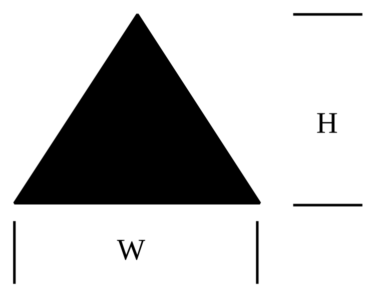
(1) Squares and Rectangles

W X H = AREA

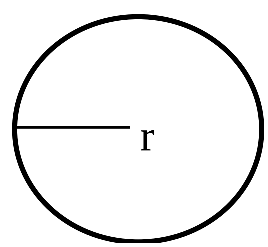


(2) Triangles

$$\frac{W \times H}{2} = \text{AREA}$$



NOTE: WE USE 2 BECAUSE A TRIANGLE IS ONE HALF OF A SQUARE. ANY TIME WE DIVIDE BY 2, WE GET ONE HALF OF THE SUM.



(3) Circles

$3.14\ (r^2) = \text{AREA}$

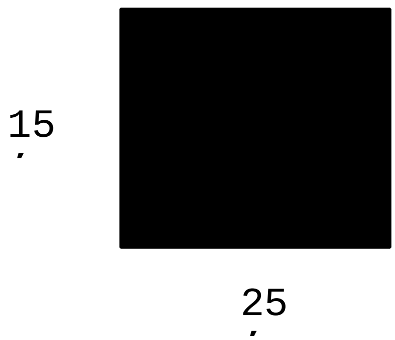
NOTE: RADIUS = 1/2 THE DIAMETER OF THE CIRCLE.

WHAT HAVE YOU LEARNED:

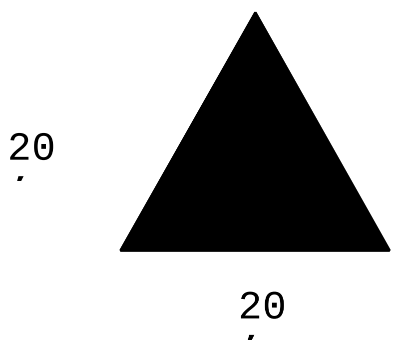
FIND THE AREA OF THE FOLLOWING:

YOUR SOLUTIONS:

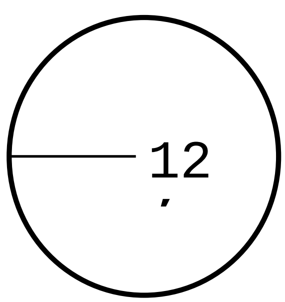
A)



B)



C)



VOLUMES

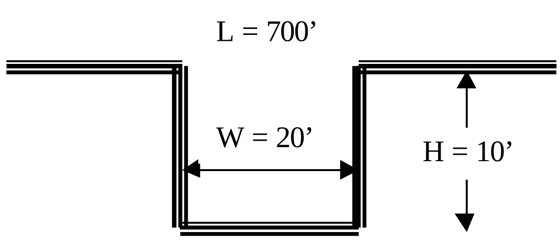
b. **Volume:** is the space occupied by a three dimensional figure as measured in units.

(1) When figuring production, the unit of measure is cubic yards (CY). The volume must be changed into cubic yards. To do this, use the following formulas. Your dimensions of Length, Width, and Height must be measured in feet for the formula to work. There are three feet in a yard and three dimensions in volume (3 feet X 3 sides X dimensions = 27). *The number 27 is a constant and will convert your figure into cubic yards.*

(2) **The formula to calculate the cubic yards of squares and rectangles**

$$\frac{\mathbf{L\ X\ W\ X\ H}}{\mathbf{27}} = \mathbf{(CY)}$$

Example: Determine the cubic yards of a trench with the following dimensions.



SQUARE OR RECTANGLE:

$$\frac{\mathbf{700'\ X\ 20'\ X\ 10'}}{\mathbf{27}} = \mathbf{5185.19\ OR\ 5186\ (CY)}$$

NOTE: ROUND UP CY WHEN DETERMINING AMOUNT TO BE REMOVED

L = 700'
W = 20'
H = 10'

NOTE * IF YOUR MEASUREMENTS ARE IN INCHES YOU MUST CHANGE THEM INTO FEET. THIS CAN BE DONE BY DIVIDING INCHES BY TWELVE.

6" ÷ 12" = .5 FEET

WHAT HAVE YOU LEARNED:

PROBLEM #1: You have been assigned to dig two (2) trenches. Figure the total cubic yards of material to be removed from each trench.

TRENCH # 1:

600' Long, 70' Wide, 25' Deep

YOUR SOLUTION ?

TRENCH # 2:

350' Long, 22' Wide, 12' 8" Deep

YOUR SOLUTION ?

Volume of a Berm

c. The volume of a berm can be calculated with the use of two formulas.

(1) The formula to calculate the cubic yards of a ***CONE***

$$\frac{3.14\ (\ r\ )\ H}{3} = \frac{\text{CUBIC FEET (CF)}}{27} = \text{(CY)}$$

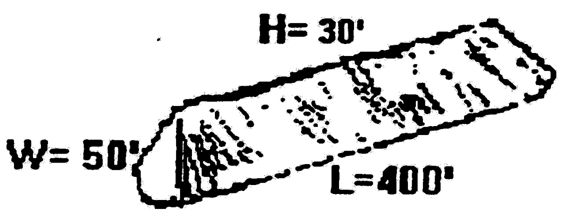
*** NOTE: RADIUS = 1/2 THE WIDTH OF THE BERM ***

(2) The formula to calculate the cubic yards of a ***PRISM***

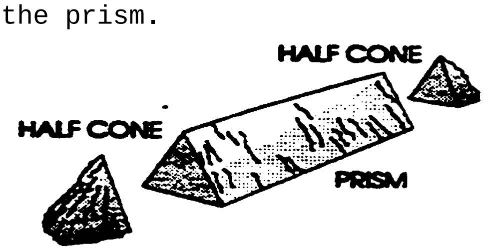
$$\frac{W \times H}{2} = \text{AREA} \qquad \frac{(A) \times L}{27} = \text{(CY)}$$

Example: Determine the cubic yards of a berm with the following dimensions.

(Step 1) MEASURE: The Length, Width, and Height in feet

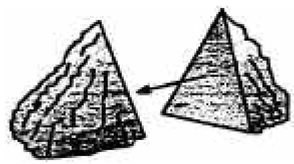


(Step 2) LENGTH OF PRISM: Mathematically dissect the berm into three portions. This is done by cutting ***half the width of the berm off of each end,*** thus creating a prism and two half cones. After cutting off the ends, **the remaining length,** is the length of the prism.

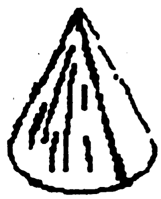


(Step 3) **<u>RADIUS OF CONE</u>**: Take the two half cones and put them together to make a mathematical cone. **Remember that half the width of the berm will always be the radius of the cone, <u>FOR EXAMPLE, THE WIDTH OF THIS BERM IS 50',</u> <u>THIS MEANS THAT THE RADIUS OF THIS CONE IS 25'.</u>**

Half cone + Half cone



(Step 4) **<u>FORMULATE THE CONE:</u>**



<u>3.14 (25r) 30'</u>
3 **=** **<u>19,625 CF</u>**
27 **=** **<u>726.85 CONE *CY*</u>**

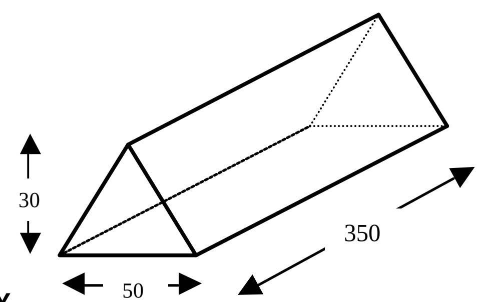
NOTE: DO NOT ROUND OFF AMOUNT OF MATERIAL UNTIL THE CONE AND PRISM ARE ADDED TOGETHER

***NOTE: RADIUS = 1/2 WIDTH OF BERM*, AND IN THIS FORMULA THE RADIUS IS SQUARED, THIS MEANS THAT YOU WILL MULTIPLY IT BY ITSELF.**

EXAMPLE: 25 X 25 = 625

(Step 5): **<u>FORMULATE THE PRISM:</u>**

<u>W 50' X 30' H</u>
2
= <u>A 750 X 350 L</u>
27
= <u>9,722.22 PRISM CY</u>



NOTE: DO NOT ROUND OFF AMOUNT OF MATERIAL UNTIL THE CONE AND PRISM ARE ADDED TOGETHER

(Step 6) **<u>ADD CONE TO PRISM:</u>**

<u>726.85</u> + <u>9,722.22</u> = <u>10,449.07 OR 10,450</u>
CONE *CY* + PRISM *CY* = BERM *CY*

***NOTE:* ROUND UP TO THE NEXT FULL CUBIC YARD.**

WHAT HAVE YOU LEARNED:

PROBLEM #2: You have been assigned to remove a berm. What is the total cubic yards of soil to be removed?

BERM DIMENSIONS: 650' Long, 61' Wide, 40' High

CONE FIRST

$$\frac{3.14\ (r^2)\quad H\_\_\_}{3} = \frac{\_\_\_\_\_\_\_\_\_\_\_\_\ \_\_CF}{27} = \underset{\textbf{CONE CY}}{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}$$

NOTE: DO NOT ROUND OFF

PRISM

$$\frac{W \quad X \quad H\_\_}{2} = \frac{\_(A \qquad)\_\_\_\_\_\ \_\_L}{27} = \underset{\text{PRISM } \textbf{CY}}{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_}$$

NOTE: DO NOT ROUND OFF

TOTAL BERM

________	+	___________	=	________________
CONE CY	+	PRISM CY	=	TOTAL CY OF BERM

NOTE: ROUND UP TO THE NEXT FULL CUBIC YARD, WHEN DETERMINING THE AMOUNT OF SOIL TO BE REMOVED.

3. **SOIL CONVERSION**

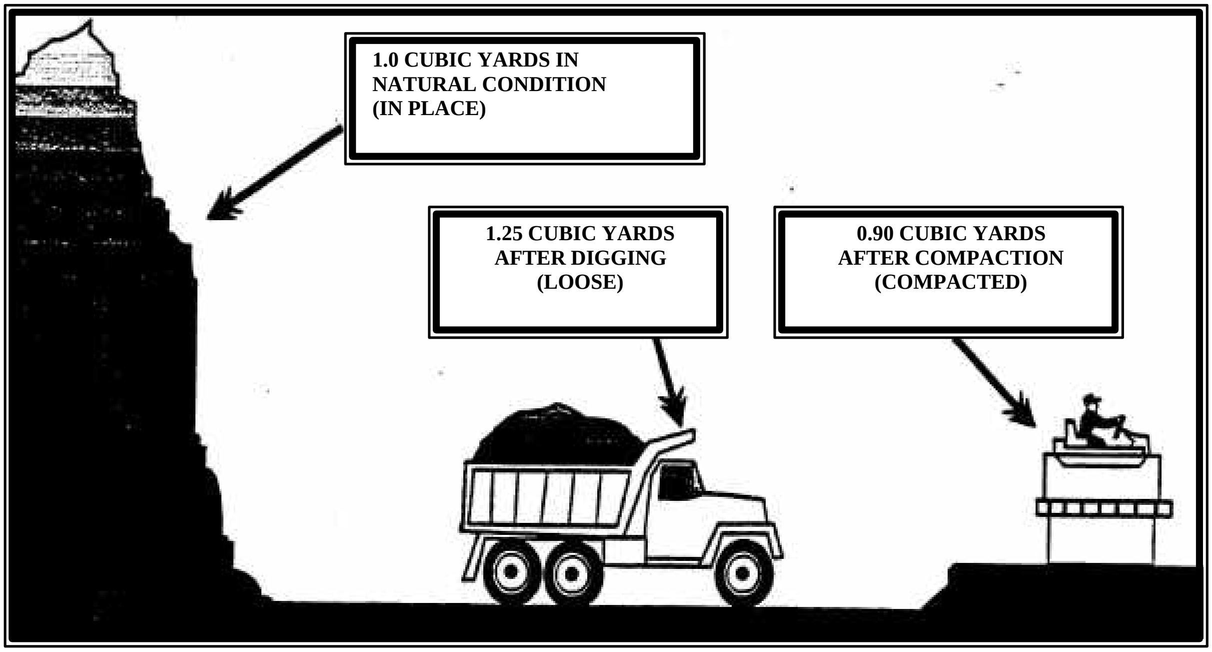
a. Soil is found in THREE different **STATES** or **VOLUME** 1) bank 2) loose 3) compacted. Sometimes it is necessary to convert from one volume to the other. To do this we use (TABLE# 1-1)

(1) **Bank Soil Volume:** is any soil that has not been disturbed from its natural state for at least ten years. This is also known as Bank Cubic Yards **(BCY)**

(2) **Loose Soil Volume:** is any soil that has been disturbed. Note: soil is always in a loose volume when being hauled, worked or stockpiled. This is also known as Loose Cubic Yards **(LCY)**

(3) **Compacted Soil Volume:** is any soil that has been compacted by artificial means. This is also known as Compacted Cubic Yards. **(CCY)**

b. Now that you understand that soil is found in three basic volumes, you must also know that we can convert from bank volume, to loose volume, to compacted. This can be done by using ***(Table #1-1)***.



EXAMPLE FOR THE VARIOUS STATES OF COMMON EARTH

c. Due to the volume change of material in different states, it is necessary to use a conversion factor to determine the correct amount of material needed for a project. These factors are in **Table #1-1**. The conversion chart has five columns. The first is the type of soil that is being worked with. The second column identifies the initial soil condition as being either Bank, Loose, or Compacted. Columns three through five identify the conversion factor used to convert the volume of the soil from its initial condition to another form. An asterisk indicates a soil condition which is the same as the initial soil condition.

TABLE #1-1
SOIL CONVERSION FACTORS
NOTE: * IS CONSIDERED 100% VOLUME OR 1.00 CY

SOIL TYPE	INITIAL CONDITION	TO BANK	TO LOOSE	TO COMPACT
SAND	FROM BANK	*	1.11	.95
	FROM LOOSE	.90	*	.86
	FROM COMPACTED	1.05	1.17	*
LOAM	FROM BANK	*	1.25	.90
	FROM LOOSE	.80	*	.72
	FROM COMPACTED	1.11	1.39	*
CLAY	FROM BANK	*	1.43	.90
	FROM LOOSE	.70	*	.63
	FROM COMPACTED	1.11	1.59	*
BLASTED ROCK OR GRAVEL	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*
HARD CORAL OR LIMESTONE	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*

EXAMPLE: If we needed to make a road that is **1500' long** with a **3" lift** of **gravel** and **24' wide,** it would be necessary to compute the volume first in compacted cubic yards and then convert it to a Loose state . This determines how much material our haul units would have to move. This is done by multiplying the volume of the compacted material by a conversion factor.

NOTE:When working with inches you must convert inches to feet.ie. 3" ÷ 12" =.25'

1500' (L) X .25' (H) X 24' (W) = 9000 ÷ 27 = 333.33 OR, ***334 (CCY)***

334 (CCY)
X 1.15 CONVERSION FACTOR
384.10 OR 385 (LCY)

NOTE: ROUND UP TO THE NEXT FULL CUBIC YARD

WHAT HAVE YOU LEARNED

PROBLEM #3: Your crew is tasked to dig a trench which is 300 feet long, 9 feet wide, and 6 feet deep. The material that you are working with is Earth Loam, Dry, and the soil has been undisturbed for more than 10 years. Using a 1085 Excavator, how many loose cubic yards **(LCY)** of soil will you remove?

PROBLEM #4: In Problem #3 you removed _____________ loose cubic yards of soil. However your requirement for a road you are working on is 16,600 compacted cubic yards (CCY). Will you have enough soil to do the road? If yes, how much over? If not, how much under?

PRODUCTION TIME

a. Even though each piece of equipment has different formulas to arrive at production times, the basic principal needs to be talked about before we can move into equipment production.

(1) **CUBIC YARDS PER HOUR (CYPH)** All equipment productions are based on this simple principal, Cubic Yards Per Hour (CYPH), whether it be

Loose Cubic Yards Per Hour **(LCYPH)**

Bank Cubic yards Per Hour **(BCYPH)**

Compacted Cubic Yards Per Hour **(CCYPH)**

(2) **CUBIC YARDS PER DAY (CYPD)** Daily production can simply be found by multiplying the total cubic yards moved per hour by the total hours worked per day.

EXAMPLE:

100 **CYPH X** 8 **HR WORK / DAY =** 800 **CYPD**

NOTE: ROUND DOWN CYPD

(3) **TOTAL PRODUCTION DAYS:** Can be found by taking the total requirement of cubic yards needed, and dividing it by the total CYPD moved.

EXAMPLE:

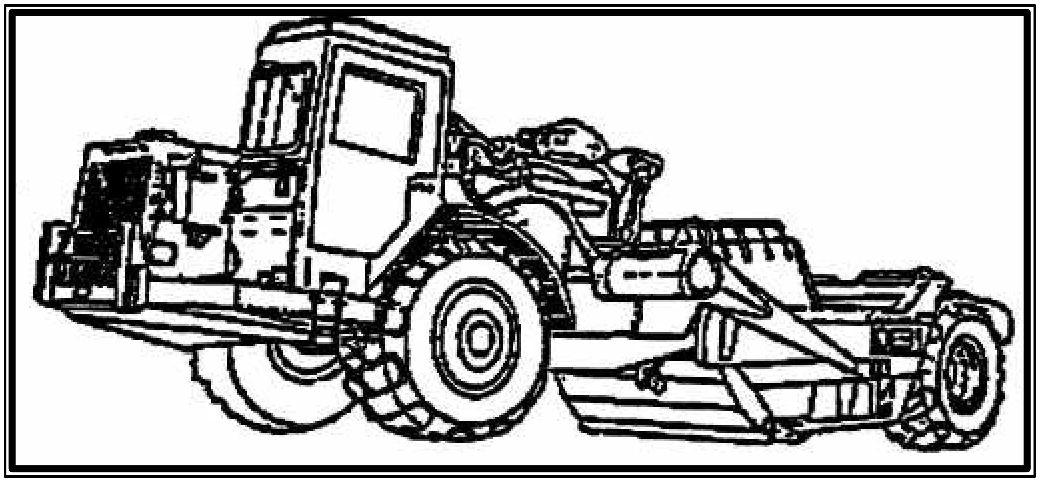
16,600	÷	800	=	20.75 OR 21
REQ CY	÷	***CYPD***	**=**	***DAYS NEEDED TO MOVE REQ*.**
				NOTE: ROUND UP DAYS TO NEXT FULL DAY

WHAT HAVE YOU LEARNED

PROBLEM #5: It has been determined that you are moving 150 LCYPH and you're working 5 hours per day, due to bad weather. The requirement to be moved is 17,000 LCY. How much material is being moved per day, and how many days will it take to move the required amount of material?

PROBLEM #6: It has been determined that you are moving 250 LCYPH and that you're working 8 hours per day. The requirement to be moved is 18,000 LCY. How much material is being moved per day, and how many days will it take to move the required amount of material?

SCRAPER 621B



INTRODUCTION

Scrapers are designed for loading, hauling, and dumping on long-haul earthmoving operations. The scraper has three basic operational parts; the bowl, the apron, and the ejector. The bowl, which is equipped with a cutting edge on the front bottom, is the loading and carrying component. The apron is the front wall of the bowl, and can be raised and lowered independently of the bowl. The ejector is the rear wall of the bowl. It is moved back to load, and forward to discharge materials.

1. **USE**: In the field of heavy construction, tractor-scrapers serve the primary purpose of loading, and hauling material. The distinct advantage of the tractor-scraper, in earthmoving, is the ability to load, haul, and spread in one continuous cycle. The tractor-scraper is capable of working alone for leveling operations, but is supplemented with push-tractors for cut and fill operations.

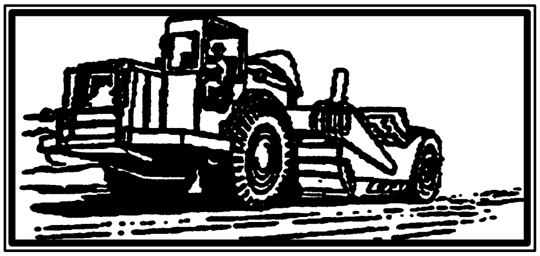
2. **CLASSIFICATION**: Tractor-scrapers are classified according to load capacity, and rated load. Capacity is measured in heaped and struck capacity. A heap load is the maximum load of the machine, and a struck load is the minimum effective load.

3. **CHARACTERISTICS:** Tractor-scrapers are wheeled vehicles characterized by a tractor and scraper. They serve as prime earthmovers in cut and fill operations and in bringing elevations to rough, final grades. Since scraper bowls are of open design, they can also be loaded from above, with a shovel or a bucket. Scrapers have three types of cutting edges; straight, which is most effective for smooth grade finishing; curved, which provides better penetration than a straight edge; and the three-piece cutting edge, where the center piece (called a stinger) is held ahead of the two side pieces for better penetration. The 621B has a rated load weight of 48,000 lbs.

4. **OPERATION:** Scrapers are hydraulically operated and powered by a tractor. The tractor-scraper is most efficient during downhill loading. Other methods that will increase production include straddle loading, and pump loading. Straddle loading is most effective in stripper operations and will gain time on every third trip becase the center strip has less resistance than a full cut. Pump loading is a technique used in sand, and gravel, where material is heaped in front of the bowl and when the pusher lugs down, the bowl is raised and lowered to create a pumping effect. All loading should be accomplished with a

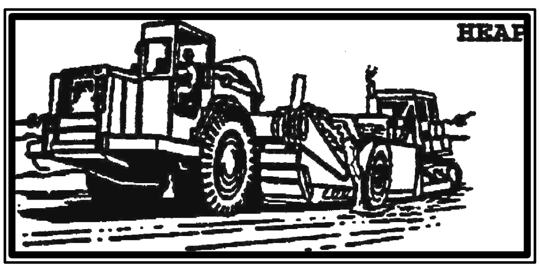
pusher, within (1) minute, and within (100) feet of travel. Longer loading times and distance are justified only when such efforts are offset by hauling fewer loads over long hauling distances. It is important to remember that whenever soil is hauled in a haul unit, it is considered to be loose soil. Haul units, particularly scrapers, are generally said to have two (2) volume capacities, Struck and Heap Loads.

a. **Struck load** Is when the unit is loaded with soil until the material is approximately even with the top of the side boards. The capacity of the 621B Scraper, when struck loaded is ***14 loose cubic yards.***



STRUCK LOAD

b. **Heap load**. Is when the unit is loaded to its maximum capacity and the material is overflowing the side boards. The capacity of the 621B Scraper when heap loaded, is ***18 loose cubic yards***.



HEAP LOAD

c. These terms are used as a general reference to load size. **Actual load size** will vary considerably, being somewhere between struck & heap due to variables such as soil weight, moisture content, and the manner in which the scraper is being loaded. For example, if the 621B is being loaded by a TRAM with a 2 1/2 cubic yard bucket, the volume of the load would be some multiple of 2.5.

5. **PRODUCTION:** There are 15 steps to determine scraper production, starting with soil weight.

(STEP 1) ***ACTUAL SOIL WEIGHT:*** *To determine the* ***actual soil weight*** *per cubic yard, start by taking the soil weight from* ***(Table #2-2)****.*

EXAMPLE:

EARTH LOAM DRY IS *2200 lbs*. PER CUBIC YARD

TABLE #2-2
APPROXIMATE WEIGHT OF SOIL

TYPE OF SOIL	POUNDS PER (CY)	TYPE OF SOIL	POUNDS PER (CY)
CINDERS	1200 LBS.	***LIMESTONE***	2500 LBS.
CLAY, DRY	2000 LBS.	***SANDSTONE***	2200 LBS.
CLAY, WET	3000 LBS.	***SAND, DRY***	2900 LBS.
CLAY & GRAVEL	2700 LBS.	***SAND, WET***	3100 LBS.
GRAVEL, DRY	3000 LBS.	***SHALE & SOFT ROCK***	2700 LBS.
GRAVEL, WET	3100 LBS.	***SLAG, BANK***	1940 LBS.
EARTH LOAM, DRY	2200 LBS.	***SLATE***	2500 LBS.
EARTH LOAM, WET	3200 LBS.	***TRAP ROCK***	3500 LBS.
HARDPAN	3100 LBS.	***CORAL (HARD)***	2440 LBS.
		CORAL (SOFT)	2030 LBS.

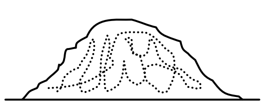
Now that you know how to get your soil weight per cubic yard, Step 2 adds the weight of the moisture to the soil weight. This is called moisture content. This factor must be taken into consideration when determining the weight of the load. Notice that in Table #2-2, the approximate weights of many different types of soil are listed. For many of the soils listed, a weight is given for both wet and dry materials. For most general applications, these weights may be used to estimate the weight of the soil being worked with. However, there will be times that a more specific weight is needed, and then the moisture content of the soil must be taken into consideration. Soil analysis personnel are trained to determine the moisture content, and the weight of this moisture must be calculated and added to the weight of the **DRY** soil. This moisture will be expressed as a percentage of the weight of the dry soil. To determine the weight of the moisture, multiply the dry weight by the percentage of the moisture content, then add the result to the dry weight to determine the actual weight of the soil.

If the weight of dry earth loam is 2200 lbs. per cubic yard, then 2200 lbs. is 100% of the original weight. The initial moisture content is 7% of the original weight. Therefore, the actual soil weight is 107% of the original weight. 107% converted to a decimal is 1.07. Now by multiplying the original weight of 2200 lbs. by 1.07, we will get the end result of 2354 lbs.

NOTE: *If you are given a wet soil,* take the weight of the wet soil off of the chart.

******If you are not given either wet or dry condition***, take the weight of dry soil off of the chart.**

****If you are given a wet soil and a moisture content*, take the weight of dry soil and multiply the moisture content.**



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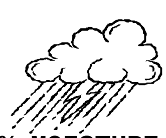


= 107% OR 1.07

100% INITIAL SOIL WEIGHT — **7% MOISTURE CONTENT** — **ACTUAL SOIL WEIGHT**

EXAMPLE:

2200	**WEIGHT OF DRY EARTH LOAM PER CY FROM *TABLE 2-2***
X 1.07	**100% OF SOIL WEIGHT + 7% MOISTURE**
2354	***ACTUAL SOIL WEIGHT*** **(ASW)**

NOTE: NEVER ROUND OFF ASW.

(STEP 2)***: CUBIC YARDS OF A LOAD:*** *Remembering that you want to keep the* ***weight of the load*** *under 48,000 lbs, determine how many cubic yards can be hauled without exceeding 48,000 lbs. To do this, divide 48,000 by the actual soil weight per cubic yard.*

48,000 LBS (RATED CAPACITY)
÷ 2,354 LBS (ACTUAL SOIL WEIGHT) FROM STEP# 1
20.39 *CY NO MORE THAN 18 CY*

If the resulting figure is over 18 cubic yards, you must go with 18. It is the maximum cubic yards that the 621B can haul. If the resulting figure is less than 18, use that entire number as it appears on the adding machine in step 3.

NOTE: ROUND DOWN TO 18 IF MORE THAN THE MAXIMUM CAPACITY.

(STEP 3): *BUCKETS LOADED**: To determine the number of* ***buckets loaded*** *that is equal to or less than the figure determined in step #2. Divide that figure, in this case 18, by the size of each bucket load which for the TRAM is 2 1/2 or 2.5.*

18 CUBIC YARDS
÷ 2.5 CUBIC YARDS (BUCKET SIZE FROM TABLE)
7.2 BUCKETS OR 7 BUCKETS LOADED

NOTE: ROUND DOWN TO WHOLE BUCKETS LOADED.

TABLE #3-2
BUCKET SIZE

TRAM 644-E	CASE 1155E	CASE/1085	1085/ GENERAL PURPOSE BUCKET	HSHMC CRANE CLAM SHELL
2-1/2 CY OR 2.5 CY	1-3/4 CY OR 1.75 CY	1-1/2 CY OR 1.5 CY	3/4 CY OR .75 CY	1 CY

(STEP 4) *ACTUAL LOAD SIZE :* *To determine the volume of the load, take the answer from Step #3, 7 buckets per load, multiplied by the bucket size 2.5 for a TRAM.*

7 # OF BUCKETS
X 2.5 TRAM BUCKET SIZE
17.5 *ACTUAL LOAD SIZE* (ALS)

NOTE: NEVER ROUND OFF ALS .

(STEP 5) *LOAD WEIGHT (LW)**: Regardless of how much volume that you may be able to haul, you should try to keep your load weight under 48,000 pounds. Table #2-2 shows the weight of Cinders as 1200 pounds per loose cubic yard. A struck load would weigh 16,800 pounds, while the heap load would weigh 21,600 pounds. These weights would be easily hauled, but it is a different story with other materials. Take a look at Earth Loam, Wet for instance:*

TABLE #2-2

TYPE OF SOIL	POUNDS PER (CY)	TYPE OF SOIL	POUNDS PER (CY)
CINDERS	1200 LBS.	***LIMESTONE***	2500 LBS.
CLAY, DRY	2000 LBS.	***SANDSTONE***	2200 LBS.
CLAY, WET	3000 LBS.	***SAND, DRY***	2900 LBS.
CLAY & GRAVEL	2700 LBS.	***SAND, WET***	3100 LBS.
GRAVEL, DRY	3000 LBS.	***SHALE & SOFT ROCK***	2700 LBS.
GRAVEL, WET	3100 LBS.	***SLAG, BANK***	1940 LBS.
EARTH LOAM, DRY	2200 LBS.	***SLATE***	2500 LBS.
EARTH LOAM, WET	3200 LBS.	***TRAP ROCK***	3500 LBS.
HARDPAN	3100 LBS.	***CORAL (HARD)***	2440 LBS.
		CORAL (SOFT)	2030 LBS.

3,200 Weight of Earth loam WET, PER/CY
X 14 (LCY) Struck
44,800 LBS. STRUCK LOADED

3,200 Weight of Earth loam WET, PER/CY
X 18 (LCY) Heaped
57,600 LBS. HEAPED LOADED

a. As you can see, the struck load weighs less than the rated capacity, but **the heaped load is over the 48,000 pound limit** by 9,600 pounds. Therefore, if you are going to be hauling this type of material, and you are self loading, you should plan on hauling a struck load. However, if you are loading the scraper with another piece of equipment, such as a scoop loader, you must determine how many loads the loader can put on the scraper and still keep the weight of the load within the acceptable weight limits.

b. Each cubic yard weighs 2354 lbs (Step #1), and you are hauling 17.5 cubic yards. Therefore, the weight of your load will be 41,195 lbs.
EXAMPLE:

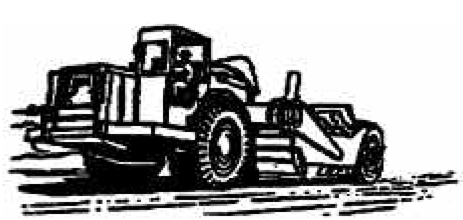
2354 **ASW**
X 17.5 **ALS**
41,195 **LOAD WEIGHT (LW)** NOT OVER THE 48,000 LBS MAX LOAD WEIGHT

NOTE: NEVER ROUND OFF LOAD WEIGHT

Now that you have the weight of the load, you need to find the weight of both the load & tractor together. This is called gross weight. Use this to get your short tons.

(STEP 6): SHORT TONS: Are found by dividing the gross weight by 2,000 lbs. (the weight of one ton)

Example:



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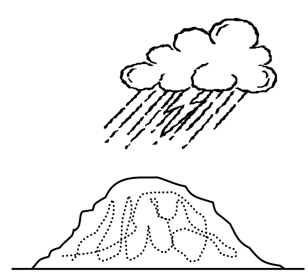


66,590 LBS. TR. WT. PLUS **41,195 LOAD WT.**

EQUALS 107,785 LBS. GROSS WEIGHT

	41,195	**LW (from step #5)**
+	**66,590**	**Tractor Weight**
	107,785	**GROSS WEIGHT**
÷	**2,000**	**weight of one ton**
	53.89	**SHORT TONS (ST)** Now take the Short Tons to steps 7 & 8

NOTE: NEVER ROUND OFF SHORT TONS (ST)

WHAT HAVE YOU LEARNED

PROBLEM #1: If you were told by the soil analysis team that the Gravel being hauled had an initial moisture content of 12%, what would the **weight of each CY** be?

PROBLEM #2: When hauling this Gravel in a 621B loaded with a TRAM 644E, what would the **load weight** be?

PROBLEM #3: If the 621B has a load weight of 46,590 pounds, what **would your short tons be?**

(STEP 7) ROLLING RESISTANCE: Is the resistance of movement to wheeled vehicles over a haul surface caused by irregularities in the surface such as compacting and displacement of material, caused by the flexing of tire sidewalls on the roadway. Rolling resistance is measured by the rim pull in pounds per short ton required to overcome resistance. This resistance effects the cycle time.

To do this multiply **SHORT TONS** (from step #6) by the **ROLLING RESISTANCE FACTOR** (RRF) found in **(TABLE #4-2)**. The resulting answer will be your **ROLLING RESISTANCE (RR)**

TABLE #4-2
ROLLING RESISTANCE FACTORS

HARD, SMOOTH, STABILIZED ROADWAY WITHOUT PENETRATION UNDER LOAD (CONCRETE OR BLACKTOP)	**40** LBS. A TON
FIRM, SMOOTH-ROLLING ROADWAY FLEXING SLIGHTLY UNDER LOAD 1" PENETRATION (GRAVEL TOPPED ROAD)	**65** LBS. A TON
RUTTED DIRT ROADWAY, FLEXING CONSIDERABLY UNDER LOAD 2" TO 3" PENETRATION (HARD CLAY ROAD)	**100** LBS. A TON
RUTTED DIRT ROADWAY, NO STABILIZATION UNDER LOAD 4" TO 6" PENETRATION (SOFT CLAY ROAD)	**150** LBS A TON
NO STABILIZATION 7" OR GRATER PENETRATION (SOFT, MUDDY, RUTTED ROADWAY, OR IN SAND)	**400** LBS A TON

Example: Determine the rolling resistance for a 621B scraper traveling over a **firm, smooth-rolling roadway flexing slightly under load 1" penetration.** The weight of the soil in the scraper is 41,195 pounds.

53.89	**(ST) Short Tons**
X 65	**(RRF) Rolling Resistance Factor**
3502.85 OR 3503	**(RR) Rolling Resistance NOW TAKE RR TO STEP #9**

NOTE
ROUND OFF RULE: (ROUND UP 5 OR GREATER, ROUND DOWN 4 OR LESS.)FOR (RR).

WHAT HAVE YOU LEARNED

PROBLEM # 4: Figure **Rolling Resistance** for the following situation.

Caterpillar 621B Scraper

Struck loaded

Hard pan

Rutted, dirt roadway, flexing considerably under load with 2" to 3" penetration.

PROBLEM #5: Figure **Rolling Resistance** for the following situation.

Caterpillar 621B Scraper

Loaded with CASE 1085 (1 1/2 CY Bucket)

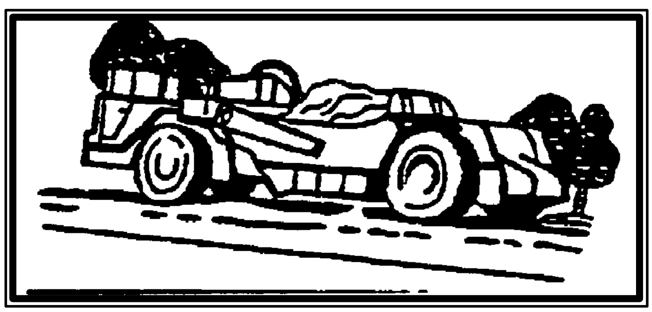
Trap rock

Hard, smooth, stabilized roadway without penetration

(STEP 8): ***GRADE RESISTANCE (GR) OR GRADE ASSISTANCE (GA):***
Grade Resistance or Grade Assistance is the addition, or decrease, in the amount of pounds of pull required as the result of adverse or favorable grades on haul roads. Rules of thumb generally accepted as reliable measures of the effect of grades are as follows:

Grade resistance effects the cycle time by slowing the scraper.

1. Each 1 percent of (uphill) grade increases the resistance by 20 pounds per short ton pull of gross vehicle weight.



The Formula:

Short Tons x 20 (constant) x % of Grade = Grade Resistance or Grade Assistance

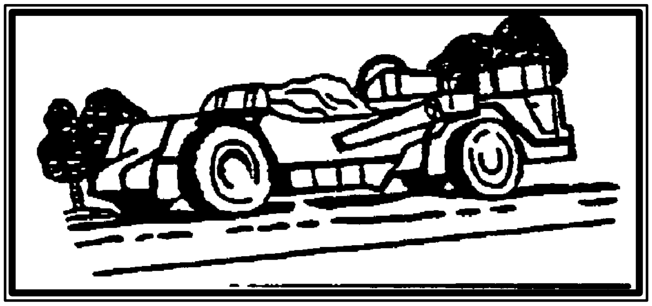
Note: ROUND UP 5 OR GREATER, ROUND DOWN 4 OR LESS

Example: The total weight of the loaded scraper on the haul is 107,785 lbs. Calculate the grade resistance factor for climbing a (+2) uphill grade.

53.89	**X**	20	**X**	**2**	**=**	2155.60 or **+2156**
Short Tons	**X**	**20**	**X**	**% GRADE**	**=**	***Grade Resistance (GR)***

NOTE: ***ROUND UP 5 OR GREATER ROUND DOWN 4 OR LESS (GR/GA).***

2. Each 1 percent of (downhill) grade decreases the amount of pull required by 20 pounds per short ton of gross vehicle weight.



Example: For the return, the tractor is empty so the total weight is 66,590 lbs. Calculate the grade assistance factor for (-2) downhill grade.

33.30	X	20	X	**2**	=	**- 1,332**
Short Tons empty	**X**	**20**	**X**	**% GRADE**	**=**	***Grade Assistance (GA)***

NOTE: ROUND UP 5 OR GREATER ROUND DOWN 4 OR LESS (GR/GA).

WHAT HAVE YOU LEARNED

PROBLEM #6 Determine **Grade Resistance** for a 621B Scraper with the following factors.

Struck load

Sand

7% Initial moisture

3% uphill grade

PROBLEM #7: Determine **Rolling and Grade Resistance** for a 621B on the haul with the following factors.

Heap load

Sandstone

Rutted, dirt roadway, no stabilization under load 4" to 6" penetration.

6% uphill grade

(STEP 9): REQUIRED POUNDS OF PULL (REQPP): Is the total power required to move a unit. We can find our ***REQPP*** by adding ***GR*** with ***RR*** for uphill, or subtracting ***GA*** from ***RR*** for downhill. **When on level terrain, your *RR* is your *REQPP*.**

EXAMPLE 1. *When traveling **uphill** a vehicle must overcome both rolling resistance and grade resistance.*

3503 (RR)
+2156 (+GR)
5659 = **(REQPP)** Using **Table 5-2**, you can see that the scraper will not give you enough Rim Pounds Pull (RPP) in 8th or 7th gear, but in 6th gear you have enough RPP. The ***travel speed is 14 MPH***

EXAMPLE 2 *When traveling **downhill** a vehicle must overcome rolling resistance less grade Assistance.*
2165 (RR)
- 1332 (-GA)
833 = (REQPP)

Using Table 5-2, we see that 8th gear gives you 3,393 pounds of pull, but you only need 833, so 8th gear will give you more than enough. The ***travel speed is 26 MPH.***

EXAMPLE 3. *When traveling over **level terrain**, a vehicle must overcome rolling resistance only.*

3503 RR = (REQPP)

SUB STEP: TRAVEL SPEED: To get your travel speed you first must make a gear selection .

Gear selection for the 621B is easy now that you know how much REQPP are needed to go uphill, downhill, or on level terrain. By looking at the table below, we can use the rim pounds of pull compared to the required pounds of pull to get our gear and travel speed. For example, you used 6th gear to go up and 8th to come down.

TABLE #5-2
POWER CHARACTERISTICS OF 621B SCRAPER

AVAIL (RPP)	35,062	23,375	16,187	13,148	9,146	6,657	5,008	3,393
GEAR:	1ST	2ND	3RD	4TH	5TH	6TH	7TH	8TH
(TS) SPEED MPH	2 MPH	4 MPH	6 MPH	8 MPH	11 MPH	14 MPH	19 MPH	26 MPH

NOTE: If your TM doesn't have this table you can use this formula to get your (RPP) table.

$$\frac{\textbf{375 X ENGINE HP X 80\% EFFICIENCY}}{\textbf{TRAVEL SPEED IN MPH}} = \textbf{RIM POUNDS PULL (RPP)}$$

WHAT HAVE YOU LEARNED

PROBLEM #8: Determine **TRAVEL SPEED** with the following factors.

Caterpillar 621B Scraper

Heap load

Earth loam

10% Initial moisture

Hard, smooth roadway with no penetration under load.

4% downhill grade

PROBLEM #9: Determine TRAVEL SPEED with the following factors.

Caterpillar 621B Scraper

Struck load

Clay and gravel

3% Initial moisture

Rutted, dirt roadway, no stabilization under load, 4" to 6" penetration.

6% uphill grade

RETURN

The return is done by repeating steps 6-9 and using empty vehicle weight to get the short tons

EXAMPLE :

(STEP 6) *SHORT TONS* ***(ST)*** *WITH EMPTY VEHICLE WEIGHT*

```
   66,590
 ÷  2,000
    33.30    (ST, CONSTANT FOR A EMPTY 621B)
    33.31
```

(STEP 7) *ROLLING RESISTANCE* ***(RR)***

```
   33.30  (ST)
 X    65  (RRF) ROLLING RESISTANCE FACTOR
2,164.50 or 2,165 (RR)
```

(STEP 8) *GRADE RESISTANCE /* **GRADE ASSISTANCE**
33.30 (ST) X 20 X -2 = 1,332 (-GA)

(STEP 9) *REQUIRED POUNDS OF PULL (RPP) TRAVEL SPEED MPH.*

2,165 (RR)
– **1,332 (-GA)**
833 (RPP)

NOW THAT YOU HAVE YOUR TRAVEL SPEED FOR HAUL ***AND RETURN*** YOU CAN FORMULATE THE CYCLE TIME (STEP #10).

(STEP 10) **CYCLE TIME***: is the time required to LOAD, HAUL, SPREAD, and RETURN. This is figured by adding* ***Fixed Time (Fix-T)*** *and* ***Travel Time (TT)*** *to get* ***cycle time (CT).***

a. **Fixed Time:** is the time spent during an equipment cycle other than hauling and returning. This includes positioning, loading, unloading, turning, accelerating and decelerating all of which are fairly constant or fixed. Fixed times are determined from **Table #6-2**. To use Table 6-2, start with what gear you are hauling in.

TABLE #6-2 FIXED TIME

EQUIPMENT LOADING SCRAPER	**1ST GEAR HAUL 2ND GEAR HAUL 3RD GEAR HAUL**		**4TH GEAR HAUL**		**5TH GEAR HAUL 6TH GEAR HAUL 7TH GEAR HAUL 8TH GEAR HAUL**	
	STRUCK	HEAP	STRUCK	HEAP	STRUCK	HEAP
SCRAPER LOADING ITSELF	2.50	N/A	2.80	N/A	3.0	N/A
1155E	7.0	9.0	7.30	9.30	7.50	9.50
TRAM	6.0	7.0	3.30	4.30	6.50	7.50
1085 WITH 1.5 BUCKET	12.0	14.0	12.30	14.30	12.50	14.50
1085 WITH .75 BUCKET	16.0	22.0	16.30	22.30	16.50	22.50
CLAMSHELL HSHMC	16.0	19.0	16.30	19.30	16.50	19.50
SCRAPER PUSH LOADED	1.43	NA	1.73	NA	1.93	NA

NOTE *: These are average fixed times only and are based on an average operator who is familiar with the attachments and equipment operation. These times are basic starting points only. Actual fixed times can vary considerably due to varying conditions. Timing of several actual fixed cycles is necessary in order to obtain a more realistic fixed time average for the particular job being performed.**FOR CLASS ROOM PURPOSES IF THE LOAD FALLS SOMEWHERE IN BETWEEN STRUCK AND HEAP LOADS. USE THE HEAP LOAD TIME FOR THE FIXED TIME.**

b. **Travel Time:** is the time spent on the haul road transporting material and returning empty. Travel Time depends on: (1) Size of hauling unit (2) Rolling resistance (3) Grade resistance and Distance traveled. All of which have already been figured to get your gear selection and speed to put into the cycle time formula.

c. To figure **Cycle Time (CT)** you first must figure Travel Time (TT). To get Travel Time divide the distance in feet of the haul or return road by the sum of the travel speed (TS) in mph multiplied by 88. Do this for the haul and return. The Total Travel Time plus Fixed Time will equal **Total Cycle Time.**

NOTE: 88 is the conversion factor to change the speed in MPH to feet traveled per minute.

Example #1: A Caterpillar 621B Scraper, hauling 17.5 CY of material, travels 7500 feet to the fill area using 6th gear and returns empty by a different route of 8200 feet in 8th gear. What is the total cycle time, if the 621b is being loaded by a Tram?

haul distance in feet

$$\frac{7500}{\underline{14}\ \text{TS} \times 88} = \underline{6.09}\ \textbf{HAUL Time (HT)}$$

(from step 9)

return distance in feet

$$\frac{8200}{\underline{26}\ \text{TS} \times 88} = \underline{3.58}\ \textbf{RETURN Time (RT)}$$

(from step 9)

6.09	**+**	**3.58**	**+**	**7.5**	**=**	**17.17 *MIN.***
(HT)	**+**	**(RT)**	**+**	**Fixed Time (FT)**	**=**	***CYCLE TIME* (CT)**

NOTE: NEVER ROUND OFF TIME .

WHAT HAVE YOU LEARNED

PROBLEM #10: Figure total **CYCLE TIME**.

Caterpillar 621B Scraper, self loaded

Haul distance - 8250'

Return distance - 7125'

Haul gear - 4th

Return gear - 8th

PROBLEM #11: Figure total **CYCLE TIME**.

Caterpillar 621B Scraper, self loaded

Haul distance - 9000'

Return distance - 9176'

Haul gear - 6th

Return gear - 8th

(STEP 11) **TRIPS PER HOUR***: To determine Trips Per Hour (TPH) divide the working minutes per hour (normally a 60-minute work hour) by the cycle time.*

MIN. WORKED PER/HR
________________________ = ***TRIPS PER HOUR (TPH)***
CYCLE TIME — **NOTE: NEVER ROUND OFF TPH**

EXAMPLE: How many trips per hour can a 621B make during a 60-minute work hour, if it has a cycle time of 17.17 minutes?

60 MIN. WORKED PER/HR
________________________ = 3.49 **TRIPS PER HOUR (TPH)**
17.17 **CYCLE TIME** — **NOTE: NEVER ROUND OFF TPH**

(STEP 12) **HOURLY PRODUCTION RATE (LCYPH)***: To determine the Hourly Production Rate, you must know the Actual Load Size (in LCY), the number of Trips per Hour, and the Efficiency Factor of the operator and equipment.*

_______	X	____	X	__________________	=	_____
TPH	**X**	**ALS**	**X**	**EFFICIENCY FACTOR**	**=**	**LCYPH**

(from step #11) (from step #4) **NOTE: ALWAYS ROUND DOWN LCYPH**

TABLE #7-2 EFFICIENCY FACTOR

TYPE UNIT	OPERATOR	DAY	NIGHT
TRACKED	EXCELLENT	1.00	0.75
	AVERAGE	.75	.56
	POOR	.60	.45
WHEELED	EXCELLENT	1.00	.67
	AVERAGE	.60	.40
	POOR	.50	.33

NOTE: These factors include operator efficiency and visibility (dust, rain,snow, fog and darkness) with a job efficiency of a 60-minute hour.

EXAMPLE: What is the hourly production rate for a 621B with an average operator, working a day shift, making 3.49 TPH, with a load of 17.5 LCY?

3.49	X	17.5	X	0.60	=	36.65 OR 36
TPH	**X**	**ALS**	**X**	**EFFICIENCY FACTOR**	**=**	**(LCYPH)**

NOTE: ROUND DOWN (LCYPH)

(STEP 13) ***SOIL CONVERSION (SC) (IF NEEDED) :*** *In some cases the hourly production rate may be needed in compacted cubic yards (CCY) for a road or runway*

______	X	__________________	=	__________
LCYPH	**X**	***CONVERSION FACTOR***	**=**	**(____CYPH)**

NOTE: ROUND DOWN CYPH

TABLE #1-1
SOIL CONVERSION FACTORS
NOTE: * IS CONSIDERED 100% VOLUME OR 1.00 CY

SOIL TYPE	INITIAL CONDITION	TO BANK	TO LOOSE	TO COMPACT
SAND	FROM BANK	*	1.11	.95
	FROM LOOSE	.90	*	.86
	FROM COMPACTED	1.05	1.17	*
LOAM	FROM BANK	*	1.25	.90
	FROM LOOSE	.80	*	.72
	FROM COMPACTED	1.11	1.39	*
CLAY	FROM BANK	*	1.43	.90
	FROM LOOSE	.70	*	.63
	FROM COMPACTED	1.11	1.59	*
BLASTED ROCK OR GRAVEL	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*
HARD CORAL OR LIMESTONE	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*

EXAMPLE: What is the production rate in (CCY) for a 621B with an hourly production rate of 36 LCYPH, working in Earth Loam, Dry?

36 X .72 = 25.92 OR **25** **(C CYPH)**
LCYPH X CONVERSION FACTOR = ***NOTE: ROUND DOWN (CYPH)***

(STEP 14) ***TOTAL HOURS REQUIRED TO COMPLETE MISSION:*** *To determine the total time required to complete the mission, you must know the total volume to be moved, the hourly production rate, and the number of scrapers you will use on the job.*

VOLUME NEEDED (CY)
(CYPH) X ____ # OF SCRAPERS **= TOTAL HOURS REQUIRED**
NOTE: NEVER ROUND OFF TIME

EXAMPLE:

VOLUME NEEDED (CY)
19,440 **(** C **CY)** ______= 259.20 **HOURS REQUIRED**
25 (C CYPH) X 3 SCRAPER

(STEP 15): ***TOTAL PRODUCTION (DAYS)*** To get the production days required to complete the mission, divide total hours required by the hours worked per day, which will equal the total number of days required.

EXAMPLE: ***TOTAL PRODUCTION (DAYS)***

259.20 ÷ 8 = 32.40 OR 33_
HOURS REQUIRED ÷ HOURS WORKED A DAY = **DAYS**

NOTE: ROUND DAYS TO NEXT FULL DAY

WHAT HAVE YOU LEARNED

PROBLEM #12: Figure total number production days with the following factors.

Three Caterpillar 621B Scrapers

Heap loaded, loam

7 hour production day

Excellent Operator

13.08 minute cycle time

Compacted volume required for job - 250,000 CY

WHAT HAVE YOU LEARNED

PROBLEM #13: A project requires you to build a parking lot using gravel. How many work nights, at 8 hours per night, are required to complete the project? You are working only during the hours of darkness. The job conditions are as follows. Show and label all figures and formulas.

Compacted fill required	150,000 CY
Class of earth	Gravel
Initial moisture content	14%
Average haul distance	7000 ft
Return by same route	
Grade of haul road	6% downhill
621B's	5
Struck loaded	
Average operators	

Rutted, dirt roadway, with no stabilization under load 4" to 6" penetration.

PUSH LOADING

a. Push loading a scraper is one of the most effective methods of loading a scraper. A self loaded Scraper may require twice the time and distance than one being assisted by a push tractor, thus effecting the cycle times and production throughout the project. Usually, a 621B is pushed by a Caterpillar D7G Dozer. The D7G is the only dozer in the Marine Corps with a reinforced blade for push loading.

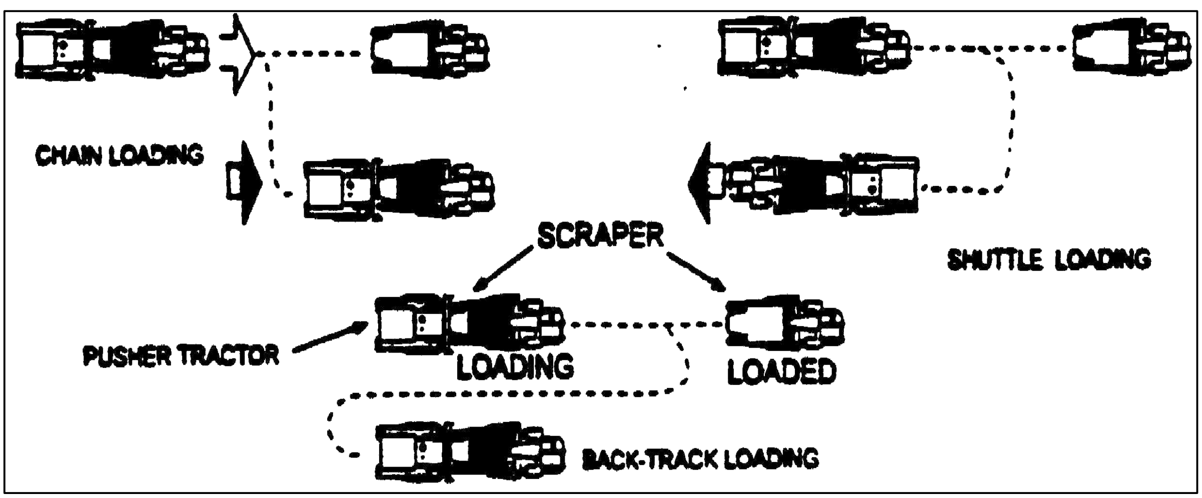
b. Load time should be one minute or less. The optimum loading distance is around 90' to 125'. The optimum depth of cut for a push loaded scraper is 4 to 6 inches. These will be governed by the type of soil, its moisture content, loadability, operator efficiency, actual load size, and the method of equipment employment.

c. Normally the gear used during push loading is second for the D7G and first for the 621B Scraper. The MPH listed in Table #5-2 for the scraper and Table #8-2 for the D7G reflect maximum and/or average speed in miles per hour. When push loading is employed, the maximum MPH will not be the loaded MPH reflected in the Tables, therefore, for **CLASSROOM PURPOSES USE 2 MPH WHEN PUSH LOADING.**

TABLE 8-2 PUSH-TRACTOR LOADING SPEEDS AND GEARS

GEAR	MAXIMUM SPEED	MINIMUM SPEED
FIRST	2.3 MPH	1.15 MPH
SECOND	4.0 MPH	**2.0 MPH**
THIRD	6.3 MPH	3.15 MPH

d. There are three types of push loading. They are, ***Chain Loading, Shuttle Loading*** and ***Back-Track Loading.*** Chain Loading and Shuttle Loading are the most efficient at keeping the dozer from excess movement. Back-Track Loading is the most inefficient method of push loading. It takes more movement by the dozer, but it is still useful if the work area allows no other type of operation.



NUMBER OF PUSH TRACTORS REQUIRED

a. To get the number of Push Tractors (PT) required, we must go through 7 steps starting with load time.

(STEP 1) LOAD TIME. **Load time** is the time required to load the haul unit during which the dozer is in contact with the push block of the scraper. Load Time is figured by using the formula below. **NOTE: USE 2 MPH FOR CLASSROOM PURPOSES.**

$$\frac{\textbf{LENGTH OF CUT}}{\textbf{MPH} \times \textbf{88}} = \textbf{LOAD TIME (LT)} \text{ in min.}$$

NOTE: NEVER ROUND OFF TIME

Example:

$$\frac{150' \text{ feet length of cut}}{2 \text{ mph} \times 88 \text{ conversion factor mph}} = \textbf{.85 min.} \text{ LOAD TIME } \textbf{(LT)}$$

(STEP 2) BOOST TIME. **Boost time** is the time expended after the scraper is loaded during which the push tractor assists the scraper in attaining momentum. **(For Boost time use a constant of 0.25).**

(STEP 3) RETURN TIME. **Return time** is the time required for the push tractor to return to the starting point. This portion of the cycle time will be greatly reduced by "chain" or "shuttle" loading. To get Return Time use the formula below.

LOAD TIME (LT) X .4 = RETURN TIME (RT)
NOTE: NEVER ROUND OFF TIME

Example:

.85 load time X .4 = **0.34 min.** RETURN TIME. **(RT)**

(STEP 4) FORMULATE CYCLE TIME.

LOAD TIME + BOOST TIME + RETURN TIME = PT CYCLE TIME (CT)

Example:

(LT) (BT) (RT)

(.85 + .25 + .34) = 1.44 ***min. PT CT***
NOTE: NEVER ROUND OFF TIME

(STEP 5) SCRAPER CYCLES PER HOUR*: This is found by dividing scraper cycle time into the constant 60 (minutes) .*

$$\frac{\textbf{60}}{\text{scraper (CT)}} = \text{scraper cycles per hour}$$

(FROM STEP #10) NOTE: NEVER ROUND OFF

Example:

$$\frac{60}{17.17\text{min.}}$$

scraper (CT) = 3.49 ***scraper cycles per hour***

(STEP 6) PUSH TRACTOR CYCLES PER HOUR: *This is found by dividing push tractor cycle time into the constant 60 (minutes).*

$$\frac{60}{\text{push (TR)(CT)}} = \text{Push Tractor Cycles per Hour}$$

(FROM STEP #4) NOTE: NEVER ROUND OFF

Example:

$$\frac{60}{1.44}$$

push (TR)(CT) = 41.67***Push Tractor Cycles per Hour***

STEP #7 FORMULATE:

$$\frac{\text{scraper cycles per hour X number of scrapers employed}}{\text{push tractors cycles per/hr.}} = \text{Number of PT required}$$

NOTE: ALWAYS ROUND UP

Example: Use the formulas above to determine how many push tractors are required to support eleven (11) 621Bs operating on a 17.17 minute cycle time. The push tractor cycle time is 1.44 minutes.

scraper cycles per hour X number of scrapers employed

$$\frac{3.49 \quad X \quad 11}{41.67}$$

push (TR) cycles per/hr.= .92 or ***1 push (TR)***

Number of Push (TR) required

WHAT HAVE YOU LEARNED

PROBLEM #14: Figure the number of push tractors required for (4) 621B's, with a 12.58 minute cycle time. The length of cut is 150 feet.

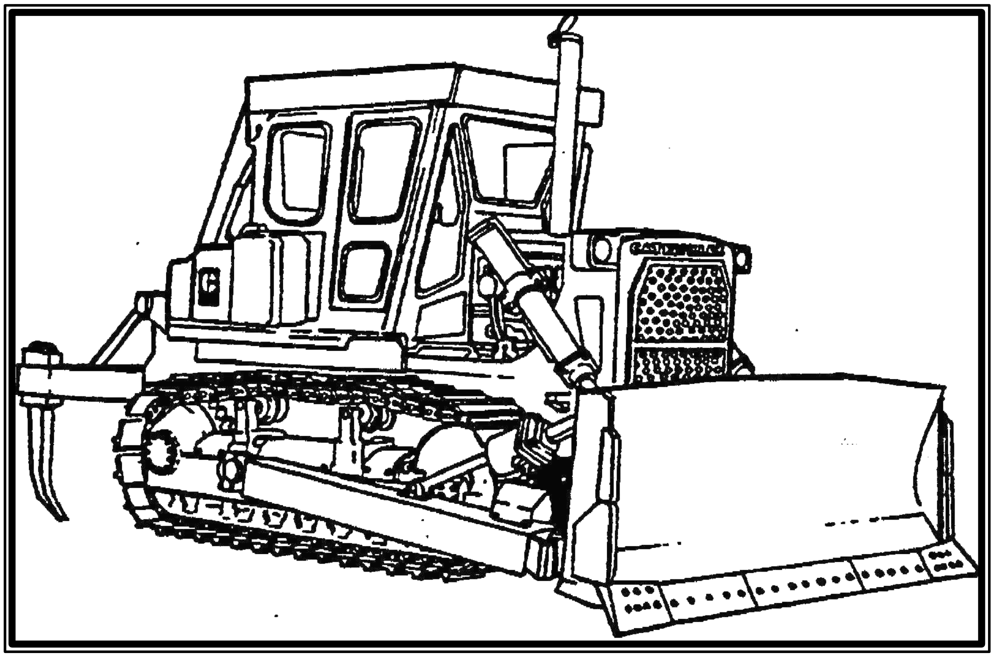
PROBLEM #15: Figure the number of push tractors required for (7) 621B's, with a 8.92 minute cycle time. The length of cut is 125 feet.

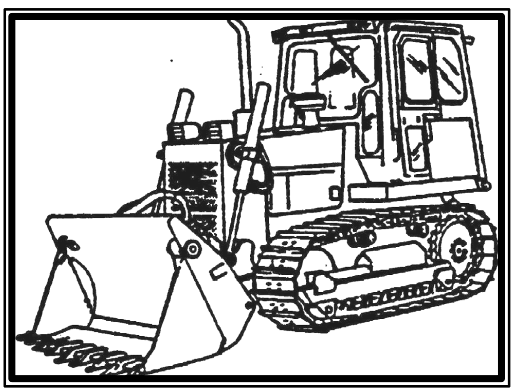
WHAT HAVE YOU LEARNED

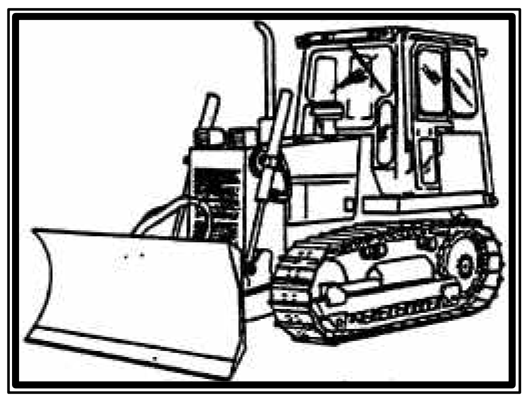
PROBLEM #16: A project requires you to build a road using clay and gravel with an 8% moisture content. The borrow pit area allows you to push load the 621Bs with D7G. How many days are required, at 10 hours per day, to complete the project? Also figure the total number of push tractors required. The job conditions are as follows. Show and label all figures and formulas. If you need help, raise your hand.

Compacted fill required	175,000 CY
Use Clay for Soil Conversion Factor	
Initial moisture content	8%
Average haul distance	6600 ft
Average return distance	6600 ft
Grade of haul road	7 % Uphill
Rutted, dirt roadway, flexing considerably under load	
621B's	6
Push loaded by D7G	
Average operators	
Length of cut	80'

CRAWLER TRACTOR







INTRODUCTION

Dozers and scrapers are the most common pieces of equipment on a project. It is important to be able to properly use these prime earthmovers to get maximum production, to establish production estimation rates, and to insure the prompt completion of an earth moving task.

1. **USE:** In the field of heavy construction, crawler tractors serve many purposes. They may be used as prime movers for pushing or pulling loads, as power units for winches and hoists, and as moving mounts for dozer blades. They are used primarily where it is advantageous to obtain high drawbar pull and traction. The crawler tractor is the most suitable piece of equipment for pushing or pulling loads through marshy areas.

2. **CLASSIFICATION:** Crawler tractors are classified according to weight. They are classified for easy identification as light, medium, and heavy. For example, the 1150E and the 1155 are in the light class, the D7G is in the medium class,

and the D8 is in the heavy class. The ACE is an armored class dozer. All of the dozers, except the D8, are in the Marine Corps inventory.

3. **CHARACTERISTICS**: Crawler tractors are tractors which are supported on the ground by track assemblies. Commonly called "bulldozers", they are the work horses of construction. Due to their versatility, they are usually the first piece of machinery on a construction job, and often the last to leave. They are used to cut haul roads, move dirt, trees, and rocks, and are used on many other jobs. A bulldozer is simply a crawler tractor with a blade mounted on the front which is used for pushing objects or materials. Once the blade is removed and the machine is used as a towing unit, it is referred to as a tractor. Since the weight of the machine is supported by the track sections, the crawler tractor has great traction pull. The ability to "lock" one side section of track while pulling with the other one enables the crawler tractor to pull itself out of material that would easily cause a wheeled machine to become stuck.

4. **OPERATION**: These tractors are equipped with a diesel engine rated from 85 to 202 brake horsepower, and either 4 or 6 cylinders, depending on the make and model. The all-terrain versatility of the crawler tractor is due to its' low ground bearing pressure, varying from 6 to 9 pounds per square inch, which gives it a distinct "flotation" advantage. Crawler tractors are capable of operating in muck or water as deep as the height of the track. Crawler tractors can move from jobsite to jobsite under their own power at slow speeds, however, this tends to shorten their operational life. For this reason, they should be transported by trailer if a long distance is involved. A paved or finished surface may also suffer extensive damage from the tracks.

5. PRODUCTION ESTIMATION FOR DOZERS: Dozer production can be estimated using the production from Table #9-3, and then adjusting the table with six (6) correction factors.

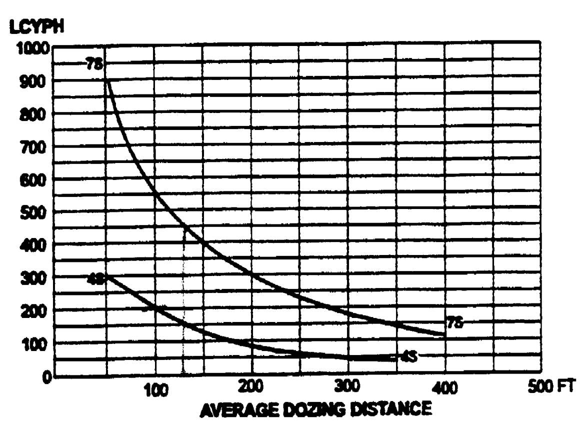
STEP 1 X STEP 2 X STEP 3 X STEP 4 X STEP 5 X STEP 6 = _________LCYPH

NOTE: ROUND DOWN LCYPH

NOTE: For classroom purposes, if you are not given the information for any step, that step will be N/A

(STEP 1): Use **(Table 9-3)** to determine **Maximum Basic Production.** First find the average dozing distance line on the bottom of the scale, read up until you intercept the production curve for the dozer you are using, then read to the left to get the production rate in LCYPH.

TABLE #9-3



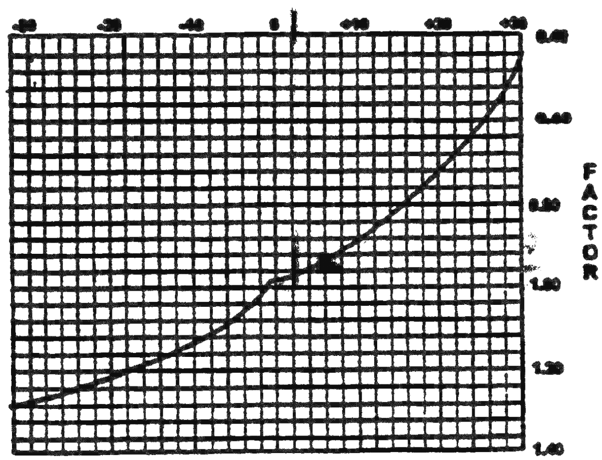
EXAMPLE: Determine the Maximum Basic Production for a D7G with an average dozing distance of 200 feet.

300 LCYPH

(STEP 2): Determine the **Grade Correction Factor** using **(Table 10-3)**. Find the % of grade (-) Favorable or (+) unfavorable on the top of the scale, read down until you intercept the grade correction curve, then read to the right to determine the grade correction factor. Each vertical line on this scale represents multiple of two. Each horizontal line represents 0.04.

NOTE: For class room purposes round off, up or down to the closest factor line.

***(REFERENCE: TABLE #10-3 GRADE CORRECTION FACTOR)**



EXAMPLE: Move the material up a 2% grade(+). **Grade correction factor = .96**

(STEP 3): ***Determine Soil Weight Correction Factor****. Using Table #2-2 find the listed soil weight for the type soil you are working in. Add the moisture content to determine the actual soil weight for that soil. Divide 2,300 LBS/CY by the actual soil weight to find the correction factor. (2,300 LB'S is a constant which is the weight of soil used to determine* **Table #9-3)**.

$$\frac{\textbf{2300 constant}}{\textbf{ACTUAL SOIL WEIGHT}} = \textbf{SOIL WEIGHT CORRECTION FACTOR}$$

NOTE: NEVER ROUND OFF

TABLE #2-2

TYPE OF SOIL	POUNDS PER (CY)	TYPE OF SOIL	POUNDS PER (CY)
CINDERS	1200 LBS.	***LIMESTONE***	2500 LBS.
CLAY, DRY	2000 LBS.	***SANDSTONE***	2200 LBS.
CLAY, WET	3000 LBS.	***SAND, DRY***	2900 LBS.
CLAY & GRAVEL	2700 LBS.	***SAND, WET***	3100 LBS.
GRAVEL, DRY	3000 LBS.	***SHALE & SOFT ROCK***	2700 LBS.
GRAVEL, WET	3100 LBS.	***SLAG, BANK***	1940 LBS.
EARTH LOAM, DRY	2200 LBS.	***SLATE***	2500 LBS.
EARTH LOAM, WET	3200 LBS.	***TRAP ROCK***	3500 LBS.
HARDPAN	3100 LBS.	***CORAL (HARD)***	2440 LBS.
		CORAL (SOFT)	2030 LBS.

EXAMPLE: What is the soil weight correction factor for clay with 5% moisture content ?

2,000	**lbs. Clay**
X 1.05	**% of Moisture**
2,100	**Actual Soil Weight**

2,300 constant
2,100 Actual Soil Weight = 1.10 **SOIL WEIGHT CORRECTION FACTOR**

NOTE: NEVER ROUND OFF

(STEP 4): ***SOIL TYPE CORRECTION FACTOR***.*: The dozer blade is designed to cut the material and give it a rolling effect for a production factor of 1.00. Material found in different states will effect dozer production as follows.*

TABLE 11-3 SOIL CORRECTION FACTOR

SOIL TYPE	FACTOR
LOOSE, STOCKPILE	1.20
HARD TO CUT (WITH TILT CYLINDER)	0.80
HARD TO CUT (WITHOUT TILT CYLINDER)	0.70
HARD TO DRIFT (STICKS TO BLADE)	0.80
ROCK, RIPPED OR BLASTED	0.60

EXAMPLE: Hard packed clay is Hard to drift (sticks to blade) = **.80**

(STEP 5):***Determine Equipment / Operator Efficiency Correction Factor***

TABLE #7-2 EFFICIENCY FACTOR

TYPE UNIT	**OPERATOR**	**DAY**	**NIGHT**
TRACKED	EXCELLENT	1.00	0.75
	AVERAGE	.75	.56
	POOR	.60	.45
WHEELED	EXCELLENT	1.00	.67
	AVERAGE	.60	.40
	POOR	.50	.33

NOTE: These factors include operator efficiency and visibility (dust, rain, snow, fog and darkness) with a job efficiency of a 60-minute hour.

EXAMPLE: Operator and equipment efficiency factors are average, working daylight = **.75**

(STEP 6): ***Determine the Management Technique correction factor:***

TABLE # 12-3

MANAGEMENT TECHNIQUE	**FACTOR**
SLOT DOZING	1.20
SIDE BY SIDE DOZING	1.25

EXAMPLE: Slot Dozing is being Employed = **1.20**

(STEP 7)*: Production Calculation:*

STEP 1 X STEP 2 X STEP 3 X STEP 4 X STEP 5 X STEP 6 = ______LCYPH/PER DOZER

NOTE: **ROUND DOWN LCYPH**

EXAMPLE: 300 LCYPH X .96 X 1.10 X .80 X .75 X 1.20 = 228.10 or 228 LCYPH

(STEP 8): ***Soil Conversion Factor (IF REQUIRED):***

Material conversion factor, if required.

TABLE #1-1
SOIL CONVERSION FACTORS
NOTE: * IS CONSIDERED 100% VOLUME OR 1.00 CY

SOIL TYPE	INITIAL CONDITION	TO BANK	TO LOOSE	TO COMPACT
SAND	FROM BANK	*	1.11	.95
	FROM LOOSE	.90	*	.86
	FROM COMPACTED	1.05	1.17	*
LOAM	FROM BANK	*	1.25	.90
	FROM LOOSE	.80	*	.72
	FROM COMPACTED	1.11	1.39	*
CLAY	FROM BANK	*	1.43	.90
	FROM LOOSE	.70	*	.63
	FROM COMPACTED	1.11	1.59	*
BLASTED ROCK OR GRAVEL	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*
HARD CORAL OR LIMESTONE	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*

EXAMPLE: If your requirement is 4,500 compacted cubic yards and you are moving 228 loose cubic yards per hour, you must convert the loose cubic yards per hour to compacted cubic yards per hour.

228 **X** .63 = 143.64 OR 143 (C CYPH)
(LCYPH) **X** CONVERSION FACTOR (TABLE #1-1) = ***SOIL CONVERTED*** ***(___ CYPH)***

ROUND DOWN (CYPH)

(STEP 9): ***Total Hours Required:***

(1) Quantity to be moved divided by the hourly production rate multiplied by the number of dozers you have employed equals the total time in hours to complete the job.

(2) The formula:

Quantity to be moved (__CYPH)
= Total Hours Required
Hourly production rate (___CYPH) **X # of dozers**

NOTE: NEVER ROUND OFF TIME

EXAMPLE: How long would it take to move 4,500 CCY of clay, using 3 D7G's with a production rate of 143 CCYPH.

$$\frac{\mathbf{4{,}500}}{\mathbf{143 \times 3}} = \mathbf{10.49\ HRS}$$

(STEP 10): ***Total Production (DAYS)***

EXAMPLE:

HOURS REQUIRED 10.49 ÷ 8 HOURS WORKED A DAY = 1.31 OR 2 **DAYS**

ROUND DAYS TO NEXT FULL DAY

TOTAL NUMBER OF DOZERS REQUIRED

(1) Quantity of material to be moved divided by the hourly production rate per hour multiplied by the number of hours you have to complete the job. Use the formula below to formulate.

$$\frac{\textbf{QUANTITY TO BE MOVED}}{\textbf{HOURLY PRODUCTION RATE PER DOZER} \times \textbf{REQUIRED COMPLETION TIME IN HOURS}} = \textbf{\textit{TOTAL \# OF DOZERS REQUIRED}}$$

*** NOTE: ALWAYS ROUND UP***

EXAMPLE: How many D7G's (with a production rate of 143 CCYPH) would be needed to move 4500 CCY of Loam in 5 hours?

$$\frac{\textbf{4500 CCY Required}}{\textbf{143 CCYPH} \times \textbf{5 Hrs}} = \textbf{6.29 or 7 D7G's}$$

PROBLEM #1: Using the following information, determine how long it will take two (2) D7G Tractors to complete the job ?

Average Dozing Distance..................................130 ft
Average % of Grade..+2%
Quantity of Soil to be Moved.............................1548 CCY
Material Type...Clay with 2% Moisture Content
Material Type Factor...Hard to Drift (sticks to blade)
Operator Efficiency Factor................................Poor/Night
Blade-to-Blade Dozing is Employed
Equipment Available..(2) D7G

SOLUTION:

WHAT HAVE YOU LEARNED

PROBLEM #2: Using the following information, determine how many MC1150E Tractors are required to complete this job in five (5) hours?

Average dozing distance......................................100 ft.
Average % of grade...+6%
Quantity of soil required....................................2976 LCY
Material type..Sandstone
Material type factor...Hard to Cut (with tilt cylinder)
Operator efficiency factor...................................Excellent/Daylight
Slot Dozing is Employed
Equipment available..(6) MC1150E Tractors

SOLUTION:

CLEARING, GRUBBING and STRIPPING

a. Clearing and Grubbing consists of removing all trees, fallen timber, brush, and other vegetation from a designated area. Clearing techniques vary with the type of vegetation being cleared, soil, and moisture conditions. Table 2-1 shows average clearing rates for normal jobs.

b. Stripping consists of removing and disposing of the top soil and vegetation which would be objectionable as a subgrade for a road or runway.

1) Brush and small trees: Dozers operating in first or second gear can clear brush and small trees (6" or less) at the rate of 900 to 1000 square yards per

2) Medium Trees: To remove medium trees (7 to 12 inches in diameter), the average clearing time is 2 to 9 minutes per tree.

3) Large Trees: Removing large trees (over 12 inches in diameter) is much slower and more difficult, because the trees have large, deeply embedded root systems. Average clearing time is 5 to 20 minutes per tree.

4) Rocks: Use a rock rake, if possible, to remove small rocks. The rake lets the soil remain while digging the rocks from the earth. A rake can be made by your welding section. When removing large partially buried rocks or boulders, tilt the dozer blade and dig the earth out from around three sides. Lower the blade on the fourth side push forward and lift blade lifting the rock upward rolling out of hole If needed, have somone place a log or some other object under the rock so the dozer can get another hold. If you have more than one dozer, have them work together to remove large boulders.

b. **Production Estimates:** The two methods for estimating clearing, grubbing and stripping are:
The Quick Method and ***The Tree Count Method.***

1) *Quick Method*. Table 13-3 gives quick estimates for clearing, grubbing and stripping trees. Use these estimates only when a detailed reconnaissance and tree count are not possible.

2) *Tree- Count Method*. Use this method, when a detailed reconnaissance and tree count are possible, for a better production estimate.

EXAMPLE : QUICK METHOD A road construction project requires that an area two (2) miles long and sixty (60) feet wide be cleared, grubbed and stripped. The average size of the trees on the site are six (6) inches in diameter. You have two (2) D7G tractors available to do the task. How many hours will the task take? The operator is average and the equipment will be working under daylight conditions.

Step 1. *Determine area to be cleared in acres:*
First change miles to feet -----2 miles X 5,280 = 10,560'

$$\frac{\begin{array}{ccc}\textbf{width (ft)} & & \textbf{Length (ft)} \\ \textbf{60'} & \textbf{X} & \textbf{10560'}\end{array}}{\textbf{43,560 sq ft /acre}} = \textbf{14.55 Acres}$$

NOTE: NEVER ROUND OFF ACRES

Step 2*. Determine the Size and Number of Dozers Available:*

Dozer size ___D7G_________Number dozers available ___2___

Step 3*. Determine the Size of Trees to be Cleared:*

Small trees____X___ Medium trees _______ Large trees________

Step 4. *Determine Production Rates (hours per acre) for Clearing,* based on dozer size and tree size (Table 13-3)

Small trees___2.50_____hr/acre

Step 5. *Determine **Basic Production Rate (average hrs per acre)** by averaging*

TABLE #13-3 QUICK ESTIMATES FOR CLEARING

EQUIPMENT	MAN OR EQUIPMENT (HOURS PER ACRE)		
	SMALL TREES (6 INCHES OR LESS)	MEDIUM TREES (7 TO 12 INCHES)	LARGE TREES (over 12 TO 30 INCHES)
BULLDOZER:			
Med tractor (D7)	**2.50**	**5.00**	**10.00**
Heavy tractor (D8)	1.50	3.00	8.00
SPADE PLOW:			
Medium tractor (D7)	1.33	2.20	3.90
SHEAR BLADE:			
Medium tractor (D7)	0.40	0.80	1.30
Heavy tractor (D8)	0.30	0.50	0.80

Note: These clearing rates are averages for tree counts of 50 trees per acre. Adverse conditions can reduce these rates significantly *individual production rates:* ***(IF NEEDED)***

$$\frac{\text{hr/acre(small trees)} + \text{hr/acre(med trees)} + \text{hr/acre(large trees)}}{\text{\# of different size trees}} = \text{basic production (hrs per acre)}$$

Step 6. ***Determine Equipment and Operator Efficiency Factor, using Table 7-2.***

Average Operator, working during daylight hours **=** **Efficiency factor** 0.75

TABLE #7-2 EFFICIENCY FACTOR

TYPE UNIT	OPERATOR	DAY	NIGHT
TRACKED	EXCELLENT	1.00	0.75
	AVERAGE	.75	.56
	POOR	.60	.45
WHEELED	EXCELLENT	1.00	.67
	AVERAGE	.60	.40
	POOR	.50	.33

NOTE: These factors include operator efficiency and visibility (dust, rain,snow, fog and darkness) with a job efficiency of a 60-minute hour.

Step 7: ***Total hours required to Complete Mission:***

$$\frac{\underset{\text{(STEP 1)}}{\mathbf{14.55\ (acres)}} \ \mathbf{X\ Production}\ \underset{\text{(STEP 4)}}{\mathbf{2.50}}\ \mathbf{(hr/acre)X\ 1.6}}{\underset{\text{(STEP 6)}}{\mathbf{Efficiency\ 0.75}}\ \mathbf{X}\ \underset{\text{(STEP 2)}}{\mathbf{2\ Number\ of\ dozers}}} = \frac{\mathbf{58.20}}{\mathbf{1.50}} = \mathbf{38.80\ Total\ hours}$$

NOTE: NEVER ROUND OFF TIME

NOTE: If estimating clearing and grubbing only, omit 1.6 from numerator of equation. The 1.6 hours is there for disposal and stripping of vegetation.

STEP 8: ***Total Production (Days)***

Hours Required 38.80 ÷ 8 Hours Worked a Day = 4.85 OR 5 **DAYS**

NOTE: ROUND DAYS TO NEXT FULL DAY

WHAT HAVE YOU LEARNED ?

PROBLEM 3: QUICK METHOD A road construction project requires that an area five (5) miles long and eighty (80) feet wide be cleared, grubbed and stripped. The average size of the trees on the site are 10 inches in diameter. You have three (3) D7G tractors available to do the task. How many hours will the task take? The operator is average and the equipment will be working under daylight conditions.

EXAMPLE: TREE-COUNT METHOD -- A road construction project requires that an area two (2) miles long and sixty (60) feet wide be cleared, grubbed and stripped. The average size of the trees on the site are six (6) inches in diameter. You have two (2) D7G tractors available to do the task. How many hours will the task take? The operator is average and the equipment will be working under daylight conditions.

Step 1. ***Determine area to be cleared in acres:***

$$\frac{\textbf{width (ft) X Length (ft)} \quad 60' \quad 10560'}{\textbf{43,560 sq ft/acre}} = \textbf{14.55 Acres}$$

NOTE: NEVER ROUND OFF ACRES

Step 2. ***Determine the Size and Number of Dozers Available:***

Dozer size ____D7G________ Number dozers available ____2

Step 3. ***Determine the average number of each size of trees per acre: (use Table 14-3 as a guide.)***

_____50______Small trees/acre

_____30______Med trees/acre

_____10_____Large trees/acre

Table 14-3 Clearing time for trees and brush

TREE SIZE	MEDIUM DOZER (D7)	HEAVY DOZER (D8)
BRUSH AND SMALL TREES (UP TO 6 INCHES)	.5 minutes per tree	.25 minutes per tree
MEDIUM TREES (7 TO 12 INCHES)	3 to 9 minutes per tree	2 to 6 minutes per tree
LARGE TREES (12 TO 30 INCHES)	5 to 20 minutes per tree	5 to 20 minutes per tree

Note: These clearing rates include removal of entire tree and stump and piling the trees in windrows. Clearing may take longer per tree than the table allows, depending on the size and location of the tree.

Step 4. Determine **Basic Production Rate (Hrs per acre)** based on size of dozer and size of trees to be cleared (Table 2-3):

__50___Small trees/acre X___.50___ Minutes/tree = __25____ Min per acre (small trees)

__30___Med trees/acre X __9___ Minutes/tree = __270____ Min per acre (Med trees)

__10___Large trees/acre X __20___ Minutes/tree = __200____ Min per acre (Large trees)

Min per acre(Small) + Min per acre(Med) + Min per acre(Large)

$$\frac{\text{25 min.} + \text{270 min.} + \text{200 min.}}{\textbf{60-min/hr}} = \textbf{8.25 Hours per Acre.}$$

NOTE: NEVER ROUND OFF TIME

Step 5. ***Determine Equipment and Operator Efficiency Factor: (Use Table 2-2,)***

Efficiency factor __.75 _

Step 6. ***Total Hours Required to Complete Mission:***

(STEP 1) (STEP 4) **14.55 (acres) X Production 8.25 (hr/acre) X 1.6**		**192.06**	
	=		**= 128.04 Total hours**
Efficiency 0.75 X 2 Number of dozers (STEP 6) (STEP 2)		**1.50**	**NOTE: NEVER ROUND OFF TIME**

NOTE: If estimating clearing and grubbing only, omit, 1.6 from numerator of equation. The 1.6 hours is there for disposal and stripping of vegetation.

STEP 7: ***Total Production (DAYS)***

Hours Required 128.04 ÷ 8 Hours Worked a Day = 16.01 OR 17 **DAYS**

NOTE: ROUND DAYS TO NEXT FULL DAY

RIPPER PRODUCTION

a. Ripping is still more art than science, and much will depend on the skill and the experience of the operator. Ripping for scraper loading may call for different techniques than if the same material is to be dozed away. If cross ripping is called for, it too requires a change of approach. The number of shanks used, the length and depth of the shank, the tooth angle, direction, and throttle position must all be adjusted according to the field conditions encountered. Ripping success may well depend on the operator finding the proper combination for those conditions.

b. Consider the following precautions when evaluating the feasibility of ripping a given formation.

(1) Tooth penetration is often the key to ripping success, regardless of seismic velocity. This is particularly true in homogeneous materials such as mudstone, claystone and fine-grained caliches. It is also true in tightly cemented formations such as conglomerates, some glacial till and caliches containing rock fragments.

(2) Low seismic velocities of sedimentaries can indicate probable rippability. However, if the fractures and bedding joints do not allow tooth penetration, the material may not be ripped effectively.

(3) Pre-blasting or "popping" may induce sufficient fracturing to permit tooth entry, particularly in the caliches, conglomerates and some other rocks. The economics should be checked carefully when considering popping of sandstones, limestones, and granites.

c. There are three methods of estimating ripping production:

(1) The best method is to record the time spent ripping then remove (using scrapers or loader) and weigh the ripped material. The total weight divided by the time spent will give hourly production. Some care will be needed to assure that only ripped materials are removed.

(2) Another method is to cross-section the area and then record the time spent ripping. After the material has been removed, cross-section the area again to determine the volume of rock removed. The volume divided by the time spent ripping gives the ripping rate per minute or hour.

(3) The least accurate method, but valuable for quick estimating on the job, is timing the ripper over a measured distance. Determine the average cycle time from a number of timed cycles. Turn around or backup time must be included. Measure the average rip distance, shank spacing, and depth of penetration. This data will give the volume per cycle from which the production in bank cubic yards can be calculated. Experience has shown that results obtained from this method are about 10 to 20 % higher than the more accurate method of cross-sectioning.

(4) The effective width of a single shank placed in the center position of the tool bar is 36" or 3' . The effective width of two shanks placed one on each side of the tool bar is 72" or 6 '. The effective width of three shanks, one placed in each position of the tool bar, is 108" or 9'.

(5) There is no ready answer or "rule-of-thumb" solution to predict ripping production. Even if everything is known about seismic velocity of the material, its composition, job conditions, equipment, and the operator, only a "guesstimate" can be given. The final answer must come from a production study obtained from the job site.

EXAMPLE of the measured distance method for calculating ripper production:

Data

D7G..............Model # 7 Ripper with one (1) tooth (3' width)

1 mph............Average Speed (including slippage and stalls)

300'.............Ripping Distance

Every 300' requires .25 min. to Raise, Pivot, Turn, and Lower again.

24"..............Tooth Penetration

2,000............BCY needed

8...............Hours Worked per Day

You are working 45 minutes per hour

SOLUTION.

STEP #1 MIN/PASS

$$\frac{\text{RIPPING DISTANCE} \quad 300'}{88} = 3.41 \text{ MIN} + .25 \text{ TURN TIME} = 3.66 \text{ MIN/PASS}$$

NOTE: NEVER ROUND OFF

STEP #2 PASS/ HR

$$\frac{\text{MIN WORKED PER HOUR} \quad 45}{3.66 \text{ MIN/PASS}} = 12.30 \text{ PASSES PER HOUR.}$$

NEVER ROUND OFF

STEP #3 VOLUME RIPPED

RIPPING DISTANCE WIDTH OF RIP DEPTH RIPPED

$$\frac{300' \times 3' \times 2'}{27'} = 66.67 \text{ BCY PER PASS}$$

NEVER ROUND OFF

STEP #4 BCYPH

66.67	X	12.30	=	820.04 OR 820
BCY/PASS	X	PASS/HR	=	BCYPH

NOTE: ROUND DOWN BCYPH

STEP #5 TOTAL NUMBER OF HOURS REQUIRED

$$\frac{\textbf{VOLUME NEEDED (BCY)}\ \ \textbf{2,000 BCY}}{\textbf{820}\ \text{(BCYPH)} \times \textbf{1}\ \text{NUMBER OF DOZERS RIPPING}} = 2.44$$

HOURS REQUIRED

NOTE: NEVER ROUND OFF TIME

TOTAL PRODUCTION (DAYS)

Hours Required 2.44 ÷ 8 Hours Worked a Day = 0.31 OR 1 **DAY**

NOTE: **ROUND DAYS TO NEXT FULL DAY**

WHAT HAVE YOU LEARNED?

PROBLEM 4: Measured distance method for calculating ripper production:

D7g..............Model # 7 Ripper with two teeth (6' width)

1 mph............Average speed (including slippage and stalls)

100'.............Ripping Distance

Every 100' requires .25 min. to Raise, Pivot, Turn, and Lower again.

24"...............Tooth Penetration

3,000.............BCY needed

8.................Hours Worked per Day

You are working 60 minutes per hour

GRADERS

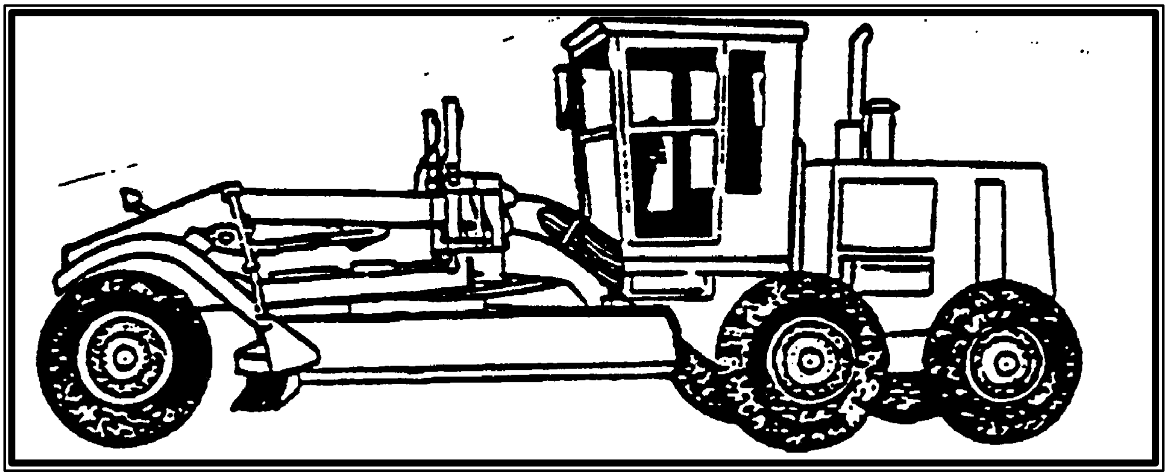


FIGURE 1-1. CAT 130G GRADER

INTRODUCTION

Graders are mutipurpose machines used primarily for general construction and maintenance of roads and runways. When properly used, the grader can be employed for crowning and leveling, mixing and spreading materials, ditching and bank sloping, and side-casting material.

1. USE: Graders serve as the finishers for the construction project. The grader is capable of finishing slopes and grades, blending and mixing materials, snow removal, and scarifying. Graders are used in conjunction with other earth movers when leveling, maintaining, and spreading.However,additional safety precautions should be used when equipment is performing different tasks in the same area.

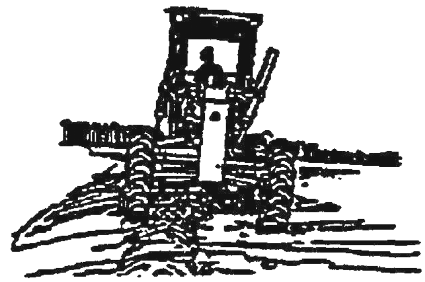
2. CLASSIFICATION: Graders are classified as multipurpose machines. The grader can be used in a wide variety of operations from the beginning to the end of construction.

3. CHARACTERISTICS: Graders are wheeled vehicles characterized by a moldboard or blade and scarfier. Graders bring elevations to a final grade. The blade is used to side cast the material it encounters. The blade ends can be raised or lowered together or separately. Also, the blade can be angled and pitched for more effective operation. The scarfier is used to break up material too hard for the blade to cut. It is composed of eleven removable teeth capable of cutting to a depth of twelve inches. Graders are used for shallow cuts in medium to hard materials.

4. OPERATION: Graders are hydraulically operated and powered by a diesel engine. Graders are effective during leveling, ditching, and snow removal. During ditching operations, the grader can make progressive cuts to a depth of 3 feet. It is more economical to use other types of equipment to cut ditches deeper than 3 feet. Graders have a high center of gravity. The right pressure, at a critical point on the blade can cause the machine to roll over. Graders are used to create bank slopes. Well finished slopes help prevent slope failure. During the ongoing operation, the grader maintains haul roads. This is usually done by working the material from one side of the road to the other. Corrugated material should be scarified prior to leveling and compacted after the grader has made the final leveling passes. During snow removal operations the blade should be inspected hourly for excessive wear. Exercise caution and watch for hidden objects in the snow, as hitting these can damage the grader and injure the operator.

GRADER PRODUCTION

a. The time required to complete a grader operation depends on the number of passes necessary and the speed maintained on each pass. In turn, this speed depends largely on skill of the operator and the type of material handled.
A WORK-TIME FORMULA MAY BE USED TO PREPARE PRELIMINARY ESTIMATES OF THE *TOTAL TIME IN HOURS* REQUIRED TO COMPLETE A GRADER OPERATION.



$$\textbf{TOTAL TIME} = \frac{P \times D}{S \times E}$$

P= NUMBER OF PASSES REQUIRED
D= DISTANCE (IN MILES) TRAVELED IN EACH PASS
E= GRADER EFFICIENCY FACTOR
S= SPEED OF GRADER IN MILES PER HOUR

b. FACTORS IN FORMULA

(1) NUMBER OF PASSES (P) . The number of passes depend on the operation. Careful consideration must be made when determining the "number of passes" required. These passes must be based upon the effective grading width of the moldboard in the material worked, and/or the number of passes required for cut or fill of a given lane which will bring the surface to the desired grade.

(2) DISTANCE (D). Distance traveled in each pass is expressed in miles and is determined before construction begins. Note: if the distance has been measured in feet, you must change it into miles with this formula.

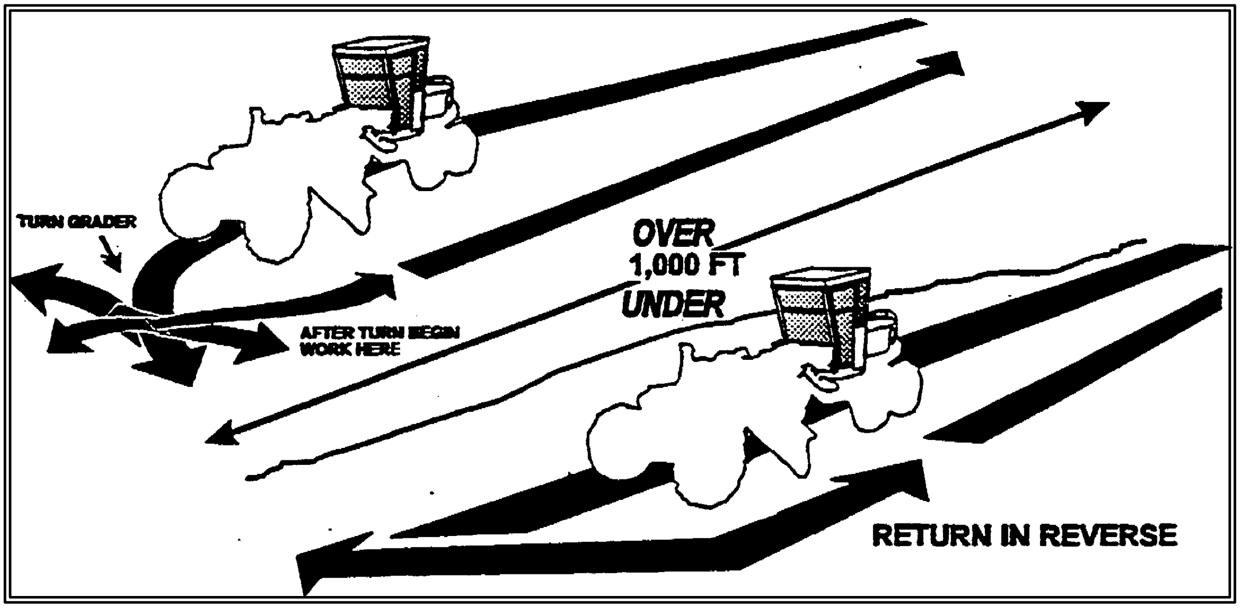
$$\frac{\textbf{DISTANCE IN FEET}}{\textbf{5280 (number of feet in 1 mile)}} = \textbf{DISTANCE IN MILES}$$

(3) EFFICIENCY FACTOR (E) . The grader efficiency factor takes into account the fact that a 60 minute work hour is attained. Efficiency varies depending on supervision, operator skill, maintenance requirements and the site conditions. This formula is based on a 60 percent efficiency factor.

EFFICIENCY = 0.60

(4) SPEED (S). Speed is expressed in miles per hour. It is the most difficult factor in the formula to estimate correctly. As work progresses, conditions may require that speed estimates be increased or decreased. The work output is computed for each operation which is performed at a different rate of Speed. The sum of all the values obtained in each part is the total time required for the operation. Care must be taken to use the correct number of passes for each speed used.

TABLE #15-4					**130G GRADER SPEEDS PER GEAR**	
	SPEED	BOTH	FORWARD	AND	REVERSE	IN MPH
GEAR	1ST	2ND	3RD	4TH	5TH	6TH
MPH	2.3	3.7	5.8	9.6	15.5	24.5



*** NOTE**: When a grader makes a number of passes over a distance of less than 1000 feet, it normally is more efficient to back the grader the entire distance to the starting point than to turn the grader around and continue work from the far end.When this is the case, each time that the grader backs up must be considered as a pass and be included in the formula.

EXAMPLE #1 Five (5) miles of gravel road is to be leveled and reshaped by a motorized grader with a twelve (12) foot moldboard. Six (6) passes are estimated to be required to complete leveling and reshaping. The type of material permits passes one and two (1 & 2) in second gear, passes three and four (3 & 4) in third gear, and passes five and six (5 & 6) in fifth gear.

(2nd gear passes 1 & 2)

$$\frac{2 \text{ (passes) } \times 5 \text{ (distance) IN MILES}}{3.7 \text{ (speed) } \times .60 \text{ (efficiency factor)}} = \frac{10}{2.22} = \textbf{\textit{4.50 hrs.}}$$

(3rd gear passes 3 & 4)

$$\frac{2 \text{ (passes) } \times 5 \text{ (distance) IN MILES}}{5.8\text{(speed) } \times .60 \text{ (efficiency factor)}} = \frac{10}{3.48} = \textbf{\textit{2.87 hrs.}}$$

(5th gear passes 5 & 6)

$$\frac{2 \text{ (passes) } \times 5 \text{ (distance) IN MILES}}{15.5 \text{ (speed) } \times .60 \text{ (efficiency factor)}} = \frac{10}{9.3} = \textbf{\textit{1.08 hrs.}}$$

4.50 hrs +***2.87 hrs.*** + ***1.08 hrs.*** = ***8.45 hrs.*****total hours**

TOTAL PRODUCTION (DAYS)
HOURS REQUIRED 8.45 ÷ 8 HOURS WORKED A DAY = 1.06 OR 2 **DAY**

NOTE: ROUND DAYS TO NEXT FULL DAY

EXAMPLE #2 A gravel road of 1,500 feet requires leveling and reshaping. The work requires two (2) passes in second gear, and three (3) passes in third gear.

$$\frac{500 \text{ feet}}{5280 \text{ feet per mile}} = \textbf{.28 miles}$$

(2nd gear passes 1 & 2)

$$\frac{2\text{ (passes)} \times .28\text{ (distance) IN MILES}}{3.7\text{ (speed)} \times .60\text{ (efficiency factor)}} = \frac{.56}{2.22} = \mathbf{.25\ hrs.}$$

(3rd gear passes 3, 4, & 5)

$$\frac{3\text{ (passes)} \times .28\text{ (distance) IN MILES}}{5.8\text{ (speed)} \times .60\text{ (efficiency factor)}} = \frac{.84}{3.48} = \mathbf{.24\ hrs.}$$

.25 + .24 = .49 total hours

TOTAL PRODUCTION (DAYS)
HOURS REQUIRED .49 ÷ 8 HOURS WORKED A DAY = 0.06 OR 1 **DAY**
NOTES: ROUND DAYS TO NEXT FULL DAY

WHAT HAVE YOU LEARNED ?

PROBLEM #1: You have six (6) miles of sandy road that needs to be leveled and reshaped. Six (6) passes are estimated to be required to complete the job. The type of material permits passes (1 & 2) in first gear, passes (3 & 4) in second gear, and passes (5 & 6) in forth gear.

PROBLEM #2: There are 2,640 feet of a dirt road that needs to be leveled and reshaped. It is estimated that it will require six (6) passes to complete the job. The type of material permits passes (1 & 2) in first gear, passes (3 & 4) in third gear, and passes (5 & 6) in fifth gear. Figure the total production time to complete this job.

NOTE * FEET = $\frac{\text{MILES}}{5280}$

GRADER PRODUCTION WORKSHEET

STEP 1. NUMBER OF PASSES: ______________________________

STEP 2. DISTANCE: ______________________________

STEP 3. SPEED: ______________________________

TABLE #15-4 GEAR						130G GRADER SPEEDS PER
	SPEED	BOTH	FORWARD	AND	REVERSE	IN MPH
GEAR	1ST	2ND	3RD	4TH	5TH	6TH
MPH	2.3	3.7	5.8	9.6	15.5	24.5

STEP 4. PRODUCTION CALCULATION:

(passes) **X** (distance)
____
(speed) **X** **.60** (efficiency) = ______________ hrs.

+

(passes) **X** (distance)
____
(speed) **X** **.60** (efficiency) = ______________ hrs.

+

(passes) **X** (distance)
____
(speed) **X** **.60** (efficiency) = ______________ hrs.

+

(passes) **X** (distance)
____
(speed) **X** **.60** (efficiency) = ______________ hrs.

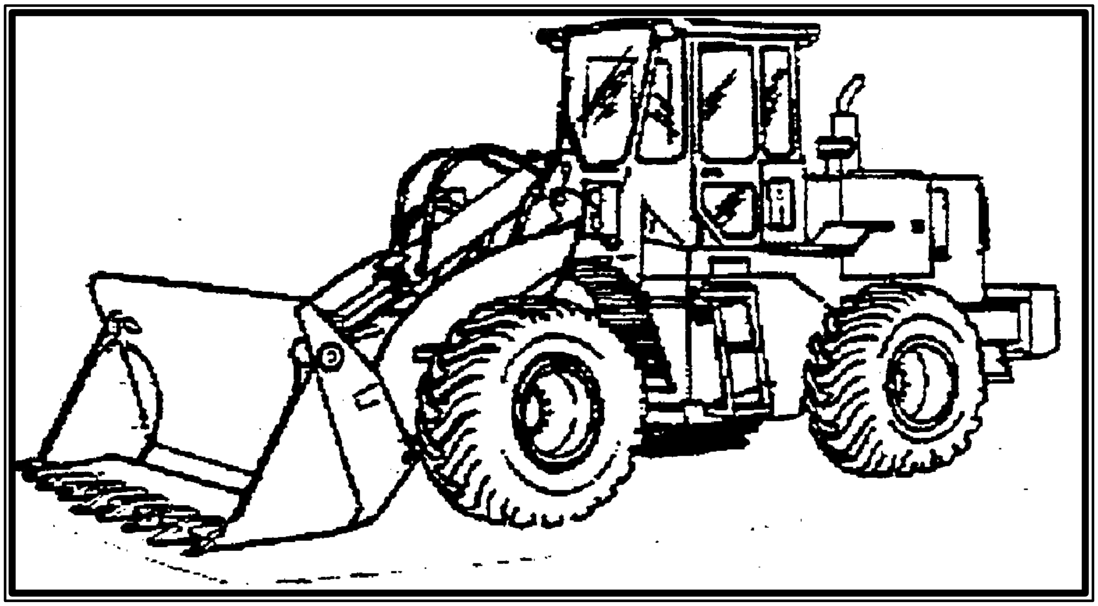
HOURS REQ

TOTAL PRODUCTION (DAYS)

HOURS REQUIRED ________ ÷ __________ HOURS WORKED A DAY = __________ OR __________ **DAY**

NOTES: ROUND DAYS TO NEXT FULL DAY

SCOOP LOADERS



INTRODUCTION

Loaders are available in varied sizes and bucket capacities. Loaders have a hinged frame which provides the steering, this steering method is referred to as articulated, and provides greater maneuverability. Articulated steering provides zero clearance for personnel at the point of articulation. Most loaders have a towing pintle for towing small trailers. Special caution should be exercised when the bucket is fully raised, because the cahances of rollover or tipping are greatly increased.

1. USE: The primary use of the front end loader is lifting and loading. The loader is also used for excavating, snow removal, and back-filling. The loader is capable of numerous other operations with the proper attachments. These include forks, sweeper, snowplow, and muti-segmented bucket. Loaders are used in and around rock quarries, but should be equipped with rock-type tread tires. Loaders are used in many miscellaneous tasks, including, stripping overburden, charging hoppers, and carrying materials.

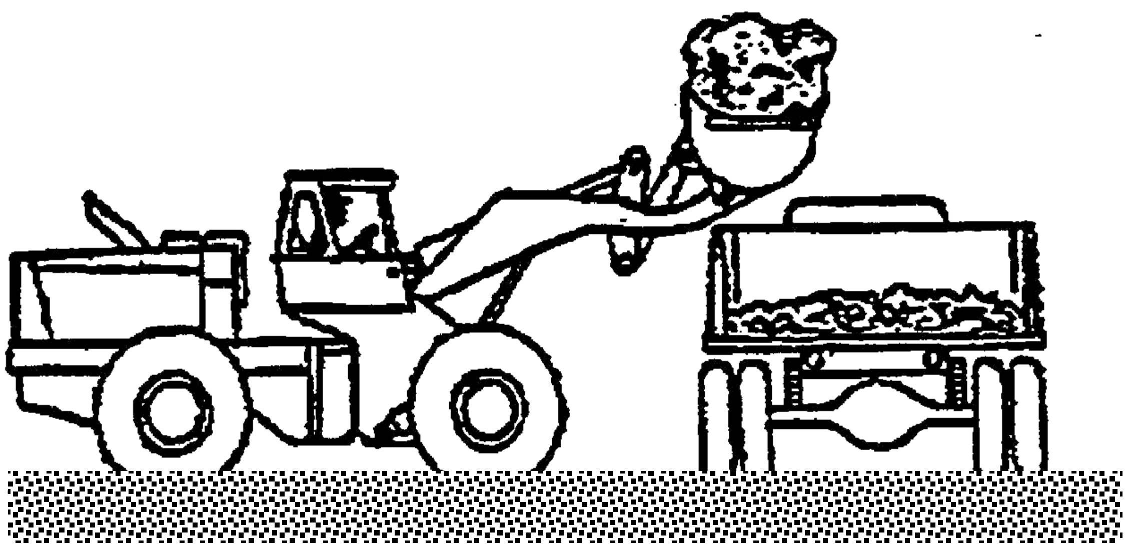
2. CLASSIFICATION: Loaders are classified according to bucket size. The normal buckets are 2 1/2 cubic yards and 5 cubic yards, however, the buckets are available in many sizes, both larger and smaller.

3. CHARACTERISTICS: Loaders are wheeled vehicles characterized by an attachmant for lifting and loading. The most common scooploader attachmants are the shovel-type bucket and the forklift. The loaders hydraulic system provides the power for these attachments. The bucket is available in two types, the general purpose and the muti-segmented bucket. The general purpose bucket is a one-piece bucket made of heavy duty all welded steel. The muti-segmented bucket is a hinged jaw bucket, commonly referred to as a clamshell. It has bolted or welded replaceable cutting edges and bolt on teeth for excavation. The two-piece bucket has many capabilities not available to the single-piece bucket. These include clamshell, dozer, and scraper operations.

4. OPERATION: Loaders are hydraulically operated and powered by a diesel engine. The loader is extremely versatile and capable of many different operations. When working in a stockpile, the bucket should be parallel to the ground when loading, and raised after penetration of the material. Crowding the material will prevent spilling, and maximize loading. When loading trucks from a bank or stockpile with a single loader, the "V" method should be used. This method will produce the best production, because the angle and the moving distance are kept to a minimum. A loader can dig excavations such as defilades and gun emplacements. When digging the excavation, a ramp should be constructed prior to the emplacement. This provides an area where the material can be removed from the hole. Material that is difficult to excavate should be broken up or loosened for greater effectiveness.

SCOOPLOADER PRODUCTION

5. **PRODUCTION:** SCOOP LOADERS ARE AFFECTED BY NUMEROUS FACTORS WHICH MUST BE CONSIDERED PRIOR TO THEIR EMPLOYMENT. AMONG THE FACTORS ARE OPERATOR SKILL, EXTENT OF PRIOR LOOSENING OF THE MATERIAL, WEIGHT AND VOLUME OF THE MATERIAL, SLOPE OF THE OPERATING AREA, HEIGHT OF THE MATERIAL, CLIMATIC CONDITIONS, AND MANAGEMENT FACTORS.



a. THE MARINE CORPS CURRENTLY HAS THREE SCOOP LOADERS IN THE SYSTEM, THE **SMALL ENPLACEMENT EXCAVATOR (SEE) TRACTOR**, THE **1155 CASE ,** AND THE **644E TRAM** . THE BASIC PRODUCTION FOR SCOOP LOADERS IS GIVEN IN TABLE #19. THESE FIGURES ARE BASED ON BUCKET SIZE AND CYCLE TIME AND REPRESENT OPTIMUM PRODUCTION IN LOOSE CUBIC YARDS WITH A 60 MINUTE WORK HOUR (NO TIME ALLOWED FOR SPOTTING HAUL UNITS, CLEANING WORK AREA, ETC.). THE FORMULA TO FIGURE SCOOP LOADER PRODUCTION IS:

BASIC PRODUCTION X EFFICIENCY X SOIL CONVERSION = PRODUCTION

* **NOTE:** AS WITH MANY OTHER FORMULAS, SOIL CONVERSION MAY NOT ALWAYS BE NEEDED, SO BE SURE TO WATCH YOUR COMPUTATIONS.

(STEP 1). ***BASIC PRODUCTION***___________________________

TABLE #16-5 (BASIC PRODUCTION FRONT END LOADER OPERATIONS)

NOTE: PRODUCTION ESTIMATED IN LOOSE CUBIC YARDS PER 60 MINUTE HOUR.

IF THE BUCKET SIZE TO BE USED IS NOT ON THE CHART ABOVE, YOU CAN FIGURE BASIC PRODUCTION USING THE FOLLOWING FORMULA:

Bucket Size x Seconds per Hour Worked
Loader Cycle Time (in sec) **= Basic Production in LCYPH**

BUCKET SIZE	CYCLE TIME IN SECONDS																
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1 1/8 CY	202	162	135	115	101	90	81	73	67	62	57	54	50	47	45	42	40
1 1/2 CY	270	216	180	154	135	120	106	98	90	83	77	72	67	63	60	56	54
2 1/2 CY	450	360	300	257	225	200	180	163	150	138	128	120	112	105	100	94	90
4 1/2 CY	811	648	540	463	405	360	324	294	270	249	231	210	202	190	180	170	102
5CY	900	720	600	514	450	400	360	327	300	276	257	240	225	211	189	189	180
BUCKET SIZE	CYCLE TIME IN SECONDS																
	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185
1 1/8 CY	38	36	35	33	32	31	30	28	27	27	26	25	24	23	23	22	21
1 1/2 CY	51	49	46	45	43	41	40	38	37	36	34	33	32	31	31	30	29
2 1/2 CY	85	81	78	75	72	69	69	64	62	60	58	56	54	52	52	50	48
4 1/2 CY	154	147	141	135	129	124	120	115	111	108	104	101	98	95	95	90	87
5 CY	171	163	156	150	144	138	133	128	124	120	116	112	109	105	105	100	97

(STEP 2)*. MANAGEMENT FACTORS*

TABLES # 17-5 **MANAGEMENT FACTORS**

JOB FACTORS	EXCELLENT	GOOD	FAIR	POOR
EXCELLENT	.84	.81	.76	.70
GOOD	.78	.75	.71	.65
FAIR	.72	.69	.65	.60
POOR	.63	.61	.57	.52

NOTE: THERE IS A TENDENCY TO OVER RATE MANAGEMENT FACTORS. EFFICIENCY FACTORS BASED ON ACTUAL EXPERIENCE OF THE UNITS HAVE PROVEN TO BE MORE SATISFACTORY.

(STEP 3). ***BASIC PRODUCTION X MANAGEMENT FACTORS =*** ____________________ ***(LCYPH)***

EXAMPLE: 360 X .75 = 270 LCYPH

NOTE: ROUND DOWN LCYPH

(STEP 4): ***(SC)*** *(IF NEEDED)*

________ **X** ________________________________ = ________OR________ (___ CYPH)
(LCYPH) **X** CONVERSION FACTOR (TABLE #1-1) = ***SOIL CONVERTED*** ***(____CYPH)***
NOTE: ROUND DOWN (CYPH)

TABLE #1-1
SOIL CONVERSION FACTORS
NOTE: * IS CONSIDERED 100% VOLUME OR 1.00 CY

SOIL TYPE	INITIAL CONDITION	TO BANK	TO LOOSE	TO COMPACT
SAND	FROM BANK	*	1.11	.95
	FROM LOOSE	.90	*	.86
	FROM COMPACTED	1.05	1.17	*
LOAM	FROM BANK	*	1.25	.90
	FROM LOOSE	.80	*	.72
	FROM COMPACTED	1.11	1.39	*
CLAY	FROM BANK	*	1.43	.90
	FROM LOOSE	.70	*	.63
	FROM COMPACTED	1.11	1.59	*
BLASTED ROCK OR GRAVEL	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*
HARD CORAL OR LIMESTONE	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*

(STEP 5): *Total Hours Required*

QUANTITY TO BE MOVED

______________________________ = _________________________ **TOTAL HOURS REQUIRED**

(___CYPH)

(STEP 6): *Total Production (DAYS)*

HOURS REQUIRED _______ ÷ _______HOURS WORKED A DAY = _____OR_____ **DAYS**

ROUND DAYS TO NEXT FULL DAY

EXAMPLE # 1: A TRAM IS LOADING TRUCKS WITH DRY EARTH LOAM. THE AVERAGE CYCLE TIME IS 30 SECONDS. THE JOB FACTOR IS FAIR AND THE MANAGEMENT FACTOR IS POOR. THE PROJECT REQUIRES 400 COMPACTED CUBIC YARDS OF MATERIAL. HOW MANY COMPACTED CUBIC YARDS CAN THE LOADER LOAD PER HOUR? HOW MANY HOURS WILL IT TAKE THE LOADER TO LOAD ENOUGH MATERIAL TO MEET THE COMPACTED REQUIREMENT?

BUCKET SIZE	2.5 CY
CYCLE TIME	30 SECONDS
PRODUCTION	300 LCYPH
EFFICIENCY FACTOR	.60
SOIL CONVERSION FACTOR	.72

PRODUCTION RATE

300 X .60 X .72 = 129.60 or 129 CCYPH

PRODUCTION HOURS

$$\frac{400 \text{ (CCY REQUIRED)}}{129 \text{ (CCYPH)}} = \mathbf{3.10\ HRS}$$

TOTAL PRODUCTION (DAYS)

HOURS REQUIRED 3.10 ÷ 8 HOURS WORKED A DAY = .39 OR 1 **DAY**

ROUND DAYS TO NEXT FULL DAY

WHAT HAVE YOU LEARNED

PROBLEM #1: FIGURE THE PRODUCTION RATE IN COMPACTED CUBIC YARDS

BUCKET SIZE	2 1/2 CY
CYCLE TIME	120 SECONDS
JOB FACTOR	FAIR
MANAGEMENT FACTOR	FAIR
MATERIAL	COMMON EARTH, LOAM

PROBLEM #2: FIGURE THE PRODUCTION RATE IN LOOSE CUBIC YARDS.

BUCKET SIZE	1.75CY
CYCLE TIME	90 SECONDS
JOB FACTOR	POOR
MANAGEMENT FACTOR	POOR
MATERIAL	LIMESTONE

WORKING A 45 MINUTE WORK HOUR

RATIO OF LOADING UNITS TO HAULING UNITS

a. For the cycle time to be of any value, you have to have enough loaders. There is no time computed into the cycle time for the scrapers to wait due to the loader's inability to keep up. Therefore, you have to have the proper ratio of loading units to hauling units.

b. The formula below will give you the **Number of Hauling Units that One Loader can handle.**

CYCLE TIME
LOAD TIME = # Hauling UNITS THAT ONE Loading UNIT CAN HANDLE
(TABLE #18-5)

EXAMPLE: Figure the Number of haul units (scrapers) that one Loading unit can handle if you are loading with a HSHMC to a heap load and the scrapers (CT) is 28 min.

CYCLE TIME
28 min.
18 min. **=** 1.56 **or** 1 **Hauling unit that ONE loading unit can handle with no waiting.**
LOAD TIME

TABLE # 18-5 LOADING TIME

LOADING EQUIPMENT	**621B STRUCK LOADED**	**621B HEAP LOADED**
1155E SCOOP LOADER	6 MIN.	8 MIN.
TRAM SCOOP LOADER	5 MIN.	6 MIN.
1085 EXCAVATOR		
@ 1-1/4 BUCKET	11 MIN.	15 MIN.
@ 5/8 BUCKET	15 MIN.	21 MIN.
HSHMC @ CLAMSHELL	15 MIN.	**18 MIN.**

Total Number of Loading Units Needed

a. To get the ***Total Number of Loading Units Needed*** use this formula.

 # HAUL UNITS ÷ CYCLE TIME
LOAD TIME = # OF LOADING UNITS NEEDED
(TABLE #18-5)

EXAMPLE: Figure the Total Number of Loading Units Needed.

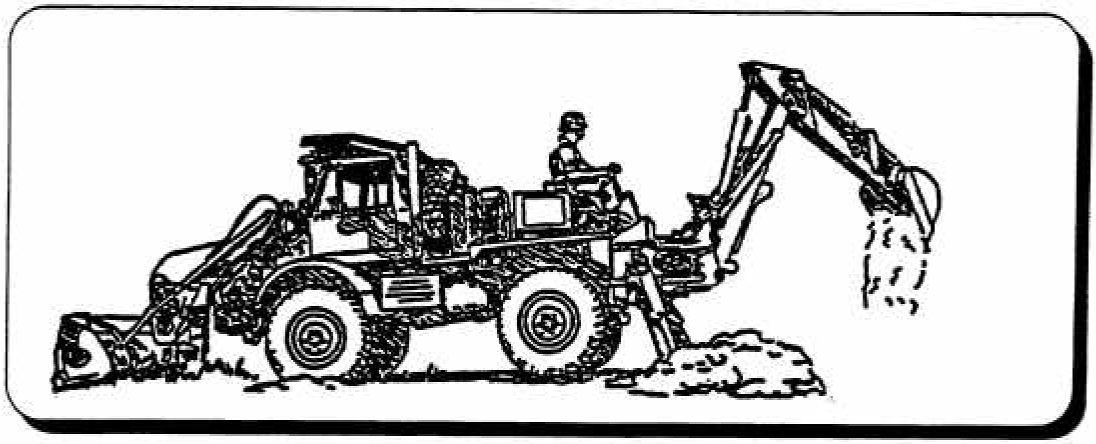
CYCLE TIME
 # HAUL UNITS 1 ÷ 28 min.
18 min.
LOAD TIME = .64 or 1 **TOTAL # OF LOADING UNITS NEEDED**

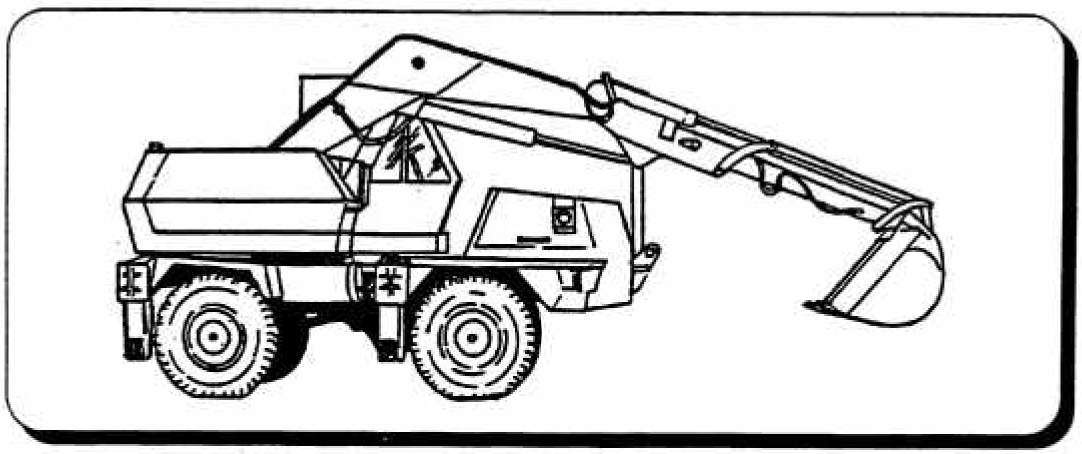
WHAT HAVE YOU LEARNED

PROBLEM #3: Figure the Number of haul units (scrapers), that one Loading unit can handle if you are loading with a Tram to a struck load and the scrapers CT is 15 min.

PROBLEM #4: Figure the Total Number of Loading Units Needed for scenario #3.

BACKHOES AND EXCAVATORS





INTRODUCTION:

Fast-acting, variable-flow hydraulic systems and easy-to-operate controls give hydraulic excavators the high implement speed and breakout force to excavate trenches, the precision to set pipes, and the capacityto backfill. The small emplacement excavator **(SEE)** and the excavator operate on those 4 principles. They have the precision to work in tight places and the mobility to move quickly from job to job.

1. **USE:** The backhoe and excavator are best suited for trench excavating, since it can dig well below the ground level. A large variety of booms, sticks, buckets, and attachments give excavators the versatility to excavate trenches, load trucks, clean ditches, breakout old concrete, install outlet pipes, remove "FOD" (Foreign Object Disposal) from runways, and so forth.

2. **CLASSIFICATION:** Backhoes and excavators are classified by horsepower. The Small Emplacement Excavator **(SEE)** is rated at 110 HP. The **1085 Excavator** has a rated HP of 148 at 2200 RPM and a maximum speed of 29 MPH. Generally speaking, the greater the horsepower the greater the output.

3. **CHARACTERISTICS:** The SEE is a lightweight, all-wheel drive, diesel driven, high mobility vehicle with backhoe, bucket loader, and other attachments such as the hand-held hydraulic rock drill, chainsaw, and pavement breaker. The SEE

weighs less than 16,000 pounds, is air transportable, and can travel at speeds of more than 50 MPH on improved roads. The SEE has excellent off road mobility, but is restricted to side slopes of less than 30 percent. The SEE, when fitted with the backhoe ripper bucket, can excavate frozen or hard ground. The Backhoe bucket bucket size is **0.26 (CY)**, the front loader is **0.75 (CY).** The 1085 has other attachments such as the compactor & shovel front bucket...

4. **OPERATION:** Since the excavator is used primarily for below ground level excavation, a survey should be conducted for underground hazards, as well as surface obstacles before starting operation. This applies particularly to populated areas with underground utilities. It is important that the machine be positioned properly on the job to gain its greatest effectiveness. Efficient positioning of the backhoe depends on the type of work to be done. Before operating the backhoe, level the machine. Lower the front bucket to the ground. Insure the gearshift and the range shift levers are in the neutral positions. Plan and layout the work area. Always operate with the least amount of dipper arm swing. The backhoe is also capable of loading trucks. This operation is sloppy and somewhat inefficient. The sloppiness is due to the material falling off the teeth as the bucket is lifted. The attachments that are used with the SEE requires special care. These tools are hydraulically powered and manually operated. Care should be taken, especially when connecting and disconnecting the tools, since the hydraulic fluid is under pressure and could be hot.

5. **PRODUCTION ESTIMATION:** IS FOUND WITH THE FOLLOWING FORMULAS.

a. SEE Tractor production estimation:

(STEP 1). CONVERT SOIL FROM BANK TO LOOSE USING TABLE 1-1, THEN TAKE REQUIREMENT TO STEP #8

NOTE: ROUND UP TO NEXT FULL CUBIC YARD OF MATERIAL TO BE REMOVED

TABLE #1-1
SOIL CONVERSION FACTORS
NOTE: * IS CONSIDERED 100% VOLUME OR 1.00 CY

SOIL TYPE	INITIAL CONDITION	TO BANK	TO LOOSE	TO COMPACT
SAND	FROM BANK	*	1.11	.95
	FROM LOOSE	.90	*	.86
	FROM COMPACTED	1.05	1.17	*
LOAM	FROM BANK	*	1.25	.90
	FROM LOOSE	.80	*	.72
	FROM COMPACTED	1.11	1.39	*
CLAY	FROM BANK	*	1.43	.90
	FROM LOOSE	.70	*	.63
	FROM COMPACTED	1.11	1.59	*
BLASTED ROCK OR GRAVEL	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*
HARD CORAL OR LIMESTONE	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*

(STEP 2) *CYCLE TIME:* ________________*SECS*

TABLE 19-6 DEPTH OF CUT (FT)

DEGREE OF SWING	**2 FEET**	**4 FEET**	**6 FEET**	**8 FEET**	**10 FEET**	**12 FEET**	**14 FEET**
45 DEGREES	12 SEC.	16 SEC.	22 SEC.	25 SEC.	31 SEC.	38 SEC.	46 SEC.
90 DEGREES	22 SEC.	25 SEC.	30 SEC.	36 SEC.	42 SEC.	49 SEC.	55 SEC.

(STEP 3). *BASIC PRODUCTION CALCULATION:*

$$\frac{\text{BUCKET SIZE IN CY X MINUTES WORKED/HOUR X 60 SEC/MIN}}{\text{CYCLE TIME (SECS)}} = \text{PRODUCTION}$$

_______________**LCY/HR**

NOTE: ROUND DOWN LCYPH

(STEP 4). *SOIL WEIGHT CORRECTION FACTOR:*

***(REFERENCE: TABLE #2-2 SOIL WEIGHT CORRECTION FACTORS)**

TABLE #2-2
APPROXIMATE WEIGHT OF SOIL

TYPE OF SOIL	**POUNDS PER (CY)**	**TYPE OF SOIL**	**POUNDS PER (CY)**
CINDERS	1200 LBS.	***LIMESTONE***	2500 LBS.
CLAY, DRY	2000 LBS.	***SANDSTONE***	2200 LBS.
CLAY, WET	3000 LBS.	***SAND, DRY***	2900 LBS.
CLAY & GRAVEL	2700 LBS.	***SAND, WET***	3100 LBS.
GRAVEL, DRY	3000 LBS.	***SHALE & SOFT ROCK***	2700 LBS.
GRAVEL, WET	3100 LBS.	***SLAG, BANK***	1940 LBS.
EARTH LOAM, DRY	2200 LBS.	***SLATE***	2500 LBS.
EARTH LOAM, WET	3200 LBS.	***TRAP ROCK***	3500 LBS.
HARDPAN	3100 LBS.	***CORAL (HARD)***	2440 LBS.
		CORAL (SOFT)	2030 LBS.

$$\frac{\text{2300 LBS/LCY}}{\text{ACTUAL MATERIAL WEIGHT}} = \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ WEIGHT FACTOR}$$

(STEP 5). *EQUIPMENT OPERATOR EFFICIENCY CORRECTION FACTOR :*

TABLE #7-2 EFFICIENCY FACTOR

TYPE UNIT	**OPERATOR**	**DAY**	**NIGHT**
TRACKED	EXCELLENT	1.00	0.75
	AVERAGE	.75	.56
	POOR	.60	.45
WHEELED	EXCELLENT	1.00	.67
	AVERAGE	.60	.40
	POOR	.50	.33

(STEP 6). *MANAGEMENT FACTORS* ________________________

TABLES # 17-5
MANAGEMENT FACTORS

JOB FACTORS	EXCELLENT	GOOD	FAIR	POOR
EXCELLENT	.84	.81	.76	.70
GOOD	.78	.75	.71	.65
FAIR	.72	.69	.65	.60
POOR	.63	.61	.57	.52

(STEP 7). *HOURLY OUTPUT CALCULATION:*

STEP 3 X STEP 4 X STEP 5 X STEP 6 = ______________ LCYPH

NOTE: ROUND DOWN LCYPH

(STEP 8). *TOTAL HOURS REQUIRED (IF NEEDED)*

$$\frac{\textbf{QUANTITY TO BE MOVED}}{\textbf{HOURLY PRODUCTION RATE}} = \underline{\hspace{4cm}}\ \textbf{HRS REQ}$$

(STEP 9). *TOTAL PRODUCTION (DAYS)*

HOURS REQUIRED _______ ÷ ____HOURS WORKED A DAY = ___OR____ **DAYS**

ROUND DAYS TO NEXT FULL DAY

WHAT HAVE YOU LEARNED ?

PROBLEM #1: Your platoon has been tasked with digging a pipeline trench that is six feet deep, in loam, weighing 2200 pounds per loose cubic yard. The swing angle is 45 degrees. You will be working during daylight hours for 8 hours a day with newly assigned operators rated as poor. The job factor is fair and management factor is poor since you decided to train operators with this project. You estimate that 1250 banked cubic yard will be excavated.

REQUIREMENT: How long will it take you to complete the project?

SOLUTION:

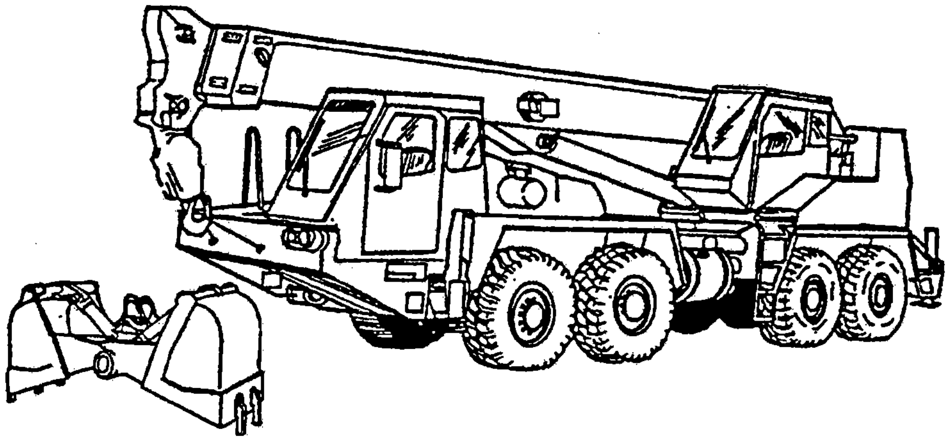
WHAT HAVE YOU LEARNED

PROBLEM #2: Your platoon has been tasked with digging 21 fighting holes in clay weighing 2000 pounds per loose cubic yard. Each fighting hole is six feet deep and contains 3.0 bank cubic yards of clay. Management factors will be excellent and the job factor is good. You decide to use your SEE Tractor and best operator to work during the day for 8 hours. The best swing angle the operator can obtain is 45 degrees.

REQUIREMENT: How long will it take to complete the project?

SOLUTION

CLAMSHELL PRODUCTION



a. Because of the factors which effect operation of the clamshell, it is difficult to arrive at production rates that are dependable. These factors include:

1. The difficulty of loading the bucket in different type of soil.

2. The height of the lift.

3. The slow swing required.

4. The method of disposing of the load.

b. The best method of production estimation is to observe the equipment on the job and measure the cycle time.

CLAMSHELL PRODUCTION ESTIMATION

EXAMPLE: Determine the production rate and time required to complete the job. The job conditions are as follows:

Clamshell cap......................................1 CY
Job factor..Fair.
Management factor.............................Good.
Average cycle time..............................45 seconds
Minutes per hour worked.....................50 min (3000 seconds)
Production required..............................450 LCY

(STEP 1) *CONVERT WORKING MINUTES PER HOUR TO WORKING SECONDS PER HOUR.*

(50WORKING MIN/HR X 60 SEC/MIN = 3,000 SEC/HR)

(STEP 2) *EFFICIENCY FACTORS.* *.69*

TABLES # 17-5 MANAGEMENT FACTORS

JOB FACTORS	EXCELLENT	GOOD	FAIR	POOR
EXCELLENT	.84	.81	.76	.70
GOOD	.78	.75	.71	.65
FAIR	.72	.69	.65	.60
POOR	.63	.61	.57	.52

(STEP 3) *PRODUCTION FORMULA:*

(STEP #1) (STEP #2)
BUCKET SIZE X SEC/HR WORKED X EFF. FACTOR
1.00 X 3,000 X .69
45 sec CYCLE TIME (IN SEC) = 46 LCYPH

(STEP 4) *DETERMINE SOIL CONVERSION (IF NEEDED)*

LCYPH X CONVERSION FACTOR = (___CYPH)

TABLE #1-1
SOIL CONVERSION FACTORS
NOTE: * IS CONSIDERED 100% VOLUME OR 1.00

SOIL TYPE	INITIAL CONDITION	TO BANK	TO LOOSE	TO COMPACT
SAND	FROM BANK	*	1.11	.95
	FROM LOOSE	.90	*	.86
	FROM COMPACTED	1.05	1.17	*
LOAM	FROM BANK	*	1.25	.90
	FROM LOOSE	.80	*	.72
	FROM COMPACTED	1.11	1.39	*
CLAY	FROM BANK	*	1.43	.90
	FROM LOOSE	.70	*	.63
	FROM COMPACTED	1.11	1.59	*
BLASTED ROCK OR GRAVEL	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*
HARD CORAL OR LIMESTONE	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*

(STEP 5) *DETERMINE TOTAL TIME REQUIRED TO COMPLETE JOB*

QUANTITY TO BE MOVED
450 LCY
= 9.78 HRS REQUIRED
46
LCYPH

(STEP 6) *TOTAL PRODUCTION (DAYS)*

HOURS REQUIRED **9.78** ÷ **8** **HOURS WORKED A DAY** = 1.22 OR 2 **DAYS**

ROUND DAYS TO NEXT FULL DAY

WHAT HAVE YOU LEARNED ?

PROBLEM #1: Your platoon has been tasked to move 15,500 cubic yards of loose gravel (stockpile) to an airfield construction site. You find that the scoop loaders are tied down to a higher priority project and you will be required to use your 1 cubic yard clamshell. The cycle time of the clamshell is 50 seconds. Job factors are good and management factors are fair. You are working 45 minutes per hour, and 7 hours per day. Determine how long it will take to load the gravel into haul units.

CLAMSHELL PRODUCTION WORKSHEET

STEP #1 *CONVERT THE BUCKET SIZE TO A DECIMAL:*

USING A 3/4 LCY BUCKET = .75

STEP #2 *CONVERT WORKING MINUTES PER HOUR TO WORKING SECONDS PER HOUR.*

__________ WORKING MIN/HR X __________ 60 SEC/MIN = __________ SEC/HR

STEP #3 *EFFICIENCY FACTOR. (TABLE 17-5)___*

STEP #4 *PRODUCTION FORMULA:*

(STEP #1) (STEP #2) (STEP #3)
BUCKET SIZE X SEC/HR WORKED X EFF. FACTOR

__________ X __________ X __________ = __________ LCY/HR

CYCLE TIME (IN SEC)

STEP #5 *DETERMINE SOIL CONVERSION (IF NEEDED)*

_______ X ________________ = __________
LCYPH X CONVERSION FACTOR = (___CYPH)

STEP #6 *DETERMINE TOTAL TIME REQUIRED TO COMPLETE JOB*

QUANTITY TO BE MOVED
____________________ = ________ **HRS REQUIRED TO COMPLETE JOB**

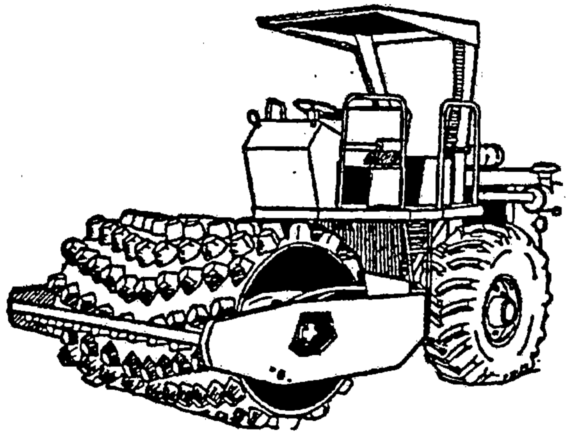
LCYPH

STEP #7 *TOTAL PRODUCTION (DAYS)*

HOURS REQUIRED _____ ÷ _____HOURS WORKED A DAY =______ OR ______**DAYS**

ROUND DAYS TO NEXT FULL DAY

COMPACTOR



Compaction is the process of mechanically densifying a soil by the application of a moving load. No other construction process, applied to natural soils, so drastically affects a soil's properties. Although compaction does not effect all soils alike, the advantages gained by compaction have made it a standard and essential part of the horizontal construction process.

1. **USE:** Compaction equipment and used strictly for mechanical stabilization. Compaction equipment and unique in that they are specialized for that purpose. Proper compaction is the most critical part of construction. Compaction allows the structure to meet loading requirements. In roads and airfields, compaction is used from the sub-grade to the final wearing surface.

2. **CLASSIFICATION:** Compaction equipment are classified by weight, type, and method of operation. There are basically two types of compactors; Towed and Self-Propelled. However, when classified by method of operation, there are three catagories of compactors; Pneumatic, vibratory, and Rollers. Classification by weight is the maximum static weight delivered to the surface

3. **CHARACTERISTICS:** Because of the nature of compactors, it is difficult to catagorize them. There are many different types, models, and functions, ranging from hand-held models used for compaction in small areas to larger models used in heavy construction. Some are diesel powered, gasoline powered, pneumatic powered.

4. **OPERATION:** Compactors are driven, towed, or manually operated. Because of the weight and basic design of the compactors, it is best to operate the power unit behind the compactor. The exception to this is with towed compactors. Extreme caution must be used when compacting on any side slopes, since once the compactor reaches the tip over point there is usually no recovery. Compactors are by nature slow, with most speeds ranging from 3 - 7 miles per hour depending on the material being compacted. Operators should be switched often to prevent boredom and fatigue.

5. SELECTION AND TESTING OF EQUIPMENT: Even though the Marine Corps has one type of compactor (Vibratory), the military community has several to choose from. If the job you are working on needs a specific type that the Corps does not have, do not forget that you may be able to temporarely loan one from another service.

a. **SELECTION FACTORS:** Soil-compacting equipment normally available to the military engineers includes, tamping-foot rollers, , smooth steel-wheel rollers, and vibratory types. By knowing the characteristics, capabilities, and limitations of the different types of rollers, a project officer can select the most appropriate type of compaction equipment. Table 20-8 shows the spectrum of capabilities of each type of roller and the type of compactive effort associated with each roller.

(Table 20-8) SELECTING COMPACTION EQUIPMENT

ROLLER TYPE	SOIL TYPE	COMPACTIVE EFFORT
Tamping foot (BOMAG)	All soils except pure sands and pure clays	Kneading
Vibratory	Sand/gravel; gravelly and sandy soils	Vibratory (for granular-type soils)
Steel wheel	Gravelly soils; asphalt	Static
Grid roller	Rock; large grains; till	Static

NOTE: USE THIS TABLE ONLY IF TEST STRIP IS UNATTAINABLE.

6. COMPACTOR PRODUCTION: Once you have selected the correct compaction equipment, you can now figure your production. Use the following formula to calculate compactor production in compacted cubic yards per hour:

a. Formula:

$$\frac{16.3 \times W \times S \times L \times E}{P} = \text{CYPH}$$

W = EFFECTIVE WIDTH OF THE ROLLER 6 FEET: The compactors drum is 7 feet wide, however to eliminate noncompacted strips, each pass should overlap the preceeding pass by 1 foot, thus giving the 6 foot effective width.

S = ___________________________ Compactor speed, in mph
(table 21-8)

L = ___________________________ Compacted lift thickness, in inches
(table 21-9)

E = ___________________________ Efficiency factor
(table 22-8)

P = ___________________________ Number of passes required
(table 21-8)

16.3 = Constant used in formula

b. Production estimation starts with determining what type of soil you are working in and then looking to table 21-8 for the rest of the information you need to put in the formula.

EXAMPLE: YOU ARE COMPACTING CLAY. (YOU WILL SEE CLAY ABBREVIATED AS CL ON TABLE 21-8.) THE OPERATOR IS WORKING A 50 MIN/HR DURING THE DAY.

THE TOTAL AMOUNT TO BE COMPACTED IS 1,500 CCY. YOU ARE WORKING 8 HOURS A DAY.

STEP #1: *SOIL TYPE* CL

STEP #2: *Determine compaction requirements by using Table 21-8 In this table, you should first determine type of soil you are working in, then take the speed, lift thickness and passes from the table.*

TABLE 21-8 Soil classifications and compaction requirements (average)

SYMBOL	DESCRIPTION	LIFT THICKNESS COMPACTED INCHES	ROLLING SPEED (MPH/VPM)	NUMBER OF PASSES
GW	**Well-graded gravels or gravel sand mixture with 5% or less fines**	**18 (BEST)**	**4 mph 1400 vpm**	**8**
GP	**Poorly graded gravels or gravel-sand mixture with little or no fines**	**18 (BEST)**	**4 mph 1400 vpm**	**8**
GM	**Silty gravel and poorly graded gravel-sand silt mixtures**	**12**	**4 mph 1100 vpm**	**6**
GC	**Clayey gravel and poorly graded gravel-sand-clay mixture**	**12**	**4 mph 700 vpm**	**6**
SW	**Well-graded sands or gravelly sand mixture with 5% or less fines**	**18 (BEST)**	**4 mph 1400 vpm**	**8**
SP	**Poorly-graded sands or gravelly sand mixture with 5% or less fines**	**18 (BEST)**	**4 mph 1400 vpm**	**8**
SM	**Silty sands, sand-silt mixture**	**12**	**4 mph 1100 vpm**	**6**
SC	**Clayey sands, sand-clay mixture**	**12**	**3 mph 700 vpm**	**7**
ML	**Inorganic silt of low plasticity, silty fine sands**	**8**	**3 mph 700 vpm**	**7**
CL	**Inorganic clay of low to medium plasticity, lean clays**	**8**	**3 mph 700 vpm**	**7**
OL	**Organic silt and organic silt-clay of low plasticity**	*****	**N/A**	**N/A**
MH	**Inorganic silt micaeous or diatomaceous silty soil**	*****	**N/A**	**N/A**
CH	**Inorganic clay of high plasticity, fatty clays**	*****	**N/A**	**N/A**
OH	**Organic clay medium to high plasticity**	*****	**N/A**	**N/A**

S ***3 MPH*** ***L*** ***8"*** ***P*** ***7***

STEP #3: *Determine Operator/Time Factor (E). Due to the fact an operator cannot physically operate a vibratory compactor for more than 50 minutes without a break, it is necessary to figure an efficiency factor. This is taken from the table below.*

E **.83**

TABLE 22-8 Efficiency factors for compaction equipment

	WORKING HOURS	**EFFICIENCY FACTOR**
DAY OPERATIONS	50 MIN/HR 45 MIN/HR	0.83 0.75
NIGHT OPERATIONS	50 MIN/HR 45 MIN/HR	0.75 0.67

STEP #4: *Production Calculation. At this point, take all the information gathered and place in the formula below.*

$$\frac{\mathbf{16.3 \times W \times S \times L \times E}}{\mathbf{P}}$$

$$\frac{16.3 \times 6' \times 3\ \text{MPH} \times 8'' \times .83}{7} = 278.31 \text{ OR } 278\ \textbf{CCYPH}$$

STEP #5: *TOTAL HOURS REQUIRED*

TOTAL QUANTITY TO BE COMPACTED

$$\frac{1{,}500}{278} = \mathbf{5.40} \quad \textbf{TOTAL HOURS REQUIRED}$$

HOURLY PRODUCTION RATE CCYPH

STEP #6: *TOTAL PRODUCTION (DAYS)*

HOURS REQUIRED 5.40 ÷ 8 HOURS WORKED A DAY = .68 OR 1 DAY
ROUND DAYS TO NEXT FULL DAY

RATIO OF LCYPH TO COMPACTORS:

(IF NEEDED) THIS IS A LOGISTICAL CONCERN THAT SHOULD BE ASKED IF THERE ARE MORE THAN ONE COMPACTOR AVAILABLE.

EXAMPLE: If you have 36 LCYPH of clay being delivered by three 621Bs, How many compactors will it take to keep up with the delivery rate so that there will be no slow down in production?

AMOUNT DELIVERED/HOUR	**X**	**SOIL CONVERSION**
36 LCYPH	X	.63

$$\frac{}{278\ \textbf{CCYPH}} = .08 \text{ OR } 1$$ **COMPACTOR REQUIRED**

TABLE #1-1
SOIL CONVERSION FACTORS
NOTE: * IS CONSIDERED 100% VOLUME OR 1.00

SOIL TYPE	INITIAL CONDITION	TO BANK	TO LOOSE	TO COMPACT
SAND	FROM BANK	*	1.11	.95
	FROM LOOSE	.90	*	.86
	FROM COMPACTED	1.05	1.17	*
LOAM	FROM BANK	*	1.25	.90
	FROM LOOSE	.80	*	.72
	FROM COMPACTED	1.11	1.39	*
CLAY	FROM BANK	*	1.43	.90
	FROM LOOSE	.70	*	.63
	FROM COMPACTED	1.11	1.59	*
BLASTED ROCK OR GRAVEL	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*
HARD CORAL OR LIMESTONE	FROM BANK	*	1.50	1.30
	FROM LOOSE	.67	*	.87
	FROM COMPACTED	.77	1.15	*

WHAT HAVE YOU LEARND ?

PROBLEM #1: Your platoon has been tasked with an airfield construction project. You have estimated that your scrapers will be delivering 600 LCYPH of fill material. The total amount to be compacted is 20,000 CY . The compaction will be performed with a self-propelled vibratory roller with a 6 foot compaction width during daylight hours. Job conditions are as follows:

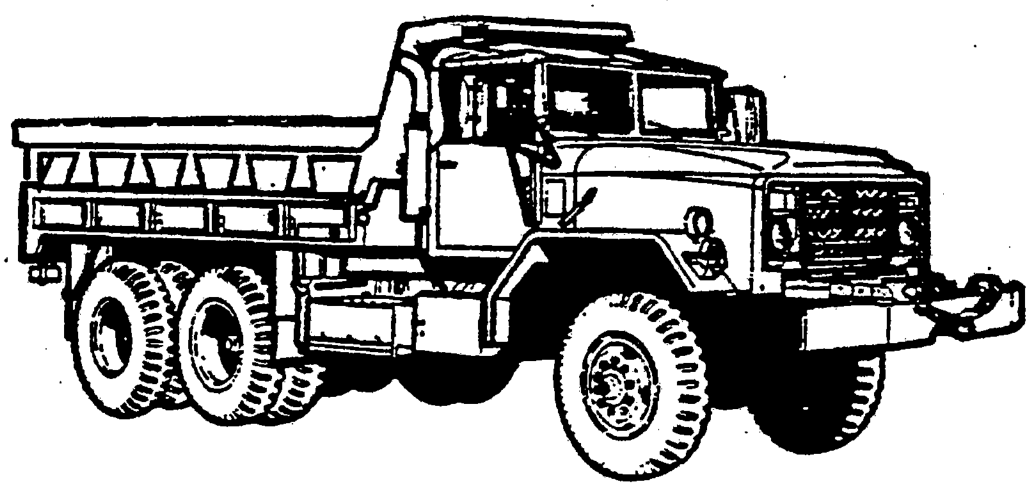
TYPE OF FILL MATERIAL	SAND
OPTIMUM DEPTH OF LIFT	8 INCH (COMPACTED)
NUMBER OF PASSES REQUIRED	14
AVERAGE SPEED OF COMPACTORS	3 MPH
WORKING HOURS	45 MIN/HR

REQUIREMENT: Determine how many compactors are required to support this fill operation.

PROBLEM #2: Your platoon has been tasked for a road construction project. You will have 880 LCY of fill material per hour delivered by 5 ton dump trucks. The total amount to be compacted is 10,000 CCY. The compaction will be performed with a self-propelled vibratory roller with a 6 foot compaction width during the night. Job conditions are as follows:

TYPE OF FILL MATERIAL	CLAY
OPTIMUM DEPTH OF LIFT	6 INCH (COMPACTED)
NUMBER OF PASSES REQUIRED	5
AVERAGE SPEED OF COMPACTORS	2 MPH
WORKING HOURS	50 MIN/HR

REQUIREMENT: Determine how many compactors are required to support this fill operation.



DUMP TRUCKS

The most common hauling equipment used for military purposes are the 2 1/2, 5, and 20 ton dump trucks. They serve as the major haul units for the engineer. The 2 1/2 ton truck is capable of hauling 2 1/2 cubic yards of material. The 5 ton truck is capable of hauling 5 cubic yards. The 20 ton truck widely used in quarry operatons, carries 12 cubic yards. Special attention must be paid to the weight of soil loaded so as not to exceed the weight limitations of the vehicle. Materials weighing more than 2000 pounds per loose cubic yard will reduce the load size.

1. **USE:** Dump trucks are the most common hauling equipment for the engineers. Their primary purpose is to haul and deliver material. Dump trucks are also used to transport troops and equipment in support of the unit mission. The trucks are equipped with a towing hook and are a tremendous asset for moving equipment and trailers. Trucks equipped with winches are valuable for recovery operations.

2. **CLASSIFICATION:** Dump trucks are classified by the weight they carry in tons, by the truck volume in cubic yards, or by the heaped capacity in cubic yards. For example, a 5 ton truck is capable of carrying 5.88 cubic yards of loose dry clay weighing 1,700 pounds per loose cubic yard but is restricted to the 5 cubic yard capacity. Wet clat weighing 3200 pounds per cubic yard, for instance, would be restricted to the 5 ton capacity.

3. **CHARACTERISTICS:** Dump trucks are characterized by a hydraulic lift cylinder that is used to raise and lower a bed. Most trucks are capable of all wheel drive that permit operation in different terrains. The raised bed can create problems when operated around overhead utilities. The bed also becomes top heavy when fully raised, so caution should be excercised when operating on side slopes. For the safest operation, the assistant operator should dismount the truck and ground guide the operator.

4. **OPERATION:** Dump trucks are hydraulically operated and powered by a diesel engine. Haul at the highest safe speed (without speeding) and in the proper gear. Speeding is unsafe and hard on the equipment. When several trucks are

hauling, it is essential to maintain the proper speed to prevent hauling delays or bottlenecks at the loading or dumping site. Slow trucks, as well as speeding ones, disrupt normal traffic patterns. Until the maintenance crew can repair a sluggish truck, replace it with a standby truck. Layout traffic patterns in loading and dumping sites to minimize backing, passing, and cross traffic. Keep truck bodies clean and in good condition. Accumulations of rust, dirt, dried concrete, or bituminous materials hamper dumping operatons. The time spent cleaning and oiling truck bodies must be considered in computing transportation requirements. The 900 Series dumps can not raise the bed and move forward at the same time. Whereas the 800 Series dumps can, Allowing them to spread the loaded material. Capacities of dump trucks are expressed in two ways.

(1) TONS (use TABLE 23-9 or check data plate for load weight.)

(2) CUBIC YARDS (use TABLE 23-9 for CY or call Motor Transport)

TABLE 23-9 TRUCK VOLUMES

TYPE OF TRUCK	LOAD CAPACITY IN POUNDS	STRUCK VOLUME IN LCY	HEAP VOLUME IN LCY
2 1/2 TON	5,000	call MT for volume	call MT for volume
5 TON	10,000	5 LCY	7.5 LCY
20 TON	40,000	call MT for volume	call MT for volume

NOTE: TABLE INFORMATION COMES FROM TM 9 2320-260-10 AND TM 9 2320-2720-10

5. PRODUCTION: Other than scrapers, dump trucks are the primary haul units for earth work in the military inventory. Primarily, dump trucks are used for hauling, dumping, spreading base course and surfacing materials, hauling other material incident to construction, and for general hauling where distance is greater than 1500 feet. There are ten steps to calculating dump truck production, starting with soil weight.

***STEP #1* ACTUAL SOIL WEIGHT:** *To determine the **actual soil weight** per cubic yard take the dry soil weight from (Table #2-2).*

TABLE #2-2
APPROXIMATE WEIGHT OF SOIL

TYPE OF SOIL	POUNDS PER (CY)	TYPE OF SOIL	POUNDS PER (CY)
CINDERS	1200 LBS.	***LIMESTONE***	2500 LBS.
CLAY, DRY	2000 LBS.	***SANDSTONE***	2200 LBS.
CLAY, WET	3000 LBS.	***SAND, DRY***	2900 LBS.
CLAY & GRAVEL	2700 LBS.	***SAND, WET***	3100 LBS.
GRAVEL, DRY	3000 LBS.	***SHALE & SOFT ROCK***	2700 LBS.
GRAVEL, WET	3100 LBS.	***SLAG, BANK***	1940 LBS.
EARTH LOAM, DRY	2200 LBS.	***SLATE***	2500 LBS.
EARTH LOAM, WET	3200 LBS.	***TRAP ROCK***	3500 LBS.
HARDPAN	3100 LBS.	***CORAL (HARD)***	2440 LBS.
		CORAL (SOFT)	2030 LBS.

EXAMPLE:

EARTH LOAM DRY IS *2200 lbs*. PER CUBIC YARD

100% INITIAL SOIL WEIGHT + 7% MOISTURE = 107% OR 1.07

EXAMPLE:

```
    2200  LBS. WEIGHT OF DRY EARTH LOAM PER CY  FROM TABLE 2-2
 X  1.07  100% OF SOIL WEIGHT + 7% MOISTURE
    2354  LBS.  ACTUAL SOIL WEIGHT  (ASW)
```

STEP #2: *CUBIC YARDS OF A LOAD:* *Remembering that you want to keep the* ***weight of the load*** *under 10,000 lbs, determine how many cubic yards can be hauled without exceeding 10,000 lbs. To do this, divide 10,000 by the actual soil weight per cubic yard.*

```
     10,000   LBS (RATED CAPACITY)
 ÷    2,354   ASW FROM STEP# 1
       4.25   CY OR NO MORE THAN 7.5 CY
```

If the resulting figure is over 7.5 cubic yards, you must go with 7.5. It is the maximum cubic yards that the M809 series can haul. If the resulting figure is less than 7.5, use that figure in step 3.

NOTE: NO MORE THAN MAX VOLUME OF TRUCK

STEP #3: *BUCKETS LOADED:* *To Determine the number of* ***buckets loaded*** *that is equal to or less than the figure determined in step #2, divide that figure, in this case 4.25, by the size of each bucket load which for the TRAM is 2 1/2 or 2.5.*

```
     4.25   CUBIC YARDS
 ÷    2.5   CUBIC YARDS (BUCKET SIZE FROM TABLE)
     1.70   OR 1 BUCKET LOADED
```

NOTE: ROUND DOWN TO WHOLE BUCKETS.

TABLE #3-2
BUCKET SIZE

TRAM 644-E	CASE 1155E	CASE/1085	1085/ GENERAL PURPOSE BUCKET	HSHMC CRANE CLAM SHELL
2-1/2 CY OR 2.5 CY	1-3/4 CY OR 1.75 CY	1-1/2 CY OR 1.5 CY	3/4 CY OR .75 CY	1 CY

STEP #4 *ACTUAL LOAD SIZE OR VOLUME:* *To determine the volume of the load take the answer from Step #3, 1 bucket per load, and multiply by the bucket size (2.5 for a TRAM).*

```
      1   # OF  BUCKETS
 X  2.5   TRAM BUCKET SIZE
    2.5   ACTUAL  LOAD SIZE (ALS)
```

NOTE: NEVER ROUND OFF LOAD SIZE OR VOLUME

STEP #5 *LOAD WEIGHT:* *Regardless of how much volume that you may be able to haul, you should try to keep your load weight under 10,000 pounds. Table #2-2 shows the weight of cinders as 1200 pounds per loose cubic yard. A struck load would weigh 6,000 pounds, while the heap load would weigh 9,000 pounds. These weights would be easily hauled, but it is a different story with other materials. Take a look at Earth Loam, Wet for instance:*

TABLE #2-2

TYPE OF SOIL	POUNDS PER (CY)	TYPE OF SOIL	POUNDS PER (CY)
CINDERS	1200 LBS.	***LIMESTONE***	2500 LBS.
CLAY, DRY	2000 LBS.	***SANDSTONE***	2200 LBS.
CLAY, WET	3000 LBS.	***SAND, DRY***	2900 LBS.
CLAY & GRAVEL	2700 LBS.	***SAND, WET***	3100 LBS.
GRAVEL, DRY	3000 LBS.	***SHALE & SOFT ROCK***	2700 LBS.
GRAVEL, WET	3100 LBS.	***SLAG, BANK***	1940 LBS.
EARTH LOAM, DRY	2200 LBS.	***SLATE***	2500 LBS.
EARTH LOAM, WET	3200 LBS.	***TRAP ROCK***	3500 LBS.
HARDPAN	3100 LBS.	***CORAL (HARD)***	2440 LBS.
		CORAL (SOFT)	2030 LBS.

EXAMPLE: OF OVERLOADING

3,200 Weight of Earth loam WET, PER/CY
X 5 (LCY) Struck
16,000 LBS. STRUCK LOADED

3,200 Weight of Earth loam WET,PER/CY
X 7.5 (LCY) Heaped
24,000 LBS. HEAPED LOADED

a. As you can see, the struck load and the heaped load are over the 10,000 pound limit . Therefore, if you are going to be hauling this type of material, you must determine how many loads the loader can put on the dump and still keep the weight of the load within the acceptable weight limits.

b. Each cubic yard weighs 2354 lbs (Step #1) and you are hauling 2.5 cubic yards. Therefore the weight of your load will be 5,885 lbs.

2354 **ASW (FROM STEP #1)**
X 2.5 **ALS**
5,885 ***LOAD WEIGHT (LW)***

NOTE: NOW THAT YOU KNOW THAT YOU ARE NOT OVERLOADED, YOU CAN CALCULATE YOUR CYCLE TIME.

STEP #6: ***TRAVEL SPEED: To get your travel speed look at the table below.***

TABLE 24-9 TRAVEL SPEED

LOADED	**35 MPH**
EMPTY	**50 MPH**

c. To figure **Cycle Time (CT)** you first must figure Travel Time (TT). To get Travel Time divide the sum of the Travel Speed (TS) in MPH multiplied by 88. Do this for haul and return. The Total Travel Times equal **Total Cycle Time.**

NOTE: **88** is the conversion factor to change the speed in MPH to feet traveled per minute.

HAUL :

Distance in feet
____ TS X 88 = __________ **HAUL Time (HT)**

RETURN **:**

$$\frac{\textbf{Distance in feet}}{\underline{\quad}\ \textbf{TS X 88}} = \underline{\qquad\qquad}\ \textbf{RETURN Time (RT)}$$

__________ + __________ + _____________ =
HT + RT + 2 MIN FXT = CT

NOTE: USE 2 MIN. AS A CONSTANT FIXED TIME FOR DUMP TRUCKS IN THE CLASS ROOM.

Example #1: A dump truck travels 7500 feet to the fill area at 35 mph and returns by a different route of 8200 feet at 50 mph. What is the total cycle time?

HAUL :

Distance in feet

$$\frac{7500\text{ ft.}}{35\ \textbf{TS X 88}} = \underline{2.44}\ \textbf{HAUL Time (HT)}$$

RETURN **:**

Distance in feet

$$\frac{8200\text{ ft}}{50\ \textbf{TS X 88}} = \underline{1.86}\ \textbf{RETURN Time (RT)}$$

$$\frac{2.44}{\text{HT}} + \frac{1.86}{\text{RT}} + \frac{2\text{ MIN}}{2\text{ MIN FXT}} = \frac{6.30}{\text{CT}}$$

(2 min constant for dumps)

NOTE: ROUND OFF CYCLE TIME TWO PLACES AFTER THE DECIMAL POINT.

STEP #7 ***TRIPS PER HOUR:*** *To determine Trips Per Hour (TPH) divide the working minutes per hour (normally a 60-minute work hour) by the cycle time.*

$$\frac{\textbf{60 WORKING MIN. PER/HR}}{\textbf{CYCLE TIME}} = \textbf{\textit{TRIPS PER HOUR (TPH)}}$$

NOTE: NEVER ROUND OFF TPH

EXAMPLE: How many trips per hour can a dump truck make during a 60-minute work hour and a cycle time of 6.30 min/trip?

$$\frac{\textbf{60 MIN. PER/HR}}{6.30\ \textbf{CT}} = 9.52\ \textbf{TPH}$$

NOTE: NEVER ROUND TPH

STEP #8 ***HOURLY PRODUCTION RATE:*** *To determine the Hourly Production Rate, you must know the size of the load (in LCY), the Number Of trips Per Hour, and the Efficiency of the operator and equipment.*

____________ X _____________ X _________________ =
TPH X ALS X EFFICIENCY FACTOR = (LCYPH)
(FROM STEP #4)

TABLE #7-2 EFFICIENCY FACTOR

TYPE UNIT	OPERATOR	DAY	NIGHT
TRACKED	EXCELLENT AVERAGE POOR	1.00 .75 .60	0.75 .56 .45
WHEELED	EXCELLENT AVERAGE POOR	1.00 .60 .50	.67 .40 .33

EXAMPLE: What is the hourly production rate of a dump truck with an average operator, working a day shift, making 9.52 TPH, with a load of 2.5 LCY?

9.52	X	2.5	X	0.60	=	14.28 OR 14
TPH	**X**	**ALS**	**X**	**EFFICIENCY FACTOR**	**=**	**(LCYPH)**

(FROM STEP #4) *NOTE: ROUND DOWN (LCYPH)*

STEP #9 ***SOIL CONVERSION (IF NEEDED) :*** *In some cases hourly production rate may be needed in compacted cubic yards (CCY) for a road or runway.*

________	X	________	=	________
(LCYPH)	**X**	**CONVERSION FACTOR**	**=**	**(___CYPH)**

TABLE #1-1
SOIL CONVERSION FACTORS
NOTE: * IS CONSIDERED 100% VOLUME OR 1.00 CY

SOIL TYPE	INITIAL CONDITION	TO BANK	TO LOOSE	TO COMPACT
SAND	FROM BANK FROM LOOSE FROM COMPACTED	* .90 1.05	1.11 * 1.17	.95 .86 *
LOAM	FROM BANK FROM LOOSE FROM COMPACTED	* .80 1.11	1.25 * 1.39	.90 .72 *
CLAY	FROM BANK FROM LOOSE FROM COMPACTED	* .70 1.11	1.43 * 1.59	.90 .63 *
BLASTED ROCK OR GRAVEL	FROM BANK FROM LOOSE FROM COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *
HARD CORAL OR LIMESTONE	FROM BANK FROM LOOSE FROM COMPACTED	* .67 .77	1.50 * 1.15	1.30 .87 *

EXAMPLE: What is the production rate in (ccy) for a dump with an hourly production rate of 14 lcy/hr, working in loam.

14	X	.72	=	**10.08 OR 10**
LCYPH	**X**	***CONVERSION FACTOR***	**=**	**(C CYPH)**

NOTE: ROUND DOWN (__CYPH)

RATIO OF TRUCKS TO SCOOPLOADER

a. THE NUMBER OF TRUCKS TO KEEP ONE SCOOPLOADER MOVING WITH NO DOWN TIME, IS FOUND BY THE FORMULA BELOW.

STEP #1: LOADS/HR

$$\frac{\textbf{LOADER OUTPUT (LCYPH)}}{\textbf{TRUCKS (LCY/LOAD)}} = \textbf{LOADS/HR}$$

STEP #2: LOADING TIME PER TRUCK

$$\frac{\textbf{MIN. WORKED/HR}}{\textbf{LOADS/HR}} = \textbf{LOADING TIME/TRUCK}$$

STEP #3: FORMULATE

$$\frac{\textbf{TRUCK CYCLE TIME}}{\textbf{LOADING TIME/TRUCK (MIN.)}} + 1 = \textbf{TRUCKS REQUIRED TO KEEP LOADER WORKING}$$

EXAMPLE: The TRAM is putting out 150 LCYPH and you are using a 5 ton Dump Truck with a 2.5 LCY/LOAD. You are working 50 MIN/HR.
.

STEP #1

$$\frac{\text{LOADER OUTPUT (LCYPH)} \quad 150}{2.5 \quad \text{TRUCKS (LCY/LOAD)}} = 60 \quad \text{LOADS/HR}$$

STEP #2:

$$\frac{\text{MIN. WORKED/HR} \quad 50}{60 \quad \text{LOADS/HR}} = .83 \text{ LOADING TIME/TRUCK}$$

STEP #3:

$$\frac{\text{TRUCK CYCLE TIME} \quad 6.30}{.83 \quad \text{LOADING TIME/TRUCK (MIN.)}} = 7.59 + 1 = 8.59 \text{ OR 9 TRUCKS REQUIRED}$$

STEP #10 ***TOTAL HOURS REQUIRED TO COMPLETE MISSION:*** *To determine the total time required to complete the mission, you must know the total volume to be moved, the hourly production rate, and the number of trucks you will use on the job.*

EXAMPLE:

$$\frac{\textbf{1,900 (C CY)}}{\textbf{10 (C CYPH)} \times \textbf{3 DUMP TRUKS}} = \textbf{63.33 (hr) REQUIRED}$$

NOTE: *NEVER ROUND OFF TIME.*

STEP #11: *TOTAL PRODUCTION (DAYS)* To get the production days required to complete the mission, divide total time required by the hours worked per day, which will equal the total number of days required.

EXAMPLE: $\dfrac{63.33}{\textbf{(hr) REQUIRED}} \div \dfrac{8}{\textbf{hr WORK DAY}} = \dfrac{7.92 \text{ or } 8}{\textbf{DAYS}}$

NOTE: ROUND UP DAYS TO THE NEXT FULL DAY.

WHAT HAVE YOU LEARNED ?

PROBLEM #1: A project requires you to build a road using clay and gravel with an 8% moisture content. How many days are required, at 10 hours per day, to complete the project? Also, figure the total number of 5 ton dump trucks needed. The job conditions are as follows. Show and label all figures and formulas.

COMPACTED FILL REQUIRED -----------------170,000 CY

CLASS OF EARTH --------------------------CLAY

INITIAL MOISTURE CONTENT ---------------8%

AVERAGE HAUL DISTANCE ------------------6600 FT

AVERAGE RETURN DISTANCE------------------6600 FT

AVERAGE OPERATORS

TRUCKS ARE LOADED BY 1085 WITH 1 1/2 CY BUCKET

1085 CYCLE TIME IS 30 SECONDS

REFERENCE(S):

FM 5–434 EARTHMOVING OPERATIONS

UNITED STATES MARINE CORPS
MARINE CORPS ENGINEER SCHOOL
COMBAT ENGINEER INSTRUCTION COMPANY
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C-01A10
19 Jun 00
(98 POI)

STUDENT HANDOUT

MILITARY BRIEFING

LEARNING OBJECTIVES:

1. TERMINAL LEARNING OBJECTIVE:

a. Given a tactical situation, a map, an engineer situation report, a commander's intent, a concept of operations, and references, brief the commander on the engineer situation to provide a description of the current engineer situation, including a summary of current engineer activities, capabilities and limitations per the references. (1301.08.03)

2. ENABLING LEARNING OBJECTIVES:

a. Given a topic, a brief outline and references, employ techniques of effective briefing per the references. (1302.08.03a)

b. Given a tactical situation, a brief requirement and references, select the appropriate type of military brief to present per the references. (1302.08.03b)

c. Given a tactical situation, a brief requirement and references, create a military brief to present to a commander per the references. (1302.08.03c)

OUTLINE:

1. COMMUNICATION TECHNIQUES: Effective verbal communication involves the effective use of each of the following eight (8) techniques:

a. Volume. Volume is vital in holding listeners' attention. A speaker should use the volume necessary to reach an entire audience, regardless of the speaking environment. Do not, however, overpower the closest members of an audience. Various situations call for different volume levels.

b. Inflection. Inflection is directly related to volume. More commonly referred to as "pitch," inflection aids in maintaining listener attention. A lack of inflection results in a monotone speaker. Inflection is often used to express an emotional or persuasive point. This helps make a brief or lecture more meaningful.

c. Rate. The speed of delivery. Speak too fast and listeners may miss important material. Speak too slowly and you may bore them to death. Vary your rate of delivery to increase interest.

d. Force. Force is used to emphasize a particular syllable, word or point. The use of force in certain instances may alter the meaning of what you say. "It's not what you say, but how you say it."

e. Pause. Pauses are used to accomplish the following: allow the listener to absorb information provide punctuation provide the listener an opportunity to prepare for the upcoming topic. Often, instead of using pauses effectively, we tend to fill them with useless "pet words" or nervous fillers such as "umm, OK, like, and alright." A purposeful pause is perfectly acceptable, and highly effective. An awkward pause, one that is too long, used at the wrong time or nervously, can be just as detrimental as the use of pet words.

f. Grammar. The correct usage of a written language. Always use proper grammar in front of any audience. Refrain from using slang. The use of improper grammar damages a speaker's credibility and hinders effective communication.

g. Pronunciation. Speaking individual words properly, without deviation. Regional accents are acceptable if words are spoken clearly and distinctly. For example, the word CREEK can be pronounced either "creek" or "crick" depending upon where a person was raised in our country. Both refer to the same object, a small stream, and are commonly accepted. The mispronunciation of a word is never acceptable.

h. Articulation. Articulation refers to the clarity of spoken words. It is closely related to pronunciation in that each vowel and consonant is spoken clearly and completely. Words, and therefore thoughts, communicated clearly and completely are readily understood.

2. TYPES OF MILITARY BRIEFS. Military briefs are designed to present selected information to commanders, staffs and other audiences in a clear, concise and expedient manner. The types of military briefs are dictated by purpose. There are four (4) basic types: the information brief, the decision brief, the staff brief, and the mission brief.

a. Information Brief. Designed to merely provide information to an audience. An information brief deals only with facts. The desired endstate of this type of brief is listener comprehension. No conclusion or decision needs to be drawn form the brief. Examples include:

(1) Information of high priority which requires the immediate attention of proper authority.

(2) Complex information requiring detailed explanation.

(3) Format.

(4) Introduction.

(a) Greeting. Recognize senior members of audience. Follow up with "gentlemen" or "ladies and gentlemen" in recognition of others present. Finally, identify yourself.

(b) Purpose. Explain purpose and scope.

(c) Procedure. Explain conduct of brief, lecture, demonstration, display, tour, combination, etc.

(5) Body.

(a) Organization. The body should follow an organization providing the best arrangement, presentation and support of main ideas. Sequence may be chronological, such as what happened, is happening, and is expected to happen; or it may be presented as cause-and-effect, as in an after action report.

(b) Plan for effective, smoothly executed transitions.

(c) Be prepared for questions at any time.

(6) Conclusion.

(a) Summarize main ideas.

(b) Closing statement. "This concludes my brief, are there any questions." Or, if briefing a senior, "Sir, pending your questions, this concludes my brief."

(c) Introduce next speaker, if applicable.

b. Decision Brief. Designed to be presented to a commander of staff in order to elicit a decision. The outcome is usually the manner in which a unit will execute a pending mission. For example, a commander may be presented a decision brief containing three (3) Courses of Action (COAs), all of which are designed to accomplish the same mission, but in different manners. After being presented and considering the strengths and weaknesses of each COA, the commander can make an educated decision. Of course the commander retains the prerogative to modify or reject the choices and send his staff back to the drawing board. You'll hear more about that in an upcoming lesson.

(1) Format

(a) Introduction

1 Greeting. Recognize the senior members of the audience. Follow up with "gentlemen" or "ladies and gentlemen" in recognition of others. Finally, identify yourself.

2 Purpose. State the purpose is to obtain a decision.

3 Procedure. Explain any special procedures or introduce additional briefer(s).

4 Coordination. State any previous coordination.

5 Classification. Identify security classification of brief.

(b) Body.

1 Assumptions. State all that are valid, relevant and necessary.

2 Facts Bearing. Any supportable facts bearing on the problem should be stated concisely and accurately.

3 Discussion. Analyze COAs. The initial statement should indicate the origin of the problem and point out any command guidance given. Plan for smooth transitions. THIS IS THE CRITICAL PHASE OF THE DECISION BRIEF!

4 Conclusion. State conclusions reached as a result of your analysis. Rank the COAs based upon level of supportability. Do not introduce new COAs or suggest modifications at this point. Restrict to only logical conclusions derived from discussion phase.

5 Recommendations. State recommended actions. Read recommendations to insure accuracy and phrase them so the commander can mentally accept or decline. Recommendations must be specific and not solicitations of opinion.

(c) Conclusion.

1 Ask for questions.

2 Solicit decision or inquire if recommendation is approved or disapproved.

c. Staff Brief. A forum for the exchange of information within a unit, any unit – MEF, Division, Regiment, etc. This type of briefing is used to “get everyone on the same page” and can include brainstorming. It is perhaps the most widely used form of military briefing, at every level of command. The anticipated outcome is a coordinated and unified effort. Can be formal or informal in nature, the CO sets the tone. The Executive Officer usually controls the conduct and pace.

(1) Format. The presentations of each staff member vary and are largely dependent upon commander preference. The format may be elaborate with visual aids depicting the activities of each staff section, or it may be informal with extreme emphasis on brevity and the passing of only that information of concern to all.

d. Mission Brief. Designed specifically for operational conditions. The purpose can be to relay information, provide specific instructions or taskings, impress an appreciation of the mission, amplify written orders, or all. The CO, company commanders and staff participate throughout the course of the brief.

(1) Format. There is no prescribed format for the mission brief. In most cases the operation order format (SMEAC) can be used if it is not unnecessarily repetitious considering the specific situation.

3. PREPARING A BRIEF. The preparation or creation of a brief involves several steps. A briefer must have a thorough knowledge of the subject to be presented. Knowledge is gained through research. Knowledge alone, however, does not guarantee an effective brief. Planning is also vital. An application of the following steps and checklists can result in a successful presentation:

a. Analysis.

(1) Analyze your audience. Who will you brief? Does a shared level of experience or knowledge exist, or will the audience require background information to understand your presentation. Determine size and composition. Seek guidance S-3/G-3 concerning commander's preferences.

(2) Analyze your purpose. What and why are you briefing? Do you intend to inform, interpret, task, or propose? What is your desired outcome, comprehension, compliance, unification, or decision? Again, seek guidance if necessary.

b. Research Topic/Write Outline.

(1) Tailor topic(s) to meet time restraints/constraints.

(2) Collect authoritative material to support your position. Examples include statistics, surveys, and interviews.

(3) Determine main ideas to form the foundation of your brief.

(4) Sequence main ideas in logical order.

(5) Write outline. Your "rough draft." Main ideas should be in logical sequence natural transitions from idea to idea.

c. Organize Brief. Keep in mind, emphasis is not on what you say, but is what your audience must hear.

(1) Introduction – sets the stage

(2) Body – passes main ideas

(3) Conclusion – summarizes and provides an opportunity to receive intended outcome.

d. Prepare Brief Packet. An effective packet helps to guide an audience through your brief. Creating a packet is not always necessary or even feasible depending upon the situation and environment. Determine the requirement, or lack thereof, in your initial analysis. Effective packets serve as a "tour guide" and follow the following guidelines:

(1) Synchronized with presentation to prevent constant page turning.

(2) Simple, large – bulletized format.

(3) Contains only essential information. If detailed, amplifying data is needed, include it as an enclosure at the end of the packet or provide as an additional handout.

(4) Incorporates most, if not all of the following:

(a) Map of area of interest.

(b) Operational schedule, a Gantt chart or timeline.

(c) Depiction of Table of Organization (T/O) of involved units.

(d) Depiction of Table of Equipment (T/E) of involved units.

(e) General Scheme of Maneuver (SOM) or plan of attack.

(f) Any major concerns or recommendations.

4. BRIEFING CHECKLIST.

a. Analysis.

___ Purpose

___ Audience

___ Timeline/Schedule

___ Equipment/Facilities (overhead, projector, pointer, etc.)

___ Brief SOP (standard procedures for uniform, protocol, etc.)

b. Create Brief.

___ Grammar/Spelling (outline can be converted to brief packet, proofread now!)

___ Local SOP (many units have standard briefs, only the info changes from brief to brief)

___ Advance approval (may be required by your unit)

c. Briefing Notes. Think of notes as road signs. You pick up information at a glance as you whiz past. Create notes with which you can do the same.

___ Use numbered cards

___ Keep notes brief, use key words/phrases to jog the memory, don't take it on a marathon.

___ Type or print in **LARGE, BOLD, BLOCK LETTERS.**

___ Underline vital points with color.

___ Do not fold or staple.

___ Do not try to conceal. Notes tell an audience you have taken at least some time to prepare.

Occasionally you may have to read a portion of your presentation, such as quotes and complex or detailed information. If so, use the following guidelines:

___ Preview and be familiar with the material.

___ Punctuate with your voice.

___ Make occasional eye contact.

___ Read out and over material, not into it.

___ Don’t get lost; use thumb or finger to hold place on page.

d. Rehearse. The complexity of the brief combined with speaker knowledge of material and time available will determine the time devoted to rehearsals.

___ Rehearse alone to work out timing and use of any equipment.

___ Rehearse with assistants to coordinate prompts and timing.

___ Rehearse in front of live, critical audience.

___ Full dress rehearsal, with all media, aids and assistants in the venue of the actual brief, if possible. The audience should be the only missing piece.

___ Final Check. Done in the last hour. Ensure everything is prepared and functioning properly. Allow adequate time to correct problems. Pay special attention to seating arrangements and physical layout of venue.

Often the items listed above will not be feasible. The briefer must, however, at a minimum walk and talk through the main points of the brief to set to mind the basic organization of the presentation.

e. Visual Aids. Visual aids can be either highly effective or terribly distracting. The following considerations apply:

___ Clear, concise and pertinent to presentation.

___ Stay close to aid but do not hinder audience view.

___ If right handed, stand stage left, if left, stage right.

___ Turn off projectors when not in active use.

___ Turn off or cover overhead projector when changing slides.

___ Remove charts, graphs, maps, etc. from audience sight when not in active use. Lay them down or face to bulkhead.

___ Distribute additional handouts prior to or at conclusion of brief. If you must pass out material during brief, pause until audience receives it and focuses back on you before continuing.

f. Pointers. Great tool, if used properly.

___ Use a solid pointer, metal or wood.

___ Point at current item of interest.

___ Hold pointer steady.

___ Emphasize key words or point horizontally.

___ Put down when not in active use.

___ Let assistant point

5. BRIEF DELIVERY. Preparation is complete, now what?

a. A military brief is a highly specialized type of speech. It is characterized, more than any other type of speech, by conciseness, objectivity and accuracy. A successful brief depends, not only on organized content, but also on how the briefer presents it. A confident, precise and forceful delivery, based on in-depth subject knowledge, and the following will succeed:

(1) Present the subject as directed and ensure it is understood.

(2) Conclusions and recommendations must be logical.

(3) Need for brevity precludes a lengthy introduction and/or summary.

b. Interruptions. Interruptions and/or questions can occur at any point throughout the course of a brief.

(1) Do not become distracted.

(2) Answer questions before proceeding, or…

(3) Indicate that the question will be answered at a later point in the brief, but refer back to the question when reaching that point.

(4) Prepare to provide further support for any part of the brief.

c. Bad Mannerisms. Avoid the following:

(1) Generalities and “scoop words” (et cetera, and so on, I believe). They suggest shallow thinking or a lack of confidence. Specifics command respect and present firm belief in the presented material.

(2) Sarcasm, belligerence or hostility used in the defense of a point or when responding to naïve or unfriendly questions begets a negative reaction and damages rapport. Courtesy also commands respect.

(3) Do not slouch. You’ll appear either unconfident or slovenly.

(4) Lack of eye contact. Look audience members straight in the eye. This is especially effective in emphasizing a key point.

(5) Do not remain motionless for an inordinate period of time, it suggests nervousness.

(6) Pacing. Excessive pacing suggests nervousness also.

(7) Use neither acronyms, abbreviations nor special jargon before determining the audience understands and can decipher them without effort.

(8) Nervous “fiddling”. Key jangling, pen clicking, ear pulling, nose and body scratching, rocking, weaving, wandering, playing with the

pointer, and/or putting hands in and out of pockets are all indicators of nervousness and a lack of preparation and confidence.

d. Characteristics of an Effective Briefer:

(1) Has an orderly mind

(2) Evaluates the purpose of the brief

(3) Is prepared

(4) Varies rate and inflection

(5) Recognizes and responds to audience feedback

(6) Is **BRIEF**

REFERENCES:

1. MCRP 3-17, MAGTF ENGINEER OPERATIONS

2. MCWP 3-17B, ENGINEER FORMS AND REPORTS

3. MCWP 5-1, MARINE CORPS PLANNING PROCESS

4. RT 1300-05, PROFESSIONAL COMMUNICATIONS

UNITED STATES MARINE CORPS
COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA 28542

C-01A11
19 Jun 00
(98 POI)

STUDENT HANDOUT

ENGINEER PLANNING

LEARNING OBJECTIVES:

a. TERMINAL LEARNING OBJECTIVES

(1) Given a tactical situation, a map, commander’s intent, courses of action, an engineer task organization, and references, conduct engineer planning to utilize engineer personnel and equipment in support of mission requirements, per the references. (1302.08.01)

(2) Given a tactical situation, a map, commander’s intent, a concept of operations, and references, prepare the engineer portions of the operations order consistent with the concept of operations and commander’s intent, per the references. (1302.08.02)

(3) Given a tactical situation, a map, an engineer situation report, commander’s intent, a concept of operations, and references, brief the commander on the engineer situation to provide a description of the current engineer situation, including a summary of status of current engineer activities, capabilities and limitations, per the references. (1302.08.03)

b. ENABLING LEARNING OBJECTIVES:

(1) Given a tactical situation, a map, commander’s guidance, courses of action, an engineer task organization, and references, prepare an engineer estimate to support each course of action per the commander’s guidance and the references. (1302.08.01a)

(2) Given a tactical situation, a map, commander’s guidance, courses of action, an engineer task organization, and references, determine mission support requirements per the commander’s guidance and the references. (1302.08.01b)

(3) Given a tactical situation, a map, commander’s intent, a concept of operations, an engineer estimate, and references, prepare an engineer Appendix to Annex C of an operations order to support the commander’s intent per the references. (1302.08.02a)

BODY:

1. COMMAND AND STAFF PLANNING -VS- RAPID STAFF PLANNING

a. Rapid Staff Planning.

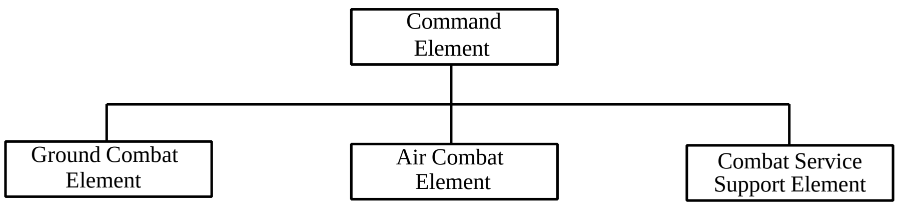
(1) Goal: Commence execution within six hours of receipt of Warning Order.

(2) Prior to receipt of the mission:

(a) Significant pre-deployment work-ups and training (e.g., SOC Training, MAPEX's, STEX's, TEWT's).

(b) Utilizes Standard Operating Procedures (SOP's).

(c) Battle Staff Identified.

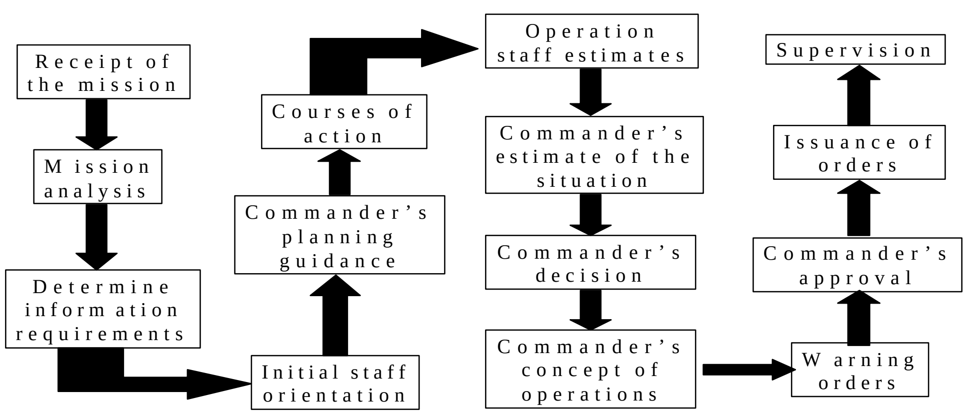


(3) Anticipates probable missions.

(4) Utilizes the half-time rule.

(5) 14 step planning process.

b. Command and Staff Planning.



(1) Time of execution specified by the situation. Falls outside the 6- hour window.

(2) Often focuses on developing mission specific procedures when time permits.

(3) Planning action dependent on receipt of the mission.

(4) Focuses of the preparation of detailed staff estimates followed by the development of detailed plans.

(5) 15-step planning process.

2. RECEIPT OF THE MISSION **(Step 1)**:

a. Initiates the planning sequence.

b. Notification comes from three sources:

(1) Directive from higher authority.

(2) Commander's initiative based on his own estimate of the situation.

(3) Implied tasks deduced from another assigned or anticipated mission.

c. Commanders confer immediately and assemble their staff and special staff sections.

3. MISSION ANALYSIS **(Step 2)**:

a. Mission analysis is conducted to develop all tasks required to accomplish the mission. Standby orders are issued to subordinate commanders in order for them to prepare men and equipment, and to cross deck key leaders. From these orders, subordinate commanders can begin to draw out their own taskings.

b. Constraints are developed in the mission analysis phase. These constraints include Rules of Engagement, limits on use of assets, and diplomatic or political matters.

c. Mission Statement.

(1) Two parts of a mission statement are the purpose statement and the tasking statement.

(a) Purpose statement is the most important aspect of the mission. This statement defines the higher commander's intent. Key words; "In order to" preface the purpose statement.

(b) Implied Tasks -vs- Specified Tasks.

1 When engineers provide support to the MAGTF, their mission statements will be derived from specified and implied taskings received from the higher headquarters or supported unit.

(c) Specified Tasks are specifically stated in the higher headquarters order or plan. Sources include:

1 Mission statement.

a Specific taskings taken from the mission statement. Specific taskings are those tasks that are outlined in the wording of the mission.

In the following example mission statement:

The attack and capture of the ATF objective is the specified task.

2 Paragraph 3 (Tasking Statements).

3 Coordinating Instructions.

(d) Implied Tasks are those tasks NOT specifically stated in the order or plan which might be required in the course of the operation. They are deduced from the following sources:

1 Mission Statements (Not only from one's own mission but from Higher, Adjacent, Supporting missions).

2 Commander's Intent.

3 Paragraph 3 (Tasking Statements).

4 Coordinating Instructions.

Examples of engineer implied taskings include;

(1) Offensive operations which will imply mobility enhancement and/or breaching operations.

(2) Defensive operations which will call for survivability taskings and countermobility operations. If a unit is tasked with the formation of a blocking position, the same tasks of survivability and countermobility apply.

(e) Initial Analysis of METT-TSL.

1 The engineer or special staff officer always conducts his analysis from the engineer perspective to cover mobility, countermobility, survivability, general engineering and engineer reconnaissance.

2 Analysis includes three actions:

a List the facts.

b Determine which facts are significant and why.

c Draw a conclusion that requires action.

4. DETERMINE INFORMATION REQUIREMENTS **(Step 3)**:

a. From existing intelligence information, gaps in knowledge must be ascertained and the loops closed. Requests for information must be clear and to the point, regarding such details as terrain, weather and enemy forces, equipment, disposition, capabilities and intent. Information that is not available must be quickly collected and processed in order for integration into the upcoming estimation process.

b. An example of this for the engineer is the fact that a 100 meter minefield's existence is not enough information. In order to plan properly, and complete an accurate estimate, the engineer must have more details such as width, depth, breadth, density, mix of mines, mine type, etc.

c. Request for Information (RFI) and Assumptions.

(1) Attempts to fill gaps from initial analysis of METT-TSL.

(2) Updated continuously.

(3) Identified to the S-2 (Intelligence Officer) for action.

(4) Collects information that is critical to mission accomplishment.

(5) Provides information which enhances mission accomplishment but which is not the basis for mission accomplishment.

(6) RFI's that cannot be answered become assumptions.

5. INITIAL STAFF ORIENTATION **(Step 4)**:

a. This conference is held to provide key staff members an overview of the situation.

b. G-2/S-2 Conducts Intelligence brief.

c. G-3/S-3 Conducts Mission brief.

d. Commander is present to issue his planning guidance for the staff.

6. COMMANDER'S PLANNING GUIDANCE **(Step 5)**:

a. Once the staff briefs are complete, the commander will present his planning guidance relative to the issues of the operation. This will allow the staff to plan within the framework of the commander's intent, and aids them in forming courses of action that are acceptable to the commander.

b. Also within the commander's guidance are reiterations on restrictions on the conduct of the operation. This ranges from ROE to employment of NBC. Subordinate commanders and staff must ask for guidance if none is given. Nothing should be left in doubt.

c. Purpose: To direct the efforts of the staff along a common line of inquiry in search of the best available course of action. Guidance is also given to preclude duplicate staff efforts.

d. Key elements of commander's guidance:

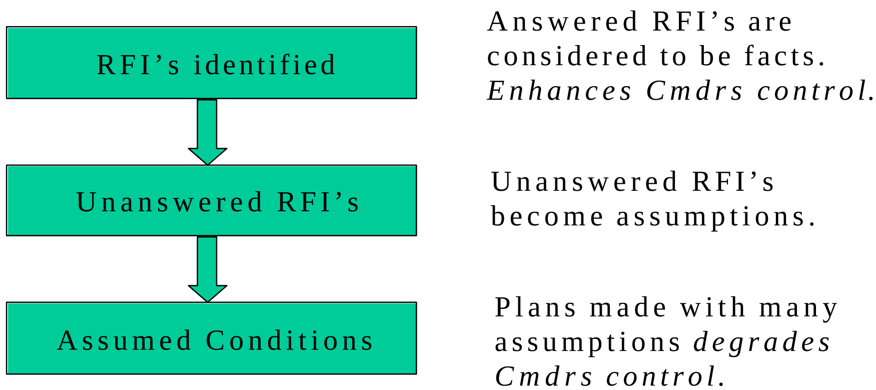
(1) Clarification of commander's intent one and two levels above.

(2) State the commander's own intent.

(3) State the time and place the order will be issued.

(4) Other elements of commanders guidance.

(a) Use of NBC
(b) guidance on time
(c) guidance on C/A
(d) level of acceptable risk
(e) command and control
(f) pertinent assumptions
(g) use of reserves
(h) enemy capabilities
(i) CSS considerations
(j) fire support coordination
(k) phasing operations
(l) tactical determinations
(m) security
(n) operational restrictions



7. <u>DEVELOP COURSES OF ACTION **(Step 6)**</u>:

a. The commander will designate the G-3/S-3 officer to develop courses of action for accomplishment of the mission. These separate, distinct courses of action offer the commander and staff alternatives and different perspectives on the means to accomplish the tasks at hand.

b. The courses of action are developed according to the mission, capabilities of the unit, given restrictions and the commander's planning guidance. By the same token, there should be no bias or predisposition for one specific course or method.

c. Criteria for Course of Action.

(1) Must be feasible.

(2) Must accomplish the mission.

(3) Must comply with the commander's guidance.

(4) Must be significantly different from other's under consideration.

d. Techniques used in developing a course of action.

(1) Broad in scope, yet detailed enough to distinguish it from others.

(2) Designate size of units involved, but do not designate specific units.

(3) Limited to three to five separate COAs.

(4) Eliminate inferior courses immediately.

(5) Each COA displayed graphically (i.e. map overlays, sand-table, IPB, etc.). At a minimum each portrayal should include:

(a) The Objectives.

(b) Line of Departure.

(c) Arrows depicting which avenues of approach the main attack and supporting attack will use.

(d) The type and size of unit using each avenue of approach, and what order the units will move in.

e. Develop a Concept of Operations which includes:

(1) Overview Statement.

(2) Main Attack.

(3) Supporting Attack.

(4) Reserves.

(5) Priority of Fires or Priority of Effort.

8. STAFF ESTIMATES **(Step 7)**:

a. Each staff section and special staff officer prepares supporting papers and briefs the commander on their estimate of supportability from their perspective (e.g. Engineer Estimate of Supportability). The estimate needs to be detailed in the preparation, yet brief in the presentation. The staff officer should be definitive in the ability to support each course of action, the strong and weak points of each course, and above all, make a confident recommendation on which course is most supportable or preferred, from his respective expertise.

b. For the engineer estimate of supportablility, the engineer should focus on the impact of tactical mobility, countermobility, survivability and sustainment engineering that will be required with each proposed course of action. Obviously the focus of the estimate will vary according to the type of engineer unit, yet these four operational areas are a common thread to all engineer operations, regardless of wing, group or division ties.

c. Preparation of the estimate will use all the planning acronyms familiar to the military, yet METT-TSL will be the main driver of the estimation planning. Each course of action must be balanced against METT-TSL, the commander's intent, and the other courses of action.

d. Format for the final paper product of the estimate of supportability can be found in FMFM 13 and FM 5-100.

(1) FORMAT:

(a) Heading.

____
(Classification)

Copy no. __ of __ copies

Issuing Headquarters
Place of Issue
Date/Time Group

Engineer Estimate to Operation (XXXXXXX) 1-94

Ref: (a) Map: M501 PENNSYLVANIA: Sheets 5563 I SW, 5563 I SE, 1:50,000
(b) Standard Operating Procedures for Engineer Operations, 1st CEB, Camp Pendleton, California 92654-5041

Time Zone: R (Commencing 30 May, 1994)

<u>1</u> *Classification. Documents must show CLASSIFICATION on the top and bottom of each page/overlay and centered on the document.*

<u>2</u> *Copy Number. Copy numbers are assigned by the issuing headquarters to each copy of a classified document. A record is kept of each specific copy issued to each addressee, which enables security control. The blank lines should be visible and the copy numbers written in ink. This allows for identification of originals vice copies.*

<u>3</u> *Issuing Headquarters. The official designation of the issuing headquarters will be used.*

<u>4</u> *Place of issue. The place of issue appears in the heading of a combat document and is designated by its geographical location, including map coordinates when necessary. The place of issue is written in all capital letters.*

<u>5</u> *Date/Time Group. The DTG depicts the day, hour, month, and year that the document was signed, issued, or becomes effective.*

<u>6</u> *Title. States the title of the document.*

<u>7</u> *References. List all maps, charts, photographs, higher adjacent plans or orders, SOP's, etc. Each reference listed is preceded by a lower case letter in parentheses. If there are no references, the caption is followed by the word "None."*

<u>8</u> *Time Zone. If the time zone is the same for the place of issue and execution and will be the same throughout the execution to the order, the entry may be omitted. This omission is discouraged, however, because air and amphibious operations often involve two or more time zones.*

(b) Body.

1. <u>MISSION</u>

a. Basic Mission. The engineer officer filling a staff position with a maneuver headquarters uses the mission statement of that headquarters in his estimate. The commander of an engineer unit supporting the maneuver headquarters performs a separate mission analysis for his unit. Therefore, a **staff engineer** will not perform the mission analysis steps listed under this paragraph of the estimate, but will incorporate his input into the overall staff analysis. An engineer unit commander will perform this analysis for his unit.

b. Identify the following:

(1) Intent of the supported commander and the commander two levels up.

(2) Discuss the Area of Operations.

(3) Tasks to be performed: Specified, Implied, Essential.

(4) Constraints. Things the supported or higher headquarters have said must be done (*accomplish NLT _________, directed obstacles, total time available*).

(5) Restrictions. Things that the supported or higher headquarters has prohibited (*obstacle restricted areas*).

c. Purpose of the estimate.

2. <u>SITUATION AND CONSIDERATIONS</u>

a. Considerations affecting the possible courses of action.

(1) Operations to be supported. Cover the nature of the operations, the composition of supported forces, unusual requirements, and other factors affecting the size and scope of the support mission.

(2) Characteristics of the area of operation. Discuss the impact of the characteristics of the area of operation on the engineer's options and ability to support the operation.

(a) Weather. Forecast weather for mission duration, ambient light data, and impact of weather on mobility/ countermobility/ survivability/ sustainment engineering in the area of operation.

<u>1</u> Precipitation/temperature impact on trafficability (*potential engineer missions to improve/maintain roads and trails*).

<u>2</u> Precipitation impact on river crossing (*depth, flow rate, bank conditions, tidal influences, and ambient light availability*).

<u>3</u> Precipitation/temperature impact on ability to dig (*saturated/frozen ground*).

<u>4</u> Fog/limited visibility impact on positioning of obstacles.

<u>5</u> Engineer vehicle capabilities to maneuver in limited visibility vs. maneuver unit fighting vehicle capabilities.

(b) Terrain.

1 Observation/fields of fire. Identify potential engineer requirements to clear fields of observation/fields of fire, special skills, equipment, and coordination necessary to clear vegetation, rubble buildings, eliminate power lines.

2 Cover and concealment. Consider the extent and value of existing cover and concealment such as vegetation, relief of terrain and man-made potential reinforcing obstacle locations; assess impact on requirements for survivability enhancement. Consider the protection and concealment of engineer supply points and/or equipment parts in river crossing operations.

3 Obstacles. Identify locations and significance of existing obstacles and potential reinforcing obstacle locations; assess impact on countermobility and/or mobility requirements for the operation.

4 Key terrain. Identify key/decisive terrain in area of operation *(dominant terrain, key bridges, ford sites, passes through constricted terrain)*; determine potential engineer tasks required to facilitate friendly control and/or deny enemy control of this terrain.

5 Avenues of approach. Friendly: determine engineer requirements to support rapid movement of combat, combat support and combat service support elements along avenues of approach *(reduction of existing obstacles, improving trafficability)*. Enemy: identify location/engineer tasks to degrade enemy use of avenues of approach.

(c) Other characteristics. If pertinent, hydrography of rivers/lakes/streams, transportation, telecommunications, politics, material, and personnel in area of operations that affects engineer operations.

(3) Own situation. Developed in conjunction with G-2/S-2 analysis.

(a) Strength, disposition, capabilities, recent and present significant activities, and likely courses of action.

(b) Enemy capabilities affecting the mission and engineer activities. Specifically assess the availability/capabilities of enemy countermine/counterobstacle, gap crossing, and countermobility equipment and his tactics/techniques for employing it. When applicable, develop an overlay of anticipated enemy obstacles, fortifications, and other significant engineer activities.

(4) Own situation.

(a) Tactical situation. Examine the present dispositions of major tactical elements, possible courses of action of the supported headquarters, current operations, and projected operations.

(b) Personnel, logistics, and civil military operations. Determine the present disposition of logistic units supporting engineer operations. Locate facilities *(ASP, POL point, etc)*. Determine the levels of engineer related Class IV and V items available to support the operation. Identify available indigenous support and required coordination. Assess the availability of transportation assets to support the engineer operations.

(c) Engineer situation. Determine the present dispositions, levels of effectiveness, capabilities, and command/support relationships of engineer units. Identify combat support units that can assist with M/CM/S operations. Examine the status of current engineer operations and establish estimated completion times. List important assumptions.

b. Own courses of action. Develop an engineer plan as part of each course of action being considered by the supported headquarters. The plan should attempt to create an enemy vulnerability or take advantage of an existing one.

(1) Identify requirements. Determine all tasks required for each engineer plan. Consider support needed by the maneuver forces, fire support, C4I, CSS elements, and that necessary due to environmental factors (support dictated by terrain, weather, NBC contamination), regardless of the maneuver scheme.

(2) Summarize resource requirements. Summarize in terms of manpower, equipment, and logistics by major supported element.

(3) Determine general priorities for tasks. Based on the commander's guidance.

(4) Allocate engineer forces.

3. ANALYSIS OF COURSES OF ACTION

a. Wargame the engineer plan for each course of action against each anticipated enemy action/reaction. Begin with the most probable one. As a minimum, evaluate the plan against the significant factors that impact upon it.

b. Shortfalls. Compare resource requirements with the assets available. Determine shortfalls.

c. Reduce the demand for engineer assets to match those available, based upon time, identified shortfalls, and the enemy threat. Do this by establishing priorities, sequencing engineer activities, selecting alternate methods, and altering the engineer plan as necessary. Identify advantages and disadvantages. Engineer support to critical maneuver events must be forthcoming. If the engineer plan cannot meet the minimum maneuver requirements, then it is not feasible and the plan under consideration ceases to be valid.

4. COMPARISON/EVALUATION OF COURSES OF ACTION

The engineer on a maneuver HQ staff selects the best course of action from an engineer perspective. That recommendation is then provided to the maneuver G-3/S-3 for incorporation into his decision process for the maneuver commander. The engineer recommendation is usually summarized as one factor among others for the commander to consider.

The supporting engineer commander or his staff chooses the course of action that will best accomplish the engineer unit's mission.

The decision may be quantified by using a comparison/decision matrix, which is developed in the same manner by either the engineer staff officer or commander. The significant factors, upon which the decision will be based, are selected and listed. The ability of each course of action to meet the requirements of each significant factor is assessed. A subjective judgment then determines the best course of action.

5. RECOMMENDATIONS/DECISION

The recommendation begins with a statement as to the supportability of the maneuver course of action under consideration. State which course of action can best be supported from their engineer perspective.

Cover major deficiencies from the engineer perspective. Include recommendations for eliminating or improving inferior courses of action.

Recommend task organizations, command/support relationships, obstacles/tasks to be directed to subordinate elements, and establish priorities to the engineer efforts.

N. G. NEER
Colonel, U.S. Marine Corps
Force Engineer Officer

ANNEXES: (As Required)

(Page Number)

CLASSIFICATION

ENGINEER PLANNING EXERCISE

S-2 BRIEF

1. WEATHER

Time on deck is now ______ hours.

Weather for the last 24 hours has been: _________________________________.

Weather forecast for the next 48 hours is expected to be:

High Temp	__________
Low Temp	__________
Wind	__________
Moonrise	__________
Moonset	__________
% Illumination	__________
Sunrise	__________
Sunset	__________

BMCT __________

EECT __________

2. GENERAL SITUATION

"We are operating off the coast of the country of Insomnia. Insomnia is a democratic nation in a desperate state of unrest. Three company size elements of the Insomnia Socialist Republic (ISR) have overthrown the democratic government of Insomnia. They now control the two major port cities in the country, Jacksonville and Swansboro. The ISR have taken up defensive positions in Jacksonville and Swansboro and also control the New River International Airport and are allowing no one to leave or enter the country. Their mission has been to close off the Main Supply Route's (MSR) leading from the port of Onslow Beach and from the port of Swansboro. By doing this they have created political unrest in the capital city of Jacksonville and now control the country's economic livelihood. The 22nd MEU (SOC) was directed to the country as a part of Task Force Klondike when the ISR surrounded the American Embassy located in downtown Jacksonville. The ISR are threatening 165 Americans which have taken up refuge there."

3. ENEMY INFORMATION

Size: Bn size unit. Companies are separated and operating independently from one another.

Activity: Defending in position. Threatening to take some or all of the 165 Americans as hostages at the Embassy in Jacksonville if American forces intervene in their operations.

Location: One company at GC 0541 blocking Hwy 24 to Jacksonville.
One company at GC 7747 surrounding the American Embassy.
One company at GC 7544 controlling the International Airport.

Unit: 654th Bn of the elite Insomnia Socialist Republican Army.

Time: Latest intel reports received 3 hours ago.

Equipment: Small arms rifles (M-16 and AK-47's).
Significant light machine gun capabilities.
Limited heavy machine gun capabilities.
Section of 60mm mortars with company at GC 7747.
Large quantities of explosives.
Limited anti-personnel and anti-tank mines.

Key Terrain: Terrain is characterized by thick vegetation, woodlands and swamps.

Obstacles: Complex obstacle along Red Beach One from GC 9026 to GC 9228.
Complex obstacle at GC 864415.
Blown bridge at GC 839402.

Capabilities: The enemy has the capability to launch a limited attack, however it is believed they will defend their positions and attempt to gain hostages from the American Embassy. Also believed they will attempt to reinforce with forces from Swansboro to strengthen their hold in

Jacksonville and at the airport. Once reinforcements arrive from Swansboro, the ISR will attempt to blow the bridge located at GC 845462 to isolate the city of Jacksonville. The enemy has no armored vehicles and forces move mostly in light trucks and cars.

4. KEY OBJECTIVES AND AREAS

ATF OBJ A:	GC 7643 (New River International Airport).
ATF OBJ B:	GC 779476 (American Embassy, Jacksonville).
ATF OBJ C:	GC 845462 (Bridge).
BLT OBJ 1:	GC 894343 (Intersection of 5 mile road and Onslow Beach Dr).
BLT OBJ 2:	GC 865401 (Intersection of Holcomb Blvd and Onslow BeachDr).
BLT OBJ 3:	GC 907306 (Intersection of Hwy 172 and Onslow Beach Dr).
Red Beach One:	Onslow Beach.
Intersection	GC 907306 (Intersection of Hwy 172 and Onslow Beach Dr).
Intersection	GC 855452 (Intersection of Holcomb Blvd and Hwy 24).
Intersection	GC 865401 (Intersection of Holcomb Blvd and Onslow BeachDr).
Bridge	GC 916279.
Bridge	GC 864415.
Bridge	GC 845462.
Blown Bridge	GC 839402.
Complex Obstacle:	GC 864415.
Complex Obstacle:	Along Red Beach One from GC 9026 to GC 9228.
High Speed Avenue	Onslow Beach Road to Holcomb Blvd.
High Speed Avenue	Hwy 24 from Swansboro to Jacksonville.
High Speed Avenue	Hwy 172 from Swansboro to Onslow Beach Road.

S-3 BRIEF

1. HIGHER MISSION. On order, Task Force Klondike will attack in zone and seize and secure Amphibious Task Force Objectives Alpha, Bravo and Charlie in order to conduct a Non-Combatant Evacuation Operation of 165 American personnel located in the American Embassy in Insomnia.

2. MISSION. On order, 22nd MEU(SOC) will seize and secure ATF OBJ C in order to prevent the enemy from reinforcing from Swansboro and/or blowing the bridge located on the objective. You are also responsible for opening the MSR from the Port of Onslow Beach to the city of Jacksonville in order to allow follow on forces and critical supplies to reach the capital city.

3. COURSES OF ACTION (C/A)

COA #1:"At H-hour, 22nd MEU (SOC) will conduct an amphibious assault onto Red Beach One with two companies forward and one company in reserve. The main attack will be the company with Light Armored Vehicles (LAV's) and Amphibious Assault Vehicles (AAV's) who will use the high speed avenue of approach to move quickly up the MSR and seize ATF OBJ C. Simultaneously, one company (REIN) will conduct a supporting attack by seizing and holding BLT OBJ 2 and controlling the intersection. They will tie in with the main attacking force and help reinforce the key intersection at GC 855452. One company (REIN) will act as the Bn Reserve and will follow in trace of the main attack and hold BLT OBJ's 1 and 3. They must control the key intersection at GC 907306 and prevent the enemy from counter-attacking from Swansboro along Hwy 172. Priority of fires will go to the main attack."

COA #2:"At H-hour, 22nd MEU (SOC) will conduct a helo-borne assault with two companies forward and one in reserve. The main attack consisting of one company will fly in CH-53's with LAV's externally lifted into LZ Bluebird and seize and hold ATF OBJ C. Simultaneously, one company (REIN) will conduct a supporting attack by flying into LZ Penguin and seize BLT OBJ 2 while controlling the key intersection at GC 865401. They will tie in with the main attacking force and help reinforce the key intersection at GC 855452. One company (REIN) will fly into LZ Goose and seize and hold BLT OBJ's 1 and 3, opening the beach for follow on forces and will be the reserve. You must ensure to control the key intersection at GC 907306 and prevent the enemy from counter-attacking from Swansboro along Hwy 172. Priority of fires will go to the main attack."

COA #3:"At H-hour, 22nd MEU(SOC) will conduct a two pronged, deliberate attack with one company forward and two companies back. The main attack will consist of one company (REIN) which will fly in CH-53's with LAV's externally lifted into LZ Bluebird and seize and hold ATF OBJ C. Simultaneously, two companies will conduct a supporting attack across Red Beach One by conducting an amphibious assault and secure BLT OBJ's 1 and 3. From the supporting attack one company (REIN) will continue the attack north, clearing the MSR and seizing and holding BLT OBJ 2. They will control the key intersection located at GC 865401 and tie in with the main attack in order to reinforce the key intersection at 855452. The other company will remain and hold BLT OBJ's 1 and 3 allowing follow on forces and supplies to move up the MSR. They will become the Bn Reserve once Red Beach One is secured. they must ensure to control the key intersection at GC 907306 to prevent the enemy from counter attacking from Swansboro along Hwy 172. Priority of fires will go to the main attack."

S-4 BRIEF

"The companies are presently maintaining a prescribed load of three Days of Supply (DOS) of Class III (Fuel and POL) and Class V (Ammunition) materials. We will maintain resupply at the Company level until we reach ATF OBJ C. However, the opening of the MSR leading from the Port of Onslow Beach to the capital city of Jacksonville is essential for the resupply of adjacent forces. All resupply requests with a priority of "immediate" or higher will be conducted by helo until the MSR is cleared and secured for follow on traffic. Medevacs should pose no major problems and all casualties will be evacuated to the nearest Battalion Aid Station (BAS). All seriously injured will be evacuated from the aid stations to the hospital ship USHS MERCY off the coast of Insomnia. As of now, we believe we have sufficient organic and attached motor transport assets to handle our daily needs."

BATTALION COMMANDER GUIDANCE

"Before I begin issuing my guidance, I want to make sure that everyone understands where our Battalion fits into the big picture, so I quickly want to review the missions of the MEU and the Task Force. The Task Force's mission is twofold; first, to safely evacuate all Americans from the American Embassy and secondly, regain control of the country of Insomnia from the ISR rebels. The Task Force's mission is to spearhead this attack by seizing ATF OBJ's A, B and C in order to conduct a NEO of 165 American personnel located in the American Embassy in Insomnia. Our mission is to seize and hold ATF OBJ C in order to prevent the enemy from reinforcing from Swansboro and/or blowing the bridge. We are also responsible for opening the MSR from the Port of Onslow Beach to the city of Jacksonville in order to allow follow on forces and critical supplies to reach the capital city. We are the Task Force's right flank. My intent and concerns are:

FIRST, SPEED IS PARAMOUNT! We must gain control of the bridge before the enemy can reinforce the capital or isolate the capital by blowing the bridge.

SECOND, Opening the MSR is critical to the resupply of the regiment. Engineer Officer...in each COA take a close look at your ability to conduct breaching operations along the MSR.

LAST, I'm not only concerned with protecting the Task Force's right flank, but our own as well. As we transition to a mobile defense, I want to ensure that we have a significant engineer effort to develop a barrier plan which enhances our right flank as well as the Task Force's. Engineer Officer...the high-speed avenues to our right are of major concern to me. I don't want some suicide ISR rebels trying to take as many of our Marines with them as they die martyr's for their cause."

"Are there any further questions?"

"XO, coordinate the rest of our time table. I want my staff and all my special staff officers/chiefs to prepare estimates of supportability. The staff will have their estimates completed to turn in to me and will brief me at _________ hours on ____________. Ladies and Gentlemen, if you need further guidance on the operation, work with the S-3 or come by and see me. Let's get a move on this one."

9. COMMANDER'S ESTIMATE OF THE SITUATION **(Step 8)**:

a. As a result of the careful consideration of all factors, the commander develops his own estimate of the situation. The net result of this step is his selection of the best course of action and the stating of his concept of the operation.

b. The factors that the commander uses to arrive at his own estimate is a combination of all factors regarding the situation and all the estimates and recommendations prepared by his staff, special staff and subordinate commanders.

c. Commander's Responsibilities:

(1) Selecting the best C/A.

(2) Formulating and announcing his decision.

(3) Stating his concept of the operation.

d. Two formats for the Commander's Estimate:

(1) Informal. The informal estimate is the mental process that begins with the receipt of the mission and continues throughout the planning sequence. After which, the commander will verbally give his estimate of the situation.

(2) Formal. The formal estimate is the process by which the commander recalls all the information that has been presented to him, and

uses it as the basis for his decision. After which, the commander's formal estimate is usually done in writing.

10. COMMANDER'S DECISION **(Step 9)**:

a. The commander's estimate of the situation always concludes with a decision. In his decision statement, the commander does one of the following:

(1) Selects one course of action.

(2) Modifies one course of action.

(3) Directs the staff in a new direction.

11. COMMANDER'S CONCEPT OF OPERATIONS **(Step 10)**:

In conjunction with his decision, the commander publishes his concept of operation. This is a more detailed amplification of the commander's decision. The how and why questions of the operation are answered, to include the scheme of maneuver, fire support, and if required, the landing plan. The concept of operations now becomes the basis for the completion of planning by the staff and subordinate commanders.

NOTE: The selected course of action now becomes a concept of operations as specified units are listed into the concept of operations.

a. Contents of the Concept of Operations:

(1) Overview Statement.

(2) Main Effort.

(3) Supporting Effort.

(4) Reserve.

(5) Priority of Effort.

12. ISSUE WARNING ORDER **(Step 11)**:

a. Once a firm decision has been reached, warning orders are issued to all subordinate commanders in order for them to have the maximum time available for preparations. The warning order should have as much information as is available, and should be followed by the more detailed operation order.

13. PREPARATION OF DETAILED PLANS **(Step 12)**:

a. Details of the execution of the operation are planned and coordinated by the staff and subordinate commanders. The detailed plans are all-encompassing, and range from fire support to logistics, serial assignment and sub-unit taskings. During this time, the commander is continuously involved and accessible to his staff. While not interfering with the activity of the staff, the commander's presence ensures that the focus is maintained on his intent, and that all questions are answered.

b. The result of the preparation of detailed plans is the operation order. The format follows the familiar five paragraph SMEAC, and is, on the surface a rather simple document. Yet the operation order is made up of supporting papers which amplify the order and make the order a "working document".

c. LOI's, Plans, and Orders.

(1) LOI's are used to convey broad aims and strategic plans or general policy guidance of an operational nature. LOI's are not suited for promulgation like an operation plan or order.

(2) Operation plans are used when planning takes place well in advance of the execution phase. Operation plans are not directive in nature, however they become a directive when an obligation to execute is made. It is at this time when an operation plan becomes an operation order. Operation plans:

(a) Follow the SMEAC format.

(b) Time of execution is not determined.

(c) Contain subparagraphs 1a GENERAL and 1e ASSUMPTIONS.

(3) Operation orders are defined as directives, usually formal, issued by a commander to his subordinate leaders in order to coordinate execution of an operation. Orders:

(a) Follow the SMEAC format.

(b) Carry an obligation of immediate execution or execution at a specified time or date.

(c) Subparagraphs 1a GENERAL and 1e ASSUMPTIONS are omitted.

d. Fundamentals.

(1) Timeliness. A primary requirement for plans and orders is timeliness. An order fails to accomplish its purpose if it does not reach the subordinate units in time for them to conduct their planning too. Subordinate commanders require sufficient time to analyze the contents of a plan or order to plan for proper employment of their units. REMEMBER THE "HALF RULE" WHEN PLANNING AN OPERATION. A leader will always dedicate at least half of his total planning time to the subordinate leader. For example: A company commander who receives a mission, has 6 hours to plan and coordinate his attack before his unit must cross the line of departure. The company commander will therefore, issue his order to his platoon commanders at least 3 hours prior to crossing the LOD. Likewise, each platoon commander will issue their orders to their squad leaders at least 1.5 hours prior to crossing the LOD, and so on.

(2) Simplicity and Brevity. Use of common words and short, direct sentences promotes ease of understanding. Brevity is achieved by the amount of material presented in the plan and order. Subordinates are provided with all they need to know, but no more.

(3) Completeness. Every plan and order is as complete as the information at the time of preparation and the capability that the

transmission means allows. All of the essential elements of the commander's decision and the information necessary to permit sound decisions at lower echelons are included.

(4) Flexibility. All plans and orders are based on known facts and/or assumptions. Obviously, these facts/assumptions are subject to change on a fluid battlefield. Plans and orders must be flexible enough that such changes do not completely jeopardize their success. Plans and orders that have more than one opportunity for success are preferred.

e. Written format

(1) Heading.

(2) Body. Follows the SMEAC format.

(3) Ending.

(a) Acknowledgment. The acknowledgment intructions are included in every order and separately issued portions (ANNEXES, Appendices, Tabs, and Enclosures). Positive instructions ensure that addressees have received and understand the order.

(b) Signature. All documents are signed by the originator. Plans and orders are normally signed by the commander when he approves them, although they may be signed by the Chief of Staff or Executive Officer for the Commander when the latter will expedite reproduction and issuance.

1 Original signed by Commander.

John H. Smith
Colonel, U.S. Marine Corps
Commanding

2 Original signed by Executive Officer.

BY COMMAND OF COLONEL SMITH
R.U. READY
Lieutenant Colonel, U.S. Marine Corps
Executive Officer

3 KEY UNDERSTANDING! The Staff Officers/SNCO's who write the supporting papers to the Order/Plan must remember who they are writing for and from what perspective their supporting papers must come.

a Written for the supported commander.

b Written from the supported commander's perspective.

(c) Authentication. Copies of Plans/Orders which do not bear the signature of the commander or executive officer are authenticated by the staff officer responsible for their preparation or assembly. It indicates that the original was signed by the commander or executive officer. The authentication consists of the word "OFFICIAL" followed by the signature, name, rank, service, and official position of the authenticating officer.

OFFICIAL:

U. R. WRIGHT
Captain, USMC
Engineer Officer

(d) Supporting Papers. Supporting papers usually make up the bulk of a commander's operation order/plan. They add brevity, clarity, and completeness to the parent document. Numbering of the complete order is an alpha-numeric system that allows the user to identify where each document fits into the overall order. Annexes, appendices, tabs, and enclosures make up the supporting papers which amplifies the order.

1 ANNEXES.

a Amplify the Plan/Order.

b Alphabetically titled.

c Standardized titles. (Remain the same from order to order).

d Key Engineer supporting papers are found in ANNEX C, M, P, and R, depending on the type of engineer unit and type of operation.

An Overview of Operational Order ANNEXES:

A. Table of Organization
B. Intelligence
C. Operations
D. Logistics
E. Personnel
F. Public Affairs
G. Civil Affairs
H. Environmental Services
J. Command Relationships
K. Communication/Electronic
L. Operational Security
M. Air Operations
N. Administration
P. Combat Service Support
R. Amphibious Operations
X. Coordinating Instructions
Y. Reports Required
Z. Distribution

2 APPENDICES.

a Amplify the Annex.

b Numerically titled.

c No engineer standardized titles (See MCWP 5-1CD, Page 284).

d Written in SMEAC format.

Traditional Engineer Appendices:

(1) APPENDIX 15 (Breaching) to ANNEX C (Operations)

(2) APPENDIX 16 (Obstacle/Barrier Plan) to ANNEX C (Operations)

3 TAB's.

a Amplify the Appendix.

b Alphabetically titled.

c No standardized titles.

d Written in SMEAC format as it applies.

4 ENCLOSURES.

a Amplify the TAB.

b Numerically titled.

c No standardized titles.

d No specified written format.

14. COMMANDER'S APPROVAL/CONFIRMATION BRIEF **(Step 13)**:

a. The operation order will be presented to the commander for approval and signature. This is the final opportunity to scrutinize the plan and to ensure that the mission is understood by the key players. As the name implies, it is not a decision brief, since all the decisions and coordination should have been made. However, adjustments to the plan can be made if problems are uncovered during the brief.

15. ISSUE THE ORDER **(Step 14)**:

a. Once signed, the order is issued to all subordinate commands.

16. COMMANDER AND STAFF SUPERVISION **(Step 15)**:

a. Now that the order is in the hands of the subordinate commands, the commander and staff supervise through the preparation phase and into the execution phase. As the situation develops, the commander exercises his command by issuance of mission related orders, or the more flexible fragmentary order (FragO).

REFERENCES:

MCWP 5-1 MARINE CORPS PLANNING PROCESS

MCWP 3-17 MAGTF ENGINEER OPERATIONS
FM 5-100 ENGINEER COMBAT OPERATIONS
MCRP 3-17B ENGINEER FORMS AND REPORTS
MCWP 4-1 LOGICTICS OPERATIONS

UNITED STATES MARINE CORPS
COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C01A13
19 Jun 00
(97 POI)

STUDEN HANDOUT

COMBAT ENGINEER EQUIPMENT CAPABILITIES

1. PURPOSE: The purpose of this period of instruction is to familiarize you with the capabilities, uses, and maintenance of combat engineer equipment.

2. ENABLING LEARNING OBJECTIVE (S)

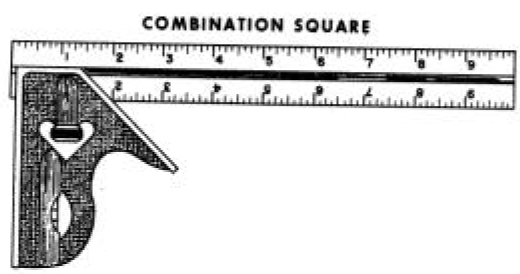
(a) Given an engineer tool set and an SL-3, inventory the set in accordance with the SL-3. (1302.5.5e)

(b) Given an engineer task, identify the equipment appropriate to perform the task in accordance with TM 5-461 and TM 9-243. (1302.5.5f)

BODY

1. LAYOUT, MEASURING, AND LEVELING TOOLS

a. Combination Square (1 EA)

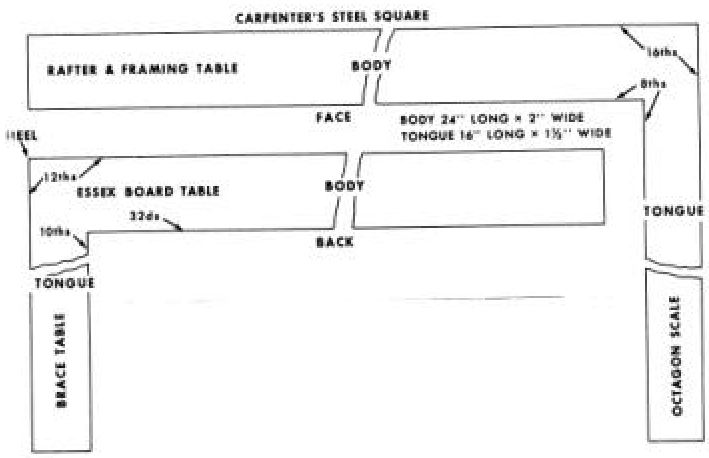


(1) Description. The combination square is a steel blade, 12 inches long, grooved along its entire length on one side and fitted to a metal head that can be clamped at any position along the blade using the clamping screw. The blade is graduated in sixteenths of an inch. The head has machined edges at 90 degree and 45 degree angles to the blade. It is fitted with one leveling vial, and a steel scribe (scratch awl) is set into the head.

(2) Uses. The combination square can be used as a try square, for checking 45 degree angles, to test for plumb or level, as a depth gauge, or as a marking gauge.

(3) Maintenance and Care. The combination square is a precise instrument. Lay it down gently when finished using it. Keep the blade lightly oiled to prevent rust.

b. Carpenter's square (2 EA)



(1) Description. The carpenter's square consists of two arms set at exact right angles to each other. The larger arm, which is 24 Inches long, is called the "blade". The smaller arm, called the tongue" is 16 inches. The angle or junction between the arms is called the "heel", whether it is inside or outside the angle remains 90 degrees.

(2) There are five tables on the square.

(a) The Essex Board Measuring Table is on the back of the blade. It is used to quickly compute board feet in solid lumber that comes in standard sizes.

(b) The Brace Measure Table is along the back of the tongue. This table gives the lengths of commonly used braces.

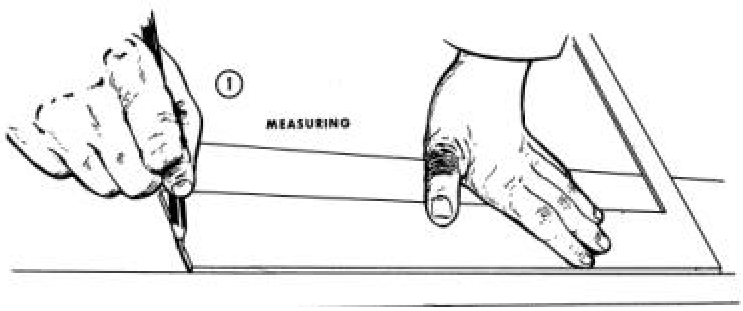
(c) The Rafter Table is along the face of the blade. On some squares a second rafter table is also found on the back of the blade. This table is used to determine rafter lengths, slopes, and overhangs.

(d) The Hundredth Scale is located on the tongue near the heel, on the back of the square. It can be used to obtain fractions or decimals of an inch.

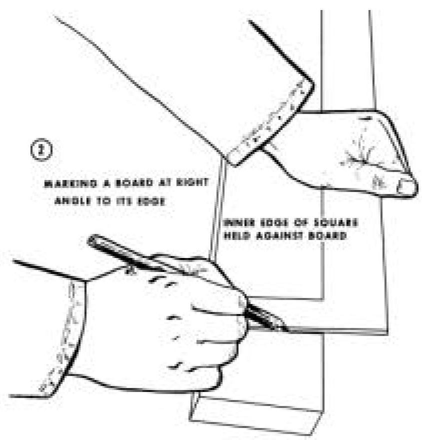
(e) The Octagon Scale is on the face of the tongue and is used to lay off lines when it is necessary to cut an octagon shape from a square piece of lumber.

(3) Uses. There are so many uses for the carpenter's square that entire books have been written on the subject. A few of the uses are listed below.

(a) To measure the length of a board, place the blade on the board with the heel at one end, and mark where the other end is with a sharp tool. This will be 24 inches. Place the heel at this mark and continue measuring in the same manner until you have reached the end of the board.



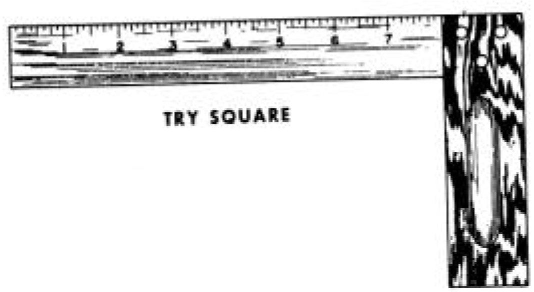
(b) To mark across a board, place the edge of the blade along the edge of the board. The tongue will now be at right angles to the edge of the board. Make your mark along the tongue.



(c) To test for squareness, place the edge of the blade along the board, with the edge of the tongue at the end of the board. The edge of the tongue should exactly match the end of the board with no light showing through.

(4) Maintenance and Care. Clean the square with a light abrasive and keep it lightly oiled.

c. Try Square (2 EA)



(1) Description. The try square is a steel blade eight inches long, graduated in eighth inch increments and set into a wooden or metal handle. The handle is called the "beam".

(2) Uses. The try square is used for marking lines at right angles, to test surfaces or edges for consistent thickness throughout their lengths, and to test for straightness. To test for straightness, place the handle against the edge of the board with the inside of the edge of the blade against the edge to be tested. You should not see space or light between the blade and the cut being tested.

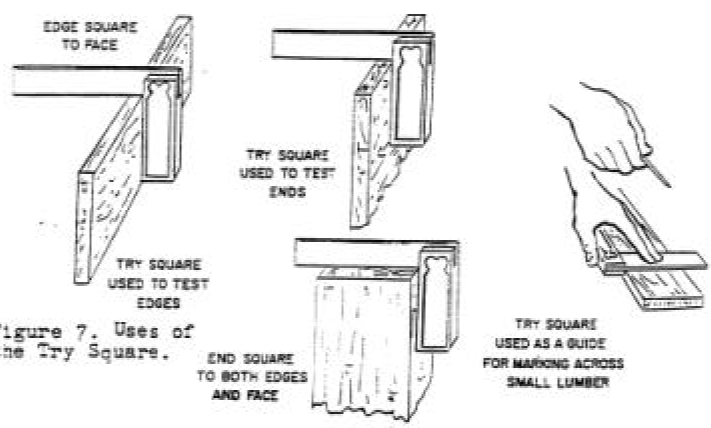


Figure 7. Uses of the Try Square.

(3) Maintenance and Care. The same maintenance given the carpenter's square should be given to the try square. Lightly oil the wooden handle occasionally with linseed oil to prevent it from drying out.

d. Wing Dividers (1 EA)

(1) Description. Dividers consist of a pair of legs joined together at or near their tops. Dividers of the type furnished in the engineer carpenter's tool set are called "wing dividers." The "wing" is an arc used to allow accurate repetitive measurements by means of a graduate scale and a setscrew. At one end of the arc is an adjusting screw spring that permits a fine setting of the legs.

(2) Uses. Dividers are used to mark lengths into equal parts, to scribe circles and arcs, or to transfer measurements from the work to a rule or from a ruler to the work.

(a) To set the dividers at a given distance, place the point of the divider on a graduation mark on a scale or on a rule. Set the leg at the desired distance. Tighten the setscrew holding the arc; then turn the adjusting screw in or out.

(b) To lay off equal spaces, set the legs at the desired spacing in the manner described above and lay the dividers along the line to be marked off rotating the dividers from one leg to the other.

(c) To scribe circles or arcs with the dividers, place the point of one leg on the center of the circle or arc and rotate the dividers letting the point of the other leg mark the material.

(d) The sharp point on one end of each leg may also be used as a scriber for marking boards.

(3) Maintenance and Care. Keep the points of the dividers sharp by rotating them against an oil stone. If they are dulled or bent, grind them by rotating them against a grinding machine. Take care to cool the points with

water to prevent loss of temper. Take care also to not make one leg shorter than the other.

(a) When not in use set the setscrew lightly to prevent possible damage to the arc or bending of the dividers in case they roll to the floor.

(b) Dividers should be laid flat on the toolbox or hung in a rack when not in use. They should not be set on their points.

(c) Dividers should be kept lightly oiled.

e. Sliding T-Bevel (2 EA)

(1) Description. The sliding T-bevel consists of a slotted eight-inch steel blade set into a handle called the stock, beam, or head with a thumbscrew to hold it at any desired angle with the head.

(2) Uses. The sliding T-bevel is used for testing bevels or for making angles on a board. It may be set in various angles by the aid of triangles, a carpenter's square, or a protractor. To set the sliding T-bevel, at any angle, loosen the thumbscrew, place the edge of the handle against one side of the angle to be set off and set the blade against the other side of the angle. Tighten the thumbscrew to hold it.

(3) Maintenance and Care. Keep the sliding T-bevel lightly oiled and in a tool box when not in use.

f. Carpenter's Level (5 EA)

(1) Description. The carpenter's level is an aluminum or cast iron block with true surface edges. There are three bubble tubes in it, of which one is in the middle of one of the long edges. The others are at right angles to this and parallel to the sides of the level. It comes in both 48 and 24 inches.

(2) Uses.

(a) To test for a level surface, lay the carpenter's level on the surface and see where the bubble comes to rest. If the surface is level and the level is in adjustment, it will come to rest exactly between the two scratch marks. Turn the level end for end and recheck. The bubble should come to rest in the same place. If it does not, raise the end of the surface being tested which is toward the low end of the tube until it checks level. If the level is out of adjustment, it can still be used. Note the position of the bubble in relation to the scratch marks. When the level is turned end for end, the bubble should come to rest at the same relative position to the scratch marks but toward the other end of the work being tested.

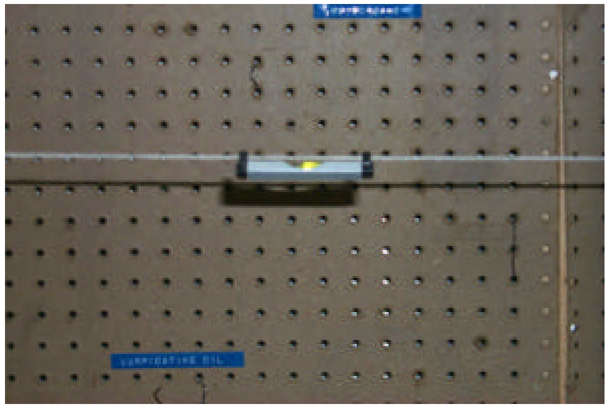
(b) To check for plumb, set the long side of the carpenter's level the upright to be tested and use the bubble which is set in the end in the same manner previously described.

(3) Maintenance and Care.

(a) The carpenter's level is made of wood and it should be handled gently to prevent scratching or gouging its wood surfaces. Scratches or gouges in the true surfaces will make them untrue.

(b) Rub the level lightly with oil to prevent the wood from drying out and cracking.

g. Line Level (2 EA)



(1) Description. The line level consists of a bubble tube set into a metal case with a hook at each end to permit it to be hung on a line or cord.

(2) Uses. The line level is used to test whether a line cord is level. It is particularly useful when the distance between two points to be checked is too long to permit the use of a board and carpenter's level. To use the level:

(a) Stretch a cord between the two points which are to be checked for plumb.

(b) Hang the line level on the cord and see whether the bubble rests in the middle of the tube. If it is not, raise the end of the cord that is toward the lower end of the bubble until the bubble rests in the middle of the tube.

(c) Unhook the level, turn it end for end, hang it on the cord, and re-test.

(3) Maintenance and Care. The level is a delicate instrument. Keep it in a box when not in use to protect the bubble tube from being broken and the hooks from being bent.

h. Plumb Bob (1 EA)

(1) Description. The plumb bob is a pointed iron weight, weighing nine ounces. Holes at its top allow it to be hung on a cord.

(2) Uses. The plumb bob is used to check uprights for vertical (plumb).

(a) Fasten a cord long enough to extend below the end of the upright to be checked to the bob. Lay a rule or a piece of wood on the top of the upright so that it extends just two inches beyond the face of the upright. Hang the bob from the end of the rule or piece of wood. Measure the distance from the cord to the face of the upright. Move the upright in or out until the string is exactly two inches from the upright.

(b) Brace the upright to hold this vertical plumb while checking the plumb of the face, which is at a right angle to the one just tested. Check the second face in the same manner as previously described. When both faces have been plumbed, the upright is vertically plumb.

(3) Maintenance and Care. Do not throw the bob to the ground when not in use. The point may be broken from the iron, which will cause it to hang crookedly, or out of plumb. Keep the cord wrapped neatly around the bob when not in use to avoid wasting time trying to untangle it when it is needed and keep the bob lightly oiled to prevent rust.

i. Multiple Folding Rule (8 EA)

(1) Description. The multiple folding rule is of aluminum or wood and is six feet long. The sections are so hinged that it is six inches from the center of one hinge joint to the center of the next. It is graduated in sixteenths of an inch.

(2) Uses. For measuring distances.

(3) Maintenance and Care. The folding rule can be easily bent or broken if carelessly used, particularly when it is opened. Close the rule and keep it closed when not in use.

j. Tape Measure, 50 & 100 Foot (1 EA)

(1) Description. The steel tape is a ribbon of steel, 1/2 inch in width and 50 and 100 feet long. It is Graduated in feet, inches, and fractions of an inch down to 1/8 inch. One end of the tape is fastened to a reel that is housed in a leather-covered metal box.

(2) Uses. For measuring distances greater than 25 feet.

(3) Maintenance and Care. Reel the tape back into the case whenever it is not actually being used. Do not permit the tape to be twisted. Keep the tape clean and lightly oiled.

k. Chalk line (1 EA)

(1) Description. The chalk line is a container with chalk and string inside, with a crank on the side for rewinding.

(2) Uses. The chalk line is used to mark straight lines.

(3) Maintenance. Keep clean and refill as needed. Chalk is included in the kit for refilling.

l. Twine (3 EA)

(1) Description. A one pound ball (1020’) of cotton string with a minimum 35 pound breaking strength. Some kits may contain a one pound ball of polymide string with 1950’. Minimum breaking strength of the polymide ball is 70 pounds.

(2) Use. A wide variety of uses, such as to mark the boundaries of a building, also used with a line level to level fence posts and other projects.

(3) Maintenance. Keep clean and dry.

m. Apron, Construction Worker’s (12 EA)

(1) Description. Nail apron made of Leather.

(2) Use. The nail apron may be used to store nails and small tools while working.

(3) Maintenance. Keep clean and dry.

2. BORING TOOLS, SCREWDRIVERS, PLIERS

a. Ratchet-Type Brace (1 EA)

(1) Description. The brace consists of a head, crank, ratchet box, and a chuck. The head is a circular wooden knob fastened to the crank. The crank is a steel shaft to provide leverage.

(2) Uses. The brace is used to turn auger bits, expansive bits, countersinks, or screwdriver bits. To insert a bit, hold the chuck with the left hand while turning the crank backward. Do not press with too much force on the head of the brace when boring

(3) Maintenance and Care. Occasionally grease the bearings of the head with light grease. Oil the handle bearings, jaws, and ratchet.

b. Hand Drill (1 EA)

(1) Description. The hand drill, ratchet type consists of a shaft with a handle at one end and a chuck for holding twist drills at the other. Near the middle of the shaft is a ratchet gear wheel with a crank handle attached which drives a smaller gear attached to the chuck.

(2) Uses. The hand drill is used for drilling holes in metal or wood.

(3) Maintenance and Care. Use a light machine or engine oil on the gear teeth, the handle bearings, and the chuck.

c. Auger Bit Set (1 EA)

(1) Description. The auger bit is a tool designed for use with the brace to bore holes. The set consists of seven auger bits, varying in size from 1/4 inch to 1 inch, graduated in 1/8-inch increments. The bit has six features.

(a) The spur is a screw at the end of the bit that feeds or pulls the bit into the wood.

(b) The nibs are vertical cutters that cut the side of the hole.

(c) The lips are horizontal cutters that chip the wood in the bottom of the hole.

(d) The twist or flute carries the chipped wood away from the cutting edges and out of the borehole.

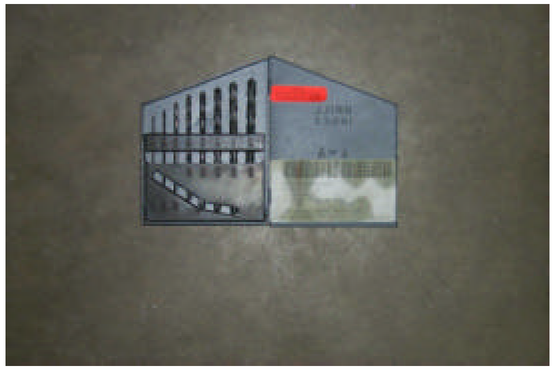
(e) The shank

(f) The tang is the tapered top that fits in the brace.

(2) Uses. The auger bit set is used to bore holes in wood.

(3) Maintenance and Care. Make sure no nails or other metal or any other dirt is in the way of the bit before boring a hole. Clean and oil the bit after use. Keep the bits in the roll provided for that purpose when not in use. Use an auger bit file to sharpen the bit.

d. Drill Set, Twist (1 EA)



(1) Description. Twist drills are straight shank boring tools used for boring holes smaller than it is possible to bore with the smallest auger bit.

(2) Uses. The twist drill is used with the ratchet type hand drill for boring small holes in wood or soft metal.

(3) Maintenance and Care. Sharpen the drill bits on a grinding wheel. First grind the tip to the proper angle. Both cutting edges must make the same angle with the drill axis, and both cutting edges must be of the same length. Keep twist drills oiled and protected to prevent them from striking metal objects when not in use. A means of protection is to keep the set of twist drills bits wrapped in a piece of cloth, in such a manner that each drill is separated from the next by the cloth when not in use.

e. Expansive Bit (2 EA)

(1) Description. The tip of the expansive bit has an adjustable cutter that can be extended to fit various size holes, from 7/8 inch to 3 inches in diameter. By loosening the setscrew in the side of the bit and extending the cutter blade, the size of the hole can be varied. A scale on the cutter indicates the diameter of the hole.

(2) Uses. This bit is used for boring holes in wood larger than the largest auger. When using the expansive bit to bore completely through a board, clamp a piece of waste wood to the back of the piece to be bored through to prevent slipping when the bit comes through.

(3) Maintenance and Care. See Bit Set, Auger.

f. Countersink Bit (1 EA)

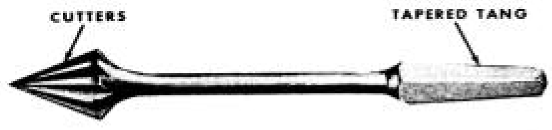


Figure 89. Countersink bit.

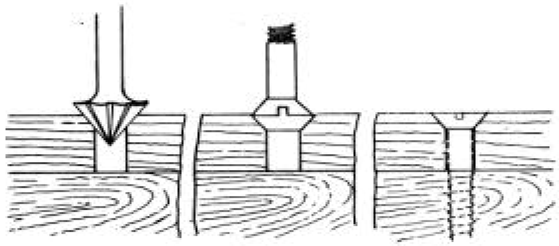


Figure 90. Using the countersink bit.

(1) Description. It has a "rose-head". These act as cutters.

(2) Uses. Its purpose is to enlarge and taper a hole so that a screw head may be sunk flush with or below the surface.

(3) Maintenance and Care. Sharpen the cutting edges of the countersink flutes with a tapered file using extreme care to retain the original shape.

g. Screwdriver Bit (4 EA)

(1) Description. The screwdriver bit is a screwdriver with a shank designed to fit the chuck of a ratchet-type brace.

(2) Uses. As a regular screwdriver the bit used with the ratchet type brace.

(3) Maintenance and Care. Keep clean, with a light coat of oil.

h. Flat Tip Screwdriver (3 EA)

(1) Description. Flat tip screwdrivers are issued for use with slotted-head screws. The flat tip screwdriver normally is referred to as a "common" screwdriver. They are issued in lengths of 4”-8” with various widths of tips.

(2) Uses. To drive or remove screws from bore holes, as a means of attaching one or more wooden or metal objects together.

(3) Maintenance and Care. Do not use the screwdriver as a lever or as a chisel. When the tip of a common screwdriver becomes nicked or rounded off from use, regrind it on the grinding machine. Grind the tip straight across to remove any nicks or rounded edges.

1. Pliers, Slip Joint (1 EA)

(1) Description. Pliers are holding or gripping tools. Slip joint pliers are pliers with straight, serrated (grooved) jaws.

(2) Uses. Pliers are used to hold material that is being worked on; to reach into and grasp objects that are hard to reach with the fingers; or to bend wire and small bars.

(3) Maintenance and Care. Keep the jaw serrations of the pliers sharp. Apply a light coating of oil. Keep the pin or bolt at the hinge just tight enough to hold the two parts of the pliers in contact.

j. Drill, electric, portable. (2 EA)

(1) Description. There are two drills in the kit. One is an electric 120-volt. The other is a cordless battery powered drill. The cordless drill has a rechargeable battery pack.

(2) Uses. The main purpose is to drill holes in wood or metal.

(3)Maintenance and Care. Keep chuck oiled and drill away from water.

k. Screw, Wood. (HD EA)

(1) Description. Wood screws are of the below listed sizes.

(a) 3/8″

(b) 1 1/4″

(c) 1 1/2″

(d) 3″

(2) Uses. For securing wood projects together

(3) Maintenance and Care. Keep clean and organized.

l. Wrench, Pliers. (1 EA)

(1) Description. 8 1/2″ vice grip

(2) Uses. The wrench is used to grip a wide variety of nuts or bolts.

(3) Maintenance and Care. Keep clean, with a light coat of oil

3. DRIVING AND PRYING TOOLS

a. Carpenter's Hammer (9 EA)

(1) Description. The carpenter's straight-claw nail hammer is a steel headed, wooden handled tool used for driving nails, wedges, and dowels. The "claw" portion is the two straight prongs used to pull out 8d and smaller nails. The other parts of the head are the eye and face.

(a) Hammer face types

1 The flat face is called a "plain" face. It is difficult to drive the head of a nail flush with the work surface without leaving hammer marks. The plain face hammer is used on rough work where the finish is not important.

2 A slightly rounded or convex face is called a "bell-faced". The bell-faced hammer is generally used in finish work. When handled by an expert it can drive the nail head flush with the surface of the work without damaging the surface.

(2) Uses. To drive nails simply grasp the handle with the end of the handle flush with the lower edge of the palm. Keep the wrist limber and relaxed. Grasp a nail with the thumb and forefinger of the other hand and place the nail point at the exact spot where it is to be driven. Unless the nail is to be driven at an angle, it should be perpendicular to the surface of the work. First rest the face of the hammer lightly on the nail and give the nail a few light taps to start it and to fix your aim. Then take the fingers away from the nail and drive the nail with finishing blows with the center of the hammer face. Strike the nail head squarely keeping the hand level with the head of the nail.

To pull out a nail, slide the claw of the hammer under the nail head. Pullback on the handle extracting the nail until the hammer handle is nearly vertical. Then place a block of wood under the head of the hammer and continue to pull the nail completely free. The claw should not be used for pulling nails larger than an 8d. For larger size nails, a wrecking bar is recommended.

(3) Maintenance and Care. Replace or tighten hammer handles, when broken or loose. If tile handle is loose, set it by striking the end of the handle with a mallet and drive the wedges back into the handle. Wedges may be of either metal or straight grained softwood. Do not use nails or screws. If the handle is broken, remove it, seat a new handle, and replace the wedges. If it is difficult to remove the old handle, saw it off close to the head and drive it through the larger end of the eye. Save and restore the face. Keep the hammer face clean and smooth. This is usually done by rubbing it with emery cloth. If it is necessary to grind the face to restore its surface, make notice of whether it is a bell or plain face and then grind it to obtain the proper shape. Dip the head in water often to prevent overheating and loss of temper while grinding. Do not grind the hammer face often, nor remove more material than necessary to restore the face.

b. Plastic Faced Hammers (1 EA) (point to plastic hammer)

(1) Description. The plastic faced hammer has a metal head on a wooden handle, with replaceable plastic faces that can be screwed onto the ends of the metal head.

(2) Uses. The plastic faced hammer is used for striking chisels and other tools that would be damaged by a metal hammer.

(3) Maintenance and Care. The plastic face is soft material and can be easily damaged. Restore the face by rasping off the damaged surface with a wood rasp, then smoothing the surface with a file and sandpaper. Take care to remove the same amount from each end of the head, to maintain the proper balance of the hammer. When the faces are too scarred for repair, unscrew them from the head and screw in new ones.

c. Nail Set (1 EA)

(1) Description. The nail set is a round steel tool, with one flat end for striking and a tapered end. The tapered end varies in size.

(2) Uses. The nail set is used to drive a nail below the surface of the wood.

(3) Maintenance and Care. Nail sets require very little care. Keep them lightly oiled when not in use to prevent rusting. Replace nail sets that have mushroomed heads.

d. Pinch bar (1 EA)

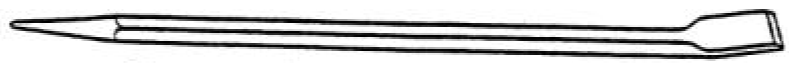


Figure 38. Pinch-Bar

(1) Description. The pinch bar is a steel rod, usually of 3/4-inch material, with one pointed end and one chisel or wedge shaped end. The wedge is set at a slight angle to the bar.

(2) Uses. The pinch bar is used for light ripping and prying jobs.

(3) Maintenance and Care. Keep the pointed ends of the bar sharp by filing or by grinding the chisel point or the tips of the claws may be kept in condition in the same manner. Pinch bars require very little care. Keep them lightly oiled when not in use to prevent rusting.

e. Nailer, Portable, Pneumatic. (2 EA)

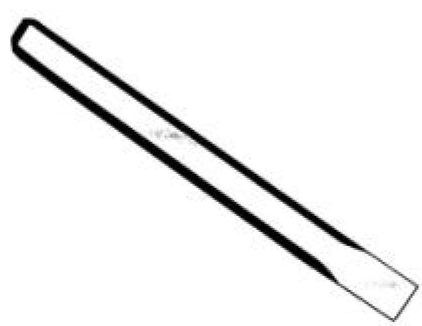
(1) Description. 15 LB 8 oz; holds 150 nails, capable of driving nails from 4″ - 5″ in length.

(2) Uses. Driving nails for wood frame construction.

(3) Maintenance and Care. Keep clean and lubricate moving parts.

4. CUTTING AND PARING TOOLS

a. Cold Chisels (1 EA)



(1) Description. The machinist cold chisel is a steel tool with a sharpened cutting edge on one end and a double beveled head at the other. The bevel of the cutting edge is usually 60 to 70 degrees.

(2) Uses. The cold chisel is used for chipping or cutting cold metal. Place the chisel with its cutting edge on the cutting line and strike the head of the chisel with a ball peen hammer to force the edge into the metal.

(a) It is better to make a series of light cuts rather than trying to cut completely through the cold metal all at once.

(b) When cutting steel, keep the edge of the chisel lubricated with light oil to reduce friction.

(c) When cutting cast iron, always cut from the edge toward the center to avoid breaking off corners of the material being worked upon.

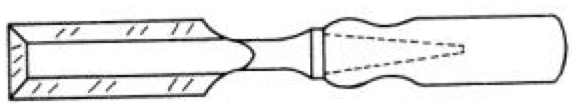
(3) Maintenance. Keep cutting tip sharp without taking temper out of blade, also keep light coat of oil on it to avoid rust.

b. Wood Chisels (6 EA)

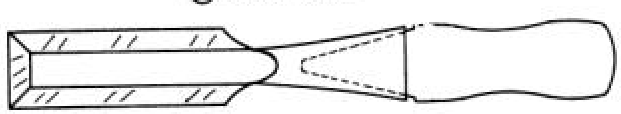
(1) Description. A wood chisel is a steel tool fitted with a wooden handle. It has a single bevel, cutting edge at the end of the steel part or blade.

(a) Types

1 Wood chisels are divided into two types (tang and socket) depending upon which of their handles are attached. They are also divided into types depending up on their weight, thickness, shape or design of the blade, and the work they are intended to do. These types are paring, firmer, and framing. The framing chisel is the heaviest and most useful of these and is the chisel issued with engineer tool sets.



① TANG CHISEL



② SOCKET CHISEL

2 Framing chisels are socket type chisels. Their handles normally are fitted with an iron band to prevent them from splitting when struck by a mallet or plastic hammer.

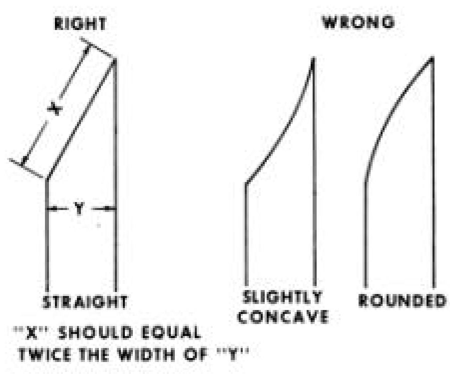
3. Tang chisels are used only for light work, which can be done by pushing or tapping with the hand against the end of the handle.

(2) Uses. Wood chisels are used to chip or to pare away sections of wood. Examples of this are in cutting a socket, preparing a lap joint, or paring the edge or surface of a board.

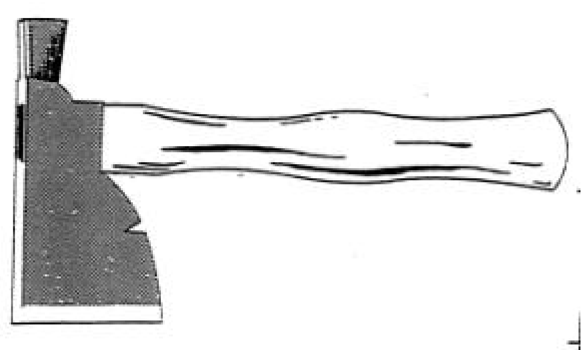
(a) Choose a chisel smaller than the width of the cut to be made and cut as much as possible with the grain of the wood. Cutting against the grain splits the wood fiber and leaves a rough job. Start the cut slightly away from guideline and continue away from guideline so that any splitting will occur in the waste and not in the finished work.

(b) Holding the chisel with the bevel down gives a lifting or gouging action. Holding the bevel up or away from the surface gives a planing action. Finish the cut by holding the chisel flat, bevel side up, on the surface of the cut and making light paring cuts. The cut will be smoother if the cutting edge is held at a slight angle to the direction of the cut.

(3) Maintenance and Care. Keep chisels in racks when not using them to protect their edges. Keep them clean and covered with a thin film of oil to prevent rusting. When the handle of a chisel becomes mushroomed from use, repair it. Never use the chisel to pry open boxes or as a screwdriver. Sharpen a wood chisel by using a grinding machine or oilstones. Use the grinding machine only when the cutting edge has been nicked, or when the bevel cannot be restored by using the oilstone.



c. Half-Hatchet (6 EA)



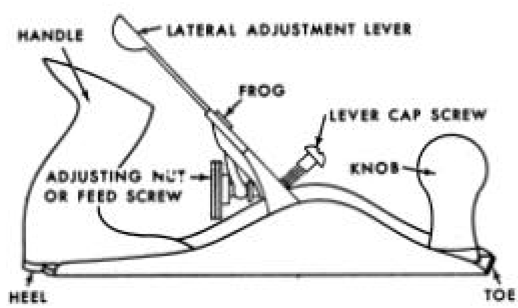
(1) Description. The half-hatchet is a chopping and driving tool. It has a wooden handle and a steelhead. The blade has a notch for pulling nails.

The edge of the blade is usually beveled only on one side. The single bevel is better for chopping along a line.

(2) Uses. The half-hatchet usually is held with one hand. Most effective use of the hatchet is made when cutting with the grain of the wood. Before using the tool, prevent deflection of the hatchet by clearing all branches and debris from the work area, and do not allow chips to accumulate on the work surface as work progresses. Do not use the notch in the blade to pull nails larger than 8d. For larger nails use the claws of a wrecking bar.

(3) Maintenance and Care. Inspect the half-hatchet frequently to see that the head fits tightly and that the handle is not split or broken. If the handle is loose, seat it into the eye by striking the end of the handle with a mallet and re-seat the wedges. If the wedges will not spread the end of the handle enough to make it tight, add another wedge or use larger wedges. Replace the handle if it is split or broken. If a broken handle is too tight to pull out of the head, saw off the handle close to the head and drive the remaining piece through the large end of the eye. Shape a new handle to fit, using a spoke shave or wood rasp. Seat the new handle. If it fits properly, saw off the projecting end and drive wedges into the handle. Do not use screws or nails for wedges. (2) Stand hatchets on their heads or hang them in a rack when not in use. After using a hatchet, clean, sharpen, and coat it with a light film of oil to prevent rusting. Do not drive a hatchet into the ground. Place the wood to be chopped on another block to keep the edge of the hatchet from striking the earth.

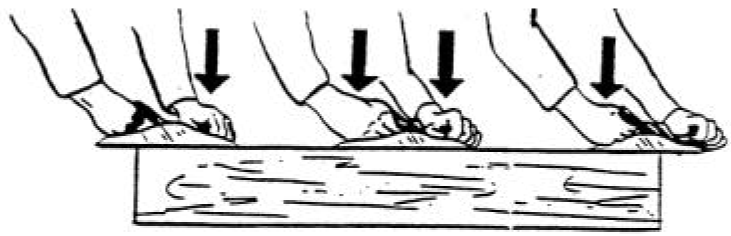
d. Smoothing Plane (1 EA)



(1) Description. A plane is a tool used to smooth boards or to remove wood from the surface or edge to obtain a desired thickness or width. The smoothing plane is a bench plane and is designed for use with both hands while the work is supported on a workbench or sawhorse. The smoothing plane is the plane issued in engineer tool sets. It is nine inches long. It is designed for general use in smoothing rough edges and surfaces where precise straight lines are not essential.

(2) Using the plane.

(a) Clamp the piece of wood securely in a vise, using scrap pieces of wood to prevent marring of the surface, or nail a thin strip of wood to the piece and push the piece being worked upon against it. Control the plane bench with both hands. Hold the plane with the left hand on the knob and the right hand on the handle. Make thin cuts. The most common mistake made by beginners is to adjust the plane so that it cuts too deep. The shavings should come through the mouth and be deflected by the cap-iron. If the mouth becomes clogged, clear it with a splinter of wood. Never with a screwdriver or other metal objects.



(b) Bear down firmly on the knob when beginning the stroke, and evenly on both knob and handle when in the middle of the stroke. Lighten the pressure on the knob and bear down on the handle when finishing, the stroke. Keep well over the work, so the pressure can be carefully watched. On return strokes, raise the cutting edge so it will not drag on the finished surface. The plane should be angled 10 to 15 degrees with each stroke (in making rough-cuts, about 30 degrees). If the grain is torn or roughened by the plane, reverse the direction in which the plane is being pushed. When planing sides and edges, work from the outside toward the middle and as much as possible with the grain. Use steady, level strokes.

(c) Edges can be kept true holding a block of wood against the side of the work and under the plane as a guide and as support. In planing the end grain, plane from both edges of the work toward the center to avoid splitting the edges.

(3) Maintenance and Care. Sharpening plane blades in the same manner as described for the wood chisel. The angle of the bevel is 25 degrees. Take care to keep the cutting edge straight and exactly perpendicular to the length of the blade. Round off the corners slightly. Never lay a plane face down on its cutting surface. Always lay it on its side, otherwise the blade may be nicked or dulled. Ensure that the wood to be planed is entirely free of nails, dirt, or other foreign matter.

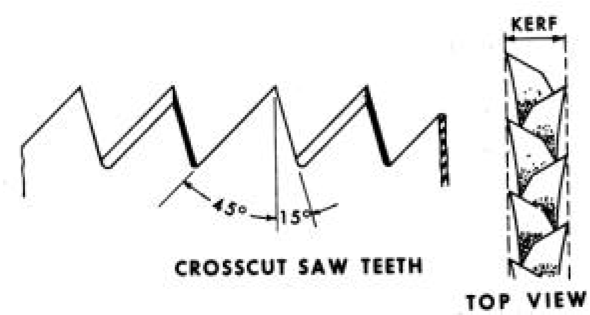
e. Hand Saws (5 cross cut and 2 rip)

(1) Description. Saws are tools for cutting wood or metal. The handsaw consists of a steel blade with a handle at one end. The blade is narrower at the end opposite the handle. This end of the blade is called the "point" or "toe". The end of the blade nearest the handle is called the "heel". One edge of the blade has teeth, which are two rows of cutters. When the saw is used, these teeth cut two parallel grooves close together. The chips (called "sawdust") are pushed out from between the grooves (the kerf) by the beveled part of the teeth. The teeth are bent alternately to one side or the other to make the kerf wider than the thickness of the blade. This bending is called the "set" of teeth. The number of teeth per inch, the size and shape of the teeth, and the amount of set depends on the use to be made of the saw and the material to be cut. Saws, except the hacksaw, are described by the number of

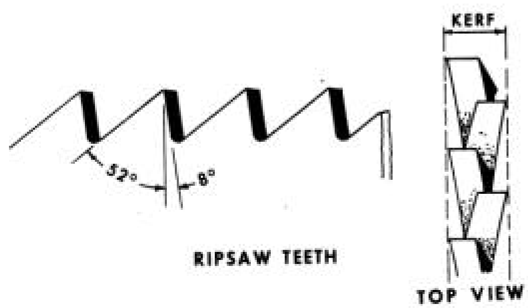
tooth points per inch. There is always one more point than there are teeth per inch. A number stamped near the handle gives the number of points of the saw.

(a) Types

1 Crosscut. The crosscut saw is used for cutting across the grain of the wood. The blade has eight or more points per inch. The points are sharpened like the ends of knife blades. A crosscut with coarse teeth and a wide set is needed for cutting green, unseasoned wood. A fine toothed saw does more accurate cutting and is best for dry, seasoned wood.



2 Ripsaw. The ripsaw is designed for cutting with the grain of the wood. The teeth, unlike those of the crosscut saw, are sharpened straight across the leading nearly vertical edge, or at right angles to the edge of the blade. Thus the teeth of the ripsaw are like two rows of chisels in their action. The ripsaw in the engineer tool set has 5 1/2 points per inch.



(2) Uses. In cutting with either the crosscut or the ripsaw, first draw a guideline for the saw to follow. Grasp the wood with the left hand and brace it with one knee to hold it securely. Guide the saw with the left thumb by resting it against the blade above the teeth. Keep your right shoulder directly behind the cut to be made. This will ensure that the saw is cutting in a plane perpendicular to the surface of the wood.

(a) Rest the teeth of the saw against the edge of the wood with the blade on the waste side of your guideline. Start the cut by drawing the saw toward you to make an initial groove.

(b) Hold the saw lightly. Do not force it into the wood, but simply draw it back and forth, using long strokes.

(c) If the saw tends to run off the line or the cut is not perpendicular to the work, slightly twist or bend the blade back into place.

(d) Test a portion of the blade occasionally with a try square to ensure that the cut is being made perpendicular to the surface of the wood.

(e) The crosscut saw should make an angle of 45 degrees between the edge of the saw and the surface of the wood. The ripsaw should be used at an angle of 60 degrees.

(f) In ripping long boards, insert a wooden wedge into the cut to spread it apart and keep the saw from binding.

(3) Maintenance and Care. Care must be taken that the saw is not crooked. If the saw binds in the cut and pressure is then applied to force it through the wood, a kink is almost certain to result. A crooked saw blade is useless.

(a) Make certain that nails, spikes, and other foreign objects are removed from the wood before it is cut.

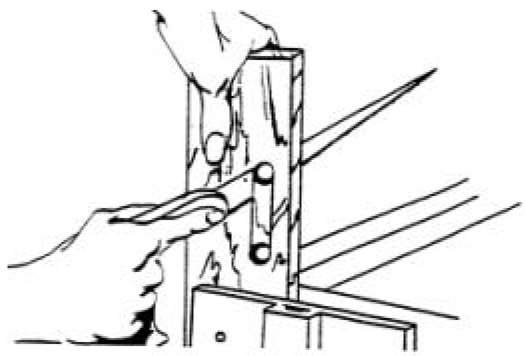
(b) When not in use, saws should be oiled and kept in a toolbox. Saws rust easily, and a rusty saw will bind in the cut.

f. Nested Saws (1 EA)

(1) Description. The nested saws consist of a handle common to three blades that are the keyhole, compass, and plumbers saw blade. The handle typically is of wood and shaped somewhat like a pistol rip. Each of the blades has a slot in the heel by which it is fastened to the handle. The handle has a thumbscrew that is tightened to hold the blade securely in place.

a. Types of blades.

1 Keyhole Saw Blade. The keyhole saw blade is narrow. The point is narrow enough to enter a 1/4-inch hole. It is commonly used for cutting keyholes to fit locks in doors, and for smaller types of work. It cuts a wider kerf than either the crosscut or the ripsaw, in order that the blade may turn quickly to make curved cuts.



2 Compass saw. This blade is designed for cutting curves. It is also used for starting cuts to be completed by larger saws, particularly interior cuts. The blade is tapered to a point and the teeth are filed in such a manner that the saw may be used either for crosscutting or for ripping. The kerf left by this saw is wider than that of either the crosscut or the ripsaw, in order to provide freedom for the blade to turn when cutting curves.

3 Plumber's saw. This is a heavy blade with fine teeth designed for cutting nails or soft metals. The blade is thick enough to permit a wood cutting saw to pass freely through the cut it makes in a nail.

(2) Uses. In using a compass saw or a keyhole saw, you must first bore a hole with an auger bit. Then insert the compass or keyhole saw into the hole and start the cut, working slowly and carefully with a minimum of pressure. These narrow bladed saws are easily bent. When the cut is long enough to permit it, remove the compass saw or keyhole saw and finish the cut with a regular crosscut saw or ripsaw. Use a plumber's saw to cut through any nail encountered while sawing. Then continue the cut with the regular wood saw.

(3) Maintenance. Attempt to keep saw blades straight with a light coat of oil.

g. Files (10 EA)

(1) Description. Files are hardened steel tools. Their surfaces are covered with sharp edged furrows or teeth. Files are used for cutting, smoothing off, or removing small amounts of metal, wood, plastic, or other material. Files are fitted with removable handles and should never be used without the handle on the tang.

(a) Types. There are over 3,000 types of files. Files may be square, triangular, round, half-round, rectangular, or tapered toward one edge in cross-section. They may be single cut, in which case the rows of teeth cross one another. Some of these are discussed below.

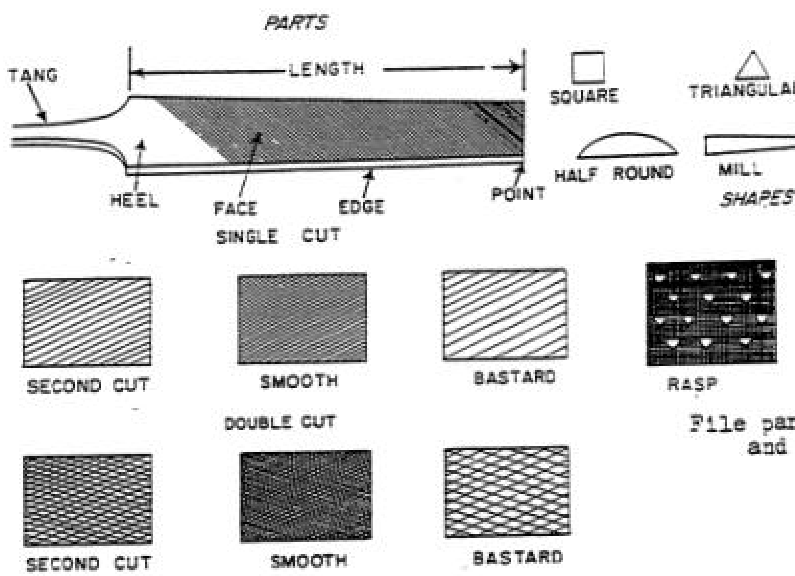


Figure 66

File parts, shapes and cuts.

1 Flat. The flat file is rectangular in cross-section and is tapered both in width and in thickness. It may be either single-cut or double-cut. The flat file is a general-purpose file.

2 Tapered. The tapered file is triangular in cross-section and is tapered on all three sides. The slim taper is smaller in cross-section than a regular taper. Because of their shape, tapered files can get into sharp angles and can be used for filing handsaws.

3 Auger bit. The auger bit file is a special file used for sharpening the nibs and lips of auger bits. At either end is a small file and the middle section forms the handle. The file is seven inches long. At one end the faces are single cut with safe edge; that is, the edges have no teeth. At the other end the faces are double cut.

4 Mill: mill files are used for sharpening the 2 man and 1-man crosscut saws. The mill file is thinner at one edge than at the other. One edge of the mill file has no teeth and is called the safe edge. Mill files are single-cut.

5 Wood Rasp: The wood rasp is a very course half-round file. It has teeth which consist of points instead of V shaped projections, running diagonally across one or more surfaces. It has a tang at the point for a handle, and should never be used without a handle. The rasp is used for cutting away wood or for finishing rough edges left by a new saw.

(2) Uses. Select a file for the job by considering the amount of material to be removed. Fit a handle to the file selected, except the auger bit file. Slip the handle over the tang of the file and then striking the base of the handle sharply to set the tang securely in the handle.

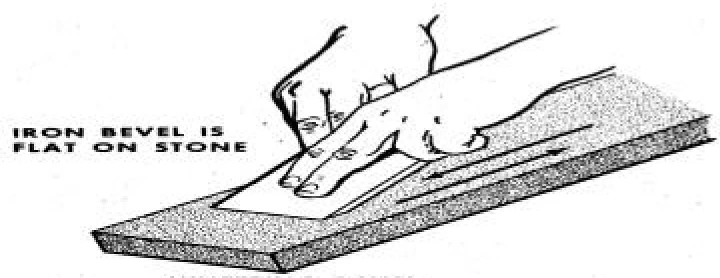
(a) Secure the work piece in a vise or other device. Hold the file and use alternating strokes, right to left then left to right at an angle of about 30 degrees for rough cutting.

(b) In finish filing, use parallel strokes across the work. Any unevenness in the work can be felt by the fingers held lightly on the file.

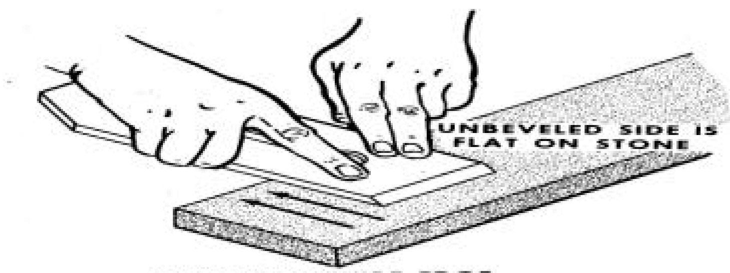
(3) Maintenance and Care. New files should be carefully broken in by first using them on soft material. Clean with file card in the event file is clogged. Files should be cleaned after each use and a light coat of oil applied before Storage.

h. Oil Sharpening Stones (1 EA)

(1) Description. The issued oilstone (sharpening stone) is a natural or artificial stone three inches wide, eight inches long and one inch thick. One face is of coarse grit for rapid cutting; the other a fine grit for slow, fine cutting. It is issued not mounted. A wooden box should be made to protect it.



WHETTING BEVEL



REMOVING WIRE EDGE

(2) Uses. The sharpening stone is used for putting keen edges on tools after they have been ground or filed to shape. A "feather" or "wire" edge can be removed by rubbing each side of a cutting edge alternatively against the oilstone. To use, set the stone on a firm base and apply a few drops of light oil to its surface. Hold the tools cutting edge at the desired angle and with a circular motion move across the face of the stone and apply only enough pressure to cause the stone to cut.

(3) Maintenance and Care. A good stone should be soaked in light (No. 10 or lighter) oil before each use. This not only cleans the pores of the stones and gives better cutting action, but also acts as a lubricant for the tool being sharpened.

(a) If a stone becomes too oily after much use and presents a "slick" surface on which the tool slips. Boil the stone in water. This will clean the pores of the embedded materials. After the stone has dried, oil it again before using.

(b) When an oilstone becomes uneven through use, dress it by rubbing it against a piece of sandpaper, emery cloth, or a grindstone.

i. Saw Set (1 EA)

(1) Description. The saw set is a tool that, by means of a plunger and anvil, bends the teeth of the saw outward to make the kerf wider than the thickness of the blade of the saw.

(2) Uses. The saw set is used to reset damaged saw teeth.

(3) Maintenance. Apply a light coat of oil when not in use.

j. Oiler (1 EA)

(1) Description. Usually a canister that contains one pint of lubricating oil, which is forced out of the oiler by depressing the handle trigger.

(2) Uses. To hold oil while coating tools during maintenance.

(3) Maintenance. Keep clean with a light coat of oil.

k. <u>Lubricating Oil</u>. (1 CN)

(1) <u>Description</u>. One pint or quart of oil that is normally 10 wt. oil

(2) <u>Use</u>. To keep tools lubricated and to prevent rust.

(3) <u>Maintenance</u>. Keep clean, with a light coat of oil.

l. <u>Saw, Circular, Portable, Electric</u>.(1 EA) (OFF CG #13/ON CG#14, point to saw)

(1) <u>Description</u>. The portable electric circular saw blade spins at 5800 RPM. The blade (8” in diameter) is a combination rip and cross cut type.

(2) <u>Use</u>. Used to rip or cross cut lumber.

(3) <u>Maintenance</u>. Clean after use and change the blade as needed to keep a sharp blade on the saw.

m. <u>Blade, Circular Saw, Woodcutting</u>. (2 EA)

(1) <u>Description</u>. Combination blade for the circular saw.

(2) <u>Use</u>. For cutting wood with the circular saw.

(3) <u>Maintenance</u>. Keep clean and sharpen as needed.

n. <u>Aural Protectors</u>. (2 EA)

(1) <u>Description</u>. Earmuff type hearing protection.

(2) Use. Hearing protection for any loud noises. Such as the noise from the circular saw, table saw etc.

(3) Maintenance. Keep clean and secure in box when not in use.

o. Goggles, Industrial. (2 EA)

(1) Description. Plastic frame eye protection.

(2) Use. Use when operating any tool that presents a possible eye hazard.

(3) Maintenance. Clean after each use for the next Marine that will need them.

p. Shears, Metal Cutting, Hand. (1 EA)

(1) Description. Duck bill combination, single lever, 12" overall length.

(2) Uses. Used for cutting light metal and wire.

(3) Maintenance. Keep clean, with a light coat of oil.

5. PIONEER TOOL KIT/Land Clearing Tools

a. Adz (2 EA)

(1) Description. The adz resembles an ax of which the edge of the blade is at a right angle to the handle. It has a curved (or arched) steelhead, attached by its eye handle that is curved to give balance and to provide the proper angle for cutting.

(2) Uses. The adz can be used like an ax for taking bark off trees and logs.

(3) Maintenance and Care. Clean the adz by using an abrasive such as emery cloth steel wool or a steel brush if it becomes rusty. Keep the adz in the pioneer kit when not in use. Oil the head and paint the head with the exception of the cutting edge.

b. Single Bit Ax (12 EA)

(1) Description. The single bit ax has a 4 lb.. Head. The blade is 7 1/2 inches long, 4 3/4 inches wide, and has a tapered hammer side.

(2) Uses. The single bit ax can be used for many different tasks, e.g., clearing small brush, clearing limbs off trees, felling trees, and driving wedges.

(3) Maintenance and Care. Clean the ax with steel wool, emery cloth, or a steel brush. Check the wedges in the head and also check to see if the handle needs water soak to counter wood shrinkage. Sharpen the blade and remove any nicks then paint the head to prepare it for storage. Then store it with a light coat of oil to prevent rust.

c. Bush Hook (2 EA)

(1) Description. The bush hook is a strap-eye type of blade with an 11 3/4-inch long cutting edge connected to an ax type handle.

(2) Uses. The bush hook is used to cut brush and briars.

(3) Maintenance and Care. Use steel wool emery cloth or a steel brush to clean the brush hook and put it away with a light coat or oil. Also before storage check for nut and bolt tightness and blade to handle tightness.

d. Rigid Handle Machete (6 EA)

(1) Description. The spring steel blade is 18 inches long, 2 1/4 inches wide with a 5 39/64-inch long handle, class I size.

(2) Uses. To be used to cut small brush and limbs of trees while clearing land.

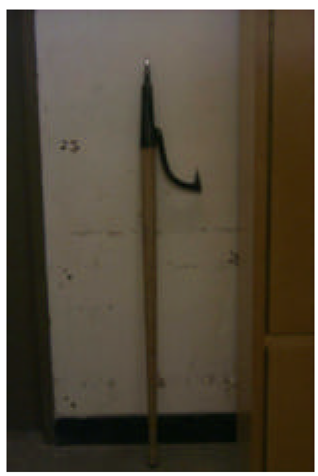
(3) Maintenance and Care. Nicks and dulled cutting edge should be removed with rounded, smooth file, sharpening from both sides. Use steel wool to clean it and put a light coat of oil on it before storing.

e. Timber Carrier (4 EA)

(1) Description. The timber carrier has a four-foot handle with a set of chisel billhooks in the center. This tool requires two men to a carrier.

(2) Uses. Designed to assist in carrying timber and logs.

(3) Maintenance and Care. Use a steel brush to clean the carrier then put a light coat of oil on the hooks. Put linseed oil on the handle to prevent the wood from drying out.

f. Peavey (2 EA)

(1) Description. The peavey has a hook, ½″ x 1″ and 10 ½″ long and a 54 inch long handle.

(2) Uses. To move logs and small trees during timber operations.

(3) Maintenance and Care. Lightly oil all metal parts and lightly linseed oil the wooden handle

g. Tree and Pole Climber's Set (1 EA)

(1) Description. The tree and pole climber's set have an adjustable support bar, 14'1/4” to 19’1/4” long, with pads and straps to connect to the climber's legs.

(2) Uses. The climber's set is used to climb trees and poles.

(3) Maintenance and Care. Use saddle soap to clean and lubricate the pads and straps, and use steel wool to clean the set of climbers. Put away with a light coat of oil.

h. Industrial Safety Strap (1 EA)

(1) Description. It is 70 inches long, 2 inches wide, and has hooks on each end that snaps onto the safety belt.

(2) Uses. To fit around a tree or pole to stabilize a person while he performs whatever work is necessary.

(3) Maintenance and Care. Use saddle soap to clean and lubricate the pads and straps, and use steel wool to clean the set of climbers. Put away with a light coat of oil.

i. Industrial Safety Belt (1 EA)

(1) Description. The safety belt is an adjustable leather belt that has loops in which to carry tools. It also has two D rings fastened to it for holding the safety strap. The safety strap is a leather strap with metal snap links on each end, for hooking into the D ring of the safety belt.

(2) Uses. To carry tools and hook on to the safety strap.

(3) Maintenance and Care. Keep leather items soft and supple by occasionally applying foot oil. Also examine all stitching frequently and repair immediately if needed. Always inspect D ring on the safety belt and snap-hooks of the safety strap frequently.

j. Mattock, Pick (2 EA)

(1) Description. The mattock head weighs 5 lb.. and is 191/2 inches long with a flat curved blade at one end and tapered point at the other end. The overall handle length is 36 inches.

(2) Uses. Used to break up hard soil or turn ground over in small sections.

(3) Maintenance and Care. Use steel wool or steel brush to clean it, then put it away with a light coat of oil.

k. Digging, Pick Type (2 EA)

(1) Description. The railroad head weighs 7 lbs. The overall handle length is 36 inches.

(2) Uses. Used to break through rock and other hard material.

(3) Maintenance and care. Use steel wool or wire brush to clean followed with light coat of oil.

l. Two Man Cross Cut Saw (2 EA)

(1) Description. The two man cross cut saw has a high grade of steel blade with two types of teeth, known as cutters and rakers. The cutter teeth are slightly longer than the raker. The cutters do the cutting and the rakers chisel. The saw is 5 to 6 1/2 feet long with a handle at each end of the blade.

(2) Uses. The two-man crosscut saw is used for heavy work such as falling trees, cutting large trees into logs, and sawing heavy timbers.

(3) Maintenance and Care. Check the nuts and bolts for tightness, use steel wool to clean it and put a light coat of oil on it before storage.

m. Timber Wedge (2 EA)

(1) Description. The timber wedge is a steel tool, one end of the wedge is slightly fan shaped and sharpened to a dull edge. The other is squared off to furnish a flat surface, which a sledge can strike when driving the wedge into the log.

(2) Uses. Used with a sledge, primarily to split logs and timber. When sawing timber or thick lumber, it may be used to spread the kerf or sawed cut so the saw will not bind.

(3) Maintenance and Care. File the chisel end to keep sharp and use a light coat of oil before storage.

n. Wrecking Bar (1 EA)

(1) Description. It is a shaft of tough steel with a gooseneck claw end. The other end is called the pinch point and is tapered down to resemble a chisel. The bar is 30 to 48 inches, with a diameter of 1/2 to 11/8 inches.

(2) Uses. Used for removing large nails, spikes and for prying.

(3) Maintenance and Care. Remove rust and repair the edge then lightly oil before storage.

o. Crowbar (1 EA)

(1) Description. The crowbar, sometimes called a tank bar is issued with the pioneer tool set. It is a steel bar, about 5 feet long, tapered to a rounded point at the end where it usually is held. There is a pinch point with a chisel-like, squared-off wedge, at the other end. Some crowbars have the pinch point set at a slight angle.

(2) Uses. Used for heavy prying and for moving heavy timbers and other large objects for short distances.

(3) Maintenance and Care. Lightly oil before storage.

p. Hammer Sledge, Blacksmith's (6 EA)

(1) Description. The blacksmiths sledgehammer has a wooden handle with an eight pound metal head.

(2) Uses. It is used to drive engineer stakes and large drift pins.

(3) Maintenance and Care. Keep lightly oiled and stored in tool kit when not in use.

q. Shovel (16 long, 8 D - Handle)

(1) Description. Open back blade, 11½ in. long, 9½ in wide; two styles.

(a) Long handle - 52" long

(b) D handle - 28" long

(2) Uses. To move dirt, rocks, or sand; can also use them to dig with.

(3) Maintenance and Care. Use steel wool to clean the shovels and then put a light coat of oil on them before storage.

r. Open End, Adjustable Wrench (4 EA)

(1) Description. Has a single head with an adjustable lower jaw, and comes in lengths of 8, 10 and 12 inches.

(2) Uses. To remove bolts and used to adjust various tools.

(3) Maintenance and Care. Put a light coat of oil on the wrenches before storage.

s. Post hole Digger (2 EA)

(1) Description. Has two clamshell shovel spade ends, with two 5 foot long handles.

(2) Uses. To dig holes for posts.

(3) Maintenance and care. Lightly oil moving joints and metal parts. Use wire brush to remove soil. Lightly sand handles to remove splinters.

t. Earth Auger (1 EA)

(1) Description. Extendible shaft with a removable wooden handle and two shovel-like curved scrapers at the cutting end.

(2) Uses. Used to make holes in clay or hard compacted soil, by turning the auger in a clockwise direction.

(3) Maintenance and care. Lightly oil all metal parts, repair any bent parts of the cutting blades. Lightly sand wooden handle to remove any splinters.

6. MANUAL LABOR TOOLS:

a. Hacksaw Blade (10 EA)

(1) Description. The hacksaw blade is a saw blade with 18 teeth per inch and 12 inches long.

(2) Uses. For sawing through both soft and hard metals.

(3) Maintenance and Care. Keep lightly oiled and you may use a stiff brush to clean the teeth.

b. Tackle Block

(1) Description:

Sheaves Qty	Nomenclature	Shell Pattern	Safe working load in Lbs.
2	II Rig 1O	Round	*5,100*
1	II Rig 10	Round	3,300
1	III Rig 23	Oval	43,800

(2) Uses. Used with fiber rope in making different block and tackle systems, (i.e., shears, gin pole, boom derrick).

(3) Maintenance and Care. Keep lightly oiled and stored in tool kit when not in use.

c. Fiber Rope

(1) Description. 3 Strand, twisted right/left lay, mildew resistant. Unit of issue 300’ coils.

(a) Rope 1.5 inches circumference, 2650 lb. min breaking strength.

(b) Rope 2.25 inches circumference, 5400 lb. min breaking strength.

(c) Rope 3 inches circumference, 9000 lb. min breaking strength.

(d) Types of rope. Manila, Sisala, Nylon

(2) Uses. With block and tackle set for heavy lifting.

(3) Maintenance and care. Store in a cool dry place keep clean, dirt free and dry when not in use. Rope management is a necessity.

d. Chain Assembly (1 EA)

(1) Description. Single leg, open linked chain, welded with 4 inch ring at one end and a grab hook at the other; 14 feet long with 20,000 lb. breaking strength.

(2) Uses. To move or tie down heavy objects.

(3) Maintenance and Care. Apply a light coat of oil and store in toolbox when not in use.

e. Marking Crayon (1 DZ.)

(1) Description. Has a clay base, hexagon type, 4 1/2 inches long and 1/2 inch wide.

(2) Uses. For marking on wet or dry lumber.

(3) Care. To be stored in container when not in use.

f. Cutter, Cable (1 EA)

(1) Description. Hand operated compound lever with 3/8-inch diameter cutting capacity, a hook guide, and insulated handles.

(2) Uses. For cutting and holding wire rope during splicing.

(3) Maintenance and Care. Keep lightly oiled. Bit should not be sharpened by file or grindstone because of the tungsten steel tip. Store in tool kit when not in use.

g. Cutter, Bolt (1 EA)

(1) Description. Hand operated compound lever with a 3/8-inch diameter cutting capacity.

(2) Uses. For cutting bolts, nuts, chains, wire, etc.

(3) Maintenance and care. Keep lightly oiled. Bits should not be sharpened by file or grindstone because of the tungsten steel tip. Store in tool kit when not in use.

h. Jaw, Cable Grip (1 EA)

(1) Description. The jaw cable grip is a metal tool with an eye at one end that is used for fastening it to a hook. The other end has both smooth and saw tooth notched jaws.

(2) Uses. Has a grip strong enough to hold 5,000 lb.. safe load during splicing operations.

(3) Maintenance and Care. Keep lightly oiled and stored in tool kit when not in use.

i. Hand Oilier (1 EA)

(1) Description. Is a hand type oiler with spout and internal pump and valve lever control.

(2) Uses. To be used to pump oil as required for lubricating tools and equipment.

(3) Maintenance and Care. Keep clean, rust free and at least 1/3 full. Keep it in the tool kit when not in use.

j. Wedge, tool handle. (1 DZ.)

(1) Description. Steel wedges 1.25 in length 1.75 in width.

(2) Uses. Attaching wooden handles to sledge hammers, axes.

(3) Maintenance and care. Store in kit when not in use.

k. Wire, non-electrical. (2 EA)

(1) Description. Steel wire 480’ per spool, 100,000 lb. psi min tensile strength, 5 lb. each.

(2) Uses. General purpose.

(3) Maintenance and care. Keep in kit when not in use, and lightly oiled.

l. Pipe Wrench. (2 EA)

(1) Description. Made of iron or steel; 1 in min and 2 in max, 18” in length.

(2) Uses. Gripping and turning a cylindrical object (as in a pipe).

(3) Maintenance and care. Kept free of rust and lightly oiled, and stored in kit when not in use.

m. Puller, Ratchet Lever, Cable type. (2 EA)

(1) Description. 20’ take up; .25 cable dia; Cable assembly designed for 5000 lb. static load; 3000 lb. working load.

(2) Uses. Used for lifting, Tying down, Tightening fences, light vehicle recovery.

(3) Maintenance and care. Kept clean and free of dirt and cable lightly greased.

n. Gloves, barbed wire. (12 PR)

(1) Description. Leather Gloves lined with flannel (Gauntlets), stapled palm side.

(2) Uses. For caring or laying barbed wire or concertina.

(3) Maintenance and care. Keep clean by brushing with a stiff brush, kept in kit when not in use, if wet air dry do not store if wet or they will mildew.

o. Nails

(1) Description. Cold formed; flat; smooth round shank; diamond point; fastener. 100 lb. of 40D, 20 lb. of 8D

(2) Uses. For general and heavy wood construction.

(3) Maintenance and care. Keep in a dry place.

7. INVENTORY AND MAINTENANCE

a. Inventory. All sets, kits, and chests contain a stock listing which lists all the tools for that particular set, kit or chest. This listing is called an SL-3. The SL-3 not only contains the name of each tool in the kit, but also contains:

(1) Description of the tool

(2) The National Stock Number (NSN) of each tool which enables you to order missing or unserviceable components.

(3) The unit of issue (i.e. - each, roll, feet, etc.) for that particular tool.

(4) The quantity of each tool that is to be in that particular set, kit or chest.

(5) Some SL-3's contain pictures of the components of that set, kit or chest.

(6) A description of the set, kit or chest and how it is used.

b. Maintenance: It is every engineer's responsibility to ensure they are familiar with all tools and equipment and their use. Also the cleaning and maintenance of each.

8. GENERAL SAFETY RULES IN USING HAND TOOLS

a. Before using any hand tool, inspect it. Repair and replace loose, splintered or defective handles, damaged blades or parts; rough edges or burs; and any other defects that lessen the strength of the hand tool or make it unsafe for use.

b. Store hand tools in a suitable storage space so that the tools do not injure persons who are storing removing, or working with them in the tool room. Serious injuries can result from a cluttered tool room.

c. Be sure hand tools are not dirty, oily, or greasy. Dirt or grease can cause the tools to slip out of the hand or off the work surface, resulting in injury.

d. Do not carry sharp edged or pointed tools in pockets where they can protrude and cause injury. Types of tools that can be carried on the person, like the machete or small twist drill bits, should be carried in a safe container or sheaths.

e. Do not use tools made of metal or power tools in locations where sources of ignition may cause a fire or explosion.

f. Wear safety goggles or other approved safety type face and eye protectors when breaking rocks, grinding, striking metal with metal, drilling, driving wedges chipping, or performing similar operations that might result in flying particles. Be sure others in the vicinity are protected in the same way.

g. Do not toss tools from one location to another. Do not drop tools to another level or throw them to another worker. When hand tools cannot be passed between personnel use suitable containers or rope.

h. Do not work on electrical circuits while the current is on. Turn the current off at the source. Even though a wooden handle may give some protection, the current could arc and cause body burns as well as damage to the hand tool.

i. Do not wear loose fitting (or torn clothing, or jewelry that may cause injury by becoming entangled with the hand tools.

j. Steady or secure with clamps or vises any loose material to be cut, sheared, chiseled, or filed to prevent the tool from slipping and causing injury.

k. Keep all hand tools in good condition because dull or defective tools can injure the user or others in the vicinity.

1. Do not swing a chopping or chipping tool until certain that no one in the vicinity will be endangered by the back swing; by a possible glancing off of the tools; by chips flying from the work or by a tool head loosening from the impact of the work.

m. Do not allow pointed or edged tools to lie around on work surfaces, sawhorses, or on the ground in such a position that persons brushing against them may suffer injuries. When not in use all tools should be placed in a toolbox or in a position that will prevent injuries to persons in the area.

n. When hand tools are being used, do not expose fingers or parts of the body of the worker or those in the vicinity to injury by the tool.

o. Use each hand tool only for the purpose which it is intended. Tools used improperly can break or become damaged in a manner that may cause injury.

9. POWER TOOLS

a. Radial Arm Saw

(1) The radial arm saw can be positioned for most angle cutting and finishing work when equipped with the proper accessories. The radial arm saw can be fixed for ripping as well as cross cutting. The arm can be moved to an angle of 45 degrees to 90 degrees to the fence "left or right". The motor can be tilted allowing for bevel cutting.

(2) Safety rules for the Radial Arm Saw

(a) The stock must be held firmly on the table and against the fence on all cutting operations.

(b) Before turning on the motor, be sure clamps and locking devices are tight. Check depth of cut and table slope.

(c) Keep the guard and the anti kickback device in position at all times.

(d) Maintain a six-inch margin of safety, keep your hands this distance away from the saw blade at all times.

(e) Shut off motor and wait for the blade to stop turning completely before making any adjustments.

(f) When ripping, always feed stock into the blade so that the bottom teeth are turning toward you.

b. Portable Circular Saw

(1) This power tool is also called an electrical handsaw. Its size is determined by the diameter of the largest blade it will take. The depth of cut is adjusted by raising or lowering the position of the base shoe. On most saws

it is possible to make beveled cuts by tilting the shoe. The types of blades that are used with the electric handsaw are; Rough cut combination, Rip, Crosscut, and standard combination or mitered. To use a portable saw grasp the handle firmly with one hand with the forefinger ready to operate the trigger switch. The other hand should be placed on the hand knob. Rest the base on the work and align the guide mark with the layout line. Turn on the switch, allow the motor to reach full speed, and then feed it smoothly into the stock. Release the switch as soon as the cut is finished. Hold the saw until the blade stops.

(2) Safety Rules for the Portable Circular Saw

(a) The stock must be well supported in such a way that the kerf will not close and bind the blade during the cut.

(b) Be careful not to cut into supporting devices.

(c) Adjust the depth of the cut to the thickness of the stock plus 1/8 of an inch.

(d) Be aware that kickback can occur at anytime. Kickback is the tendency of the saw to lift and back out of the wood piece. When the blade binds or encounters excessive resistance (dull blade).

(e) Always wear ear and eye protection.

(f) Unplug power source before changing blade.

c. <u>Jig Saw/Saber Saw</u>

(1) <u>The saber saw</u> is also called a portable jigsaw. It is used for a wide range of light work. The stroke of the blade is about l/2 inch. The saw operates at a speed of approximately 2500 strokes per minute.

(a) For general-purpose work, a blade with ten teeth per inch is satisfactory. Always select a blade that will have at least two teeth in contact with the edge being cut.

(b) Saws will vary in the way the blade is mounted in the chuck.

(c) The saber saw can be used to make straight or beveled cuts. Curves are usually cut by guiding the saw along a layout line. However, circular cuts may be made more accurately with a special guide attachment.

(d)Since the blade cuts on the upstroke, splintering will take place on the topside of the work.

(2) Safety rules for the Saber/Jig Saw

(a) The switch must be in the off position before plugging the saw in.

(b) Select the correct blade.

(c) Disconnect the saw before you change the blade or for adjustments.

(d) Place the base of the saw firmly on the stock before cutting.

(e) Turn on the motor before the blade makes contact with the work.

(f) Do not attempt to cut curves so sharp that the blade will be twisted.

d. Portable Electric Drills

(1) Portable electric drills come in a wide range of types and sizes. The size is determined by the chuck capacity; usually 1/4, 1/8, or 1/2 inch. Speed of approximately 1000 rpm is best for woodworking.

(2) Bits for portable electric drills come in several types:

(a) Spade bits for light duty work.

(b) High speed twist drills.

(c) Extended double twist bits.

(d) Ship auger.

(3) Safety rules for portable electric drills.

(a) Select the correct drill bit for your work and secure it in the chuck.

(b) Hold the stock so that it does not move during operation.

(c) Be sure that the switch is in the off position and the plug disconnected before changing drill bits.

(d) Hold the drill firmly in one or both hands and at the correct drilling angle.

(e) Turn on the switch and feed the drill into the work.

(f) The amount of pressure required on the drill will vary, according to the size of the drill and the kind of wood being drilled.

(g) During operation keep the drill aligned with the direction of the hole.

(h) When drilling deep holes, especially with a twist drill, withdraw the drill several times to clear the hole.

(i) Always remove the bit from the drill as soon as you have completed your work.

e. Cordless Driver/Drill and Charger

(1) Refer to operating instructions of electric drill.

(2) Safety instructions for charger

(a) Before Using A Battery Charger. Read all instructions and cautionary markings on battery charger and battery pack.

(b) Caution. To reduce risk of injury, Porter-Cable charger Model 8501 should only be used to charge Porter-Cable battery pack Model 8500. Other types of batteries may burst causing personnel injury and damage. Do not charge Porter-Cable Model 8500 battery pack with any other charger.

(c) Do not expose charger to rain, snow or frost.

(d) Do not operate charger if it has received a sharp blow, been dropped or otherwise damaged in any way; take it to a qualified serviceman.

(e) Do not disassemble charger or battery pack. Take it to a qualified serviceman when service or repair is required. Incorrect reassembly may result in a risk of electric shock or fire.

(f) Unplug charger from outlet before attempting any maintenance or cleaning to reduce risk of electric shock.

(g) Charge the battery pack in a well-ventilated place, do not cover the charger and battery pack with cloth, etc., while charging.

(h) Do not charge battery pack when the temperature is BELOW 50 degrees F or ABOVE 104 degrees F. This is very important for proper operation.

(i) Do not incinerate battery pack as it can explode in a fire.

(j) Do not charge battery in damp or wet locations.

(k) Do not attempt to charge any other cordless tool or battery pack with the Porter-Cable Model 8501 charger.

f. 10" Tilting Arbor Saw

(1) The tilting arbor saw is also referred to as the table saw. It is used for ripping stock to width and cutting it to length. It can also cut bevels, chamfers and tapers. When used for construction the smaller 8 to 1O inch size table saw is used.

(2) Safety rules for the tilting arbor saw

(a) Be sure the blade is sharp and right for the job.

(b) Make sure the saw is equipped with a guard and use it.

(c) Extend the blade 1/4-inch above the stock to be cut.

(d) Maintain a 4-inch margin of safety. (Do not let your hand come closer than 4 inches to the operating blade).

(e) Always use a push stick when ripping short narrow pieces.

(f) Stop the saw before making adjustments.

(g) Remove any special blades after use.

(h) Control the feed and the direction of the cut.

(i) As work is completed, turn off the machine and remain until the blade stops turning.

(j) Clear the saw table of all waste.

(k) Lower the blade when not in use.

g. Portable Sanders

(1) Portable sanders include three basic types; belt, disc, and finish.

(2) Sanders vary widely in size and design. The manufacturer's instructions should be followed carefully in the mounting of abrasive belts, discs, and sheets. The belt sanders size is determined by the width of the belt.

(3) Using the sander takes some skills. Make sure the stock is supported firmly and make sure the switch is in the off position before plugging in the electrical cord. Check the belt and make sure it is tracking properly.

(4) Hold the sander over the work and start the motor. Lower the sander carefully and evenly onto the surface. when using belt and finish sanders, make sure to travel with the grain, move it forward and backward over the surface. Do not press down on the sander.

(5) When the work is completed raise the sander from the surface and allow the motor to stop.

(6) Finishing sanders are used for final sanding when only a small amount of material needs to be removed. There are two types; orbital and oscillating.

(7) Safety rules for portable sanders

(a) Ensure that you are wearing eye and ear protection.

(b) Make sure that you are not wearing any loose clothing or jewelry.

h. <u>Jointers</u>

(1) The jointers are used for jointing and planing operations. These operations are basically the same. Jointing cuts the edge of the wood to make it square. Planing is identical to jointing except for the position of the work piece. For planing, the major flat surface of the work piece is placed on the table of the jointer with the narrow edge of the work piece against the fence.

(2) Safety rules for the jointer.

(a) Before turning on the machine, make adjustments for the depth of the cut and position of the fence and that the guard is operating properly.

(b) The maximum cut for jointing on a small jointer is 1/8 inch for the edge and 1/16 inch for a flat surface.

(c)Stock must be 12 inches in length and stock to be surfaced must be 3 1/8″ thick.

(d) Use stock free from knots and splits.

(e) Maintain at least a four inch margin of safety.

(f) Use a push block when planing a flat surface.

(g) Do not plane end grain unless the board is at least 12 inches wide.

(h) When work is completed turn off the machine.

i. Pneumatic Stick Nailer

(1) Operation:

(a) Always handle the tool with care, never engage in horseplay. Never pull trigger unless nose is directed toward the work. Keep others a safe distance from the tool while tool is in operation as accidental actuation may occur, possibly causing injury.

(b) The operator must not hold the trigger pulled on contact arm tools except during fastening operation as serious injury could result.

(c) Keep hands and body away from the discharge area of the tool. A contact arm tool may bounce from the recoil of driving a fastener and an unwanted second fastener may be driven possibly causing injury.

(d) Check operation of the contact arm mechanism frequently. Do not use the tool if the arm is not working correctly as accidentally driving of a fastener may result. Do not interfere with the proper operation of the contact arm mechanism.

(e) Do not drive fasteners on top of other fasteners as this may cause deflection of fasteners which could cause injury.

(2) Safety Rules for Pneumatic Nailer

(a) Always wear ear and eye protection.

(b) Do not use oxygen, combustible gases, or bottled gases as a power source for this tool as tool may explode, possibly causing injury.

(c) Do not use supply sources which can potentially exceed 200 psi. As tool may burst, possibly causing injury.

(d) The connector on the tool must not hold pressure when air supply is disconnected. If a wrong fitting is used, the tool can remain charged with air after disconnecting and thus will be able to drive a fastener even after the air line is disconnected possibly causing injury.

(e) Do not pull trigger or depress contact arm while connected to the air supply as the tool may cycle, possibly causing injury.

(f) Always disconnect air supply: (1) Before making adjustments. (2) When servicing the tool. (3) When clearing a jam. (4) When tool is not in use. (5) when moving to a different work area, as accidental actuation may occur, possibly causing injury.

(g) When loading tool: (1) Never place a hand or any part of body in fastener discharge area of tool. (2) Never point tool at anyone. (3) Do not pull the trigger or depress the trip as accidental actuation may occur, possibly causing injury.

10. General rules for power tools

a. Safety must be practiced continually. Before operating any power tool, read the manual to become thoroughly familiar with the way the tool works and the correct way to use it.

b. You must be wide awake and alert. Never operate a power tool when tired or ill. Know what you are going to do and what the tool is capable of doing. Make all adjustments before turning on the power. Be sure the blades and cutters are sharp and are of the correct type for the work. While operating a power tool, do not allow yourself to be distracted. Keep all safety guards in position and wear safety glasses and hearing protection. When operation is completed, turn off the power and wait until the moving parts have stopped before leaving the machine. When making adjustments to power tools the plug should be disconnected from the power source.

c. Always make sure that the source of the electrical power is the correct voltage and that the tool switch is in the "OFF" position before it is plugged into an electrical outlet.

d. The electrical cord and plug must be in good condition and must provide a ground for the tool. If hooking up to a generator or extension line, make sure the conducting wire is large enough to prevent excessive voltage drop.

e. Place electrical extension cords where they will not be damaged or interfere with other workers.

f. Wear clothing appropriate for the work and weather condition. Keep utility shirts and jackets buttoned. Never wear loose, ragged clothing or jewelry around moving machinery.

g. Never leave power tools running or unattended. Be sure the motor is turned OFF prior to leaving a power tool.

NOTE: All portable electric tools should not be operated near flammable liquids or in gaseous or explosive fumes. Motors in the tools normally spark. Do not expose power tools to rain.

REFERENCE(S):

TM 5-461 Engineer Hand tools

UNITED STATES MARINE CORPS

COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C-01A14
6 Mar 01
(98 POI)

STUDENT HANDOUT

TEMPORARY FACILITIES

1. **Purpose**: This period of instruction is to provide you with the knowledge necessary to design and build temporary facilities.

2. **Learning Objectives**:

a. Terminal Learning Objective(s):

(1) Given a construction directive and blueprints, with the aid of reference, identify specifications within the blue prints, per the reference. (1302.1.30)

(2) Given a mission, construction drawings, specifications, a construction plan, with the aid of reference, construct a temporary facility, per the reference. (1302.1.31)

(3) Given a mission requiring temporary facilities and references, design temporary facility to meet mission requirements per the reference. (1302.1.39)

b. Enabling Learning Objectives:

(1) Given a mission to plan temporary facility, with the aid of reference, identify the building specifications per the reference. (1302.1.30a)

(2) Given a set of blueprints, construction drawings, and materials required, with the aid of reference, lay out a building per the specifications, per the reference. (1302.1.31a)

(3) Given a mission to lay out a building per the specifications, with the aid of reference, make out a tool and material list, per the reference. (1302.1.31b)

(4) Provided with a construction drawing, with the aid of reference, establish building lines per the reference. (1302.1.31c)

(5) Provided with construction drawings, with the aid of reference, set batter boards per the specification, per the reference. (1302.1.31d)

(6) Provided with a set of construction drawings, with the aid of reference, identify the components of a wood frame structure, per the reference. (1302.1.31e)

(7) Provided with a construction drawing, with the aid of reference, estimate the material needed to build the structure, per the reference. (1302.1.39a)

OUTLINE

1. **CONSTRUCTION PRINTS**: Construction prints or as they are sometimes called "blueprints", is a set of drawings. These drawings are called working drawings. With construction prints you can identify the shape, description, and the material types and sizes of an object. This enables you to visualize the object that is on the print. All manufactured items have prints to show how they are made, how the parts fit together, and how the finished product should appear. Prints or working drawings are very useful in assisting in such areas as: planning, scheduling, estimating, and developing a CPM for a project. They assist in such areas as determining if a modification is needed and knowing what components are used in the assembly or structure after the project is completed.

a. Types of Views Used in Architecture Drawings.

(1) Perspective Views are drawings of an object as it would actually appear to an observer. Perspective views have vanishing points, which are imaginary points off the drawing that are used to create a 3 dimensional view. Most common types are the two-point perspectives.

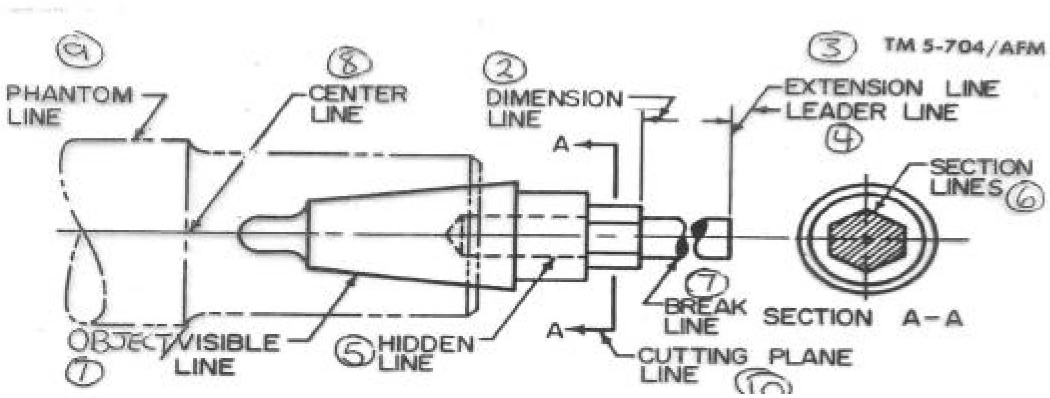
(2) Isometric Views are picture-like views, in which vertical lines or angles remain vertical. The horizontal lines are drawn at a 30-degree angle. All lines are scale measurements and do not have vanishing points. Due to the vertical lines being the reference point isometric drawings are distorted views.

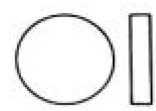
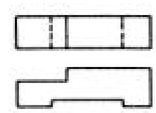
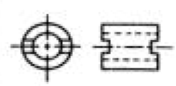
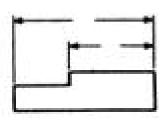
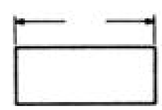
(3) Plan views display the interior arrangement of a structure, as it would appear from above. Plan views make imaginary section cut approximately 4 feet above the finish floor, removing the roof to show outside shape of the structure. Most common types are floors, foundation, electrical, plumbing.

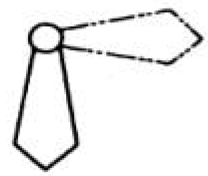
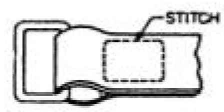
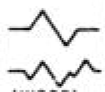
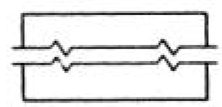
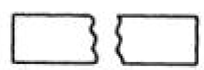
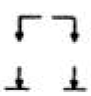
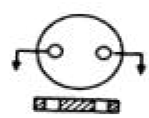
(4) Elevation Views shows an object, as it would look if you were standing directly in front of it.

(5) Sections and Details drawings are cut-away drawings that show assemble of the structure. Builders use section and detail drawings to plan the construction procedures. Most common are wall sections, roof section, fascia details, door and window details and foundation details.

b. Convention Lines. All necessary information on a drawing in a meaningful manner, different types and weights of lines is used to represent the features of the object.



VISIBLE LINES		HEAVY, UNBROKEN LINES. USED TO INDICATE VISIBLE EDGES OF AN OBJECT.	
HIDDEN LINES		MEDIUM LINES WITH SHORT, EVENLY SPACED DASHES. USED TO INDICATE CONCEALED EDGES.	
CENTER LINES		THIN LINES MADE UP OF LONG AND SHORT DASHES ALTERNATELY SPACED AND CONSISTENT IN LENGTH. USED TO INDICATE SYMMETRY ABOUT AN AXIS AND LOCATION OF CENTERS.	
DIMENSION LINES		THIN LINES TERMINATED WITH ARROWHEADS AT EACH END. USED TO INDICATE DISTANCE MEASURED.	
EXTENSION LINES		THIN, UNBROKEN LINE. USED TO INDICATE EXTENT OF DIMENSIONS.	
LEADER		THIN LINE TERMINATED WITH ARROWHEAD OR DOT AT ONE END. USED TO INDICATE A PART, DIMENSION, OR OTHER REFERENCE.	

NAME	CON-VENTION	DESCRIPTION AND APPLICATION	EXAMPLE
PHANTOM OR DATUM LINE		MEDIUM SERIES OF ONE LONG DASH AND TWO SHORT DASHES EVENLY SPACED ENDING WITH LONG DASH. USED TO INDICATE: ALTERNATE POSITION OF PARTS, REPEATED DETAIL, OR A DATUM PLANE.	
STITCH LINE		MEDIUM LINE OF SHORT DASHES. EVENLY SPACED AND LABELED. USED TO INDICATE STITCHING OR SEWING.	
BREAK (LONG)	 (WOOD)	THIN, SOLID RULED LINE WITH FREE-HAND ZIGZAGS. USED TO REDUCE SIZE OF DRAWING REQUIRED TO DELINEATE OBJECT AND REDUCE DETAIL.	
BREAK (SHORT)		THICK, SOLID FREE-HAND LINES. USED TO INDICATE A SHORT BREAK.	
CUTTING OR VIEWING PLANE—VIEWING PLANE OPTIONAL		THICK, SHORT DASHES. USED TO SHOW OFFSET WITH ARROWHEADS TO SHOW DIRECTION IN WHICH SECTION OR PLANE IS VIEWED OR TAKEN.	
CUTTING PLANE FOR COMPLEX OR OFFSET VIEWS		THICK, SHORT DASHES. USED TO SHOW OFFSET WITH ARROWHEADS TO SHOW DIRECTION VIEWED.	

(1) Object lines are thick lines that show the boundaries of the object (i.e. floor plan walls, machine parts).

(2) Dimension lines terminate with arrowheads or tick marks at both ends. They may be broken or unbroken depending on what type of dimension symbol is used. Unidirectional dimension systems will have broken dimensions lines, which is used for machine drawings. Architectural dimension systems will have unbroken dim lines used for architectural (building) drawings.

(3) Extension lines are used to show the extent of the dimension or measurement.

(4) Leader lines will be used to indicate the part or feature to which a number, note or other information refers.

(5) Hidden lines are dotted lines that show hidden features of an object.

(6) Section lines show where the imaginary cut is made for the cross-section view of an object.

(7) Break lines are thin lines interrupted by a Z-shaped symbol. They indicate that the object may have been shortened to save space on the drawing. The true length is shown on the dimension line.

(8) Centerlines are composed of long and short dashes. They are used to indicate the center of: holes, curves, arcs, finished floor, finished ceiling, and are used to indicate the centerlines of roads.

(9) Phantom lines are medium series of one long dash and two short dashes evenly spaced ending with a long dash. They are used to indicate the alternate position of parts or repeated detail.

2. **WORKING DRAWINGS**: Working drawings are the architectural plans for the construction of temporary facilities. They enable the viewer to create what the engineer of the drawings has envisioned. The drawings come in sets, which include all the plans that are required to pass the information along.

a. The perspective drawing is an artist's conception of the finished building (but not always included); this allows the customer to see the finished product.

b. The index sheet contains an index of all of the drawings in the set. It also contains a list of symbols as contained in TM 5-704.

c. The site plan or plot plan, which may contain a proximity drawing which, enables the user to locate the working area. The site plan specifies details where the structure is to be located. Included in the site plan are:

(1) Boundaries.

(2) Contours.

(3) Roads.

(4) Utility Lines.

(5) Structure Location.

(6) North Arrow (for orientation).

(7) Legend to identify marks and symbols used.

d. The foundation plans are used to show the substructure of the building. Other pertinent information derived from the foundation plan includes:

(1) Shows footings, perimeter walls, piers, pilasters or girders.

(2) Framing information.

(3) Shows what the finished grade is required to be.

(4) Notes about the project, which must be read and understood.

e. The floor plan is the first drawing made of the structure and shows:

(1) The shape of the building.

(2) Size and shapes of rooms.

(3) Location of doors and windows (also enclosed on door and window schedule.

(4) Stairs.

(5) References to other drawings.

(6) Used to draw the electrical plan, foundation plan, plumbing plan, and HVAC plan and elevation drawings.

f. Elevation drawings are used to show final height and finish materials. Included on this drawing:

(1) Rough-opening height of windows and doors.

(2) Roof overhangs distance.

(3) Type of exterior materials (siding, roofing, etc.).

g. The electrical plan is used to build the material takeoff for electrical components, and the location of all the electrical components. Included on this drawing:

(1) Service entrance.

(2) Power Panel.

(3) Convenience outlets (receptacles).

(4) Switches.

(5) Type of wiring (to include sizes).

(6) Circuits to lighting panel (numbered).

(7) Location of installed lighting.

h. The plumbing plan is also used to develop the material takeoff for the plumbing materials, and the location of all plumbing components. Included on this drawing:

(1) Complicated systems will be detailed with isometric drawings.

(2) Waste system.

(3) Water supply - hot and cold.

(4) Symbols (plumbing fixtures such as water closets, sinks, etc.).

(5) Venting system.

i. HVAC (Heating, Venting, and Air Conditioning) plan is also used to develop the material takeoff for the HVAC materials, and the location/type of all HVAC components. Included on this drawing:

(1) Heater location and type.

(2) Air condition location and type.

(3) Ducts location and sizes.

(4) Any special features to move air (turbo fans, ceiling fans, etc.).

3. **SECTION AND DETAIL DRAWINGS**: May have one or more section/details on one sheet. The types of section/details that may be encountered include:

a. Typical wall section - next to the floor plan the wall section is probably the most important drawing in the set of prints. It explains everything about how the wall is to be constructed. In construction, a wall is the exterior portion of the framing. A partition is the divider between rooms.

b. Stair detail - includes the placement as well as the stringers, risers and treads.

c. Sill detail - includes the type of material to be used, size, and whether it will be used for a regular door or a sliding door.

d. Wall framing detail and roof framing for unusual situations.

e. Any feature that may be unique or that engineer deems appropriate.

4. **MARKING UP OF WORKING DRAWINGS**: After the building is complete the working drawings must be turn in to the S-3 section. These working drawings should be marked up to show any changes or improvements.

a. YELLOW is used for showing the building as built. This is also a method to check your work.

b. BLUE is used to show minor changes on your working drawings (i.e. dimension incorrect).

c. RED is used to show major changes on your working drawings (wall placement, design change).

5. **BUILDING ALIGNMENT**

a. Building alignment is the correct placement of the building on the site. To ensure that the building will look square in relation to the other buildings or structures, several methods may be used.

b. Use an existing structure as a reference point to start measuring from.

(1) To keep alignment, hold a string line from the far corner of an existing building and run the string along the foundation, making sure the string line just touches the existing structure, to the site of the new structure.

(2) Measure distance between buildings from the near corner out to where the building will be located. As a rule of thumb you should not go any further than 90 feet.

c. Use the centerline of a highway because it is usually the straightest part of the road. This will also ensure that the building will not look out of position or be misaligned.

d. Use monuments as a reference.

(1) Natural: Boulders, streams, trees, etc.

(2) Man-made.

(a) Pipe or stake driven into ground.

(b) Bench markers - predetermined areas on the earth (a point of reference from which measurements may be taken).

6. **CORNER STAKES**

a. Purpose

(1) The finishing nail, located in the center of the corner stakes, shows where the final corners of the building will be located.

(2) It gives the exact measurement of the building's perimeter.

b. Methods of determining a right angle

(1) Purpose: To place the stakes squarely or line the stakes up with each other.

(2) Use of Carpenters Square

(a) Least preferred method because it is not very accurate for buildings over 8'x 8'.

(b) Place the square at one corner where two strings come together and square the strings by moving the ends in or out. This process has to be done at all four corners. Remember not to move the corner already squared.

(3) 3-4-5/6-8-10 method.

(a) Much more accurate, but you must start with two strings anchored at 90 degrees to each other.

(b) Place a thick mark 4' out on one line and 3' out on the other line and measure 5' between.

(4) The two steel tape measuring method.

(a) Most accurate method, but requires at least three people.

(b) Must use a diagonal distance for this method. Get this distance with the use of the Pythagorean Theorem; $A^2 + B^2 = C^2$

(c) Our example is a building 16 x 32.

Step #1 Pythagoream Theorem Formula:

$$\begin{array}{rl} & A^2\ (16' \times 16' = 256') \\ + & \underline{B^2\ (32' \times 32' = 1024')} \\ & C^2 \qquad\qquad 1280' \end{array}$$

Step #2 Take the square root of 1280': $\sqrt{1280}$ = 35.777087'

Step #3 Convert this answer to inches:

$$\begin{array}{r} 35.777087' \\ \underline{-\ 35.000000} \\ .777087' \\ \underline{\times\ 12\text{" per foot}} \\ 9.325044\text{"} \end{array}$$

Step #4 Convert this answer to 16^{th} of an inch:

$$\begin{array}{r} 9.325044\text{"} \\ \underline{-\ 9.00000} \\ .325044\text{"} \\ \underline{\times\ 16\ (16^{th}\text{/inch}} \\ 5.200704 \end{array}$$

Step #5 Overall answer $A^2 + B^2 = C^2$: 35.777087' or 35' 9 5/16"

c. Placing the corner stakes using the two steel tape method.

(1) First stake

(a) Get the building alignment

(b) Measure distance from existing structure.

(c) Drive 2 x 2 stake under string.

(d) Remeasure and put a finish nail at the exact point of measurement and under the string.

(2) Second Stake

(a) Lay out width of building from the nail on the first stake and place a 2 x 2 stake under the string at the exact measurement.

(b) Remeasure and place a finishing nail at the exact width under the string. Remeasure from the nail to the stake for accurate placement of the nail.

(c) Check both the alignment and the measurement of first and second stakes.

(3) Third Stake

(a) Using the two steel tape method, place the first steel tape on the first corner stake and measure out the length of the building to approximate point of where the third stake will go.

(b) Place the second tape on the second stake and run it diagonally to where the third stake should be.

(c) Make the two tapes intersect at the length measurement and its diagonal measurements (35' 9 5/16").

(d) At the intersection place the third stake. Move the tape and drive the stake in.

(e) Remeasure and place a finish nail at that intersection.

(4) Fourth Stake. Follow the same procedure that was used for the third stake.

(5) Check Corner Stakes

(a) Ensure a 90-degree angle is obtained.

(b) Check diagonal distances and make sure they are equal and correct.

(c) If there are any corrections to be made, the first and second stakes will not be moved. These stakes are also called alignment stakes. Adjust the layout by moving the third and fourth stakes.

7. **BATTER BOARDS**

a. Purpose

(1) Supports the building lines during early stages of construction.

(2) Used as a reference point, should the building lines be needed once construction has started.

b. Requirements for Batter Board Stakes

(1) Should be cut from 2 x 4 material at least five feet long.

(2) Need at least three per corner.

(3) Stakes should be pointed on one end for easy driving and should be driven in at least one foot.

c. Requirements for Batter Boards

(1) Should be at least five feet long and made from 1 x 4 or 1 x 6 material. Need two per corner.

(2) Placed at least three feet from the corner stakes to give enough working room when digging footings.

(3) Placed at 90 degrees or as close as possible for appearance.

d. Method of installation

(1) First install the batter board stakes to hold the batter boards.

(2) With the stakes in place, begin to set up the batter board starting at the highest point if ground is not level.

(3) The height of the batter boards will usually represent the height of the finished floor.

(4) Measure up on the corner batter board stake to the desired height of the finished floor.

(5) Place batter boards on stakes and level them.

(6) Once leveled, run a string line to the next set of stakes and use a line level to get the next set of batter boards level with the first set.

(7) Repeat until all batter boards are installed.

e. Check Installations

(1) Run line with line level to see if all sets of batter boards are level.

(2) Check each set of batter boards with carpenter's level.

8. **BUILDING LINES**

a. Purpose

(1) Shows the outline of the building.

(2) Provides a ready reference of the building's dimensions.

(3) Preserves the building's dimensions during early stage of construction.

b. Installation of Building Lines.

(1) Run string from the head of the nail on stake #1 to the top of the batter board at corner #2.

(2) Set up the carpenter's level on stake #2 up against the finish nail and make the head plumb.

(3) Roll the string so that it easily touches the level and mark the batter boards.

(4) Once the board is marked, check it and make a saw cut on the top back side of the board. Cuts are made for easy removal and replacement of building lines.

(5) Place a nail below the cut.

(6) Repeat the process until all batter boards are marked and cut.

(7) After all boards are marked and cut, install the strings.

c. Final Check

(1) Check diagonal distance to see if they are correct and equal.

(2) Insure strings cross over each other lightly and that they intersect directly over the finishing nails.

9. **WOOD FRAME CONSTRUCTION**

a. Framing is the rough timberwork of a building.

b. Types of Wood Frame Construction

(1) Heavy Wood Framing

(a) Heavy wood framing consists of framing members at least six inches in dimension (timber construction).

(b) This type of construction is used in structures such as bunkers and nonstandard bridges.

(2) Light Wood framing

(a) Light framing is used in barracks, administration buildings, light shop buildings, hospital buildings, and similar structures.

(b) Light wood framing consist of framing members of common lumber as in 2 x 4's, 1 x 2's, plywood, etc.

c. The major differences between heavy and light framing are the size of the timber used and the type of fastener used.

10. **LUMBER**

a. Size.

(1) Lumber is usually sawed into standard size, length, width, and thickness. Standards have been established for dimension differences between quoted size of lumber and its standard sizes when dressed. Quoted sizes refer to the dimensions prior to surfacing.

(a) These dimension differences must be taken into consideration. A good example of the dimension difference is the common 2 x 4 untreated. The familiar quoted size 2 x 4 is the rough or nominal dimension but the actual dressed size is 1 1/2 by 3 1/2 inches.

(b) The treated lumber may vary due to swelling or shrinkage during the pressure treating process.

(2) Plywood is usually in a standard size of 4’ x 8’ and thickness varies; 1/2", 5/8", and 3/4".

b. Grade. Lumber is subdivided into classifications of select lumber and common lumber. Common lumber is suitable for general construction and utility purposes.

(1) Common lumber is graded from No 1 to No 5 common (No 1 being of the best grade). No 2 common is the most commonly used for framing construction.

(2) Plywood is graded a little different with the best being AA and the worst being CD. CD is the most commonly grade used for exterior sheathing.

11. **FASTENERS**

a. Nails

(1) Common nails. The Common Wire nail is used in housing construction framing.

(2) Finishing nails. The finishing nail is made of finer wire and has a smaller head than the common nail. It may be set below the surface of the wood and leaves only a small hole easily filled with putty. It is generally used for interior and exterior finishing work and for finished carpentry and cabinet-making.

(3) Scaffold or form nails. These nails appear to have two heads. The lower head (shoulder) permits the nail to be driven securely home while the upper head projects above the wood to make it easy to pull. This nail is not meant to be permanent.

(4) Roofing nails. Roofing nails are round-shafted, diamond-pointed, and galvanized. They are of relatively short length and large head. They fasten flexible roofing and resist continuous exposure to weather.

(5) Cut nails. Cut nails are wedge-shaped with a head on the large end. They are often used to nail flooring because they are of a very hard steel and have good holding power.

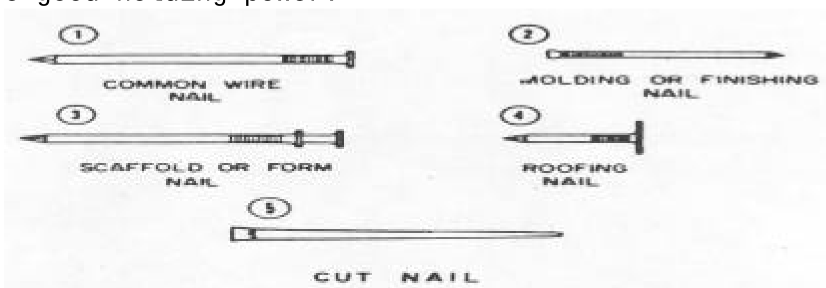
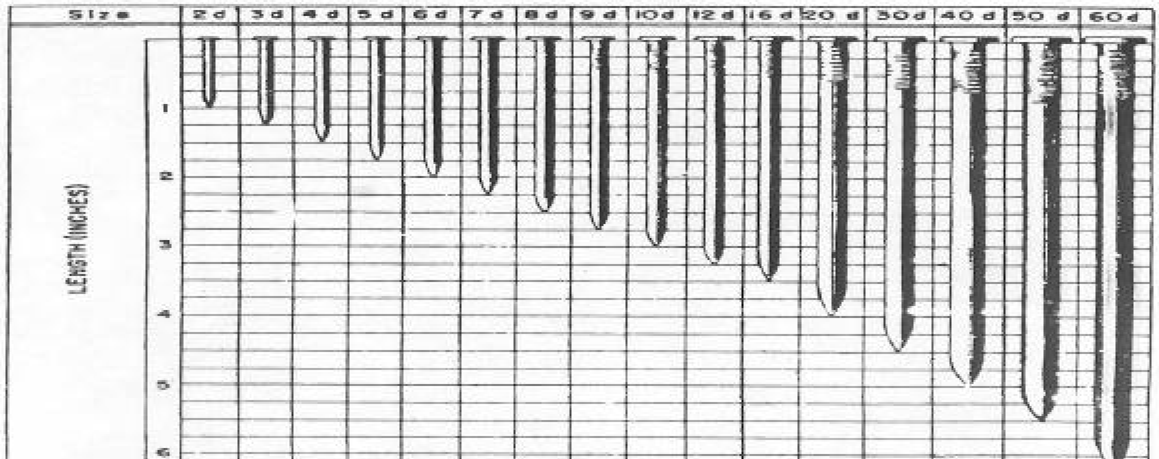


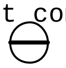
Figure 3-6. Types of nails.

(6) Nail size. Nail sizes are designated by the term "penny." This term applies to the length of the nail. The "d" next to the number is the abbreviation for "penny". The approximate number of nails per pound varies according to the type and size. Common nails range from 2d, which are 1 inch long and contain approximately 900 nails per pound, to 60d, which are 6 inches long and contain approximately 11 per pound. The nail used should be at least three times as long as the thickness of the wood it is intended to hold. Two-thirds of the length of the nail is driven into the second piece for proper anchorage; one-third-anchors of the lenght the piece being fastened.



Size	2d	3d	4d	5d	6d	7d	8d	9d	10d	12d	16d	20d	30d	40d	50d	60d
Diameter (inches)	.072	.08	.098	.098	.113	.112	.131	.131	.148	.148	.162	.192	.207	.225	.244	.262
Steel wire gage	15	14	12	12	11	11	10	10	9	9	8	6	5	4	3	2
Number per pound	900	615	322	254	200	154	106	85	74	57	46	29	23	17	14	11

b. Screws. Screws are more expensive in time and money than nails, but sometimes are necessary for superior results. They provide more holding power than nails, can be easily tightened to draw the material securely together, are neater in appearance, and may be withdrawn without damaging the material.

(1) Wood screws. Wood screws are designated according to their head style. The most common type are flathead, oval head, and roundhead with either slotted;  or Phillips heads; .

(2) Lag screws. They are longer and heavier than the common wood screw and have coarser threads, which extend from a cone or gimlet point slightly more than half the length of the screw. Square-head and hexagon-head lag screws are usually placed with a wrench.

c. Bolts. Bolts (sometimes referred to as lag bolts) are used when great strength is required or when the work must be frequently disassembled.

d. Expansion shields. Expansion shields are inserted in pre-drilled holes, usually masonry, to provide a gripping base or anchor for a screw, lag bolt, or nail.

e. Drift pins. Drift pins (called drift bolts for supply purposes) are long, heavy, thread-less bolts used to hold heavy pieces of lumber/timber together.

f. Corrugated fasteners. Corrugated fasteners are used to fasten joints and splices in small timber and boards.

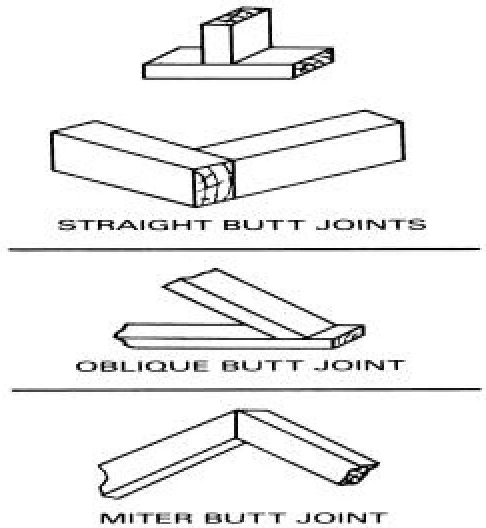
12. **JOINTS AND SPLICES**:

a. Joints. Joints are connections between two pieces of timber, which come together at various angles.

(1) Straight butt joint. Form the straight butt joint by bringing the square-cut end of one board against the square face of another. The butt end of one board should be square and the face of the other smooth so that the pieces fit perpendicular to each other. This is the most common joint used in wood frame construction.

(2) Oblique butt joint. Form the oblique butt joint by bringing the end of one board, cut to form the desired angle, against the face of another board with which it is to be joined. Bracing is a typical application for this joint. Do not use this joint where great strength is required.

(3) Miter butt joint. Form the miter butt joint by bringing the mitered ends of two boards together to form a desired angle. To form a right-angle miter joint (the most commonly used miter joint), cut each piece at a 45 degree angle so that when the pieces are joined they form a 90 degree angle. The miter joint is a very weak joint and is not to be used where strength is important.



(4) Plain lap joint. Form the plain lap joint by laying one board over another and securing the two by means of screws or nails. This joint is as strong as the fasteners and material used.

(5) Half-lap joint. Construct this splice by cutting away portions (usually half) in equal lengths from the thickness of two boards and joining them in such a way that the cutaway portions overlap to form the joint. Overlapping surfaces must fit snugly and smoothly.

b. Splices. Splices connect two or more pieces of timber together so they will be as strong as a single timber of the same length and the joint will be as strong as the disconnected portions **same size lumber is used to make the splice.**

(1) Butt splice. Construct the butt splice by butting the squared ends of two pieces of timber together and securing them in this position by means of two wood pieces (scabbing) fastened on opposite sides of the timber. When nails are used with scabs, stagger them and drive them in at an angle away from the splice. Too many nails, or nails that are too large, will weaken the splice.

(2) Halved splice. Construct the halved splice by cutting away half the thickness of equal lengths from the ends of two pieces of timber and fitting the complementary tongues or laps together. The laps should be long enough to have sufficient load bearing surface.

13. **STRONGBACK AND SEA HUT**

a. The strongback is a wooden structure that is used as a frame or shell for a 16' x 32' General-Purpose (GP) tent.

b. When a 16' x 32' wood frame is modified by a metal roof, extended rafters, and screened in area, it is called a SEA hut.

c. The SEA hut is usually a standard prefabricated unit, but the design can be easily changed to fit the existing condition, such as lengthening the floor and making the roof higher.

14. **BILL OF MATERIALS (BOM)**:

a. Bill of materials is used to order all of the materials to construct a project. It must include NSN, nomenclature, size, quantity, unit of issue (BF, SHT, EA, etc), price and remarks section.

b. Each unit will have a set format on how the bill of material must be done.

c. BOM sample

BILL OF MATERIALS

ITEM	NSN	NOMENCL	QTY/BF	UNIT	TOTAL PRICE
1	5511001C000604	2x4x10’0"	134/893.33	.34	$303.73
2	552001C000599	2x4x8’0"	184/981.33	.33	323.25
3	551001C000626	2x8x12’0"	96/1536.00	.42	645.00
4	551101C000609	2x8x14’0"	9/168.00	.30	70.00
5	553001C000645	3/4" Plywd	35 sh	14.50	507.50
6	553001C000644	1/2" Plywd	81 sh	9.5	769.50
7	565000C900068	Shingles	14 sq	6.99	97.86

8	5315001985624	Roof Nail	14 Lbs	.95	38.95
9	5315007533885	Nail 16D	124 Lbs	.68	84.32
10					

15. **MATERIAL TAKEOFF SHEET**:

a. Material takeoff sheet is used to list all materials needed to build the building. It must include nomenclature, size, quantity (Qty), unit of issue [Board Feet (BF), sheet (sht), pieces (pcs), etc.] and remarks section.

b. Total board footage is acquired up to the second number after the decimal point without rounding up.

c. Sample Material Takeoff Sheet.

MATERIAL TAKEOFF SHEET

ITEM	# OF PCS.	SIZE LUMBER	TOTAL BDFT.	REMARK
SILL	**16**	**2″ x 8″ x 10′**	**213.33**	
GIRDER	**22**	**2″ x 12″ x 10′**	**440**	
JOIST	**95**	**2″ x 8″ x 12′**	**1,520**	**8 trimmer joist**
HEADER	**11**	**2″ x 8″ x 10′**	**168**	
BRIDGING	**10**	**2″ x 8″ x 16′**	**213.33**	**16′ = 13 pcs of 14.5″ long solid bridging**
STRINGER	**5**	**2″ x 10″ x 12′**	**100**	**2 stringers/stairs**
TREAD BOARD	**19**	**2″ x 4″ 12′**	**152**	**12′ = 3 pcs of 3′ long treads**
PLATES	**60**	**2″ x 4″ x 14′**	**400**	
STUDS	**184**	**2″ x 4″ x 8′**	**981.33**	**LONG METHOD**
UPPER CHORD	**62**	**2″ x 4″ x 12′**	**496**	**Lgt: 11′ 7-13/16″**
LOWER CHORD	**58**	**2″ x 4″ x 10′**	**386.66**	**Lgt: 10′**
CENTER POST	**7**	**2″ x 4″ x 16′**	**74.66**	**16′=5 pcs of 37″ long ctr.post**
SUBFLOOR	**38 shts.**	**3/4″ x 4′ x 8′**	**Plywood**	
EXTERIOR WALL	**42 shts.**	**3/4″ x 4′ x 8′**	**Plywood**	
GABLE	**6 shts.**	**3/4″ x 4′ x 8′**	**Plywood**	
ROOF	**49 shts.**	**1/2″ x 4′ x 8′**	**Plywood**	**Roof = 1296 sqft**
INTERIOR WALL	**104 shts.**	**1/2″ x 4′ x 8′**	**Sheet rock**	
SHT. ROCK NAIL	**31 Lbs.**			
FELT PAPER	**5 rolls**	**400 sqft/roll**		
SHINGLES	**45 bundles**	**4 bundles/square**		
ROOFING NAILS	**29 Lbs.**			**Roof = 1296 sqft**
8d NAILS	**96 Lbs.**			
16d NAILS	**135 Lbs.**			

16. **LUMBER CONSOLIDATION SHEET**:

a. Lumber consolidation sheet is used to consolidate lumber items of the same size from the Material Takeoff Sheet. It must include nomenclature, size, quantity, unit of issue (bf, sht, ea, etc) and remarks section.

b. Sample of lumber consolidation sheet.

Lumber Consolidation Sheet

ITEM	QTY	UNIT SIZE	LENGTH	BF	REMARKS

17. **BASIC MATH REVIEW**:

a. Converting a measurement from feet into inches or inches into feet.

(1) There are 12 inches in one foot.

(2) Convert feet to inches, multiply the measurement by 12.

(3) Convert inches to feet, divide the measurement by 12.

(4) Converting factions to become decimal, divide the numerator (top number) by the denominator (bottom number).

b. Some of the common conversion factors that may be encountered when calculating for materials are listed below.

FRACTIONS TO DECIMALS	INCHES TO FEET
1/16" = .0625"	1" = .083′
1/8" = .125"	2" = .166′
3/16" = .1875"	3" = .250′
1/4" = .250"	4" = .333′
5/16" = .3125"	5" = .416′
3/8" = .375"	6" = .500′
7/16" = .4375"	7" = .583′
1/2" = .500"	8" = .666′
9/16" = .5625"	9" = .750′
5/8" = .625"	10" = .833′
11/16" = .6875"	11" = .916′
3/4" = .750"	12" = 1.00′
13/16" = .8125"	16" = 1.33′
7/8" = .875"	24" = 2.00′

15/16" = .9375"

c. Subtraction: 12’ 4-3/8"
- 1’ 7"

___’ _____"

d. Pythagorean theorem: If the two sides of a right triangle are known, the third side can be found mathematically. The formula used is:
$A^2 + B^2 = C^2$ **NOTE**: To get the exact lengths do not round off the answers.

18. **ECONOMICAL ORDER LENGTH (EOL)**:

a. Lumber comes in common lengths of 8, 10, 12, 14, 16, 18 and 20-foot pieces. Lengths of 18 and 20-foot pieces are special order.

b. Length of board that provides you with the most required pieces with the least amount of waste.

(1) EOL is approximately the same length as the building component. The formula is the **process of elimination**.

(a) Example: EOL on a floor joist for a building 13’ wide.

(b) Answer: EOL = 14’; because 8’, 10’ and 12’ pieces are too short, and the 14’ will cover the span with less waste than a 16’.

(2) **EOL needs to cover a total linear feet (TLF)**. The formula is to divide the linear feet to be covered by the EOL board length or
TLF ¸ EOL = # of EOL pieces (Round up to the whole number, if required).

(a) Ex: Length of lumber available is only a 16’, 14’ or 12’.

$\frac{50'}{16'}$ = _____ or ___pcs $\frac{50'}{14'}$ = 3.**5**71 or ___pcs $\frac{50'}{12'}$ = _____or ___pcs

(b) Determine which has least amount of waste.

16’ x 4 pcs = 64’	14’ x 4 pcs = 56’	12’ x 5 pcs = 60’
- 50’	- 50’	- 50’
14’ wasted	**6’ wasted**	10’wasted

(c) **GENERAL RULE: IF THE ANSWER IS NOT A WHOLE NUMBER**; then choose the answer with the **HIGHEST** number after the decimal point; of the lumber available above, 14’ has the least amount of waste.

(3) **EOL is long enough to acquire more than one building component** when cut (Round down to the whole number, if required).

(a) Example: A center post is 3’-9"; length of lumber available is only 16’, 14’ or 12’.

$\frac{16'}{3.75'}$ = ______ or ____ pcs $\frac{14'}{3.75'}$ = ______ or _____ pcs $\frac{12'}{3.75'}$ = ______ or ____ pcs

OR

$\frac{192"}{45"}$ = 4.266 or 4 pcs $\frac{168"}{45"}$ = 3.733 or 3 pcs $\frac{144"}{45"}$ = 3**.20** or 3 pcs

(b) Determine which has least amount of waste.

3.75′ x 4 pcs = 15′   16′ – 15′ = 1′ wasted

3.75′ x 3 = 11.25′   14.00′ – 11.25′ = 2.75′ wasted

3.75′ x 3 pcs =   **12.00′** -11.25′ = **.75′ wasted**

(c) **GENERAL RULE: IF THE ANSWER IS NOT A WHOLE NUMBER**; then choose the answer with the **LOWEST** number after the decimal point; of the lumber available above, 12′ has the least amount of waste.

19. **FOUNDATIONS**:

a. Foundations vary according to their use, the bearing capacity of the soil, and the type of material available. The material may consist of cut stone, rock, brick, tile, wood, or concrete. The material used will depend on the type of foundation structure, the availability of materials, and the amount of weight it must support.

b. An inadequate foundation will result in uneven settling, and may cause cracked plaster, ill-fitting doors, or sticking windows.

c. May be classified as wall or column (pier) foundations.

(1) Wall foundations

(a) The continuous Tee foundation [Foundation Wall in diagram below paragraph (b)] is the most common type of concrete wall foundation used in construction today, it is made of concrete or cement blocks and are used in crawl spaces, basements, and bridge abutments, to name a few applications.

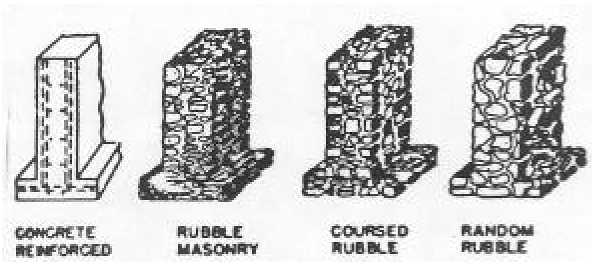


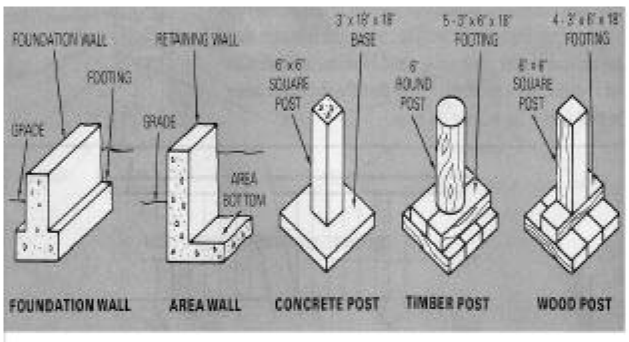
Figure 5-10. Foundation walls.

(b) The continuous Tee is a solid wall throughout its length, and it is designed to carry heavy loads where the earth has low supporting strength.

(c) Because of time, labor, and material required to build this type of wall, it will only be used when other types cannot be used.

(2) Column or post foundation

(a) Columns and piers are **CONSTRUCTED TEMPORARY IN NATURE AND USED 90% OF THE TIME AS THE FOUNDATION OF CHOICE FOR BASE CAMP CONSTRUCTION WHEN WOOD IS BEING USED.** The use of these foundations saves time, labor and, material.



(b) Columns are spaced according to the amount of weight to be carried, generally from 6 to 10 feet apart. Structure that is higher than three feet above the ground must have cross bracing.

(c) Material for columns and piers are constructed of masonry or wood. Generally when wood is used, it is laminated.

1 Bearing plates should be used at the base and top to distribute the load evenly onto the column.

2 Columns should be securely anchored to the footers and the sills.

(d) Timber post buried at least three feet into the ground. Post must be at least 6" in diameter.

(3) Continuous mud sill **(Most common in the field)**

(a) This type of foundation is used frequently in the field for the construction of strongbacks (a wood frame structure used to support GP tents, which will be discussed later on in the outline). Consist of material, at least 2"x 6" wide, laid directly on the ground.

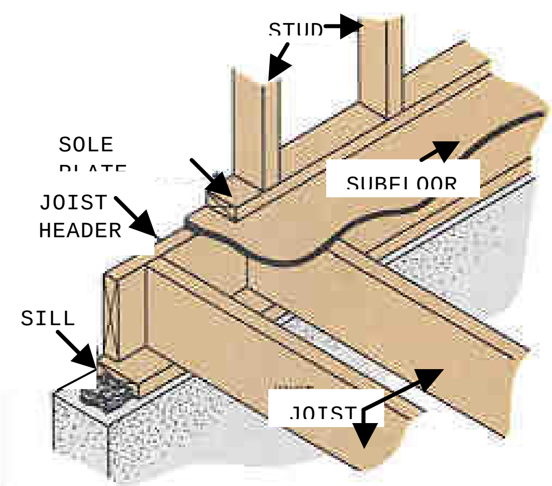
(b) 2" x 4" or larger may be used as a sleeper. Placed on edge on the center of the 2" x 6" running the length of structure.

20. **Floor Frames and Floor Coverings**:

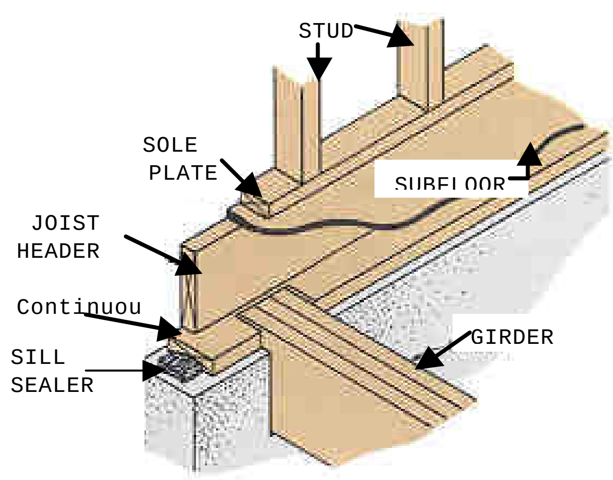
a. Sills

(1) It supports all the building above it and provides a nailing surface for the remainder of the framing.

(2) It is the first part of the superstructure to be set in place. It is fastened to the foundation and rests directly upon it. The sill is continuous and joined at the corners, and is spliced when necessary.



EXTERIOR WALL



EXTERIOR WALL AT GIRDER END

(3) Sills are designed for the type of foundation used.

(a) Continuous sills

1 Designed for wall foundations. It consists of 2" material laid flat around the entire length of the building.

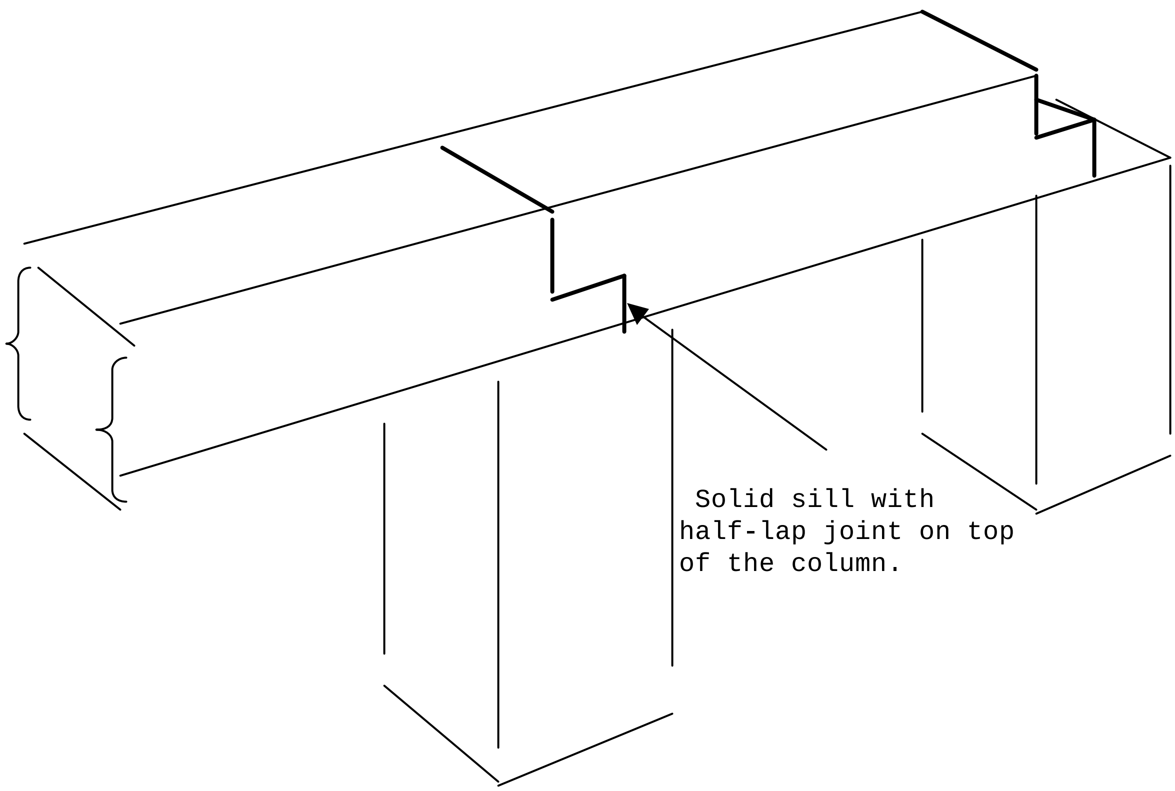
2 Wall foundation is built with some type of device to anchor the sills.

(b) Solid sills

1 Designed for column and pier foundations. It consists of 6"x6" or larger timber to meet the required dimension.

2 Use timbers that are straight as possible and free of defects. If the timber has a crown, place the crown up.

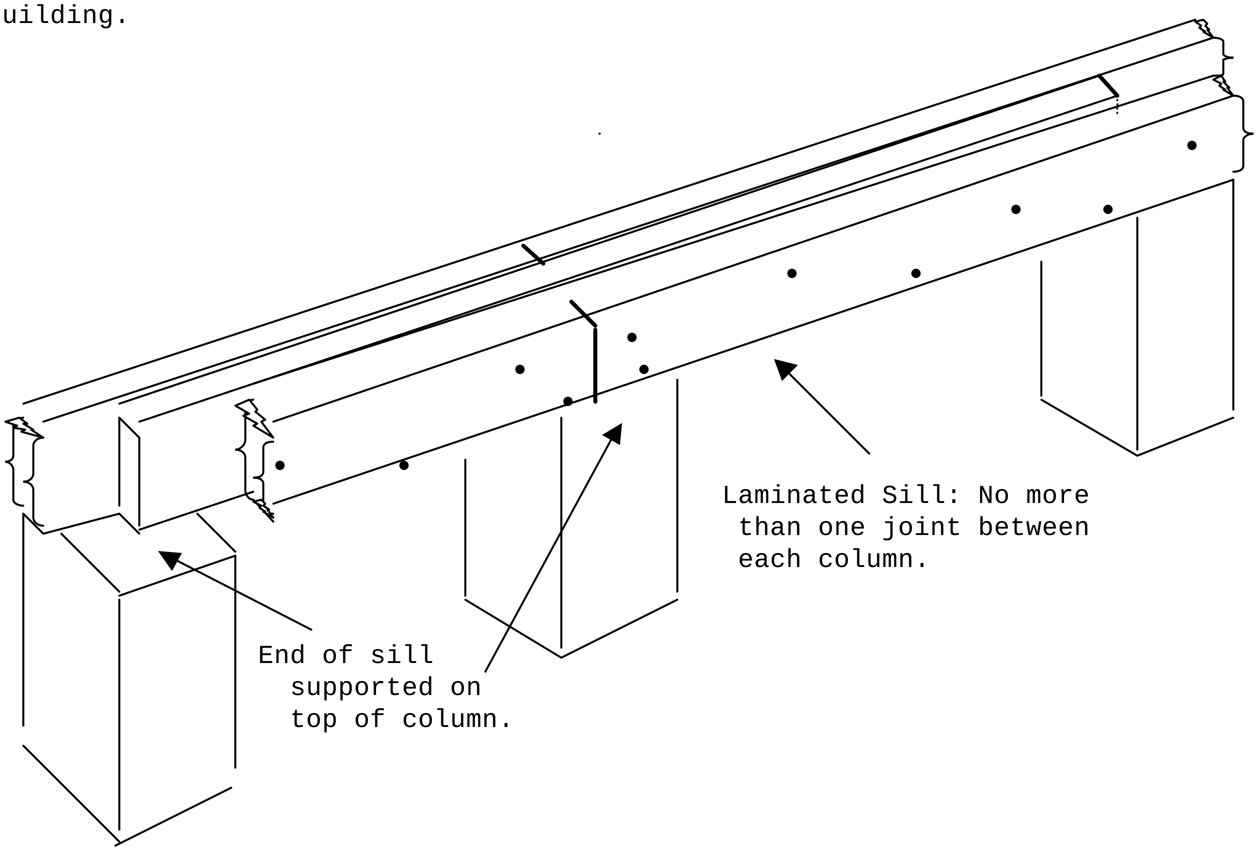
3 Join all ends over a column or pier using a half lap.



Solid sill with half-lap joint on top of the column.

(c) Laminated sills

1 Designed for column and pier foundations. It consists of two or more pieces of lumber nailed together, with 16d or 20d nails, to meet the required dimension. The laminated material is laid on edge the length of the building.



2 Joints are staggered over the columns or piers. Successive butt joints are used at the corners. No more than one joint should span between columns.

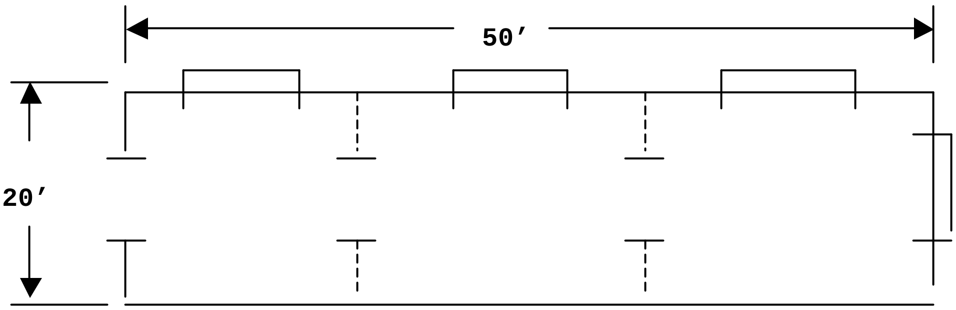
(d) Use a preservative between the sill and foundation (building paper, termite shields, etc.).

(e) Level the sills using wood wedges or grout.

(4) Estimation for sill materials.

(a) Continuous Sill:

1 Determine number of pieces required for a building; **20’-0" by 50’-0".**



2 [(Length + width) x 2 sides] = Total Linear Feet (LnFt)

[(50' + 20') x 2] = ________ **or** 50' + 50' + 20' + 20'=______(LnFt)

3 Determine economical order length (EOL).

a (Total LnFt divided by best EOL) = # of pieces needed for continuous sill (Round up, if needed).

b $\frac{\text{Total LnFt}}{\text{EOL}}$ or $\frac{140'}{10'}$ = 14 pcs: 2" x 8" x 10'(Round up).

or $\frac{140'}{14'}$ = 10 pcs : 2" x 8" x 14'-0"

c Add 10% waste (always round up).

14 pcs x 1.1 = __________or _______pcs: 2" x 8" x 10'-0"

d Change to board feet (Quantity x Thickness x Width x Length) divided by 12 (12 is a constant number).

$$\left(\frac{\text{16 pcs (Qty) x 2" (Tk) x 8"(Wth) x 10'(Lgt)}}{\text{12 (Constant \# to convert to BF)}}\right) = \_\_\_\_\_\_\_\_ \text{ BoardFeet(BF)}$$

e Record on Takeoff sheet.

(b) Solid Sill:

1 (Length of building divided by pier spacing) times number of rows of piers equals the total number of pieces required for building.

2 A pier foundation will be used with the piers spaced 10' apart.

$\frac{\text{Length of bldg.}}{\text{Pier spacing}}$ = __________ = _______pcs per sill (Round up, if needed).

There are 2 rows of piers (Two outside sills).

```
   5 pieces per sill
 x 2 rows
  10 pcs total
```

3 Add 10% waste (always round up).

10 x 1.1 = ________ total pieces:

4 Determine the best EOL. It has been determined that a 6" x 6" solid sill is sufficient size material for this building.

EOL of 6" x 6" x _____’ is determined.

5 Change to board feet.

$$\frac{11 \times 6'' \times 6'' \times 12'}{12} = \underline{\hspace{3cm}}$$ BF; record on takeoff sheet.

(c) Laminated Sill:

1 Determine the best EOL for pier spacing at 10’. It has been determined that a 2" x 8" laminated sill is sufficient size material for this building.

50’ ÷ _______’ = 5 pcs (Round up, if needed)

2 Building length divided by best EOL equals total amount required for 1/3 the thickness of one sill.

```
  5 pcs of 10’ EOL
x 3 lamination of sill
 15 pcs per sill
```

3 Multiply the number of pieces required for one-sill times the number of sills to get total pieces required.

```
  15 pcs per sill
x  2 sills (Two outside sills)
  30 pcs total
```

4 Add 10% waste (always round up).

30 pcs x 1.1 = _______ pcs: 2" x 8" x 10’-0"

5 Change to board feet.

$$\frac{\underline{\hspace{1.5cm}}\text{ pcs} \times 2'' \times 8'' \times 10'}{12} = \underline{\hspace{2.5cm}}$$ BF record on takeoff sheet

b. Girder

(1) The foundation walls or columns carry the building load. The distance between the foundation walls or sills is often too great to carry the weight at the center of the building. An intermediate support girder or girders must carry this weight.

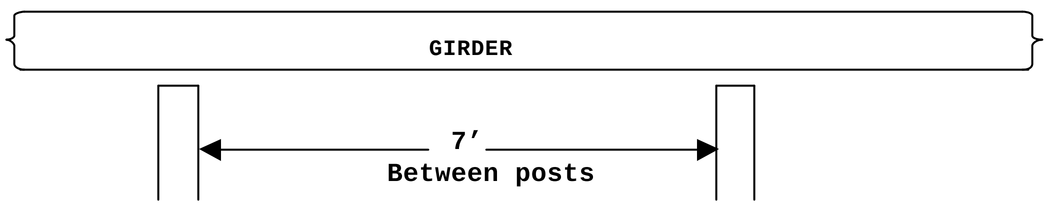
(2) A girder is a large beam that supports other small beams or joists. A girder may be made from several beams nailed together with 16d common nails; or may be solid wood, steel, reinforced concrete, or a combination of these materials.

(3) Columns and piers generally support girders. It is constructed that all beams run level when framed to the foundation walls and other girders.

(4) A girder with the depth doubled will increase the safe load four times. A girder 3" wide and 12" deep will carry four times the weight of a girder 3" wide and 6" deep.

(5) Size requirements are determined by the girder principles:

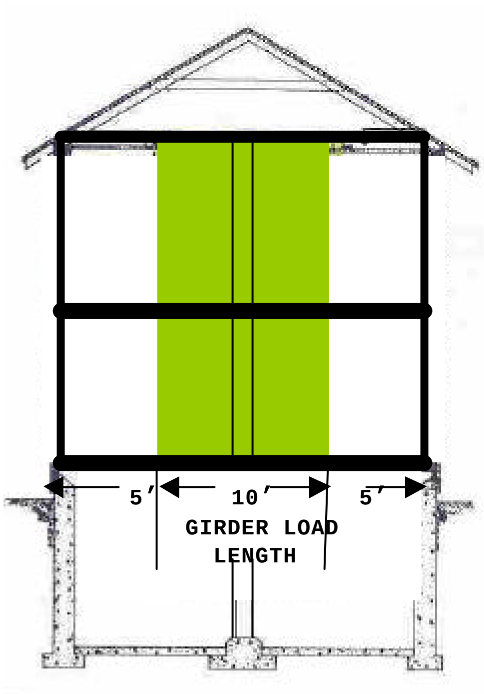
(a) The distance between the girder posts.

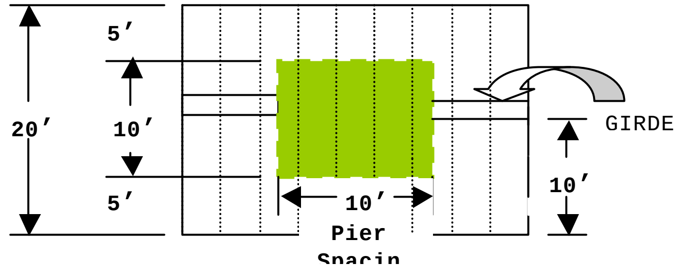


(b) The girder load area.

1 Since the building load is carried by the outside foundation walls and the girder; the girder supports twice as much load.

2 Determine the total length from midway points of the floor joist on both sides of the girder.





DEAD LOAD ALLOWANCE

1. Average subfloor, finish floor, and joists without basement plaster should be 10 Lbs/sqft. For each floor.

2. If the basement ceiling is plastered add an additional 10 Lbs/sqft.

3. If the attic is unfloored, an allowance of 20 Lbs must be added for ceiling plaster and joists when girders or bearing partitions support the first floor partition.

LIVE LOAD ALLOWANCE

1. If the floors are used for living purposes add 30 Lbs/sqft

(c) The total floor

1 Add all the total dead and live load on the girder load area.

2 Multiply the total weight of the load times the length of the girder load width.

(d) The material to be used.

1 Laminated girders warp less easily than solid wooden girders and are less likely to decay in the center.

2 Using the chart in the FM5-426, page 6-11, determine the material used by cross referencing the distance between the girder post and the total floor load on the girder per square foot.

Sizes of Built Up Wood Girders *For Various Loads and Spans* (Based on Douglas Fur 4-SQUARE Guide-Line FRAMING; deflection not over 1/360 of span allowable fiber stress 1600lb/in^2					
LOAD PER LINEAR FOOT OF GIRDER	LENGTH OF SPAN (FEET)				
	6	7	8	9	10
	NORMAL SIZE OF GIRDER REQUIRED (INCHES)				
750	6 x 8	6 x 8	6 x 8	6 x 10	6 x 10
900	6 x 8	6 x 8	6 x 10	6 x 10	8 x 10
1050	6 x 8	6 x 10	8 x 10	8 x 10	8 x 12
1200	6 x 10	8 x 10	8 x 10	8 x 10	8 x 12
1350	6 x 10	8 x 10	8 x 10	8 x 12	10 x 12
1500	8 x 10	8 x 10	8 x 12	10 x 12	10 x 12
1650	8 x 10	8 x 12	10 x 12	10 x 12	10 x 14
1800	8 x 10	8 x 12	10 x 12	10 x 12	10 x 14
1950	8 x 12	10 x 12	10 x 12	10 x 14	12 x 14
2100	8 x 12	10 x 12	10 x 14	12 x 14	12 x 14
2250	10 x 12	10 x 12	10 x 14	12 x 14	12 x 14
2400	10 x 12	10 x 14	10 x 14	12 x 14	
2550	10 x 12	10 x 14	12 x 14		
2700	10 x 12	10 x 14	12 x 14		
2850	10 x 14	12 x 14	12 x 14		
3000	10 x 14	12 x 14			
3150	10 x 14	12 x 14			
3300	12 x 14	12 x 14			
NOTES: The 6" girder is figured as being made with three pieces 2" dressed to 1-3/4" thickness The 8" girder is figured as being made with four pieces 2" dressed to 1-3/4" thickness The 10" girder is figured as being made with five pieces 2" dressed to 1-3/4" thickness The 12" girder is figured as being made with six pieces 2" dressed to 1-3/4" thickness **For solid girders**, multiply above loads by 1.130 when 6" girders is used; 1.150 when 8" Girders is used; 1.170 when 10" is used and 1.180 when 12" girder is used.					

3 Alternate method is using the chart provided below.

a Multiply the total weight of the load times the total floor load on the girder per square foot.

b Cross-reference the distance between the girder post and the material used ensuring the total is sufficient to support the weight calculated above.

GIRDERS	SAFE LOAD IN LB. FOR SPANS FROM 6 TO 10 FEET				
SIZE	6FT	7FT	8FT	9FT	10FT
6 x 8 SOLID	8306	7118	6220	5539	4583
6 x 8 BUILT UP	7359	6306	5511	4908	4062
6 x 10 SOLID	11357	10804	9980	8887	7997
6 x 10 BUILT UP	10068	9576	8844	7878	7086
8 x 8 SOLID	11326	9706	8482	7553	6250
8 x 8 BUILT UP	9812	8408	7348	6544	5416
8 x 10 SOLID	15487	14782	13608	12116	10902
8 x 10 BUILT UP	13424	12768	11792	10504	9448

(e) Estimating material for girders:

1 Laminated girder

a A girder requires intermediate support(s) (i.e. Piers, continuous wall). The spacing for this building is 10’ apart.

b Determine the best EOL for pier spacing at 10’. It has been determined that a 2" x 12" laminated girder is sufficient size material for this building.

EOL of 2" x 12" x ________’ is determined.

c Formula: Building length divided by best EOL = 1/4 girder x 4 for lamination = total girder material.

d EXAMPLE: 50' ¸ 10’ = 5 pcs (Round up); 5 x 4 = 20 pcs

e Add 10% waste: 20 x 1.1 = 22 pcs (Round up)

f Convert to Board Feet:

(22 pcs x 2" x 12" x 10’) ¸ 12 = _____________BF

2 Solid girder:

a A solid girder will be created from heavy timber members and will not require lamination. It has been determined that a 8" x 12" is sufficient size material for this building.

b Determine the best EOL for pier spacing at 10’.

EOL of 8" x 12" x ________’ is determined.

c Formula: Building length divided by pier spacing = total pieces required (Round up, if needed).

50 ¸ 10 = 5 pcs

d Add 10% waste: 5 x 1.1 = 5.5 or 6 pcs

e Convert to BF: (6 pcs x 8" x 12" x 12′) ¸ 12 = __________BF

c. Floor joists

(1) Joists are wooden members, usually two or three inches thick, which make up the body of the floor frame. Joists as small as 2"x 6" are sometimes used in light building; these are too small for floors with spans over ten feet, but are frequently used in ceiling joists.

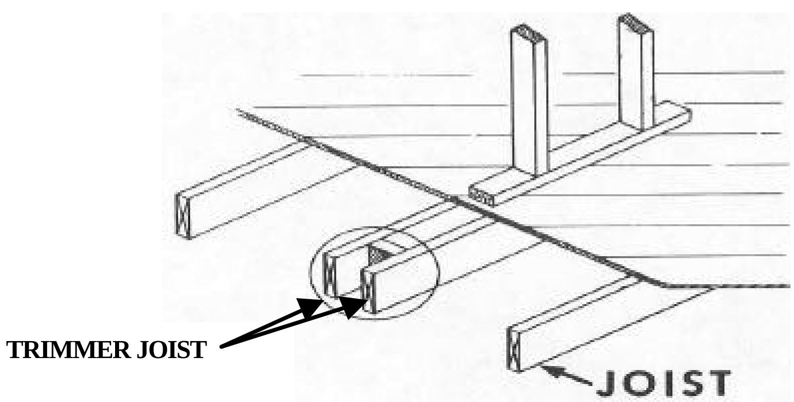
(2) Joists usually carry uniform load of materials and personnel known as the live load; dead load is the weight of the building.

(a) It distributes the load directly on ends to the nearest sills, girders, load bearing partitions, or load bearing walls.

(b) Space the joists 16" or 24" apart, on center or center to center (O.C. or O/C). Sometimes a spacing of 12" may be used for heavy loads.

(c) When placing the joists, always place on edge with the crown up because this counteracts the weight on the joist.

(d) In certain parts of the floor frame, to support heavily concentrated loads, a partition wall, or floor openings, it is necessary to double the joists. These double joists are called trimmer joists.



(3) Joists are secured by various methods.

(a) Resting the joist on top of the sill or girder is the most common, provided headroom is not restricted.

1 Joists are cut long enough to extend the full width of the sill or girder.

2 If joists are butt spliced midway on the girder; the joint must be scabbed.

(b) Ledger plates/strips allow the joist to be dropped lower creating more headroom.

1 Nail a 2" x 4" to the face, flush with the bottom, of the sill or girder. Use 20d nails every 12 inches.

2 If joists are notched, splitting can be prevented by using ledger plates/strips. Joist should not be notched over one-third of its depth.

(c) Metal fasteners, like straps, hangers and iron stirrups are among the strongest joist supports.

(4) Joists must be able to hold the weight it will carry.

(5) Estimating material for floor joists.

(a) You must determine the number of floor joists you will need. Determine the center to center floor joist spacing; for this example the joists will be spaced 16" on center (16" = 1.33’).

1 Formula: Divide the length of the building, by the floor joist on center spacing, to get the number of spaces between joists.

$$\frac{\text{50' Building Length}}{\text{1.33' Joist Spacing}} = \_\_\_\_\_\_\_\_ \text{(Round up, if needed)} = \_\_\_\_\_\_\_\_\ \textbf{Spaces}$$

2 Add one to the total of joist spaces (for the extra end joist).

38 spaces + 1 = 39 joists

3 Add 2 trimmer joist for each partition, then add total of trimmer joist needed to floor joists. **Note: Outside floor joist for columns and piers will be doubled to carry the weight of the exterior wall**.

39 pcs(answer after adding starter)
+ 4 pcs of trimmer joists(2 partitions x 2 trimmers/wall)
43 joists for one span

4 Multiply the number of joists per span by the number of identical spans.

43 joists x **2 spans of joists** = _____________Joists

5 Add 10% for waste:

86 pcs x 1.1 waste = __________or __________pcs

6 Determine an EOL or Economical Order Length.

EOL of 2" x 8" x _________’ is predetermined.

7 Change to BF: (95 pcs x 2" x 8" x 12’) ¸ 12 = __________BF

d. Headers or Headerband.

(1) The headerband is placed on the ends of the floor joists at right angles. Headerband forms a box that encases all the floor joists.

(2) Estimate material for header.

(a) You must determine the number of headers you will need.

1 Header is the same as the length of the building, 50’.

2 There are two (2) headers; one on each side of the building.

(b) Determine the best EOL; ____" x ____" x ______’.

(c) Determine the number of 2" x 8" x 10’-0" required for the header by dividing the length of the building by the EOL.

50 ¸ 10 = ______________(Round up, if needed)

(d) Since there are two headers multiply times 2.

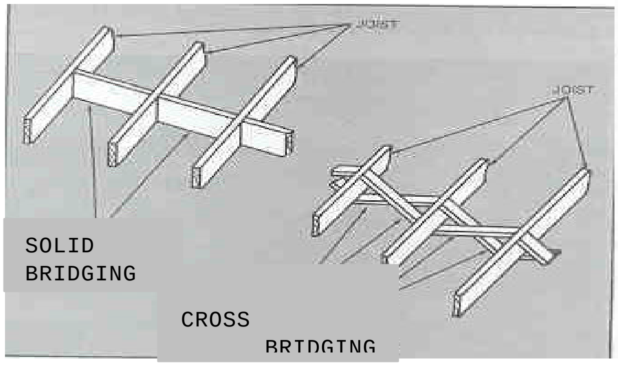
2 headers x 5 pcs = 10 pcs: 10’-0"

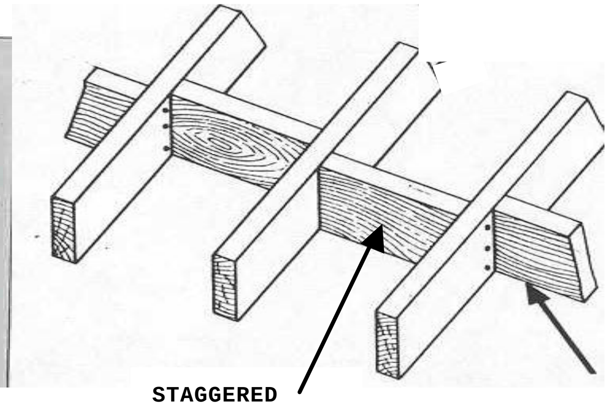
(e) Add 10% waste: 10 x 1.1 = 11 pcs: 2" x 8" x 10’-0"(Round up, if needed)

(f) Change to BF: (11 pcs x 2" x 8" x 10’) ¸ 12 = __________BF

e. Bridging. When joists are used over a long span, they have a tendency to sway from side to side. Therefore, add bridging to stiffen the joist and tie the joist together. There are several types of bridging.

(1) Horizontal Bridging. It is necessary the use the same dimension width size lumber as the joists. These are placed perpendicular to and between the joists in the middle of the joist run. They can also be offset slightly to allow room to nail them to the joists, which is the most common method.





STAGGERED
SOLID

(2) Cross Bridging. Cross bridging looks like a cross and consists of pieces of lumber, usually 1" x 3" or 2" x 3" in size, cut and placed diagonally between the floor joists. When nailing onto the bridging, nail the tops of the bridging first. Do not nail the bottoms until the subfloor is laid. This will give the joist time to adjust to its final position.

(3) Estimate for material.

(a) You must determine the number of pieces of bridging required. Count the spaces between the floor joists, then multiply by the number of rows of bridging.

_____spaces = _____pcs of solid bridging x **3** rows = ________pcs of bridging.

NOTE: Multiply answer by 2, if cross bridging.

(b) Determine the EOL for bridging compared to floor joist spacing.

1 One piece of horizontal bridging is 14.5" for floor joists that are 16" on center or 22.5" for 24" on center.

2 Divide EOL length by the size of piece of bridging to determine how many pieces of bridging you can get out from one EOL.

a EOL for this problem is 2" x 8" x 16′-0"

b Convert 16′ to inches:

16′ x 12" = ___________ ¸ 14.5" = __________**or** ________**pcs**
(EOL) (12 in/ft) (Lgt of bridging)

(c) Determine the # of EOL needed.

1 (Divide the number of pieces for bridging needed by the number of pieces from one EOL) = number of EOL needed.

2 Example: 114 pcs of bridging needed, 13 pcs of bridging can be cut out of one 2" x 8" x 16’-0" board.

114 ¸ 13 = ___________(Round up) or ____________**pcs**: 16’-0"

(d) Add 10% waste: 9 x 1.1 = _________(Round up) or _______pcs

(e) Change to bdft: (10 pcs x 2" x 8" x 16’) ¸ 12 = ________BF

f. Finish Floors and Subfloors.

(1) Finish floor and subfloors are the same in military construction. A finish floor in the theater of operations in most cases is 3/4" plywood material, square edged. It is laid directly on the floor joists and nailed with eight-penny common nails in every joist.

(2) Estimate material.

(a) A finished floor in the theater of operations, in most cases, is 1/2 inch or 3/4-inch plywood material. A standard panel size is 4 ft wide by 8 ft long, which equals 32 square feet (sqft) per sheet.

(b) Determine total surface area = Length times width of bldg.

50’(Lgt.of floor) x 20’(Width of floor) = 1000 sqft of surface area

(c) Divide total sqft of surface area by 32 (sqft/sheet of plywood)

1000 ¸ 32 = ____________sheets **(DO NOT ROUND UP UNTIL THE FINAL ANSWER FOR PLYWOOD CALCULATIONS)**

(d) Add 20% waste: 31.25 x 1.2 = __________(Round up) or

____________sheets; record on take off sheet.

21. **STAIR FRAME**:

a. Stringers. The sides that supports the weight of the live and dead weight on the stairs.

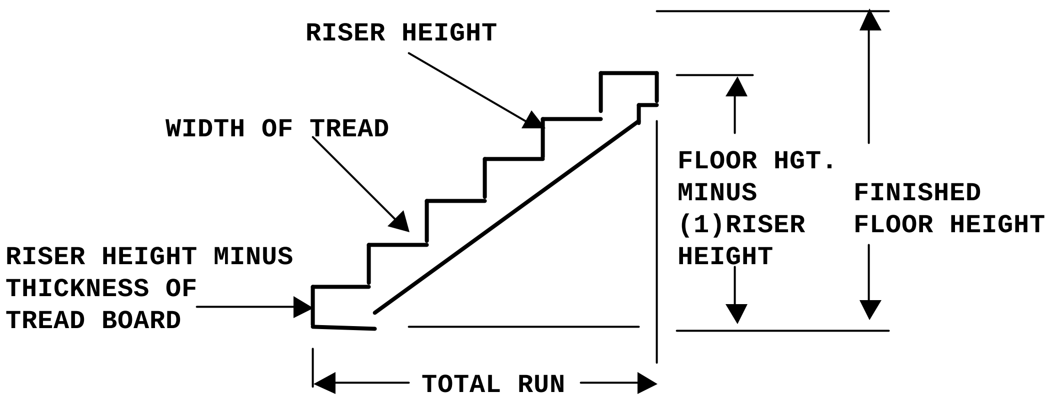
(1) Consist of material 2" or 3" thick and 8" wide or wider.

(2) Stringer material may be cut or blocks may be secured to the stringer to hold the step of the stairs.

(3) Intermediate stringer(s) may be required due to the width of the stairs or excessively heavy live load.

b. Treads. Material that forms the horizontal step and distributes the weight to the stringers.

c. Risers. Risers are materials that covers the vertical opening created between the stringers and the treads.



d. Stair Design. Most important in stair design is the mathematical relationship between the riser and tread. The ideal rise and tread totals 17 inches. The following are two rules of thumb that may be used to check the dimensions of risers and treads.

(1) Riser height + tread width = between 17 and 19 inches

(2) Riser height x tread width = between 70 and 75 inches

(3) If the sum of the height of the riser and the width of the tread falls between 17 and 19 inches, and the product of the two equals between 70 and 75 inches, the design is satisfactory.

(a) Determine the number of risers for the stairs and each riser height.

1 Story Pole Method. Using a story pole with the finished floor height marked off on it and a divider set at seven inches, step off the distance on the story pole. If this distance will not divide evenly into the length of the story pole, adjust the divider span slightly and again step off the distance. Continue the adjusting and the stepping off until the story pole is marked off evenly. The span must be near seven inches. This represents the rise of each step. The number of spaces stepped off evenly by the divider on the story pole is the number of risers and the span of the divider is the height of each riser.

2 Mathematical Method. Convert the finished floor height into inches to get the total rise. Divide the total rise by 7 (Round up to the next whole number) to acquire the number of risers. Then divide the total rise by the number of risers (Round up or down to the nearest 1/4") to acquire the height of each riser. Example: The finished floor height is 6 feet 10 inches.

Step 1: 6′ x 12" = 72" + 10" = ____________" **total rise**

Step 2: 82" ÷ 7 = _________(ROUND UP) or __________**risers**

Step 3: 82" ÷ 12 risers = __________" **height of each riser**

Step 4: Convert to closest 1/4" measurement (7" or 6.75”).

```
  7.00        6.83
 -6.83       -6.75
   .17         .08
```

Riser height is closer to 6-3/4"

(b) Determine the number of treads for the stairs and the width of each tread.

1 The number of treads is acquired by subtracting the number of risers by one.

2 The width of the treads is determined by the two rules of thumb discussed previously. Adjustments are made to the tread width to ensure the stair design is satisfactory.

3 Example for a finished floor height of 6 feet 10 inches.

Step 1:
```
 12 risers
- 1 actual finished floor is the last riser
 11 treads
```

Step 2: 6.75"(Riser hgt) + 10.25"(Tread width) = 17

Step 3: 6.75"(Riser hgt) x 10.25"(Tread width) = _________

Step 4: Adjust by increasing the tread width to satisfy the stair design.

Sum of hgt + width = 17 to 19 inches, and the product of hgt x width = 70 to 75 inches

6.75" + 10.50" = ___________ and 6.75" x 10.50" = __________

Step 5: Calculate the total run

11 Treads x 10.5” Tread width = 115.5” or 9′ 7-1/2”

(c) Estimate material.

Finish floor height = 82”
(12) Risers at 6-3/4” height
(11) Treads at 10-1/2” width
Total run = 115-1/2”

1 Determine stringer material.

a Pythagorean theorem:

Step 1:(_________" **x** _______") **+** (__________" x _________") = C^2
Floor height **Total run**

Step 2: (___________") + (____________") = C^2

Step 3: $\sqrt{\quad .\quad}$ " = C^2

Step 4: ___________" = C

(2) Convert to feet: 141.64833" ¸ 12 = __________’

(3) Convert the decimal point in feet into inches:

.________feet x 12"/foot = ___.______” or _________(.6" from conversion table = 5/8")

(4) Overall 141.64833" **= 11’ 9-5/8**"

(5) EOL determined at 2" x 10" x 12’; 2 sets of 3 feet wide stairs.

(a) 2 stringers/stair x 2 sets of stairs = 4 pcs

(b) Add 10% waste: 4 x 1.1 = 4.4 or 5 pcs: 2" x 10" x 12’

(c) Convert to BF:(5 pcs x 2" x 10" x 12’) ¸ 12 = _________BF

f. Determine tread material. EOL determined is 2" x 4" x 12’.

(1) Number of tread boards required:

```
   3 pcs/tread (3.5" x 3 = 10.5")
x 11 treads/stair
  33 pcs
 x 2 sets of stairs
  66 pcs: 2" x 4" x 3’
```

(2) Number of EOL required: 66 pcs ÷ 4 pcs/EOL =_______pcs

or ________pcs: 2" x 4" x 12’

(3) Add 10% waste: 17 x 1.1 = ____________or __________pcs

(4) Convert to BF:

(_______pcs x 2" x 4" x 12’) ¸ 12 **=** ________BF; record on takeoff sheet.

22. **Wall Frame**: Wall framing includes regular studs, diagonal bracing, cripples, trimmers, headers, fire blocks, corner posts, partition posts, door and window headers, and window sills.

a. Sole Plate. The bottoms of all partition walls and outside walls are finished with either a 2" x 4" or with a piece of lumber corresponding with the thickness of the wall. This is laid horizontally on the floor or joists. It carries the bottom end of the studs and is called the sole or sole plate. The sole plate should be nailed with 16 penny or 20 penny nails at each joist it crosses.

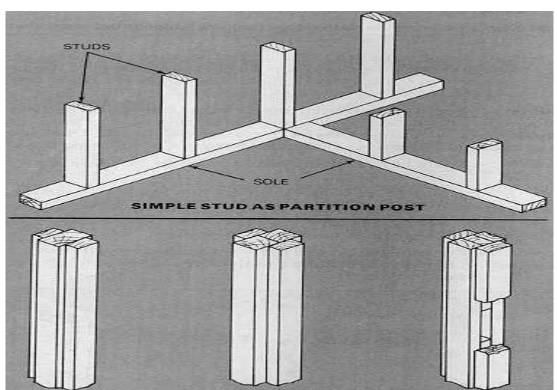
b. Top Plate. The top plate ties the studding together at the top and forms a finish for the walls. The top plate serves as a connecting link between the wall and roof. The top plate may be double or single (Most common are doubled).

c. Wall Studs. Studs are the closely placed vertical members of partition and outside walls. Their purpose is to support the weight of the upper floors and provide a framework for interior and exterior finishes. Studs are normally spaced 12, 16, or 24 inches on center.

d. Corner/T Posts. The studs used at the corners of frame construction are usually built up from three or more ordinary studs to provide greater strength. These built-up assemblies are called corner posts or partition posts. The corner posts may be made in the following ways.

(1) A corner post may consist of a 4" x 6" with a 2" x 4" nailed on the board side, flush with the edge. This type of corner is for a 4-inch wall. Where the walls are thicker, heavier timber is used.

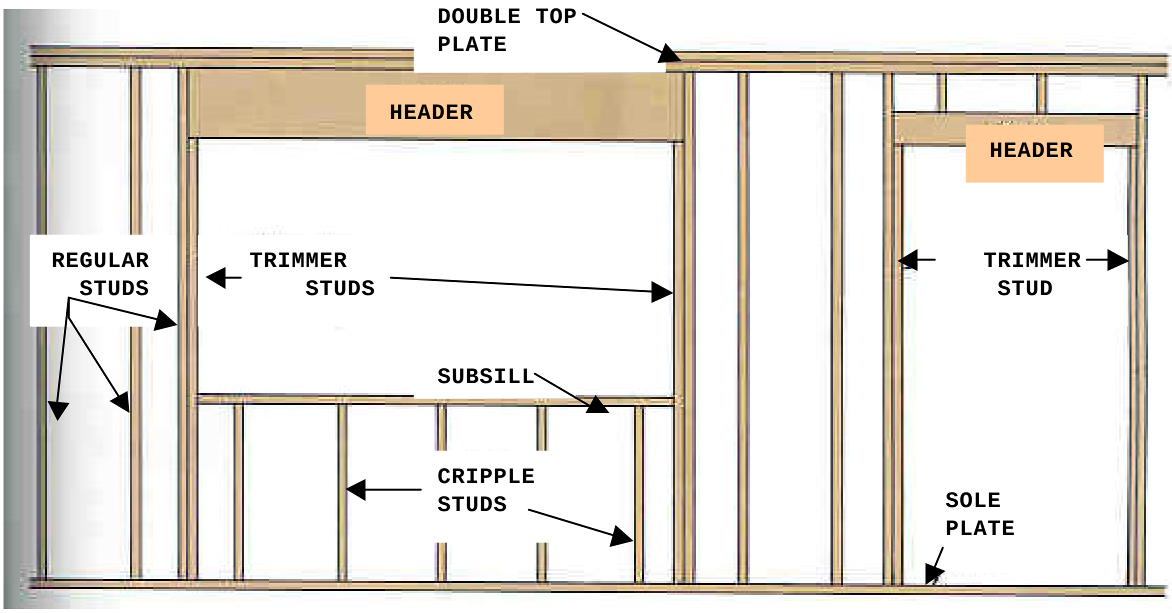
(2) A 4" x 4" may be used with a 2" x 4" nailed to each of two adjoining sides.



Partition Posts

(3) Two 2" x 4" may be nailed together with blocks between them, and a two by four flush with one edge.

(4) A 2" x 4" may be nailed to the edge of another 2" x 4". The edge of one flush with the side of the other. This type is used extensively in the theater of operations where no inside finish is needed.



e. Wall frame openings in hasty construction have no frames because the studs on each side of the opening act as a frame.

(1) Trimmer Studs. Trimmer Studs are normally placed 16 inches apart on center. When it is desirable to double the post of the door opening, the outboard studs are first placed into position and nailed securely. Then the short studs, or trimmers, are cut to the size of the opening. The trimmer studs are then nailed to the inside face of the outside studs so that the header can sit on top of trimmer studs as shown in diagram on page SH-15.

(2) Headers. The header is the horizontal member located over the tops of window and door openings. It is usually a doubled two-inch board, placed on edge, which transfers any weight to the trimmers.

(3) Sub-sill. A horizontal member which supports the window component and distributes any load to the studs. Usually a board of two inch material laid flat at the bottom of the rough opening of a window.

(4) Cripple (Jack) studs. Distributes the weight from the top plate to the header, or the weight on the subsill to the sole plate.

(5) Doorframe openings are generally 2-1/2 inches larger than the actual door. Window frame openings varies according to the style of the window component.

f. Plumbing and straightening walls

(1) After the corner posts, T-post and intermediate wall studs have been nailed to the plates, the walls must be plumbed and straightened so that the permanent braces and rafters may be installed. Using a level or a plumb bob and a chalk line does this. To plumb a corner using a plumb bob, first attach a string to the plumb bob long enough to extend the plumb bob as far

down the corner post as possible. Using a ruler laid upon the top of the corner post, measure out 2 inches allowing the plumb bob to hang free. The bottom of the plumb bob string should also measure 2 inches from the post. Once the post is plumbed the temporary braces are placed.

(2) To straighten the wall after corner posts have been plumbed, attach a string to the outside of a corner post and run the string to another corner. Place a block of wood (of equal measurement) under the string at the corners for clearance. Using another dimension block of wood, check the distance between the wall and the string, moving the wall and placing temporary braces to hold the wall. Once all walls, interior and exterior, have been straightened permanent bracing is added and the temporary bracing removed.

g. Braces. Bracing is used to stiffen framed construction and make it rigid. Bracing may be used to resist winds, storms, twisting or strain stemming from any cause. There are three methods commonly used to brace frame structures.

(1) Let-in bracing is set into the edges of studs, flush with the surface. The studs are always cut to let in the braces; the braces are never cut. Usually 1" x 4" or 1" x 6" are used, set diagonally from top plates to sole plates.

(2) Cut-in bracing is toenailed between the studs. It usually consists of 2" x 4" cut at an angle to permit toe nailing which are inserted in diagonal progression between studs running up and down from corner post to the sill or sole plates.

(3) Diagonal sheathing is the strongest type of bracing. Each board braces the wall. If plywood sheathing 5/8 inch thick or more is used, other methods of bracing may be omitted. Plywood can be used to sheath corners and the rest of the building may be sheathed with any sheathing material.

h. Exterior wall sheathing.

(1) The exterior surfaces of a building usually consist of vertical, horizontal, or diagonal sheathing and composition, sheet metal, or corrugated roofing. However, in theaters of operation those materials are not always available and substitutes must be provided. Concrete blocks, brick, stone, rubble metal or earth may be substituted for wood in treeless regions. For substitute, expedient, and improvised construction refer to TM 5-302 for details.

(2) Sheathing is nailed directly to the framework of a building. It is used for the following:

(a) To strengthen the building.

(b) To provide a base wall onto which the finish siding can be nailed.

(c) To act as insulation.

(d) In some cases to be a base for further insulation.

(3) Some of the common types of sheathing are:

(a) Wood, 1 in. thick by 6, 8, 10, or 12 inches wide of #1 common square or matched edge material.

(b) Gypsum board, 1/2 in. thick by 4 feet wide by 8 to 10 feet long. Made by casting a gypsum core within a heavy water-resistant fibrous envelope.

(c) Fiberboards, 25/32 in. thick by 2 or 4 feet wide by 8, 9, 10, or 12 feet long.

(d) Plywood, 1/4, 3/8, 1/2, or 5/8 in. thick by 4 feet wide by 8,10, or 12 feet long. (Most common).

i. Estimate wall frame materials.

(1) Sole Plate and Double Top Plate.

(a) Determine the perimeter of the building: 20’ x 50’

50’ + 50’ + 20’ + 20’ = __________ or

(50’ + 20’) x (2 sides & ends)= ___________ LnFt

(b) Add any additional length for partitions: 2 partition walls

20’+ 20’= 40’ LnFt of partitions
+ 140’LnFt of bldg perimeter
180 total linear feet of bldg and partition(s)

(c) Multiply total linear feet by number of sole plates and top plate(s). There are two top plates and one sole plate for a total of three plates.

180’ total Lnft x 3 plates = __________ LnFt for all plates

(d) Determine the best EOL. EOL is predetermined 2" x 4" x 10’

_______(Lnft of all plates) ÷ 10(EOL) = _______pcs: 2” x 4” x 10’
(Round up, if needed)

(e) Add 10% waste:

54 x 1.1 = ________ (Round up, if needed) or __________pcs

(f) Convert to BF: (________x 2" x 4" x 10’) ¸ 12 **=** ________BF

(2) Studs.

(a) The perimeter of the building plus the total length of all partitions is the total wall linear feet (The total wall linear feet were determined in the last problem).

(b) Determine the number of spaces. The total linear feet divided by center to center spacing of studs will equal the number of spaces.

_________Lnft ÷ 1.33’Stud spacing **=** __________ (Round up to the next whole number, if needed) or _____________ spaces

(c) Add to the total spaces one additional stud per corner, if interior finish is not required. If interior finish is required, add additional two studs per corner for corner post and T-post.

_______corners x 2 studs (Interior is finished) = _____corner studs
+ 136 wall spaces

________total studs

(d) Add one additional stud per opening to the total studs.

1 Windows exterior, door exterior, and windows interior, doors interior.

2 Add to total studs:
4 Window Exterior
2 Door Interior
+ 1 Door Exterior

_____Total Openings

+_____ Studs for Walls and corners

_______ Total studs needed for Building

(e) Determine an EOL. Standard wall is 8’ high;

EOL = ____" x ____" x ______’

167 studs required = number of EOL required

(f) Add 10% waste:

___________pcs x 1.1 waste = ___________ or _________pcs

(g) Convert to BF:

(____________ x 2" x 4" x 8’) ¸ 12 **=** _____________BF

(h) **Alternate (expedient) method for estimating wall frame studs**.

1 Determine total linear feet of walls and partitions.

(50′ + 20′ + 50′ + 20′ walls) + (20′ + 20′ partitions) = _______′

2 If studs are 16" O/C divide total linear feet by one. If studs are 2 feet O/C divide total linear feet by 1.33′.

(a) Studs needed for 16" O/C: 180 ¸ 1 = ______________

(b) Studs needed for 2′-0" O/C:

___________ ¸ 1.33 = _____________ or ______________

3 Total studs needed include extra for corners, extra for door and window openings and waste factor.

4 Convert to board feet.

(3) Exterior wall sheathing.

(a) Determine the square footage of the outside walls. Walls are 8 feet high.

50′ one side	20′ one end
x 8′ height	x 8′ height

(________sqft + _______sqft) = ________ total sqft
x 2 sides

________ sqft to be covered

(b) Divide total sqft by the square footage of one sheet of siding or sheathing (4′ x 8′ = 32 sqft/sheet).

(______total sqft) ¸ (32 sqft/sheet) = ______sheets **(DO NOT ROUND UP)**

(c) Add 20% waste: _______ x 1.2 = ________sheets; record on take off sheet.

(8) Gable sheathing.

(a) Determine the square footage of the gable end of the building. 4/12 pitch. The following are key gable end sheathing and roofing terms.

1 The "RUN" is 1/2 the width of the building to be covered

2 The "PITCH" is the slope of the roof determined by the prints

3 The "CONSTANT #" is the size of the material used for the rafter.

a 2" x 4" material = 4

b 2" x 6" material = 6

4 Formula: ("RUN" x rise of "PITCH") + "CONSTANT #" for rafter material = gable rise (in inches) ¸ by 12 to convert to feet = gable rise (in feet) x total width of bldg = sqft of one gable ¸ by 32 = # sheets of plywood x 1.2 waste factor = # of sheets x 2 gable ends = total sheets of plywood for both gable ends **(DO NOT ROUND UP UNTIL RECORDING THE LAST ANSWER TO THE TAKE OFF SHEET).**

(b) Example: (_______’ x ______) + ______ = _______" ¸ 12 =

___________’ x 20’ = ___________ ¸ 32 = ___________ x 1.2 = __________ x 2 =

_________ **or** ______ sheets of plywood; record on take off sheet.

(9) Interior wall and ceiling sheathing.

(a) Determine the square footage for interior wall and ceiling sheathing.

{[Total linear footage + (double length of all partitions walls)] x height of wall} divided by 32 = # of sheets for interior wall, then add ceiling (same as the subfloor prior to adding the 20% waste factor) = total sheets x 1.2 waste = total sheathing required.

Sheets to cover walls: (140 + ______) **=** ______x 8 = ______¸ 32 = _______

Sheets to cover ceiling: (50 x 20) = 1000 ¸ 32 = _____________

Total sheathing: _________Walls **+** ________Ceiling = ________

x 1.2 waste

_______(Round up)

or _______sheets

(b) Determine sheet rock nails to secure sheathing.

1 Sheet rock nails are calculated at the rate of one pound per every 100 square feet.

2 Formula: {[(Total linear footage + double length of all partition walls) x height of wall] + Square footage of the ceiling} = total square footage ¸ 100 sqft/Lb of nails.

_________(Total sqft) ¸ 100 = ______Lbs (DO NOT round up) x 1.1

waste =_________(Round up) or ___________Lbs of sheet rock nails.

23. **ROOF FRAMING AND COMPONENTS**:

a. Types of roofs.

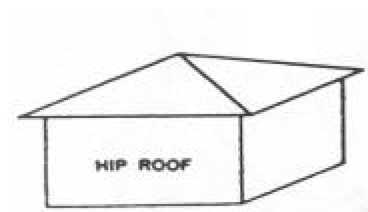
(1) Lean-to or Shed roof. This nearly flat roof is used where large buildings are framed under one roof. It may also be used where hasty or temporary construction is needed, and where sheds and additions to buildings are erected. The slope of this roof is one direction.

LEAN-TO or SHED ROOF

GABLE ROOF

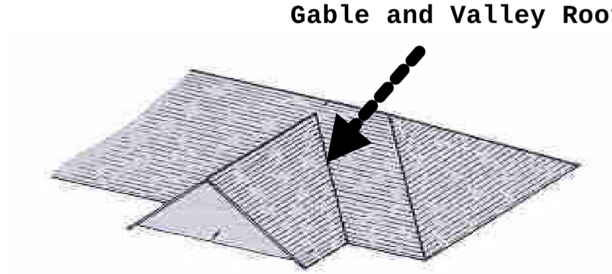
(2) Gable roofs. This roof has two roof slopes that meet at the center, or ridge, forming a gable. It is the most common roof because it is simple and economical, and may be used on any type of structure.

(3) Hip roof. This roof has four sides or slopes running towards the middle of the building.



(4) Gable and Valley roof. This roof is formed by two intersecting gable roofs, which meet at a valley. Each roof slants in a different direction. This roof is seldom used, since it is complicated and requires much time and labor.

Gable and Valley Roof



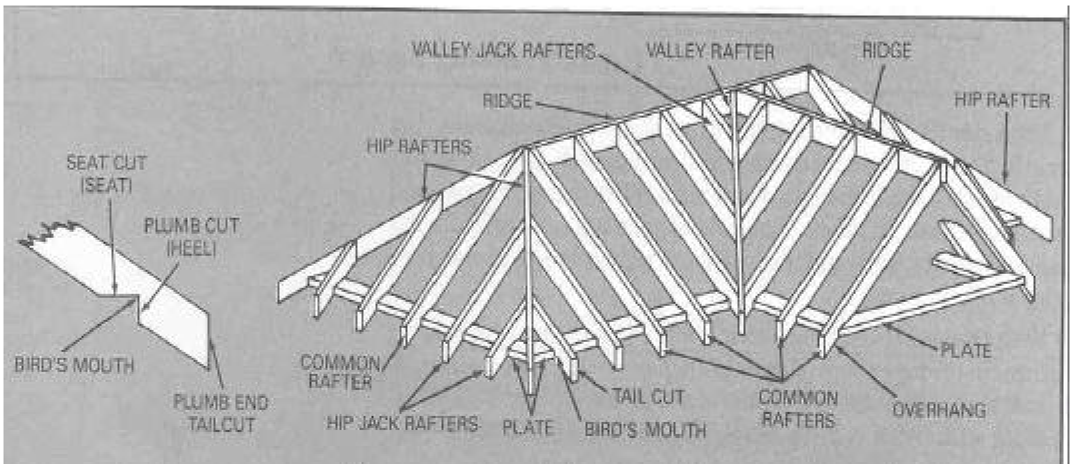
b. Components

(1) Ceiling joists form the framework of a room. They are usually lighter than floor joists, but must be strong enough to resist buckling or bending. Ceiling joists starts at one side of the building and continues across, parallel to the rafters.

(2) Ridge (Ridge Board). The ridge is the highest horizontal framing member, which helps align the rafters and tie them together at the upper end.

(3) Rafters. Rafters make up the main body of the framework of roofs. They do for a roof what the floor joists and studs do for the walls.

(a) Types of rafters:



Common Roof Framing Terms

1 Common Rafters. Common rafters are the framing members that extend at right angles from the plate line to the ridge of the roof. They are called common rafters because they are common to all types of roofs and used as the basic for laying out rafters.

2 Hip rafters are roof members that extend diagonally from the corner of the top plate to the ridge board.

3 Valley rafters extend from to top plate to the ridge boards along the lines where the two gable roofs intersect.

4 Jack rafters

a Hip jack rafters extend from the top plate to the hip rafter.

b Valley jack rafters extend from the ridge board to the valley rafter.

c Cripple jack rafters are placed between a hip and valley rafter.

(4) Pitch of the roof is the angle of the roof slope in relation to the horizontal plane. This is measured as a ratio, i.e. 4/12, 5/12.

(5) Bird's mouth is a cutout, near the bottom of the rafter that fits over the plate.

(6) Overhang is the portion of the roof, which extends beyond the outside edge of the plate or walls of a building. The overhang is often referred to as the lookout, eve, or tailpiece.

(7) Truss construction. Reinforced rafters where large spans provide wide unobstructed floor space.

(a) Rafters for truss construction are laid out the same as a common rafter except no shortening allowance, as there is no ridge board.

(b) Upper and lower chord

1 Ties the rafter and distributes the weight.

2 Lower chord becomes ceiling joist.

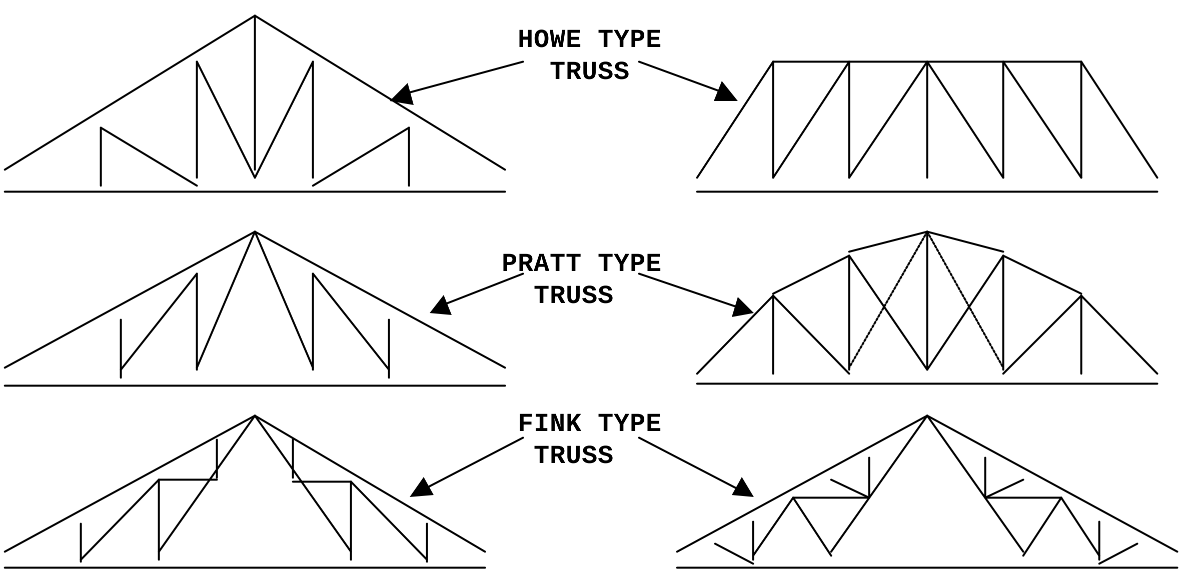
3 May be one piece or jointed, stagger the joints.

(c) Diagonal brace

1 Ties the upper and lower chord together and helps distribute the weight.

2 General rule for braces: 15 - 25 degrees.

(d) Types of trusses. Details for trusses are usually found in the "detail drawings" of blueprints.



(e) Cut all pieces from one pattern and make a jig.

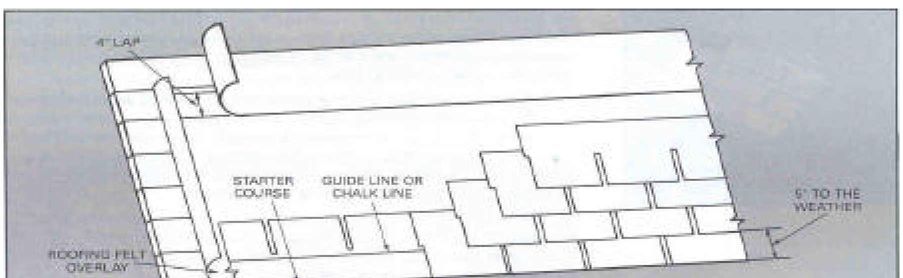
(f) Hand or power (crane, gin pole, block and tackle) may erect trusses.

(8) Roof Coverings. Asphalt roofing products are widely used in modern construction; the components of roof coverings are as follows:

(a) Roof Sheathing. Roof sheathing should be smooth, dry and securely attached to the rafters or ridge board. The roof sheathing must provide an adequate base to receive and hold the roofing nails or fasteners, 1/2, 5/8, or 3/4” plywood adequate enough as a nailing surface.

(b) Flashing. This is placed between roof sheathing and roof underlay in places especially vulnerable to leakage and must be water tight.

(c) Roofing Underlay. Roofing underlay is made of roofing felt and is placed over the secured roof sheathing. Roofing felt or underlay comes in rolls 36" wide and should be laid with a 4” lap. Felt paper is laid for extra protection. A roll usually covers 400 or 500 sqft. The felt or tar paper is rated by weight, 15-50 Lbs according to it’s thickness.



Laying an Asphalt Shingle Roof

(d) Asphalt Roofing Singles. The most commonly used, is the flat strip. They must be weather resistant and they measure 1’ x 3’. Their base material is organic felt and/or fiberglass. This base is saturated and then coated with a special asphalt that is resistant to weathering. A surface of ceramic-coated mineral granules is then applied. The mineral granules shield the asphalt coating from the sun’s rays, add color, and provide fire resistance. Roofing Shingles may come as a roll or single strips. Most common is single strips, where 3 or 4 bundles will cover a square (100 square feet). 1-1/4” or 1-1/2” zinc coated nails are the best nails to use.

1 Laying of Asphalt Roofing Singles. Each row of singles is called a course. The first course at the eaves (the starter course) is laid by inverting the first course of shingles. Stretching a guideline or snapping a chalk line from edge to edge begins each course that follows. This positions the course. The above shows the method of laying a 1’x 3’ asphalt strip shingle roof. Strip shingle should be nailed with a 1 inch copper or hot dipped galvanized roofing nails, two to each tab; this means six nails to each full strip. Nails should be placed about 6-1/2 inches from the butt edges to insure that each nail will be covered by the next course (blind nailing) and

driven through two courses. There should be no more than 3/4-inch overhang all the way around the roof.

c. Estimate roof materials.

(1) Determine the number of truss required for the building. The building length is divided by the center to center spacing of the truss. For this example, the spacing is 24" O/C.

50′ ¸ 2′ = ________ truss (Round up, if required)
+ 1 truss to account for the first position

____
+ 2 false rafters

_______total truss

(2) The estimation of truss framing members requires the estimator to remember that the rise and run components will alter the distance that the framing member must cover.

(a) The formulas for determining the component lengths begin the same way as the sheathing for the gable. Determine the total rise of the roof; the building from the previous projects has been 50′ X 20′ with a 4/12 pitch.

"RUN"		"PITCH"		"CONSTANT"		
(10	x	4)	+	4	=	44" or 3.66666′ or 3′- 8"

(b) With the span and the rise measurements, the upper chord length can be determined by using the "Pythagorean Theorem".

Step 1: (10 x 10) + (**3.66666** x **3.66666**) = C^2

Step 2: 100 + 13.444395 = C^2

Step 3: $\sqrt{113.44439}$ = C^2

Step 4: __________ = C

Step 5: 10.651027′ = 10′ + (.651027')
x 12"
10′ + (7.812324") or 10′-7 13/16"; The upper chord length is now determined.

Step 6: If an overhang is required, the additional length will be added to the length. With a 1′ overhang the total length of the upper chord is now 11′ 7-13/16".

(c) The truss will consist of 2 upper chords, 2 lower chords, and 1 center post. Using our 28 truss required, we determine we need;

1 Upper chord

a Best EOL: **2" x 4" x ______'-0"**

b ______(# of truss) x _____(# of upper chords) = _____pcs

c Add 10% waste:________ x 1.1 = __________ or _________pcs

d Convert to BF: (_____pcs x 2"x 4"x 12') ¸ 12 **=**_________BF

2 Lower chord

a Best EOL: 2" x 4" x _______'

b _________(# of truss minus false rafter)

x __________(# of lower chords/truss)

_________ pcs

c Add 10% waste: 52 x 1.1 =_________or _________ pcs

d Convert to BF:(________x 2" x 4" x 10') ¸ 12 **=** _______BF

3 Center post **Note:** The actual length of the center post is the riser height minus the width of the upper and lower chords.

a Number of center post: ____________pcs at _________"

b Determine the best EOL. ____" **x** ____" **x** ____'

c Exact number of EOL needed: 26 pcs ¸ 5 (pcs from the best EOL of _______') = ____________ or ____________pcs of 2" x 4" x 16'

d Add 10% waste: 6 x 1.1 = ______ or ______ pcs

e Convert to BF: (____ **x 2" x 4" x** _____') ¸ 12 **=** _________BF

(3) Roof sheathing.

(a) Determine the amount of roof area to be covered: multiply the length of the upper chord times (the length of the building plus any overhang desired). The overhang over the gable is 2 feet.

Upper chord is 11' 7-11/16" or round up to the next whole feet = 12'

[12’ x (50’ + 4’)] = ______ sqft/side

(b) Multiply this answer times 2 since there are 2 sides to the roof.

__________ x 2 = ____________ total square feet

(c) Divide by 32 sqft/sheet of plywood

_________ ¸ 32 = ___________sheets (DO NOT ROUND UP)

(d) Add 20% waste: ________ x 1.2 = ________(Round up, if needed)

or _____________sheets of 1/2" plywood

(4) Roofing felt paper

(a) Rolls of either 400 or 500 square foot per roll.

(b) Example: 1296 ¸ 400 = ________ rolls(Round up, if

needed) or ________rolls
x 1.1 waste

________rolls

(5) Asphalt roofing (Shingles)

(a) Material comes in either **100 square feet rolls** or in squares, which require either **3 or 4 bundles to make a square (one square covers 100 square feet).**

(b) Example:

1296 ¸ 100 = 12.96 squares or 13 squares
x 1.1 waste
14.3 or 15 squares
x 3 bundles/square

_______bundles of shingles

(6) Roofing nails

(a) Nails are calculated at the rate **of one pound per every 100 square feet** of roofing shingles.

(b) Example: 1296 ¸ 100 = 12.96 Lbs
x 1.1 waste
14.256 pounds
x 2 felt and shingles
28.512 or 29 Lbs of roofing nails

24. **ESTIMATE NAILS FOR SHEATHING AND FRAMING**:

a. Nails are ordered by the pound (Lb). The first method of determining nail requirements is called the mathematical formula. There are three different formulas/method that are used.

(1) The first formula is for determining the amount of nails for flooring, sheathing, and other 1" material, using 2d to 9d nails.

(a) First determine the total board footage of all 1" material (All plywood material is considered one inch thick; there is no need to divide by 12 as plywood is already in feet; 4’ x 8’).

1 **38** sheets for floor
42 sheets for walls
6 sheets for gable
+ **49** sheets for roof

_______total sheets of plywood

2 (_____sheets x 1" x 4’ x 8’) =______BF of plywood

+ **0** BF of 1" lumber

_______Total BF

(b) The next step is to determine the pounds of nails. The formula is: Lbs of nails (2d - 9d) = (nail size x BF) ¸ constant number (400 for 2d to 9d nails).

EX: (_______**d** x 4320 BF) ¸ _______ **=** ________ (DO NOT ROUND UP)
x 1.1 waste

________ or _______Lbs of 8d nails

(2) The second formula is used for calculating nails for framing lumber. This includes 2" material and larger, using 10d to 60d nails. The formula is the as the sheathing formula using 600 as the constant number for 10d to 60d nails. Lbs of nails = (nail size x BF) divided by 600.

(a) Using the material takeoff sheet list all board footage of 2-inch material. Add all framing board footage to get a total.

(Sills, joist, studs, etc.): 140 + 226.66 + 1520 + 146.66 + 213.33 + 400 + 981.33 + 496 + 386.66 + 74.66 = **4585.3** BF

(b) Determine the pounds of nails.

(______d x __________**)** ¸ __________= _________(DO NOT ROUND UP)
x 1.1 (Waste)

_________or _____ of 16d nails

(3) The third method is the "Consumption Factors for Expendable Supplies" table.

Framing	
8d common	5 Lbs/Mfbm
10d common	15 Lbs/Mfbm
16d common	**10 Lbs/Mfbm**
Sheathing (8d common)	30 Lbs/Mfbm
Flooring (8d casing)	30 Lbs/Mfbm
Roofing (8d common)	30 Lbs/Mfbm
Wall board (6d common)	15 Lbs/1000sqft
Trim 4d finish	3 Lbs/1000 Lnft
6d finish	7 Lbs/1000 Lnft
8d finish	14 Lbs/1000 Lnft

Note: Mfbm = thousand foot board measure

(a) EXAMPLE: **4585.3 BF or 5 Mfbm** of 2" framing lumber using 16d nails.

(b) Using table for 16d nails: 10 Lbs/Mfbm
x 5 total Mfbm of 2" lumber
50 Lbs of 16d nails

(c) NOTE: BE ALERT TO THE GREAT DIFFERENCE BETWEEN THE MATHEMATICAL FORMULA AND THE CONSUMPTION FACTORS TABLE METHOD.

25. **ESTIMATE WORK HOURS**:

a. There are to many factors to get an exact completion time on any projects (i.e. number of workers and their skill level, equipment availability and it's condition, weather conditions, etc.)

b. Estimations are acquired by using the Manpower Estimation Tables in either the references, FM5-551 (Appendix C) or the TM 5-333.

(1) Example: For every 1000sqft of plywood subfloor = 16 man hours

(2) **Note: 16 man-hours is with a typical crew of 1 leader and 4 men**.

26. **Controlled Practical Application**:

a. The following student materials are needed to complete this practical application.

(1) Student handout

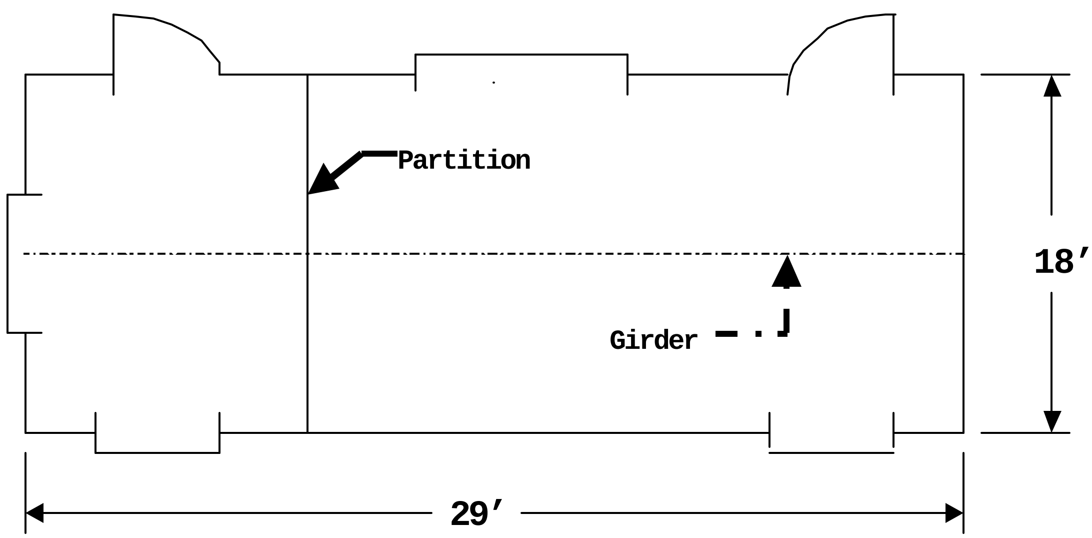
(2) Calculator

b. Read all directions carefully.

c. You will be informed as to the result of this practical application as soon as they become available.

d. You have 3 hours in which to complete this practical application. Note the time now. You may begin.

Situation: You are given a building with the following dimensions of 18 feet wide and 29 feet long.



Foundation is a continuous "T" Wall

Laminated girder 2" x 8" (Laminated 3 times); located at the center of the building and supported by columns and piers every 10′

Sill board 2"x 8"

Floor Joist 2" x 8" at 2′ O/C with solid bridging; joist is plain lapped on top of the girder and sill

Floor Sheathing 3/4" plywood

Studs 2" x 4"; 2’ O/C

Standard 8’ walls; double top plate

Two exterior doors and four windows

One partition

Exterior sheathing 3/4" plywood

Interior finished with 1/2" Sheet Rock and sheet rock nails

Truss 2" x 4"; 24" O/C; only (1) center post

Roof pitch is 5/12 with a 1’4" overhang around entire Building with (2) false rafters

Roof sheathing 1/2" plywood

One Roll of roofing felt covers 500 SqFt/roll

Shingles take 4 bundles/square

No EOL's larger than 16' will be used

Show all formulas and calculations used.

Material Take Off Sheet

ITEM	# OFPCS.	SIZE LUMBER	TOTAL BDFT	REMARK
SILL				
GIRDER				
JOIST				
HEADER				
BRIDGING				
PLATES				
STUDS				
UPPER CHORD				
LOWER CHORD				
CENTER POST				
SUBFLOOR SHEATHING				
EXTERIOR WALL				
GABLE SHEATHING				
ROOF SHEATHING				
INTERIOR WALL				
SHEET ROCK NAILS				
FELT PAPER				
SHINGLES				
ROOFING NAILS				
8d NAILS				
16d NAILS				

1. Calculate material for sill.

2. Calculate material for girder.

3. Calculate material for joist to include trimmer joist.

4. Calculate material for headers.

5. Calculate material for bridging.

6. Calculate material for subfloor.

7. Calculate material for all plates.

8. Calculate material for all studs.

9. Calculate material needed for exterior wall sheathing.

10. Calculate material for exterior gable sheathing.

11. Calculate upper chord length.

12. Calculate # of trusses required.

13. Calculate material for the upper chord.

14. Calculate material for the lower chord.

15. Calculate material for the center post.

16. Calculate material for roof sheathing.

17. Calculate material needed to finish interior walls and ceiling, and nails.

18. Calculate for # rolls of roofing felt.

19. Calculate for total bundles of shingles.

20. Calculate # Lbs. of nails needed for:

    a. Roofing

b. Sheathing (8d)

c. Framing (16d)

REFERENCE(S):

1. FM 5-35, Engineer Reference and Logistical Data

2. FM 5-551, Carpentry

3. TM 5-704, Construction Print Reading in the Field

UNITED STATES MARINE CORPS
COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C01A15
31 Jan 01
(98 POI)

STUDENT HANDOUT

CONCRETE CONSTRUCTION

1. **Purpose:** This period of instruction is to provide you with the knowledge necessary to design and build concrete structures.

2. **Learning Objectives**:

a. Terminal Learning Objective(s):

(1) Given a location, and the compressive strength and dimensions of a required structure, with the aid of reference, Design concrete Mix needed for the structure per the reference. (1302.28)

(2) Given the dimension of a concrete structure, with the aid of reference, Design Concrete Forms per the reference. (1302.1.29)

(3) Given a mission, with the aid of reference, Design Reinforced Concrete Structures per the reference. (1302.1.29)

(4) Given a construction directive, with the aid of reference, Supervise the construction of a reinforced concrete structure per the reference. (1302.1.33)

b. Enabling Learning Objectives:

(1) Given the type of concrete structure and exposure conditions and requirements of concrete, with the aid of reference, select the cement to be used per the reference. (1302.1.28a)

(2) Given the compressive strength of a concrete structure, with the aid of reference, Select the Water/Cement Ratio per the reference. (1302.1.28b)

(3) Given the type of concrete structure, with the aid of reference, select the proper slump per the reference. (1302.1.28c)

(4) Given the dimensions of a concrete structure, with the aid of reference, determine the type of form to be used on the structure, per the reference. (1302.1.29a)

(5) Given the type of material and quantity of material, with the aid of reference, figure the bill of material needed to construct a concrete structure, per the reference. (1302.1.29b)

(6) Given the form design and requirements of a concrete structure, with the aid of reference, determine the proper spacing for all components of the form, per the reference. (1302.1.29c)

(7) Given a mission with the aid of reference, determine the overall strength requirements for the concrete structure, per the reference. (1302.1.32a)

(8) Given the dimension of a concrete structure, with the aid of reference, determine the type and amount of reinforcement required, per the reference. (1302,1,32b)

(9) As a member of a team, given mixing equipment, with the aid of reference, use the equipment to mix concrete per the reference. (1302.1.33a)

(10) As a member of a team, given a mixed batch of concrete with the aid of reference, place the batch into a concrete form per the reference. (1302.1.33b)

(11) As a member of a team, given a poured concrete pad with the aid of reference, finish concrete per the reference. (1302.1.33c)

OUTLINE

1. **CONCRETE MIX PROPORTIONS**

a. COMPONENTS OF CONCRETE. Concrete is a mixture of aggregate, and often-controlled amounts of entrained air, held together by a hardened paste made from cement and water.

b. DESIRABLE PROPERTIES OF CONCRETE.

(1) Plastic Concrete. This is concrete in a relatively fluid state, which is readily molded by hand, like a clump of molding clay.

(a) Workability - This property describes the relative ease or difficulty of placing and consolidating concrete in the form.

(b) Homogeneity - Plastic concrete must be carefully handled to keep segregation to a minimum.

(c) Uniformity - The uniformity of plastic concrete affects both its economy and strength. Each separate batch of concrete must be proportioned and mixed exactly the same to insure that the total structural mass has uniform structural properties.

(2) Hardened Concrete. This is the end product of any concrete design that has completed hydration.

(a) Strength - The ability of concrete to resist a load in compression, flexure, or shear is a measure of its strength.

(b) Durability - Concrete's ability to resist the effects of wind, frost, snow, ice, and abrasion is a measure of its durability.

(c) Water tightness - Tests show that the water tightness of a cement paste depends on the water cement ratio.

c. PORTLAND CEMENT. Portland cements contain lime and clay minerals (such as limestone, oyster shells, moral, clay, and shale), silica sand, iron ore, and aluminum.

(1)

Standard Types	Design	Compression Strength at	Purpose
Type I	Normal	28 days	Non-critical
Type II	Modified	45 days	Moderate Sulfate
Type III	High-Early	7 days	Cold Environments
Type IV	Low Heat	90 days	Massive Structure
Type V	Sulfate Resistant	60 days	Sewage Drainage

(2) Properties

Weight/Sack - 94 Lbs/sack
Volume/Sack - 1 cubic foot/sack
Specific Gravity - 3.15 (constant)

NOTE: Specific Gravity - The ratio of aggregate weight to the weight of an equal volume of water, or Specific Gravity compares the density of a mineral to the density of water.

d. WATER - Water has two functions in the concrete mix-to effect hydration and to improve workability.

(1) Water should be free of organic, oils, acids, and alkalis.

(2) Salt Water reduces the strength 10-20% and should not be used in reinforced concrete.

NOTE: DRINKABLE-WATER IS THE BEST WATER USED FOR CONCRETE CONSTRUCTION.

(3) The amount of water used in concrete ranges from 4 minimum to 7 gallons maximum per sack. 2 1/2 gallons for hydration and 1 1/2 to 4 1/2 gallons for workability.

(4) Weight - 8.33 Lbs per gallon

62.40 Lbs. per cubic foot

7.50 gallons per cubic foot

(5) Rule of thumb for ordering water is 8 gal. per sack of cement.

(6) Specific Gravity of water is 1.0

e. WATER/CEMENT RATIO (W/C). The strength, durability, and water tightness requirements of the hardened concrete determine the water cement ratio.

(1) Expressed as a decimal: mathematical relationship between the Weight of Water per unit volume of concrete and the Weight of Cement per unit volume of concrete.

Example: $$\text{W/C of .50} = \frac{\text{300 Lbs of water per cubic yard of concrete}}{\text{600 Lbs of cement per cubic yard of concrete}}$$

(2) Expressed in gallons of water per sack of cement:

Example: 5.6 gallons of water/sack of cement Note: This is equal to a W/C ratio of 0.49

$$\frac{5.6 \times 8.33 \text{ Lbs/gal}}{94 \text{ Lbs/sack}} = .496$$

f. AGGREGATES. Aggregates make up from 60 to 80 percent of concrete volume. Their characteristics influence the mix proportions and economy of the concrete considerably.

(1) Purpose.

(a) Reduce Shrinkage Cracks

(b) Economy

(2) Desirable Characteristics.

(a) Strong

(b) Durable

(c) Clean

(d) Bulky

(e) Well graded

(3) Specific Properties

(a) Fine Aggregate (Sand)

1 Gradation: Must pass a #4 sieve, retained on #200 sieve.

2 Fineness Modules - An index to the relative fineness or coarseness of fine aggregate with typical values ranging from 2.3 to 3.1.

3 Maximum Allowable Fines - (percent by weight of material finer than a No. 200 sieve.)

a Abrasive Structure $\leq$ 3%

b Non Abrasive Structure $\leq$ 5%

(b) Coarse Aggregate (Gravel)

1 Gradation: Passes 3-inch sieve, retained on #4 sieve.

2 Maximum Allowable fines $\leq$ 1%

3 Maximum Size Aggregate (MSA). Choose the smallest course aggregate answer using the following formulas:

a MSA = $\leq$ 1/5 (or.20) of the WALL thickness.

b MSA = $\leq$ 1/3 (or.33) of the SLAB thickness.

c MSA = $\leq$ 3/4 (or.75) of the MINIMUM CLEAR SPACE (MCS).

d MSA for the type of mixing equipment; FOR THE 11-S MIXER = 3" OR LESS)

e ** Select the smallest of the four rules from above.

(c) Bulk Unit Weight. The weight of the aggregate that fills a 1 cubic foot container.

(d) Specific Gravity. The average specific gravity for normal-weight aggregates is 2.6.

(e) Moisture Conditions. Bulking is the increase in volume caused by surface moisture holding the particles apart. Too much moisture on the aggregate surfaces also adds to the concrete mixing water. The amount can be considerable, especially the excess water in fine aggregate.

g. **AIR ENTRAINMENT**. An admixture that produces air bubbles in the concrete mixture.

(1) Advantages - Increases Durability, Workability and Water tightness

(2) Disadvantages - Decreases Strength (.05% for every .01% air)

(3) Methods

(a) Air entraining cement

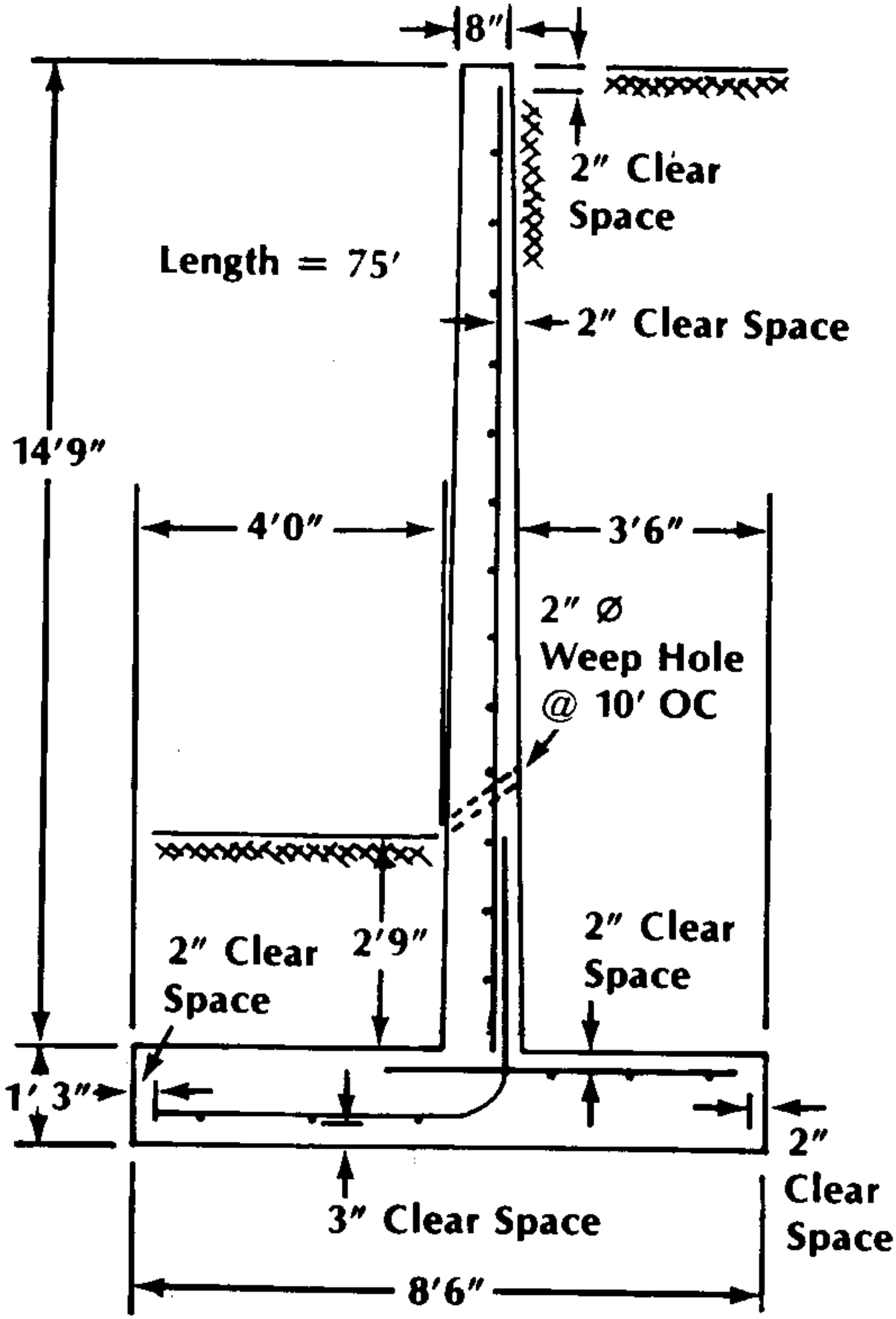
(b) Chemical Admixtures

h. **Designing Concrete Mix Proportion**: Obtain the preliminary proportions for a one cubic yard concrete mix to be used in a reinforced concrete retaining wall. It will be constructed at Camp Lejeune, NC. The climate is moderate. An 11-S Mixer is available. (The next page is a sketch for your project).

SPECIFICATIONS
Strength @ 28 days - 3,000 psi
Cement Types Available - I, IA, III
Water available from a potable source

Fine Aggregate:	F.M.	S.G.	B.U.W.	%FINES
Source A	2.50	2.65	120 Lbs/cf	4
Source B	2.95	2.60	125 Lbs/cf	6

Course Aggregate:	TYPE	MSA	S.G.	B.U.W	%FINES
Source A	Gravel	2"(-)	2.85	110 Lbs/cf	0.5
Source B	Gravel	1"(-)	2.69	95 Lbs/cf	1.0
Source C	Gravel	.5"(-)	2.70	103 Lbs/cf	1.3


8″
2″ Clear
Space
Length = 75′
2″ Clear Space
14′9″
4′0″
3′6″
2″ Ø
Weep Hole
@ 10′ OC
2″ Clear
Space
2′9″
2″ Clear
Space
1′ 3″
2″
Clear
Space
3″ Clear Space
8′6″

PROCEDURE

(l) Select Cement Type:

Availability: I, IA, III TYPE:________**(ANSWER)**

(2) Select An Aggregate Source:

(a) Fine Aggregate

1 Source ________**(ANSWER)**

2 Fineness Modules (FM) ________**(ANSWER)**

3 Specific Gravity (SG) ________**(ANSWER)**

4 Bulk Unit Weight (BUW) ________**(ANSWER)**

5 Percent Fines ________**(ANSWER)**

(b) Coarse Aggregate

1 Maximum Allowable fines $\leq$ 1%

2 Maximum Size Aggregate allowable for the project:

1/5 x Thickness of Wall: 1/5 x ________ = ________**(ANSWER)**

1/3 x Thickness of Slab: 1/3 x ________ = ________**(ANSWER)**

3/4 x Min. clear space: 3/4 x ________ = ________**(ANSWER)**

MSA for mixing equipment: = ________**(ANSWER)**

MSA for the Project (Smallest of above) = ________(**ANSWER)**

3 Chosen Course Aggregate

Source ________**(ANSWER)**

Type ________**(ANSWER)**

Max. size aggregate (MSA) ________**(ANSWER)**

Specific Gravity (SG) ________**(ANSWER)**

Bulk Unit Weight (BUW) ________**(ANSWER)**

Percent Fines ________**(ANSWER)**

(3) Select Water/Cement Ratio:

(a) Durability/Watertightness **(Pg. 3-2, Table 3-1)** =________(**ANSWER)**

Exposure Condition	Normal-Weight Concrete (Absolute W/C Ratio by Weight)
Concrete protected from exposure to freezing and thawing or the application of deicer chemicals	Select a W/C ratio on the basis of strength, workability, and finishing needs
Watertight concrete* • In freshwater • In seawater	 0.50 0.45
Frost-resistant concrete* • Thin sections; any section with less than a 2-inch cover over reinforcement and any concrete exposed to deicing salts • All other structures ←	 0.45 → 0.50
Exposure to sulfates* • Moderate • Severe	 0.50 0.45
Concrete placed underwater	Do not use less than 650 pounds of cement per cubic yard (386 kg/m^3).
Floors on grade	Select W/C ratio for strength, plus minimum cement requirements described in Table 3-7.

* For the properties of watertight concrete, frost-resistant concrete and exposure to sulfates, use designing strength for air-entrained concrete.

(b) Strength (**Pg.3-2, Table 3-2**) = ________**(ANSWER)**

Table 3-2. Maximum permissible W/C ratios for concrete

Specified Compressive Strength, in psi*	Maximum Absolute Permissible W/C Ratios by Water	
	Nonair-Entrained Concrete	Air-Entrained Concrete
2,500	0.67	0.54
3,000	0.58	0.46
3,500	0.51	0.40
4,000	0.44	0.35
4,500	0.38	**
5,000	**	**

NOTE: 1,000 psi = 7 MPa.

*28-day strength. The W/C ratios will provide average strengths that are greater than the specified strengths.

**For strength above 4,500 psi (nonair-entrained concrete) and 4,000 psi (air-entrained concrete), proportions should be established by the trial-batch method.

(c) Choose the lowest of the above; W/C Ratio = _________**(ANSWER)**

(4) Select Design Slump (**Pg. 3-5, Table 3-4):**

Table 3-4. Slumps for various types of construction (with vibration)

Concrete Construction	Slump, in Inches	
	Maximum*	Minimum*
Reinforced foundation walls and footings	3	1
Plain footing, caissons, and substructure walls	3	1
Beams and reinforced walls	4	1
Building columns	4	1
Pavements and slabs	3	1
Mass concrete	2	1
NOTE: 1 inch = 25 mm		
*May be increased 1 inch for consolidation by methods such as rods and spades.		

(a) Slump = _________**(ANSWER)**

(b) Slump testing determines the cement concrete consistency.

1 Dampen the mold and place it on a flat surface.

2 Fill the mold with three equal layers of concrete.

3 Tamp each layer 25 strokes with the tamping rod, penetrating the previous layer only 1″.

4 Strike off the excess concrete from the top of the mold.

5 Lift the mold from the concrete and place it beside the specimen.

6 Place the tamping rod across the top of the mold and measure the distance between the bottom of the rod and the top surface of the specimen.

7 Test 3 times a day as specs dictate; Acceptance of ±1 inch.

(5) Select Water Content and Percent Air: **(Pg. 3-4,Table 3-3)**

Maximum Aggregate Size: ______	3/8 Inch	1/2 Inch	3/4 Inch	1 Inch	1 1/2 Inches	2** Inches	3** Inches	6** Inches
Water in Pounds Per Cubic Yard of Concrete*								
Slump, in Inches	Nonair-Entrained Concrete							
1 to 2	350	335	315	300	275	260	240	210
3 to 4	385	365	340	325	300	285	285	230
6 to 7	410	385	360	340	315	300	285	
	Air-Entrained Concrete							
1 to 2	305	295	280	270	250	240	225	200
3 to 4	340	325	305	295	275	265	250	220
6 to 7	365	345	325	310	290	280	270	-
Approximate percentage amount of entrapped air in nonair-entrained concrete								
	3	2.5	2	1.5	1	0.5	0.3	0.2
Recommended percentage average and total air content for air-entrained concrete								
Anticipated Usage								
Mild exposure	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0
Moderate exposure	6.0	5.5	5.0	4.5	4.5	4.0	3.5	3.0
Severe exposure	7.5	7.0	6.0	6.0	5.5	5.0	4.5	4.0

*These quantities of mixing water are for use in computing cement factors for trial batches. They are maximums for reasonably well-shaped, angular CA graded within limits of accepted specifications.

**The slump values for concrete containing aggregate larger than 1 1/2 inches are based on slump tests made after removal of particles larger than 1 1/2 inches by wet screening.

(a) Water Content = _______Lbs/cuyd **(ANSWER)**

(b) Percent Air = _______ (**ANSWER)**

(6) Calculate Cement Content:

$$\textbf{Cement} = \frac{\textbf{Water (Lbs/cu yd)}}{\textbf{W/C ratio}}$$

________Lbs H2O ¸ ________W/C ratio =________Lbs/cuyd (**ANSWER)**

(7) Calculate Gravel Content: **(Pg. 3-10, Table 3-6)**

Table 3-6. Volume of CA per cubic yard of concrete

Maximum Size of Aggregate, in Inches	Fineness Modulus of FA			
	2.40	2.60	2.80	3.00
	CA, in Cubic Feet Per Cubic Yard			
3/8	13.5	13.0	12.4	11.9
1/2	15.9	15.4	14.8	14.3
3/4	17.8	17.3	16.7	16.2
1	19.2	18.6	18.1	17.6
1 1/2	20.2	19.7	19.2	18.6
2	21.1	20.5	20.0	19.4
3	22.1	21.6	21.1	20.5

NOTE: Volumes are based on aggregates in a dry-rodded condition, as described in Method of Test for Unit Weight of Aggregate (ASTM C29). These volumes are selected from empirical relationships to produce concrete with a degree of workability suitable for usual reinforced construction. For less workable concrete, such as that required for concrete pavement construction, the volume may be increased about 10 percent. When placement is to be by pump, volume should be decreased about 10 percent.

(a) Loose Volume of Gravel = ________cf/cuyd **(ANSWER)**

(b) Weight of Gravel = **(Loose Volume x BUW)**

_______ x _______ = _________Lbs/cuyd (**ANSWER)**

(8) Calculate Sand Content:

(a) Convert the Cement, Water, Air and Gravel Contents to Absolute Volumes.

Cement = $\frac{\text{(Lbs of cement)}}{(3.15 \times 62.4)}$

(_____________) ¸ **(______________)** = ___________cf/cy **(ANSWER)**

Water = $\frac{\text{(Lbs of water)}}{(1.0 \times 62.4)}$

(_____________) ¸ **(______________)** = ___________cf/cy **(ANSWER)**

Gravel = (Lbs of gravel)
(S.G. x 62.4)

(_____________) ¸ **(______________)** = __________cf/cy **(ANSWER)**

Air = (Percent Air) x 27 cf/cy

(__________) x 27 = ____________cf/cy **(ANSWER)**

Partial Volume (PV):

Add all the total absolute volumes = ____________cf/cy **(ANSWER)**

(b) Absolute Volume of Sand:

27 cuft/yd – (PV) = AbsVol of sand:

27 – (__________) = __________Abs.Vol of sand **(ANSWER**)

(c) Weight of Sand = **AbsVol of sand x SG.of sand x 62.4**

_______ x _______ x 62.4 = ________Lbs of sand **(ANSWER)**

(d) Loose Volume Sand = **Weight of Sand** ¸ **BUW SAND**

__________ ¸ __________ **=** __________ cf/cy **(ANSWER)**

(9) Preliminary Mix Proportions for a one cubic yard:

SUMMARY

Cement = _______ Lbs/cy ÷ 94 = _______Sacks/cy

Water = _______ Lbs/cy ÷ 8.33 = _______Gallons/cy

Sand = _______ Lbs/cy ÷ _____BUW = _______cf/cy

Gravel = _______ Lbs/cy ÷ _____BUW = _______cf/cy

Air = _____ %

Slump = _____ Inches

NOTE: THESE PROPORTIONS ASSUME A SATURATED SURFACE DRY (SSD) MOISTURE CONDITION FOR THE AGGREGATES. ADJUSTMENTS MUST BE MADE FOR THE ACTUAL MOISTURE CONDITIONS ON THE JOB SITE.

2. **CONCRETE MIXING EQUIPMENT**

a. Concrete Mixing Equipment Available at the Company Level.

b. 11S MODEL MIXER

(1) 11 cf capacity per batch.

(2) Charging time takes 2 1/2 minutes.

(3) Drum rotation speed is 17 RPM when charged.

(4) Mixing time is 1 1/2 minutes after all materials and water is in the drum.

(5) Discharge time is 1 minute.

c. Batching proportions for the 11S Mixer. The procedure for calculating each ingredient for batching the mixer to maximize the uniformity is as follows:

NOTE: Use the answers for the summary of the Preliminary Mix Proportion for a one cubic yard from lesson 1:

(1) Convert all the ingredients into volume/cubic feet:

Cement: _____ sacks/cy ÷ 1 cf per sack = _______ cf/cy

Water: _______ gallons/cy ¸ 7.5 = _______ cf/cy

Sand = _______ cf/cy

Gravel + _______ cf/cy

Add all the ingredients above = ________Total cf **(ANSWER)**

NOTE: Since the total cubic feet for this particular batch equals 40.25 we will use this number to equate the rest of the procedure.

(2) Proportion the cement:

[(cf cement ¸ total cf) x 11 cu/ft] = total cement cu/ft per batch

(_________ ¸ ___________) x 11 cu/ft = _________cf/batch **(ANSWER)**

(3) Proportion the water:

[(Cf water ¸ total cf) x 11 cu/ft] x 7.5 = gallons of water per batch

(________ ¸ _________) x 11 cu/ft x 7.5 = __________gal/batch **(ANSWER)**

(4) Proportion the sand:

(cf sand ¸ total cf) x 11 cu/ft = total sand cu/ft per batch

(________ ¸ __________) x 11 cu/ft = __________ cu/ft per batch **(ANSWER**)

(5) Proportion the gravel:

(cf gravel ¸ total cf) x 11 cu/ft = total gravel cu/ft per batch

(__________ ¸ _________) x 11 cu/ft =___________cu/ft per batch **(ANSWER**)

SUMMARY

Cement Per Mixer Batch	=	________	cf/sacks
Water Per Mixer Batch	=	________	gallons
Sand Per Mixer Batch	=	________	cf
Gravel Per Mixer Batch	=	________	cf

d. Free Surface Moisture.

(1) Prior to mixing check for Free Surface Moisture (FSM) (Appendix B pg. B-1 of FM5-742)

(2) Determine the total amount of water on fine aggregates by performing the field test (appendix B). Determine the amount of water on the coarse aggregates by observation. Coarse aggregate will only hold 1 percent of water.

(3) Free Surface Moisture (FSM) - Fine aggregates have a tendency to bulk (expand in volume) when wet. This factor becomes very important if the concrete is being batched at a mixer by volume; **the initial mix design must be adjusted in order to maintain the water:cement ratio the concrete mix called for.**

EXAMPLE PROBLEM: The materials are on site, and you are now ready to start mixing operations. But, first you must check your aggregates for free surface moisture. You're informed that you have **4% moisture on your fine aggregate and 1% moisture on your course aggregate**. Adjust the mix proportions **for (1) one mixer batch** due to the FSM on the aggregates.

Cement Per Mixer Batch: 1.86 cf/sacks x ______ = _________Lbs.

Water Per Mixer Batch: 9.67 gallons x _______ = _________Lbs

Sand Per Mixer Batch: 2.68 cf x ________ = __________Lbs

Gravel Per Mixer Batch: 5.16 cf x ________ = __________Lbs

Procedure

(a) Calculate the amount of FSM

Sand: .04 FSM x _______ Lbs/batch of sand = _______

Gravel: .01 FSM X _______ Lbs/batch of gravel = + _______

= _______Lbs. of FSM

(b) Decrease the mixing water due to FSM.

________Lbs. of water/mixer batch

\- _______ Lbs. of total FSM in aggregrates

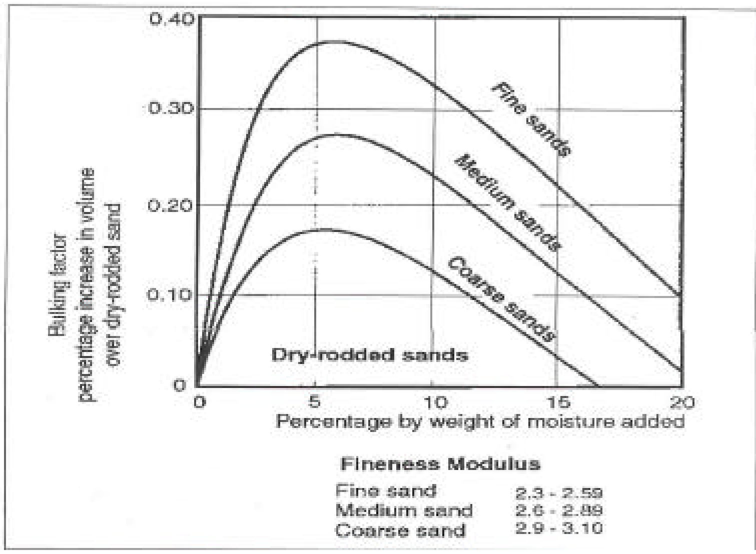
= _______ Lbs. of adjusted water/mixer batch

(c) Adjust the aggregates by volume using the bulking factor (BF) obtained from figure 3-4 on page 3-13.

[Cubic Feet of sand per Mixer Batch x (1 + Bulking Factor)] = Vwet
or
[Vdry x (1 + Bulk Factor)] = Vwet

Sand: [_______ x (1 + _______)] = _______ cf/mixer batch (**ANSWER**)

Gravel: [_______ x (1 + _______)]= _______ cf/mixer batch (**ANSWER**)



(d) Adjusted Mix Design for one (1) mixer batch due to FSM.

Cement _______ Sacks **(ANSWER)**

Sand _______ cf/batch **(ANSWER)**

Water _______ Lbs. **(ANSWER)**

Gravel _______ cf/batch **(ANSWER)**

Slump _______ **(ANSWER)**

3. **CONCRETE FORMWORK**

a. Forces on Formwork.

(1) Hydrostatic Fluid Pressure - The basis of form design is to offset the maximum pressure developed by the concrete during placing. The amount of pressure depends on the rate of placing and the ambient temperature of the plastic concrete. Knowing these two factors (rate of placement and ambient temperature) plus the specified type of form material, you can calculate a tentative design. The following formula will help you determine the maximum concrete pressure that will be exerted on the form you are to design:

$P_{max} = 150 + [(9000 \times R) \div T]$ **Note: $T = °f$ and for $R < 7$ ft/hr**

(2) Rate of placement (R) – The speed of placing the concrete mix into the formwork expressed in feet per hour.

(a) For an economical form design, the recommended placement rate **should not exceed 5 feet per hour**.

(b) There are two stipulations: P max cannot exceed 2000 psf for wall forms and 3,000 psf for column forms.

(3) **EXAMPLE PROBLEM**: Determine the PMax for the concrete retaining wall in Student Handout page 6. An 11-S Mixer will be used. It can produce 1 cy of concrete every 12 min. The concrete temperature is estimated to be **70 degrees Fahrenheit**.

PROCEDURE

(a) Mixer Output:

(Mixer Capacity x 60 min/hr x # of Mixers) ¸ **Batch Cycle = Mixer Output**

NOTE: BATCHING CYCLE WILL VARY, DEPENDING ON THE SPEED OF THE CREW; WE ARE USING AN EXPERIENCE CREW.

(______ cf x 60 min/hr x_____) ¸ **5 minutes** = _______ cf/hr

(b) Plan Area: **Length (ft) x width (ft) = Plan Area in Sq.Ft.**

1 FOR TRAPEZOID SHAPE WALLS USE THE FOLLOWING FORMULA FOR THE AVERAGE WIDTH OF THE WALL:

(Top + Bottom) ¸ **2 = Average width of wall**

Example (.66’ + 1’) ¸ **2   =** $.\overline{8}3$

2 Find the Square Footage of the plan area

_________(length) x __________(width) = _________ sf

(c) Rate of placement (R):   **Mixer Output** ¸ **Plan Area = Rate in ft/hr**

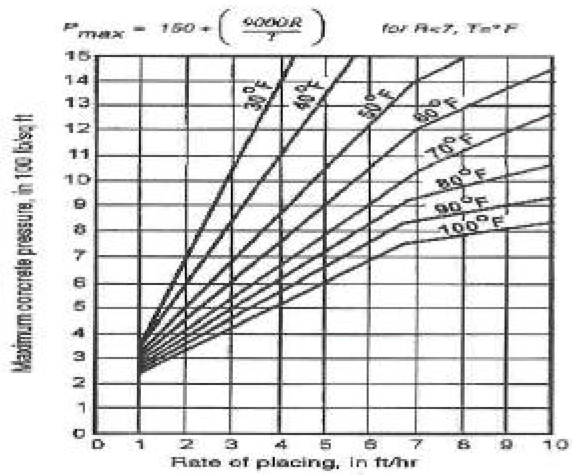
_________cf/hr ¸ __________sf = __________ ft/hr **(ANSWER)**

(d) Time required to place concrete.

(Height of form ¸ **Rate of placement) = Time Required to Pour**

_______ ÷ _______ = _______ Hours

(e) Estimated Concrete Pressure: Use the formula for an accurate answer.



OR

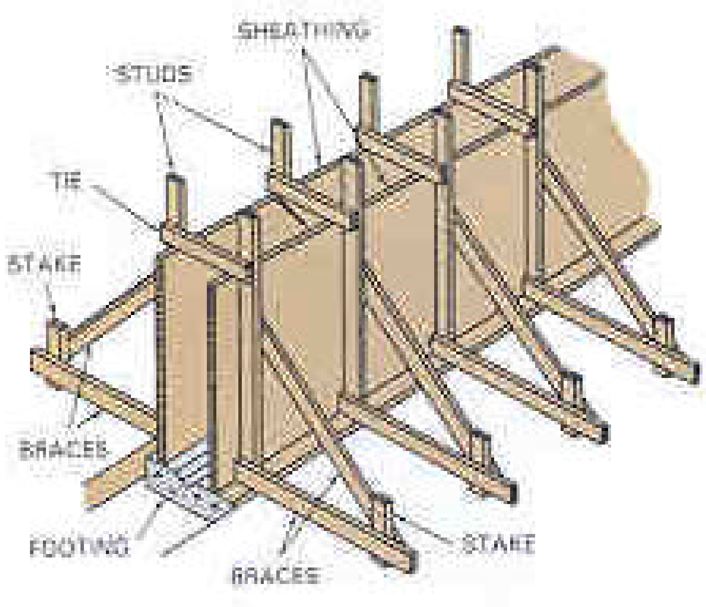
Concrete Pressure: P max = 150 + [(9000 x R) ¸ T]

[(9000 x ________ ft/hr) ¸ ______°] + 150 = ___________ Lbs/sf

b. Wall Form Design.

(1) Select Materials and Grain Direction:

Sheathing	-	3/4" plywood/strongway
Studs	-	2" x 4" lumber; single member
Wales	-	2" x 4" lumber; double member
Ties	-	#8 Gage Wire



(2) Maximum Stud Spacing.

NOTE: When using charts on table, always round up the Pmax answer to next larger number.

Stud Spacing = _______inches O/C

Table 4-2

Table 4-1. Maximum stud (joist) spacing for board sheathing

Maximum Concrete Pressure, in Pounds per Square Foot	Nominal Thickness of S4S Boards, in Inches			
	1	1 1/4	1 1/2	2
75	30	37	44	50
100	28	34	41	47
125	26	33	39	44
150	25	31	37	42
175	24	30	35	41
200	23	29	34	39
300	21	26	31	35
400	18	24	29	33
500	16	22	27	31
600	15	20	25	30
700	14	18	23	28
800	13	17	22	26
900	12	16	20	24
1,000	12	15	19	23
1,100	11	15	18	22
1,200	11	14	18	22
1,400	10	13	16	20
1,600	9	12	15	18
1,800	9	12	14	17
2,000	8	11	14	16
2,200	8	10	13	16
2,400	7	10	12	15
2,600	7	10	12	14
2,800	7	9	12	14
3,000	7	9	11	13

Maximum Concrete Pressure, in Pounds per Square Foot	Strong Way - 5-Ply Sanded Face, Grain Perpendicular to the Stud				Weak Way - 5-Ply Sanded Face, Grain Parallel to the Stud			
	1/2	5/8	3/4	1 (7 ply)	1/2	5/8	3/4	1 (7 ply)
75	20	24	26	31	13	18	23	30
100	18	22	24	29	12	17	22	28
125	17	20	23	28	11	15	20	27
150	16	19	22	27	11	15	19	25
175	15	18	21	26	10	14	18	24
200	15	17	20	25	10	13	17	24
300	13	15	17	22	8	12	15	21
400	12	14	16	20	8	11	14	19
500	11	13	15	19	7	10	13	18
600	10	12	14	17	6	9	12	17
700	10	11	13	16	6	9	11	16
800	9	10	12	15	5	8	11	15
900	9	10	11	14	4	8	9	15
1,000	8	9	10	13	4	7	9	14
1,100	7	9	10	12	4	6	8	12
1,200	7	8	10	11	-	6	7	11
1,300	6	8	9	11	-	5	7	11
1,400	6	7	9	10	-	5	6	10
1,500	5	7	9	9	-	5	6	9
1,600	5	6	8	9	-	4	5	9
1,700	5	6	8	8	-	4	5	8
1,800	4	6	8	8	-	4	5	8
1,900	4	5	8	7	-	4	4	7
2,000	4	5	7	7	-	-	4	7
2,200	4	5	6	6			4	6
2,400	-	4	5	6			4	6
2,600	-	4	5	5			-	5
2,800	-	4	4	5			-	5

(8) Uniform Load on the Stud **(ULS):**

[Concrete Pressure x Stud Spacing (in inches)] ¸ 12 in/ft = ULS

[__________Lbs/ft x ______inches] ¸ 12in/ft = ___________Lbs/Lf **(ANSWER)**

(9) Maximum Wale Spacing **(Page 4-7, Table 4-3 or Table 4-4):**

NOTE: When using charts on table, **always round up the ULS answer** to the next larger number on the chart.

Pressure on 2”x 4”material = __________ Lbs/Lf

Wale Spacing = __________ inches O/C

Table 4-3. Maximum spacing, in inches, for whales, ties, stringers, and 4" x 4 or larger shore where member to be supported is a SINGLE member

Uniform Load in Pounds per Linear Foot	Supported Members Size (S4S)*				
	2 x 4	2 x 6	3 x 6	4 x 4	4 x 6
100	60	95	120	92	131
125	54	85	440	80	124
150	49	77	100	75	118
175	45	72	93	70	110
200	42	67	87	65	102
225	40	62	82	61	97
250	38	60	77	58	92
275	36	57	74	55	87
300	35	55	71	53	84
350	32	50	65	49	77
400	30	47	61	46	72
450	28	44	58	43	68
500	27	41	55	41	65
600	24	38	50	37	59
700	22	36	46	35	55
800	21	33	43	32	51
900	20	31	41	30	48
1,000	19	30	38	29	46
1,200	17	27	35	27	42
1,400	16	25	33	25	39
1,600	15	23	31	23	36
1,800	14	22	29	22	34
2,000	13	21	27	21	32
2,200	13	20	26	20	31
2,400	12	19	25	19	30
2,600	12	19	24	18	28
2,800	11	18	23	17	27
3,000	11	17	22	17	26
3,400	10	16	21	16	25
3,800	10	15	20	15	23
4,500	9	14	18	13	21

*S4S indicates surfaced four sides.

Table 4-4. Maximum spacing, in inches, for ties and 4" x 4" or larger shores where member to be supported is a double member

Uniform Load, in Pounds per Linear Foot	Supporting Member Size (S4S)				
	2 x 4	2 x 6	3 x 6	4 x 4	4 x 6
100	85	126	143	222	156
125	76	119	135	105	147
150	70	110	129	100	141
175	64	102	124	96	135
200	60	95	120	92	131
225	57	89	116	87	127
250	54	85	109	82	124
275	51	84	104	78	121
300	49	77	100	75	118
350	46	72	93	70	110
400	43	67	87	65	102
450	40	63	82	61	97
500	38	60	77	58	92
600	35	55	71	53	81
700	32	51	65	49	77
800	30	47	61	46	72
900	28	44	58	43	68
1,000	27	43	55	41	65
1,200	25	39	50	38	59
1,400	23	36	46	35	55
1,600	21	34	43	33	51
1,800	20	32	41	31	48
2,000	19	30	39	29	46
2,200	18	29	37	28	44
2,400	17	27	36	27	42
2,600	17	26	34	26	40
2,800	16	25	33	25	39
3,000	15	24	32	24	38
3,400	14	23	30	22	35
3,800	14	21	28	21	33
4,500	12	20	25	19	30

(10) Uniform Load on the Wale **(ULW):**

[Concrete Pressure x Wale Spacing(in)] ¸ 12 in/ft = ULW

[___________Lbs/ft x ___________inches] ¸ 12in/ft =__________Lbs/Lf **(ANSWER)**

(11) Tie Spacing based on ULW **(Page 4-7, Table 4-3 or 4-4):**

NOTE: When using charts on table, **always round up the ULW answer** to next larger number on the chart.

Pressure on Wale = ___________ Lbs/Lf (ULS rounded up)

Tie Spacing = ___________ inches O/C

(12) Tie Spacing based on the strength of tie **(Page 4-8, Table 4-5):**

Table 4-5. Average breaking load of tie material, in pounds

Steel Wire	
Size of Wire Gage Number	Minimum Breaking Load Double Strand, in Pounds
8	1,700
9	1,420
10	1,170
11	930
Barbwire	
Size of Wire Gage Number	Minimum Breaking Load
12 1/2	950
13*	660
13 1/2	950
14	650
15 1/2	850
Tie-rod	
Description	Minimum Breaking Load, in Pounds
Snap ties	3,000
Pencil roads	3,000
*Single-strand barbwire	

[Tie Strength x 12 in/ft] ¸ ULW = Tie Spacing (TS)

[_______ x 12in/ft] ¸ _________Lbs/Lf =_______**(rd. down)** =______inches

(13) Maximum Tie Spacing:

(Pick the smaller between tie spacing due to ULW or wire breaking strength) = ________inches

(14) Adjusted Tie/Stud Spacing (Wire Ties Only):

Maximum Tie Spacing = _________ inches

Stud Spacing = ________ inches

Select the smaller of the two = _______inches

(15) Procedure to determine area of wall structure for sheathing:

(a) Area of walls = (Length x Height) x 2 sides

Walls: _______ft x _______ft x 2 sides = _______ SF

(b) Area of end walls = (Height x Width) x 2 ends

Ends = _______ft x _______ft x 2 ends = _______ SF

(c) Sheets of plywood = (Add total area of both walls)÷ 32 sf/sht

_________sf of walls

+ _________sf of end walls

_________Total sf ÷ 32 = _______ x 1.2 Waste factor = __________Sheets
(Round up whole #)

(16) Required number of studs per side:

[(Lgt of form x 12in/ft) ¸ Stud Spacing] + 1 = # of studs (Round Up)

[(_______ft x 12in/ft) ¸ ______inches] + 1 = ____ ____studs per side

Note: The spacing between the last two studs may be <u>less</u> than the maximum allowable spacing.

(17) Procedure to determine material for studs:

(a) Calculate studs both sides;

_______ Studs/(1) Side x 2 Sides = _______Studs for both side walls

(b) Calculate studs for ends;

_______ Studs/(1) End X 2 Ends = _______Studs for both end walls

(c) Total studs = _________ + _________ = _____________
(sides) (ends) (Total Studs)

(d) Determine the best EOL and the number of pieces required:

(Total studs ÷ # of studs/EOL = # of pieces required) x 1.1 waste factor

(__________ ÷ __________) x 1.1 = ____________Total # of EOL needed

(e) Total bdft: (______ x ____ x ____ x ______)÷ 12 = ________bdft
Qty   Thick   Width   Length

(18) Required number of Wales per side:

(Height of form x 12in/ft) ¸ Wale spacing = Number of Wales(Round up)

(_______ft x 12in/ft) ¸ ________inches = _____ ____Wales per side

(19) Procedure to determine material for wales:

(a) Calculate material in Linear Feet for the length of wales;

(b) Determine the length of the wale for the wall

NOTE 1: The wales go beyond the actual wall length to make the form.

[(Width of two 2^{2} x 4^{2} is 7 inches + .75^{2} thickness of plywood) x 2 for both ends] = 15.5 inches ¸ 12 (to convert to feet) = 1.29 feet (Add to the actual length of the wall)

_________LF x _____ Wales/Side x 2 Sides x 2 (Doubled) = _______LF(Round up to the next whole number)

(c) Calculate the wale length for the width of the end wall;

NOTE 2: Same as note 1, but add the thickness of the walls vice the length of the wall.

Wale extends 15.5^{2} + 10^{2} (Average thickness of end wall) = 25.5 inches
¸ 12” per foot
2.125’

2.125 LF/Wale x 8 Wales/End x 2 Sides x 2 Ends(Doubled) = ______LF(Round up to next whole number)

(d) Total Material: _______LF(Walls) + _______LF(Ends) = _______
Total LF

(e) Determine the best EOL and the number of pieces required:

(Total Lnft ÷ best EOL = # of pieces required) x 1.1 waste factor

(__________ ÷ __________) x 1.1 = ____________Total # of EOL needed

(f) Total bdft:(______ x ____ x ____ x ______) ÷ 12 = ________bdft

(20) Procedure to determine for ties:

(a) Use wire ties at every stud-wale intersection.

NOTE: Intersection is every time a stud comes in contact with a wale.

_______ Studs(1)Side x _______ Wales/Side = _______ Total Intersections

(b) Calculate length of wire tie (inches).

NOTE: See length of wale for width of end wall

Wale length on end wall: 25.5" x 2(Top/bottom) = ______ inches

Thickness of wale doubled (two 2″ x 4″): 3" x 2 (sides) = ______ inches

Twisting and tying: 1 ½″ x 2 = _______ inches

Add total length of wire of above answers = _______ Total length of wire in inches

(c) Calculate the total linear feet of wire required

(_______# of Intersections x _______Lgt.of wire) ÷ 12 in/ft = _______ LF

x 1.1 Waste

Total wire needed ________LF

c. BRACES FOR WALL FORMS.

(1) External Forces - wind, men, and equipment will move forms out of place or tend to tip them over. Braces are used to prevent this possible movement.

(2) Design.

(a) Expedient.

1 Brace every stud or every other stud.

2 Ensure brace angle is between 2O to 60 degrees.

3 Brace supports are required, if angle brace is greater than 6.5 feet.

(b) Exact Method.

1 Terms- To work the formula, you first must understand the following terms.

Lb- The total length of the brace member in feet from end connection to end connection.

Lmax - The maximum allowable unsupported length of the brace in feet, due to buckling and bending. For 2" material = 6.5'; for all 4" material = 14.5'.

L - The actual unsupported length of the brace used in feet.

H - The overall height of the wall form in feet.

Y - The point of application of the brace on the wall form, measured in feet from the base of the form.

Ø = The angle in degrees, that the brace makes with the horizontal. For best effect, ***Ø*** should be between 20 and 60 degrees.

J - Factor applied which includes all constant values (material properties and assumed wind force) measured in ft4; use Table 4-6, page 4-13.

Material, in Inches	J, In Feet^4
2 x 4	2,360
2 x 6	3,710
2 x 8	4,890
2 x 10	6,240
2 x 12	7,590
4 x 4	30,010

COS - cosine; Ratio of the distance from the stake to the wall divided by the length of the brace.

SIN - sine; The ratio "Y" divided by "Lb".

Smax - Maximum safe spacing of braces (ft) center to center, to support the walls against external wind forces.

Formula: **{(J x y) ¸ [(h^2) x (L^2)]} x cos Ø = Smax**

2 Designing the brace support for the wall in Student Handout page 6.

H - 14.75' (14' 9") **Lmax -** 6.5' (6' 6")

Lb - 16' **Y -** 10.5 (10' 6") **L – 4'**

NOTE 1: Lb = 16'; based on the factor that our form is 14.75 feet high, we determined that a 16'- 2^2 x 4^2 would be needed.

NOTE 2: Y = (10.5); this is randomly picked as a starting point that will fall into the 20 to 60 degree angle range.

NOTE 3: For our project we will use 4' as L, because it will divide evenly into 16' and is within our requirements)

a To determine **J;** consult Table 4-6 on page 4-13. Using 2" x 4" material, the **J** factor is 2,360.

b Determine the angle of placement, **Ø** through the following equation.

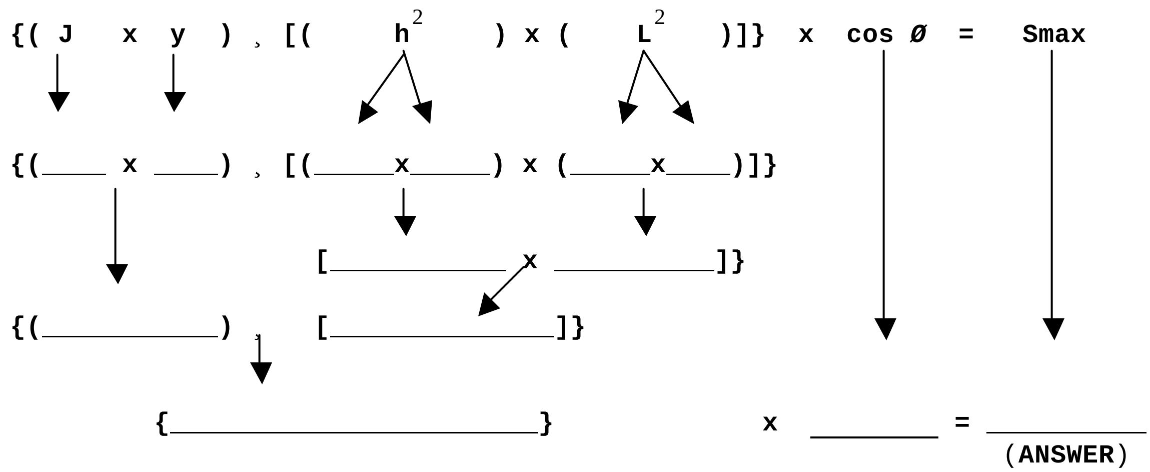
$$\sin Ø = \frac{y}{Lb} \qquad \sin Ø = \frac{10.5}{16} = \_\_\_\_\_\_\_\_$$

c Using the TRIGONOMETRIC TABLE on page 10-9 of FM 5-34, determine the **DEGREE OF ANGLE,** and the **COSINE.**

Sin Ø = .656 **Degree of angle Ø** = ______ **degrees**

Cosine = _________

d With the information we now have, we can determine the **Smax** of our braces, using the following equation.



e The braces must be attached to a stud, and since our stud spacing is 15" we can adjust our **Smax** to **5'** and brace every 4th stud.

4. **Materials Estimation for Concrete**: After designing a mix and a form design, it is necessary to estimate the total amounts of material needed for the job.

a. Compute the total volume of concrete to be poured, adding a waste factor, and multiplying this volume times the amount of each component in the 1 cubic yard mix design.

EXAMPLE PROBLEM: Estimate the quantities of cement, water, sand, and gravel required to construct the concrete retaining wall from Shudent Handout page 6. Use the mix design calculated for 1 cubic yard.

SUMMARY

Cement	=	**641.3**	Lbs/cy	÷	**94**	**=**	**6.82** Sacks/cy
Water	=	**295**	Lbs/cy	÷	**8.33**	=	**35.41** Gallons/cy
Sand	=	**1177.36**	Lbs/cy	÷	**120 BUW**	=	**9.81** cf/y
Gravel	=	**1795.50**	Lbs/cy	÷	**95 BUW**	=	**18.9** cf/cy

Procedure

(1) To figure for total cubic yards of concrete use the following formula:

[(Length x Width x Height) ¸ 27 cf] = Total cubic yards needed to pour

NOTE 1: THIS IS A STANDARD FORMULA FOR CONCRETE. THERE ARE 27 CUBIC FEET IN A CUBIC YARD OF CONCRETE.

NOTE 2: FOR A PROJECT FORM LIKE THE ONE WE HAVE BEEN DESIGNING, IT IS EASER TO FIGURE FOR EACH SECTION SEPERATELY. THEN ADD THEM TOGETHER FOR TOTAL YARDAGE.

(a) Wall [(______′ x ______′ x ______′) ÷ 27] = ____________cy
Lgt Hgt Thickness (**ANSWER**)

(b) Slab [(_______′ x ______′ x ______′) ÷ 27] = ___________cy
Lgt Wth Thickness (**ANSWER**)

(c) Add the cy for both wall and slab: Total = ___________cy
(**ANSWER**)

(d) Add waste factor

1 When ordering concrete, use the following waste factor as a rule of thumb.

a Volume > 200 CY, Waste Factor = 5%

b Volume ≤ 200 CY, Waste Factor = 10%

c Project Volume with the waste factor

_______Total cy x _____waste factor = (Rd. up whole #)_________TOTAL CY
(**ANSWER**)

(e) Order Quantities

1 Ordering by each concrete mix ingredients.

NOTE 1: WHEN ORDERING SAND AND GRAVEL ORDER BY TONNAGE OR CUBIC YARDS.

Total cubic yards X Quantities = Required material to order

Cement: _______ x _______Sacks =_______Total Sacks (Rd up to a full sack)

Sand: (_________ x ____________Lbs.) ÷ 2000 =________Tons (Rd up to whole #)

Gravel:(________ x ____________Lbs.) ÷ 2000 =________Tons (Rd up to whole #)

NOTE 2: REMEMBER TO ORDER 8 GALLONS OF WATER PER SACK OF CEMENT.

Water: _______ x _______Gallons =______Total Gallons

2 Ordering through a Commercial Ready Mix Company.

a The commercial ready mix trucks are capable hauling from 8 to 10 cubic yards of concrete. Most commercial concrete companies prefer to haul at least three yards or more on each truck. If you need less than three yards of concrete, the company may charge an extra fee.

b Procedures for ordering concrete from a commercial source will depend on your unit's purchasing policies. Most units would require you to inform the Supply NCOIC of your request. He in turn, would notify the Purchasing And Contracting Branch who would then contact the commercial concrete company that will give the best price for the concrete. However, it is up to you, the requester, to inform the Supply NCOIC of any specifications that the Concrete Company may need to know, e.g., type of concrete, slump, PSI's, air entrainment, etc.

5. **REBAR**:

a. Basic Theory.

(1) Although concrete is strong in compression, it is relatively weak in tension. But the reverse is true for slender steel bars. Therefore, when the two are materials are combined, one makes up the deficiency of the other.

(2) The design of a reinforced concrete structure consists mainly of predicting both the position and direction of potential tension cracks in concrete, and in preventing the cracks by locating sufficient reinforcing steel across their positions.

(a) **Shear** - An action or stress resulting from applied forces that causes or tends to cause two contiguous parts of a body to slide relatively to each other in a direction parallel to their plane. Shear strength of concrete is about one-third the unit compressive strength.

(b) **Tensile Strength -** The greatest longitudinal stress a substance can bear without tearing apart. Tensile strength is less than one-half the shear strength. Horizontal steel bars well embedded in the tension area provide tensile resistance.

(c) **Bending Strength** - Tension by curving or bowing. A beam subjected to a bending moment deflects because its compression side shortens and its' tension side lengthens. Therefore, the weak tension areas must be reinforced with steel.

b. Identification of Steel.

(1) Welded Wire Fabric - Its primary use is to control crack widths due to temperature changes.

(a) Does not add reinforcement

(b) Used to prevent shrinkage cracks

(2) Deformed Steel Bars - Bars are available in 11 sizes designated by numbers that range in size from 3/8 inch to about 2-1/4 inch in diameter.

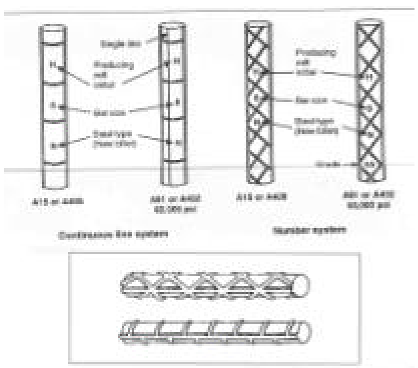


Figure 6-2. Deformed steel-reinforced bars

Table 6-1. Standard steel reinforcing bar

Bar Designation Number*	Unit Weight, in Pounds per Foot	Diameter, in Inches	Area, in Square Inches	Perimeter, in Inches
3	.376	0.375	0.11	1.178
4	.668	0.500	0.20	1.571
5	1.043	0.625	0.30	1.963
6	1.502	0.750	0.44	2.356
7	2.044	0.875	0.60	2.749
8	2.670	1.000	0.79	3.142
9	3.400	1.128	1.00	3.544
10	4.303	1.270	1.27	3.990
11	5.313	1.410	1.56	4.430
14	7.65	1.693	2.25	5.320
18	13.60	2.257	4.00	7.090

NOTE: The nominal dimensions of a deformed bar are equivalent to those of a plan round bar having the same weight per foot as the deformed bar.

*Bar numbers are based on the number of eighths of an inch included in the nominal diameter of the bars (example: a number 3 bar is 3/8 inch in diameter).

c. Fabrication. Splicing - Because reinforcing bars are available only in certain lengths, you must splice them together for longer runs. If one bar is not long enough for the spans, never butt reinforcing bars. A common way to splice bars is to lap them.

(1) Principles. It is usually best to locate splices beyond the center of a beam. When possible, stagger the splices so that all of them do not fall at the same point.

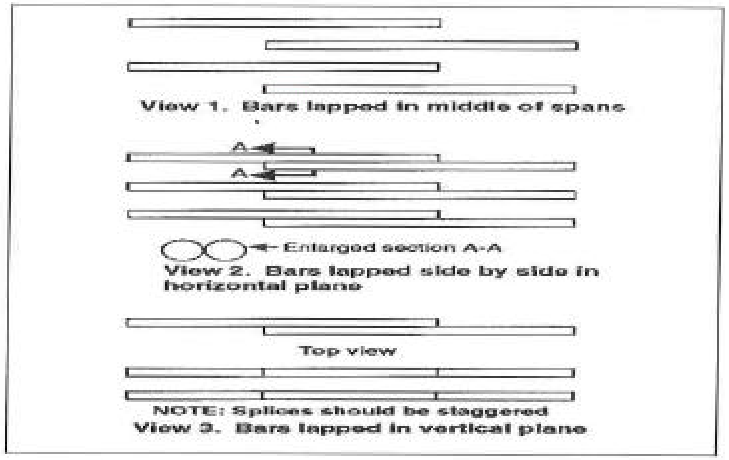


Figure 6-8. Method of splicing reinforcing bars

Table 6-4. Minimum splice overlap

(2) Methods.

(a) The Splicing Method is satisfactory when bar spacing is large, but do not use this method in a similar member having several closely spaced bars, or when the overlapping section interferes with the proper bar covering or form filling.

(b) Lapping bars in a horizontal plane is the most practical arrangement if the spacing provides enough clearance for aggregate to pass.

(c) Lapping bars in a vertical plane is used when the aggregate is too large for the horizontal plane method.

(d) Lap Welded Wire Fabric should be spliced and tied at one square plus 2 inches.

(3) Cutting Reinforcing Steel.

(a) Bolt cutters

(b) Hacksaw

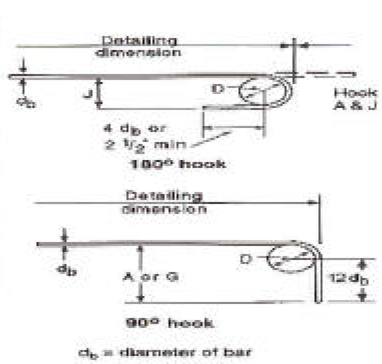
(c) Rebar Cutting Set

d. Bending of bars. Hooks should be fabricated to meet dimensional requirements stated in table 6-3, page 6-8, FM 5-742.

Table 6-3. Recommended end hooks (all grades)

Bar Size Number	D*	180° Hooks		90° Hooks
		A or G	J	A or G,
2	2 1/4"	5"	3"	6"
4	3"	6"	4"	8"
5	3 3/4"	7"	5"	10"
6	4 1/2"	8"	6"	12
7	5 1/4"	10"	7"	14"
8	6"	11"	8"	16"
9	9 1/2"	13"	11 3/4"	19"
10	10 3/4"	15"	11 1/4"	22"
11	12"	17"	12 3/4"	24"
14	18 3/4"	23"	19 3/4"	31"
18	24"	30"	24 1/2"	41"

*D = Finished bend diameter.



e. Placement.

(1) Spacing is based on specifications. Check alignment and overlap.

(2) Cover Minimums are based on several factors.

(a) If the concrete structure is cast against and will be permanently exposed to the earth should have a minimum concrete cover around the reinforcing steel of 3 inches.

(b) If the concrete structure is exposed to the earth or weather using #6 through #18 bars should have a minimum concrete cover around the reinforcing steel of 2 inches.

(c) If the concrete structure is exposed to the earth or weather using #5 bars should have a minimum concrete cover around the reinforcing steel of 1-1/2 inches.

(d) Concrete structures such as slabs, walls, and joists, using #14 and #18 bars that are not exposed to weather nor in contact with the ground should have a minimum concrete cover around the reinforcing steel of 1-1/2 inches.

(e) Concrete structures such as slabs, walls, and joists, using #11 bars and smaller that are not exposed to weather nor in contact with the ground should have a minimum concrete cover around the reinforcing steel of 3/4 inch.

(f) Concrete structures such as beams and columns with the primary reinforcement being ties, stirrups, or spirals that are not exposed to weather or in contact with the ground should have a minimum concrete cover around the reinforcing steel of 1-1/2 inches.

(g) Concrete structures exposed to salt water should have a minimum concrete cover around the reinforcing steel of 4 inches.

f. <u>Supports</u>.

(1) All steel reinforcement must be accurately located in the forms and held firmly in place both before and during placing of concrete.

(2) Manufactured - High Chairs, Bolsters usually support the horizontal reinforcing bars and hold them in place during construction. Support horizontal bars at minimum intervals of 5 or 6 feet, and secure all bars to supports and other bars using tie wires not smaller than 18 gage. The twisted tie ends should project away from an interior surface.

Figure 6-4. Typical shapes of reinforcing steel for beams

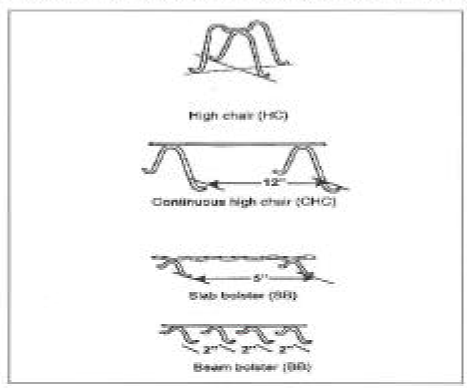


Figure 6-5. Supports for horizontal reinforcing steel

(3) Field Expedient - Wire Fabric, Mortar Cubes

(a) Wire fabric is sometimes used to pre-assemble the reinforcing steel for concrete walls in place.

(b) Mortar cubes can be made from the mortar having the same consistency as the concrete, but without the coarse-aggregate. Spacer blocks are usually 1-1/2 inches to 4 inches square, varying in length as required. Cast tie wires into the blocks to secure them to the reinforcing bars.

6. **<u>Quality Control</u>**:

a. Testing Materials

(1) Cement.

(a) Storage - Portland Cement that is kept dry will retain its quality indefinitely. Store sacked cement in a warehouse or shed that is as nearly airtight as possible.

1 Keep Dry, Palletized, Covered
2 Use old cement first
3 Stack 14 bags high if used < 60 days
4 Stack 7 bags high if used > 60 days

(b) Packing sacks to tightly or too high cause warehouse Pack.

1 Looks solid
2 Will return to powder form
3 Usable

(c) Partial Hydration is caused when moisture comes in contact with the cement.

1 Lumpy, Gritty
2 Has lost some strength
3 Will not break down to powder

(2) Excess Fines on Sand

(a) Lab Test: Sieve Analysis

(b) Field Test

1 2" Sand, 3" of Water above the sand level
2 Shake
3 Let Stand 1 hour
4 1/8" Silt or less is good sand

(c) Course of Action

1 Find another source
2 Resift, Wash

b. Site Preparation.

(1) Prior to placing check the trimming, compaction, and moistening of the subgrade. Moistening the subgrade is especially important in hot weather to prevent water extraction from the concrete.

(2) Check placement of forms.

(3) Check placement of anchor bolts. It is used to anchor either machinery, or structural steel and wood frame components.

(a) Meet Specification

(b) Properly aligned

(4) Air Content (Air-entrained concrete only)

(a) Acceptance ±1%

(b) Air Entrainment Meter

c. Construction Joints.

(1) Isolation Joints. These joints are used to separate adjacent structural members.

(2) Control joints. These joints are cut into the concrete slab to create a plane of weakness which forces cracking (if it happens) to occur at a designated place rather than randomly.

(3) Construction Joints. These joints are made where the concrete placement operations end for the day or where one structural element will be cast against previously placed concrete.

d. Placing.

(1) The principles of proper concrete placement include:

(2) Segregation. Avoid segregation during all operations from the mixer to the point of placement, including final consolidation and finishing.

(a) Place against previous load in layers of 6 to 12 inches.

(b) Never allow concrete to free fall more than 5 feet.

(c) Chutes no flatter than 3:1 and no stepper than 2:1 ratio.

(3) Consolidation. Thoroughly consolidate the concrete, working solidly around all embedded reinforcement, and filling all form angles and corners. Vibrate every foot for 3 to 5 seconds.

(4) Bonding. When placing fresh concrete against or upon hardened concrete, make sure that a good bond develops.

e. Finishing. The finishing process provides the desired final concrete surface. There are many ways to finish concrete surfaces, depending on the effect required.

(1) Screed. Screeding brings the surface to the correct elevation by striking off the excess concrete.

(2) Float. Floating has three purposes: to embed aggregate particles just beneath the surface; to remove slight imperfections, high spots, and low spots; and to compact the concrete at the surface in preparation for other finishing operations.

(3) Trowel. For a dense, smoother finish, follow floating with steel troweling when the moisture film or water sheen disappears from the floated surface and the concrete has hardened enough to prevent fine material and water from working to the surface.

(4) Broom. Brooming can produce a nonskid surface by following the floating operation (after waiting 10-15 minutes) by brooming the concrete before it hardens thoroughly.

(5) Edger and jointer. For rounding the edges or control joints.

f. Curing. Take the appropriate steps to control the temperature of any fresh concrete from mixing through final placement, and protect the concrete from temperature extremes after placement.

(1) Desired Concrete Temperature

(a) Concrete Thermometer

(b) Acceptance $\pm 5\ ^{o}F$

(2) Adjustment Temperature

$$Ra = \frac{(Rd \times Ta)}{Td}$$

NOTE: Ra = Rate of placement adjusted
Rd = Rate of placement designed
Ta = Temperature actual
Td = Temperature designed

(3) Curing is the period of time from consolidation to the point where the concrete reaches its design strength.

(a) Moisture - Several curing methods will keep concrete moist and, in some cases, at a favorable hydration temperature. They fall into two categories: those that supply additional moisture, and those that prevent moisture loss.

(b) Temperature - 73 degrees Fahrenheit

(c) Time 3-14 days

(4) Adverse Weather Conditions.

(a) Hot weather.

1 Effects

a Rapid Evaporation

b Flash Set - Cracking

c Reduced Workability

2 Courses of Action

a Retarding Admixture

b Cool aggregates

c Ice water

d Work at night

e Shade, Cover

f Flood, Spray

(b) Cold Weather

1 Effects

a Slow curing

b Freezing concrete

2 Courses of Action

a Accelerator Admixture - 2% CaCl

b Use Type III Cement

c Heat Aggregates, Water

d Insulate

e Enclose and heat structure

(c) Wet Weather

1 Effects

a Change water cement ratio

b Affect finish

2 Courses of Action

a Delay project

b Cover

c Increase Crew size

7. **Slab projects**. Concrete slabs on grade are the most often constructed concrete projects by engineer units.

a. Basic assumptions.

(1) Minimum slab thickness will be 4 inches for Class 1, 2 and 3 floors.

(2) Only the static load (SL) area and flexural strength required will be considered, ie. Heaviest concentrated load the slab carries.

b. Design procedure.

EXAMPLE: Determine the slab thickness for the floor of a wheeled vehicle shop. Total weight on one wheel is 7,500 Lbs, and the loaded area = 40 square inches. Abrasive wear is expected. Maximum size aggregate from the source is 1 inch.

(1) Determine the floor classification; page 4-20, Table 4-9.

Class = ______**(ANSWER)**

Table 4-9. Concrete floor classifications

Class	Usual Traffic	Use	Special Consideration	Concrete Finishing Technique
1	Light foot	Residential or tile-covered	Grade for drainage; make plane for tile	Medium steel trowel
2	Foot	Offices, churches, schools, hospitals Ornamental residential	Nonslip aggregate; mix in surface Color shake, special	Steel trowel; special finish for nonslip Steel trowel, color, exposed aggregate; wash if aggregate is to be exposed
3	Light foot and pneumatic wheels	Drives, garage floors, sidewalks for residences	Crown; pitch joints Air entrainment	Float, trowel, and broom
4	Foot and pneumatic wheels*	Light industrial commercial	Careful curing	Hard steel trowel and brush for nonslip
5	Foot and wheel abrasive wear*	Single-course industrial, integral topping	Careful curing	Special hard aggregate float and trowel
6	Foot and steel-tire vehicles - severe abrasion	Bonded two-course, heavy industrial	Base: Textured surface and bond	Surface leveled by screeding
			Top: Special aggregate and/or mineral or metallic surface treatment	Special disc-type power floats with repeated steel troweling
7	Same as classes 3, 4, 5, 6	Unbonded topping	Mesh reinforcing; bond breaker on old concrete surface; minimum thickness 2 1/2 inches	

***Under abrasive conditions on floor surface, the exposure will be much more severe and a higher quality surface will be required for class 4 and 5; for a class 6, two-course floor, a mineral or metallic aggregate monolithic surface treatment is recommended.**

(2) Determine the Slump Range and the Minimum Compressive Strength (F’c).

Slump = _____________**(ANSWER)** F’c = _____________**(ANSWER)**

Table 4-10. Recommended slumps and compressive strengths

Class of Floors	Slump Range, in inches	Minimum Compressive Strength, f'_c in Pounds per Square Inch*Use
1	2-4	3,000
2	2-4	3,500
3	2-4	3,500
4	1-3	4,000
5	1-3	4,500
6 base	2-4	3,500
6 topping**	0-1	5,000 - 8,000
7	1-3	4,000

NOTE: These recommendations are specially for concrete made with normal-weight aggregate. For structural slabs, the requirements of ACI 318 and the contract documents should be met.

*Refer to the minimum compressive strength of cylinders made and tested according to applicable ASTM standards for 28 days. The average of any five consecutive strength tests of continuously moist-cured specimens representing each class of concrete should be equal to or greater than the specified strength.

**The cement content of the heavy-duty floor topping depends upon the severity of the abrasion. The minimum is 846 pounds per cubic yard.

(3) Determine the allowable flexural tensile stress (F't);

Formula: F't = 4.6 x (Square of F'c)

F't = 4.6$\sqrt{______}$ = _________Round up next whole number =_______**(ANSWER)**

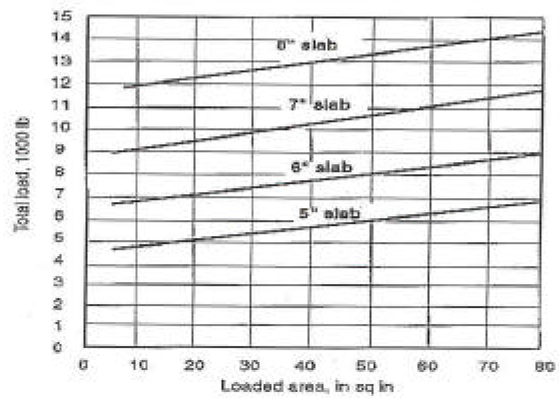
(4) Determine the equivalent static load (ESL). Generally, the expected impact loading is 25% more than the static load (SL) for vehicles; ESL = (1 + 25%) x SL

ESL = (1.25) x ____________Lbs. = ____________**(ANSWER)**
SL

(5) Correct the equivalent static load (CESL), if F't ≠ 300 psi. This is necessary to use the standard thickness figure chart; CESL = ESL x (300 ÷ F't)

CESL = _________x (300 ÷ ______) = __________Round up next whole number = ________Lbs.**(ANSWER)**

(6) Determine slab thickness; page 4-21, figure 4-6 (Round up to the next higher 1/4 inch thickness; _____________**(ANSWER)**



NOTE: This chart is based on flexural tensile stress of 300 psi

(7) Determine the minimum cement content and recommended air content; page 4-21, table 4-11; __________**Lbs/CY and** _______**%(ANSWER)**.

Maximum Size of Coarse Aggregate	Minimum Cement Content, in Pounds per Cubic Yard	Air Content for Freeze-Thaw Resistance, Shown in Percentage*
1 1/2	470	5 ± 1
1	520	6 ± 1
3/4	540	6 ± 1
1/2	590	7 1/2 ± 1
3/8	610	7 1/2 ± 1

NOTES: These mixtures are specially for concrete made with normal-weight aggregate; different mixtures may be needed for lightweight aggregate concrete. For structural slabs, the requirements of ACI 318 and the contract document must be met.

*Smaller percentages of entrained air can be used for concrete floors that will not be exposed to freezing and thawing or deicing. This may improve the workability of the concrete and the finish product.

(8) Procedure with the same steps as figuring for the design for one cubic yard.

8. **Controlled Practical Application**:

a. The following student materials are needed to complete this practical application.

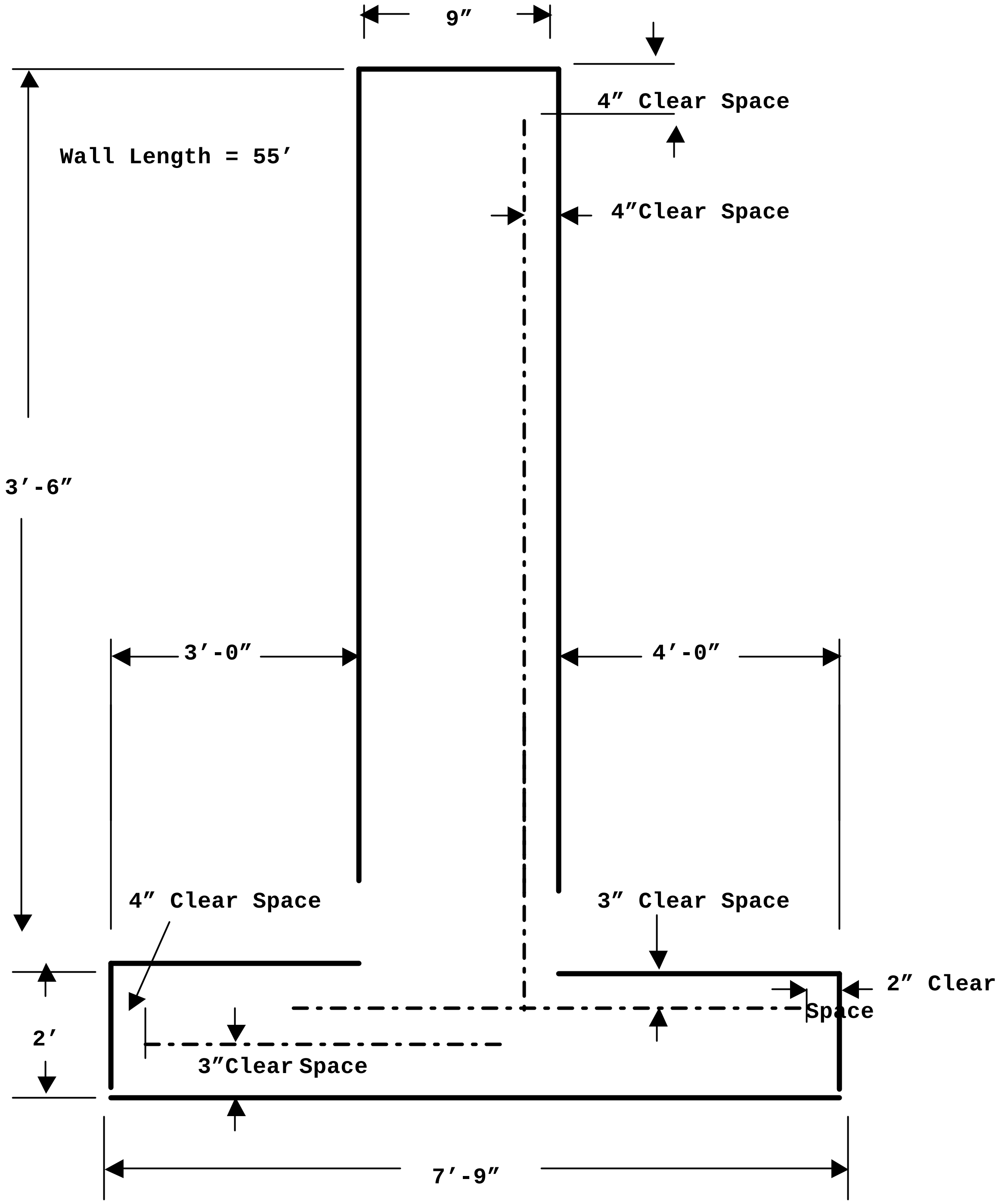
(1) Student Outline

(2) Calculator

(3) FM5-742, Concrete and Masonry

b. Read all directions carefully.

c. This practical application is self paced. **DO NOT** advance to fast in order that the instructor may check your work.



SPECIFICATIONS:

Strength @ 28 days – 4000 psi

Cement Types Available I, IA, IIIA

Water is from a potable source

FINE AGGREGATES:

	F.M.	S.G.	BUW	% FINES
Source A	2.60	2.80	125 Lbs.	4
Source B	2.85	2.60	120 Lbs.	7

COURSE AGGREGATES:

	TYPE	MSA	S.G.	BUW	% FINES
Source A	Gravel	3 inch	2.52	125 Lbs.	1.0
Source B	Gravel	2 inch	2.70	115 Lbs.	1.0
Source C	Gravel	1 inch	2.60	110 Lbs.	0.5

PART ONE (1): OBTAIN PRELIMINART MIX PROPORTIONS

OBTAIN THE PRELIMINARY MIX PROPORTIONS FOR A ONE CUBIC YARD CONCRETE MIX TO BE USED IN A **REINFORCED RETAINING WALL**. IT WILL BE CONSTRUCTED AT CAMP LEJEUNE, NC. **THE CLIMATE IS MODERATE**. **TWO (2) 11-S MIXERS** ARE AVAILABLE.

PROCEDURE:

1. Select Cement Type: ____________ **(ANSWER)**

2. Select Aggregates:

   a. Fine Aggregate Source: _____________ **(ANSWER)**

   b. Course Aggregates:

      1) Maximum size aggregates allowable for the project:

MSA for Wall = ________ **(ANSWER)**

MSA for Slab = ________ **(ANSWER)**

MSA for Clear Space = _________ **(ANSWER)**

MSA for Mixing Equipment Type used _________ = _________ **(ANSWER)**

MSA possible to use for this Project = _________ (ANSWER)

2) Choice of Course Aggregate Source: _________ **(ANSWER)**

3. Select Water:Cement Ratio:

   a. Durability/WaterTightness ________ **(ANSWER)**

   b. Strength ________ **(ANSWER)**

   c. Chosen Water:Cement Ratio ________ **(ANSWER)**

4. Select Slump Design: ________ **(ANSWER)**

5. Select Water Content and Percent of Air:

   a. Water Content ___________ **(ANSWER)**

   b. Air % ________ **(ANSWER)**

6. Calculate Cement Content: _____________ **(ANSWER)**

7. Calculate Gravel Content/Weight:

   a. Loose Volume of Gravel = _____________ **(ANSWER)**

   b. Weight of Gravel = ____________ **(ANSWER)**

8. Calculate Sand Content:

   a. Convert to Absolute Volumes

      1. CEMENT: ___________ **(ANSWER)**

      2. WATER: _____________ **(ANSWER)**

3. Gravel: ______________ **(ANSWER)**

4. Air: _____________ **(ANSWER)**

5. Partial Volume: _________ **(ANSWER)**

6. Absolute Volume of Sand: _________ **(ANSWER)**

7. Weight of Sand: ____________ **(ANSWER)**

8. Loose Volume of Sand: ____________ **(ANSWER)**

9. Preliminary Mix Proportions for a One (1) Cubic Yard:

Cement _________ Sacks/Cy **(ANSWER)**

Water _________ Gallons/Cy **(ANSWER)**

Sand _________ CuFt/Cy **(ANSWER)**

Gravel _________ CuFt/Cy **(ANSWER)**

Air _________ % **(ANSWER)** Slump _________ Inches **(ANSWER)**

PART TWO (2) BATCH PROPORTIONS

1. Determine the batch proportion for the 11s mixer:

a. Total Cubic Feet of all ingredient proportions = _________**(ANSWER)**

b. **Cubic Feet of Cement per Batch** = ________ **(ANSWER)**

c. **Gallons of Water per Batch** = ________ **(ANSWER)**

d**. Cubic Feet of Sand per Batch =** ________ **(ANSWER)**

e. **Cubic Feet of Gravel per Batch** = ________ **(ANSWER)**

PART THREE (3) ADJUST MIX DUE TO THE FREE SURFACE MOISTURE

THE MATERIALS ARE ON SITE. PRIOR TO STARTING MIXING OPERATIONS, YOU PERFORM A FIELD TEST ON YOUR AGGREGATES. YOU DETERMINE THAT YOU HAVE **APPROXIMATELY 2% FREE SURFACE MOISTURE ON YOUR FINE AGGREGATES**, AND **1% ON YOUR COURSE AGGREGATES.**

1. Determine the amount of water:

   a. Sand = _______ Lbs. of FSM **(ANSWER)**

   b. Gravel = _______ Lbs. of FSM **(ANSWER)**

   c. Total Pounds of FSM = _______ Lbs. **(ANSWER)**

2. Amount of Mixing Water after adjustment for FSM: _______ Lbs/batch **(ANSWER)**

3. Adjust the Aggregates due to Bulking from FSM:

Sand = ____________ cuft/batch due to FSM **(ANSWER)**

Gravel = __________ cuft/batch due to FSM **(ANSWER)**

4. Adjusted Mix Design for (1) Mixer Batch due to FSM:

Cement _______ Lbs. **(ANSWER) or** _________ Sacks/Batch **(ANSWER)**

Water _______ Lbs. **(ANSWER) or** _________ Gallons/Batch **(ANSWER)**

Sand _______ Cf/Batch **(ANSWER)**

Gravel _______ Cf/Batch **(ANSWER)**

Slump _______ **(ANSWER)**

PART FOUR (4) FORM DESIGN

DESIGN THE FORMS FOR THE CONCRETE RETAINING WALL. **TWO (2) 11s MIXER** WILL BE USED. THE CREW IS EXPERIENCED WITH A **FIVE (5) MINUTES BATCHING** TIME. CONCRETE TEMPERATURE IS ESTIMATED AT **70 DEGREES FAHRENHEIT**.

MATERIAL AVAILABLE:

2 x 4 LUMBER, 3/4 PLYWOOD **(STRONGWAY)**, # **9** GAGE TIE WIRE
Single member stud, Double member wale

Procedure:

1. Mixer Output: _______CuFt per Hour **(ANSWER)**

2. Plan Area: ________ SF **(ANSWER)**

3. Rate of Placement: _________ Feet Per Hour **(ANSWER)**

4. Time Required to Pour Concrete: ________ **(ANSWER)**

5. Estimated Concrete Pressure: _______ **(ANSWER)**

6. Maximum Stud Spacing: _______ **(ANSWER)**

7. Uniform Load On Stud: ________ **(ANSWER)**

8. Maximum Wale Spacing: _______ **(ANSWER)**

9. Uniform Load on Wale: ________ **(ANSWER)**

10. Tie Spacing based on ULW: _______ **(ANSWER)**

11. Tie Spacing based on Strength: _______ **(ANSWER)**

12. Maximum Tie Spacing: ________ **(ANSWER)**

13. Adjusted Tie / Stud Spacing: ________ **(ANSWER)**

PART FIVE (5) ESTIMATE MATERIALS

ESTIMATE THE MATERIALS NEEDED FOR THE CONCRETE RETAINING WALL.

MATERIAL AVAILABLE:

2 x 4 LUMBER, 3/4 PLYWOOD, # 9 GAGE TIE WIRE

1. Required Number of Studs Per Side: ________Per Side **(ANSWER)**

2. Required Number of Wales Per Side: _______Per Side **(ANSWER)**

3. Determine number of Sheathing Required: _______Total Sheets **(ANSWER)**

4. Determine Stud Requirements: _________ Total Studs **(ANSWER)**

_________ Best EOL **(ANSWER)**

_________ Total Board Feet **(ANSWER)**

5. Determine Material for Wales: _________ LF **(ANSWER)**

_________ Best EOL **(ANSWER)**

_________ Total Board Feet**(ANSWER)**

6. Determine # of Tie Wire: _________ Total Intersections **(ANSWER)**

7. Determine Total Linear Feet of Tie Wire: ________ Total LnFeet **(ANSWER)**

8. Determine Total Amount of Concrete Material:

a. Preliminary Mix Proportions **for One (1) Cubic Yard**:

Cement _________ Sacks

Water _________ Gallons

Sand ________ Cubic Feet = __________ Lbs.

Gravel ________ Cubic Feet = __________ Lbs.

b. Figure For Total Cubic Yards = _______ Total Cubic Yards **(ANSWER)**

c. Order Quantities

Cement _______ Total Sacks **(ANSWER)**

Water _______ Total Gallons **(ANSWER)**

Sand _______ Total Tonnage **(ANSWER)**

Gravel _______ Total Tonnage **(ANSWER)**

REFERENCES:

1. FM 5-34, Engineer Field Data

2. FM 5-426, Carpentry

3. FM 5-428, Concrete and Masonry

UNITED STATES MARINE CORPS
COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C-01A17
22 Jun 00
(98 POI)

STUDENT HANDOUT

CONSTRUCTION MANAGEMENT

LEARNING OBJECTIVES

1. Terminal Learning Objectives:

a. Given written project specifications and necessary materials, with the aid of references, prepare a project schedule in accordance with FM 5-412. (1302.1.41)

b. Given a completed project schedule and necessary materials, with the aid of references, update the project schedule as required in accordance with FM 5-412. (1302.1.43)

2. Enabling Learning Objectives:

a. Given written project specifications, necessary materials and references, develop an activities list in accordance with the references. (1302.1.41a)

b. Given written project specifications, a completed activities list, necessary materials and references, create a logic diagram/precedence network in accordance with the references. (1302.1.41b)

c. Given written project specifications, a completed activities list, a completed logic diagram/precedence network, necessary materials and references, estimate individual activity duration in accordance with the references. (1302.1.41c)

d. Given written project specifications, a completed activities list, a completed logic diagram/precedence network, completed activity estimate sheets, necessary materials and references, create a project schedule in accordance with the references. (1302.1.41d)

e. Given a completed project schedule, notional TO/TE constraints, necessary materials and references, perform resource leveling in accordance with the references. (1302.1.43a)

f. Given a completed project schedule, notional weekly progress reports, necessary materials and references, update the project schedule in accordance with the references. (1302.1.43b)

OUTLINE

1. **CONSTRUCTION DIRECTIVES**: The construction management process starts with the receipt of a directive, which is an order to construct, rehabilitate or maintain a facility.

a. Construction directives vary in both form and content, and may be issued in one of two ways:

(1) Orally, for simple projects.

(2) Written, for more complex projects.

b. The construction directive may be issued in any of three stages of detail:

(1) It may contain detailed plans and specifications. The more stable the operational environment, the more detailed the directive becomes.

(2) It may refer to standard drawings or procedures already published in technical manuals, field manuals, automated software programs or previously issued directives.

(3) It may require the tasked unit to prepare plans and specifications for subsequent approval by the issuing organization.

c. Regardless of how the construction directive is issued or how detailed it is, it should contain the following information:

(1) Mission. The mission should state the exact assignment with all necessary details, and may include implied missions.

(2) Location. This may be a definite location, or the directive may require the tasked unit to select a site within a general area; either way, a site investigation should be conducted. A site investigation should provide answers to the following questions:

(a) What are the *terrain* features of the proposed site?

(b) What are the existing *drainage* characteristics?

(c) Are there any problems with *accessibility*?

(d) What is the *soil* type?

(e) Are there *existing facilities* that can be used?

(f) What *natural resources* are located near the site?

(g) What *weather* conditions can be expected during construction?

(h) What is the *enemy* situation?

(3) Time. Time determines the start and finish of the project.

(4) Personnel. This item of the construction directive tells what additional personnel are available, if needed.

(5) Equipment. Any additional equipment to be made available.

(6) Materials. The construction directive is generally the authority for requisitioning materials (JON #, purchase authority, etc.). This item will also address lead-time necessary for procurement and delivery information. Care must be exercised so that critical resources, whether man or materiel, are identified and requested early in the planning phase.

(7) Priority. This gives a single priority for the entire project or separate priorities for different stages of a project.

(8) Reports. Any reports required by higher headquarters.

(9) Special Instructions. This item gives any additional information concerning the project to include coordination and liaison instructions, and any unusual problems peculiar to the mission.

2. **PLANNING**. Planning simply means laying something out in advance. Planning creates an orderly sequence of events, defines the principles to be followed in carrying them out, and describes the ultimate disposition of the results. A solid plan serves us by pointing out the things to be done, their sequence, how long each task should take, and who is responsible for what. The goal of planning is to minimize resource expenses for a given task. It aims at producing an even flow of equipment, materials, and labor and ensuring coordinated effort. Planning is a continuous cycle; effective planning requires continually checking on events in order to make forecasts and revise plans to maintain proper course toward the objective. In military construction, the planning phase should be divided into two stages: **preliminary planning** and **detailed planning**.

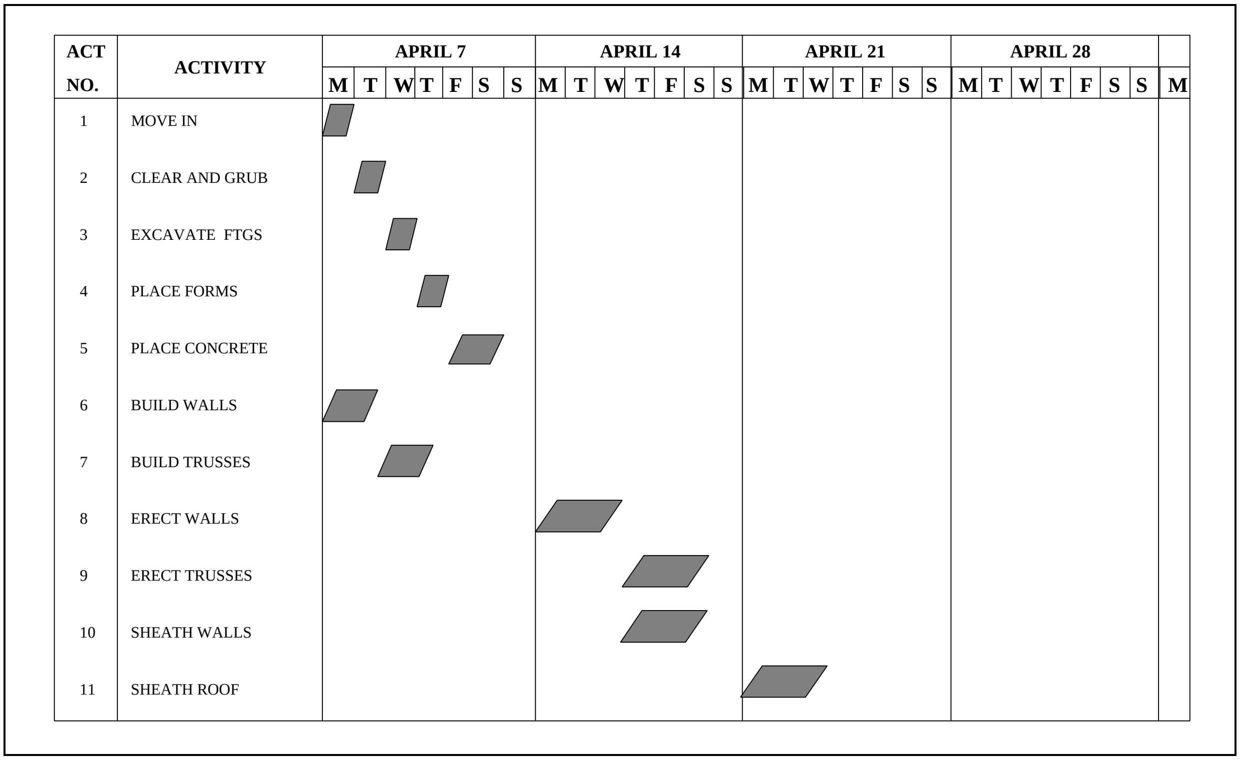
a. Preliminary planning. Gives the engineer a quick overview of the assigned task and the capacity of the constructing unit to accomplish it. It serves as a guide to the detailed planning which follows. Preliminary planning includes preliminary estimation, procurement of critical or long lead-time items, and the initial site survey/reconnaissance.

b. Detailed planning. Provides a schedule for the entire construction project and develops an accurate estimate of the labor, materials and equipment to perform each of the sub-tasks or *activities*. Detailed planning includes detailed estimating, scheduling, procurement, and in depth review of all project drawings and specifications.

3. **PLANNING AND SCHEDULING PROCESSES**. Engineers must manage engineer tasks, whether the task is a garrison construction project or a theater of operations combat engineer task, such as survivability positions. How well the engineer accomplishes a task depends in large part on his ability to plan, schedule, and control resources within a constrained environment. There are several systems that the engineer can employ to facilitate the management of these tasks and aid in mission accomplishment. The detailed plan will be submitted utilizing one of the two following methods:

a. **Gantt** or **bar chart**. A method of project planning and control, used primarily for small, or straight line, projects. Gantt charts are *time oriented*. Work activities on Gantt charts are shown graphically in relation to a predetermined time scale. Each bar represents the start and finish time, with the length of the bar showing the activity’s duration. The bars show an activity’s duration in its entirety, regardless of its dependency on other activities. The Gantt should be used in conjunction with the critical path.

GANTT CHART



(1) Advantages:

(a) Effortless to construct.

(b) Simple to read.

(c) Concise.

(2) Disadvantages:

(a) Must have detailed knowledge of the project and the construction techniques used to complete the tasks in order to interpret the progress of construction work.

(b) It does not clearly show the detailed sequence of activities.

(c) It does not show which activities are critical or potentially critical to the successful completion of the mission.

(d) It does not show the precise effect of a delay or failure to complete an activity on time.

(e) In an emergency, a projects delay may lead to incorrectly expediting non-critical activities.

b. **Critical Path Method (CPM).** CPM is a planning and control technique that overcomes the disadvantages of using a Gantt chart, and is used primarily for large scale construction projects. It provides an accurate, timely and easily understood picture of the project, whereby making it easier to plan, schedule and control the project. The CPM requires a formal, detailed investigation into all identifiable tasks that make up a project. This means that the project manager must visualize the project from start to finish and must estimate time and resource requirements for each task. The CPM is *activity oriented*.

(1) Advantages.

(a) Reduces the risk of overlooking essential tasks and provides a blueprint for long-range planning and coordination of the project.

(b) Gives a clear picture of the logical relationships between activities in a project.

(c) Focuses the manager's attention by identifying the critical tasks.

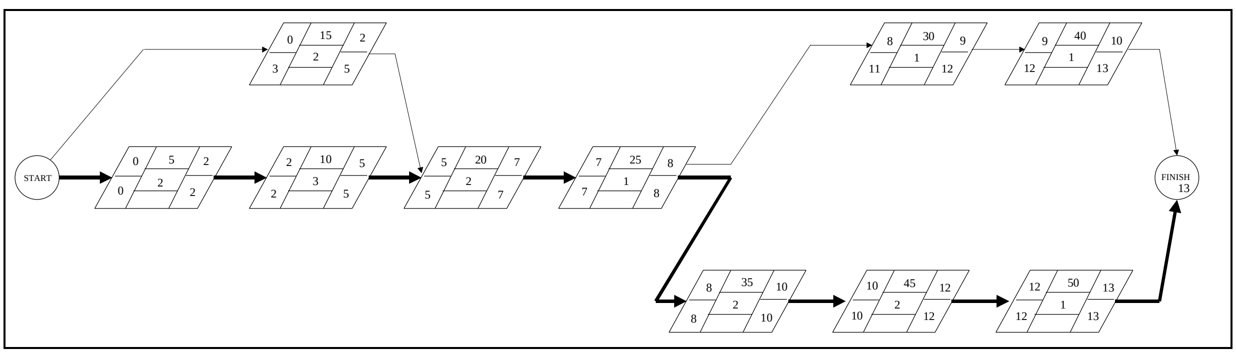
(d) Allows the project manager to make rational and timely decisions if complications develop during the project.

(e) Enables the manager to easily determine what resources he will need and when these resources will be made available.

(f) Allows the manager to quickly determine what additional resources he will need if the project must be completed earlier than originally planned.

(g) Provides feedback on a finished project that allows the manager to improve techniques and assure the best use of resources on future projects.

CPM LOGIC DIAGRAM



(2) Limitations. The CPM is not a cure-all for engineer problems. It does not make decisions for the manager, nor can it contribute anything tangible to the actual construction. The CPM should be used to assist the manager in planning, scheduling and controlling the project.

4. **EMPLOYING THE CRITICAL PATH METHOD**. To properly employ the CPM, we must first study the plans and specifications carefully, construct the project mentally, and break the project down into its component parts. Each component is called an *activity.* An *activity* is a resource-consuming element of the overall job that defines the beginning and ending.

a. **Developing the Activities List.** This is the first step in developing a CPM, commonly referred to as *brainstorming* in the fleet. It involves nothing more than mentally constructing the project by breaking it down into the activities required to accomplish the mission. The number and detail of the activities on the list will vary from job to job and will depend on the intended use of the CPM network and the experience of the person(s) putting it together. The activities list should only state what it is to be done. When developing the activities list, do **not** consider time, labor, order of construction, material or equipment.

b. **Developing the Logic Diagram**. One of the most important features of the CPM is the logic diagram. The logic diagram graphically portrays the relationship between a projects many activities. Relationships between activities are determined by asking the following questions for **each** activity:

(1) Can this activity start at the beginning of the project? (**Start**)

(2) Which activities must be finished before this one begins? (**Precedence**)

(3) Which activities may either start or finish at the same time as this one? (**Concurrence**)

(4) Which activities cannot begin until this one is finished? (**Succession**)

(5) Which activities may start when a portion of another activity is complete? (**Lag**)

One way to determine these relationships is to add a column to the right of the activities list titled *Preceded Immediately By (PIB)*. Under this column, for each activity, list all other activity numbers (or letters) which must **immediately** precede the activity in question. If the activity can begin at the very beginning of the project, it is immediately preceded by **"None"**.

LEAD-THROUGH PE I

ACT#	**ACTIVITY**	**PIB**
A	WAKE UP	
B	TAKE SHOWER	
C	LEAVE HOUSE	
D	DRIVE TO WORK	
E	START CAR	

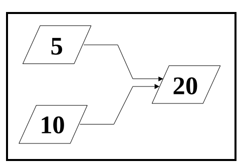
LEAD THROUGH PE II

(Site survey reveals that the assembly area for the culverts is too confined to allow for assembly of both at the same time. Once one is assembled, the other culvert can be assembled)

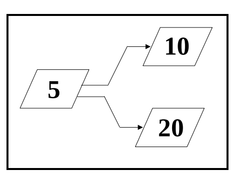
ACT#	ACTIVITY	PIB
A	DIG TRENCH 1	
B	DIG TRENCH 2	
C	ASSEMBLE CULVERT 1	
D	ASSEMBLE CULVERT 2	
E	INSTALL CULVERT 1	
F	INSTALL CULVERT 2	
G	BACKFILL CULVERT 1	
H	BACKFILL CULVERT 2	

c. **Logic Symbols.** Once the necessary activity relationships needed to develop the logic diagram have been identified, the format of logic diagramming must be determined. Activity-on-the-arrow used to be a popular method, but the current standard in the Fleet is activity-on-the-node, or *precedence diagramming*. The two basic logic symbols in the precedence diagram are the *node* and the *logic arrow*.

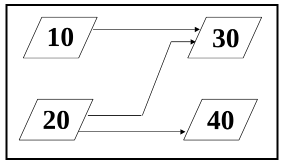
(1) Logic Arrows. Logic arrows show the order sequence and relationship between activities, such as what activities must precede or follow another activity. The configuration of the logic diagram's nodes and arrows is the result of the PIB list (or the answers to the five questions that were previously asked of each activity). In the Marine Corps, we use *finish-to-start* logic arrows, meaning that an activity cannot begin until all activities that send an arrow to it are complete. Several logic relationships are described below.



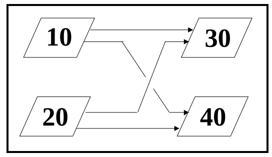
(20 cannot start until both 5 and 10 are complete)



(10 and 20 cannot start until 5 is complete)

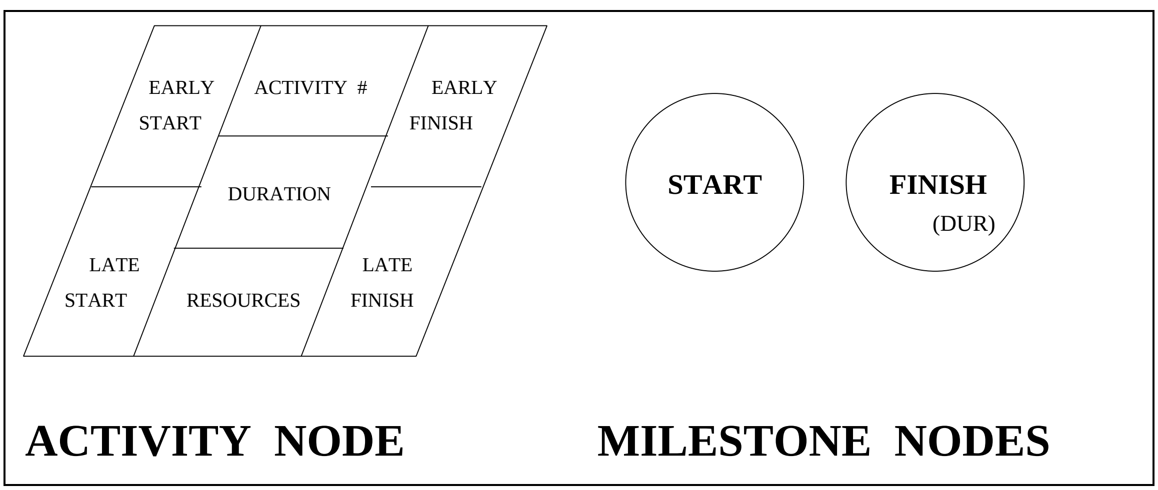


(10 and 20 must be completed before 30 can start. 40 can start immediately after 20 is complete)



(30 and 40 cannot start until both 10 and 20 are complete)

(2) Nodes. A node is a parallelogram that represents an activity, and each activity from the activities list is represented by a node on the logic diagram. The node represents a period of time equal to the activity's duration. Each node includes the activity's number, duration, required resources, early and late start times, and early and late finish times. Resource and duration information is taken straight from the *activity estimate sheet* (covered later). Early and late times are calculated during the forward and backward pass (also covered later). Start and finish nodes are represented by a circle or oval. These kinds of nodes have no duration and are better known as ***milestones***. Milestones can also be used at other points in the network to represent a checkpoint, a major accomplishment or a deliverable result.



d. **Constructing the Logic Diagram.** The logic diagram, or *precedence network*, is assembled utilizing the following six steps:

(1) Draw in the Start node.

(2) Draw activities immediately preceded by **"None".**

(3) Draw activities preceded by only one other activity.

(4) Draw activities preceded by more than one activity.

(5) Draw in remaining activities.

(6) Draw in the finish node.

LEAD THROUGH PE II (CONT.)

PRACTICAL EXERCISE 1

ACTIVITY	PIB
5	NONE
10	NONE
15	5
20	5
25	10
30	15
35	25
40	20, 30, 35

PRACTICAL EXERCISE 2

ACTIVITY	PIB
5	NONE
10	5
15	5
20	10, 15
25	15
30	20
35	20, 25
40	25
45	30, 35, 40

PRACTICAL EXERCISE 3

ACTIVITY	PIB
5	NONE
10	5
15	5
20	5
25	10, 20
30	15, 20
35	25
40	30
45	35, 40

PRACTICAL EXERCISE 4

ACTIVITY	PIB
5	NONE
10	NONE
15	NONE
20	NONE
25	5, 10
30	5, 10
35	20
40	15, 30, 35
45	25, 40
50	15, 30, 35
55	50

5. **ACTIVTIY ESTIMATES.** One of the most important steps in the planning process the estimate of activity duration. Careless estimates may lead to failure to meet completion dates. For this reason the manager must be a good estimator.

a. ACTIVITY ESTIMATE SHEET: The activity estimate sheet is used to determine activity duration. The elements of the activity estimate sheet are:
b. PROJECT: Control number assigned by management personnel.

c. ACTIVITY NUMBER: The activities assigned number. Determined by sequence during the creation of the P.I.B.

d. ACTIVITY DESCRIPTION: A detailed description of the activity to be completed. It should state what conditions must exist in order to consider an activity completed.

e. MATERIALS TAKE-OFF: Provides a listing of all materials required to complete the activity. Includes the computations used to arrive at final figures, and any waste factors.

f. EQUIPMENT-MANPOWER: The equipment-manpower section is used to determine the final duration of an activity. It is broken into 10 separate sections:

(1) COMPONENT: List the work items to be estimated. In most cases, these will be will be the work items used in the material estimate; additional activities that require workers or equipment without expending material may be added.

(2) TECHNOLOGY: Used to describe the method of accomplishing the task. Acts as a basis for determining the work rate for the task.

(3) QUANTITY: This is obtained from the material estimate. In most cases, the total quantity in the material take-off includes a waste factor. If this is the case the waste factor should not be considered in the quantity block of duration calculation.

(4) WORK RATE: Work rates can be determined using several methods. Acceptable work/time formulas are best suited for this purpose, however several other sources are also available. The FM 5-412 (PROJECT MANAGEMENT) is the most current publication intended for this purpose. Chapters 6 through 17 contain estimating tables for various tasks. The NAVFAC P-405 (SEABEE PLANNER'S AND ESTIMATOR'S HANDBOOK) is also a viable source for work rates. Unit after action reports and "hot washes" can also be an invaluable source for this purpose. ***Regardless of the source, the work rate and the quantity must be in like units.***

(5) STANDARD EFFORT: The standard effort is derived by multiplying the quantity by the work rate.

QUANTITY X WORK RATE = STANDARD EFFORT

(6) EFFICIENCY: This is a measurement of the effectiveness of the Marines in their situation compared to the standard conditions used in the estimating reference source. This is represented as a percentage.

(7) TROOP EFFORT: The troop effort derived by dividing the standard effort by the efficiency factor.

STANDARD EFFORT ¸ EFFICIENCY = TROOP EFFORT

(8) CREW: The crew is the number of Marines or pieces of equipment that are being utilized to complete the task. This relates directly to the technology portion of the form and can be used to determine the work rate.

(9) DURATION: The duration is the total time required to complete the task. It is determined by dividing the troop effort by the crew size.

TROOP EFFORT ¸ CREW SIZE = DURATION

(10) REMARKS: Any remarks concerning the calculation of the activity duration such as references and tables, formulas, etc.

PRACTICAL EXERCISE 5

You are to mix enough concrete for a building slab that is 20’ x 80’ x 6” using the 16s mixer. DO NOT CONSIDER WASTE. You are employing 1 squad consisting of 8 Marines, and the squad leader. You estimate their efficiency to be 90%. What is the activity duration?

QUANTITY	WK RATE	STD EFF	EFFIC	TRP EFF	CREW	DUR	REM

You have been directed to build a concrete block wall (8” block) that is 300 feet long, and 8 feet high. You estimate efficiency to be 75%. Using 12 Marines, how long will it take to complete the task?

QUANTITY	WK RATE	STD EFF	EFFIC	TRP EFF	CREW	DUR	REM

You have been directed to do the electrical rough-in for a barracks. The plans indicate there are 2800 linear feet of 1” conduit, fittings, and outlet boxes within the structure. You plan to use 8 Marines and estimate their efficiency to be 95%. How long will it take to complete the task.

QUANTITY	WK RATE	STD EFF	EFFIC	TRP EFF	CREW	DUR	REM

You have been directed to clear off all snow on a 25 mile stretch of road that is 24 feet wide. You have 4, 5-ton dump trucks that have a 6 foot wide plow.

The depth of the snow is 4 inches. You estimate the efficiency to be 75%. How long will it take to clear the road?

QUANTITY	WK RATE	STD EFF	EFFIC	TRP EFF	CREW	DUR	REM

6. TIME ANALYSIS. The next step in the CPM is to calculate the earliest and latest times at which an activity can occur without violating the network logic. This provides the manager with a time frame in which an activity must be completed without delay of the project. The manager can then identify which activities are critical to the timely completion of the mission.

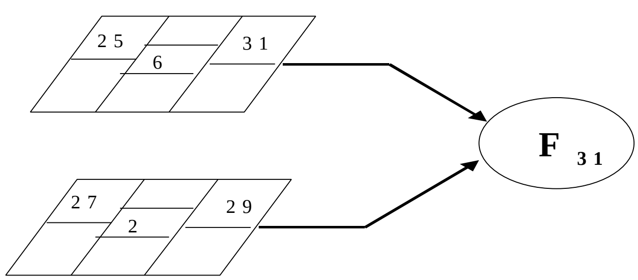
a. EARLY START (ES): The earliest time an activity can start. The ES for an activity equals the largest EF from the preceding activity.

b. EARLY FINISH (EF): The earliest possible time that an activity can end. The EF for an activity equals the ES + DURATION.

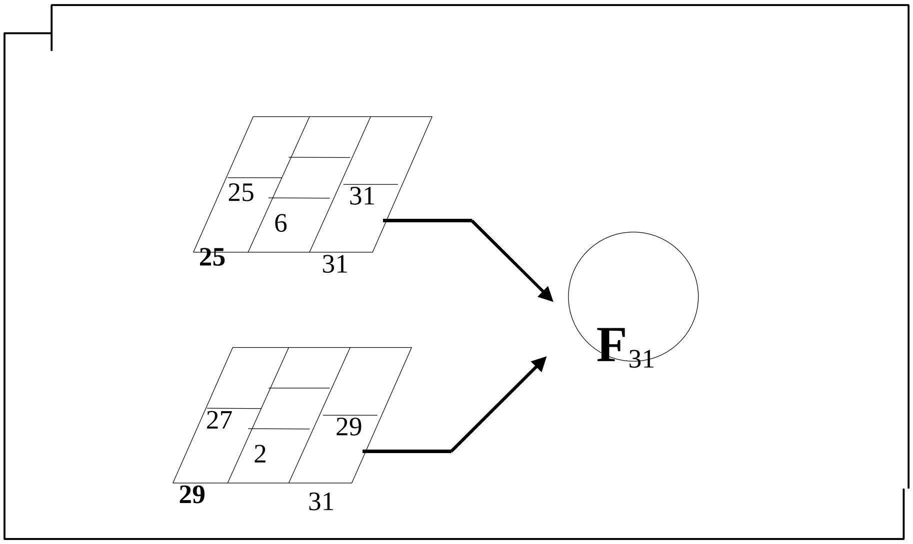
c. LATE FINISH (LF): The latest time that an activity can finish and still not delay the project. The LF equals the smallest LS from the succeeding activity.

d. LATE START (LS): The latest time an activity can start and not delay the project. The LS equals the LF – DURATION.

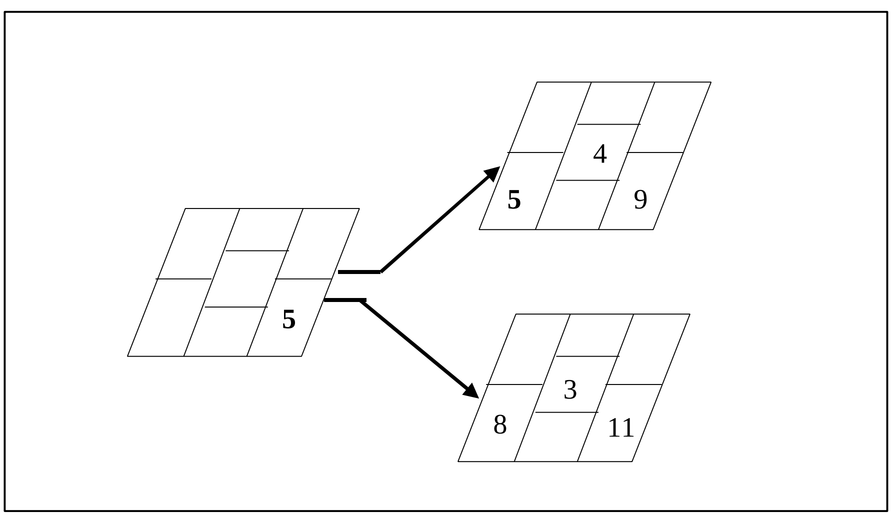
e. FORWARD PASS: The forward pass through the logic diagram is completed using the time analysis until reaching the finish node. The largest early finish from any nodes feeding into the finish node becomes the finish time of the mission, and is recorded in the lower right side of the finish node. This completes the forward pass, and determines the overall duration of the project.

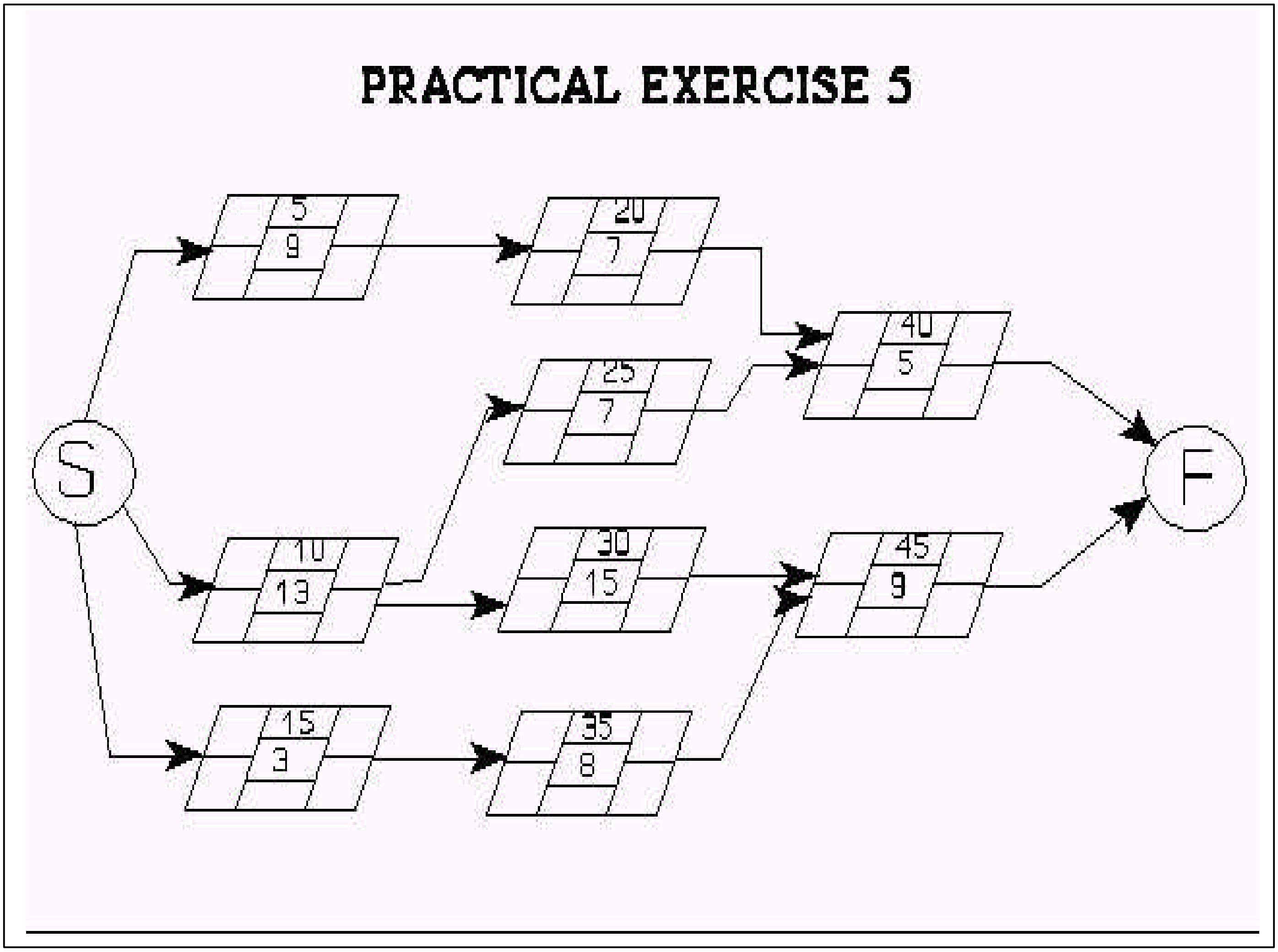


f. BACKWARD PASS: The backward, or return pass, is used to determine the late finish, and late start time for an activity. Calculation of the late finish provides the manager with the latest time when an activity can be completed without delaying the overall duration of the mission. The late finish begins with the nodes that feed into the finish node. The overall duration of the mission becomes the late finish of all activities that feed directly into the finish node. The late finish is recorded in the lower right corner of the node.



g. COMPLETING THE BACKWARD PASS: The late start of the current activity is the late finish of any activity that follows it. In the event that two or more activities feed into an activity on the backward pass, choose the smaller number. The backward pass is then completed using these rules until reaching the start node.

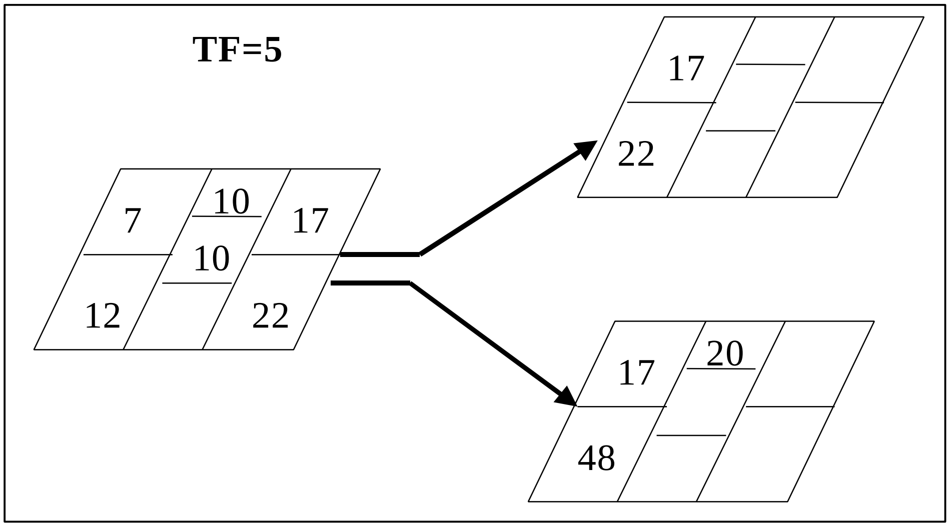




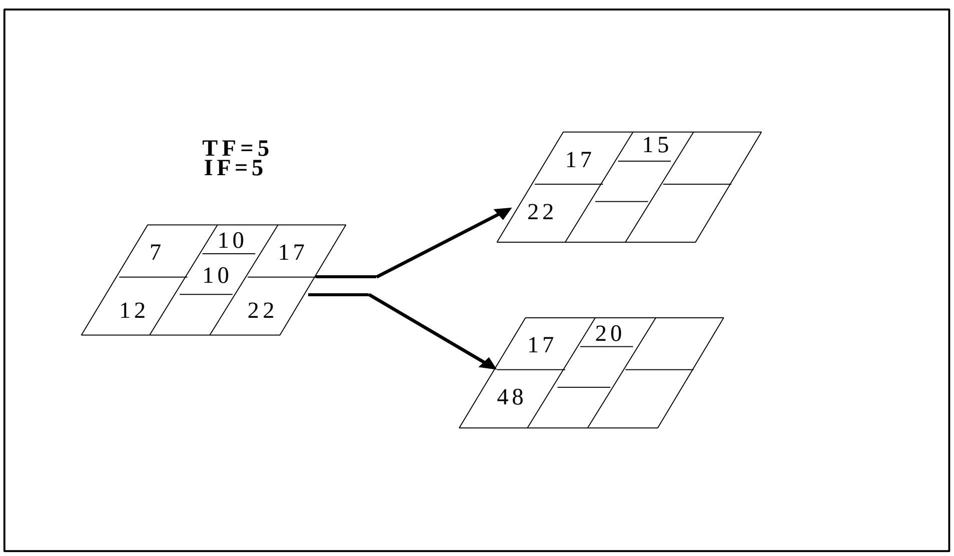
6. <u>FLOAT:</u> Float is the number of days in an activity that it can be delayed without delaying the overall duration of the mission. There are three types of float; Total float (TF), Free float (FF) and Interfering float (IF). The amount of each type of float is recorded above the activity node.

(1) TOTAL FLOAT (TF): Total amount of time that an activity may be delayed without delaying the project’s early completion date. The total float for an activity is equal to late start minus early start, of late finish minus early finish.

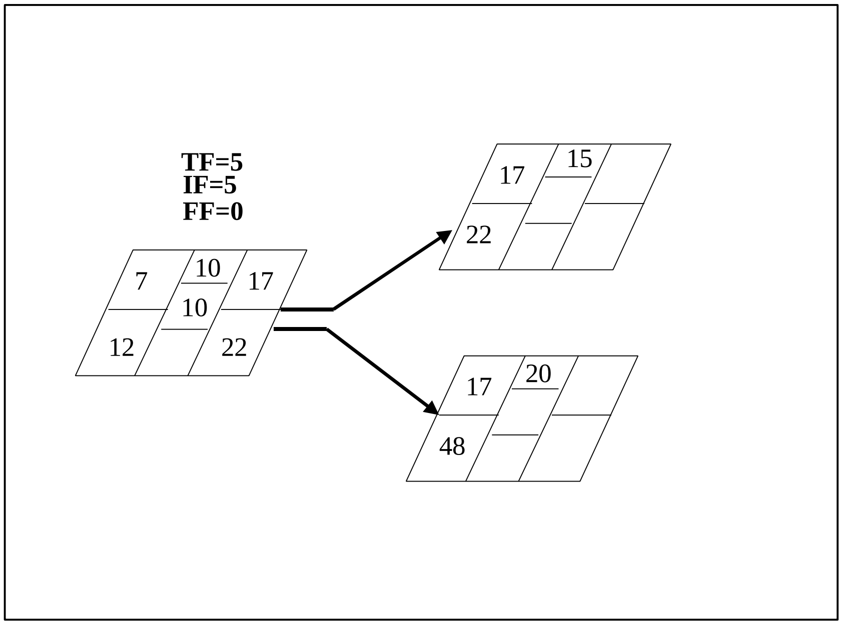
LS – ES = TF or **LF – EF = TF**



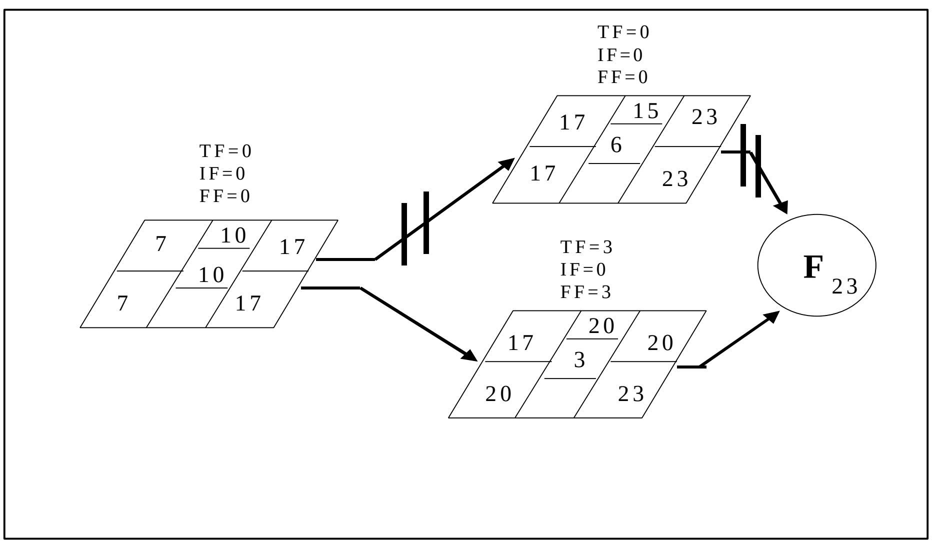
(2) INTERFERING FLOAT (IF): Interfering float is the time when used the will delay the early start of one or more following activities. Interfering float does not delay the final completion date however, at least one subsequent activity will not be able to begin at it's early start time. The calculation of interfering float is late finish minus the smallest early start of a following activity. **LF – ES (smallest of following activity) = IF** Interfering float is recorded above the node, just below total float.



(3) FREE FLOAT (FF): Free float is that time which if used will not delay any subsequent activity. Free float is calculated by subtracting interfering float from total float. **TF – IF = FF** Free float is recorded above the activity node just below interfering float.

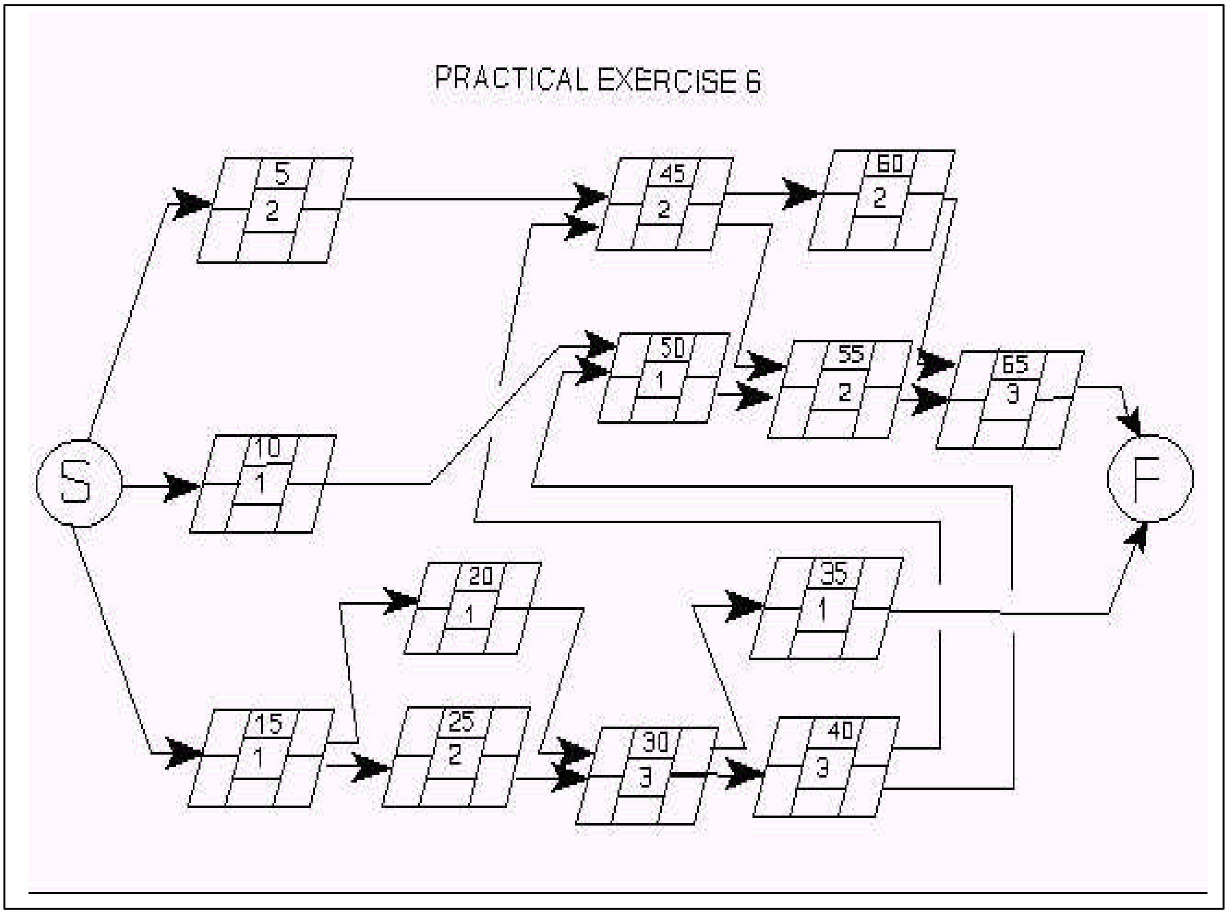


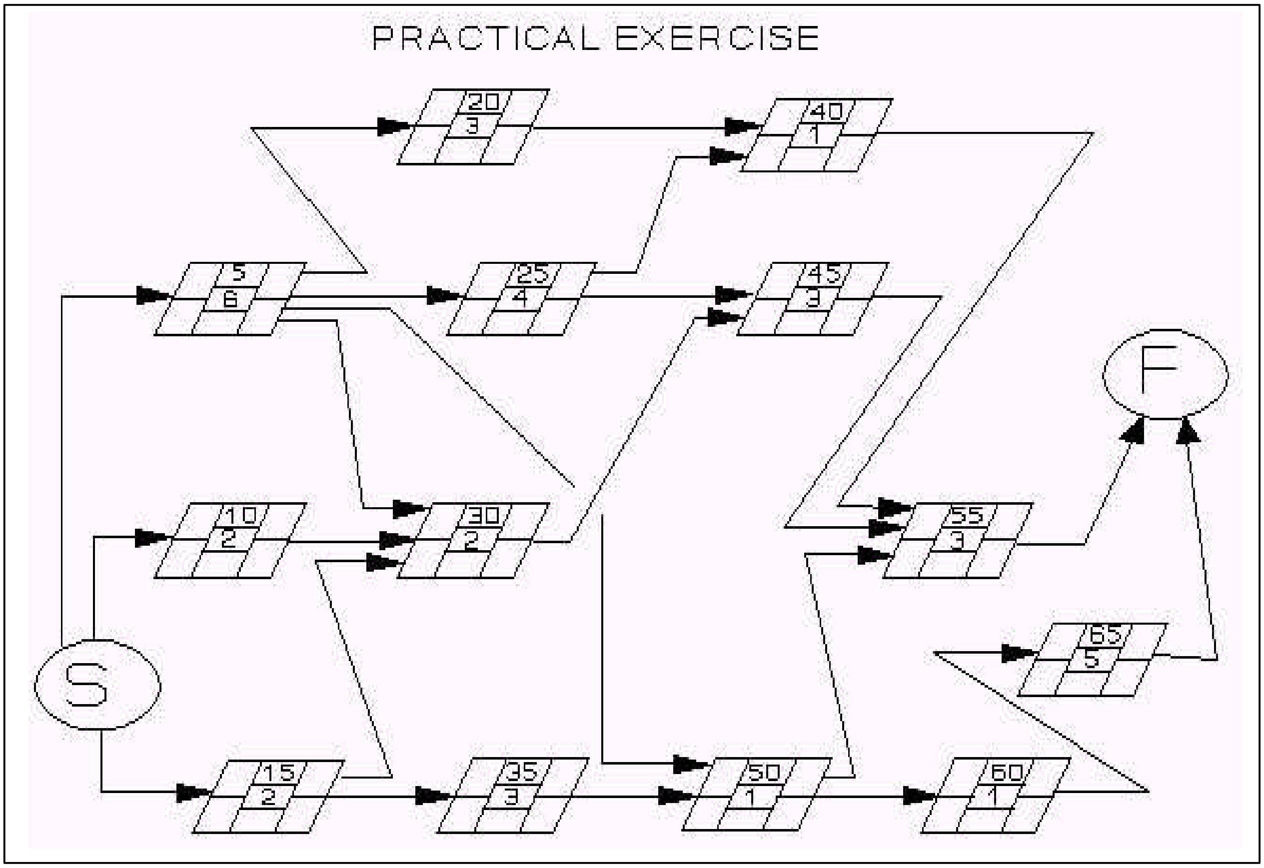
7. **CRITICAL PATH:** The path through the logic network that dictates the final completion time, and contains no float. The critical path will always be the longest path trough the network. The critical path is highlighted by placing two hash marks on the logic arrow that corresponds to it. This identifies to the manager that particular attention must be paid to these activities to prevent their delay. There may be more than one critical path through the network, and the activities along it are said to be critical. Any delay in one of these activities will prevent the mission from being completed on the day stated in the finish node.



a. CRITICAL PATH RULES: In order for a logic network to stand up several rules must be adhered to.

(1). All logic networks must have a critical path. If this is not the case, an error was made in the logic at some point in the network. absent of float.





8. **EARLY START SCHEDULE:** Once the logic network is complete, the manager is now able to construct an activity schedule, known as an early start schedule. This schedule when coupled with the logic diagram, graphically shows all necessary planning information for the manager.

(1) The first step is to list all activities in numerical order. After each activity note in parentheses all immediately dependent activities, or those activities that are connected with an arrow. If an activity feeds into the finish node, put an "F" in parentheses after the activity number.

ACTIVITY NUMBER	**1**	**2**	**3**	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
5 (20, 25)													
10 (30)													

(2) The next step is to mark on the schedule the time frame that each activity may be performed without delaying the project, or violating any of the logic sequence. Times are blocked in by bracketing the box that corresponds to the early start plus 1 (one). If the logic diagram dictates that an activity begins on day ten, the first day bracketed for the activity would be 1. The right block is determined by the late finish of the activity. If late finish of the task is day 7 the right bracket is

placed between the end of day 7, and the beginning of day 8.

ACTIVITY NUMBER	1	2	3	4	5	6	7	8	9	10
5 (20, 25)										
10 (30)										

(3) Once the brackets for all activities are place, the next step is to make a trial schedule, scheduling each activity as soon as possible within the time frame, of flush with the left bracket. To schedule a particular activity, place the number of each kind of resource inside each box along the activity line. Beginning with the left most box, and successive boxes for the duration of the activity; stop at the end of the early finish day/time. The remaining boxes are left blank for now, and will become either free or interfering float.

ACTIVITY NUMBER	1	2	3	4	5	6	7	8	9	10	11
5 (20, 25)	5	5	5	5							
10 (30)	9	9	9	9	9						

(4) Once the resources are in place, begin entering the float. Interfering float is entered first. Starting at the right of the bracket enter an “X” in each block that corresponds to a day of interfering float. After all interfering float days are marked, any open blocks represent free float days. Activities with neither an “X” or an open block represent critical activities.

ACTIVITY NUMBER	1	2	3	4	5	6	7	8	9	10	11
5 (20, 25)	5	5	5	5	X	X	X				
10 (30)	9	9	9	9	9						

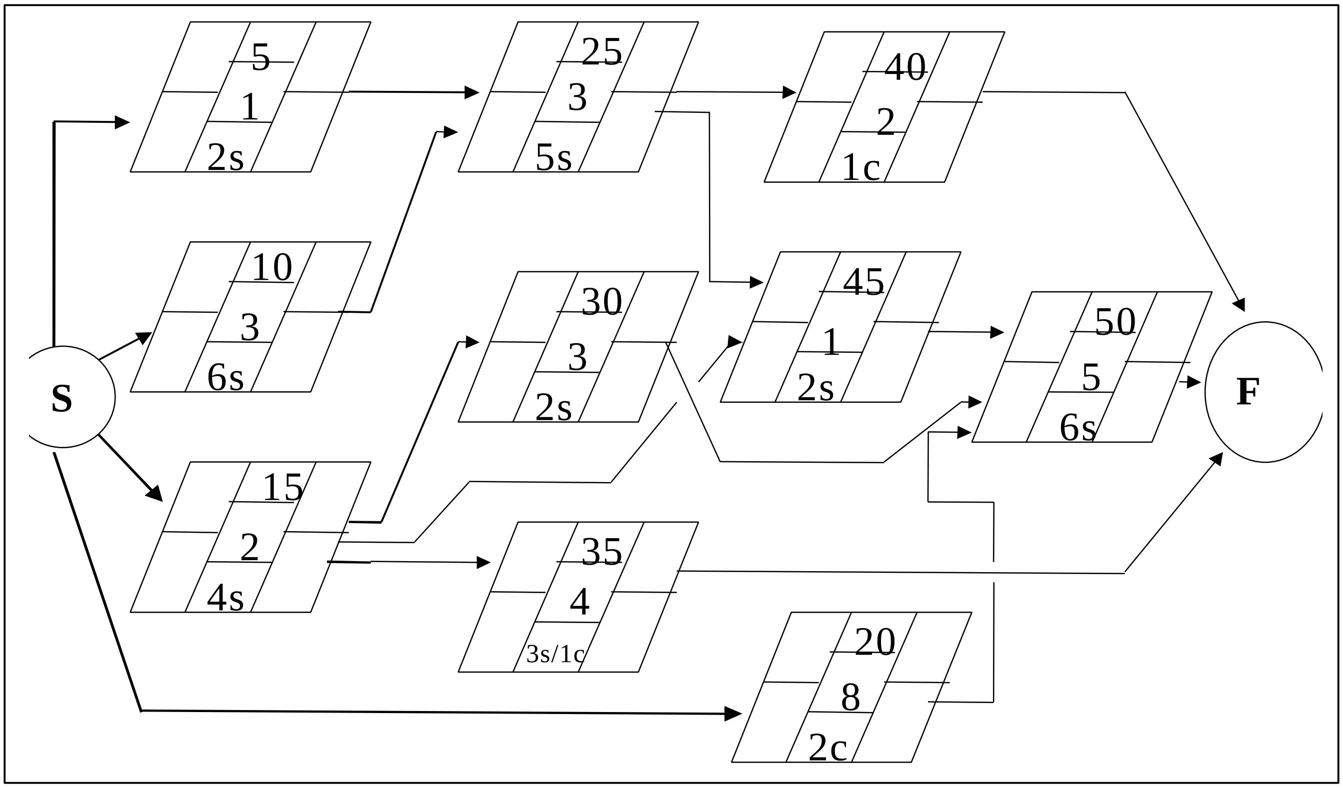
(5) If several resources are dedicated to one activity you may use more than one line for each activity to show the number of resources being applied to that task. This is known as a multiple schedule.

ACTIVITY NUMBER	1	2	3	4	5	6	7	8	9	10	11
30 (35, 50)		2c	2c	2c	2c	2c		X			
		1t	1t	1t	1t	1t		X			
		1g	1g	1g	1g	1g		X			

(6) The last step in the early start schedule is the entering of totals. At the extreme bottom of the early start schedule, create a totals column. Under the totals column list all of the resources being applied to the mission. Count the total of each asset that is being utilized on a given day, and record this number on the line representing the asset for the day it is being employed.

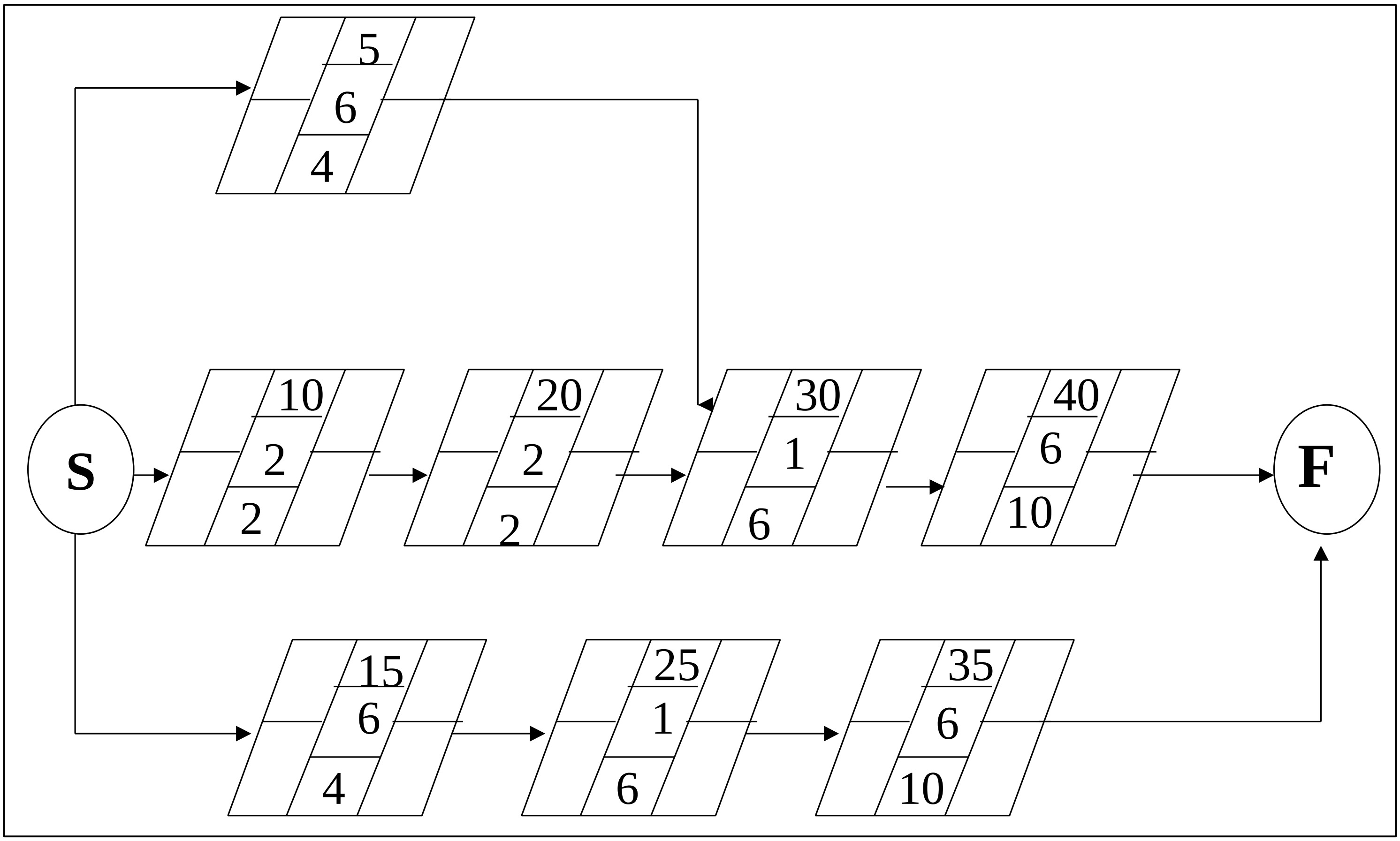
ACTIVITY NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
5 (20, 25)	5	5	5	5	X	X	X					
10 (30)	9	9	9	9	9							
15 (35, 40)	2	2							X	X	X	
20 (35,40)					8	8	8	8	X	X	X	
25 (40)					7	7	7		X	X	X	X
30 (45)						5	5	5	5	5		
35 (F)									4	4	4	4
40 (F)									2	2	2	
45 (F)											3	3
TOTALS	16	16	14	14	24	20	20	13	11	11	9	

PRACTICAL EXERCISE # 10



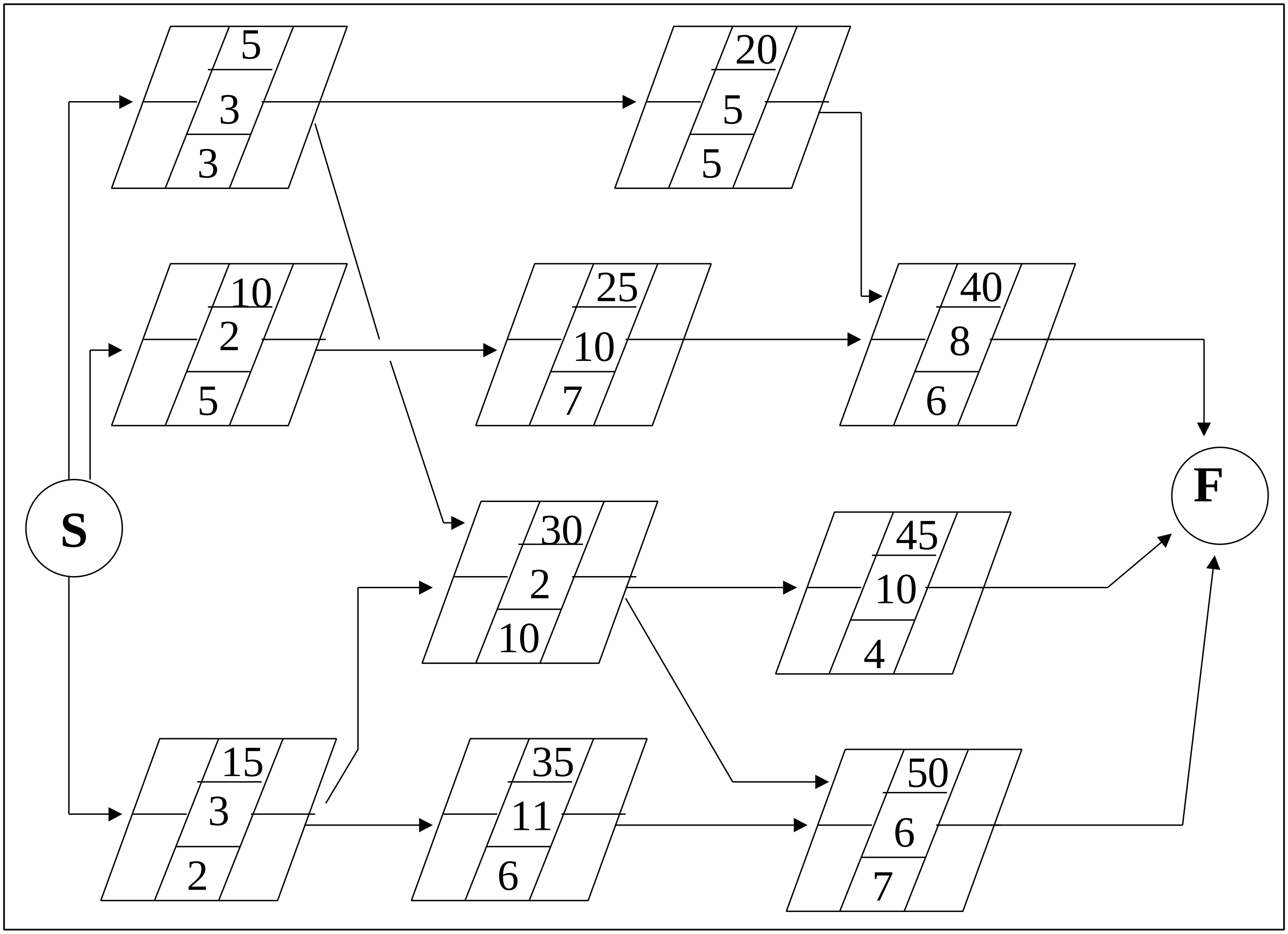
NETWORK NUMBER	EARLY START SCHEDULE																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

PRACTICAL EXERCISE #11



NETWORK NUMBER	EARLY START SCHEDULE																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

PRACTICAL EXERCISE #12



NETWORK NUMBER	EARLY START SCHEDULE																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

9. **RESOURCE CONSTRAINING:** Used by the manager when daily resources have been exceeded. This process may be used in the event that part of a resource has been lost. For example the dead lining of 2 scrapers in the middle of an activity

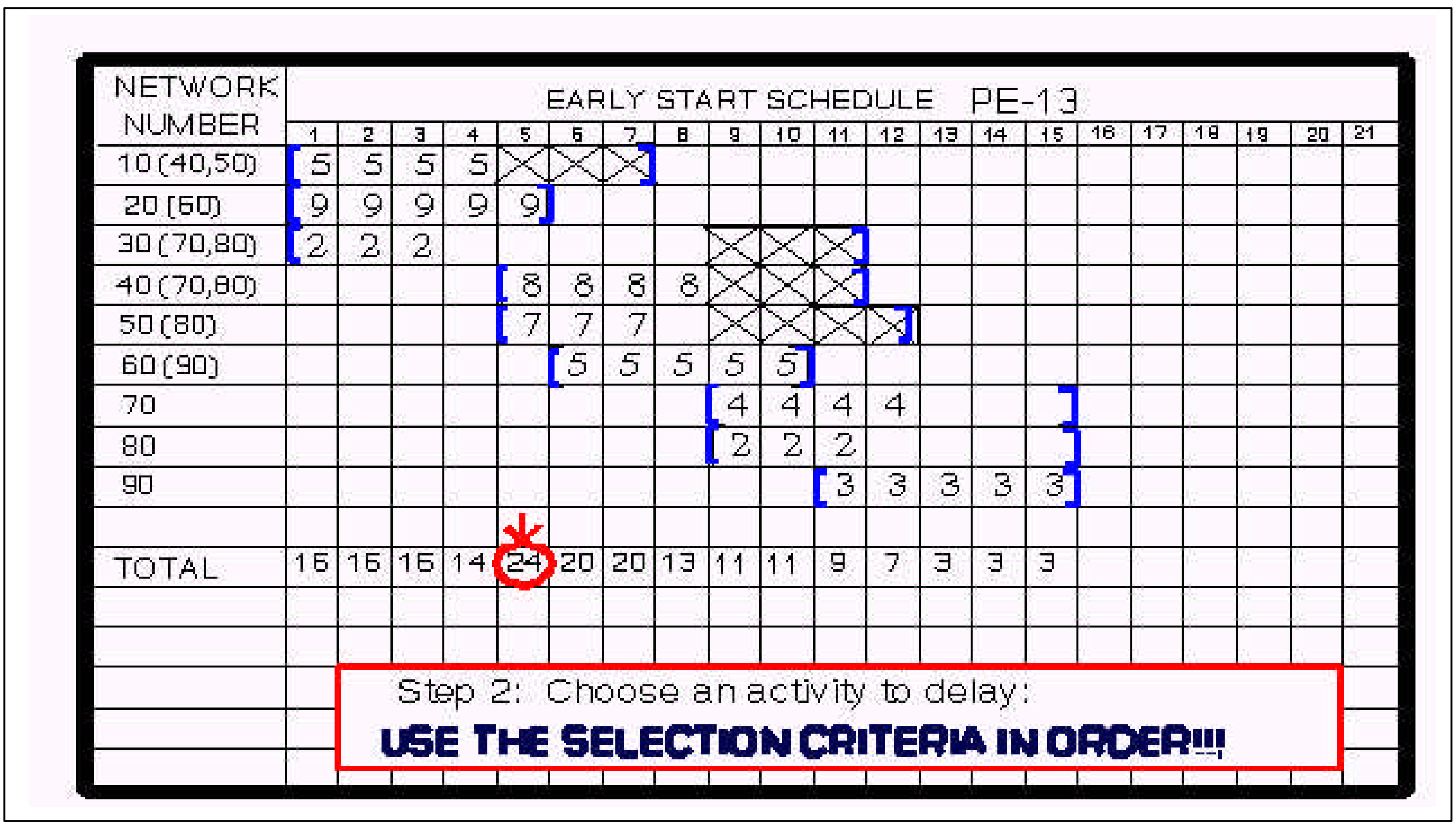
a. Resource constraining uses float to reschedule activities to subsequent days, so that daily available resources are not exceeded.

b. Resource Constraining steps

(1) Find the period that resources are exceeded.

(2) Choose an activity to delay. The chosen activity must contain float.

(3) Begin marking in blocks that correspond to the days the activity will be delayed. After marking the block, pencil in the resource into the day of float that will be worked into for that activity.



EARLY START SCHEDULE PE-13

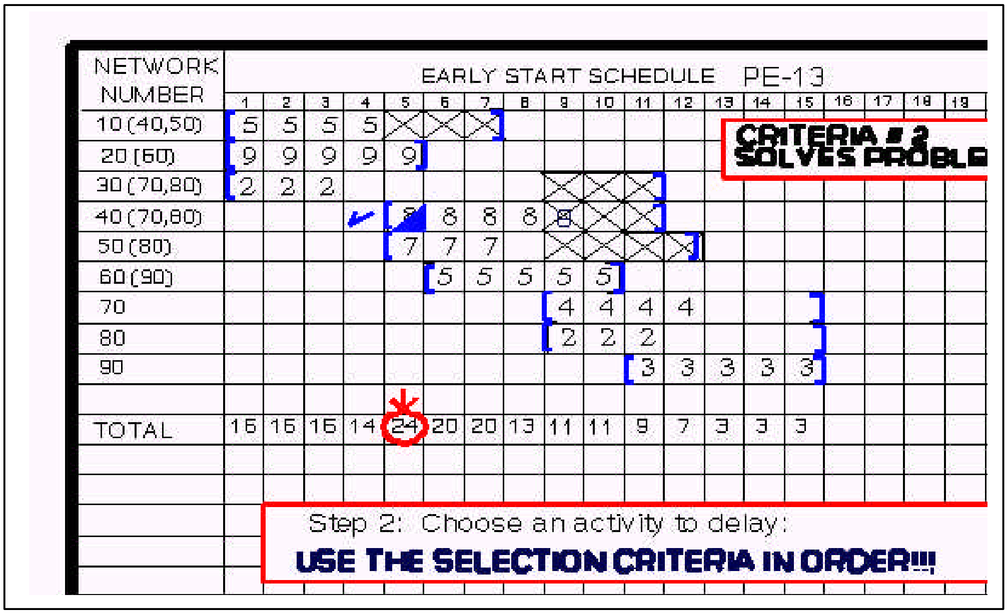
NETWORK NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
10 (40,50)	[5	5	5	5	X	X	X]														
20 (60)	[9	9	9	9	9]																
30 (70,80)	[2	2	2						X	X	X]										
40 (70,80)					[8	8	8	8	X	X	X]										
50 (80)					[7	7	7		X	X	X	X]									
60 (90)						[5	5	5	5	5]											
70									[4	4	4	4			]						
80									[2	2	2				]						
90											[3	3	3	3	3]						
TOTAL	16	16	16	14	24	20	20	13	11	11	9	7	3	3	3						

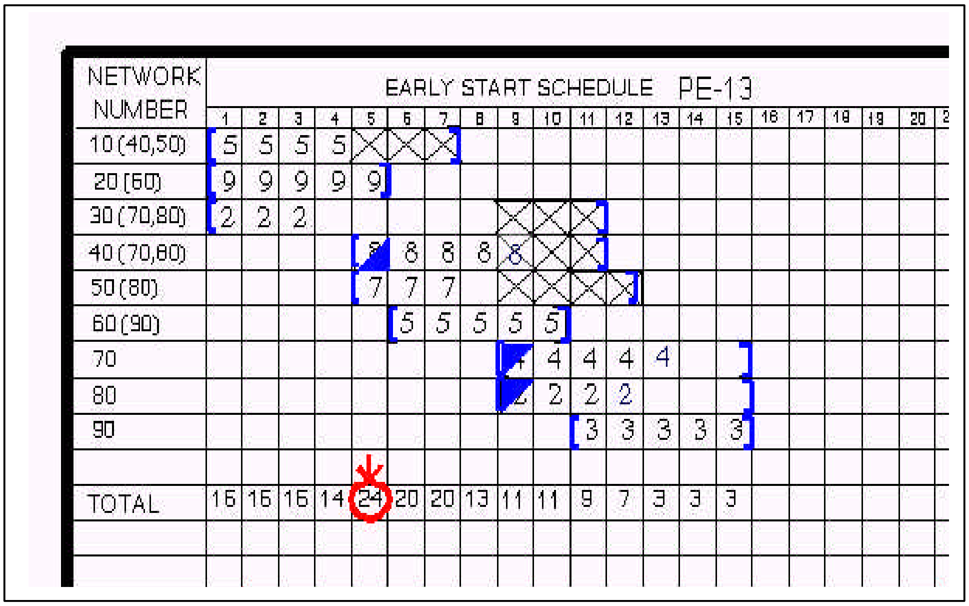
Step 2: Choose an activity to delay:

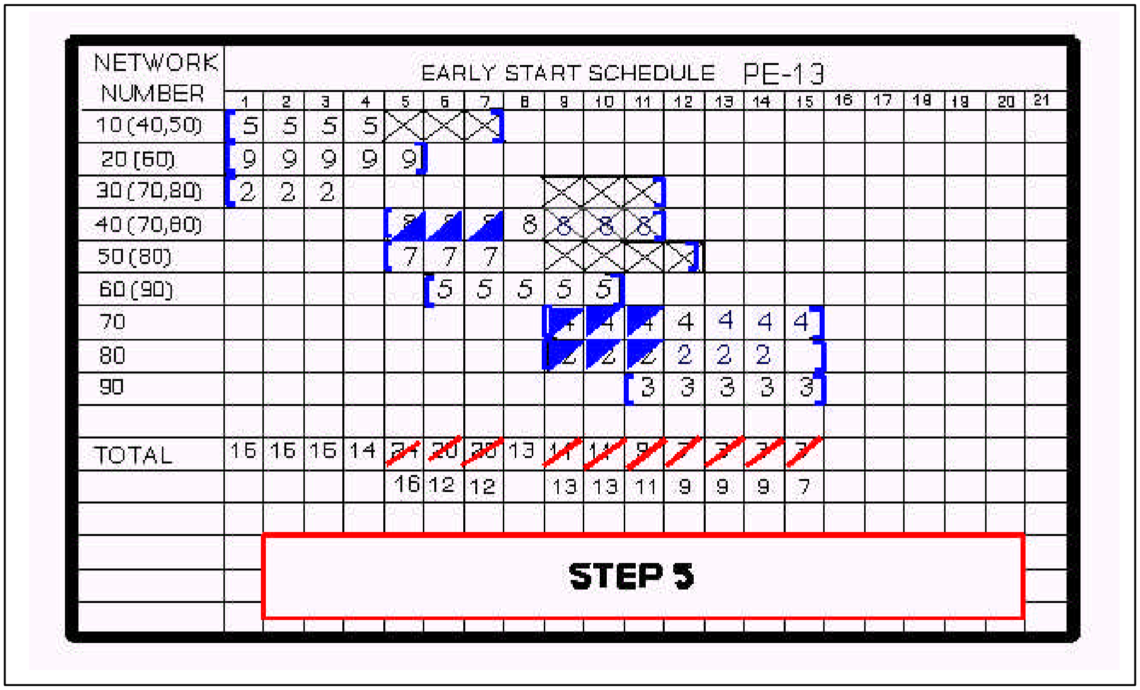
USE THE SELECTION CRITERIA IN ORDER!!!

(4) Find the any activities that will be effected by the change in the schedule, and complete the same process with these.

(5) Repeat this process until the resource problem has been resolved. Remember that the far right block of the activity cannot be exceeded.







10. RESOURCE LEVELING (CRASHING): If the CPM indicates that the project’s duration exceeds what higher headquarters gave as a completion date, or if the critical path has fallen behind schedule resource leveling will be required. This process is sometimes referred to as expediting, or compressing or crashing. It should be understood however that missions duration can only be shortened by focusing resources on activities along the critical path. No time can be gained by working on non-critical activities.

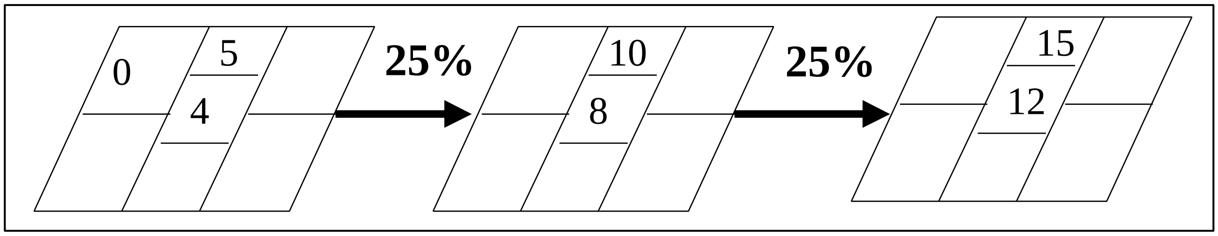
a. METHODS: There are a number of methods for project crashing;

(1) Work longer hours, or weekends
(2) Change technology
(3) Work double shifts
(4) Apply additional resources
(5) Apply additional resources
(6) Redefine the logic. (INTRODUCTION OF LAG)

b. CONSIDERATIONS: The manager must take into consideration the effects of the level project crashing process.

(1) Safety
(2) Efficiency
(3) Moral
(4) Cost
(5) Available resources
(6) Logistics/Maintenance
(7) Quality control

11. **LAG FACTORS:** A lag factor can be introduced into activities that do not need to be entirely completed before a following activity can begin. For example, the entire lift of a five mile road does not need to be placed before the scarify, and compaction process can begin. Lag factors are expressed as a percentage, and are recorded above the logic arrow, between the activities that the lag is being applied to.

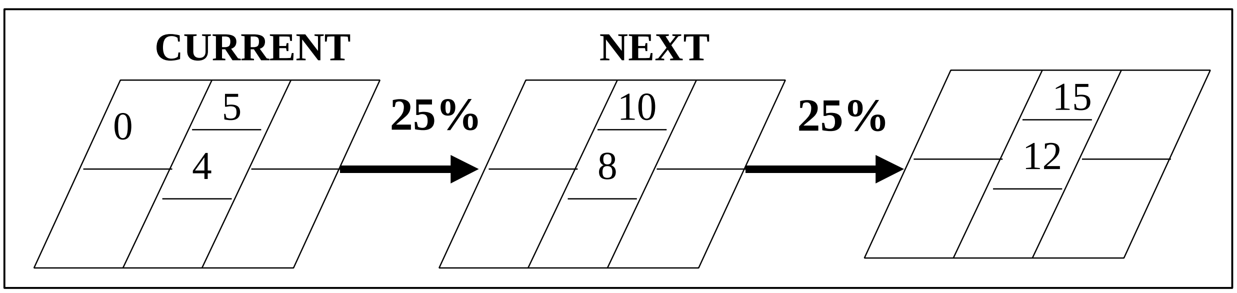


a. FORWARD PASS:

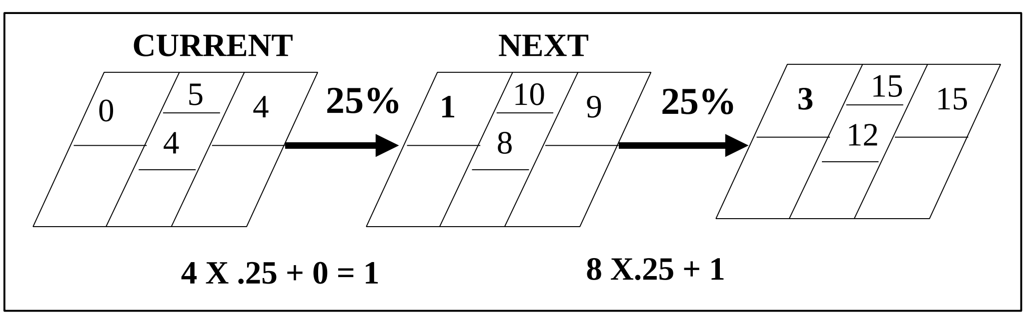
(1) TERMS: The two terms used on the forward pass are CURRENT, and NEXT.

(a) CURRENT: The left node in the diagram.

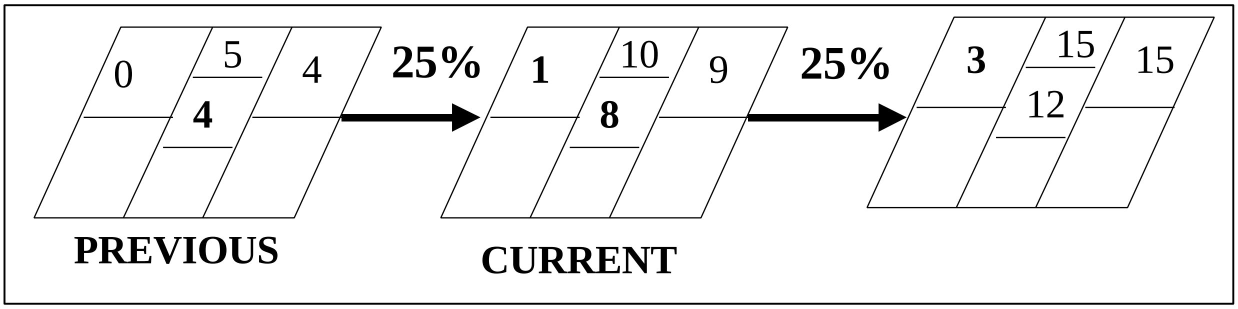
(b) NEXT: The right node in the diagram



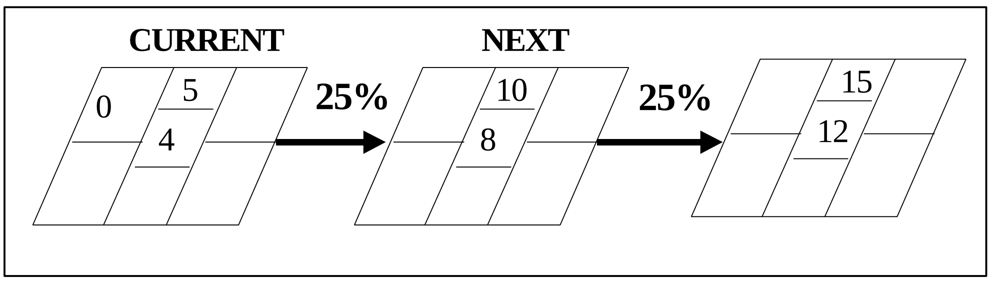
(2) FORWARD PASS CALCULATION: The calculation of the forward pass with a lag factor is accomplished using the formula;
(ES of next = DURATION (CURRENT) X % OF LAG + ES (CURRENT)



Only activities that can have lag applied to them are calculated with this process. The remainder of the forward pass is completed applying lag where necessary until reaching the finish node.



b. BACKWARD PASS: The backward begins as it would without lag factor, by placing the final completion day from the finish node into the late finish block of all activities that converge on it.

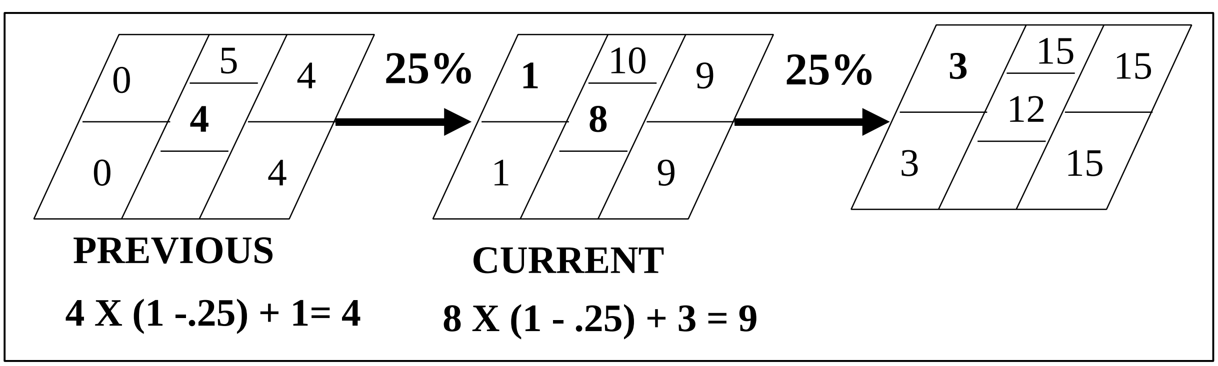


(1) TERMS: The terms used on the backward pass are CURRENT , and PREVIOUS.

(a) CURRENT: The right node in the diagram.

(b) PREVIOUS: The left node in the diagram.

c. BACKWARD PASS CALCULATION: The calculation of the backward pass with lag is accomplished using the formula;
LF of previous = DURATION (PREVIOUS) X (1 -% LAG) + LS



d. REDEFINING THE LOGIC: After applying a lag factor it will be necessary to re-compute float. With the introduction of lag, a new critical path may be created, or a path that was critical may no longer be.

12. QUALITY CONTROL: Quality control is the responsibility of the manager. It requires detailed planning, and will determine the success of the mission.

a. ESTABLISHING A QUALITY CONTROL PLAN: In order to establish a quality control plan the manager must;

(1) Study the required end product.
(2) Know the proficiency of you Marines.
(3) Know what is required by higher HQ.
(4) Know what quality control assets are available.

b. GOALS OF QUALITY CONTROL: Quality control is under-taken with the following goals in mind.

(1) Ensuring that the project meets specifications.
(2) Establishment of clear standards.
(3) Identifying mistakes before they become critical.

c. THE THREE PHASES OF THE QUALITY: The three phases of the quality control plan are PHASE 1 (PRELIMINARY), PHASE 2 (INITIAL) and PHASE 3 (FOLLOW UP).

(1) PHASE 1 (PRELIMINARY): During phase 1 the following activities are accomplished;

(a) Review of specifications
(b) Establishment of testing requirements
(c) Inspection of materials
(d) checking of preparatory work
(e) Establishment of standards

(2) PHASE 2 (INITIAL): During phase 2 the manager should;

(a)Complete a representative section of the activity.

(b) Test the representative section

(c) Establish the tested section as the standard for the activity

(3) PHASE 3 (FOLLOW-UP): In the final stage it is necessary to;

(a) Test the remainder of the activity at regular intervals.

(b) Measure against the established standard.

(c) Adjust the methods of work accordingly.

REFERENCE:

FM 5 –412 Project Management

UNITED STATES MARINE CORPS
COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C-01A19
11 Jul 00
(98 POI)

STUDENT HANDOUT

VTOL/LZs

1. LEARNING OBJECTIVES:

a. TERMINAL LEARNING OBJECTIVE(S):

(1) Provided a mission, airfield/landing zone construction requirements, and a list of personnel and equipment, with the aid of references, as a member of a team, supervise the construction of temporary airfield/landing zone in accordance with FM 5-430. (1302.1.7)

b. ENABLING LEARNING OBJECTIVE(S):

(1) Provided a mission, a map, a specified area, and tools and equipment, as a member of a team, determine if the area meets the specifications for a temporary airfield/landing zone in accordance with FM 5-430. (1302.1.7a)

(2) Provided with a mission, completed engineer reconnaissance report forms, a map, and a construction directive, as a member of a team, determine the logistical requirements for constructing a temporary airfield/landing zone in accordance with FM 5-430. (1302.1.7b)

BODY:

1. DEFINITIONS: The following definitions are directly related to this period of instruction.

a. Expeditionary Airfield: Airfields that utilize prefabricated materials such as AM-2 matting with accessories in there construction.

b. Vertical Takeoff and Landing (VTOL): A type of expeditionary airfield, which allows one aircraft to land or takeoff. Constructed with the AM-2 matting surface. Primary user of this facility is the AV-8B HARRIER

c. Landing Zones (LZ): A landing zone is an opened area on the ground used for helicopter operations. LZs are designated by a series of code names such as birds, animals, or trees. Landing Zones are divided into two areas: Landing Sites, and Landing Points.

d. Forward Operating Base: Platform designed to provide flexible AGS to the ACE of the MAGTF in an ever changing tactical environment. Airfields are further broken down into four classifications.

(1) Main Base: Secure airfield capable of handling all types of aircraft, up to and including theater lift assets. The Main Base should contain maintenance, and engineering assets to support anticipated needs. In most cases located near shore, and integrated into the MAGTF logistics pipeline. The function will be to support sustained operations ashore.

(2) Air Facility: A secure airfield capable of supporting a detachment or squadron of aircraft, and associated assets. Minor repairs, refueling, rearming, and de-arming can be accomplished at the air facility. The Air facility has little to no permanent structures. This facility may be an airfield, road segment, matted runway, or a grassy surface.

(3) Air Site: A secure location where aircraft are prepositioned to enhance response time. This area must be suitable for a fully armed and fueled aircraft to land, and await a mission. Fuel, and ordnance may be stored at this site, but a minimal number of personnel, and little to no logistical support will exist here. Upon completion of a mission from an Air site, aircraft would normally return to the Air Facility, or Main Base. Air sites are limited to receiving and launching previously loaded aircraft.

(4) Air Point: Air Points are tactical designations applied to a predetermined geographical location that will support a specific tactical mission. For the purpose of planning air points are further classified as either a FARP, or a Lagger Point.

(a) Forward Arming and Refueling Point (FARP): Provides fuel arming/de-arming necessary for mobile and flexible helicopter operations.

(b) Lagger Point: Secure locations designated by aviation units to be utilized for the rendezvous, marshaling or positioning of flights of aircraft between missions or when waiting for the completion or activation of an assigned mission. Only communication support is required. Lagger points can be isolated, or be adjacent to any of the previously mentioned facilities.

3. AIRCRAFT CHARACTERISTICS: The characteristics of the different types of aircraft utilized in the Marine Corps inventory is very important. The size of the aircraft will definitely affect the amount of area to be used, and also the amount of manpower and equipment to be used for construction of VTOL/HELO PADS/LZs:

CH-46E SEA KNIGHT

a. CH-46E Sea Knight Helicopter: The CH-46E is a twin turbine powered, tandem rotor helicopter. The primary mission of the CH-46E is to rapidly disperse combat troops, support equipment, and supplies from amphibious assault loading ships and established landing zones. The CH-46E general characteristics are:

(1) 50'each rotor

(2) Gross weight 15,452 lbs

(3) Overall length w/ rotors turning 85'

(4) Front height 11'9"

(5) Rear height 16'9"

(6) Range 350 miles

(7) Downwash 100 mph

(8) External cargo weight 5000 lbs

(9) 15 troops or 15 litters w/two medical attendants

Note: The CH-46E is considered a size 4 aircraft.

UH-1N HUEY

b. UH-1N Huey Helicopter: This twin engine helicopter is sometimes used for emergency resupply mission. It has an internal cargo space of 220 cubic feet and can lift a maximum of 2000 lbs externally. It has a seating capacity of 7 troops plus the pilot or 6 litters and an attendant. The UH-1N general characteristics are:

(1) Rotor 48'

(2) Gross weight 6,600 lbs

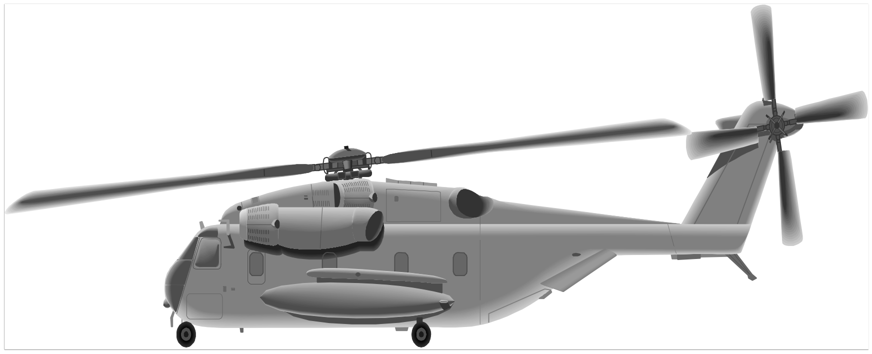
(3) Overall length w/ rotors turning 58'

(4) Range 316 miles

(5) Speed 135 knots

(6) Front height 13'4"

Note: The UH-1 is considered a size 2 aircraft



CH-53D SEA STALLION

c. CH-53D Sea Stallion Helicopter: The CH-53D is a single rotary wing, rotary rudder, dual turbine engine, assault transport helicopter. The primary helicopter is designed for both land and carrier based operation. The mission of the helicopter is the movement of cargo and equipment, and secondly, the movement of troops. The CH-53D general characteristics are:

(1) Rotor 73'

(2) Gross weight 23,000 lbs

(3) Overall length w/rotors turning 89'

(4) Range 250 miles

(5) Speed 175 knots

(6) Downwash 125 mph

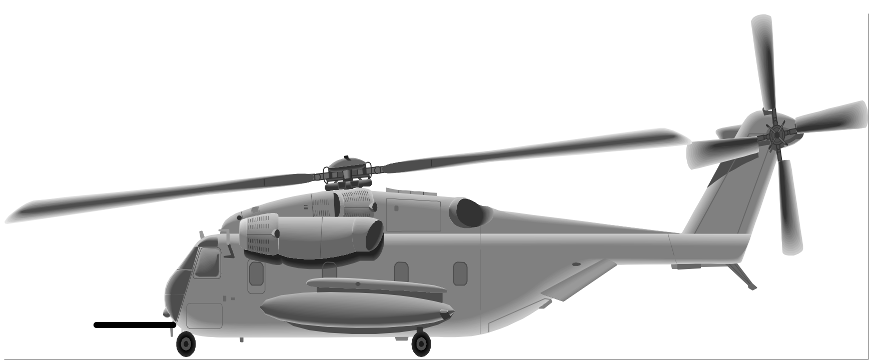
(7) Front height 10'4"

(8) Rear height 8' 9"

(9) External 13,000 lbs

(10) Troops,(combat) 37 or 24 litters w/three medical attendants

Note: The CH-53D is considered a size 4 aircraft.



CH-53E SUPER SEA STALLION

d. CH-53E Super Sea Stallion Helicopter: The CH-53E is a single rotary win, rotary rudder, triple turbine engine assault transport helicopter. The helicopter is designed for land and carrier based operations with the primary mission of the movement of supplies and equipment. The CH-53E general characteristics are:

(1) Rotor 79'

(2) Gross weight 36,000 lbs

(3) Overall length w/rotors turning 99'

(4) Internal weight 23,500 lbs

(5) External weight 23,000 lbs

(6) Cruising speed 150 knots

(7) Maximum speed 170 knots

(8) Range with tanks 750 miles (two 650 gallon external tanks)

(9) Range with inflight refueling is unlimited

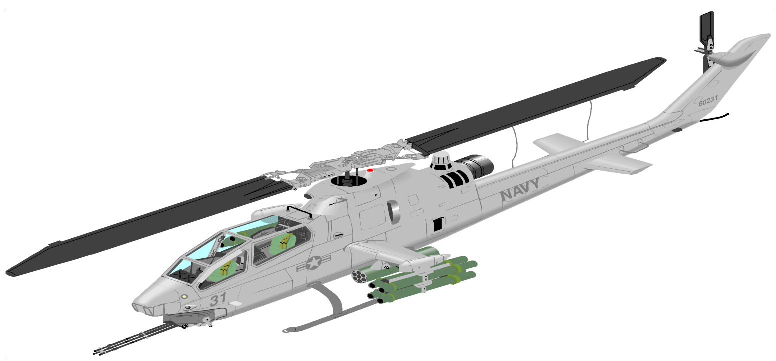
(10) Downwash 175 mph

(11) Front height 10'8"

(12) Rear height 9'1/2"

(13) Troop, (combat) 37 (up to 55 with center line seats installed) or 24 litters w/three medical attendants

Note: The CH-53E is considered a size 4 aircraft.



AH-1 COBRA

e. AH-1 Cobra Helicopter: The AH-1 is a twin engine, two seat, combat helicopter used for the escorting of other helicopters or in the role of attack and fire support for ground forces.

(1) Rotor 44'

(2) Gross weight 6,073 lbs

(3) Overall length w/rotors turning 53'

(4) Range 357 miles

(5) Speed 219 mph

(6) Height 13'5"

Note: The AH-1 is considered a size 2 aircraft.

AV-8B HARRIER

f. AV-8B Harrier: This is a fixed wing jet capable of vertical takeoff and landings. The Harriers primary mission is attack/close air support. This aircraft also serves as a sea-based defense system aboard amphibious assault ships such as LPHs, LHAs, and LHDs. The general characteristics of the Harrier are:

(1) Engine is capable of producing 21,500 lbs. of thrust

(2) Wing span 30'3"

(3) Length 42'11"

(4) Height 11'3"

(5) Weight: Empty 12,400 lbs, Maximum loaded 29,000 lbs

(6) Speed: subsonic

(7) Range w/arms 748 miles

Note: The Requirements for The AV-8B will be taught during the Vtol Pad construction portion of this class.

3. <u>VTOL PAD CONSTRUCTION</u>:

a. VTOL PADS are normally the first step in Expeditionary Airfield Operations (EAF) supporting the Marine Air Ground Task Force. The construction of a 96'x 96' landing pad is the requirement for supporting one helicopter or one AV-8B aircraft, an additional 150' must be cleared from each side of the pad, especially in heavily forested areas.

(1) AM-2 matting will be used as the surfacing material for VTOL pads.

(a) 20 F-71 pallets, 3 F-72 pallets and 1 F-28 pallet will be used to construct the pad.

<u>1</u> F-71 pallet contains 18 2'x 12' sheets and 20 locking bars.

2 F-72 pallet contains 18, 2'x 6' sheets and 20 locking bars.

3 F-28 pallet contains 130 edge clamps, 120 stakes and 80 locking bars.

(2) Manpower/equipment and time requirements for laying mat:

(a) Mat laying data prepared by the Marine Corps Landing Force Development Center, indicates a mat laying rate of 12,000 square feet/6 hour shift, utilizing two 13 man crews; this equates to 2000 square feet per hour. A F-71 pallet contains 432 square feet of mat, therefore a 13 man crew should be able to lay 5 pallets in an hour, which is 90 pieces of mat. The formula for time to lay one mat is 60 minutes divided by 90 pieces of mat equals .66 minutes per mat or 39 seconds per.

(b) Maximum efficiency is working with a sixteen man crew. The breakdown of the crew is as follows:

1 One alignment man: aligns edges of each row of mats

2 Two prybar men: adjusts mat/inserts locking bars.

3 Six 2 man teams: working with partner, carries and lays mats

(c) Equipment and tools required varies depending on the location and the terrain the pad will be constructed on. At the minimum, the following equipment should be brought:

1 Shovels, sledgehammers, crowbars, 2 lbs. hammers, 100 ft. tapes, wooden blocks, forklifts, 250 CFM Compressor and rakes.

(3) Site Preparation: Once a site is selected a soils test is conducted to identify the type of soil the VTOL pad will be constructed over. The soil and sub-base materials should be suitable for use with the AM-2 landing mats. The sub-base material shall have a bearing capacity relative to a minimum California Bearing Ratio (CBR) rating of 4 or more. The CBR of various soils can be determined by identifying the characteristics in accordance with a comparable type listed in the Unified Soils Classification Systems (USCS) chart.

(a) In many cases there will be clearing work to be accomplished, specifically that of rocks and trees. The use of bulldozers, chainsaws and military explosives will be quite extensive in a theater of operation with this type of terrain.

(b) The terrain in the area to be utilized shall be leveled and rolled to provide a compact matting base. Grading shall provide adequate drainage of surface and rain water away from the field area. If possible the soil shall be disturbed a minimum amount in obtaining the prescribed finish to provide a soil of maximum bearing capacity. Any areas under the matting requiring installation of service or drain pipes or other objects shall be back filled and thoroughly tamped. The final grading operation shall be sufficiently level so that mats when laid shall *not vary more than 1/4" in height over a 12 foot distance.* Hand raking may be necessary to accomplish this condition.

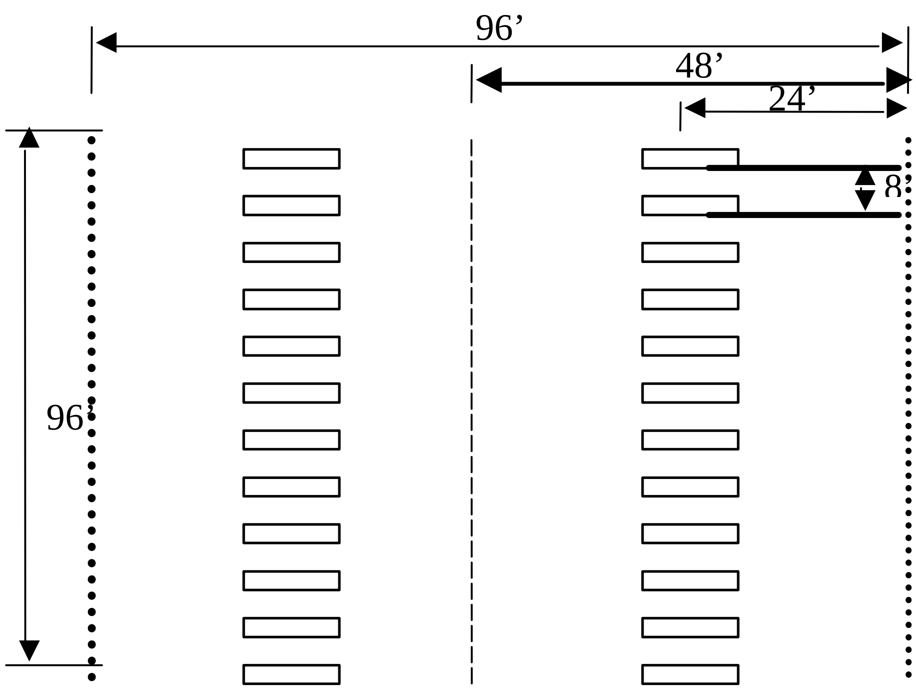
(c) Once the earthwork is accomplished have the Engineer Assistants (1361s) perform a survey to establish lines for the first row and left hand edge of the pad.

(d) Site preparation may not be required if there is an existing concrete or asphalt surface. Matting may be laid over the hard surface.

(4) Pallet Deployment: Deployment of pallets should be such as to keep manual handling of mats and related components to a minimum. Deployment should be consistent with the available equipment, manpower, and conditions under which the installation is undertaken. Pallet deployment may be accomplished by either of the following general methods:

(a) Deployment of pallets by rough terrain forklift is the most desirable method. The forklift delivers the pallet directly to the mat laying crews. Pallets are disassembled while on the forklift and it remains until the pallet load has been installed. This method obviously will require a number of forklifts to continuously supply the crews with pallets. Pallet disassembly is preferably done at the work area rather than at the storage area since loose mats are subject to spillage.

(b) On field deployment is the next method, and will probably be the one performed due to the shortage of forklifts. The pallets will be grouped on the field after major leveling operations have been completed. For a 96'wide pad, place the pallets in two rows 24 foot centerlines at 8 foot intervals. Arrange the appropriate edge clamp and stake pallet components around the edge of the pad for proper anchoring.



ON FIELD PALLET DEPLOYMENT

(5) Laying and Anchoring the Pad: The general sequence for laying matting is to start at one end and proceed in one direction. The individual mats are laid in a brickwork - type pattern from left to right. Always ensure that the edge of the mat is following the surveyors line.

(a) Edge clamps and stake assemblies are used to secure matting on all four sides. These anchor assemblies will be spaced 12 feet apart (fig.4). There are four types edge clamps in the F-28 pallet because of the four different edges of mat. The edge clamp required for each mat edge is:(fig.5).

1 9 - TYPE 1 clamps to anchor the female edge.

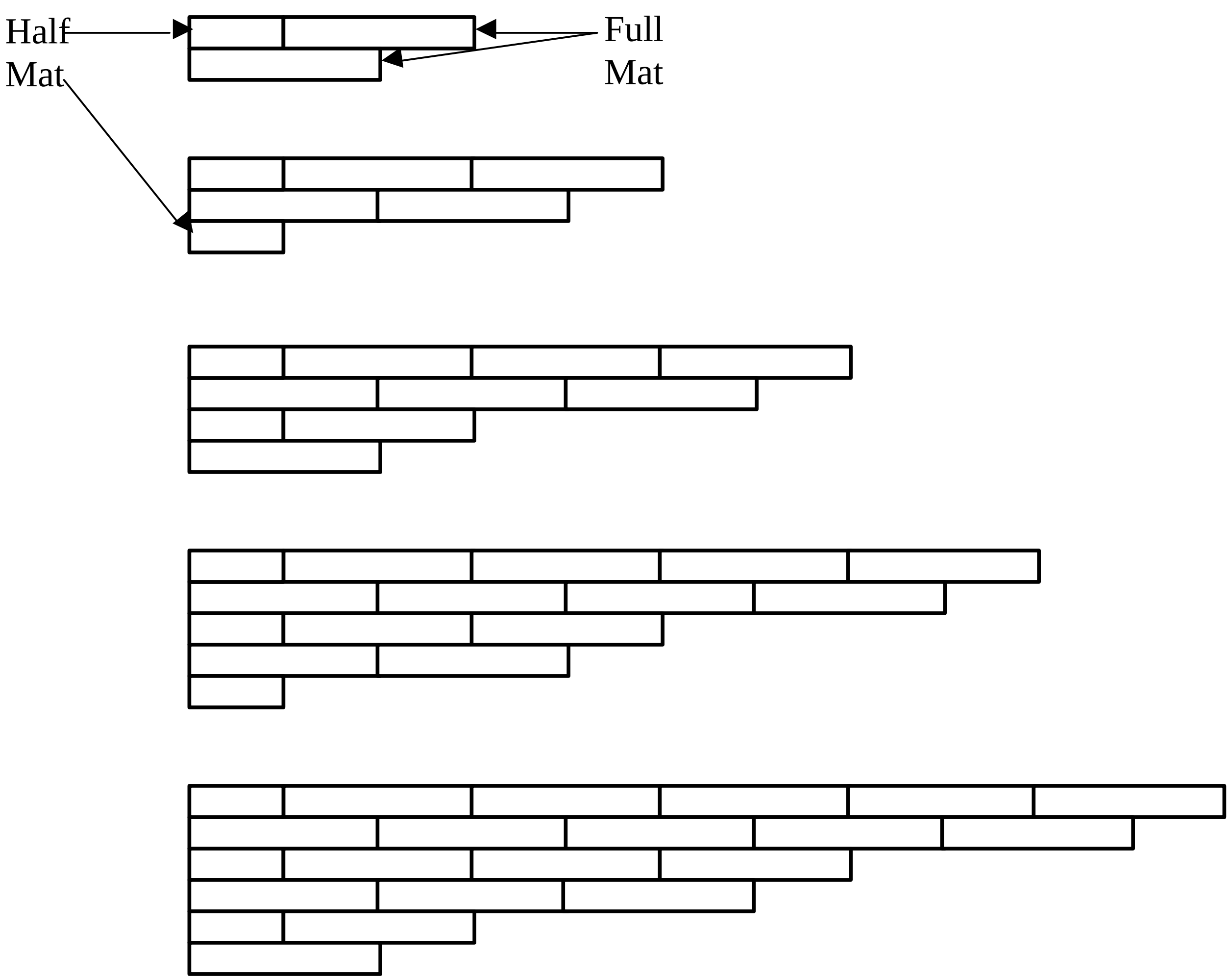
2 8 - TYPE 2 clamps to anchor the male edge.

3 8 - TYPE 3 clamps to anchor the downturned prongs.

4 8 - TYPE 4 clamps to anchor the upturned prongs.

(b) With the edge clamps in place, insert the anchor stake through the hole in the edge clamp, using a sledge hammer or paving breaker drive the stake into the ground.

Mat Laying Sequence



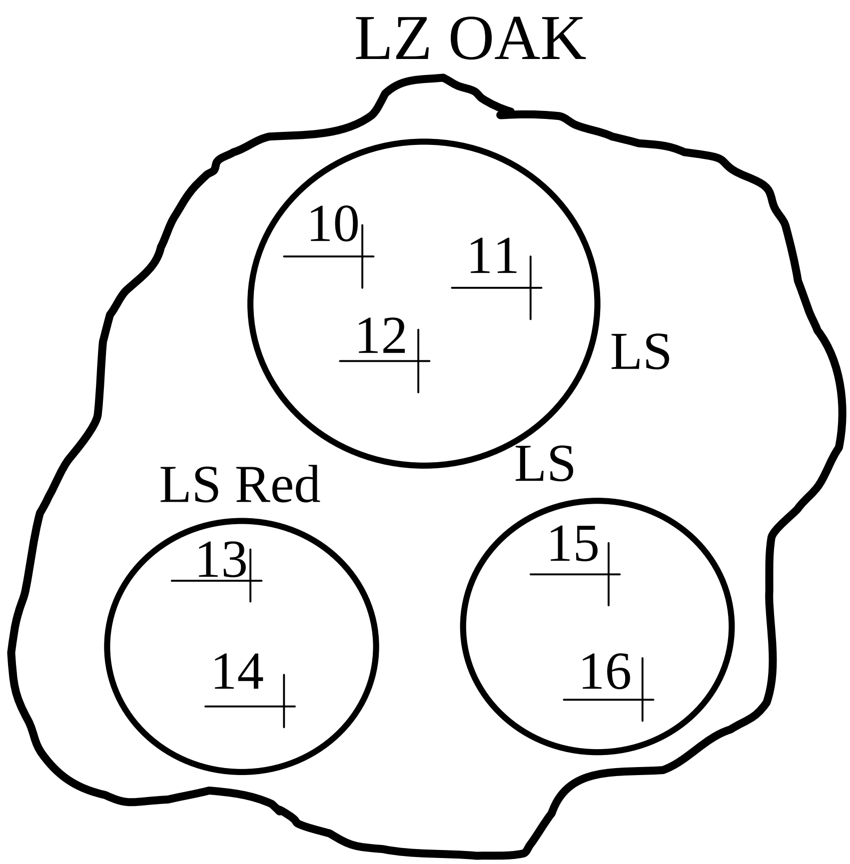
4. LANDING ZONE CONSTRUCTION: This type of facility, normally located in the battle area, represents the minimum cleared area at which a helicopter can land to discharge or pick up passengers and / or cargo under conditions existing at the time of use. Geometric requirements are kept to the absolute minimum.

a. Helicopter Landing Zone Layout:

(1) A landing zone (LZ) is the ground area used for landing a helicopter-borne force and its supplies. LZs are designated by code names such as birds, animals, or trees. The LZ will be broken down internally depicts the two areas of concern:

(a) Landing Sites: A landing site is a specified area in the LZ where one to four helicopters can land at the same time. Landing sites within the zone are used by the helicopter-borne unit as a tactical control measure to land certain subordinate units in specific locations. The number of landing sites required for a operation depends upon the mission, terrain, and number of aircraft using the zone. Landing sites are designated by an assigned color such as: green, blue, white, and yellow.

(b) Landing Points: A landing point is a specified ground area in the landing site where one helicopter lands or picks up a load. Landing points are designated by a two-digit number.



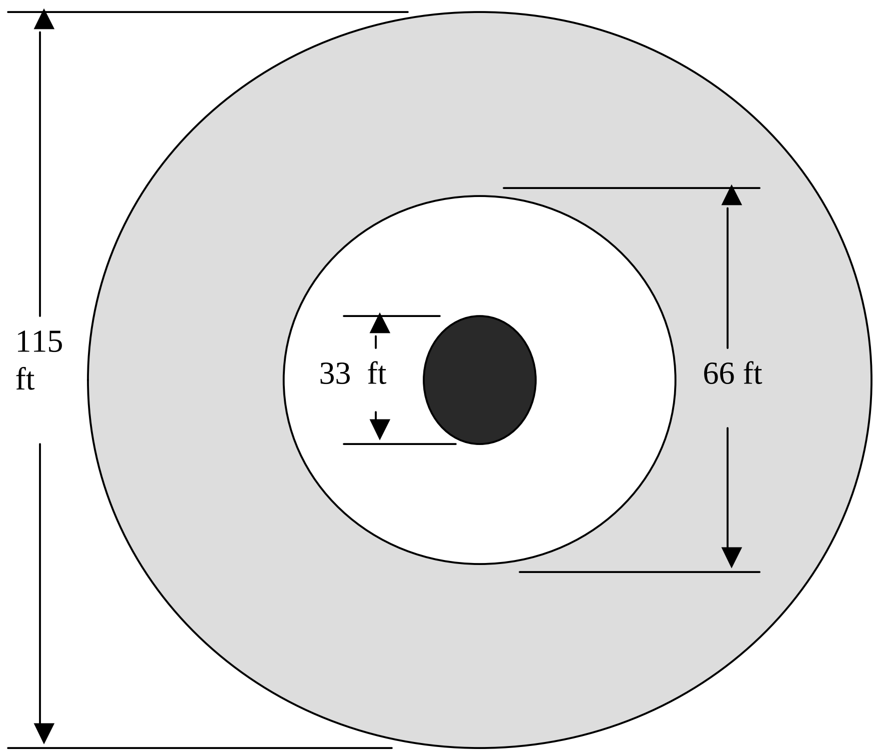
b. Landing Zone Selection: The supported or receiving unit commander, in coordination with the aviation unit liaison officer, if available, selects the location of the helicopter landing zone. The *aviation liaison officer* or *aircraft pilot* makes the final decision concerning the minimum requirements or the suitability of the zones. The following factors should be considered in the selection of a landing zone:

(1) Security and Concealment: If in a tactical situation, LZ's should be shielded from enemy observation by masking terrain or in wooded areas. Artificial camouflage measures should also be utilized to conceal the LZ.

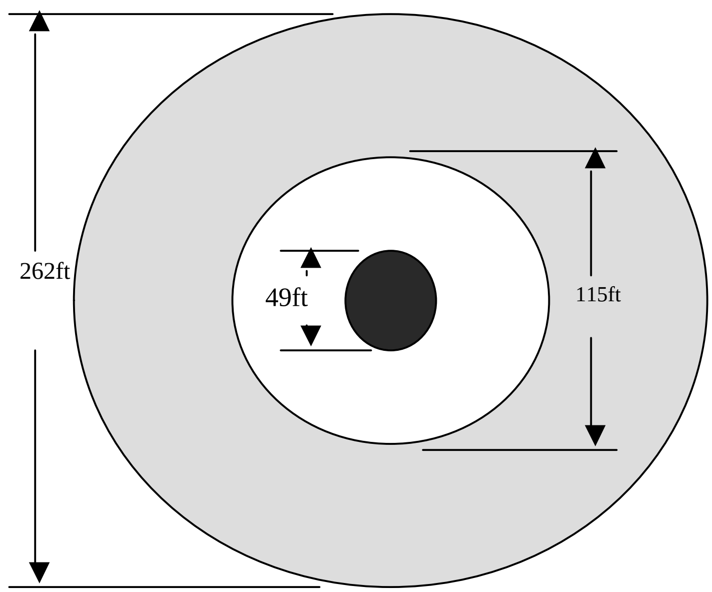
(2) Convenience: Landing sites that are used primarily for supply or

resupply should be located near storage or supply points to reduce ground movement of cargo after it is delivered.

(3) Size: The appropriate LZ size is determined primarily by the type, and number of helicopters, and by the obstructions near or around the LZ. The area required for each landing point can be determined by comparing the helicopter size to the “BULLS-EYE” chart. This is the minimum size required for each landing point. To provide maneuvering space between helicopters, the distance between landing points should be 2 to 4 times the rotor diameter of the largest aircraft utilizing the landing point. This distance is measured from the center of each point. The height of the surrounding obstructions also effects the distance separating the landing points.



SIZE 2 Landing Point
Used for: UH-1,AH-1



SIZE 4 Landing Point
Used for: CH-46E, CH-53D, CH-53E

(4) Approaches and Departures: It is not desirable to establish LZ's that require the helicopter to take off straight up and down; this decreases their allowable payload. In other words, once the load is well clear of the ground, the helicopter will require less power if it can takeoff with some forward airspeed. To allow this, landing sites should be clear of high obstructions (30 feet or higher) for at least 150 feet from the landing site. If the landing site is located where it is likely to be sheltered from the prevailing winds, the cleared area should extend to 300 feet. This increased area allows the helicopter to gain forward speed so that it can begin climbing without using all of its power. The rule that must be maintained is the <u>10:1 ratio rule</u>. This means that for every one foot of obstruction height, there must be ten feet of distance from the center of the landing point. This ratio should be maintained for a distance of 1500’.

(a) Determining Obstruction Height: One field method for determining an obstructions height is known as the “Triangulation” or “Off Set” method. The procedure for performing the Triangulation method is:

<u>1</u> Have one Marine stand at the center/base of the obstruction; For instance at the base of a tree.

<u>2</u> Holding a straight object such as a pen at arms length, position yourself so that the tip of the pen is at the highest point of the obstruction, and the bottom of the pen is at the Marines feet.

<u>3</u> Turn the pen at a 90 degree angle left or right. The base of the pen should still be at the Marines feet.

4 Have the Marine face 90 degrees to his/her left or right. Instruct the Marine to walk forward until his/her feet are at the tip of the pen and halt.

5 Mark the spot where the Marine stopped, and measure the distance to the base of the tree. This distance is equal to the height of the obstruction.

(5) Takeoff and Landing Direction: Since helicopters can takeoff and hover with less power when they are headed into the wind, landing sites should be set up to allow for a 12 o'clock wind direction into the helicopter. Otherwise adequate space should be provided at each landing point to maneuver the aircraft into the wind.

(6) Surface Conditions: Dry, barren areas should be avoided because they create dust clouds when the helicopter lands which can blind both the aircrew and the ground crew. In addition, the debris from the dust clouds could damage the helicopter engines. In general, areas of hard surface or grass make the best natural landing areas.

(7) Topography: Although helicopters can touchdown hover (one or two wheels are placed on the ground, but not all of the wheels) on any sloping ground which also provides the necessary rotor clearance on the uphill side, landing sites should be kept as level as possible. When selecting the landing site, the ground slope must be no more than 15 degrees. Helicopters cannot safely land on a slope of more than 15 degrees.

(a) When the ground slope is less than 7 degrees, the helicopter should land up-slope.

(b) When ground slope is 7 to 15 degrees, the helicopter must make a side-slope landing.

(c) The following two methods can be used to determine the slope of the ground:

DEGREE OF SLOPE = (VD X 57.3) ÷ HD
Where:
VD is Vertical Distance

57.3 is constant

HD is Horizontal Distance

PERCENTAGE OF SLOPE = (VD ÷ HD) X 100
Where:
VD is Vertical Distance

HD is Horizontal Distance

100 is constant

c. Preparation of the Landing Site: Each landing point must be level and firm enough to keep a fully loaded aircraft's landing gear from sinking into the ground. The ground is firm enough for UH-1 helicopters if it can support a 1 1/4 ton truck. If the ground can support a 5 ton truck, CH-46 and CH-53 helicopters can land without risk of sinking. The use of the trafficability test set (pentrometer) provides an accurate means of determining the soils carrying capacity.

(1) The entire landing point must be cleared of any loose material or debris to prevent it from being blown into the ground crew or rotor blades, or drawn into the helicopter engines.

(2) All trees, brush, stumps, or other obstacles that could cause damage to the rotor blades or the underside of the aircraft must be cleared around the landing points. If trees must be cut, stumps in the immediate vicinity of the landing points must not exceed 10" in height on level ground and less on sloping ground. All holes should be filled in or marked.

(3) It may be necessary to use axes, machetes, chainsaws, or demolitions to clear underbrush and trees.

(4) It may be necessary to prepare the ground with some form of soil stabilizer or other material such as matting to reduce the amount of dust raised by the helicopter rotor wash. Hard packed sod makes the best natural landing area.

5. Forward Arming and Refueling Point (FARP): Normally a temporary facility, transitory in nature, and established for a specific duration and mission.

a. Objective: The ultimate objective of the FARP is to minimize the response time, and reduce the turn around time of aircraft in support of sustained operations.

b. Location: Ideally the FARP will be located 10 to 15 miles from the Forward Edge of the Battle Area (FEBA). This positioning is far enough to the rear to prevent enemy artillery fire from targeting the FARP, yet allows for quick turn around time for aircraft and logistical transportation supporting the operation. Concealment of operation from enemy observation plays a large role in selection of the site. The final decision on the actual location of the FARP will be made by the user unit based upon analysis of the METT-TSL.

c. Construction Considerations: When construction of a FARP has been deemed necessary the following should be considered.

(1) Spacing Between Aircraft: The space between refueling points must be great enough to the largest aircraft expected to utilyze the facility. Normally all types of helicopters refuel at the FARP. Therefore, the standard layout should accommodate aircraft in size up to the CH-53E.

(2) Wind Direction: The FARP should be laid out so that aircraft can land, refuel and take off into the wind.

(3) Vapor Collection: Fuel vapors are heavier than air and will pool in a depression or hollow. If the ground slopes, arrange the FARP with the equipment on the higher ground.

(4) Drainage: Ensure that the area drains away from the FARP equipment, and refueling points in the event of a fuel spill or sudden rain fall.

(5) Foreign Object Debris (FOD): Ensure the area is clear of any loose debris or FOD producing material.

(6) Obstacles: The criteria for Landing Zone construction will apply in the take off, and landing zones. Further, ensure there are no protrusions or depressions exceeding 10 inches.

(7) Ground slope: Landing points within the FARP should not exceed 5 degrees.

(8) Soil: Utilize areas that provide minimum soil disturbance.

(9) Access Roads: When possible use areas that maximize available access roads. Roads should be capable of supporting a 5000 gallon refueling truck (max load) if trucks will be replenishing fuel stores.

d. FARP Layout: The FARP in broken down into 4 specific areas; The arming/de-arming area, pre-refueling area, refueling area, and post refueling area.

(1) Arming/de-arming area: Area in which aircraft will be de-armed prior to refueling.

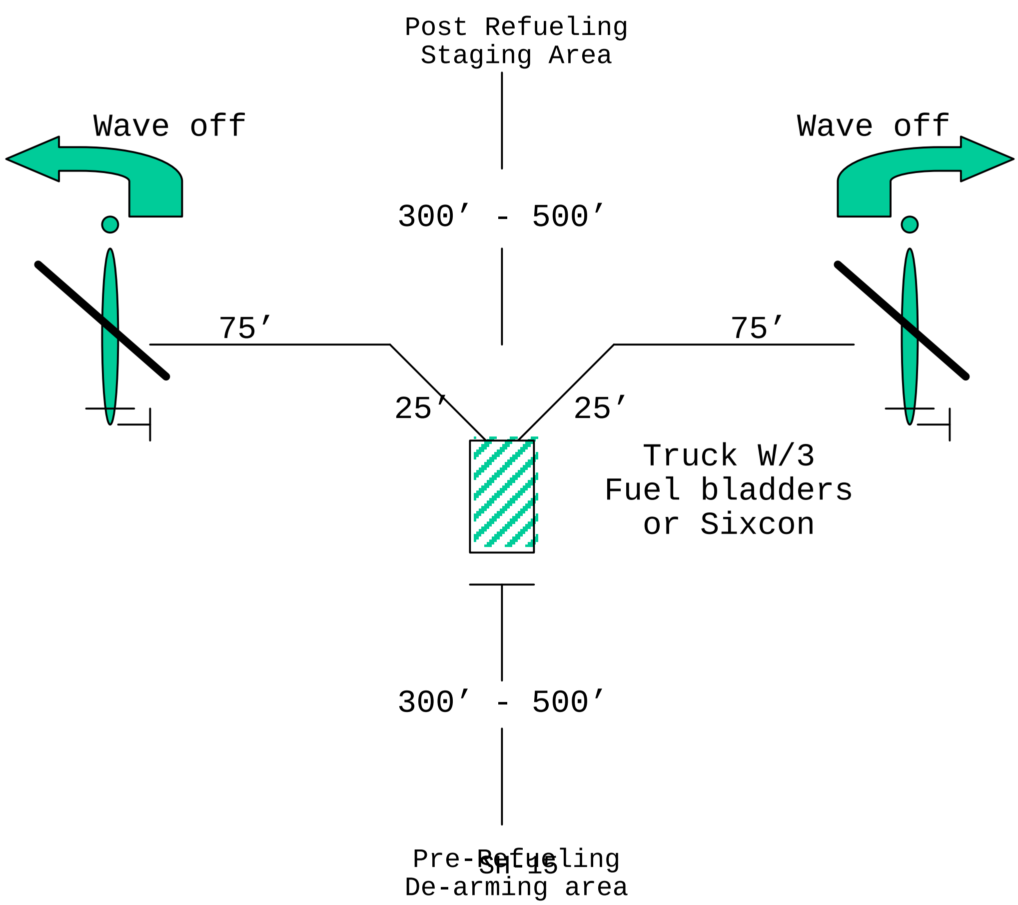
(2) Pre-refueling area: Area where aircraft will position themselves when all refueling points are full. This area should be within visual range of the FARP, and be large enough to contain a division of aircraft. The use of this area will prevent aircraft from having to orbit the FARP. The size of the refueling area will be limited by the logistical capability of the supporting unit.

(3) Refueling area: Area where the actual refueling of aircraft will take place. The size of the refueling area will be limited by the logistical capability of the supporting unit

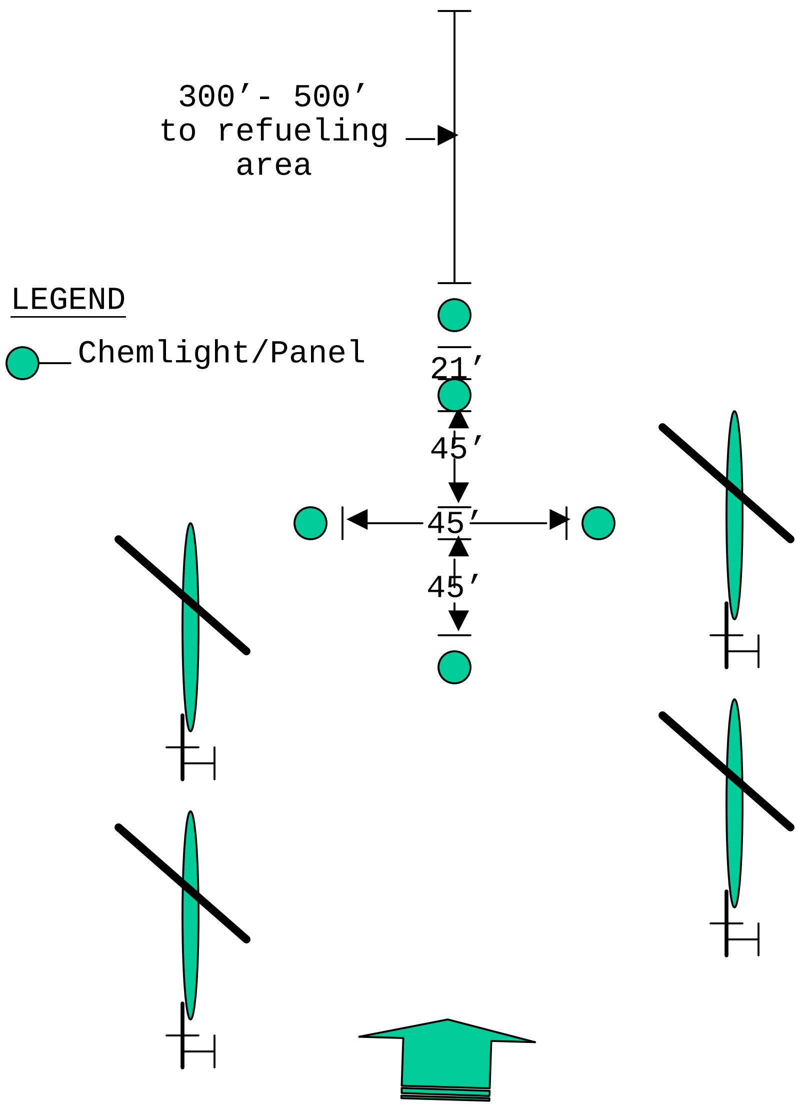
(4) Post-refueling area: Area for aircraft to stage themselves after they have refueled, and are waiting for their wingmen to join.

e. Considerations: The distances between the specific areas within the FARP should be great enough to avoid conflicts of airspace. The following are some recommended spacing, and layout designs.

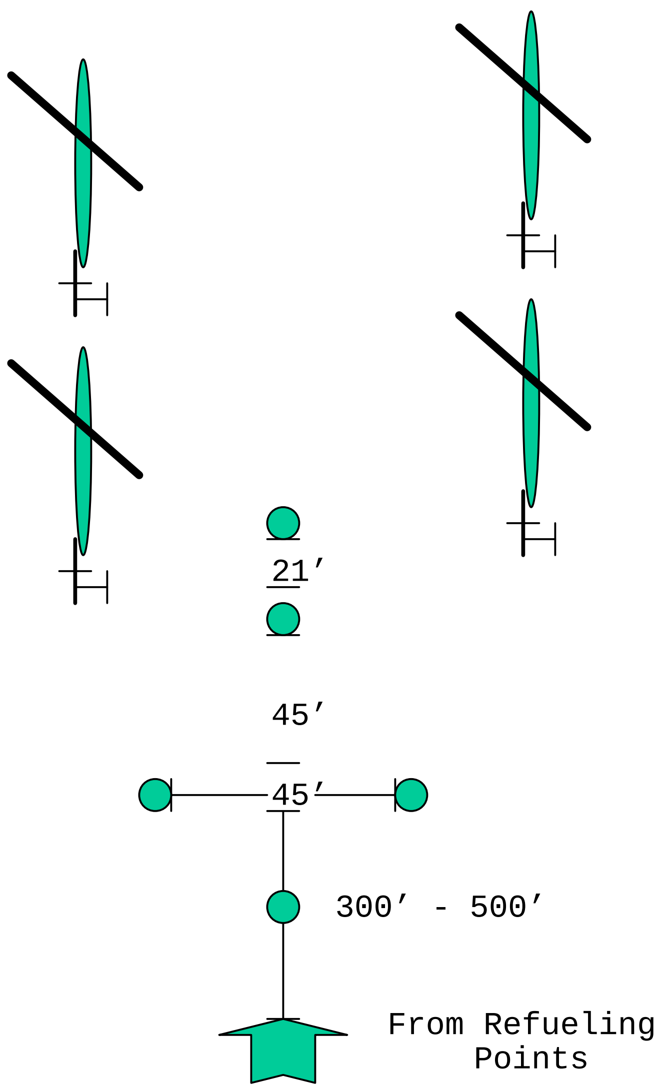
FARP Layout



Pre-Refueling Area



Post-Refueling Area



REFERENCE(S):

FM 5-330 VOL I The Design of Roads, Airfields, and Heliports in the Theater of operations

UNITED STATES MARINE CORPS
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C-01A21
22 Jun 00
(98 POI)

STUDENT OUTLINE

RAPID RUNWAY REPAIR

INTRODUCTION

1. PURPOSE: The purpose of this period of instruction is to provide you with the basic knowledge and skills necessary for rapid runway repair.

2. LEARNING OBJECTIVES:

a. TERMINAL LEARNING OBJECTIVE. Given a tactical situation, a description of airfield damage including drawings or photographs of damaged areas with critical dimensions shown, a notional T/O-T/E and references, supervise rapid runway repair to restore the airfield's minimum operating strip per the references. (1302.1.27)

b. ENABLING LEARNING OBJECTIVES:

(1) Given a description of airfield damage that includes drawings or photographs of damaged areas with critical dimensions shown, and drawings, blueprints, or specifications for the airfield, perform damage assessment per the references. (1302.1.27a)

(2) Given a description of airfield damage that includes drawings or photographs of damaged areas with critical dimensions shown, and drawings, blueprints, or specifications for the airfield, determine the types of repair required for each damaged area per the references. (1302.1.27b)

(3) Given a description of airfield damage that includes drawings or photographs of damaged areas with critical dimensions shown, and drawings, blueprints, or specifications for the airfield, estimate the resources required to repair the airfield per the references. (1302.1.27c)

(4) Given a simulated damage airfield, tools and equipment, a notional T/O-T/E, supervise rapid runway repair per the references. (1302.1.27d)

l. PURPOSE OF DAMAGE ASSESSMENT:

a. Before any repairs can be accomplished, it is essential that an effective damage assessment operation be completed.

b. Station or Squadron repair teams must know what areas are damaged, the extent of the damage and what will be required to repair the damages.

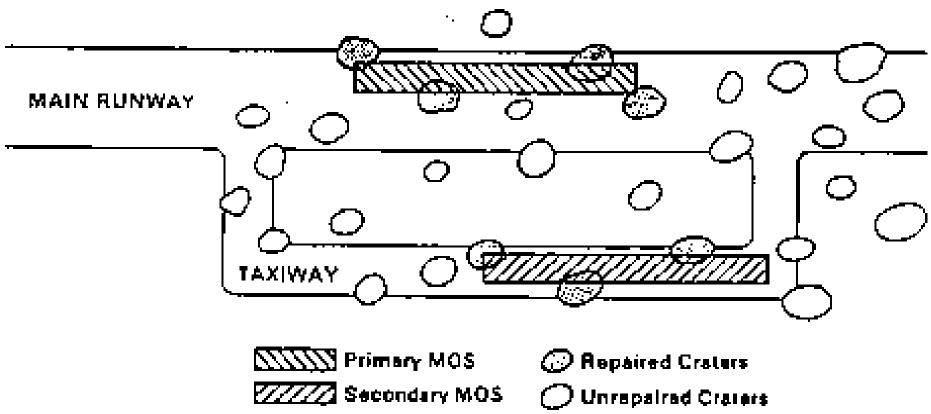
c. A rough initial estimate of damage can be obtained by observations from good vantage points around the base. This includes:

(1) Control towers, and reports by flight line observation posts.

(2) Security police and other organizations.

(3) If available, helicopters might be used to conduct aerial reconnaissance and damage assessment.

d. A more detailed assessment of damage requires the dispersal of Damage Assessment Teams (DATs) to evaluate specific destruction.



2. <u>TYPES OF DAMAGE ASSESSMENT</u>. Damage assessment activities may be separated into two distinct areas. They are:

a. Runway Damage Assessment (airfield)

(1) This involves the assessment of damage to runway, taxiway, aircraft parking apron surfaces, and any other collateral damage encountered.

(2) During runway damage assessment; the location, types, quantity of unexploded ordinance and airfield pavement damage are determined and reported to the MOS selection team.

(3) The MOS selection team uses this information to determine potential Minimum Operating Strips <u>(MOSs). (FM</u> 5-34 pg 8-11)

(4) The potential MOS list is relayed to the station command center which selects the **M**inimum **A**irfield **O**perating **S**urface <u>(MAOS)</u> that must be cleared and repaired to restore the operational capability of the air base.

(a) The MAOS consists of the MOS, the supporting taxi ways, access routes, and parking aprons needed to launch and recover aircraft.

(b) Since major recovery tasks cannot be started until damage assessment and MAOS selection is completed, speed and accuracy during damage assessment is essential.

b. Facility Damage Assessment (base):

(l) This includes assessment of all air station facilities and utilities.

(2) The facility Damage Assessment Teams (DATs), should inspect the

highest priority facilities first to determine the feasibility of repairing the facility. As directed by **S**urvival **R**ecovery **C**enter (SRC). SRC provides information and advice to wing/base command staff on base recovery activities. Provides command and control for **B**ase **C**ivil **E**ngineer (**BCE**), under which engineers fall.

(3) The DATS should develop a repair estimate for the facility which includes an estimate of the labor, materials, and equipment required to accomplish the repairs.

3. DAMAGE ASSESSMENT OPERATIONS:

a. Resources and manpower permitting, both runway and facility damage assessment operations should be conducted simultaneously.

b. To shorten air base restoration time, the damage assessment operations and Explosive Ordinance Disposal/Unexploded Ordnance, (EOD/UXO), assessment operation should be done concurrently.

c. Thus, the DATs are task organized to conduct ground assessments of UXO locations and bomb damage either on foot or from vehicles.

4. DAMAGE ASSESSMENT PRIORITIES:

a. The station Battle Damage Repair/Rapid Runway Repair (BDR/RRR) plan should provide the damage assessment priorities of the various station facilities.

b. The Squadron should integrate those priorities in its RRR plan and DAT assignments.

c. In general, the priorities of the areas to be assessed will most likely be:

(1) Runways and taxi ways, aircraft maintenance facilities, aircraft parking, loading, and refueling areas. In these areas, all craters, spalls, and UXO must be reported. (craters, spalls, UXO, will be discussed later).

(2) Station command and control, and communications facilities.

(3) Key utility substations or facilities.

(4) Medical and decontamination facilities.

(5) POL storage and pumping facilities.

5. DAMAGE ASSESSMENT TEAM (DAT) COMPOSITION. The Squadron should assign personnel to serve on the DATs as required by the station's BDR/RRR plan.

a. RRR DAT (airfield) Composition

(1) The DATs should normally consist of:

(a) One EOD technician.

(b) One Public Works or **A**ir **O**perations **R**epresentative (AOR).

(c) Three Engineers or Squadron personnel to aid the assessment, record information, and communicate data to the MOS selection team.

(2) The EOD expertise is necessary to accurately identify and

classify UXO and oversee the activities of the DAT in the hazardous UXO environment.

(3) The senior member of the team will normally be the team leader.

(a) Regardless of grade, the EOD technician will direct the teams movement through areas with UXO.

(b) Facility DAT Composition

(4) The facility DATs should have at least:

(a) One electrician/utilitiesman.

(b) One carpenter/builder (1371).

(c) EOD and disaster preparedness personnel, (NBC). Because of the presence of UXO and chemical agents.

c. Manning will probably be limited during a contingency response, so the minimum number of persons necessary to evaluate damage should be assigned.

d. The station should have the primary responsibility for manning the facility DATs.

6. <u>RRR DAMAGE ASSESSMENT INFORMATION</u>. During RRR damage assessment, the DATS gather two types of information, pavement damage caused by ordnance and the location/description of UXO.

a. The location and description of pavement damage caused by bombs, scuttling charges, or cannon fire is categorized as follows;

(1) Pavement Damage Data.

(a) Pavement damage to potential MOS surfaces will be recorded on the same scaled drawings as the UXO reports.

(b) The following information is included in each report:

<u>1</u> Damage type (crater, spall, etc.)

<u>2</u> Location (by grid coordinates or in relation to known reference markers).

<u>3</u> Size (crater diameter, spall field dimensions).

<u>4</u> Number (of spalls in a field).

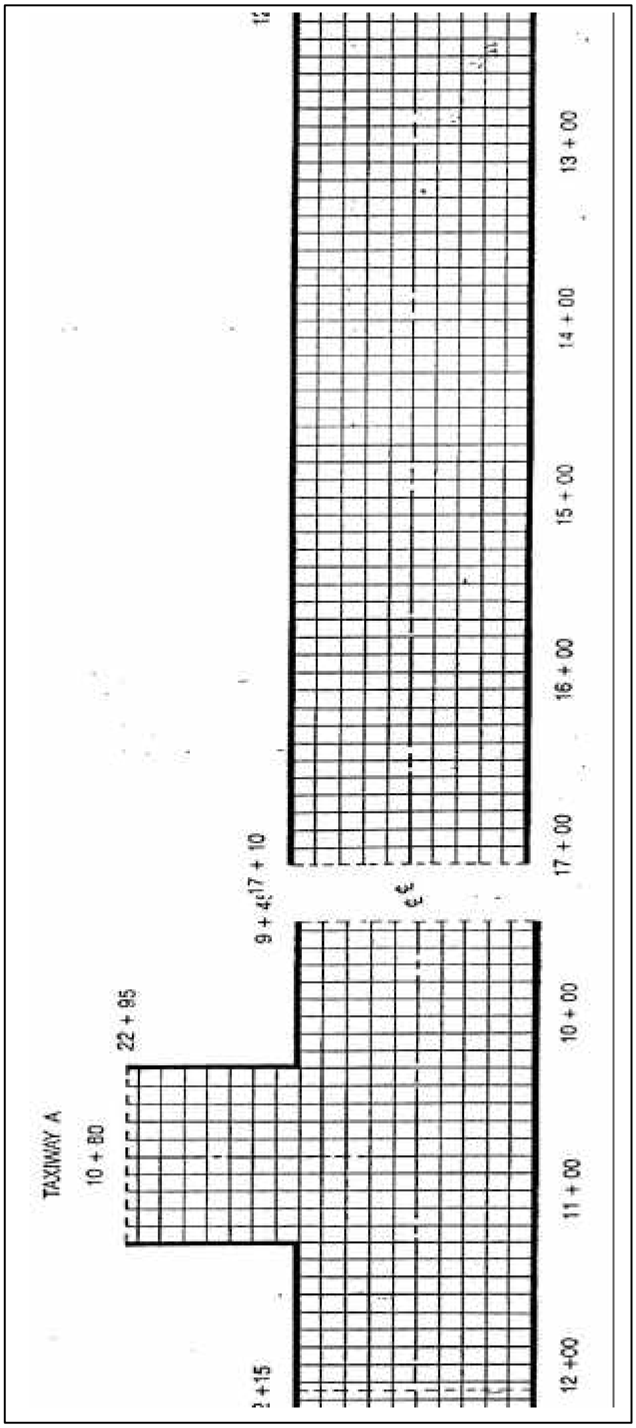
<u>5</u> Estimating Crater Size and Location

(a) Airfields will have to be measured and marked in areas of 100 foot increments.

(b) Markers will correspond with the airfield grid coordinate system.

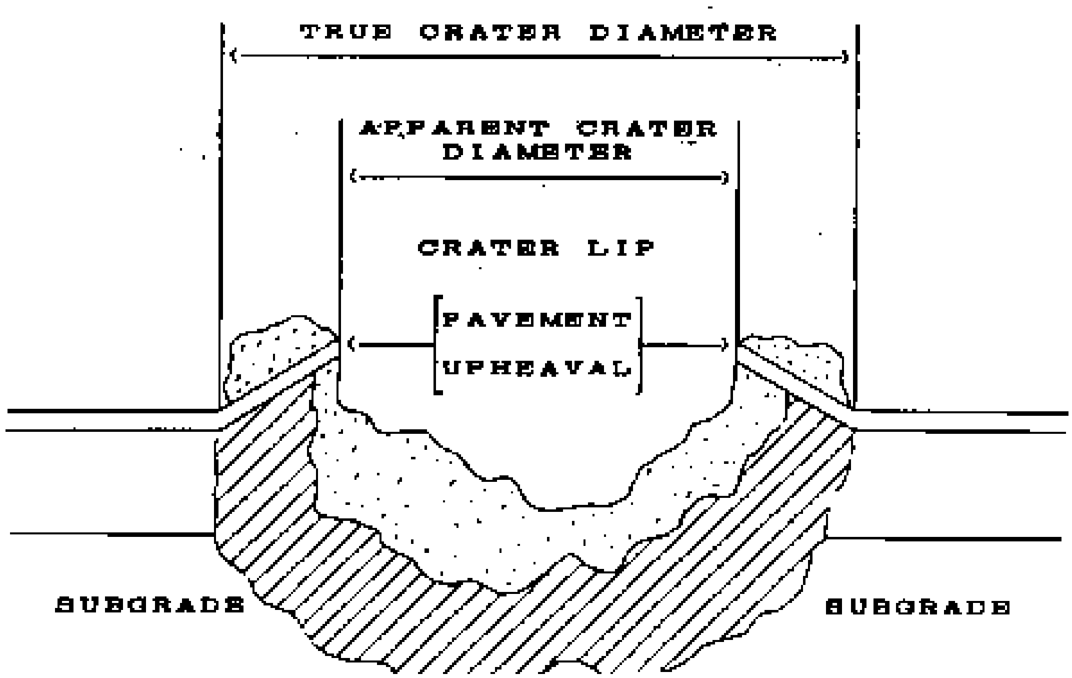
(c) Size of craters estimated by:

<u>1</u> Pacing off


TAXIWAY A
10 + 80
22 + 95
17 + 10
13 + 00
14 + 00
15 + 00
16 + 00
17 + 00
10 + 00
11 + 00
12 +00

2 Actual measurement with a tape measure. Non-metal tape. You should not have any ferrous metal (sparking) objects or tools because of magnetically influenced firing devices.

(d) Report only "apparent" diameter. Width of hole in pavement at the widest point. Depth not required.



(e) The locations and descriptions of UXO.

(1) UXO Data required:

(a) The UXO that may influence aircraft operations must be accurately located, reported, and recorded in sufficient detail for the Station Command center to determine the risk to aircraft operations.

(b) All UXO within 300 feet of repair operations or aircraft operating surfaces must be identified.

(c) Holes of entry for subsurface UXO must also be reported.

(d) Scaled drawings must show sufficient adjacent area to include the 300 foot, UXO radius of effect zone for paved surfaces and Foreign Object Damage (FOD) cover assembly areas.

(e) The following UXO information is included in the DAT report:

1 Location

2 Size

3 Shape

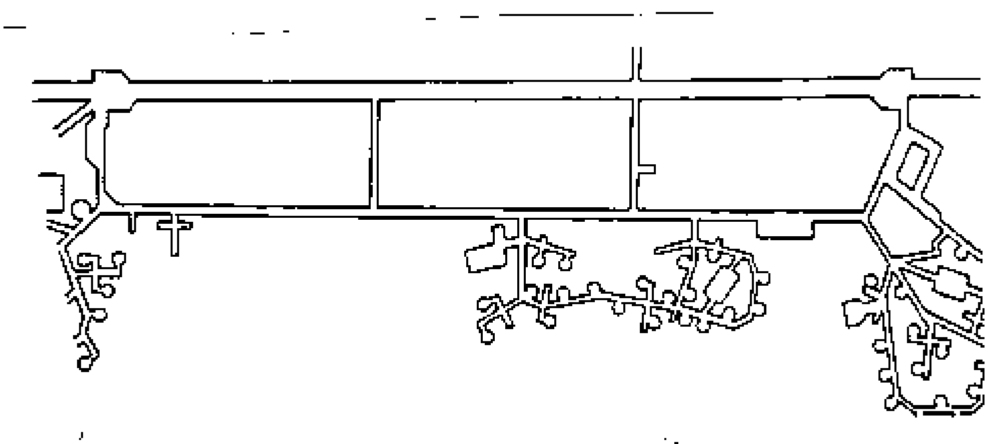
4 Color

5 Distinctive Markings

6 Fuse type and condition

(2) Equipment Required for recording UXO:

(a) An airfield map



1 Marked in grid coordinates

2 Scale 1 inch = 100 feet. This scale is used because the airfield should already be marked into 100 foot intervals and using one inch as a scale makes converting easy.

3 These plans and scale drawings could be pre-printed in the RRR plan.

(b) An armored vehicle or a "hardened" vehicle (e.g. blade tank, D7-G with armor protective kit, ACE, etc.) for removing or working around UXO.

(c) Communications equipment:

1 Radios or other reliable means to maintain contact with the Command Post/Damage Control Center, (CP/DCC), and report damage/UXO locations.

2 Hand held radios, one (l) per assessor is ideal.

(d) Measuring tapes (100 foot)

(e) Marking Stakes/Engineer tape used for:

1 Marking UXO locations, etc.

2 Marking prospective access routes etc.

3 Marking "Safety" zones etc.

7. DAMAGE ASSESSMENT PRE-ATTACK ACTIONS:

a. Ensure that you have existing pavement markings on the runways/taxiway they most likely be destroyed or covered with debris after an attack.

b. The Squadron should fabricate a marking system consisting of large stakes for use as station markers (100 foot marks) to assist in determining the location of damage and UXO after an attack.

(l) The stakes should be installed prior to an attack and be placed far enough off the runway and taxi way surfaces so that they will survive an attack, but still be visible from the runway surface.

(2) In addition, the stakes should be placed at 100 foot intervals and have visible stations markings.

8. DAT COMMUNICATIONS:

a. The success of the damage assessment operation depends on dedicated communication links and strict communication procedures to ensure accurate transmission of damage information.

b. As a result, clear, concise radio transmissions using strict radio discipline are essential.

c. Each DAT should have a communications link to the Station and Squadron Command Centers.

d. We will cover proper communication procedures later in the lesson.

9. FILLING OUT AN EXPLOSIVE ORDNANCE RECONNAISSANCE (EOR) REPORT

a. Accuracy of every detail is the most important aspect of filling out an EOR Report. It must be filled out in such a manner that everyone concerned, especially the EOD Technicians, can understand it.

EXPLOSIVE ORDNANCE RECONNAISSANCE REPORT

1. NAME:	2. DATE:	3. TIME:
4. ORGANIZATION:	5. PHONE NUMBER:	
6. LOCATION OF UXO:	7. GRID COORDINATES:	
8. TIME OF UXO IMPACT:	9. TYPE OF UXO:	
10. TYPE OF FUZING: NOSE:	TAIL:	TRANSVERSE:
11. RADIOLOGICAL/CHEMICAL MONITORING RESULTS:		
12. HOLE OF ENTRY SIZE:	13. TYPE OF SOIL	
14. ANGLE OF ENTRY:	15. FALSE CRATER DIAMETER:	
16. DIRECTION OF ATTACK:		
17. UXO LENGTH: OVERALL:	BODY:	FUZE:
18. UXO DIAMETER: OVERALL:	BODY:	FUZE:
19. ESTIMATED UXO WEIGHT:	20. OVERALL COLOR:	
21. COLOR BANDS:		(SHOW ON DRAWING)
22. COLOR OF MARKINGS:		(SHOW ON DRAWING)
23. TYPE OF STABILIZATION:		
24. ACCESSORY DEVICES:		
25. GENERAL DESCRIPTION: (USE YOUR OWN WORDS)		
26. SAFETY MEASURES TAKEN:		
27. PROTECTIVE WORKS IN PROGRESS/COMPLETED:		
28. MAKE DRAWING OF UXO ON BACK OF THIS FORM		

b. There are three (3) phases of filling out an EOR Report

(l) Phase 1: Pre-access Data

(a) All the information that can possibly be obtained before going into the damaged area.

(b) Information obtained from intelligence sources.

(2) Phase 2: Post Access Data

(a) Obtained upon gaining access to the damaged area.

(3) Phase 3: Pre/Post Access Data. Data that is obtainable as either pre or post access information from other teams.

(a) Block 26 - Safety measures taken or in progress

c. Post Incident Data

(l) Summary of information after DAT and EOD teams complete their mission.

d. Removal of sub-munitions

(1) Should not be considered by Engineer personnel.

(a) Operational necessity may require removal, if EOD Technicians are not available.

<u>1</u> Only done under war time conditions.

<u>2</u> Do not touch or try to remove by hand.

<u>3</u> Use only hardened equipment.

<u>4</u> Push or remove ordnance from area into a trench or hold and mark the area.

<u>5</u> Observe all safety precautions as closely as possible.

e. You must now establish grid coordinates for locating and plotting of UXOs, Spalls, Craters, and any other hazards.

(1) Everyone must understand the grid system.

(2) Establish a "base line" if the taxiway/runway center line is unusable or unacceptable.

(a) Center lines should now exist on all airfields.

(b) Base line should run parallel to center line.

<u>1</u> Either left or right of center line.

(c) Establish a "zero" or starting point.

<u>1</u> All taxiways/runways should have a zero end.

<u>2</u> Always start at the zero end.

(3) Establish letter designators for different words.

(a) C for Craters)

(b) X for UXO(s)

(c) S for Spall(s)

(d) R for Right

(e) L for Left

(f) D for Diameter

(g) W for Width

(h) F for Field

(i) N for Number of Spalls or UXOs

(J) MOS for Minimum Operating Strip

(k) CL for Center Line

10. <u>ESTABLISHING, WRITING, AND COMMUNICATING COORDINATES FOR UXO(S), SPALLS(S), CRATER(S), AND OTHER HAZARDS</u>:

a. UXO(s)

(l) Establishing the coordinates.

(a) Identify - "x"

(b) Measure in feet along the center/base line to the UXO. Example 1100 feet

(c) Determine if it is left or right center/base line and identify with "L" or "R".

(d) Measure in feet from the center/base line to the UXO. Example 35 feet

(e) Writing the coordinates

<u>1</u> Xll00 - L35

<u>2</u> Xll00 - R35

(f) Communicating (use phonetic alphabet in transmissions)

<u>1</u> Example: X-RAY ONE ONE ZERO ZERO LIMA THREE FIVE

<u>2</u> Example: X-RAY ONE ONE ZERO ZERO ROMEO THREE FIVE

b. Spall(s)

(l) Establishing the coordinates for l spall.

(a) Identify - "S"

(b) Measure in feet along the center/base line to the Spall. Example - 1200 feet

(c) Determine if it is left or right center/base line and identify with "L" or "R".

(d) Measure in feet from the center/base line to the Spall. Example - 35 feet

(e) Writing the coordinates

<u>1</u> Sl200 - L35

<u>2</u> Sl200 - R35

(f) Communicate. Use phonetic alphabet.

1 Saying: SIERRA ONE TWO ZERO ZERO LIMA THREE FIVE

2 Saying: SIERRA ONE TWO ZERO ZERO ROMEO THREE FIVE

(4) Establishing the coordinates for more than l spall.

(a) Identify - "S"

(b) Measure in feet along the center/base line to the first spall. Example - 1250 feet

(c) Locate the center of the damaged area.

(d) Determine if it is left or right center/base line and identify with "L" or "R".

(e) Measure in feet from the center/base line to the center of the damaged area. Example - 25 feet

(f) Identify width - "W"

(g) Measure the distance in feet. Example - 40 feet

(h) Identify the field - "F" (distance to last spall)

(i) Measure distance in feet. Example - 1450 feet

(j) Locate the center of the damaged area.

(k) Determine if it is left or right center/base line and identify with "L" or "R".

(l) Measure in feet from the center/base line to the center of the damaged area. Example - 25 feet

(m) Identify width - "W"

(n) Measure the distance in feet. Example - 40 feet

(o) Identify the Number - "N"

(p) Estimate or count to the best of your ability the total number of spalls.

(q) Writing the coordinates.

1 S1250 - L25 - W40 - F1450 - L25 - W40 - N25

2 S1250 - L25 - W40- F1450 - R25 - W40 - N25

3 S1250 - R25 - W40 - F1450 - R25 - W40 - N25

c. BOMBLETS/Sub-munitions (UXOs)

(l) Establishing the coordinates for each bomb-let/sub-munitions.

(a) One is considered and plotted the same way as a large UXO.

(2) Establishing the coordinates for more than one bomb-let/sub-munitions.

(a) Identify - "x"

(b) Measure in feet along the center/base line to the first bomb-let/sub-munitions. Example - 1480 feet

(c) Locate the center of the covered area.

(d) Determine if it is left or right center/base line and identify with "L" or "R".

(e) Measure in feet from the center/base line to the center of the covered area. Example - 45 feet

(f) Identify width - "W"

(g) Measure the distance in feet. Example 30 feet

(h) Identify the field- "F" (distance to last bomb-let/sub-munitions)

(i) Measure distance in feet.

(j) Locate the center of the covered area.

(k) Determine if it is left or right center/base line and identify

(l) Measure in feet from the center/base line to the center of the covered area. Example - 25 feet

(m) Identify width - "W"

(n) Measure the distance in feet. Example - 30 feet

(o) Identify the Number - "N"

(p) Estimate or count to the best of your ability the total number of bomb-lets/sub-munitions. Example - 25

(q) Writing the Coordinates:

<u>1</u> X1480 - L45 - W30 - F1608 - R25 - W30 - N25

d. Craters

(l) Establishing the coordinates.

(a) Identify - "C"

(b) Measure in feet along the center/base line to the approximate center of the crater.

Example - 1152 feet

(c) Determine if it is left or right center/base line and identify with "L" or "R".

(d) Measure in feet from the center/base line to the approximate center of the crater.

Example 00 feet

(e) Writing the coordinates.

1 Cl152 - L00 - D40

2 C1152 - R00 - D40

(2) Establishing coordinates for multi (overlapping) craters. They would be considered as one large crater.

STUDENT EXERCISE: Determine the coordinates for the damaged airfield on the runway provided.

SPALL FIELDS

1.

2.

UXO FIELDS

1.

2.

3.

CRATERS

1.

2.

3.

4.

5.

6.

7.

SPALLS

1.

2.

3.

4.

5.

6.

7.

UXO

1.

2.

3.

4.

5.

6.

7.

8.

9.

11. RAPID RUNWAY REPAIR METHODS:

a. The first step in determining how to repair damaged airfields is estimating the size of the damage or bomb hole. Once the hole has been measured and characterized you are ready to determine the proper type of repair to use for the hole.

b. REGULATED SET PORTLAND CEMENT (RSPC):

(1) Used for FOD cover crater repair.

(2) It must be batched from a cretemobile.

(3) It is used when crater contains water or if the debris is not suitable for use.

(4) Sequence of Repair:

(a) Break out and remove upheaval and ejects.

(b) Square the hole.

(c) Fill the crater with ballast rock to 10" of the surface.

(d) Lay down geotextile layer.

(e) Pour in RSPC

(f) Screed to surface.

c. NORMAL CRUSHED STONE REPAIR METHOD:

(1) This method is the best method to use.

(a) Sequence of Repair:

1 Remove Ejects

2 Breakout and remove upheaval

3 Fill in crater with debris and backfill to 18" - 220" from the pavement surface using nothing larger than 12" in diameter.

4 Lay down a geotextile layer.

5 Put in 1 1/2" minus, graded crushed stone and compact and screed to surface, cover with FRP matting.

d. CHOKED - BALLAST CRATER REPAIR:

(1) Used when the crater contains water or the debris is unsuitable.

(2) Sequence of Repair.

(a) Remove Ejects.

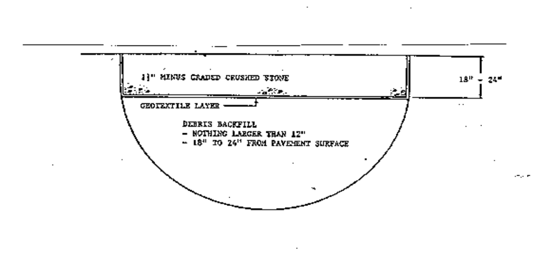
(b) Breakout and remove upheaval.

(c) Fill the crater with 3" minus ballast rock to 4" - 6" from surface.

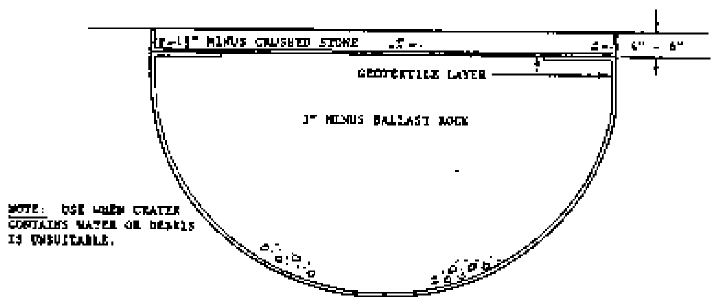
(d) Lay down geotextile layer.

(e) Fill the rest of the crater with 1 1/2" minus crushed stone, compact and screed to surface.

1 Cover with FRP matting.



NORMAL CRUSHED STONE
CRATER REPAIR METHOD
(DRY CRATER REPAIR)



CHOKED - BALLAST CRATER REPAIR

e. <u>CHEAP - BALLAST CRATER REPAIR</u>:

(1) Used for dry craters that can be back filled with debris.

(2) Sequence of Repair.

(a) Fill crater with ejects and debris to 18" - 24" from surface.

(b) Lay down the geotextile layer.

(c) Fill in remaining space (4" - 6") with 1 1/2" minus crushed stone.

(d) Compact, screed to surface.

(e) Cover with FRP matting.

f. <u>SAND GRID CRATER REPAIR</u>:

(1) Used when nothing else is available. (It will need a lot of rework)

(2) Sequence of Repair.

(a) Fill in 16" of the crater with ejects and debris.

(b) Lay down a geotextile layer.

(c) Install the first sand grid.

(d) Lay down another geotextile layer.

(e) Install the second layer of sand grid.

(f) Continue until the crater is filled.

(g) If the sand grid does not completely fill the crater, fill the remaining space with 1 1/2" minus crushed stone and compact.

(h) Cover with FRP matting.

12. <u>FIBERGLASS REINFORCED PLASTIC</u>:

a. Also called fiberglass reinforced polyester or polyurethane. (FRP)

b. Used as a FOD cover.

(1) FOD covers help to keep rain from seeping into and weakening water susceptible fill materials and to reduce the depth of ruts caused by aircraft traffic.

(2) They also provide some structural load bearing capacity.

c. General Characteristics of FRP

<table>
<tr><td colspan="2"></td><td colspan="2">RAMP PANEL</td></tr>
<tr><td>RIGHT - HALF
SIZE PANEL</td><td colspan="2">BASIC PANEL</td><td>LEFT - HALF
SIZE PANEL</td></tr>
<tr><td colspan="2">BASIC PANEL</td><td colspan="2">BASIC PANEL</td></tr>
<tr><td colspan="2">CENTER PANEL</td><td colspan="2">CENTER PANEL</td></tr>
<tr><td>LEFT - HALF
SIZE PANEL</td><td colspan="2">BASIC PANEL</td><td>RIGHT - HALF
SIZE PANEL</td></tr>
<tr><td colspan="2">BASIC PANEL</td><td colspan="2">BASIC PANEL</td></tr>
<tr><td colspan="2"></td><td colspan="2">RAMP PANEL</td></tr>
</table>

TYPICAL FRP MAT LAYOUT

(1) Made of two (2) or more layers of fiberglass impregnated with either polyurethane or polyester resin.

(2) They are 1/4 to 3/8's of an inch thick.

(3) FRP mats are damaged by long exposure to fluids, particularly paint remover and petroleum hydraulic fluids and ultraviolet rays.

13. NAVFAC P36 RAPID RUNWAY REPAIR COMPONENT: This component consists of construction equipment and materials designed to repair bomb damage to airfield pavements. It is at this time being fielded at MWSS's, USMC Engineer school, and other services for testing.

a. One P36 for each airfield to be repaired.

b. The P36 will include 9 war damage repair kits. Each kit will contain the materials and tools to repair and anchor a crater, up to a 60' diameter.

c. The P36 also contains war damage repair kit for airfield lighting.

(1) It is intended to be used as a temporary repair kit to fill any gaps in the existing system caused by battle damage.

(2) Critical material to restore the existing system to full operational condition is assumed to be stocked piled by the activity concerned.

14. FRP PANELS. There are basically five types of panels that make up FRP matting they are:

a. RAMP PANELS. The ramp panels are approximately 18'x 3' and are the last panels to be put in place.

b. CENTER PANELS. The center panels are approximately 18' x 3' and are the first panels to be put into place.

c. BASIC PANELS. The center panels are approximately 18' x 6' and are placed along the center panels.

d. LEFT HALF PANELS. The left half panels are approximately 6' x 9' and weigh approximately 150 lbs, the panel is placed so that the left edge is flush with the outside edge of the patch.

e. RIGHT HALF PANELS. The right half panels are the same as the left half panels except that the right edge of the panel is flush with the right outside edge of the patch.

15. SEQUENCE OF CONSTRUCTION: Start from the center and work out.

a. Place the center panels down, align and bolt together.

b. On either side of the center panels place two basic panels, align and bolt to the center panels.

c. On the opposite side of the center panels that the two basic panels are bolted to, place one left half panel, one basic panel, and one right half panel align and bolt to the center panels.

d. The last panels to be put into place are the ramp panels that are placed at both ends of the patch and bolted to the final row of panels.

e. After the ramp panels are placed on the patch, attach the towing equipment to the ramp panels and pull the patch over the hole or crater with the ramps facing traffic.

f. Once the mat is in place, anchor it to the runway using the anchoring equipment provided in the RRR kit.

g. The matting will be placed starting with four 12' sheets and one 6' sheet at the end. The matting will always be placed from left to right facing the key lock.

(l) The mat should be placed into the starter key lock or matting at a 45 degree angle. This is to help in easy assembly of the AM-2 matting.

(2) Double check to make sure that the first two rows of matting and key lock are straight. Then split the mat crew and place a full row of matting on the other side of the key lock. Continue placing matting on both sides of the key lock until the patch is complete.

(3) Parallel pull attach towing panels which can be fabricated by drilling 1 1/4" holes in a piece of AM-2 matting to accommodate the shackles for attaching the towing slings. Attach the center of the panels 18' in from both ends of the patch. Then attach towing slings to panels and vehicles.

16. SPALL REPAIR METHODS AND MATERIALS.

a. A spall or scab is defined as a cavity in a pavement that does not reach the base course material and results in a pavement damage area no greater than 5' in diameter.

b. What causes spalls?

(1) Small caliber artillery fire, small rocket fire, or other small caliber contact fused munitions.

c. What are we going to use?

(1) There are four types of materials that are generally accepted to repair spalls: only the RSPC is readily available the others need to be planned for and ordered threw supply systems.

(a) Silica

(b) Cold Patch Asphalt

(c) Magnesium Phosphate

(d) Regulated Set Portland Cement (RSPC)

17. SAFETY.

a. Chemical elements may be toxic and/or highly flammable and the following precautions should be taken:

(1) Properly attired

(a) Chemical resistant gloves - rubber

(b) Safety goggles

(c) Respirators

(2) Have an eyewash in the area.

(3) No eating at the repair site.

(4) If skin contacts chemicals, flush with water.

(5) Avoid breathing vapors.

(6) No smoking or spark producing devices within 50 feet.

(7) Have a chemical fire extinguisher nearby.

(8) Do not wear contact lenses when using this product.

18. SPALL PREPARATION.

a. Steps are as follows for repairs.

(1) Remove loose debris, ejects and excess water as required with the use of the following equipment:

(a) Air compressors

(b) Brooms

(c) Shovels

(d) Jack hammering equipment (recommended not to exceed 30 pounds in weight).

19. SPALL REPAIR MATERIALS.

a. Regulated Set Portland Cement (RSPC)

(1) Mixing procedures

(a) Load a concrete mixer, (6s, lls, or 16s).

1 50 lbs of sand.

2 50 lbs of pea gravel (if spall is deeper than 1 ").

3 Add 2 1/2 gallons of water.

4 Add retardant if required.

5 Mix ingredients.

6 Add air entrainment if required.

7 Add a bag RSPC (50 lbs).

8 Mix for 2 minutes but not more than 3 minutes.

(2) Application

(a) Discharge into spall.

(b) Trowel off flush to surface.

(3) Characteristics

(a) Initial set is 25 minutes in 75 degrees temperature. Quicker when hotter, slower in cooler weather.

(b) Traffic ready in two hours or less.

(4) Cleanup

(a) Trowels should be cleaned before concrete sets.

(b) Use water, acetone, methylenechloride, or trichlorethylene, depending on type of repair material used.

20. MAINTENANCE.

a. Replacement of repairs.

(1) As time dictates.

(2) When they show deterioration.

REFERENCE(S):

MCRP 3-17A\FM 5-34	ENGINEER FIELD DATA
FM 5-104	GENERAL ENGINEERING

UNITED STATES MARINE CORPS

MARINE CORPS ENGINEER SCHOOL
COMBAT ENGINEER INSTRUCTION COMPANY
PSC BOX 20069
CAMP LEJEUNE, NC 28542-0069

C-01A24
19 Jun 00
(98 POI)

STUDENT OUTLINE

FUEL OPERATIONS

LEARNING OBJECTIVES:

1. TERMINAL LEARNING OBJECTIVE: Given a tactical situation, a map, concept of operations, commander's intent, task organization of equipment and personnel, and references, prepare a fuel operations plan to meet requirements as outlined in the concept of operations and commander's intent per the references. (1302.02.08)

2. ENABLING LEARNING OBJECTIVES:

a. Given a tactical situation, a map, concept of operations, commander's intent, task organization of equipment and personnel, and references, identify the mission, equipment, and capabilities of units which handle bulk fuel to meet requirements as outlined in the concept of operations and commander's intent per the references. (1302.02.08a)

b. Given a tactical situation, a map, concept of operations, commander's intent, task organization of equipment and personnel, and references, identify the methods and equipment used to receive, store, transport, and distribute bulk fuel to meet requirements as outlined in the concept of operations and commander's intent per the references. (1302.02.08b)

c. Given a tactical situation, a map, concept of operations, commander's intent, task organization of equipment and personnel, and references, prepare a fuel operations site plan to meet requirements as outlined in the concept of operations and commander's intent per the references. (1302.02.08c)

d. Given a tactical situation, a map, concept of operations, commander's intent, task organization of equipment and personnel, and references, maintain accurate forms and records during fuel operations to meet requirements as outlined in the concept of operations and commander's intent per the references. (1302.02.08d)

e. Given a tactical situation, a map, concept of operations, commander's intent, task organization of equipment and personnel, and references, identify personnel and equipment required to conduct fuel operations to meet requirements as outlined in the concept of operations and commander's intent per the references. (1302.02.08e)

OUTLINE:

1. BULK FUEL UNITS.

a. Bulk Fuel Company. The Engineer Support Battalion (ESB) of the Force Service Support Group (FSSG) has two Bulk Fuel Companies, with one currently in a cadre status.

(1) Mission. The mission of the Bulk Fuel Company is to provide general bulk fuel support to the MEF to include receipt, storage, distribution, and quality surveillance. When supporting MAGTF airfields, the Bulk Fuel Company is responsible for fuel distribution to the boundary of the airfield. It also provides coordination and control with the Marine Aircraft Wing (MAW) for transfer of bulk fuel to the airfields.

(2) Table of Organization. Each Bulk Fuel Company is organized with a company headquarters and four bulk fuel platoons. (Figure 1.)

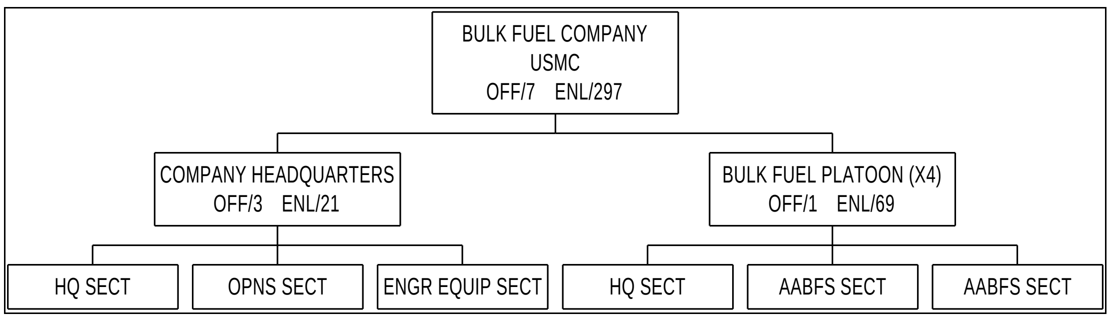


Figure 1.

(3) Equipment. To perform its mission, the Bulk Fuel Company has a robust array of bulk fuel equipment.

(a) 8 Amphibious Assault Fuel Systems (AAFSs).
(b) 60 SIXCON fuel tanks.
(c) 20 SIXCON fuel pump modules.
(d) 56 500-gallon collapsible fuel drums.
(e) 32 expedient refueler systems (ERS).

Additionally, to aid the ESB in the execution of its bulk fuel mission, the Motor Transport Battalion of the FSSG has transportation and distribution assets that include 85 SIXCON fuel tanks, 3 SIXCON fuel pump modules, and 20 M970 fuel tankers (5,000 gallon capacity each.)

b. Fuels Branch, Marine Wing Support Squadron. Within the MAW, fuel support is provided through the Marine Wing Support Squadrons (MWSSs) of the Marine Wing Support Group (MWSG). The MWSG in 2d and 3d MAW each has four MWSSs. Two squadrons are configured to provide fixed-wing support while the other two squadrons are configured to provide rotary-wing support. The MWSG in 1st MAW has two MWSSs; one is configured for fixed-wing support and one is configured for rotary-wing support. Each MWSS has a Fuels Branch within its Airfield Operations Division.

(1) Mission. The mission of the Fuels Branch is to provide refueling support of a designated Marine Aircraft Group (MAG) at two separate airfields simultaneously. Its responsibilities include receipt, storage,

distribution, and quality surveillance. Coordination and control of bulk fuel planning with the Marine Aircraft Wing (MAW) is the responsibility of the MAW G-4.

(2) Table of Organization. The Fuels Branch is organized with a branch headquarters and two fuels teams. (Figure 2.)

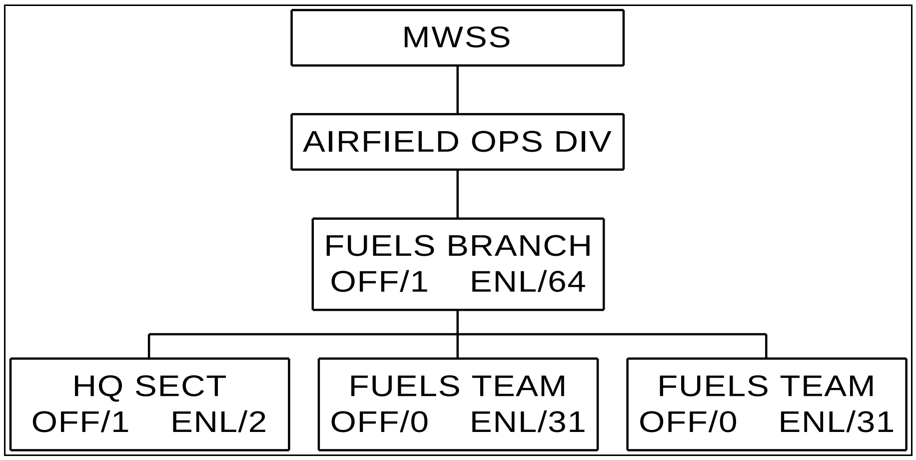


Figure 2.

(3) Equipment. To perform its mission, the Fuels Branch has the following equipment.

(a) Rotary-wing:

1 4 Tactical Airfield Fuel Distribution Systems (TAFDS.)
2 7 Helicopter Expedient Refueling Systems (HERS.)

(b) Fixed-wing:

1 6 TAFDS.
2 2 HERS.

(c) Both types of MWSSs have 10 M970 mobile refueler/defuelers.

c. Other units. Various other units may have as part of their mission the task of handling bulk fuel. Typically, this would be an engineer detachment as part of a combat service support element (CSSE) of a MAGTF, and would have task-organized equipment and personnel tailored to meet the specific requirements of the mission. The size of the unit could range from a small bulk fuel detachment taken from a MWSS to support a composite squadron (ACE) of a Marine Expeditionary Unit, to a large bulk fuel element tasked to support major theater operations as occurred during Operations Desert Shield / Desert Storm.

2. BULK FUEL EQUIPMENT.

a. Amphibious Assault Fuel System (AAFS). The AAFS is the largest of the tactical fuel systems (TFS.) Consisting of many self-contained units, the AAFS is used to receive, store, transfer, and dispense all types of fuel. The AAFS supplies bulk fuel to all elements of a MAGTF including distribution by hoseline to airfields. The system can receive fuel from offshore vessels, railcars, tank trucks, bulk storage tanks, pipeline/hoseline, and drums. Fuel is stored and can be transferred to another storage site or dispensed to individual containers, vehicles, tank trucks, and other fuel systems. (Figure 3.)

(1) Composition. Six assemblies make up the AAFS:

(a) Beach unloading assembly.
(b) Drum unloading assembly.
(c) Two booster station assemblies.
(d) Two adapting assemblies.
(e) Dispensing assembly.
(f) Five tank farm assemblies.

(g) Each AAFS has one beach unloading assembly used for receiving fuel during ship-to-shore operations. Two booster station assemblies in each AAFS are used when the distance between storage sites is greater than the pumping distance. The AAFS storage capacity comes from the five tank farms. One drum unloading assembly in each AAFS provides the capability to defuel 55-gallon drums. One dispensing assembly in each AAFS provides the capability to dispense fuel. The AAFS has two adapting assemblies to make the system compatible with commercial and other Services’ fuel systems. Versatility is an important part of the AAFS. It can be deployed as a whole or tailored to meet mission requirements. However, each AAFS may contain only one type of fuel.

(2) Capacity. The AAFS storage capacity is 600,000 gallons made up from its five tank farms. The AAFS has approximately 3.5 miles of 6-inch hose and uses ten 600-gallons per minute (gpm) pumps. Using quick-connect, cam-lock fittings, the AAFS can be assembled without tools and is compatible with the other Marine Corps TFSs.

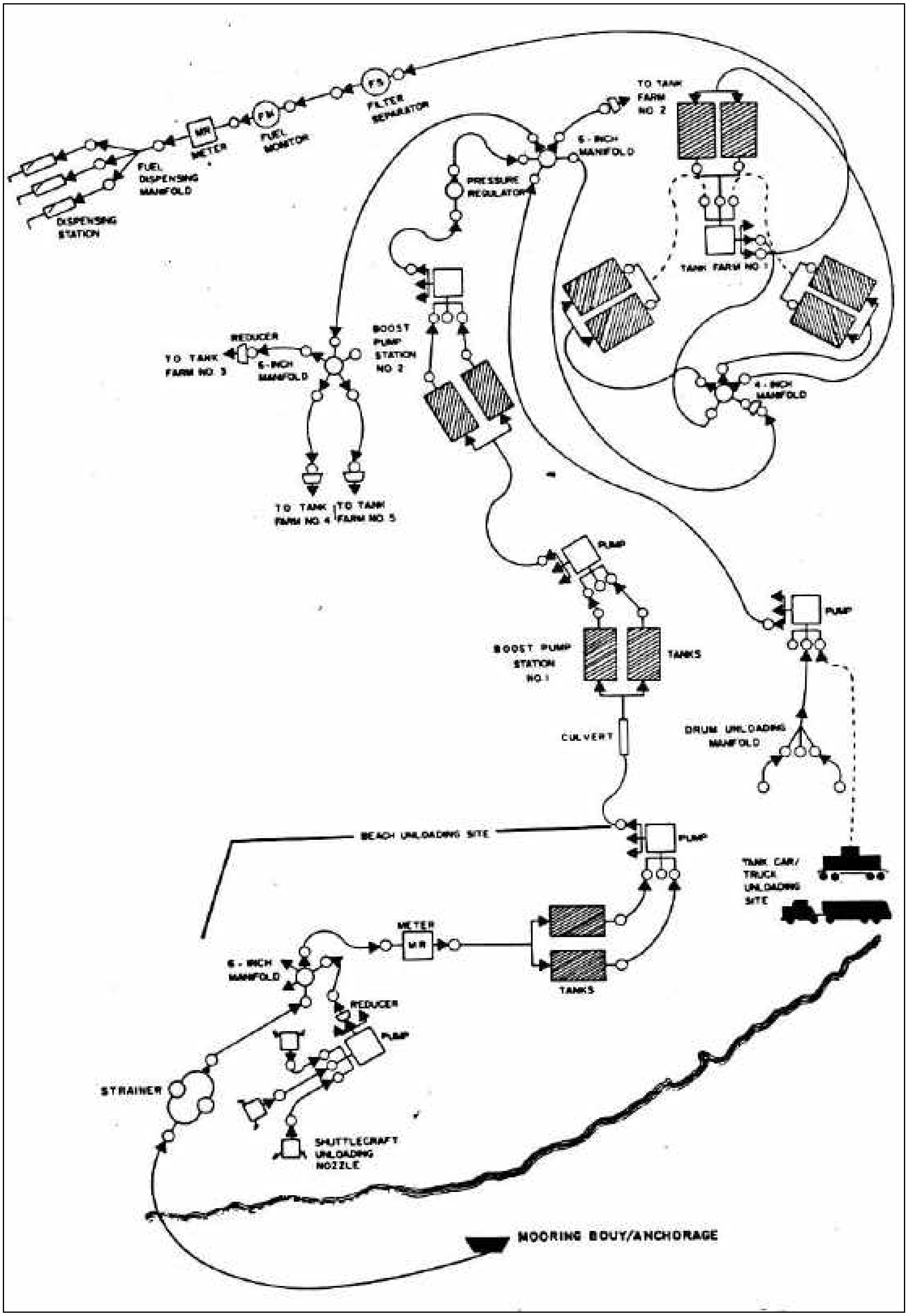


Figure 3. Amphibious Assault Fuel System

b. Tactical Airfield Fuel Distribution System (TAFDS). Similar in design to the AAFS tank farm, the TAFDS is used to provide bulk fuel support at Marine Corps expeditionary airfields. The primary purpose of the TAFDS is aircraft refueling. This system is air-transportable and versatile and can be quickly assembled. Compatible with other Marine Corps TFSs, the TAFDS can receive fuel from almost any source with the appropriate adapters. Fifty-five gallon drums may be defueled using the drum unloading portion of the TAFDS. This system is used for receiving, storing, transferring, and dispensing aviation fuel in support of expeditionary airfields. With the single fuel on the battlefield concept, the TAFDS will be able to supply aviation and ground fuel for airfields. (Figure 4.)

(1) Composition. The TAFDS is made up of the following items.

(a) Six 20,000-gallon collapsible tanks
(b) Three pumps of either 350 or 600 gpm.
(c) Filter separators.
(d) Fuel quality monitors.

(2) Capacity. With its designed pumping rate and equipment to set up 12 dispensing points, the TAFDS has a multi-plane fueling capability. The TAFDS may also be used to replenish tank vehicles. Filtration of the fuel to meet naval air requirements is accomplished using the filter separators and fuel quality monitors. The TAFDS is used for hot or cold refueling.

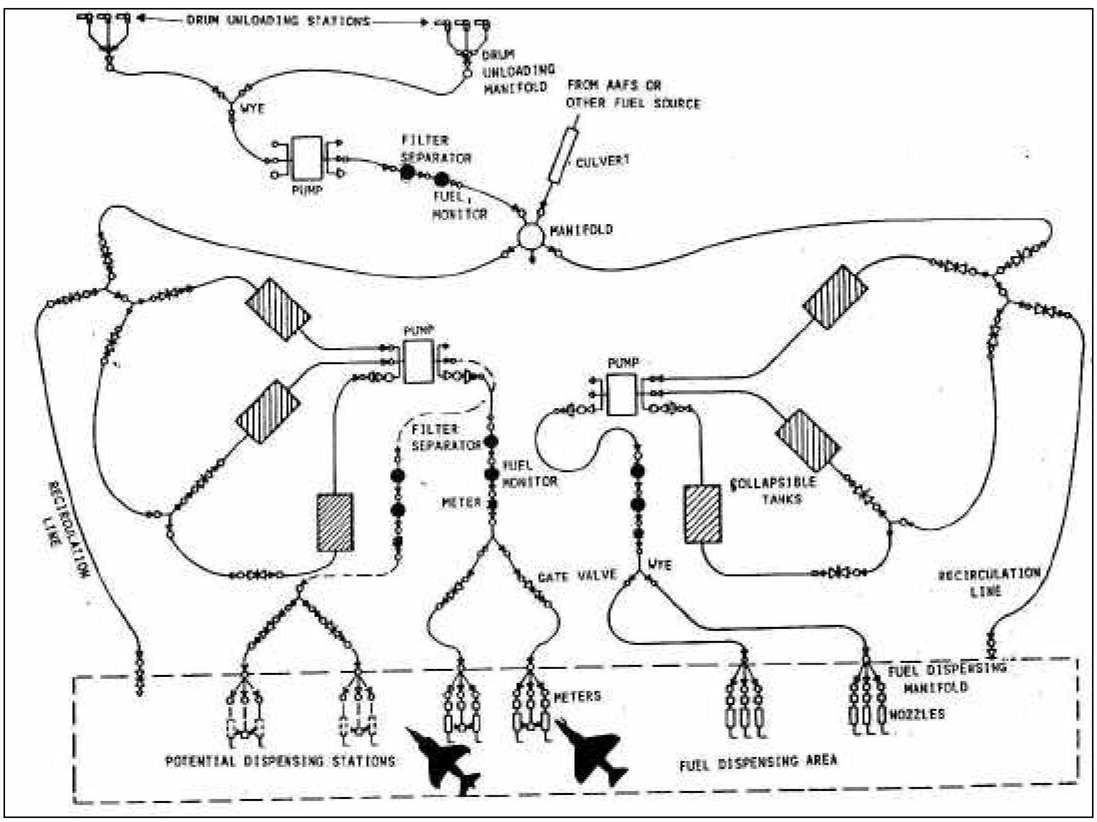


Figure 4. Tactical Airfield Fuel Distribution System

c. Helicopter Expedient Refueling System (HERS). The HERS is designed for support of helicopter operations in advanced areas and remote sites. It is normally used at forward arming and refueling points (FARPs.) Versatility, easily transportable, and a quick setup are the key elements of the HERS. (Figure 5.)

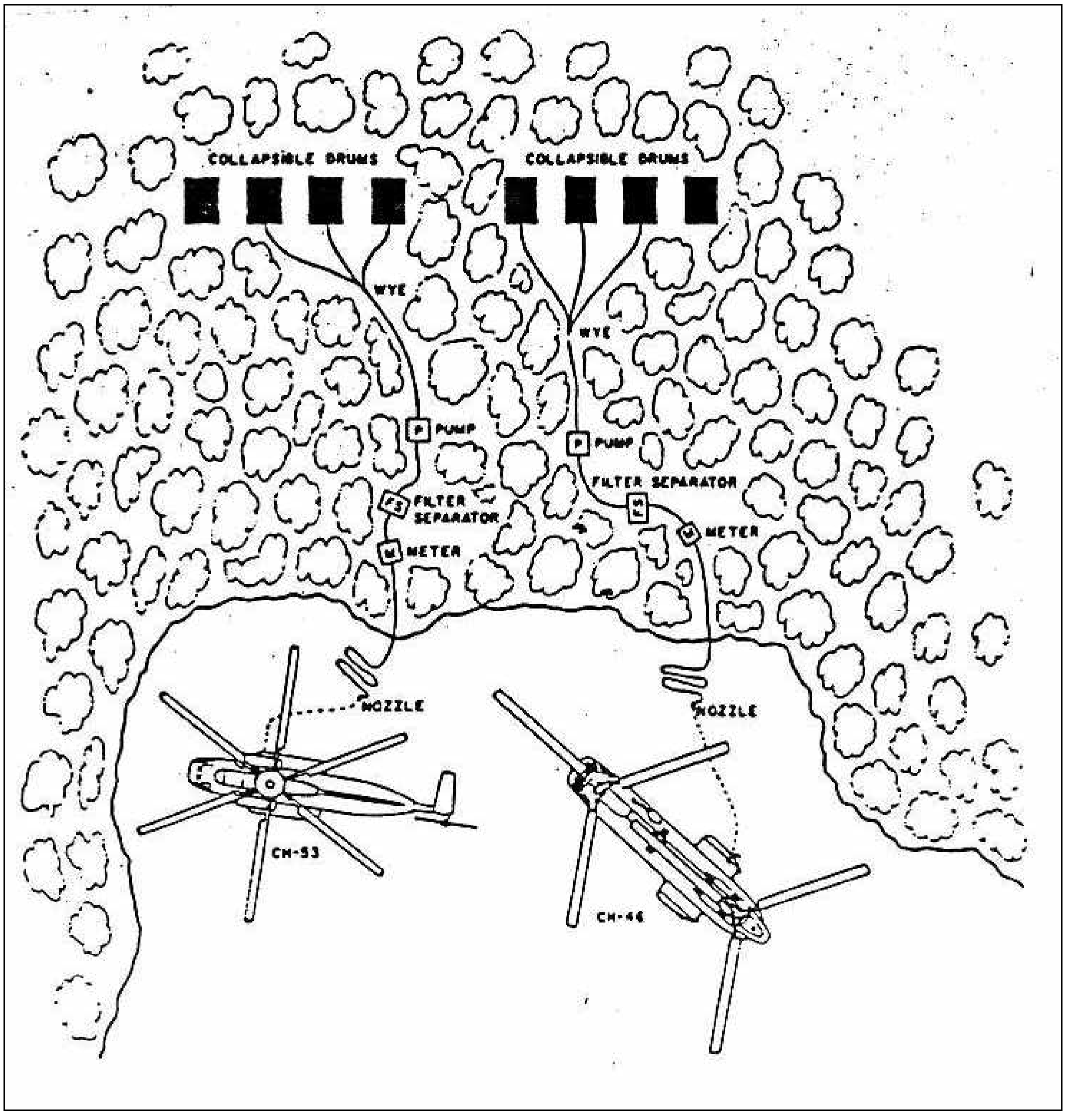


Figure 5. HERS in a Forward Arming and Refueling Point.

(1) Composition. The HERS is made up of the following items.

(a) Eighteen 500-gallon collapsible drums.
(b) Two 100 or 125 gpm pumps.
(c) Fuel meters.
(d) Dry-break couplings.
(e) Fuel filter separators.
(f) 2-inch hoses and dispensing equipment to build refueling points.

(2) Capacity. The HERS has a maximum capacity of 9,000 gallons and enough components to provide four refueling points. It may be deployed as a whole or in part to meet operational requirements. Due to the limited storage capacity and the flow rate of the HERS (100 gpm), the HERS is best used for attack and utility helicopters to increase their range.

d. Expedient Refueling System (ERS). The ERS was designed for support of ground vehicles in advanced positions. Easily transportable and highly mobile are key elements of the ERS.

(1) Components. The ERS usually consists of the 500-gallon collapsible fuel drum and either a 100 or 125 gpm pump with hoses and fittings for two refueling points.

(2) Capacity. The capacity of the ERS is limited to 500 gallons.

(3) The ERS does not have filtration equipment and should not be used for aircraft refueling or defueling.

e. SIXCON Fuel System. The Marine Corps Liquid Storage, Transporting, and Dispensing System is commonly called a SIXCON. Certain SIXCONs are used to store, transport, and dispense fuel. A SIXCON is transportable by air or ground. Components of the fuel SIXCON system are a fuel pump module and five fuel tank modules. The modules form a fuel distribution source that can be transported as a unit or individually. (Figure 6.)

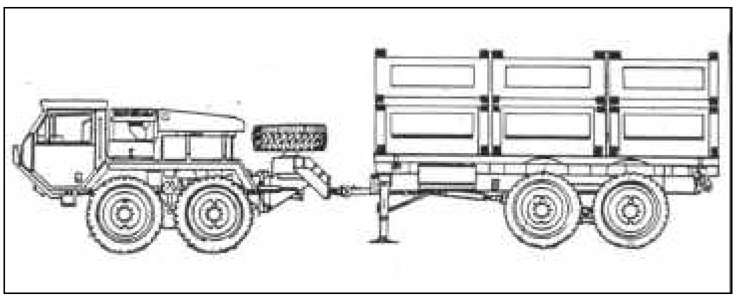


Figure 6. LVS SIXCON configuration.

(1) Components. The SIXCON fuel pump module consists of a 125 gpm pump, a 100 gpm filter separator, a 100 gpm fuel quality monitor, a meter assembly, and a hose reel. The SIXCON tank module is made of stainless steel and has a capacity of 900 gallons. (Figure 7.) Each type of module is encased in a standard 8 foot by 8 foot by 4 foot ISO frame. SIXCON modules are connected using special horizontal and vertical ISO connectors, and fuel is transferred via 2-inch hoses with dry-break connectors.

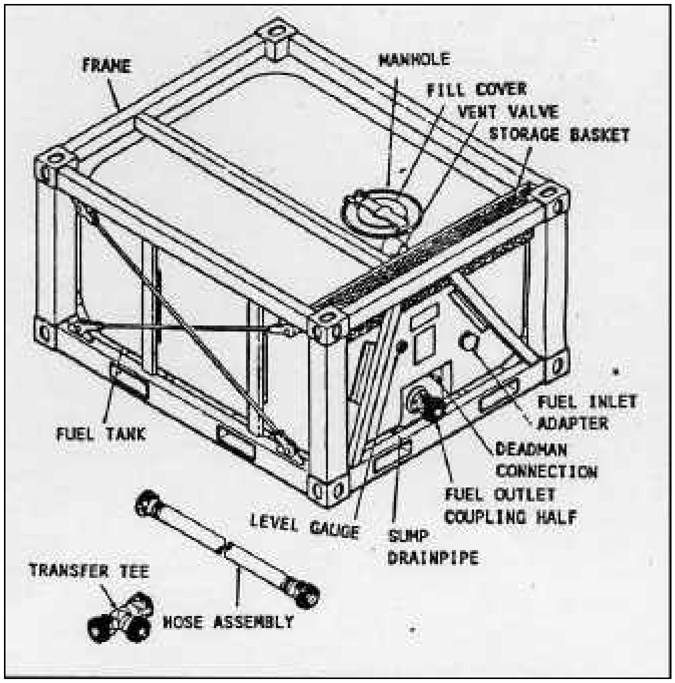


Figure 7. Fuel SIXCON Module.

(2) Capacity. In the 5-and-1 configuration, mounted to a Logistical Vehicle System (LVS) for transport, the SIXCON fuel system can provide up to 4,500 gallons. Typically, however, for safety reasons the system is usually mounted in a 2-and-1 configuration, which provides 1,800 gallons.

(3) SIXCON modules are typically assigned to general combat service support organizations for minimal fuel handling at the operator level.

f. M970 Mobile Refueler. The M970 5,000-gallon mobile refueler provides aircraft refueling/defueling and over-the-road transportation of bulk fuel. It is assigned to both the aviation combat element (ACE) and the combat service support element (CSSE). Within the ACE, the M970 is organic to the MWSS and is used primarily to refuel aircraft. Within the CSSE, the M970 is organic to the motor transport battalion and is assigned to CSSE motor transport and/or engineer detachments. The CSSE uses the M970 to transport bulk fuel between storage sites or directly to the customer.

g. USMC Aircraft Bulk Fuel Handling Systems. Air-to-air refueling or transfer of bulk aviation fuel can both extend the range of aircraft and provide a means for the MAGTF to “air deliver” jet fuel to forward operating sites. Under the single fuel on the battlefield concept, aviation fuel can also be used to fuel ground vehicles.

(1) USMC KC-130R Transport. The primary mission of the KC-130R Transport is air-to-air refueling. It can air-to-air refuel both tactical Marine fixed-wing aircraft and CH-53 helicopters. The KC-130R can also land at distant airfields carrying up to 10,000 gallons of aviation fuel.

(2) Tactical Bulk Fuel Distribution System (TBFDS). The TBFDS consists of fuel range extension tanks, hoses, and couplings that can be loaded internally on a CH-53 helicopter. This system can be used to extend

the operating range of the helicopter or allow for helicopter delivery of fuel to distant forward areas. The TBFDS configured CH-53 can refuel aircraft at FARPs or refuel diesel engine ground vehicles and equipment.

h. Tactical Petroleum Laboratory – Medium. The TPLM provides the essential testing components integrated into an ISO container (8 foot by 8 foot by 20 foot exterior dimensions) to monitor the critical physical and chemical characteristics of aviation and ground fuels. JP-4, JP-5, JP-8, diesel, and their commercial grade equivalents can be tested for composition and quality against minimum standards as specified in MIL-HDBK-200, *Quality Surveillance Handbook for Fuel, Lubricants, and Related products.*

3. BULK FUEL OPERATIONS. Conducting bulk fuel operations requires significant planning and detailed coordination. Mission analysis will lead to the development of a detailed fuel operations plan, and require critical selection of fuel operations sites and fuel operations site preparation.

a. Develop a Fuel Operations Plan. To develop a comprehensive fuel operations plan, start by asking the following questions:

(1) What are the types and quantities of fuel which will be required during the exercise or operation?

(2) How and when will we receive the fuel? (Who is/are the supplier(s)?

(3) Where and when will the fuel be required? (Who is/are the customer(s)?

(4) What equipment and personnel are available to accomplish the bulk fuel mission? (Are they adequate? How does the planner request augmentation, if necessary?)

(5) With the information available, the planner must then decide how to get the fuel from the supply point to the dispensing point using the major systems and personnel and support equipment available. The plan must make the most efficient use of pipeline, ground vehicle, and aviation distribution means available. Usually the concept of operations will dictate the amount of fuel held as a reserve, and storage means must take this into consideration.

(6) Fuel planners often take advantage of automated systems when planning total amounts required for future operations. For specific exercises or operations, however, a thorough analysis of the equipment densities and consumption rates is required. Otherwise, excess stocks will be maintained, and unnecessary effort and embarkation space will be wasted on unneeded bulk fuel capability. Consumption will be affected by (1) combat intensity, (2) hours of operation, (3) mission, (4) quantity of equipment, and (5) theater of operation.

(7) In addition to total amounts required, one factor to be considered during fuels planning is the concept of Time Phasing. Time phased requirements begin with a determination of daily requirements in the objective area, and include (1) daily demand, (2) storage capacity, (3) throughput capability, and (4) time delay from initial request until delivery.

(8) The nature of the fuel operation will dictate the equipment used, as well as the type of layout utilized. Typical layouts could include an AAFS tank farm assembly, a TAFDS tank farm, or be as simple as a FARP.

(9) The equipment and support required to conduct the operation will dictate the personnel requirement. Bulk fuel specialists (MOS 1390, Fuels Officer, and MOS 1391, Bulk Fuels Specialist) will be required to operate and maintain the fuel systems. Horizontal construction requirements will mean engineer equipment operators and mechanics (MOSs 1345 and 1341). If the distribution plan calls for significant ground vehicle use, motor transport Marines (MOS 3533, heavy motor transport vehicle operators; MOS 3534, refueler operators; and MOS 3521, motor transport mechanics) will be necessary.

b. <u>Select required fuel operations sites</u>.

(1) <u>Methods</u>. Fuel operations sites must meet minimum requirements. As when planning any operation, the planner should conduct a physical reconnaissance of each proposed fuel operations site if time and circumstances permit. At a minimum, conduct a thorough map reconnaissance.

(2) <u>Planning factors</u>. Consider the following factors when selecting fuel operations sites.

(a) <u>Distance</u>. The most efficient way to move any resource from receipt to issue points is in a straight line; minimize bypasses and turns if possible.

(b) <u>Traffickability</u>. If any portion of the distribution or transfer plan is via ground vehicle means, ensure the most improved and reliable routes are used.

(c) <u>Slope</u>. Pumps and booster assemblies are limited in the slope they can effectively navigate; conduct a thorough contour analysis of the pipeline routes.

(d) <u>Enemy threat</u>. Fuel farms provide a significant high-value target for enemy fires. Terrain and existing foliage should be used to provide cover and concealment to the maximum extent practical.

(e) <u>Landing areas</u>. If receiving fuel from offshore sources, position shore-based bulk fuel systems of the landing force to avoid conflicts with landing lanes.

(f) <u>Space</u>. Major TFSs require extensive space; plan for at least 120 feet from centerline to centerline of fuel tanks over 10,000 gallon capacity. If cleared areas are not available, significant woodcutting, leveling, or rubble removal may be required, and time and assets should be allotted for these tasks during the installation phase of the fuel operation.

(g) <u>Environmental considerations</u>. Prevailing winds should dictate the placement of a fuel farm downwind from other activities. The goal is to reduce the impact of tank farm fires. Another example of an environmental consideration would be excessive rains; the ground should be improved to provide adequate drainage, both for tank berms and for traffic routes within and around the tank farm.

c. Site preparation. Depending on the size of the fuel operations site and the expected duration of the operation, a fuel site may require significant preparation or improvement. A Forward Arming and Refueling Point, for instance, may be setup for only a few hours, while a AAFS tank farm may be in place for several months.

(1) Horizontal construction. Engineer equipment such as dozers, scooploaders (TRAMs), scrapers, and graders, may be required to improve roads and access routes. Beach improvement and drainage improvement are often on-going tasks.

(2) Tank farm construction. There are three basic styles of tank farm layout, each with its advantages and disadvantages.

(a) Radial. The radial style lays out the tanks arranged like the spokes of a wagon wheel. It uses less area and less hose, but is more concentrated and one or more tanks will be directly downwind of a fire from an upwind tank.

(b) Linear. The linear style places all tanks in a line abreast, with the perpendicular axis in line with the prevailing winds. It maximizes dispersion, but requires the most hose. Additionally, it requires more firefighting assets. It may be the most practical layout for an expeditionary airfield.

(c) Parallel. Two parallel rows of tanks are a compromise of the linear and radial styles. The parallel style minimizes the hose required and makes best use of firefighting assets, while providing minimum risk of downwind fire hazards. (Figure 8.)

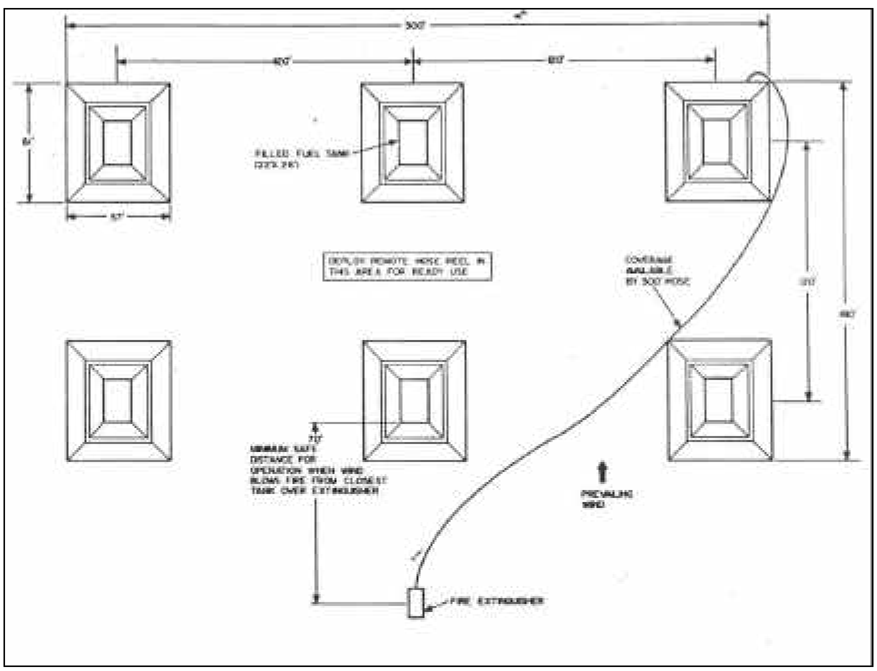


Figure 8. AAFS 20,000 Gallon Tank Farm

D. Berm construction is equipment intensive. Regardless of the size tank utilized in the fuel farm (10,000 gallon, 20,000 gallon, or 50,000 gallon), each berm should:

(1) Generally conform to the shape of the tank when filled to 100% of its capacity.

(2) Be built to contain 150 to 200% of the tank’s capacity, in case of rupture.

(3) Provide some protection from direct fire weapons.

(4) Have a sump incorporated into its construction in order to drain rainwater or spilled fuel.

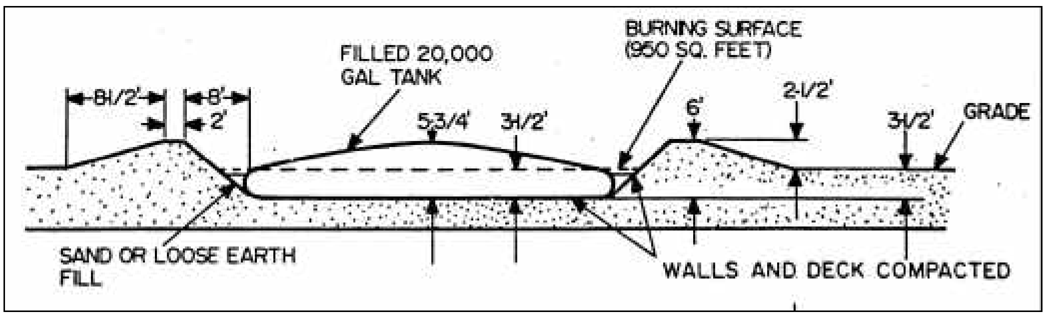


Figure 9. Cross-section view of berm construction.

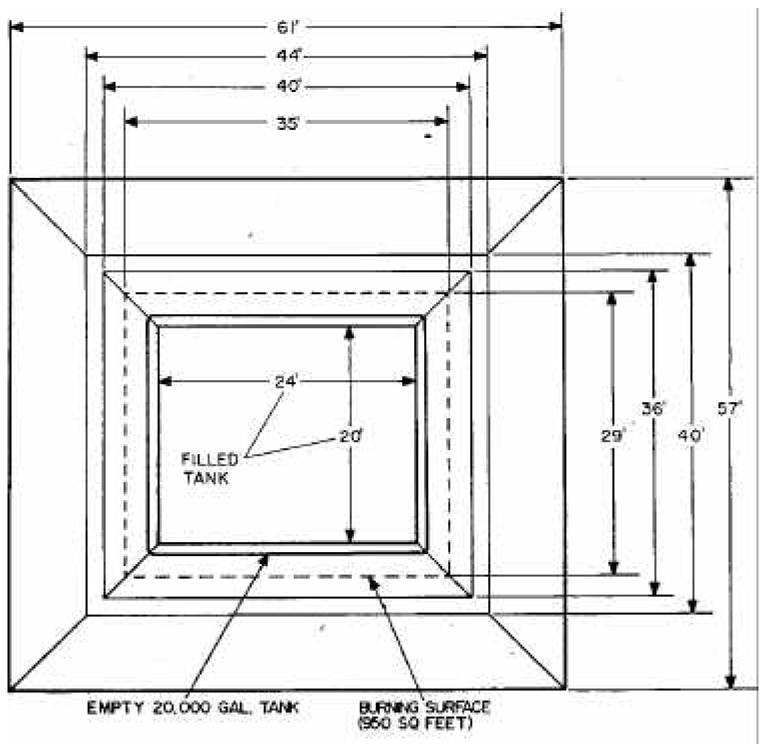


Figure 10. Overhead view of berm construction.

(5) As a rule of thumb, tanks should be spaced at least 120 feet apart (centerline to centerline) to minimize the spread of fuel fires and allow access to resupply or firefighting vehicles.

4. <u>BULK FUEL OPERATIONS FORMS AND REPORTS</u>. Accountability is the key to successful fuel operations. It is the function of higher headquarters to solicit using units' input when developing projected fuel requirements, while it is the bulk fuel specialists' job to maintain proper records and provide accurate and timely reports to higher headquarters on the status of fuel issues.

a. <u>Forms</u>. Bulk fuel units which are part of Combat Service Support Elements are responsible for generating forms for fuel resupply requests; there are no formats dictated by doctrine. These can be part of the unit's Standard Operating Procedures (Unit SOP) for logistical requests, and should identify all elements of information required to meet the requesting unit's needs. Bulk fuel units should also maintain SOPs which dictate forms used for tracking the receipt, issue, and storage of all types of fuels handled, noting at the operator level the unit and individual to whom the fuel was issued.

b. <u>Reports</u>. Reports will usually be submitted by Major Subordinate Commands (MSCs) via naval message traffic. Templates of standard report formats can be found in MCWP 4-25.5, Bulk Liquids Operations, and MCRP 3-17B, Engineer Forms and Reports. These reports are not usually originated by the bulk fuel unit; submission of required information (such as types of fuels, amounts received, amounts on hand, and amounts issued) will usually be submitted to the unit's Operations or Logistics Staff Section (S-3 or S-4) via unit SOP. Figure 11 shows one example format.

SUP PT No. 2 DATE 06 APR

REPORT PERIOD 051800 APR TO 061800 APR

UNIT

ITEM	RECEIPTS (GALLONS)	ISSUES (GALLONS)	ON HAND (GALLONS)
MOGAS	210,000	235,000	200,000
AVGAS	8,000	7,000	5,000
DIESEL	125,000	105,000	75,000
JP-4	6,000	5,000	4,500

<u>Figure 11. Sample Status Report.</u>

REFERENCES:

FM 10-67	Petroleum Supply in Theater of Operations
MCWP 3-17	MAGTF Engineer Operations
MCWP 4-25.5	Bulk Liquids Operations
FMFM 4	Combat Service Support
FMFM 4-1	Combat Service Support Operations
MCRP 3-17B	Engineer Forms and Reports

UNITED STATES MARINE CORPS

COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C-O1A26
13 June 00
(98 POI)

STUDENT HANDOUT

CANTONMENT PLANNING

TERMINAL LEARNING OBJECTIVE(S):

1. Given a tactical situation, a map, a cantonment site, the size of the unit to occupy a cantonment, with the aid of references, plan cantonment layout so the plan will result in a site which will meet the requirements of the unit per the references. (1302.1.37)

ENABLING LEARNING OBJECTIVE(S):

1. Given a tactical situation, a map, and the size of the unit to occupy a cantonment area, with the aid of references, determine the facilities required per the references. (1302.1.37a)

2. Given a tactical situation, a map, and size of the unit to occupy a cantonment area, with the aid of references plan safety precautions per the references. (1302.1.37b)

OUTLINE:

1. GENERAL:

a. Definition: Cantonment Area is a group of **temporary structures** used for the quartering of personnel/troops and the supplies/equipment required to maintain them.

b. Temporary in nature: However, the use of existing structures are used whenever possible or in conjunction with the cantonment facility.

c. Mission Responsibility:

(1) Engineer Support Battalion: Provide engineer support of a deliberate nature to the MAGTF...Cantonment planning is a **primary task** given to the ESB as they have a **heavy capability** in performing that task.

(2) Combat Engineer Battalion: Provide close combat engineer support to the MAGTF...Cantonment planning is a **secondary task** given to the CEB as they have a **light capability** in performing that task.

(3) Engineer Operations Division (MWSS): Provide essential engineer support to the Marine Aircraft Wing...Cantonment planning is a

primary task given to the MWSS Engineers as they have a **medium capability** in performing that task.

(4) Naval Construction Forces: Provide civil engineer support to the MAGTF...Cantonment planning is a **primary task** given to the "Seabees" as they have a **heavy capability** in performing that task.

d. When to Plan and Construct Cantonment Sites:

(1) Contingency Operations in War: On a doctrinal basis, during the planning and execution of general engineering missions in the theater of operations when the situation requires a sustainment of military forces, the mission of facility construction and repair will be tasked to engineer units. For example: During Operation Desert Shield, the construction of cantonment facilities and other base camp structures were given top priority for the sustainment of U.S. and Allied forces in the area of operations.

(2) Peacetime Contingency Operations: PCO's are usually politically sensitive military activities normally characterized by short-term, rapid projection or employment of forces in conditions short of war. Recent examples of cantonment missions are the housing of Haitian Refugees at Guantanamo Bay, Cuba which was tasked to 8th Engineer Support Battalion, and disaster relief operations conducted by the 15th Marine Expeditionary Unit after a hurricane hit Bangladesh. PCOs are often undertaken in crisis-avoidance or crisis-management situations requiring the use of military elements to enforce or support diplomatic initiatives. This distinguishes PCO's from contingency operations in war, which are often accomplished for purely military objectives. Cantonment missions may be tasked during the following PCO's:

(a) Disaster Relief.

(b) Non-combatant Evacuation Operations (NEOs).

(c) Show of Force.

(d) Peacekeeping Forces.

2. EXECUTION CONSIDERATIONS FOR CANTONMENT PLANNING:

a. Advance Party:

(1) Reconnaissance/Site Survey.

(2) Host Nation Support(HNS).

(3) Establish liaison.

(4) Main body preparation.

(5) Specific Missions

b. Reconnaissance/Site Survey: Obtains information by visual or other detection methods about the activities and resources of a potential enemy and secures data about meteorological, hydrographic or geographic characteristics of a particular/future area of operations. Fundamentals for the reconnaissance/site survey of a cantonment area include:

(1) Analyze reconnaissance/site survey objectives.

(2) Report information accurately.

(3) Avoid decisive engagements.

(4) Develop situation rapidly:

(a) Deploy.

(b) Reconnoiter.

(c) Regress.

(5) Debrief/Report.

c. Site Survey Team: The Site Survey Team should consist of, but is not limited to, the following:

(1) Commanding Officer or Executive Officer.

(2) Construction Officer/Chief.

(3) Drafter/Surveyor.

(4) Heavy Equipment Chief.

(5) Utilities Representative(s).

(6) Fuel Representative.

d. Civil Affairs Coordination:

(1) U.S. Governmental Agencies: U.S. Government Agencies coordinate activities between the U.S. forces operating in the area and the Host Nation. It is the executive committee of the U.S. Embassy which coordinates Host Nation contracts for U.S. armed forces and heads the U.S. team in that country. Depending on the situation and mission, the team often consist of representatives from:

(a) Department of Defense to include: Defense Attaché, individual service attaches, and the chief of the Security Assistance Organization (SAO).

(b) U.S. Agency for International Development.

(c) U.S. Information Agency.

(d) Drug Enforcement Agency.

(2) Translator Teams: Procured through the S-2/G-2.

(3) U.S. Contractors and U.S. Companies.

3. LOGISTICAL CONSIDERATIONS FOR CANTONMENT PLANNING:

a. Host Nation Support (HNS): It is the policy of the U.S. to use maximum HNS. Coordination and application of host nation agreements will be a major requirement in the planning of contingency operations. HNS will be vital after the 30 day self-sustaining requirement of the MAGTF and is often required earlier to conduct subsequent operations ashore. HNS may be furnished in the following areas:

(1) Local Government Agency Support: In many countries, government agencies build, operate, and maintain large facilities. Included are:

(a) Railways.

(b) Waterways.

(c) Utilities.

(d) Radio and television broadcasting networks.

By agreement with the host nation, these agencies provide their services and operate their systems in support of U.S. requirements.

(2) Civilian Contractors: Contractor service may be host country, third party country, or U.S. contractor using host nation or third party personnel. Civilian contractors provide supplies and services such as transportation, labor, and construction.

(3) Civilian Employees: Local populace can provide support to U.S. units and activities. Their skill levels range from low-skilled laborers to more highly-skilled equipment operators and mechanics.

(4) Host Nation Military Units (Combined Force Operations): The host nation may provide military or paramilitary reserve units to support U.S. requirements.

(a) Military police.

(b) Motor Transport units.

(c) Maintenance units.

(5) Host Nation Facilities: Hospitals, fire departments, schools, offices, garages, and truck terminals are facilities that can be used by U.S. forces for medical support, emergency relief, headquarters, and other support services.

(6) Supplies and Equipment: Supplies and equipment for missions may be more readily acquired locally than through the U.S. logistics system.

(a) Class III (Petroleum, Oils, and Lubricants {POL})

(b) Class IV (Construction materials).

(c) Class IX (Repair Parts).

(7) Maps and Charts: Providing detailed local survey control, maps and terrain data sources.

b. <u>Electrical/Power Requirements</u>:

(1) Sources of Power:

(a) Local HNS: Tap into local power sources.

(b) Organic generator support.

(c) Other equipment (i.e., batteries, vehicles, ships, etc.)

(2) High Users of Power:

(a) Water/Hygiene Equipment.

1 ROWPUs.

2 Laundry units.

3 Shower points.

(b) COC, Administrative Centers, and Communications.

1 Computers.

2 Coffee pots.

3 Lights.

4 Copier machines.

5 Hot plates.

6 Radios and communications equipment.

(c) Company/Billeting areas.

1 Computers.

2 Coffee pots.

3 Hot plates.

4 Lighting (3 bulbs per tent as a planning factor).

(d) Maintenance and Construction Areas.

1 Computers.

2 Lighting and Flood Light systems.

3 Electrical maintenance and construction equipment.

a Saws.

b Drills.

c Grinders.

(e) Mess facilities.

1 Refrigeration.

2 Mess preparation equipment.

3 Lighting.

(f) BAS.

<u>1</u> Refrigeration.

<u>2</u> Computers.

<u>3</u> Lighting.

<u>4</u> Heaters/hot plates.

(g) Class IV lots, ASPs, and Fuel Points.

<u>1</u> Floodlight systems.

<u>2</u> Computers.

c. <u>Waste Removal/Environmental Concerns</u>:

(1) Sewage and Hygiene:

(a) Locate heads down wind within base camp. (Convenient yet removed).

(b) Urination tubes with soakage pits. Locate next to heads.

(c) Burn waste in downwind location.

(d) Hand washing points around heads and chowhalls.

(e) Soakage pits for hygiene/laundry waste water or recyclable waste water.

(f) Utilize wash/shaving racks around billeting areas.

(2) Messing Facilities:

(a) Garbage pits: 4' X 4' X 4' pit <u>per</u> 100 men <u>per</u> day.

(b) Paper/wood (combustibles): Burn barrels or incline incinerators. Designate pits outside base camp perimeter.

(3) Hazardous Waste:

(a) POL: Collection, storage, and removal.

(b) Batteries: Collection, storage, and removal.

(4) Utility Locator: HNS..."Call before you dig!"

(5) Pest Control: HNS, traps, poisons, familiarize camp personnel.

d. <u>Chow and Water</u>:

(1) Control/Issue points:

(a) Access in and out.

(b) Controlled access.

(2) Storage: Possibilities of contamination?

(a) Away from hazardous wastes, POL, hygiene, and head facilities.

(b) Emergency reserve.

(c) Waste water collection points for recycling purposes.

(3) Consumption: Based on "Days of Supply" (DOS):

(a) MREs: #Meals/Man/Day **X** Total men **=** 1 DOS MREs.

(b) H20: #Gal Drink/Man/Day **+** #Gal Hyg/Man/Day **X** Total Men **=** 1 DOS WATER.

e. Equipment and Equipment Maintenance:

(1) POL: Consumption based on DOS.

(2) Class IX (repair parts): Consumption based on 30 DOS of high usage parts.

f. Facilities:

(1) Existing: Maximize the use of existing structures.

(2) Constructed: Develop in progressive stages (always continue improvements).

g. Construction/Building Materials (Class IV): Based on "Bill Of Materials" (BOM).

(1) Control and Security.

(2) Storage.

h. Social/Religious Services: Differs from area to area.

4. PLANNING STEPS: There are three elements when performing an analysis. They are: (1) List the facts, (2) State the significance of those facts, and (3) State the conclusion drawn from those facts.

a. Step 1: Issue Warning Order and begin planning by Analyzing METT-TSL.

(1) MISSION. Establishes the tasks of a contingency force, both specified & implied. It also establishes the area of operations, the time available for deployment, and the duration. **REMEMBER THE 5 Ws!**

(2) ENEMY. The level of conflict will depend upon the local enemy. U.S. forces must be prepared, immediately upon arrival, to conduct combat operations in the deployment area. Enemy forces could range from local guerillas and regional forces capable only of limited warfare, to larger well-equipped forces capable of conventional, and/or NBC warfare.

(3) TERRAIN & WEATHER. Topography, climate, and habitation in potential areas of deployment shape engineer force composition. Possible environments of U.S. strategic concern having a significant impact upon

military operations include mountains, jungles, deserts, winter in temperate zones and extreme northern regions, and urban terrain.

(4) TROOPS & FIRE SUPPORT AVAILABLE. Depending on operational commitments, personnel, supplies and equipment assets are often limited or unavailable for a given operation. Take a close look to see whom and what will be dedicated to the mission. Analyze the T/O and T/E requirements and review the unit's supporting the operation.

(5) TIME. Deployment of contingency forces may occur under circumstances of great urgency. It may be followed quickly by combat operations and in some cases even before a deployment is complete. **TIME ESTABLISHES PRIORITIES!**

(6) SPACE. Increased space requires increased time and logistics support.

(7) LOGISTICS. In contingency operations engineer forces rely on strategic airlift for rapid deployment and resupply, however, engineer equipment and supplies are heavy and bulky for aircraft. In contingency planning, pre-positioned engineer items should be considered (i.e., MPF, deployed MAGTFs, and HNS). Sea-lift of oversized equipment, follow-on engineer units and construction materials may be necessary.

b. Step 2: Identify Requests for Information (RFI's) and Assumptions that are critical to mission accomplishment. RFI's and Assumptions should be made aware to the S-2, S-3, and S-4.

c. Step 3: Create a construction schedule (Timeline 4.0 or Critical Path) of events to be accomplished. Adjust as required.

d. Step 4: Organize the planning and coordination with company and battalion staffs.

(1) PRE-DEPLOYMENT CHECKLISTS: The purpose in using pre-deployment checklists is to enhance the efficiency and effectiveness of preparations for a deploying unit. When preparation time is limited, pre-deployment checklists are essential to the OIC in preparing his/her Marines. Handout #1 contains a pre-deployment check list which covers the basic requirements.

e. Step 5: Design cantonment layout in accordance with the specifications given.

f. Step 6: Determine Class IV Bill Of Materials (BOM).

g. Step 7: Determine water/fuel requirements and create a water/fuel distribution plan.

h. Step 8: Determine electrical power and refrigeration requirements and create a power distribution plan.

i. Step 9: Analyze present Table of Organization (T/O) and Table of Equipment (T/E). Adjust T/O and T/E to meet the needs of the situation and mission whenever possible.

j. Step 10: Prioritize movement of personnel and equipment.

(1) Identify advance party personnel and equipment.

(2) Prioritize movement of main body personnel and equipment.

(3) Identify what can be moved by air and what must be moved by other means.

k. Step 11: Issue 5 paragraph order task organizing your Marines and equipment sections.

l. Step 12: Inspect and supervise all planning and preparation. Make corrections as required.

m. Step 13: Develop a retrograde plan.

n. Step 14: Execute.

Note: All steps involve direct coordination with battalion staff sections.

5. BASE CAMP LAYOUT:

a. Operational Areas and Facilities:

(1) Combat Operations Center (COC):

(a) Perimeter wire to control access.

(b) Sections: Briefing section, operations area, logistics section, communications area and any other staff areas designated by the commander.

(c) GP tents and bunkers depending on tactical situation.

(2) Staff and Administrative Areas:

(a) Tent #1 Administrative: Located next to the COC or in Rear Areas of Operations.

1 Personnel Officer (CAC).

2 S-1 Adjutant.

(b) Tent #2 Intelligence/Operations: Located next to the COC or in the COC.

1 S-2 Intelligence Officer.

2 S-3 Operations Officer.

(C) Tent #3 Logistics: Located next to the COC or in the COC.

1 S-4 Logistics Officer.

2 Maintenance Management Officer.

3 Ordnance Officer.

4 Supply Officer.

(3) Communications Area:

(a) Remote antennas away from the camp.

(b) Protection of communication wires in base camp.

1 Bury.

2 Overhead.

3 Clearly marked.

(c) 50 ft. safety zones around high-voltage areas.

(4) Billeting Areas:

(a) Housing: GP tents, strong backs, sea huts.

1 Normally 12 men per tent for planning factors.

2 Spacing: 8ft = side to side.
30ft = end to end .

3 Fire lanes and fire extinguishers.

4 Separate units and services.

5 Separate by demographics: Sex, age, family, religion.

(b) Unit supply/storage areas.

(c) Unit vehicle parking/equipment storage.

(5) Support Equipment Areas:

(a) Motor Transport.

1 Maintenance bays/tents away from main roadway.

2 Maintenance bays/tents away from dusty conditions.

3 Built on flat area.

4 M.T. parking lot away from main camp area.

5 Billeting located within MT area.

(b) Heavy Equipment.

1 Loading/unloading ramp.

2 Maintenance bays/tents away from main roadway.

3 Maintenance bays/tents away from dusty conditions.

4 Built on flat area.

5 Equipment parking lot away from main camp area.

6 Billeting located within H.E. area.

(c) Equipment/vehicle wash rack.

1 Close to the maintenance area.

2 Must provide good drainage.

3 Possibility of recycling water.

4 Water calculated as "other", not as part of "DOS".

(6) Sanitary and Support Facilities:

(a) Heads.

1 1 seat per 15 personnel as a planning factor.

2 Separate facilities for male and female.

3 Locate urinal tubes next to heads.

4 120 ft. from billeting areas.

5 300 ft. from messing areas.

6 Designate waste burning areas downwind of camp.

(b) Showers.

1 Area must provide good drainage.

2 120 ft. from billeting areas.

3 300 ft. from messing areas.

4 Separate running hours or separate facilities for male and female.

5 Changing tent along with shower facility.

6 Possibilities of recycling water?

7 Include gallons per man for showers when calculating DOS of water.

(c) Laundry.

1 Area must provide good drainage.

2 120 ft. from billeting areas.

3 300 ft. from messing areas.

4 Run specific hours for each unit.

5 Wash racks vs laundry machines?

6 Possibilities of recycling water?

7 Include gallons per man for laundry when calculating DOS of water.

(d) Battalion Aid Station (BAS).

1 Centrally located within the camp.

2 Corpsman billeting area next to BAS.

3 Bed spaces for patients in separate tent than from surgical/examination tent.

4 Constructed as a strongback or better.

5 Partitions within to allow for confidentiality.

(e) S-4 Lot/Supply Lot.

1 Located away from billeting and administrative areas.

2 Security fence and security lighting (dependent on tactical situation).

3 Located in dry, flat, open area.

4 Ease of access in and out.

5 Space for loading/unloading and operation of heavy equipment.

(f) Ammunition Supply Point (ASP).

1 1250 ft. from billeting and operational areas.

2 Provide security posts, perimeter fencing and security lighting (dependent on tactical situation).

3 Separate ammunition by different classes and DODIC's (Department of Defense Identification Codes).

4 Berm all ammunition bunkers.

5 Located in dry, flat, open area.

6 Ease of access in and out.

7 Space for loading/unloading and operation of heavy equipment.

(g) Water Point.

1 Close to source; away from waste discharge.

2 Berm all storage bags within storage area.

3 Use ROWPU and generators in pairs.

4 Maintenance lanes to move and access equipment.

5 Protect water lines from traffic.

6 Effects of extreme temperatures on equipment?

7 Entrance and exits for ease of refilling.

8 Refilling of distribution points and water bulls?

9 Positioned away from hazardous materials.

(h) Fuel Farm/Point.

1 Away from billeting areas.

2 Downhill from cantonment site.

3 Berm and separate storage bags.

4 Firefighting crews.

5 Away from water sources and water storage areas.

6 Distribution.

a Entrance and exits for ease of refilling storage containers and vehicles.

b Distribution points: Located in close proximity to high usage equipment.

c Pump or gravity fed?

d Responsible from high water mark inland.

(i) Power/Electrical Point(s).

1 Consolidate generators whenever the tactical situation permits.

a Offers safety.

b Provides ease of security.

c Provides control over equipment.

d Ease of maintenance.

2 Provide protection to power lines.

a Bury electrical wires.

b Mark location of electrical wires with marking stakes.

c Overhead clearance should be at least 18 ft. over roadways.

d Consolidate electrical wires in trenches before burying.

3 Tap into local power when the situation permits.

4 Safety.

a Ensure HNS electricity runs the same voltage as you.

b Inspect for unauthorized taps into powerlines.

c Inspect for overloaded circuits.

d Don't leave hot wires exposed to weather elements.

e Provide a 50 ft. security perimeter around high-voltage areas and generators.

(7) Dining Facility:

(a) Located in central part of camp.

(b) Separate chow hours for each unit.

(c) Consolidated or separate chow facilities?

(d) Covered mess tent.

(e) Pest control measures.

(f) Hand washing areas.

(g) Mess tent should be a multi-purpose facility.

1 Mess area.

2 Chapel for religious services.

3 Movie/recreational area.

4 Meeting area.

5 Location for informational boards.

6 Exchange complex.

b. Safety Considerations:

(1) Analyze the area of operations with respect to safety.

(a) Climate.

1 Potential for hot and cold weather injuries.

2 Adjustments to equipment as weather changes.

(b) Terrain, Vegetation, Wildlife.

(c) Environment (highly populated, rural, remote, or other).

(d) Operational Safety.

1 Ground guides.

2 Operator hours per man per day.

3 Supervisors on job sight.

4 Night operations (NVGs).

5 Operating in shifts.

6 Use of "A" drivers/operators.

(e) Local traffic rules and driving habits.

(f) Anticipated missions.

(2) Risk Management Approach:

(a) Identify potential hazards.

(b) Assess the hazards.

(c) Develop control measures to reduce or eliminate hazards.

(d) Implement and supervise control measures.

(e) Evaluate and update as necessary.

(3) Conduct safety training and safety stand-downs.

(4) Quality control and quality assurance.

REFERENCES:

FM 5-102 Counter Mobility
FM 5-103 Survivability
FM 5-104 General Engineering
FM 5-430-00-1 Volume 1 Planning and Design of Roads, Airbases, and Heliports in theater of operations
FM 5-430-00-2 Volume 2 Planning and Design of Roads, Airbases, and Heliports in theater of operations
MCRP 3-17A Engineer Field Data
MCWP 3-17 MAGTF Engineer Operations
MCWP 1-25.5 Bulk Liquid Operations

ASSIGNMENT:

1. **SCOPE**

a. Given a tactical situation on a map under a simulated Peacetime Contingency Operation, coordinate, design and task organize personnel and equipment to construct a Cantonment Layout in accordance with the scenario provided.

b. Select and prepare a military brief on how you will accomplish your mission in accordance with the guidelines set forth in the scenario provided.

2. **GENERAL**: The cantonment planning assignment is worth 300 points total. The assignment will be broken down into three separate graded areas worth 100 points each. Part I will walk the student through the step planning process, while Part II teaches the student how to task organize personnel and equipment to accomplish the assigned mission through the writing of a five paragraph order. Part III will be the final phase of the assignment, where the student will brief a panel representing the higher headquarters commanding officer and his staff. Class will be broken down into working groups consisting of 3-4 students.

3. **SPECIFIC**:

a. **PART I**: Write out the cantonment planning steps 1-10 and step 13. It is worth a total of 100 points and will be graded in accordance with the grading sheet provided with the scenario. Part I will be handed to the instructor prior to the brief.

b. **PART II**: Write out step 11 (writing the five paragraph order) task organizing personnel, equipment and attachments to accomplish the assigned mission. The student must remember that they are playing the role of the engineer detachment commander who is tasking his/her platoon commanders and attachments. Part II is worth a total of 100 points and will be graded in accordance with the grading sheet provided with the scenario. Part II will be handed in to the instructor prior to the brief.

c. **PART III**: Select and give a military brief on how you will accomplish your mission. The brief must be prepared to be given to staff members identified in your scenario. Each group will have 25 minutes to brief and all members of the group must speak during the brief. A briefing packet should be prepared for each member of the panel present representing the higher headquarters. The packet should contain only that information essential for the panel to know and should enhance the information covered during the brief. The use of visual aids and overheads is highly encouraged and should be arranged through the instructor. Part III is worth a total of 100 points and will be graded in accordance with the grading sheet provided with the scenario.

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26 Jun 00
(98 POI)

STUDENT HANDOUT

STANDARD BRIDGING

PURPOSE: The purpose of this period of instruction is to give you the knowledge and skills necessary to select the type of bridge to satisfy a particular gap and load class requirement, you will also compute the amount of bridge required to span the gap, either wet or dry, and the palletization and logistical requirements to move the bridge to the site. You will also be taught the components and construction procedures of the MGB.

LEARNING OBJECTIVE(S):

1. **TERMINAL LEARNING OBJECTIVE**(S):

a. Given a tactical situation, a gap and the load requirements, with the aid of references, design a Medium Girder Bridge in accordance with FM 5-34, FM 5-466, TM 08676A-10/1-1. (1302.1.17)

b. Given a site requiring a standard bridge supervise the erection of a standard bridge in accordance with FM 5-34, FM 5-446, TM 08676A-10/1-1. (1302.1.23)

2. **ENABLING LEARNING OBJECTIVE**(S):

a. Given a gap and load requirements, determine the configuration of Medium Girder Bridge needed to bridge the gap in accordance with TM 08676A-10/1-1, FM 5-34. (1302.1.17a)

b. Given a gap and the configuration of a Medium Girder Bridge, plan the layout of the crossing site in accordance with FM 5-34, FM 5-446, TM 08676A-10/1-1. (1302.1.17b)

c. Given a gap and the configuration of a Medium Girder Bridge, determine the support required to bridge the gap in accordance with FM 5-34, RFM 5-446, TM 08676A-10/1-1. (1302.1.17c)

d. Given a design for a Standard and a site layout, describe the construction sequence for a Standard in accordance with FM 5-34, FM 5-446 and TM 08676A-10/1-1. (1302.1.23a)

e. Given a mission to bridge a gap, determine the equipment required in accordance with FM 5-34, FM 5-446 and TM 08676A-10/1-1. (1302.1.23b)

f. Given a mission to bridge a gap, determine the quality control required in accordance with FM 5-34, FM 5-446 and TM 08676A-10/1-1. (1302.1.23c)

OUTLINE

1. MEDIUM GRIDER BRIDGE

a. **SAFETY PRECAUTIONS**:

*****WARNING WARNING*****

(1) MGB cannot be used when bridging requirements exceed the capabilities given in table 1-1 of TM 08676A-10/1-1.

(2) Death or Severe Injury to personnel and damage to equipment may result if personnel fail to observe safety precautions.

(3) Never throw tools or MGB components, injury to personnel, or damage to tools and components will occur which can cause accidents.

(4) All members of a working party must be fully aware of what actions are to take place prior to start action.

(5) Death or Injury to personnel will occur if extreme caution is not used when connecting bays. Use correct lifting techniques and make sure of secure footing. DO NOT put fingers or hands into pinholes or between components being moved or connected.

(6) Always use the access holes in the side of the Landing Roller Pedestal (LRP) to operate the jack, keep hands and feet clear of the LRP base when operating the jack.

(7) DO NOT use any type of metal object to drive pins or shoot bolts, if a pin has to be driven, use rubber nylon faced hammer or a block of wood.

(8) Death or Injury to personnel will occur if carrying bars are used to boom the bridge. Carrying bars can forcefully strike/crush personnel if the bridge were to run out of control into the gap.

(9) Death or personal injury can result if the bridge is launched or delaunched by hand. Launching/delaunching by hand can result in personnel loosing control and the bridge crashing into the gap. When a bridge is to be launched or delaunched, a vehicle must be used at all times.

(10) Personnel must be down off the bridge and out of the interior during booming, launching and delaunching.

(11) Never raise or lower one end of the bridge unless the other end is fixed on locked rollers, on the ground or secured to vehicle (when on capsule or front roller beams).

(12) Exposure to hydraulic oil under pressure is hazardous. Exercise appropriate safeguards when working with the 15 ton and 20 ton jacks.

(13) Do not perform maintenance on the equipment while traffic is on the bridge.

(14) When using compressed air, wear safety goggles or glasses and ensure air blast is not directed toward another person.

(15) Welding of steel MGB components can be done at Direct Support Maintenance level. Welding aluminum MGB components requires special skills, equipment and safety procedures to prevent the risk of explosion and ensure

structurally safe repair. Therefore welding of aluminum MGB components will only be done at depot maintenance.

b. **CHARACTERISTICS**: The Medium Girder Bridge (MGB) is a two girder bridge, with deck units fitted horizontally between the two longitudinal girders connected at each end with bankseat beams to form a 13'2" roadway width. Ramps connect at each end of the bridge to provide access, and curbs are added to the outer edge of the girders to mark the edges of the roadway. The weight bearing components are made of a fine magnesium, aluminum, zinc alloy and they are designed to handle 10,000 military load class (MLC) 70 crossings.

(1) The single story MGB provides class 70 bridging for gaps up to 29 feet (5 bays) and can be built to a maximum length of 12 bays. The four major components used in single story construction are, (1) Bankseat beams (2) Top panels (3) Deck units and (4) Ramp units.

(2) The double story MGB (without link reinforcement) provides class 70 bridging for gaps up to 95.5 feet (12 bays), can be built to a maximum length of 22 bays and is constructed using all of the seven major components.

(3) The double story bridge with Link Reinforcement will provide class 70 bridging for gaps up to 151.5 feet, (22 bays). The Link Reinforcement Set is comprised of Anchor assembly, Post tension assembly, Long and short links

(4) Bridge set capabilities: One medium girder bridge set will provide enough bridging components to build these bridge configurations and maintain a military load class of 70.

(a) (3) 5 bay single story bridges, or

(b) (1) 12 bay double story bridge, or

(c) (1) 13 bay double Story Bridge with link reinforcement.

Two sets of medium girder bridge will build;

(d) (7) 5 bay single story bridges, or

(e) (2) 12 bay double story bridge, or

(f) (1) 22 bay double story bridge with link reinforcement.

NOTE: ALL MGB ABBREVIATIONS ARE LOCATED IN THE STUDENT REFERENCE TEXT, FM 5-34, TM 08676A-10/1-1.

c. COMPONENT NOMENCLATURE: The Medium Girder Bridge is comprised of seven major components. Four are used in single story construction and all seven are used in double story construction. With every two sets of MGB, an erection set and link reinforcement set are issued. The following is a list of the seven major components in the MGB set:

(1) Bankseat Beam - 13' 3 1/2" long, 1' 9 3/8" wide, and 1’6" high, weight 570 lbs.

(2) Junction Panel - 5' 3/4" high, 3' 5 1/2" long on top, 2' 2 3/4" long on bottom, and 2' 1 1/2" wide, weight 478 lbs.

(3) End Taper Panel - 13' 2 5/8" long, 2' 4" wide, 1' 5 3/4" high, weight 600lbs.

(4) Top Panel - 6'4" long, 2' 1 3/8" wide, 1' 9 5/8" high, weight 385 lbs.

(5) Ramp Unit - (UK) or short ramp 10' 1 1/2" long, 1' 10" wide, 9 1/4" high, weight 264 lbs.(US) or long ramp 14' 1/2" long, 1' 10 3/8" wide, 1' high, weight 400 lbs.

(6) Deck Unit - 9' 1" long, 1' 5 1/4" wide, 6 7/8" high, weight 163 lbs.

(7) Bottom Panel - 6' 5" long, 2' 3" wide, 3' 7 3/8" high, weight 435 lbs.

(8) Anchor assembly LR - 10' 9 1/2" long, 2' 3 5/8" wide, 11 3/16" high, weight 362 lbs.

(9) Post tensioning assembly LR - 9' 4" long, 2' 3 3/4" wide, 2' 10 1/16" high, weight 657 lbs.

(10) Long reinforcing link - 12' 3 1/2" long, 1' 2 1/16" wide, 3 15/16" high, weight 125 lbs.

(11) Short reinforcing link - 6' 3 1/2" long, 1' 2 1/16" wide, 3 15/16" high, weight 77.5 lbs.

(12) Curbs:

(13) PINS: There are four types of pins that are commonly used in the construction of the Medium Girder Bridge.

(a)
used for:

(b)
used for:

(c)
used for:

(d)
used four

d. **CONNECTING COMPONENTS**:

(1) The bankseat beam, junction panel, and top panels all connect the same. Each have a dowel with a hole in it for the shoot bolt to go through, and each have a socket for the dowels to fit into. Align the dowels with the receiving socket and slide them together. Once the compression faces contact each other lift the shoot bolt and turn it into place this locks the components together. Now insert a panel pin into the lower jaws of the components and insert a safety clip through the pin on the inside end of the panel pin.

(2) The bottom panel connects by sliding the upper jaws under the panel pin of the top panel, when fully seated close the shoot bolts and this locks the components together. Then push down on the back end of the component to align the lower jaws into the previous panel, then slide a panel pin through the jaws and insert a safety clip through the pin on the inside end of the panel pin.

(3) The end taper panels do not have shoot bolts they simply pin into place with panel pins.

(4) Deck units fit into the deck spacers on the top panels, four per bay. These are not pinned in place either, they just set in place.

(5) Ramp units fit onto the outside edge of the bankseat beam in a tongue and grove fashion.

16. **CONSTRUCTION PROCEDURES**:

a. The first step in constructing an MGB is to organize your Marines into teams and ensure they understand their team responsibilities.

(1) Three crews:

(a) Right side crew: Responsible for setting up the front roller beam (FRB) and working the right side roller beam locks and jacks during construction, and to put in place all components that make up the right side of the bridge. The squad leader will need to designate one Marine as the Pin Marine. The pin Marine has two responsibilities first to lock the shoot bolts as components are put together second is to place pins where and when needed and ensure they have retention clips installed.

(b) Left side crew: Responsible for constructing the rear roller beam (RRB) and working the left side roller beam locks and jacks during construction, and to emplace all the components that make up the left side of the bridge. Again the Squad leader will appoint a pin Marine.

(c) Center crew: Responsible for setting up the Capsill roller beam (CRB) when constructing a link reinforced MGB. They are always responsible for installing the sway braces and launching nose components. Once the bridge has been launched and the Nose has landed on the far shore they will cross the bridge and put the Landing Roller Pedestal in position. When this is complete they will stay on the far shore and disassemble the Launching nose as directed by the Bridge master. They will also lower the far shore end of the bridge on the deck once the bridge is fully deployed. One Marine will also be designated as a pin Marine.

b. **Erect Building Frame**:

(1) Single Story Bridge:

(a) Roller Beam Location: The SS MGB requires only one Roller beam. It is placed .23 m in front of the F' peg when jack launching the bridge or .23 m behind the F' peg when push launching the bridge and is at 90 degree angle to the centerline and centered over the centerline.

(b) Roller Beam Components: The single story roller beam is construction using the single story Base Plate and fixed support. If height adjustments are required the will be made by placing Packing under the base plates.

(2) Double Story MGB:

(a) Roller Beam Location: The DS MGB requires the use of two roller beams. The Front Roller Beam (FRB) is placed three feet from the edge of the gap and is at 90-degree angle to the centerline and centered over the centerline. The Rear Roller Beam (RRB) is placed fifteen feet behind the FRB, squared to the FRB and centered over the centerline. The measurements from gap to FRB and FRB to RRB will be center to center measurements.

(b) Roller Beam Components: Both the FRB and RRB are constructed the same. Using a two Double Story Base Plate. An adjustable support will sit on each base plate, in between the two adjustable supports you place the Frame Cross girder which will space and maintain the distance between the adjustable supports. The Roller Beam is placed in the center of both adjustable supports. One jack seat is positioned in each Adj. Support.

(3) Double Story with Link Reinforcement MGB:

(a) Roller Beam location: This type of construction requires Three roller Beams. The first Roller beam is the Capsill Roller Beam (CRB) this is placed Nine feet from the edge of the gap at a 90-degree angle to the Centerline and centered on the centerline. The FRB is positioned thirty feet behind the CRB and is squared to the CRB. The RRB is placed fifteen feet behind the FRB and is squared to the FRB.

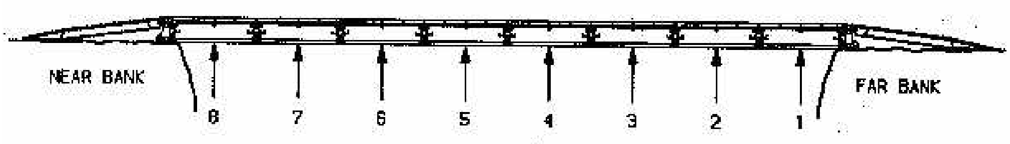
(b) Roller beam Components: The CRB is built using all the Components form the DS roller beams except in place of the normal Roller beam you will use a Capsill roller beam and two Rocking Rollers. The FRB and RRB remain the same as in Double Story construction.

c. **Construct End of Bridge and First Bay**

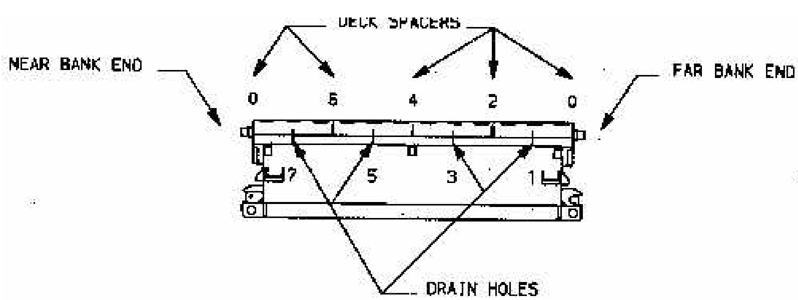
d. **PANEL POINT CODE AND CENTER OF GRAVITY**:

(1) Single story: The panel point code is a system of numbering used to identify the location of the center of gravity (CG) and the boom and launch points of the bridge. The numbering is based on the top panels, their deck spacers and drain holes. The top panel numbering starts at the top panel next to the far bank bankseat beam. The panel point numbering begins at the front of the top panel i.e. the end closest to the far bank.

(a) The top panels are the bays of bridge and are numbered 1,2,3 etc.

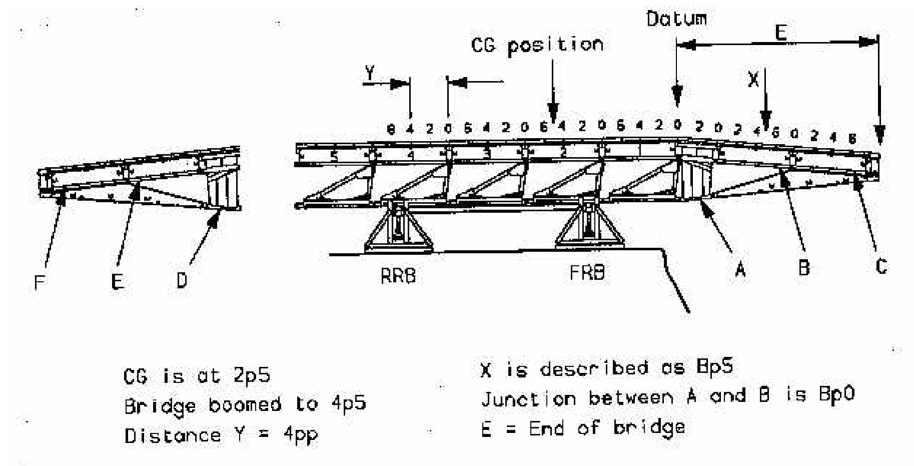


(b) The deck spacers are panel points 2,4 and 6. The deck spacer at the rear of the top panel becomes panel point 0 of the next bay.



(c) The drain holes that are halfway between each deck spacer, are panel points 1,3,5 and 7.

(2) Double story and link reinforced: The code system for double story and linked reinforced bridges is the same as described for single story bridges, except the junction and top panels at the ends of the bridge are lettered A, B and C (far bank end of bridge) and D, E and F (near bank end of bridge). The panel points run down the junction panel to the bankseat beam.

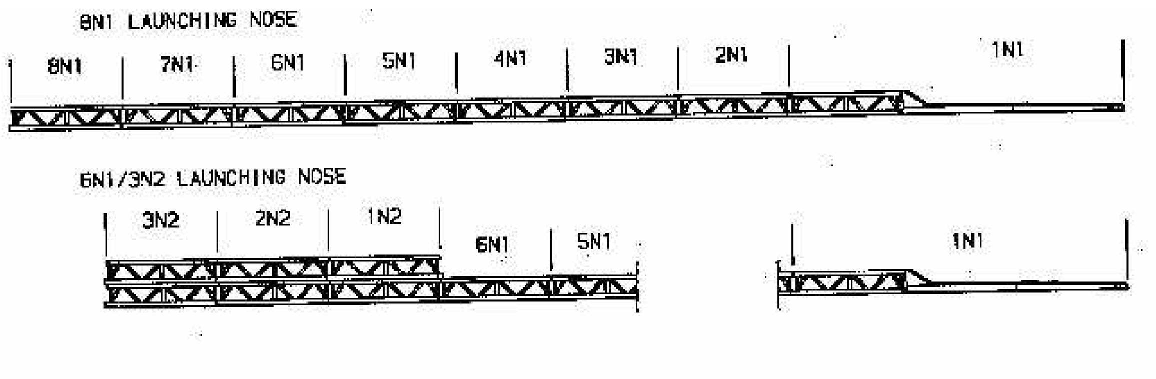


BOOMING: THIS IS THE MOVEMENT OF A SINGLE STORY (SS) OR DOUBLE STORY (DS) MGB TO A PREDETERMINED PANEL POSITION IN ACCORDANCE WITH THE TM 08676A-10/1-1. THIS MOVEMENT WILL ALWAYS TERMINATE AT A PANEL POSITION THAT ENSURES THAT THE CENTER OF GRAVITY IS BEHIND THE FRONT ROLLER BEAM. BOOMING POINTS ARE ALWAYS READ FROM THE REAR ROLLER BEAM FOR (DS) MGB'S.

e. **Assemble and install launch nose.**

f. **LAUNCHING NOSE CODE**: The launching nose is coded in the build procedures and building tables as follows.

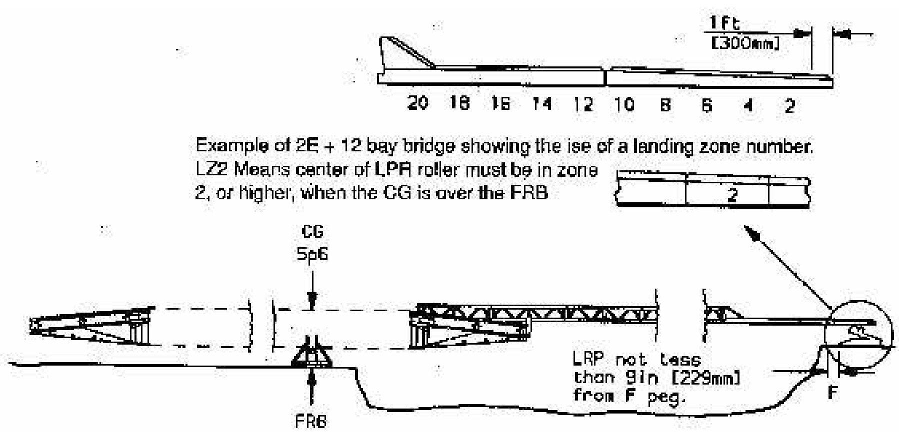
(1) The light launching nose front, light launching nose rear, and first launching nose heavy (total length 30 ft) are coded 1N1. The second launching nose heavy (10ft) is coded 2N1, the third 3N1 and so on. When the nose configuration changes to two tier (double story), the first double story is coded 1N2, the second 2N2 and the third 3N2.



g. **Assemble Bridge**

LAUNCHING: LAUNCHING OCCURS WHEN THE CENTER OF GRAVITY IS POSITIONED OVER OR FORWARD (GAP SIDE) OF THE FRONT ROLLER BEAM (OR CAPSULE ROLLER BEAM FOR LINKED BRIDGES). A VEHICLE WILL BE USED TO LAUNCH ALL (DS) MGB'S. ONCE THE CENTER OF GRAVITY PASSES OVER THE FRONT ROLLER BEAM (FRB) ALL FURTHER LAUNCH POSITIONS ARE READ OVER THE (FRB) (OR CAPSULE ROLLER BEAM FOR LINKED BRIDGES).

h. **LANDING ZONE NUMBER**: The building tables and build procedures include a landing zone number to ensure correct location of the landing roller pedestal under the launching nose. The light launching nose is considered as divided into twenty equal zones, each 1 ft (300 mm) in length. During building or delaunching, the landing roller pedestal must be positioned not less than 9 in (229 mm) from the F peg, and at this time the LZ number is checked for correct position over the landing roller pedestal roller. The landing zone Number should be that given or HIGHER. Never less than that given in the tables.



i. Set bridge on the deck:

(1) There are two methods that are used to set an MGB on the deck once the Near Shore Bankseat beam is .5 meters from the FRB, Using fifteen ton Jacks or using the Davit System.

(a) 15-Ton Jacks: Two jack posts are placed on the Near shore Bankseat Beam and pinned with a Launch nose pin. The double story base plates from the RRB are placed under the jack posts and jack supports are connected to the base plates. Using the 15-ton jack placed in the jack support and lifting on the jack post, lift the bridge until the FRB is able to be pulled from under the bridge. Once the FRB is removed put cribbage under the bridge and lower the bridge until it rests on the cribbage. Reset your jacks lift the bridge and remove Cribbing as allowable. continue this process until there is the required cribbage or the bridge is on the deck.

(b) Davit System: Used for all Bridges over 18 Bays in length

j. **RECONNAISANCE**: As in any construction project a thorough Reconnaissance must be accomplished prior to planning the task. The Medium Girder Bridge is no exception. To find a site that has selection factors desirable for construction of single or double story MGB's, the following factors must be considered during the reconnaissance and recorded on the Engineer Reconnaissance Report (DA Form 1711-R):

(1) Access routes,

(2) Approaches,

(3) Banks,

(4) Width of gap

(5) Size of construction site,

(6) Height of banks above flowing water,

(7) Wind speed,

(8) Vehicle access

(a) Access routes: There needs to be routes at each end of the bridge that tie into the main road network. these routes should not require too much maintenance or preparation for use.

(b) Approaches:

(1) Single and Double Story MGB. The approaches should be two lanes wide and straight for 160 ft at each end of the bridge. Slope of the approach should not exceed 1 in 10. Transverse (side to side) slope should not exceed 1 in 10 (up to 5 bay SS) or 1 in 20 (all other bridges) in the first 60 ft measured from the A' peg. see figures 3-1 and 3-2 in the student reference text.

(2) Linked reinforced MGB. The approaches should be two lanes wide and straight for 160 ft at each end of the bridge. Slope of the approach should not exceed 1 in 20. Transverse (side to side) slope should not exceed 1 in 20 in the first 60 ft measured from the' peg. see figure 3-2 in the student reference text.

(c) Banks:

(1) Single and Double Story MGB. The banks need to be firm and stable, and about equal height. The difference in bank height cannot exceed 10% of the bridge length, as the bridge is restricted to a 1 in 10 slope.

(2) Link reinforced MGB. The banks need to be firm and stable, and about equal height. The difference in bank height cannot exceed 5% of the bridge length, as the bridge is restricted to a 1 in 20 slope.

(3) Banks at the expected bearing points of bridge should have a soil bearing capacity (SBC) of 2 tons per square foot. Bridges constructed on soil less than 2 tons per square foot will require packing to cover a 3-foot area under the End Taper Panel, to spread the weight of the bridge. Watch settling during crossing of traffic, and increase packing if needed. Packing material required is 3" x 8" x 36" lumber, and the height of the packing will be the minimum necessary to keep the End Taper Panels from touching the bank. The following table lists the soil bearing capacity of various types of soil.

Table 1-2 Soil Bearing Capacity

SOIL DESCRIPTION	Bearing value's in tons per square foot
Hardpan overlaying rock	12
Very compact sandy gravel	10
Loose gravel and sandy gravel, compact sand and gravelly sand; very compact sand in organic silt soils.	6
Hard dry consolidated clay	5
Loose coarse to medium sand, medium compact fine sand	4
Compact sand clay	3
Loose fine sand, medium compact sand in organic silt soils	2
Firm or stiff clay	1.5*
Loose saturated sand-clay soils, medium sift clay	1*

*** Bridges constructed on this type of soil will require packing under ETP to spread weight of bridge. Watch settling during crossing of traffic, and increase packing if needed. Packing material required is 3" X 8" X 36" lumber. The height of packing will be the minimum necessary to keep ETP's from touching bank.**

(d) Width of the gap, angle of repose

(1) Select a bridge centerline. The length of the centerline (on each bank) will be determined by the R distance (construction space) required for the bridge that will be built. R distances range from 5.8m to 40.5m (this does not include the length of the launch vehicle or the push bar). Initially a centerline should extend approximately 5.0m on each bank. Once the AR Gap and the bridge length has been determined, the centerline will be extended to the correct R distance plus the length of the launch vehicle and the push bar. This will ensure that there is sufficient space on both banks for vehicle access or egress, and space on the near bank for construction of the bridge. There should be sufficient clear area extending out 3.0m on both sides of the centerline for it's full length to allow for bridge construction. Additional clearance on each side is required for pallet placement and off-loading.

(2) Determine the location of firm ground on the near and far banks.

(a) For the field method of determining firm ground, assume the AR of the soil to be at 45 degrees. The soil bearing capacity should be at least 2 tons per square foot. Capacities less than 2 tons will require placement of timber packing under the bridge.

(b) At the edge of firm ground on the near bank, place the A' peg. At the edge of firm ground on the far bank, place the A peg. **The distance between the two pegs is known as the AR Gap.** Keep in mind that the MGB must not bear on the ground for more than 2.1m (6' 11") for Single Story or 2.3m (7' 6"), for Double Story, regardless of it's length.

(c) If the actual slope of the bank does not exceed 45 degrees from the horizontal, place the A and A' pegs as shown in figure 3-5 below.

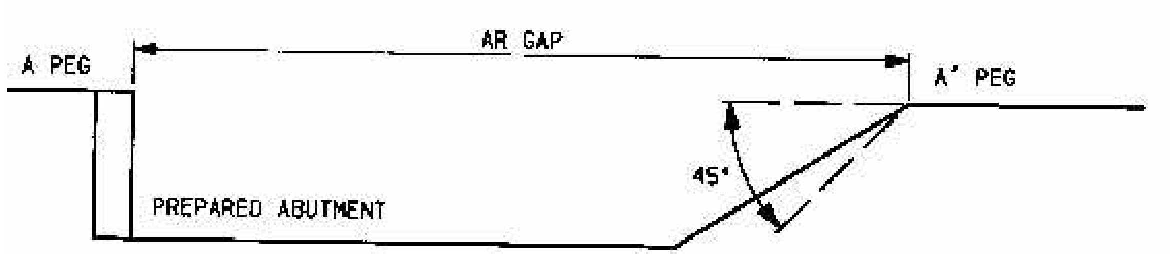
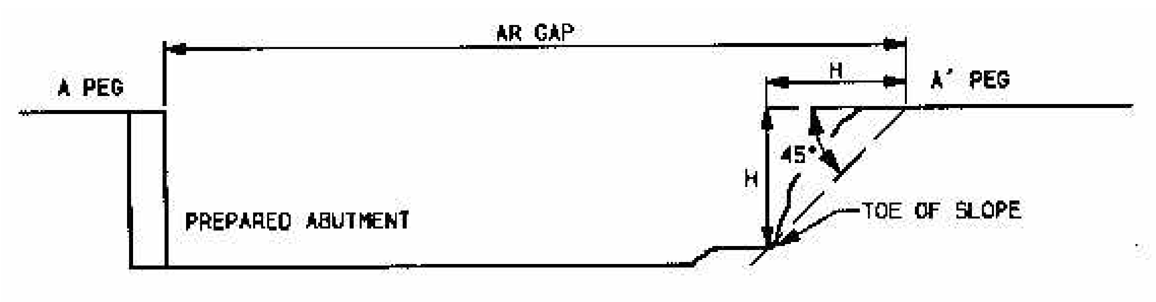


figure 3-5

(d) If the actual slope of the bank does exceed 45 degrees from the horizontal, place the A and A' pegs a distance H from the toe of the slope which is equal to the height of the bank measured from the toe of slope to the top of the gap, as shown in figure below.



NOTE

Use a bit of "common sense" when applying (c) and (d) to an actual gap.

(e) Now measure the distance from the edge of firm ground on the near bank (A' peg) to the edge of firm ground on the far bank (A peg) using one of the methods described earlier and listed below. This distance is again is known as the AR Gap.

* Inaccessible point method.

* Actual measurements of gap with tape.

* Through the use of surveying equipment.

(e) Size of construction site: there are two types of construction sites, a Normal site and Restricted site.

(1) Normal site - this site Provides construction space that allows fast and easy construction. Many times extensive engineer effort will be required to obtain enough space to be a normal site. The amount of time you have to construct the bridge is going to determine whether you improve the site or not. The paragraphs below describe normal (desired) assembly sites.

(a) Single Story Assembly Site: This assembly site is large enough for assembly of the bridge and wide enough for unloading and positioning of the loaded bridge pallets. The desired size of the assembly site for the longest single story bridge is 160 feet wide x 80 feet long. This length includes the R distance and truck with push bar attached. The width allows for ample construction space and good spacing of pallets from centerline. If needed, this area can be reduced considerably by bringing in pallet loads one at a time or as needed. The desired size of a site is shown in Figure 1 of the student reference text.

(b) Double Story and Double Story with Link Reinforcement Site: This assembly site is large enough for assembly of the bridge and wide enough for unloading and positioning of the loaded bridge pallets. The desired size of the assembly site for the longest Double Story and Double Story with Link Reinforcement is 160 feet wide x 160 feet long. This length includes the R distance and truck with push bar attached. The width allows for ample construction space and good spacing of pallets from centerline. If needed, this area can be reduced considerably by bringing in pallet loads one at a time or as needed. The desired size of a site is shown in Figure 1 of the student handout.

(2) Restricted site - this is where Construction space is reduced, requiring special construction procedures such as: longer launching nose, counterweights, and more frequent booming of the bridge.

(f) Height of banks above flowing water: If there is a stream to be crossed the stream velocity must be checked and recorded. This is done by placing a floating object at mid stream and timing its travel downstream over a known distance. To measure the stream velocity, use the below procedure:

(1) Mark a known distance on the shore A to B, throw a floating object usually a stick upstream from point A when it passes point A, time it until it passes point B. Take the time traveled between the points and divide this into the travel distance. Do this several times to get an average stream velocity.

$$\text{Velocity} = \frac{\text{AB Meters/Feet}}{\text{Time to Float From A to B (seconds)}}$$

(2) Single Story Bridges: The bank height above flowing water or obstructions in the gap, should be a minimum of 2 feet (0.6 m).

(3) Double Story Bridges (2E + 1 through 2E + 12 bay): The bank height above flowing water or obstructions in the gap should be a minimum of 2 feet (0.6 m).

(4) Link Reinforced Bridges (2E + 13 w/LRS through 2E + 22 w/LRS): The bank heights above flowing water or obstructions in the gap, should be a minimum of 12 feet (3.7 m). In addition, there must be no obstacle intruding above a plane inclined 20 degrees downward in the gap for a distance of 15 ft (4.6 m) from each AR peg as shown below.

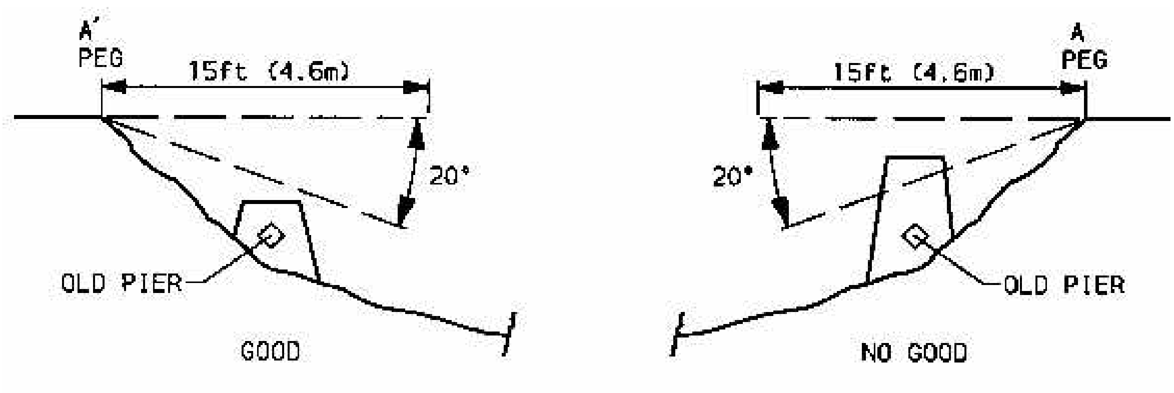


figure 3-4

NOTE: If the bank height is less than 12 feet (3.7) the rules in (a) and (b) below apply

(a) For bridges 2E + 14 bays and below there is no limit on bank height as long as the current does not exceed 5 fps (1.5 m/s) in which the reinforcing links can be immersed during launching and before tensioning.

(b) For bridges 2E + 15 bays and above there is no limit on bank height as long as the current does not exceed either:

1 3.5 fps (1.0 m/s) in which case the reinforcement can be immersed only during launching and before tensioning.

2 The current speed allowed as a vehicle crosses that particular bridge length is shown in table 3-4 below.

Table 3-4. Maximum Current Velocity vs. Bridge Length

2E + # of Bays w/lrs		22	21	20	19	18	17	16	15	14	13
Bridge Length	ft	163	175	151	145	139	133	127	121	115	109
	m	49.7	47.9	46	44.2	42.4	40.5	38.7	36.9	35.1	33.2
Current on immersed links	fps	1.64	1.64	3.08	3.67	3.93	4.29	6.95	7.67	8.43	8.43
	mps	0.5	0.5	0.94	1.12	1.2	1.31	2.12	2.34	2.57	2.57

(g) Wind Speed: The wind speed permitted for each bridge length is given below. The bridge will require lateral anchorage before crossing vehicles when wind speed exceeds those given. Lateral anchorage may be approach guys or pickets. Refer to TM for emplacement instructions. **The MGB can be launched in winds up to 30 MPH, if winds are over 30 MPH a vehicle is placed at a right angle to the bridge to keep it on line. pg 2-5 of TM08676A-10/1-1**

Table 3-5. Maximum Wind Speed vs. Bridge Length

2E + # of Bays		22	21	20	19	18	17	16	15	14	13
Bridge Length	ft	163	175	151	145	139	133	127	121	115	109
	m	49.7	47.9	46	44.2	42.4	40.5	38.7	36.9	35.1	33.2
Wind Speed	mph	50	50	95	120	120	120	120	120	120	120
	kmph	80.5	80.5	152.9	193.1	193.1	193.1	193.1	193.1	193.1	193.1

(h) Vehicle Access: An area large enough to allow trucks with trailers to completely turn around so they can back into the site, is required adjacent to the bridge site. A vehicle park, covered and concealed, should be located from .3 to 3.1 miles behind the bridge site, in which the trucks with trailers can be parked after off loading.

(i) Minimum Information needed:

(1) Location of the site - map coordinates or specific directions from the base camp to the site.

(2) Width of gap (AR gap) on bridge centerline. The unit must know the AR gap to plan the mission.

*** NOTE: IF ONLY THE MINIMUM INFORMATION IS PROVIDED, BRIDGE UNIT PERSONNEL WILL HAVE TO CONDUCT A RECONNAISSANCE TO OBTAIN ELEVATIONS, SITE CONDITIONS AND OTHER DESIGN RELATED INFORMATION.**

j. **BRIDGE LENGTH AND CLASS SELECTION**: Select the type of bridge to be built, based on AR Gap, MLC required, and resources available. This step is common to all lengths and configurations.

(1) Apply the AR Gap determined, to the AR Gap Range columns of Table 3-6 below, starting with section A, then B,C, and finally D.

Table 3-6. **Bridge Selection Tables**

SS 4-12 Bays Section A			DS 1-12 Bays Section B			DS 13-22 Bays wo/LRS Section C			DS 13-22 Bays w/LRS Section D		
AR GAP m*	MLC (T)	#of bays	AR GAP m*	MLC (T)	#of bays	AR GAP m*	MLC (T)	#of bays	AR GAP m*	MLC (T)	#of bays
3.7-7.1	70T	4	6.4-9.0	70	1	28.3-30.9	50	13	28.3-30.9	70	13
5.6-9.0	70	5	8.2-10.8	70	2	30.2-32.8	50	14	30.2-32.8	70	14
7.4-10.8	40	6	10.0-12.6	70	3	32.0-34.6	40	15	32.0-34.1	70	15
9.2-12.6	30	7	11.9-14.5	70	4	33.8-36.4	40	16	33.8-36.4	70	16
11.0-14.4	30	8	13.7-16.3	70	5	35.6-38.2	30	17	35.6-38.2	70	17
12.9-16.3	24	9	15.5-18.1	70	6	37.5-40.1	30	18	37.5-40.1	70	18
14.7-18.1	20	10	17.3-19.9	70	7	39.3-41.9	24	19	39.3-41.9	70	19
16.5-19.9	16	11	19.2-21.8	70	8	41.1-43.7	24	20	41.1-43.7	70	20
18.4-21.8	16	12	21.0-23.6	70	9	43.0-45.6	20	21	43.0-45.1	70	21
			22.8-25.4	70	10	44.8-47.4	16	22	44.8-46.2	70	22
			24.7-27.3	70	11						
			26.5-29.1	70	12						

(2) Read down the columns until an AR Gap Range is found that brackets the AR Gap measured.

(a) Read across to check MLC given against the MLC required by the testing authority. The MLC given in the chart must meet or exceed the MLC required.

(b) Consideration must be given at this time to the soil bearing capacity and the bearing requirements of the bridge.

1 If the AR Gap measured is closer to the lower part of the range, then the bridge will be approaching maximum bearing on the ground.

2 If the AR Gap measured is closer to the higher part of the range, then the bridge will be approaching minimum bearing on the ground.

(c) It is also necessary to consider the amount and type of traffic and weather, e.g., will the bridge take large numbers of heavy tracked vehicles
during 24 hours of rain.

(d) At this point, decide whether the first AR Gap range found provides the best bridge for the expected mission, or if you will have to go to the next higher AR Gap Range and bridge.

EXAMPLE:

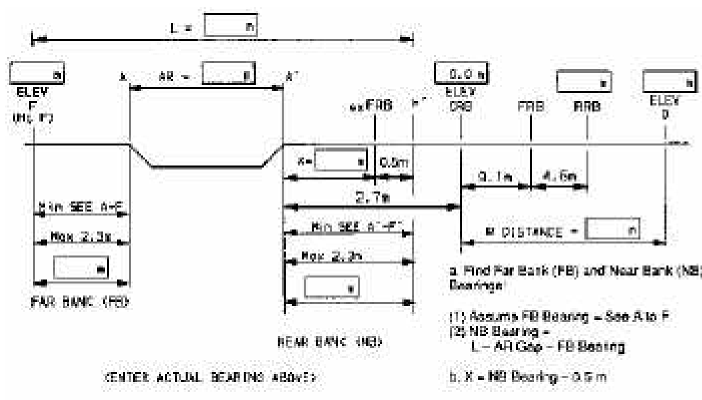
(1) AR Gap measured = 35.6m (117 ft.)
MLC required = 70

(2) Select bridge. First AR Gap range that brackets 35.6m is in section D, Double Story 13-22 bays with Link Reinforcement Set (LRS). The range is 33.8 - 36.4m, 16 bay bridge with MLC 70. The next range that also brackets 35.6m, is 35.6 - 38.2m, 17 bay bridge with MLC 70.

(a) At this point, look at the soil bearing capacity, traffic loads, and weather. If the soil bearing capacity is low and large numbers of heavy vehicles are to cross during inclement weather, it would be wise to build the 17 bay bridge. The 17 bay would have more bridge bearing on the ground (on each bank) than the 16 bay.

(b) If the soil bearing capacity is high, and the vehicle traffic is expected to be light and weather fair, the 16 bay bridge might be suitable, it would conserve resources. The 16 bay would have less bridge bearing on the ground (on each bank) than the 17 bay.

k. **CONSTRUCTION SITE LAYOUT**: Upon receiving the orders to construct a Medium Girder Bridge, the bridge commander NCOIC on site will receive a completed design proforma sheet. on this sheet it shows all the key construction points required to layout the bridge for construction. As shown in figure below



No of Bays	Minimums	
	A to F	A' to F'
13, 14, 18 thru 20	0.6 m	1.4 m
15	1.1 m	1.4 m
21	1.14 m	1.4 m
22	1.6 m	1.6 m

(1) F peg- Designates the location of the far bank end of bridge (outer edge of bankseat beam). Initially placed distance given as minimum bearing in Table 3-32 TM 08676A-10/1-1 and in the student handout, for the bridge being designed. The distance, between the A and F peg is the amount of bridge that will bear on the far bank, and is known as the far bank bearing.

(2) A peg- Edge of firm ground on the far bank.

(3) A' peg- Edge of firm ground on the near bank.

(4) AR Gap- The distance measured between the A and A' pegs. This is the actual gap to be spanned by your bridge.

(5) F' peg- Designates the location of the near bank end of bridge (outer edge of the bankseat beam). The distance (determined later), from A' to F' peg is the amount of bridge that will bear on the near bank, known as the near bank bearing. The minimum acceptable near bank bearing is 1.4m (4'6").

(6) Ex FRB peg- Designates the position of the extra Front Roller Beam (ex FRB). The distance from the A' peg to the center of the ex FRB can not be less than 0.9m (3'), and from the ex FRB to the F' peg can not be less than 0.5m (1'6"). The placement of the ex FRB is determined by using the length of the bridge (L), AR Gap, far bank bearing, and bridge overhang (0.5m /1'6") to obtain an X distance (from A' to CRB). Placement of the ex FRB in this manner will ensure minimum effort during the jack down operation.

(7) CRB peg- Designates the position of the capsill roller beam (CRB). The distance from the A' peg to the center of the CRB must be 2.7m (9').

(8) FRB peg- Designates the position of the front roller beam (FRB) (measured from center to center) must be 9.1m (30').

(9) RRB peg- Designates the location of the rear roller beam (RRB). It is placed 4.6m (15') from the FRB (measured center to center).

(10) O peg- Marks the clear distance behind the capsill roller beam required to construct the bridge. It is positioned by measuring the R distance, Table 3-31, column (e), behind the CRB peg.

l. **HOW TO COMPLETE PROFORMA**:

(1) Length of gap as determined above in section 8 and the TM 08676A-10/1-1 pg 3-16 para. 3-10a.

(2) Select a bridge as described above in section 9 and the TM 08676A-10/1-1 pg 3-17 para. 3-10b

(3) Read and note the bridge length and number of bays from table 3-31 columns (c) and (d) below and Table 1 of your proforma sheet.

(4) Read and note R Distance from column (e) of Table 3-31 below and table 1 of the proforma sheet.

(5). Read and note Nose Configuration from column (f) of Table 3-31 below and Table 1 of your proforma sheet.

Table 3-31 DS MGB Design 13-22 Bays with LRS

Site and Bridge Dimensions					
AR Gap Ranges (a)	MLC* (b)	2E + No. of Bays (c)	Bridge Length L (d)	R Distance (e)	Nose Const. (f)
28.3 - 30.9	70 (T)	13	32.9	27.7	7N1
30.2 - 32.8		14	34.8	29	
32.0 - 34.1		15	36.6	29	
33.8 - 36.4		16	38.4	29.6	8N1
35.6 - 38.2		17	40.2	29.6	8N1
37.5 - 40.1		18	42.1	29.6	6N1+3N2
39.3 - 41.9		19	43.9	35.1	
41.1 - 43.7		20	45.7	38.7	
43.0 - 45.1		21	47.6	38.7	
44.8 - 46.2		22	49.4	40.5	

(6) Calculate bearing: The minimum and maximum bearings for all DS bridges with LRS are shown in the Table 3-32 of TM 08676A-10/1-1 and below. To calculate the actual locations of the F and F' pegs, the following procedure is used:

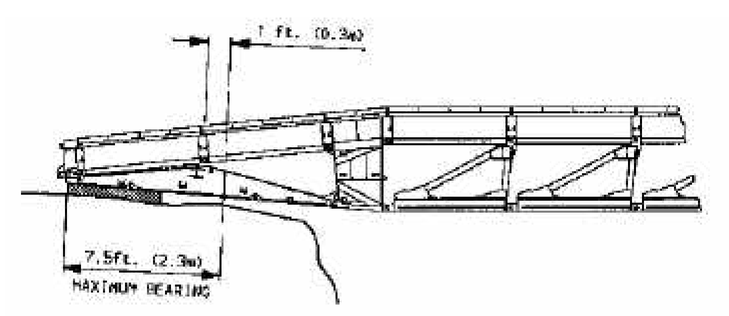
Near bank bearing = bridge length (L)-(AR gap + See note below)

Where: Bridge length is obtained from column (d) of Table 3-31. The AR gap was measured in the first step of this design procedure.

Table 3-32 Bearings

No . of Bays	Minimums		Maximum
	Far Bank A to F	Near Bank A' to F'	Near/Far Banks
13, 14, 16 thru 20	0.6m	1.4m	2.3m
15	1.1m	1.4m	2.3m
21	1.14m	1.4m	2.3m
22	1.6m	1.6m	2.3m

(7) Check bearing: On each end of the bridge there is a limit to how much or how little of the bridge can sit on the ground. This is known as bridge bearing. The maximum bearing near or far shores is 7' 6" (2.3m). The minimum bearing on either shore is 2' (0.6m).



(1) If the near bank bearing is within the minimum and maximum bearing limits, it is not necessary to shift the position of the F and F' pegs. The positions will be as initially determined, F peg (minimum from Table 3-32) from A peg and the F' peg will be placed the distance determined as the near bankbearing measured from the A' peg.

(2) If the near bank bearing is more than the maximum bearing allowable (2.3m/7'6"), it will necessary to shift the bearing.

(8) Shift bearing:

(a) Determine the amount of excess near bank bearing by subtracting the maximum bearing allowed from the amount calculated. At this point decide how to use the excess bearing as follows:

either

1. Add the excess bearing to the initial far bank bearing (minimum from Table 3-32).

or

2. Add the initial far bank and near bank bearings together, then divide by 2, resulting in an equal amount of bearing on both banks.

or

3. Add the initial far bank and near bank bearings together, then divide the total bearing as you see fit, as long as minimums are met and maximums are not exceeded.

(b) Regardless of what is done, the locations of the F, F', CRB, FRB, RRB, and O pegs will not change or shift on the site. The location of the A and A' pegs do not change, nor does the width of the AR Gap.

(c) There are situations that will result in the maximum bearings being exceeded on both banks, due to the overlaps of the gaps and bridge lengths or by making an error in the design process. When this occurs:

either

(1) Dig out the soil from the bank until the bearing area will be less than the maximum.

or

(2) Pack up (place timbers) under the end of the bridge upon completion. This packing must provide enough bearing surface to equal the minimum bearing for the bridge.

(9) Slope check:

(a) Longitudinal. Ensure that the difference in elevation between the F' (use the elevation of CRB) and F peg does not exceed 1/20th of the total bridge length. If it does, either crib up, undertake a major construction project, or find another centerline.

(b) Transverse/cross. Ensure that the transverse on both banks does not exceed 1/20th of the bridge width (4.0m / 13') for 13 - 20 bays at MLC 70(T) and 21 and 22 bays at MLC 60. No transverse slope is permitted for 21 and 22 bays at MLC 70(T) or any bridge at MLC 100(W).

(10) Calculate H and G: Calculate the far bank height (H) and the ground (at tail of bridge) clearance (G) for later comparison against N (nose lift) and T (tail lift). The values of N, H, T and G are relative to a base line drawn through the CRB and RRB.

$$H = \text{Elev F} + \frac{\text{Elev RRB} \times (L - 0.5m)}{13.7m}$$

$$G = \text{Elev O} - \frac{\text{Elev RRB} \times \text{R distance}}{13.7m}$$

(11) Rule 1: Use a Launching nose cross girder (LNCG) setting to give adequate nose clearance (N) and tail clearance (T). See Table 3-33 in the TM 08676A-10/1-1 and in the student handout, columns (g), (h) or (i). Both roller beams are in the low position.

(a) Choose a LNCG setting from Table 3-33, columns (g), (h) or (i) which give an N greater than H. If none of these three choices meet the criteria, choose the highest value available.

(b) Check to see if the T value from Table 3-33 is greater than G.

(c) If N is lesser than H or if T is not greater G, proceed to Rule 2.

(d) If N is greater H and T is greater than G, the LNCG setting chosen has adequate nose lift and the bridge selected has adequate tail clearance, proceed to loads required.

(12) Rule 2: Lower the RRB to increase N. If there is ample tail clearance, some increase in N can be obtained by keeping the CRB in its highest position and lowering the RRB to its lowest position. The mathematical equation for this process is shown under Table 3-34, column (k) in TM 08676A-10/1-1 and in the student handout.

Table 3-34 Rule 2 DS 13-22 Bay with LRS

2E + No. of Bays	Lowering RRB to Increase N (k)
13	1.9 (0.82-G)
14	1.9 (0.79-G)
15	1.9 (0.76-G)
16	1.9 (0.72-G)
17	1.9 (0.69-G)
18	1.9 (0.66-G)
19-20	1.9 (0.63-G)
21	1.9 (0.60-G)
22	1.9 (0.57-G)

N Rule 2a. = N Rule 1 + Value N calculated from the equation shown under Table 3-34, column (k) in TM 08676A-10/1-1 and in the student handout.

(13) Loads required: From Table3-35, in TM 08676A-10/1-1 and in the student handout. Determine the truck and trailer loads required for the bridge.

Figure 3-35 MGB Pallets DS 13-22 Bay w/LRS

Pallet type	No. of Bays			
	13-15	16-18	19-21	22
Erection	1	1	1	1
Bridge	8	9	10	11
Link	2	2	2	2
Total	11	12	13	14

(14) Manpower and Construction time: From Table 3-36 in TM 08676A-10/1-1 and in the student handout, determine the manpower and construction time requirements.

Table 1-5 Work Parties for MGB

BRIDGE LENGTHS	WORK PARTIES
4 and 5 Bay (26ft - 7.9m/ 32ft - 9.8 m) SSB	1 NCO + 8 PERSONNEL
5 thru 12 Bay (38 ft - 11.6 m/ thru 50 ft - 15.2) SSB	1 NCO + 16 PERSONNEL
ALL DSB's	1 NCO + 24 PERSONNEL
Link Reinforcement Party	1 NCO + 8 PERSONNEL

b. Personnel Breakdowns

TYPES OF BRIDGE	LEFT SIDE CREW	CENTER CREW	RIGHT SIDE CREW
Single Story 4 to 5 Bays	4 Marines	0	4 Marines
Single Story 6 to 12 Bays	6 Marines	4 Marines	6 Marines
Double Story	10 Marines	4 Marines	10 Marines
Double Story W/LRS	14 Marines	4 Marines	14 Marines

c. Table 1-6. Building Times (Good Conditions)

	Single Story			Double Story (without reinforcement)					Double Story (with reinforcement)		
	4-5 Bay	6-8 Bay	9-12 Bay	1-4 Bay	5-8 Bay	9-13 Bay	14-18 Bay	19-22 Bay	13 Bay	14-18 Bay	19-22 Bay
Time by day (hrs)	1/2	¾	1	3/4	1	1 1/2	1 3/4	2	2	2 3/4	3
Time by night (hrs)	3/4	1	1 1/4	1 1/4	1 1/2	2	2 3/4	3	3	4	4 1/2

All times exclusive of work on approaches.
For untrained troops, increase time by 20 percent.
For inclement weather, increase time by 30 percent.
For adverse site conditions, increase time by 30 percent.

NOTE
Additional vehicles are required to transport personnel.

(o) Final design: During the preceding design process, the information necessary to fill in the blanks below would have been obtained. Fill in these figures in the PROFORMA, at this point the design is considered complete.

(1) 2E+__________________bays	(2) LNCG Setting
(3) CRB Setting______________	(4) RRB Setting
(5) Bearing: NB______FB______	(6) Truck/Trailer loads
(7) Manpower Requirements____	(8) Time to Construct

m. **BRIDGE COMPONENT QUANTITY COMPUTATION**: Once the bridge has been designed you must wok out what type of bridge components and how many of each component will be required to build the bridge that was selected.

(1) Bridge components: Appendix E, Tables 1, 2 and 3 of the TM 08676A-10/1-1 list the components required per bridge length. With these Tables it can be identified exactly which components and how many of them will be required for that particular bridge length.

(a) Single Story (SS) component requirements - are represented in Table E-1 of TM 08676A/10-1-1.

(b). Double Story (DS) component requirements - are represented in Table E-2 of TM 08676A/10-1-1.

(c). Double Story Link Reinforced (DS w/Link) component requirements are represented in Table E-3 of TM 08676A/10-1-1.

(2) Basket loads: For each bridge there are a number of basket types that contain the smaller components required to build the bridge. Appendix E, Tables 4, 5 and 6 of the TM list the various basket types, and the number of baskets by type required for each bridge length. It also lists what components each basket contains.

(a) Single Story (SS) basket load requirements - are represented in Table E-4 of TM 08676A/10-1-1.

(b) Double Story (DS) basket load requirements - are represented in Table E-5 of TM 08676A/10-1-1.

(c) Double Story Link Reinforced (DS w/Link) basket load requirements are represented in Table E-6 of TM 08676A/10-1-1.

n. **PALLETIZATION PER BRIDGE**:

(1) Single Story (SS) Palletization

(a) There are four different types of Single Story Pallet Loads. They are:

1. ES = Erection Set

2. SRDC = Shortramp, Deck and Curb

3. SSE = Single Story End

4. SSC = Single Story Center

(b) ES pallets carry the erection components for Single Story bridges. There are nine variations, ES4 thru 12.

(c) SRDC pallets carry short ramps, decks and curbs for Single Story bridges. There are nine variations, SRDC4 thru 12.

(d) SSE pallets carry bankseat beams, top panels and deck units for each end of Single Story bridge. There are two variations SSE and SSE6/8.

(e) SSC pallets carry top panels and decks for the center of Single Story bridges there five variations, SSC8 thru 12.

(f) Pallet loads for single story bridges are represented in Table E-7 of the TM 08676A/10-1-1.

(2) Double Story (DS) Palletization

(a) There are four different types of Double Story Pallet Loads. They are:

1. ED = Erection Double

2. LR/D = Long Ramp Deck

3. EOB = End of Bridge

4. DSC = Double Story Center

(b) ED pallets contain the erection and launch components.

(c) LR/D pallets contain long ramp and deck units.

(d) EOB pallets contain all the components needed to construct the end of bridge, one variation shown (EOB1) contains two long ramps.

(e) DSC pallets contain complete bays of double story bridge (top and bottom panels). A DSC pallet has three complete bays of bridge on it. A DSC2 pallet has two complete bays of bridge on it. A DSC1 pallet has one complete bay of bridge on it.

(f) Pallet loads for Double Story bridges are represented in Table E-8 of the TM 08676A/10-1-1.

(3) Double Story Link Reinforced (DS w/Link) Palletization

(a) Double story pallet loads are palletized as for normal double story palletization 2E + 12 Bay DS except, the variations of the DSC loads used for various bridge lengths after 12 bays.

(b) There are two different types Link reinforcement pallet loads, They are:

1. LRS 1 - Link Reinforcement Set 1.

2. LRS 2 - Link Reinforcement Set 2.

(c) LRS 1 pallet contains the reinforcing components which will be assembled with the bridge.

(d) LRS 2 pallets contain the additional erection and launch components needed during reinforced bridge assembly.

(e) Link reinforced Pallet loads are represented in Table E-9 of the TM 08676A/10-1-1.

o. **LOGISTICAL REQUIREMENT FOR TRANSPORTATION**: Transportation of the pallets to the bridge site can be accomplished utilizing the following vehicles:

(1) M923/M925. Drop side cargo trucks can transport payloads of up to 20,000 pounds on the highway and 10,000 pounds cross-country. Fully loaded each will tow an additional trailer load of up to 30,000 pounds on the highway and 15,000 pounds cross-country. One pallet can fit on one M923/M925.

(2) M939/M930. Dump trucks have the same payloads and towing capabilities as the M923/M925. One pallet can fit on one M939/M930.

(3) MK48/14 (LVS). Can transport payloads up to 45,000 pounds on the highway and 25,000 pounds cross-country. One pallet can fit on one M48/14.

p. **OFF LOADING**:

(1) Normal site pallet off-loading: The procedure below should always be followed when off-loading on normal sites.

(a) Ensure that the pallets are dropped so that they are never closer than 22 feet (6.7 m) to the centerline.

(b) Ensure that the pallets have a minimum distance of twelve feet between them.

(c) Pallets should be off-loaded in the order in which they are needed for construction. For example, the pallet containing the erection and launch components is always off-loaded first, to one side of centerline, near the edge of the gap.

(d) Material handling equipment will be required to off-load the MK 48/14 lvs.

(e) Drive trucks and trailers straight on and off site. Avoid backing them.

(f) Disconnect trailers in an area clear of the site and have trucks return for off-loading.

(2) Restricted Site Pallet Off-loading: The procedure below should always be followed when off-loading on restricted sites.

(a) Ensure that the pallets are dropped so that they are never closer than ten feet (3.0 m) to the centerline.

(b) Pallets should be off-loaded in the order in which they are needed for construction. for example, the pallet containing the erection and launch components is always off-loaded first, to one side of centerline, near the edge of the gap.

(c) Material handling equipment (forklifts or cranes) will be required to off-load the MK 48/14 lvs.

(d) Backing of vehicles is required, use caution.

(e) Disconnect trailers in an area clear of the site and have trucks return for off-loading.

q. **OVERBRIDGES**:

(1) Over bridges are constructed over existing bridges that have been damaged or have a low class capacity. The abutments of the existing bridge are used as bearing points for the overbridge. It is important to ensure the overbridge does not come in contact with the existing bridge span while traffic is crossing.

(2) Overbridges can be built with or without launching noses.

(a) With launching noses: An overbridge is built as if it was being put across a gap. The roller beam closest to the existing bridge must be positioned so that it does not touch the existing span. Also, the roller beam height should be kept high enough to prevent launching nose or far bank end of bridge from coming into contact with existing span.

(b) Without launching nose: An overbridge is built in place over the existing span. Ensure that the existing span is capable of supporting the weight of the overbridge construction, particularly if a double story is being constructed over a long, low class bridge.

r. **OVERBRIDGE DESIGN**:

(1) The design for overbridges constructed with launching noses is the same as a bridge being built over a gap. Particullar attention must be paid to deflection of the far bank end of bridge and launching nose cross girder setting.

(2) For all overbridges, the amount of packing under the backseat beam must be calculated using the following formula and procedures:

FORMULA P = P1 + P2

P - Height of packing

P1 - Deflection of overbridge

P2 - Height of existing bridge above baseline through bearing points at ends of existing bridge.

(a) Measure height of existing bridge (P2) by using, the baseline joining the ground levels at the proposed locations of the BSBs as a datum.

(b) Find maximum deflection (P1) of overbridge to be constructed from the following table 6-24 in the TM 08676A/10-1-1 and student handout.

(c) Utilizing the table in your student handout, you can determine the central and eccentric deflection.

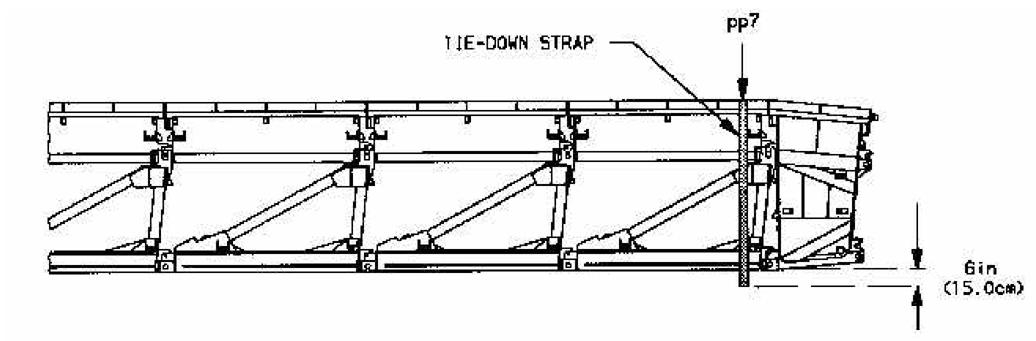
1. The DEAD LOAD, is the deflection of the bridge without any vehicles on it. The DEAD LOAD + LIVE LOAD (CENTRAL), is the deflection of bridge with a vehicle crossing at the center of the bridge. The DEAD LOAD + LIVE LOAD (ECCENTRIC), is the deflection of the bridge with a vehicle crossing over any area of the bridge other than the center. Particularly the ends of bridge.

h. **DISASSEMBLY ON FAR BANK**: When disassembling the bridge on the far bank different procedures are required. The bridge has been delaunched onto roller beams on the far bank and safety packing placed between the gap and the forward roller beam (on normal sites). Sway braces, bankseat beam end of brige top panels and end tapered panel have been removed. Because the junction panels, top panels and bottom panels are facing in the opposite direction to a normal near bank strip, they cannot be disconnected in the usual way. The drills to remove them are as follows:

(1) REMOVING JUNCTION PANEL:

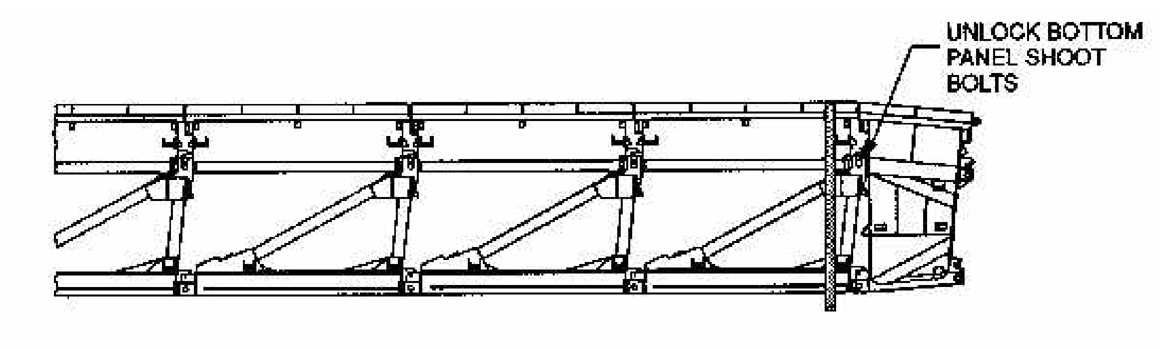
(a) Remove sway braces in the last three bays of bridge.

(b) Place one 10,000-lb cargo tie down strap around panel point 7 of last bay. This strap must be adjusted so as to provide 6 in (15.0 cm) of slack below bottom panel. Placement of this tie down strap prevents the bottom panel from dropping to far when the junction panel is removed. This strap reduces the chance of injury to personnel and damaging the panel.

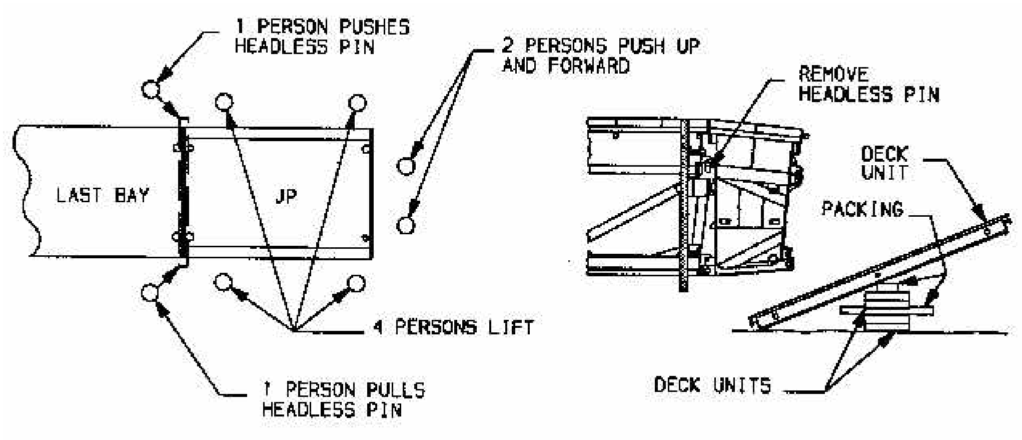


(c) Remove the retainer clips from the headless pins in the junction panel.

(d) Unlock shoot bolts of bottom panel in the last bay of bridge.



(e) Using decks as shown lift the junction panel and remove headless pin from upper pinhole in junction panel.

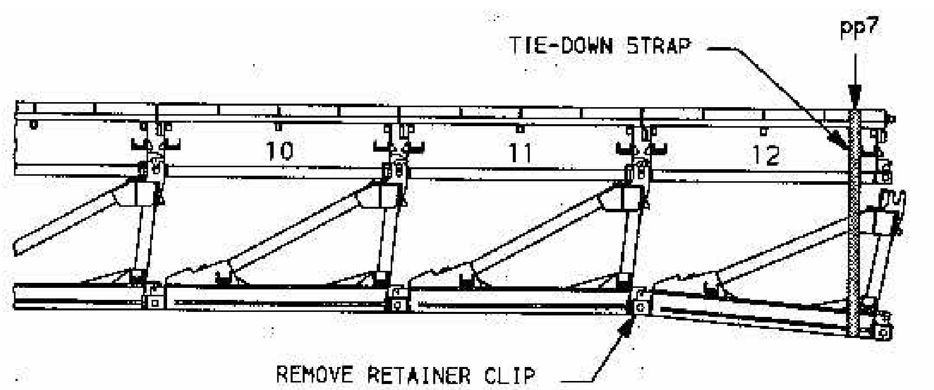


(f) Remove the panel pin from the pinhole in junction panel.

WARNING
BOTOM PANEL WILL DROP INTO STRAP AS JUNCTION PANEL IS REMOVED
KEEP FEET AND LEG CLEAR OF BOTTOM PANEL.

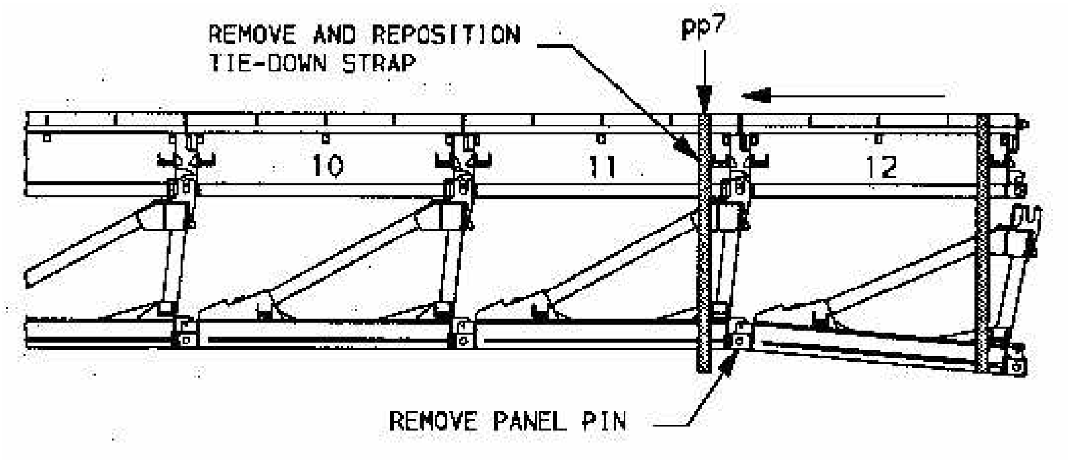
(g) Four personnel lift junction panel and unlock top panel shoot bolts. Remove junction panel from the end of bridge.

(2) REMOVING BOTTOM PANELS: When the bottom panel is ready to be removed, it will be supported by a strap at panel point seven, that was positioned there prior to removing the junction panel.



(a) Remove the retainer clip from the panel pin in the bottom panel.

(b) Four Marines lift bottom panel, while another Marine unhooks and removes the tie down strap, and repositions it at panel point seven of the next bay. Another Marine removes panel pins.



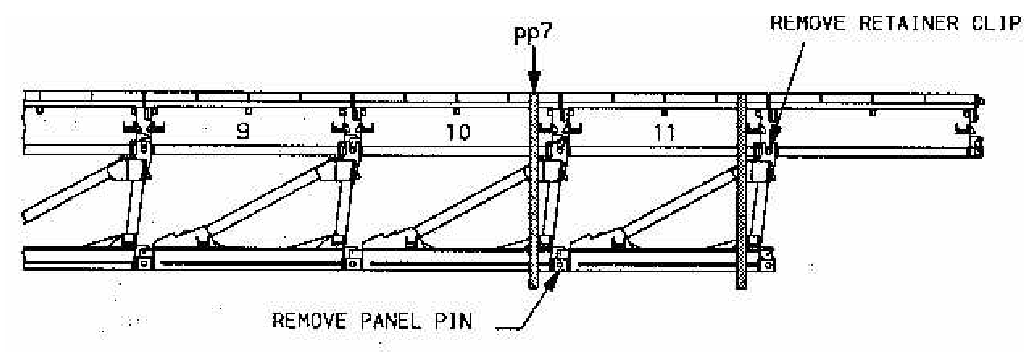
(c) Move bottom panel from under top panel.

(3) REMOVING TOP PANELS:

(a) Place second tie-down strap around panel point seven of the next unstrapped bay.

NOTE
FROM THIS POINT ON, THESE TWO STRAPS WILL BE MOVED ALONG THE BRIDGE GIRDER SO THER ARE ALWAYS TWO STRAPS AROUND THE LAST TWO BAYS OF BRIDGE.

(b) Remove the retainer pin from the panel pin in the last top panel.

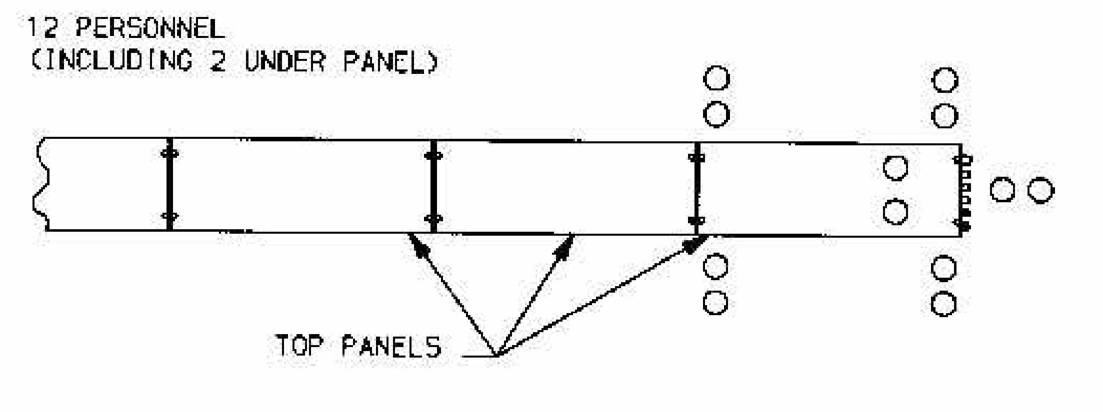


(c) Unlock the shoot bolts of the next four bottom panels.

NOTE
IT IS NECESSARY TO ULOCK FOUR SHOOT BOLTS SO AS TO PROVIDE ENOUGH SLACK IN THE GIRDER TO PERMIT RELEASING THE BOTTOM PANEL UPPER JAWS FROM THE PANEL PIN IN THE REARMOST TOP PANEL. ENSURE THAT THE FOUR SHOOT BOLTS ARE UNLOCKED BEFORE TRYING TO LIFT THE REARMOST TOP PANEL.

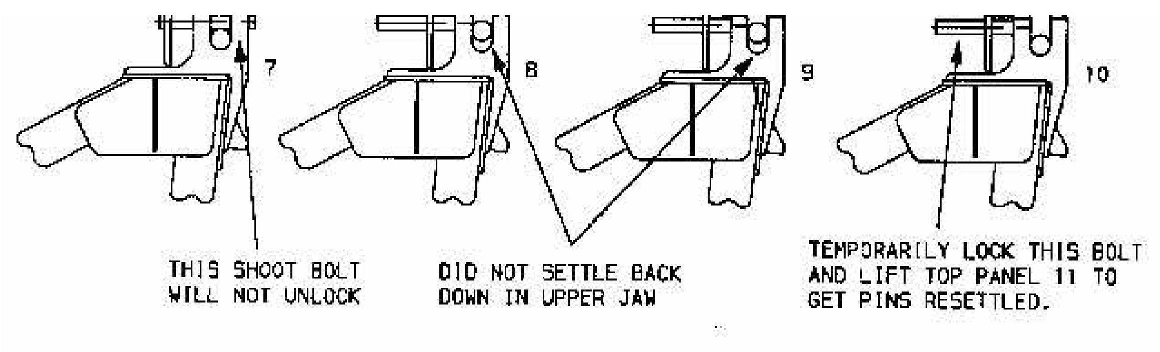
(d) Remove the next sway brace in the bridge.

(e) Using 12 Marines, as shown below, lift rearmost top panel until bottom panel falls free of panel pin in top panel.

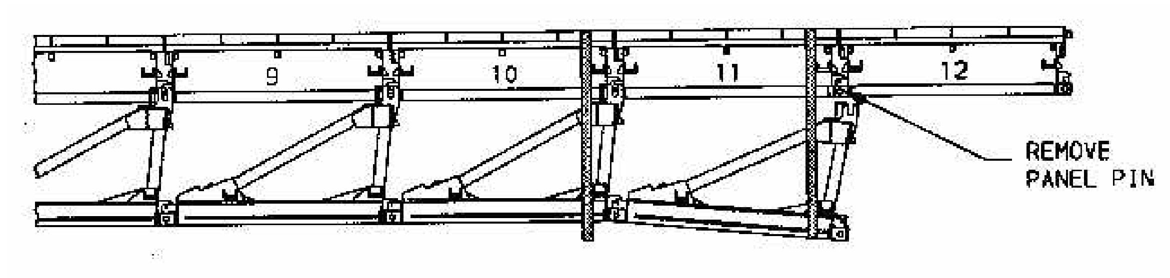


NOTE
THE PANEL PINS IN THE UPPER JAWS MAY NOT SETTLE BACK DOWN AFTER THE TOP PANEL IS LIFTED, AS SHOWN IN EXAMPLE. IF THIS HAPPENS IT WILL NOT BE POSSIBLE TO UNLOCK THE NEXT SHOOT BOLT.

TO UNLOCK THE NEXT SHOOT BOLT (BAY 7), TEMPORARILY LOCK THE SHOOT BOLT IN BOTTOM PANEL 10 AND LIFT TOP PANEL 11 UNTIL THE PINS 1N 9 AND 8 RESETTLE. UNLOCK THE SHOOT BOLTS IN BAYS 10 AND 7.



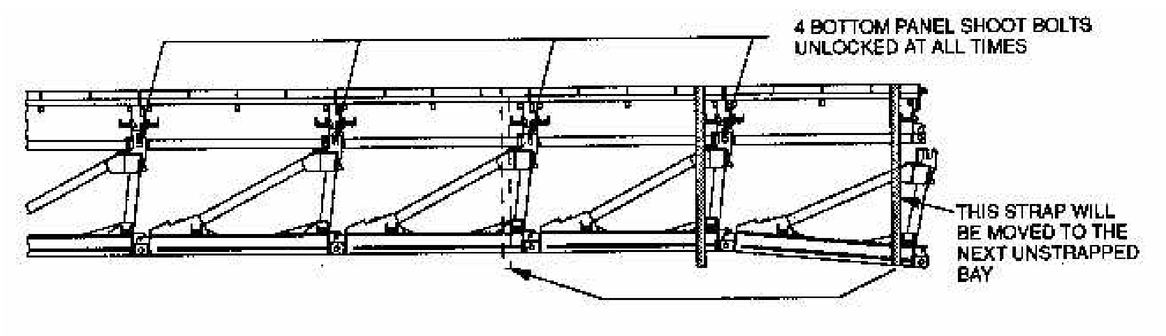
(f) Let the top panel down and remove the panel pin.



(g) Lift top panel, unlock the shoot bolts and remove the panel.

NOTE

AS THIS TOP PANEL IS REMOVED ENSURE THAT THE FOUR BOTTOM PANEL SHOOT BOLTS ARE UNLOCKED. AS THE NEXT BOTTOM PANEL IS REMOVED, UNHOOK AND MOVW THE TIE-DOWN STRAP TO THE NEXT UNSTRAPPED BAY.



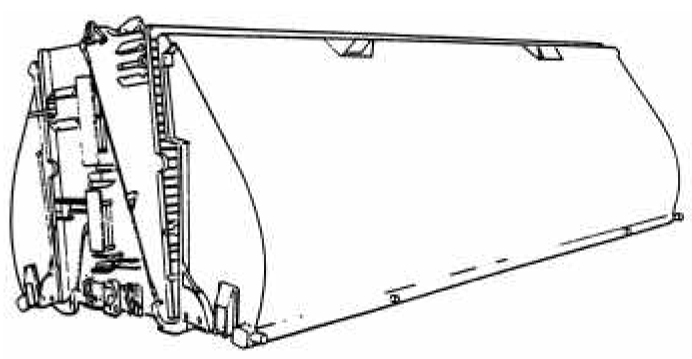
(h) Continue this process until the bridge is completely disassembled.

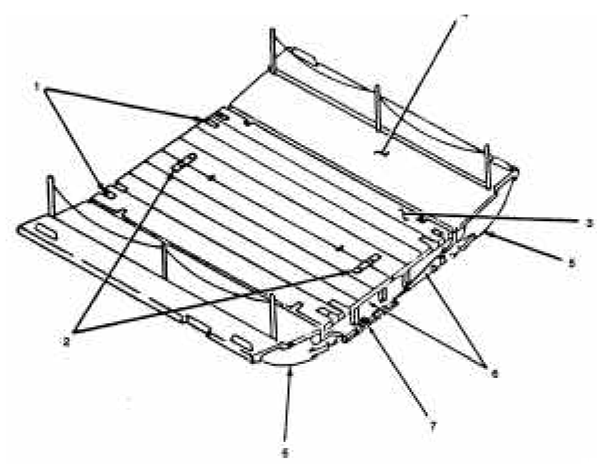
2. **RIBBON BRIDGE**:

a. General: The ribbon bridge is a floating, modular bridge with integral superstructure and floating supports. A complete ribbon bridge consists of a ramp bay at each bank and the required number of interior bays to complete the bridge between the ramp bays. The bridge has a roadway width of 13 ft 5 in (408.9 cm). In addition, there are two 4-foot (121.9cm) wide walkways on the bow pontons. The normal crossing capability is a class 70 load in currents up to 8 feet per second. This bridge can cross 200 vehicles per hour, with a 100-foot space between vehicles traveling at 10 miles per hour. Individual bays may be joined to form a raft for ferrying operations. Each bay is transported in a folded condition on a ribbon bridge transporter known as MK48/18 LVS.

b. INTERIOR BAY:

(1) Each bridge interior bay is a 4 ponton-folding module consisting of two-roadway ponton, and two-bow ponton. The two interior roadway ponton are joined to each other and to the adjacent bow ponton by hinges and pins along adjacent edges. The ponton are secured in either the open or folded positions by latches.





(2) Interior Bay Dimensions

Length	22 ft 8.5 in (692 cm)
Width (folded)	10 ft 6.6 in (322 cm)
Width (unfolded)	22 ft 8.5 in (692 cm)
Height (folded)	7 ft 7 in (231 cm)
Height (unfolded)	3 ft 8 in (112 cm)
Weight	12,000 lbs (5443 kg)

Cube	1817 cu ft (51.5 cm)
Center of Gravity	136.25 in (346 cm) inboard of connecting lock pin

(3) The welded roadway ponton are the main load carrying structure of the bridges. Each ponton is divided into two watertight compartments. When a bridge bay is mated to an adjacent bay, male and female connectors are joined by a lock pin. A plate is welded to the end of the deck extrusion; and, together they form the compression chord of the bridge structure.

(4) Upper ponton connectors are dog-bone shaped castings fitted into cast inserts welded into the deck.

(5) The interior bay bow ponton are hinged to the roadway ponton, which provide additional flotation and a personnel walkway. Two lifting and anchor pin eyes are welded outboard. A roadway-to-bow ponton latch keeps the bow ponton deployed as vehicles cross the bridge.

(6) Control on Interior Bay. The functional description of the various controls on the interior bay used in launching, emplacing, retrieving, and transporting the bay.

(a) <u>Bay Lower Lock Drive:</u> Two lower lock drives at diagonally opposite ends of the interior bay, serve to engage the bay lower lock connecting pin with the bay lower-lock yoke and the eye of the mating bay, when connecting bays together during bridge assembly and operation.

(b) <u>Bridge Bay/Bridge Bay Upper Connector:</u> Two spring-loaded "dog bone" shaped bridge bay/bridge bay upper connectors are located on each end of the interior bays. These "dog bones" connectors are attached to connector blocks. When not engaged, the "dog bones" are stowed in the connector blocks. When engaged, they mate with two connector receptacles located opposite to the blocks on the adjacent bay and prevent separation of the bays during operation. Two connector receptacles are also located on each end of the interior bays.

(c) <u>Roadway Ponton Upper Connector:</u> There is one roadway ponton upper connector mounted on the inner edge of each interior roadway ponton which engages in a connector receptacle provided on the opposite roadway ponton. These connectors are identical to the bridge bay/bridge bay upper connectors. They serve to prevent separation of the roadways when operating under load.

(d) <u>Handrail:</u> Three handrail posts are mounted in structural supports located on the waterside of each bow ponton walkway. The handrail posts are secured to the supports by the support pin, two washers, and two cotter pins. Safety ropes run between the handrail posts. The handrails are folded flat to the walkway when not in use.

(e) <u>Road-to-Bow Ponton Bridge Latch:</u> A roadway-to-bow ponton bridge latch is mounted at each end of the roadway ponton. After the bay is launched, this latch is manually engaged with a latch receptacle mounted on the lower end of each bow ponton securing the bow ponton to the roadway ponton.

(f) Roadway/Roadway Ponton Travel Latch: A manually released roadway/ponton travel latch is mounted on one end of each roadway ponton. The travel latch engages with a travel latch receptacle mounted on the adjacent roadway ponton. The travel latch, when in operating position, automatically engages the adjacent ponton receptacle to hold the roadway ponton together during the final folding operations. The travel latch also prevents unfolding of the bay during retrieval and travel. The latch is spring loaded for retention in either the stowed or locking position.

(g) Roadway/Bow Ponton Foldlock Latch: A manually released roadway/bow foldlock latch is mounted on each end of the roadway ponton. The foldlock latch when in the locking position, automatically engages the bow facing securing the bow ponton to the roadway ponton during folding operation. The foldlock latch also prevents accidental unfolding of the bow ponton during retrieval and transport. The latch is spring loaded for retention in either the stowed or locking position.

(h) Bridge Bay Unfolding Mechanism: A bridge bay unfolding mechanism is mounted to one end of the interior bay. The unfolding mechanism is comprised of two bow ponton levers, a front lifting and hinge pin, three equalizer links connecting the hinge pin to the roadway ponton, and two unfolding tension cables which extend from the bow ponton levers to opposite supports on the front lifting and hinge pin. The purpose of the unfolding mechanism is to control the folding and unfolding of the bridge bay in the water.

(i) Lifting and Anchoring Pins: Two lifting and anchoring pins are installed in structural supports on each bow ponton. The lifting and anchoring pins are used in conjunction with a lifting sling and the transporter winch for high-bank-launching of the bays, and for lifting folded bays. They are also used for securing anchor lines from bridge erection boats to the bridge bays during bridging operations.

(j) Helicopter Lift Pins: Two helicopter lift points, marked AIRLIFT HERE are provided on each bow ponton. These are to be used with the shackles and airlift sling provided in the supplementary erection set.

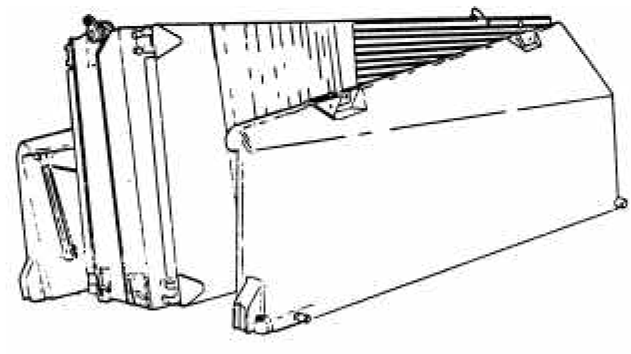
(k) Roadway Ponton Lift Points: Each roadway ponton has two lift points to be used only when the ponton is handled by itself.

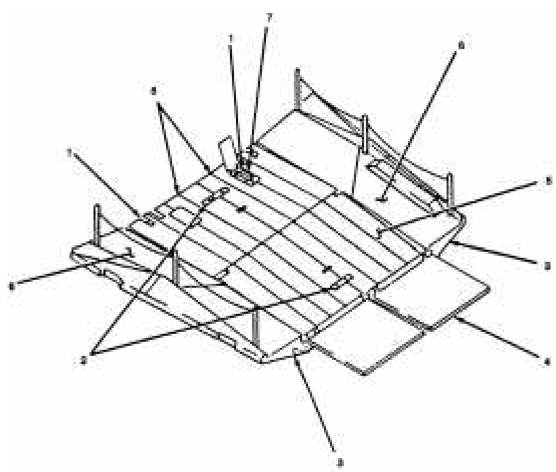
(l) Bilge Ports: Six bilge ports, three each at diagonally opposite lends of the interior bay, provide accesses to the interiors of the ponton. Two ports are on each roadway ponton and one port is on each bow ponton. These ports are sealed by adjustable bilge plugs; which, when removed, allow inspection of the ponton when the bay is retrieved and loaded on the transporter. Water pumps and hoses may be used to remove water from ponton through the bilge ports when the bay is unfolded in the water.

(m) Cable Guides: A cable guide is located on each end of the interior roadway ponton. The guide provides a means of revving the winch cable during loading and unloading operations. A hole is provided in each guide for the seating of the hydraulic lock pin.

c. **RAMP BAY**:

(1) The construction of the ramp bay is similar to that of the interior bay except that the shore end is tapered. A 7-foot long approach ramp is hinged to each roadway ponton. The bridge hydraulic system permits ramp adjustments from 0 to 20 degrees, providing access to various bank slopes.





(2) Ramp Bay Dimensions:

Length	19 ft 0.7 in (581 cm)
Length (with approach ramp extended)	25 ft 4 in (772 cm)
Width (folded)	10 ft 6 in (320 cm)
Width (unfolded)	26 ft 8 in (815 cm)
Height (folded)	7 ft 10.1 in (238 cm)
Height (unfolded)	3 ft 7 in (109 cm)
Weight	11,700 lbs (5579 kg)
Cube	1566 cu ft (44.35 cm)
Center of gravity	96 in (243.8 cm) inboard of connecting pin

(3) Control on Ramp Bay. Control on the ramp bay is used in launching, emplacing, retrieving, and transporting the bay. All of the controls on the interior bay are common with the ramp bay except quantities may differ.

(a) Hydraulic Pump: Each ramp is equipped with two hand-operated pumps which actuate two hydraulic cylinders. The pumps are mounted on brackets directly below the deck of the roadway ponton. Hinged covers are provided to gain access to the pumps. A control lever, built into the pump has three positions, when in the pump position it allows the operator to raise or lower the ramp bay to adjust to the slope of the bank. The traffic position will enable a bridge or raft to safely load vehicular traffic across the ramp bay. The transport position is used when recovering the ramp bays after the ramp bay has been disconnected from the bridge or raft, putting the control lever in the transport position relieves all the pressure from the hydraulic system, for storage.

(b) Roadway/Ponton Travel Latch: A roadway/roadway ponton travel latch identical to that on the interior bay, is mounted on the front end of the ramp roadway ponton.

(c) Ramp Bay Lower Lock Drive: The ramp bay has only one lower lock drive, located on the front of the ramp bay. The lower lock drive is similar to that on the interior bay and serves the same purpose. The lower lock drive is mounted on an adjustable yoke.

(d) Roadway/Bow ponton Foldlock Latch: Two roadway/bow ponton foldlock latches are mounted on the bay side of the ramp bay ponton. The construction is similar to those on the interior bay and they serve the same function.

(e) Bilge Plugs: There are four bilge ports located near the front end of the ramp bay. One bilge port is mounted on each roadway ponton and on each bow ponton opposite the roadway ponton plugs. They serve the same purpose and are identical to those on the interior bay.

(f) Cable Guide: A cable guide is mounted only on the front end of the ramp bay roadway ponton. It serves the same purpose as those on the interior bay.

d. **TOOLS**: The following tools are used with interior and ramp bays of the ribbon bridge or raft.

(1) Bay Drive Pin Wrench: The wrench is used to engage and disengage the lower lock drive pin.

(2) Rafting Bracket: The rafting brackets are used as fenders during longitudinal rafting operations. They are made of aluminum and fit in the bow lifting and anchor pinholes.

(3) Ramp Bay Connecting Tool: The ramp bay connecting tool is used to pull the ramp bay to the interior bay when making a connection. The hooks are placed over the roadway-to-roadway upper connectors of the two bays. This device consists of a ratchet type chain hoist and two hooks. It is issued and stored in the ramp toolbox.

(4) Wrecking Bar: The wrecking bar is used to apply force to align the bays when locking the bays together with the lower lock drive pin. The bar is also used to position the front and rear tiedown hook assemblies when launching or retrieving bays.

(5) Ramp Upper Control Tool: The ramp roadway/roadway upper connector tool is used to level the roadway ponton so that the upper (dogbone) connectors can be latched in place. It is issued and stored in the ramp tool box.

(6) Bay Latch Pin Assembly: The bay latch pin assembly is used to release the roadway travel latch after, a bay has been high bank or control launched. It is issued and stored in the ramp toolbox.

e. **RIBBON BRIDGE SITE RECONNAISSANCE AND REQUIREMENTS**:

(1) Prior to calculating bridge requirements, the following information must be extracted from reconnaissance reports, operation orders, etc.:

(a) Wet gap width: The width must be known to determine if enough assets are available to span the gap.

(b) Current velocity: This must be known to determine if a ribbon bridge can be used or if a raft is required. If a ribbon bridge can be used use the current velocity to determine the anchorage method i.e.; Bridge boats, Kedge anchors or kedge anchors with an overhead cable system.

1. Current velocity must be taken in the loading, unloading and center stream areas.

(c) Proposed bridge site conditions such as:

1. Bridge approaches, must be less than a 7% slope. (7" drop over a 12'6" distance)

2. Size and location of possible assembly sites: The assembly site must have, a water depth of at least 40 inches in the main body for operation of the bridge erection boats. A bank height of less than 48 inches to accommodate ramp bay approach ramps. There must be a launch site down stream of the assembly site with a bank height of less than 60 inches with a water depth of 72 inches for free launching bays or a bank height of less than 28 feet for high bank launching. The bank width must be 50 feet wide for maneuvering the MK48/18 transporter. There must be a good access road from the bridge bay launch site to the staging area. A minimum downstream floating area of 100 feet is required in areas where water is flowing more than 1 ft./sec.

3. Soil conditions at site: A hasty soil analysis must be done on site to design the anchorage system to be used.

4. Wet gap bottom composition: Must be known for use of kedge anchors and any obstructions below the planned bridge site.

(d) Desired MLC (Military Load Classification): It must be known from the operations order what MLC is to be crossing the bridge. The Ribbon Bridge is designed to hold a MLC of 70 in streams up to 8 ft./sec.

f. **RIBBON BRIDGE DESIGN**: As in all bridges to determine the amount of assets required to build the bridge first it must be designed. The bridge design formula is in annex B of FMFM 7-26 page B-7. Here it shows the two ways to calculate the number of bays required to reach from shore to shore, in both metric and standard measurement.

(1) First determine the gap width, then subtract the length of both ramp bays, and then divide that answer by the length of one interior bay. The answer from that equals the number of interior bays required spanning the gap.

$$\frac{\text{gap (meters)} - 14}{6.7} \quad \text{or} \quad \frac{\text{gap (feet)} - 45}{22}$$

(2) Construction time; during daylight hours a ribbon bridge can be constructed at a rate of 200 meters, 600 feet per hour. reduce by 50 percent at night or 100 meters 300 feet.

(3) Crossing capabilities; The ribbon bridge is capable of crossing 200 vehicles per hour with 30 meters, 100 feet spacing at 16 kilometers, 10 miles per hour.

(4) Bridge classification; the bridge classification is taken from the table in annex B of FMFM 7-26 page B-7. Read the top row current velocity (mps/fps) find the current velocity read down that column to identify the military load class for a normal, caution and risk crossings, the top number is for wheeled vehicles the bottom number is for tracked vehicles.

(a) Types of crossings

1 Normal - Vehicles may travel anywhere on the bridge deck at speeds up to 25 mph.

2 Caution - Vehicles restricted to within 12 inches of the bridge centerline at 8 mph with 150 ft. interval between vehicles. Stopping, accelerating or shifting gears is not permitted on the bridge.

3 Risk - Vehicles restricted to within 9 inches of the bridge centerline and a guide is required to direct the vehicle. Maximum speed is 3 mph and only one vehicle is allowed on the bridge at a time. Stopping, accelerating or shifting gears is not permitted on the bridge.

Table C-10. Determination of bridge classification

Crossing Types	Current Velocity in MPS (fps) and MLC							
	0-0.9 (0-3)	1.2 (4)	1.5 (5)	1.75 (6)	2 (7)	2.5 (8)	2.7 (9)	3 (10)
Normal: wheeled tracked	96 75	96 75	96 70	96 70	82 80	65 60	45 45	30 30
Caution: wheeled tracked	105 85	105 85	100 80	100 80	96 80	75 65	50 50	35 35
Risk: wheeled tracked	110 100	110 195	105 90	105 90	100 90	82 75	65 65	40 40

g. **ANCHORAGE SYSTEMS**: The Ribbon Bridge is only as good as the anchorage used to secure it. The Ribbon Bridge must be anchored between abutments to assure continuous alignment. There are five basic anchorage systems used to secure the Ribbon Bridge. The best overall anchorage system is the overhead cable system.

(1) Factors involved in the selection of an Anchorage System.

(a) Stream Velocity - Each system is only good in currents up to a given stream velocity. The kedge anchor system is good in currents with a velocity of up to 3 fps, the shore guy line system is good in currents with a velocity of up to 3 fps, and both of these systems together are good in currents with a velocity of up to 5 fps. The overhead cable system is good in currents with a velocity of up to 11 fps.

(b) Type of soil - some soils are not suitable for the use of deadmen as a holdfast, as some soils like fine grained soils with a high moisture content does not have a holding power for deadmen like hardpan or rock would.

(c) Height and slope of the bank - When the bank is very high the overhead system should be used since the high banks eliminate the need for constructing a cable tower.

(d) Width of the gap - Some anchorage systems cannot be used for extremely wide gaps. For example, the shore guy line system.

(e) Stream bed - If the streambed is not satisfactory for use of the kedge anchor system, you can not use this system. The streambed must be such that the fluke of the anchor can dig in and hold the float in place.

(2) Shore Guys: Description - Shore guys from the bridge to deadmen or natural holdfasts are used primarily to hold the bridge assembly, but can be incorporated into the final anchorage system of the bridge. They are constructed of 1/2-inch wire rope that is run at an angle of 45 degrees from the bridge to the shore. Shore guys should not be used at distances greater than 300 feet from either shore along the centerline of the bridge. When installed on the upstream side as a supplementary anchorage system, they must be slacked off after installation. For spans under 600 feet, shore guys can be used as the downstream anchorage unless severe eddies or tidal conditions cause current reversals. To prevent accumulation of debris, the guys should be raised clear of the water with an "A" frame or other support. Deadman or natural holdfasts must be located above the anticipated high water level to prevent washout. This system is good in stream velocities of up to 3 feet per second (fps).

(a) Installation

1. Upstream Shore Guys - The upstream shore guys are unreeled from shore and passed out along the bridge. One man is stationed at every other float to hold the cable out of the water as it is passed to shore. The guy line is passed under each bridle line except the two shoreward of the point where the guy is attached to the bridge. One line is attached every sixth bay or float.

2. Downstream Shore Guys - Downstream shore guys are best installed after the bridge is completed to avoid interference with powerboat operation. They are installed in the same manner as the upstream shore guys. One line is attached to every tenth bay.

3. Approach Guys - Approach guys are attached upstream and downstream on the first bay on both near and far shores. The purpose of the approach guy is to keep the bridge from creeping due to vehicle impact.

(3) Kedge Anchor: Kedge anchors lay on the stream bed with the stock lying flat and the fluke positioned to dig into the bottom. They are secured by cables to the bays or rafts. Kedge anchors depend on the streambed for holding power, and are useful only when the bed is composed of sand, silt, loose rock or other material into which the fluke can take hold of. On hard bottoms, the kedge anchor is useless. Where the streambed is suitable, kedge type anchors can be used as a primary anchorage system in low velocity currents up to 3 fps.

(4) Combination of Anchors and Guys: Combination of kedge anchors and shore guys may be used in currents with a stream velocity of up to 5 fps.

(5) Overhead Cable System; Overhead cable systems consists of one or more tower supported cables spanning the river parallel to the bridge on the up stream side. They are also used downstream of the bridge on tidal streams as a supplementary anchorage system under severe current conditions, providing sufficient materials and equipment are available. The system may be attached to trees or other natural holdfast as an expedient; however, the anchor tower must be erected just as soon as the time and materials are available. Bridle lines are used to make the bridge secure to the cable. The overhead cable acts in a manner similar to the cable of a suspension bridge. This system is good in currents with a stream velocity of up to 11 fps.

(a) Single Cable Anchorage - This is a tower-supported cable that spans the river on the upstream side of the bridge. Single cable systems can be built for bridges as long as 1,200 feet in low velocity streams. Installation of cable spans up to 1,500 feet are possible, but are difficult because of the practical limitations of erection equipment and cable size and weight. In rivers having reversals of currents or strong winds from downstream an additional single cable system may be used as a downstream anchorage. In reinforcing an existing bridge, it will usually be necessary to strengthen the anchorage system by increasing the holding power of the existing deadmen, or by constructing a multiple cable system.

(b) Float Supported Cable - This anchorage system is used when an overhead cable system would be overstressed. One or more cables are supported by towers on each shore span of the river and are anchored in the same manner as overhead cables. The cables are supported by rafts or floats which are spaced at an interval required to keep the cable above water. The rafts or floats are anchored in place with crib or heavy bed anchors. The length of the anchor line from the raft to the bed anchor should be at least 10, and preferably 20, times the depth of the water. Bridle lines connect the bridge to the cable in the same manner as with the overhead cable system. The rafts must have sufficient buoyancy to withstand the downward pull of the bed anchor lines, the weight of the cable and the drag of the bridle lines. Sufficient freeboard must be maintained to clear the bow wave created by the current. This anchorage system obstructs the passage of debris and ice and requires additional maintenance personnel to keep the cables and lines free.

(c) Multiple Cable Anchorage - If the cable size required for a single cable system cannot be obtained or if the cable required is too large for the bridle lines, two or more smaller cables may have to be installed.

(6) Bridge Erection Boats - May be used to anchor any length ribbon bridge. The number of boats required and their spacing will be determined by the current velocity. See table C-11 of FM 90-13/MCWP 3-17.1 pg C-14 or look in the handout given to you by the instructor.

Table C-11. Number of boats needed for anchorage of a ribbon bridge

Current Velocity in MPS (fps)	Number of Boats: Number of Bridge Bays
0 to 2.0 (0 to 6.5)	1:6
2.0 to 2.6 (6.5 to 8.5)	1:3
2.7 (9)	1:2
Over 2.7 (over 9)	Bridge must be anchored using an overhead cable system.

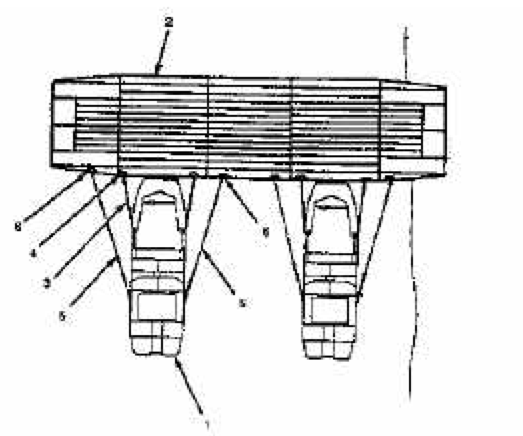
NOTE: Anchorage of ribbon bridges is normally accomplished by tying BEBs to the downstream side of the bridge. The number of boats required is shown in the table.

h. **RIBBON RAFT DESIGN**: To design a ribbon raft we must know the current velocity and maximum Military Load Class to be rafted, and what method of rafting will be used longitudinal or conventional.

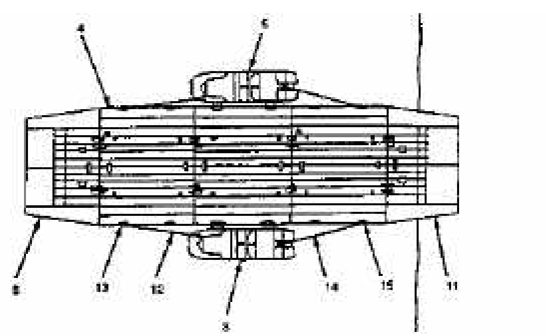
(1) Methods of rafting:

(a) They are two ways to attach the Bridge Erection Boats to the Ribbon Raft and maneuver it.

(b) Conventional rafting: the bridge erection boats are tied perpendicular to the raft, and is used when the current velocity in the loading and unloading areas is greater than 5 fps.



(c) Longitudinal rafting: the bridge erection boats are tied parallel to the raft using rafting brackets to attach the boat to the raft. This method of rafting is used when the current velocity in the loading and unloading areas is 5 fps or less.

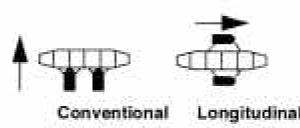


(2) Designing a ribbon raft: Annex B of FMFM 7-26 page B-6 contains the table for Ribbon Raft Design. To read this table start at the top right and find the appropriate current velocity, read down that column to find the military load class required, now read to the capabilities/raft column on the far left, and it will tell you the number of interior and ramp bays required in the raft. The second column from the left is the assembly time for the raft in minutes, increase this time by 50 percent at night.

Raft Types	Assembly Time in Minutes	Load Space in Meters (feet)	Classi-fication	Current Velocity in MPS (fps) and MLC							
				0-0.9 (0-3)	1.2 (4)	1.5 (5)	1.75 (6)	2 (7)	2.5 (8)	2.7 (9)	3 (10)
3 bays (2 ramps/ 1 interior)	8	6.7 (22)	L C	45 45	45 45	45 35	40 25	40 15	35 10	30 0	25 0
4 bays (2 ramps/ 2 interiors)	12	13 (44)	L C	70 60	70 60	70 60	60 55*	60 40*	60 30*	55 15*	45 0
5 bays (2 ramps/ 3 interiors)	15	20.1 (66)	L C	75 75	75 70	75 70	70 70*	70 60*	70 50*	60 25*	60 0
6 bays (2 ramps/ 4 interiors) wheeled/ tracked	20	26.8 (88)	L C	96 80 96 70	96 80 96 75	96 80 96 70	96 70 70 70	96 70 70 70	96 70 55 55	70 70 30 30	70 70 0

NOTES:
1. When determining raft classification, L refers to the longitudinal rafting and C refers to conventional rafting.
2. If the current's velocity in the loading/unloading area is greater than 1.5 MPS (5 fps), then conventional rafting must be used.
3. The roadway width of a ribbon raft is 4.1 meters (13 feet 5 inches).
4. The draft of a fully loaded ribbon raft is 61 centimeters (24 inches).
5. Vehicles should only be loaded on the interior bays.
6. Each raft requires a minimum of two BEBs for propulsion.
7. The assembly time for a raft increases by 50 percent at night.

*Three BEBs are required for conventional rafting of 4, 5, or 6 bay rafts in current velocities greater than 1.5 MPS (5 fps).



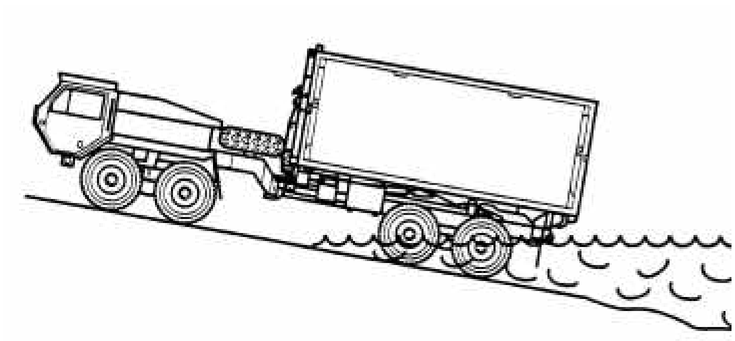
(3) Boat/Raft planning factors: To plan for the number of boats required raft use the ribbon raft design table in annex B of FMFM 7-26 page B-6. Where in the notes it calls for three bridge erection boats for conventional rafting of 4,5 or 6 bay rafts in currents greater than 5 fps. For longitudinal rafting the current velocity in the loading and unloading areas must be less than 5 fps and each raft requires a minimum of two bridge erection boats for propulsion.

(4) Crossing capabilities: Again Annex B of FMFM 7-26 page B-4 contains the table for Ribbon Raft crossing capabilities. To read this table the first two rows are the river width, read right to the appropriate width column then down. If the river width your working with falls between two of the given widths use the larger of the two for further information. The third row is the time in minutes required to make one round trip per raft, this includes the time required to load and unload the raft. Crossing times will take 50 percent longer at night. The fourth row is the number of round trips per hour each raft can make. The fifth row is the number of rafts that can safely operate on the same rafting centerline.

River Width		Minutes per Round Trip	Rounds Trips per Hour	Number of Rafts per Centerline
Feet	Meters			
246	75	7	8	1
328	100	8	7	1
410	125	9	6	1
492	150	10	6	2
610	188	11	5	2
738	225	12	5	2
861	263	14	4	3
964	300	16	3	3
1,148	350	18	3	4
1,312	400	20	3	5
1,476	450	22	2	5
1,640	500	24	2	5
1,968	600	26	2	6
2,296	700	29	2	6
2,824	800	32	1	6
2,952	900	35	1	6
3,280	1,000	38	1	6
3,808	1,100	41	1	6
3,936	1,200	45	1	6

NOTES:
1. This table is valid for ribbon and M4T6 rafts in current velocities up to and including 1.5 MPS (5 fps). This data is based on the use of crews under ideal conditions.
2. Round-trip times include the times required to load and unload the raft.
3. Crossing times will take 50 percent longer at night.
4. If the river width falls between 2 columns, use the value found in the next higher column.

i. **MK48/18 RIBBON BRIDGE/CONTAINER HAULER**: The MK48/18 LVS is designed to self-load, transport, and self unload standardized containers or ribbon bridge systems. Additionally, the MK48/18 can be utilized to self-load/unload a bridge erection boat and cradle assembly, it's also used for high-bank launch operations of ribbon bridges.



(1) There are 48 steps to configuring the MK48/18 for ribbon bridge bays, the configuration is outlined in TM 2320-10/11 SUPPLEMENT-1. Always use the TM to configure the MK48/18 or **DAMAGE TO EQUIPMENT OR PERSONNEL WILL RESULT.**

j. **LAUNCHING AND RETRIEVING RIBBON BRIDGE BAYS**: There are three ways to launch the ribbon bridge, providing us with the ability to access a variety of streams with variable bank heights. They are; High Bank Launch, Control Launch, and Free Launch.

(1) High bank launch method: This method makes possible the launching of a bay from up to a 28-foot vertical bank. This method should be used if no

other method of launching can be performed. Prior to launch a through inspection of the area should be made to ensure the bank will support the MK48/18 and bay to permit safe operation. A minimum of 17 inches of water is required for unfolding a bridge bay. Three Marines are required to launch a ribbon bridge bay using this method. An operator for the MK48/18, an assistant and a driver for the MK48 LVS.

(a) First take the bay off the truck and put it on the ground, place the bay parallel to the river.

(b) Connect winch hook to hook anchor on front locking assembly on the MK48/18 install a snatch block on the winch cable.

(c) Back up MK48/18 perpendicular to the shore side of the bay. Ensure that the rear of the MK48/18 is centered and within 20 inches of the bay.

(d) Tilt up and fully raise the mast assembly to approximately 107 degrees.

(e) Connect a four point lifting sling to the bay, and connect the snatch block to the sling.

(f) Lift the bay off the ground approximately 24 inches tilt the mast assembly down until the bay comes to rest against the platform ensure that all tiedown hook assemblies are open.

(g) Connect two lines one at each end of the bay for stability while moving the MK48/18, and receiving the bay with the bridge erection boats.

(h) Open up all foldlock latches and down stream end travel latch. Install latch pin (lanyard) in up stream travel latch.

(i) Back the MK48/18 to the edge of the bank and set the parking brake. Connect the up stream line to an anchor point or a bridge erection boat. Use the down stream line to steady the bay during launching.

(j) Lower bay into the water, move a bridge erection boat on the downstream side to hold the bay and remove the sling.

(k) Bring the up stream boat to the lanyard to release the roadway travel latch. Have bridge boats move clear of the unfolding area, then Pull the lanyard and the bay will unfold.

(2) <u>Control launch method</u>: The control launch is done much in the same manner as unloading or loading on firm ground.

(a) Two Marines are required to control launch a ribbon bridge bay; an operator for the MK48/18, and a driver for the MK48 LVS.

(b) Launch site selection: Optimal is a site that has, no more than 5 degrees side slope, no more than fifteen degrees fore and aft slope. Water depth must be at least 30 inches, however bays can be launched and will unfold in 17 inches of water if great care is taken. 11 feet aft of the MK48/18 the stream velocity must not be more than 5 feet per second.

(c) Position MK48/18 near launch site rear toward water

(d) Ensure all bilge plugs are installed

(e) Unlatch (interior bay only) two rear roadway/bow foldlock latches

(f) Unlatch two front roadway/bow foldlock latches

(g) Lock front tiedown hook assembly into launch position on both sides

(h) Lock rear tiedown hook assembly into launch position on both sides

(i) Back MK48/18 into water to appropriate launch depth

(j) Raise mast assembly to 10 degrees (if necessary)

(k) Unlock the hydraulic locking pin

(l) Winch out until front pin is located between the front and rear tiedown hook assemblies

(m) Unlock rear tiedown hook assemblies into the vertical position

(n) Winch out until the front pins are seated in the rear roller tiedown hook assembly

(o) Remove cable from cable guide on bay

(p) Winch in and tilt bed up until the bed is approximately 90 degrees

(q) Winch in lifting the bay out of the rear tiedown hook assemblies then winch out until the bay floats free of the MK48/18

(r) hold until the bridge erection boat can unhook winch cable and take control of the bay

(3) <u>Free launch method</u>

(a) Two Marines are required to free launch a ribbon bridge bay; an operator for the MK48/18, and a driver for the MK48 LVS.

(b) Launch site selection: Optimal is a site that has, no more than 5 degrees side slope, no more than fifteen degrees fore and aft slope. Water depth must be at least 36 inches, for interior bays and 44 inches for ramp bays measured 11 feet aft of the MK48/18 the stream velocity must not be more than 5 feet per second.

(c) Position MK48/18 near launch site rear toward water

(d) Ensure all bilge plugs are installed

(e) Unlatch (interior bay only) rear travel latch and two rear roadway/bow foldlock latches

(f) Unlatch two front roadway/bow foldlock latches and front travel latch

(g) Winch out cable, and remove cable from cable guide and lifting eye. Connect winch hook to chain on sliding beam assembly.

(h) Lock front tiedown hook assembly into launch position on both sides

(i) Lock rear tiedown hook assembly into launch position on both sides

(j) Back MK48/18 into water to appropriate launch depth

(k) Raise mast assembly to 10 degrees (if necessary)

(l) Unlock the hydraulic locking pin

(m) Observe the bay slide free of the MK48/18 into the water.

(4) Retrieving ribbon bridge bays

(a) Position MK48/18 near launch site rear toward water

(b) Put rear tiedown hook assemblies in vertical locked position

(c) Back MK48/18 into water to appropriate depth

(d) Raise boom to its full height 107^0

(e) Ensure the roadway ponton upper connectors are unlocked

(f) Ensure the roadway-to-bow ponton bridge latch is unlocked

(g) Ensure the front and rear roadway/bow foldlock latches are in the locked position

(h) Ensure the front and rear travel latches are in the locked position

(i) Maneuver the bay center of the MK48/18 hook the cable into the lifting eye

(j) Disconnect the bay from the bridge erection boat and clear the crew from the bay

(k) Winch in cable at a steady rate until bay is completely folded and latched.

(l) Winch in cable lifting bay 1-2 feet above rear tiedown hooks aligning the cable guide in the centering plate.

(m) Winch out cable lower until left and right front lockpins are seated in rear roller and tiedown hook assembly.

(n) Tilt the mast down while winching cable out until approximately the same angle as the bay

(o) winch out until cable can be fed through cable guide on the bay, feed the cable through the cable guide.

(p) Winch in until the front of the bay is over the front roller.

(q) Tilt mast down winch bay completely in, insert hydraulic locking pin

(r) Ensure the left and right front tiedown hook assemblies engage rear bay lockpins.

3. **BRIDGE ERECTION BOAT (BEB)**: The BEB is a transportable, hydrojet propelled, aluminum hull boat designed to maneuver components of floating bridges. It also can be used to move rafts, support diving operations, assist in maritime construction projects, serve as a troop and cargo carrier and patrol inland waters.

a. Capabilities:

(1) The BEB can safely carry 12 fully equipped Marines plus three crewmembers.

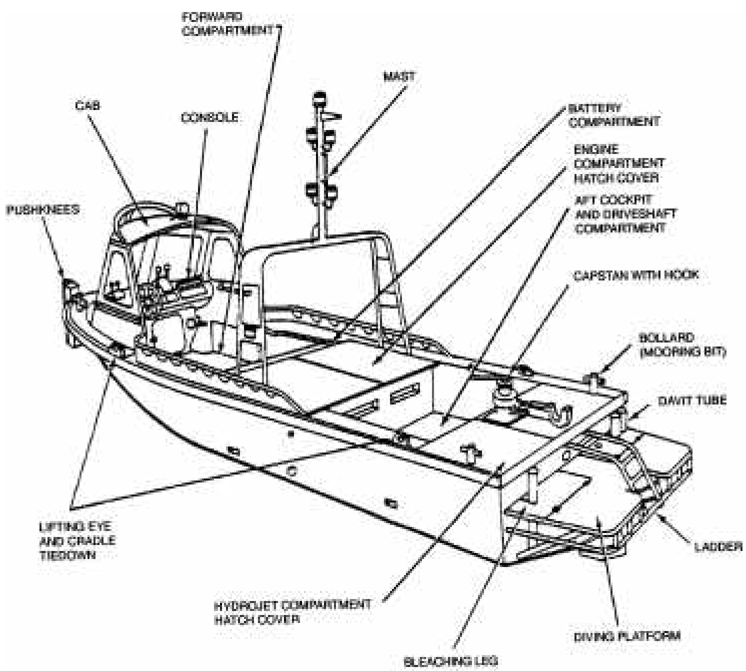
(2) It can rotate on its own axis at low engine speeds.

(3) It is all weather operational.

(4) It is transportable by rail, road, sea, and air.

(5) It has positive flotation.

b. Major Components of BEB:



(1) Cab. It is an aluminum frame with windows that provides cover for the crew during bad weather.

(2) Console. Contains all the control and indicators required to operate the boat.

(3) Pushknees. It provides the front of the boat with a flat vertical surface to push or maneuvering bridge components.

(4) Forward Compartment. Is where the crew and operator stand.

(5) Mast. Contains all of the lights to maneuver the boat at night, Navigation, towing, anchor and steaming lights.

(6) Battery Compartment. Has four 12-volt batteries to start and run the boat, a fuel tank master switch and hour meter.

(7) Engine Compartment. Has two 212 horsepower saber diesel engines that provides power to the hydrojets.

(8) Aft Cockpit. Is where the additional Marines are located when moving Marines from point A to point B.

(9) Capstan Handle with Hook. Provides the boat with a safe towing capability of 4000 pounds. It also has a quick release mechanism.

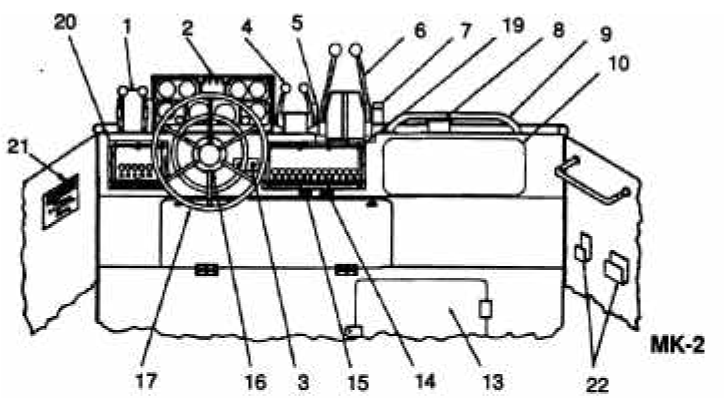
(10) Hydrojet Compartment. Contains the two hydrojets which propulsion units propel the boat and steer it.

(11) Bollard (Morning Bit). Is used to tie lines to the boat and to secure it to the dock.

(12) Beaching Legs. Support the boat in an upright position when it is not in the cradle.

(13) Keel Cooler. Provide cooling for the engine, transmission, oil, and turbocharged air and is located on the bottom of the boat.

c. <u>Forward Cockpit and Control Console</u>:



(1) Transmission Selector Lever. Allows operators to place individual gear in forward, neutral, and reverse positions.

(2) Engine Instrument Panel. Contains oil pressure gages, engine water temperature gages, engine tachometers, battery condition meter, ignition switches, and warning lights.

(3) Engine Alarm Mute Switches. Allows operator to turn off engine audible alarm. (Indicates low engine oil pressure or high water temperature.) On MK2 model switch is relocated to the left of switch panel unit 1.

(4) Engine Throttle Controls. Allows operator to control the revolutions per minute (rpm) of each engine.

(5) Cab Electrical Connector. Provides electrical connection for cab windshield wipers and searchlight.

(6) Scoop Control. Allows operator to control direction of output from hydrojet to obtain forward and reverse direction of boat. May also be used to assist in turning boat and controlling speed.

(7) Searchlight Socket. Provides electrical connection for searchlight when cab is removed.

(8) Searchlight Mounting. Provides mounting for searchlight when cab is removed.

(9) Handrail. Provides a safety rail.

(10) Map Locker. Provides stowage space for technical manuals.

(11) Storage Locker. Provides a lockable stowage compartment for life jackets and other equipment.

(12) Engine Stop Control, Starboard. Stops the starboard engine when pulled out.

(13) Engine Stop Control, Port. Stops the port engine when pulled out.

(14) Scoop Position Indicator. Provides a means for the operator to position the scoops for straight-ahead movement of the boat.

(15) Steering Wheel. Used to steer the boat.

(16) Switch Panel Unit 1. 12 circuit power panel contains electrical switches for cabin lights, inspection light, mast light, wipers (port and starboard), emergency battery link, and searchlight (MK2 only).

(17) Switch Panel Unit 2. 6 circuit power panel contains electrical switches for forward and aft bilge pumps, auto control of bilge pumps and horn (MK2 only). Engine room blower is not used.

(18) Caution Plate. Indicates to operator that hearing protection is required for noise pollution (MK2 only).

(19) Hatchet Bracket. To secure hatchet for emergency use (MK2 only).

d. Equipment Data

(1) Weights and Dimensions

(a) Operating

1	Weight, w/crew, equipment and fuel	8800 lbs (4000 kg)
2	Length	322.8 in (820cm)
3	Beam	98.0 in (249 cm)
4	Height	
	a w/o cab or mast	77.9 in (198 cm)
	b 0 w/cab	109.8 in (279 cm)
	c w/cab and mast	177.9 in (452 cm)

5 Draft

a w/crew, equipment and fuel 22.0 in (56 cm)

b fully loaded 26.0 in (66 cm)

(b) Transported, w/cradle

1 Weight 10800 lbs(4909 kg)

2 Length 326.4 in (826 cm)

3 Height w/o cab 96.3 in (244 cm)

4 Width 116.3 in (294 cm)

(2) Performance

(a) Speed, w/crew, equipment and fuel 21.6 mph(40km/hr)

(b) Speed, fully loaded 16.2 mph(30km/hr)

(c) Maximum load carrying capacity 4400 lbs(200 kg)

(d) Towing hook 4400 lbs(200 kg)

(e) Turning radius (with scoops at maximum thrust)

1 Full speed ahead 2 boat lengths in 15 seconds

2 Full speed astern 2 boat lengths in 25 seconds

3 one scoop forward and one scoop in reverse standing circle

(3) Fuel consumption (approximate)

(a) 1750 rpm 2.8 gallons/hour (11 liters/hour)

(b) 2000 rpm 4.2 gallons/hour (16 liters/hour)

(c) 2250 rpm 6.0 gallons/hour (23 liters/hour)

(d) 2450 rpm 10.8 gallons/hour (40 liters/hour)

1 Maximum forward thrust 3600 pounds (16 kN)

2 Maximum reverse thrust 2200 pounds (8.8 kN)

3 Maximum safe operating speed (No load governing setting) 2800 rpm engine

4 Capacity

a Fuel 75 gallons (280 liters)

(4) Engine Instrument Panel gauge readings:

(a) Tachometer

1 rpm idle speed 650 to 750

2 rpm operating speed 1000 to 2000

3 rpm maximum speed (under load) 250 rpm engine

(b) Oil pressure gauge

1 idle speed 20 to 30 psi

2 operating speed 40 psi or above

(c) Coolant temperature gauge (fresh water)

1 normal below 195 F

2 Overheating above 195 F

(d) Battery condition meter (eng. not running, no elec. load)

1 Battery fully charged 25.4 volts or above

2 Battery half charged 24.6 to 25.3 Volts

3 Battery fully discharged 23.7 volts or below

e. Pre Operational Checks: This is a necessity to ensure the boat is fully operational during the pre op check if you run across a condition that makes the boat not operational, do not stop your check, complete all checks so that if any other conditions exist they can be corrected at one time.

(1) Special Instructions:

(a) Leakage definitions:

1 Class I- Seepage of fluid (as indicated by wetness or discoloration) not great enough to form drops.

2 Class II- Leakage of fluid great enough to form drops but not great enough to cause drops to drip from the item inspected.

3 Class III- Leakage of fluid great enough to form drops and drop to the deck. This **deadlines** the equipment

NOTE

Equipment operation is allowable with minor leaks (class I and II). Consideration must be given to fluid level on the item/system being checked/inspected. When in doubt, notify your NCOIC. When operating with leaks continually check fluid levels.

(2) Conducting check: When conducting a check, the first thing to do is make a 360 around the boat to check the hull (if the BEB is in the cradle) and the body for dents, cracks or any damage that may cause an unsafe condition. Once the 360 is completed, start from the rear of the boat and work forward.

(a) Turn the steering control shaft grease cap 3/4 turn clockwise on port and starboard

(b) Turn the scoop control shaft grease cap 3/4 turn clockwise on the port and starboard.

(c) turn the aft grease cap 3/4 turn clockwise.

(d) Turn the forward grease cap 3/4 turn clockwise

(e) Check the forward bearing oil reservoir, it should be at least 1/2 full with no contamination.

(f) Check the hydrojet grill for debris.

(g) Make sure the capstan and hook rotates freely and has handle.

(h) make sure the tow hook quick release works and moves freely.

(i) Check water level in radiator, it should be 1" below cap.

(j) Check engine oil level- cold check.

(k) Check transmission oil level - cold check.

(l) Check drive belts, they should have no more than 1/4" play.

(m) Check the engine breather trap, make sure there is no oil present. if water is present drain.

(n) Make sure fuel water separator is free of water, if water is present drain.

(o) Check all three fire extinguishers on board, make sure glass on engine extinguishers is not broken and all three have not been discharged.

(p) Check fuel level, it should never be less than 1/4 full.

(q) Make sure battery cables are connected.

(r) Turn master switch clockwise until it stops.

(s) Check hour meter, annotate hours on conlog.

(t) Turn engine circuits on.

(u) Ensure audible alarm sounds when moved.

(v) Check battery condition, voltmeter should read above 25 volts.

(w) The generator warning light, and low oil pressure warning light should come on.

(x) Check the horn, make sure it sounds.

(y) Make sure transmission controls move in all positions.

(z) Steering wheel should move freely to right and left.

(aa) The engine throttle control should move freely forward and back.

(bb) The scoop control levers should move freely but not loosely.

(cc) Check anchor light, towing light, steaming lights and port/starboard navigational lights. Make sure lights are functional and all colors are correct.

f. Starting procedures under normal conditions:

(1) Turn the master Battery switch on by turning the switch clockwise until it stops.

(2) Set the throttle controls for half speed.

(3) Make sure transmission is in neutral.

(4) Push engine stop controls all the way in.

(5) Set the Engine circuit switches on.

(6) Push starter button on port engine until engine starts (approximately 10 seconds).

**** CAUTION ****
IF THE ENGINE FAILS TO START AFTER 30 SECONDS RELEASE THE STARTER BUTTON AND LET STARTER MOTOR COOL FOR 2 MINUTES

(7) After engine starts take finger off the starter button.

(8) Pull back on throttle lever until engine idles at 650-750 rpm.

(9) Start starboard engine using the same procedure.

(10) After both engines have been started move away from berth as soon as possible and run engines at 1800-2000 rpm until water temperature is 140-158 degrees Farinenheit.

g. During Operation Checks:

(1) Scoop controls: Operate scoop control levers all the way forward and back. scoop controls should operate freely but not loosely and within full range. Scoops should move with levers.

(2) Transmission: Operate transmission levers all the way forward and back. Levers should operate freely through the full range.

(3) Engine thrust controls: Operate throttle controls all the way forward and back. levers should operate freely and within full range.

(4) Steering wheel: Turn steering wheel to full port and full starboard verify that scoops tilt as wheel is turned. Steering wheel should turn freely through the full range.

(5) Hydrojet Grille: Open hatch cover on hydrojet compartment and secure in place. Loosen hand nuts, remove cover and check grilles for secure mounting, loose or damaged components and water passage for debris. Clean if required.

(6) Forward Oil Reservoir: Visually check that oil reservoir is at least half full and not contaminated.

(7) Capstan and Tow Hook: Check for presence of handle. Check that capstan rotates freely. check that drain holes are clear of foreign debris, check that the tow hook moves freely. Oil pins if sticking. check that spring is not rusted or weak. Check that lanyard is not worn or frayed. Check that the tow hook is not bent or cracked.

(8) Hour Meter: Be sure hour meters are operational.

(9) Fuel tank: Check level in fuel tank with dipstick.

(10) Horn: Press the large button keep your finger on the button and the horn should continue to sound.

(11) Lines Check lines for frayed spots and breaks.

NOTE

The during operations check will be done after the boat is started and has been operated for at least 10 minutes after the boat is warmed up.

**** NOTE ****

THE BEB SHOULD NOT BE OPERATED OUT OF THE WATER FOR MORE TAN 20 MINUTES, OR OPERATED IN THE WATER FOR MORE THAN 20 MINUTES IN NEUTRAL

h. Maneuvering:

(a) General: Basically the BEB is a small scale tug boat equipped with two 363 cu inch diesel engines which power two individual hydro jets. The Hydro jets provide thrust to move and steer the BEB. Water is drawn through the grilles in the underside of the boat and expelled through nozzles mounted in the back of the boat. The force with which the water is expelled depends on the speed of the engine. The transmission will be in either the idle or forward positions when maneuvering and is only placed in reverse to clear debris out of the scoops.

(b) When the transmission is in forward and the scoop control levers are forward the jets direct water straight behind the boat causing the boat to move forward. When the scoop control levers are pulled all the way back the jets direct water under the boat in the direction of the bow causing the boat to move backward. When the scoop control levers are in the middle the jets direct the water straight down causing the boat to hold its position.

i. Shutting down the BEB:

(1) Allow the engine to idle for at least one minute.

(2) Pull out the stop engine controls.

(3) Turn off the engine circuit switch.

(4) Turn off the battery master switch by turning it counterclockwise until it stops.

(5) conduct after operations check

j. Emergency Procedures:

(1) Man Overboard:

(a) Sound off "MAN OVERBOARD" until the operator acknowledges you.

(b) Immediately stop the boat and kill the engines to listen. All Marines onboard will turn their attention to locating the lost Marine.

(c) Pick up lost Marine. If lost Marine can not be immediately found the boat operator and assistant boat operator will identify a reference point (this can be a tree, buoy or a chem light anchored to act as an expedient buoy) and an 8 digit grid coordinate

(d) Radio for help or fire signaling devices

(e) Move and Listen Move the BEB downstream periodically killing the engines and conducting listening searches. This will be done for approximately one mile.

(2) Fire: The BEB has two automatic fire extinguishers in the engine compartment and since most fires will be located in the engine compartment the extinguishers will take care of the problem. in the event that there is a fire and the automatic extinguishers fail to handle it the boat operator will be responsible for determining whether to fight the fires with portable extinguishers or evacuate the boat.

(3) Capsizing:

(a) The boat operator will get a head count.

(b) Give distress signal (with signaling devices or hand and arm signals)

(c) Keep Marines calm and close to the BEB until help arrives.

(4) Raft Commander Responsibilities:

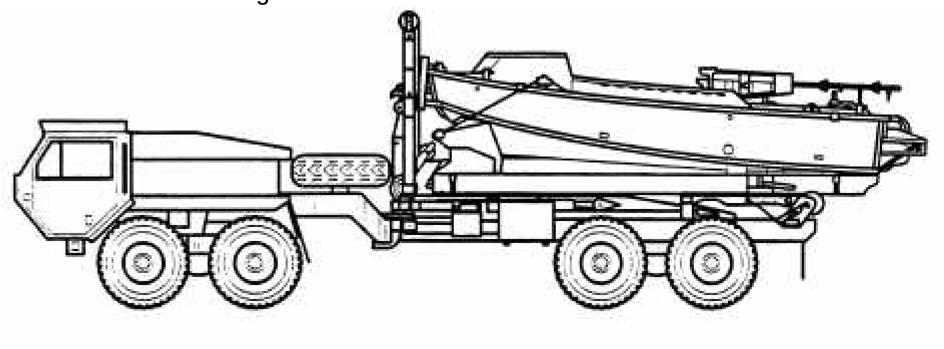
(a) Maneuvering the raft safely.

(b) Making sure the bays are connected properly.

(c) Making sure the boat operator understands all signals that you might be given from time to time.

(d) When bringing the raft to the near shore back the raft in so you can have the vehicle drive on the ramp and off load easier on the far shore.

2. **MK48/18 Ribbon Bridge/Container Hauler**: The MK48/18 LVS is designed to self-load, transport, and self unload standardized containers or ribbon bridge systems. Additionally, the MK48/18 can be utilized to self-load/unload a bridge erection boat and cradle assembly, it's also used for high-bank launch operations of ribbon bridges.



a. **Configuring**: Configuring consists of installing the appropriate SL-3 equipment in the proper positions to receive the boats or bays onto the MK48/18.

(1) There are 41 steps to Configuring the MK48/18 for bridge erection boats the configuration is outlined in TM 2320-10/11 SUPPLEMENT-1. Always use the TM to configure the MK48/18 or **DAMAGE TO EQUIPMENT OR PERSONNEL WILL RESULT.**

b. Launching the BEB:

(1) Remove all the tie downs before the MK 18 is backed into the water.

(2) Make sure to double check that the bilge plug is in place.

(3) If launching in current remove downstream aft stanchion.

**** NOTE ****
BEB CAN BE STARTED AT THIS TIME, BUT SHOULD ONLY BE OPERATED OUT OF THE WATER FOR NO LONGER THAN 20 MINUTES.

(4) When cradle is lowered and boat stern is floating the operator will put the transmission in forward.

(5) Idle forward until retaining cables slacken, under some conditions turning the wheel to one side or the other will provide additional slack.

**** NOTE ****
BE CAREFUL NOT TO REMOVE SADDLE, THE CABLES WILL NOT SLACKEN AND DAMAGE TO BOAT AND CRADLE WILL RESULT.

(6) At this point the crew will unhook the cable hooks from the lifting point shackles and place hooks in the forward stanchion eyes.

**** NOTE ****
MAKE SURE CABLES ARE ON INSIDE OF REAR STANCHION TO PREVENT DAMAGE TO FORWARD STANCHIONS AS CRADLE IS RETRIEVED.

(7) The boat operator will then put scoops in reverse (make sure wheel is on 0) and back out of cradle.

(8) The crew can raise the mast to its upright position now.

<u>REFERENCE(S)</u>:

1. FM 5-34\MCRP 3-17A   Engineer Field Data

2. FM 5-466   Military Nonstandard Fixed Bridges

3. TM 08676A-10/1-1   Medium Girder Bridge

4. FM 90-13/MCWP 3-17.1   River Crossing Operations

UNITED STATES MARINE CORPS
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C-01A30
27 Jun 00
(98 POI)

STUDENT HANDOUT

NONSTANDARD BRIDGES

LEARNING OBJECTIVE(S)

1. TERMINAL LEARNING OBJECTIVE(S): Given a nonstandard bridge construction plan and task organized equipment and personnel, with the aid of references, supervise the construction of a nonstandard bridge in accordance with FM 5-446 and FM 5-34\MCRP 3-17A. (1302.1.22)

2. ENABLING LEARNING OBJECTIVE(S)

a. Given a design for a nonstandard bridge and a site layout, describe the construction sequence for a nonstandard bridge in accordance with FM 5-446 and FM 5-34\MCRP 3-17A. (1302.1.22a)

b. Given a nonstandard bridge construction plan, with the aid of references, determine the equipment required in accordance with FM 5-446 and FM 5-34\MCRP 3-17A. (1302.1.22b)

c. Given a nonstandard bridge construction plan, with the aid of references, identify the quality control required in accordance with FM 5-446 and FM 5-34\MCRP 3-17A. (1302.1.22c)

OUTLINE

1. NONSTANDARD BRIDGES:

a. The term nonstandard is used to identify bridges constructed from raw materials, and designed to satisfy the requirements of a particular site.

b. The advantages of nonstandard bridges:

(1) Versatile.

(2) Materials are readily available.

(3) Easy to erect and construct.

2. NOMENCLATURE OF NONSTANDARD BRIDGE:

a. The two major components of the nonstandard bridge are superstructure and substructure. The substructure will be covered first.

b. The substructure consists of the foundations or the parts of the bridge that support the superstructure.

c. In the substructure there are two kinds of supports; End Supports which are called abutments and Intermediate Supports which are called Bents or Piers. Substructure - consists of the transverse support for the superstructure. The substructure takes the load from the superstructure and supports to the ground. (See FM 5-446, PAGE 7-7)

d. End Supports: these are called abutments and are found one on each end of the bridge. There are two end supports.

(1) Timbersill Abutment:

(a) Is the simplest type of end support.

(b) Most commonly used.

(c) Used where you have a good solid or firm foundation.

(d) Constructed no closer than 3 feet from embankment.

(e) Consisting of:

1 Footings to distribute the weight to the ground. Minimum size 3" x 12". Minimum of 4.

2 Sill to distribute the weight of the footings, minimum size is a 6" x 8", largest dimension placed horizontal to the footings and ground.

3 End dam to prevent approach road from caving in between stringers. Minimum size 2' x 10".

(2) Combination Pile Abutment and Retaining Wall: (See FM 5-446, PG 7-8)

(a) Used when poor soil conditions, both embankment and gap, exists.

(b) Consists of:

1 Piles, creosote material, minimum 8" in diameter measured from the butt end up 1/3 the length of the pile. Minimum of 4.

2 Cap transmits load from stringers to piles. Minimum size is 6" x 8" with largest dimension placed vertically.

3 Retaining wall prevents lateral movement of earth. Minimum size, 2" x 10" material.

4 Wing piles support the retaining wall.

3. INTERMEDIATE SUPPORTS: Ground supports between the abutments. There are five intermediate supports. (May be timber, steel, concrete, or a combination of material, they may be supported by footings or piles)

a. Timber Trestle Bent: (See FM 5-446, Page 7-40)

(1) Is the simplest type of intermediate support.

(2) Used where you have a good solid or firm foundation. (Not suitable for use in soft soil or swift or deep streams)

(3) Consists of:

(a) Footings to distribute the weight to the ground, minimum size material 3" x 12". Must be at least as many as post.

(b) Sill to distribute the weight to the footings, minimum size material is 6" x 8".

(c) Post to transmit the load from cap to sill. Accounts for bridge heights. Minimum size material is 6" x 6", minimum number of post 4.

(d) Cap to transmit load from stringers to post, minimum size material is 6" x 8".

(e) Drift pins used to fasten the cap and sill to the post. When using drift pins you must have a Pilot hole. The Pilot hole must be 2/3 the diameter of the drift pin, and 3 inches shorter than the pin.

(f) Scabbing would be used when drift pins are not available. Scabs are 2" x 10" material minimum. The length of the scab is 2 x the depth of the cap or sill, and must be used on both sides of the bent where possible.

(g) Transverse bracing to provide lateral stability. Used when bent is 4 feet or higher, minimum size material is 2" x 10".

(h) Longitudinal bracing provides stability from bent to bent and is placed on the outside of the bent. The minimum size material used is 2" x 10". (When spacing between bents exceeds 25' bracing become cumbersome to provide greater support and longitudinal stability for longer spans, use timber-trestle piers.)

b. Timber Trestle Pier: (See FM 5-446, PAGE 7-40/7-60)

NOTE: THE DESIGN OF THE TIMBER TRESTLE PIER IS IDENTICAL TO THE BENT DESIGN EXCEPT FOR THE CAP AND CORBEL SYSTEM.

(1) Used when both adjacent spans are over 25 feet or the load is too heavy for a timber trestle bent.

(2) Used where you have a good solid or firm foundation.

(3) Consists of:

(a) Two timber trestle bents framed together.

(b) Footings: There must be at least as many footings as post, minimum size material is 3" x 12".

(c) Sill distributes weight to the footings from post, minimum size material is 6" X 8".

(d) Post transmits load to sill from cap, and accounts for the bridge height. Minimum of 4 post per bent, minimum size material is 6" x 6".

(e) Cap transmits load to the post from stringers. Minimum size material is 6" x 8".

(f) Transverse bracing to provide lateral stability. Used when pier is 4 feet or higher, minimum size material is 2" x 10".

(g) Cross bracing required at all times, for longitudinal stability.

(h) Corbels transfers load to caps from common cap. Minimum equal to number of post in a single bent or more. Minimum size material is 6" x 8".

(i) Common cap transfers load to corbels from stringers. Minimum size material is 6" x 8".

c. Pile Bent (See FM 5-446, PAGE 7-41)

(1) Used in soft or marshy ground, deep water, or swift current.

(2) Consists of:

(a) Piles made of creosote material that are a minimum of 8 inches in diameter which is measured from the butt end up 1/3 the length of the pile. Minimum number of piles is 4.

(b) Cap transmits load from stringers to piles. Minimum size material is 6" x 8".

(c) Transverse bracing provides lateral stability, and is used when the bent is 11 feet above ground level. Minimum size material is 2" x 10", bolted on.

(d) Longitudinal bracing provides stability in the outside of the bents.

NOTE: PILES ARE DRIVEN WITH THE DROTT 30 CRANE WHICH HAS A DROP HAMMER WITH PILE DRIVER LEADS.

d. Pile Pier: (See FM 5-446, PAGE 7-41)

(1) Used when both adjacent spans are over 20 feet long or the load is too heavy for your pile bent.

(2) Used where you have soft or marshy ground, deep water or swift currents that are likely to scour. (See FM 5-446, PAGE 7-47)

(3) Consists of:

(a) Two pile bents framed together.

(b) Piles, creosote material, minimum of 8 inches in diameter measured from the butt end up 1/3 the length of the pile. Minimum of 4 piles per bent.

(c) Cap, transmits load to piles, minimum size material is 6" x 8".

(d) Transverse bracing, used when height of pile is 11 feet above ground level or higher. Minimum size material is 2" x 10".

(e) Corbels, transfers load to caps from common cap. Minimum of four per pier, and minimum size material is 6" x 8".

(f) Common cap, transfers load to corbels from stringer. Minimum size material is 6" x 8".

(4) Capping and Cutting of Piles:

(a) Pile must be a minimum of 8" in diameter at the butt end.

(b) Must be shaved off at 45 degree angle at butt end.

(c) When the piles go into the ground they all will not be the same height. Nail a timber across the piles where you need to cut them off. This will act as a guide. Then take chain saw with blade on its side and cut off level.

(d) Before you drive piles into the ground, you should take the diameter of the pile at the top and come down one diameter from the top, and wrap 10 to 12 wraps of number 12 wire around the pile. This will stop the mushroom effect of the top of the pile.

e. Crib Pier: (See FM 5-446, PAGE 7-39)

(1) Considered to be strongest and most versatile of all intermediate supports.

(2) Used on land or in water.

(3) Easy to erect but requires more timber, time and labor.

(4) Built from freshly cut logs that are a minimum of 6 inches in diameter. Logs are notched 1 foot back from each end.

(5) Built on land and launched into stream on rollers, floated into position and filled with rocks to provide weight and stability. Therefore, bottom has to be built solid.

(6) To determine width of base; take 1/3 of the desired height of pier and use that as base width.

(7) To determine length of base; take 1/3 of the desired height of pier plus roadway width plus 2 feet, will give you the base length.

4. <u>THERE ARE TWO TYPES OF SPANS</u>:

a. Simple Span: Extends from one intermediate support to another.

b. Continuous Span: Extends from abutment to abutment over intermediate supports without a break.

5. <u>SUPERSTRUCTURE</u>: Consists of stringers, decking, curb and handrail system. We will take each separately.

a. Stringers: Longitudinal member resting on and spanning the distance between intermediate supports or abutments. In most cases the stringer is the most critical member of the bridge.

(1) Timbers in excess of 20 feet are difficult to obtain because the capabilities of the Marine Corps Lumber Harvester is limited to 20 feet. In the theater of operations we try to limit span length to 18 feet.

(2) Usually try to use softwood because of the weight factor involved, either DOUGLAS FIR or YELLOW PINE.

(3) If a timber used is too narrow, lateral buckling may occur. Lateral buckling is when a beam is compressed in the upper portion and a

twisting action occurs. If the width of the timber will divide into the height of it more than 2, then lateral bracing will be required.

b. Steel:

(1) There are many types of steel stringers available in the U.S. I-beams come in two different shapes: wide flange (W-shape) and American standard (S-shape] beams.

(2) W - shape beams have essentially parallel flange surfaces and are the most common shape used in bridge construction. W-shape beams are most economical when moment controls the span. S-shape beams have flanges that are sloped towards the edges and have a larger web area than W-shaped beams. S-shape beams are more economical when shear controls the design of the span.

(3) There are also two types of steel beams. There is Rolled beams and Built-up beams. Rolled beams are beams that have been poured as a solid single piece. Built-up beams are beams that have their webs and flanges welded together.

(4) The biggest advantage steel has over timber is span length.

(5) The disadvantages of steel are:

(a) Lifting equipment and a welder is always needed.

(b) Lateral bracing is always needed because moment design of steel beams consists of selecting beams which satisfy the required tension and compression loads. However the beam may fail even though these stresses are not exceeded because of lateral buckling. Beams are proportioned so that the moment of inertia about the principal axis normal to the web is considerably larger than the moment of inertia about the other axis. The moment of inertia is an index of the beams ability to resist bending. This is done to produce shapes that make economical beams. The I-beam was selected because of the stress induced during simple tension on the bottom and compression on the top of the beam. The flanges of the steel beam resists compression and tension. The web serves to separate the flanges and provides shear resistance. The top flange, when in compression, acts like a loaded, slender column that buckles in the weak direction if not laterally braced. The tendency for lateral buckling in steel beams increases in direct proportion to the span length and the depth of the beam, and decreases as the area of the flanges increase.

(c) Steep stringer bearing failures; when steel stringers are placed on top of the cap or sill of the substructure, a bearing failure will result if there is insufficient area to carry the load. The two types of bearing failure are:

1. Web crippling: Web crippling occurs if the seat is insufficient. Sufficient area is especially critical when the stringer rests on timber or concrete, since these materials have lower bearing stresses than steel. A minimum seat of 6" prevents web crippling in a standard, rolled beam, but not in all cases.

2. Flange failure: Flange failure occurs if the flange is too thin. To prevent crushing or flange failures, always design bearing plates for steel stringers.

(d) Bearing plates. The final dimension of the plate over an intermediate support depends on the stringer arrangement. Connect the stringer to the support with an anchor bolt through the bearing plate and the flange. Slots the hole through the flange to provide a free end connection that allows for expansion due to temperature changes. You may also weld stringers to the bearing plates. Always allow one end of the stringer to move freely in the longitudinal direction to allow for expansion, but restrain it from lateral movement.

(e) End bearing stiffeners: End stiffeners are not normally required for standard, rolled shapes unless abutment or intermediate support dimensions restrict the length of the bearing plate. If end bearing plates are required, construct them of angles or plates on each side of the stringer web. Position them over the center of the bearing at the end of each stringer. Proportion them to transmit the load to the web of the stringer. Mill the top and the stiffener to bear against the flanges of the stringer and extend as closely as possible to the edges of the flange. End bearing stiffeners are always designed for build-up beams.

(f) Nailing strip: A nailing strip is required if you are going to employ plank or laminated decking. The expedient methods are by using nails. In the first method nails are driven into the decking on the underside and then bent under the existing stringer flange to prevent lateral movement of the decking. The second method, nails are driven into a timber member, placed length-wise on top of the stringer, then bent under the flange as in the first method. This is done before stringer placement, and when decking begins, the deck is simply fastened to this member with nails. Another method is to have the welder burn holes for the placement of bolts. Care must be taken when doing this as to not weaken the flange.

(g) Decking: There is two types of decks. One is plank decking, the second is laminated decking. The rule of thumb is that you never have a deck that is less than 3" thick. this is because the deck serves a structural role.

<u>1</u>. Plank decking: Use deck planks made from dimensioned lumber having a thickness equal to or greater than the required deck thickness. If available deck material is not thick enough, layer planks until the required thickness is achieved, plus an additional 2". the extra 2" compensate for shear between the plank layers.

<u>2</u> Placement of multiple layers; The first layer is placed perpendicular to the bridge centerline. The first board and every fifth board is extended 5' on each side of the bridge for placement of the handrail system. All planks are laid with a minimum of 1/4" space between them to allow for drainage and air circulation. The second layer is placed at a 30 to 45 degree angle to bridge centerline. Any additional layers are placed at an opposite 30 to 45 degree angle from the layer below it.

<u>3</u> Laminated deck: When the required plank deck thickness exceeds 6", consider using laminated decking. Normally, large stringer spacing and high design classifications require a thick deck. Although layering strengthens plank decks, they are not as stiff as laminated decks.

<u>a</u> Construction of laminated deck: Place planks vertically to create a laminated deck. This type of deck distributes the live load more efficiently. The percentage of lamination will be determined by the design class, but the deck can be prefabricated in 24" wide panels that are long enough to cover the roadway. The maximum spacing between members in a laminated deck should not exceed 10". (3) Wearing surface: Since the deck is designed to distribute the load to the stringer system, the deck must not be worn away by traffic. Install a wearing surface to prevent wear. On timber deck bridges, the wearing surface consists of 2" or 3" thick timber tread. The most common timber used is 2" x 12" planks. On one lane bridges, the

tread is limited to the path of wheels or tracks. The tread fully covers the deck on two lane bridges.

4 Curbs: A curb system guides traffic on the bridge. For timber trestle bridges, place 6" x 6" timbers on 5' centers on the curb risers. Risers of 6" x 12" x 30" material provide an adequate curb system. Rigidly attach curbs to the decking. The curb system will not withstand the impact of a heavy vehicle out of control. To design such a system would required curb system of excessive size and cost.

5 Handrails: You may include a handrail system when designing your bridge. The minimum size handrail post is a 4" x 4" x 40" post, that is attached to the curb riser. The knee brace and the handrail are 2" x 4" material.

6. EQUIPMENT REQUIRED: Listed below is some of the equipment that you will need, you may need more or less depending on your bridge construction requirements. Operators are always requested for any equipment that is needed.

a. 7 1/2 Ton Crane

b. See Tractor

c. Tram (Forklift)

d. D7G Tractor (Bulldozer)

e. 621B Scraper

f. 130G Grader

g. 420C Compactor

h. 250 CFM

i. High Speed, High Mobile Crane 25 ton w/ Pile Driver

j. Pioneer and Carpenters Kits.

k. Survey Kit

7. CONTROLLING FUNCTIONS:

a. Supervision: Supervision is the direction and control of subordinates; that is, telling people what to do, then making sure they do it. There are three steps in the supervision process.

(1) Set Objective Standards. The key word in this step is "objective". The standard which is set must mean the same to both subordinates and supervisor. In construction, standards of percentage completion are often vague. For example, if a unit was directed to have the construction of six concrete slabs 50 percent complete by a certain date, should it have three slabs complete or forms set for all six? This problem can be avoided by directing the unit to complete specific activities in a detailed CPM network.

(2) Measure Performance. Performance can be measured either by inspection or by report. These control devices will be further discussed.

(3) Make Adjustments. If performance does not meet standards, adjustments can be made in two ways: either improve performance or lower standards. Most of the time improving performance is appropriate. At times, however, the supervisor may face a situation where the standard becomes unrealistic; for example, a schedule is based on poor estimates or fails to reflect delays. In these cases, the supervisor must be able to adjust the schedule or be given additional resources.

b. Quality Control: The control of construction quality in theaters of operations is the responsibility of the project supervisor. Quality control includes planning, designing, and monitoring the construction process to achieve a desired end result. During the planning phase, control is achieved by the proper application of network analysis (CPM), scheduling, and estimating. Designing a project for quality involves choosing the proper configuration, material, equipment, and personnel to achieve the construction. The construction monitoring steps require adherence to standard procedures of construction, established supervision practices, and accepted testing methods. Quality control in military construction is needed for many reasons. The basic objective of quality assurance, however, is to provide a safe, functional, and enduring project with an acceptable appearance.

c. Special Considerations: The preparations of complete drawings is necessary when standard designs are not suited to conditions at the construction site. The work of preparing drawings should not begin until a thorough exploration of subsurface conditions has been made. The preparation of accurate, neat, and complete drawings, fully describing what is to be built and how it is to be built, will not only insure a satisfactory structure, but will save construction time.

d. Elevation and Profile: The bridge elevation and profile view is an important part of the design drawings. This view should show the entire structure in elevation in skeleton form, together with the ground profile along the centerline of the bridge. It should be drawn to an accurate scale both horizontally and vertically.

e. Details: Span lengths of various structural units should be given, as well as the overall length of the bridge. No effort need be made to show complete details of the structure in this view in as much as the scale of the view necessarily will be small to show the overall picture. This view, however, should be used to show identifying piece marks of the various structural elements, such as piers, abutments, and spans, which are to be drawn in greater detail elsewhere.

f. Steel Spans: In the case of steel spans, one end of the span should be fixed to the substructure, and the other end should be an expansion end, free to slide or move horizontally with temperature changes. The fixed end of a particular span is the end at which the longitudinal breaking and traction forces will be resisted. Therefore, at these points, the substructure must be designed to transmit these forces to the foundation.

g. Foundation Plan: This plan should show the outline of all footings, if any used to support piers and abutments. This plan should be drawn to scale, since it is the plan which will be used first by field construction forces.

h. Cross Sections: A cross sectional view of the superstructure roadway should be drawn to a scale sufficiently large to show all details accurately.

i. Approaches and Access Roads: To provide access to the bridge location, high priority should be given to the construction of approach and access roads to permit early delivery of equipment and supplies. Such roads are often temporary in nature, are hastily located, and built with immediately available construction equipment and labor. Certain features of approaches are important because they may affect the traffic capacity and useful life of the bridge. These are horizontal alignment, grades, approach embankments, sight distance, traffic movement and character of roadway surface.

(1) Horizontal Alignment: Sharp curvature at bridge approaches should be avoided. They make turning of long vehicles difficult and require reduced speeds.

(2) Grades: Steep grades reduce sight distance and also increase rolling resistance.

(3) Sight Distance: Sight distance at bridges should be sufficient to permit drivers to observe the full length of the structure from either approach.

8. ERECTION PROCEDURES:

a. Erection From Ground With Crane: Where ground site conditions permit, long span bridges of moderate height can be erected most easily from ground level or from rafts. A medium-sized crawler-mounted crane is more maneuverable than truck mounted cranes and can be operated over rougher and softer ground. Erection of the superstructure from the ground is as follows.

(1) If two cranes are not available, a gin pole is erected at the abutment end for use in raising one end of each of the outside stringers. Lines are attached from the gin pole and from the crane, to raise each outside stringer into position.

(2) Interior stringers are raised in the same manner until all are in place.

(3) Bracing is installed if needed. Then the deck is laid to the near shore abutment.

(4) The gin pole is moved to the end of the completed span and the procedure starts all over again.

b. Erection From Bridge Deck:

(1) Guide: Bridges consisting of a number of relatively short spans can be erected from deck level, and from a standpoint of economy of material, labor, and time, this is the best method for such structures. A medium sized truck mounted crane is appropriate for this work.

(2) Spans Supported On Pile Bents: Erection of shore spans on pile bents proceeds on the following manner:

(a) Materials and fabricated parts from the fabricating yard are delivered to the bridge within reach of handling equipment.

(b) The pile bent constructed with the crane on the abutment.

(c) Stringers for the first span are set in place with their ends on the abutment and the first bent.

(d) Deck planks are laid across the stringers and secured.

(e) The crane is moved out over the deck to the first bent. The second bent is driven and completed. This procedure is repeated until the far abutment is reached.

(f) As the crane is moved off each span, tread planks and curbs are installed and walkways and handrails are completed.

(3) Spans on Pile Piers: Procedure for erecting bridges with shorter stringer spans on pile piers is similar to that for bridges with pile bents. It is necessary to reach and construct only the nearest bent of the forward pile pier before a span can be placed temporarily and the crane moved out on the structure.

(4) Spans on Timber Trestle Bents: Foundations for timber bents are usually constructed in advance and the erection of the bents proceed as follows.

(a) Foundation sills, although framed with bents, are set separately and anchored to posts with scabs or drift bolts, or to footings with anchor bolts.

(b) The first bent is delivered to the crane in assembled form, and is placed by the crane on a previously anchored sill. The bent is carefully guided with tag lines, and bents more than one story high should be set one story at a time.

(c) The bent is braced with final or temporary bracing. Anchor bolts are tightened.

(d) The stringers are set and the deck is laid.

(e) The crane is moved out onto the structure.

(f) Temporary bracing holding the first bents are removed.

(g) Final bracing is then installed.

(h) This procedure is repeated until the far abutment is reached.

(i) As the crane is moved off of each span, tread planks and curbs are installed, walkway and handrails are completed.

9. NONSTANDARD BRIDE TERMINOLOGY

a. Moment - when a simple beam is loaded, it deflects or bends. The horizontal fibers in the lower part of the beam are lengthened due to tensile forces, while the fibers in the upper portion of the beam are shortened due to tension in a moment failure.

b. Shear - this is two forces acting in opposite directions. Most critical point for shear is within one fourth the length from either end of the span.

c. Kip - term representing 1000 pounds.

d. Live load - the live load consists of the weight of the vehicles moving across the bridge.

e. Dead load. the dead load is the weight of the bridge itself.

f. With the aid of the draft change to FM 5-34, we can design a nonstandard bridge constructed of wood or steel.

NOTE: ON PAGE B-2 OF FM 5-446 ARE NOTATIONS AND EXPLANATION OF SYMBOL USED.
DESIGN SUPERSTRUCTURE OF A TIMBER TRESTLE BRIDGE USING STEEL STRINGERS

With the listed information below and the use of the FM 5-446, page B-5 each step of design will be explained with examples so you as a student will correctly design a Timber Trestle Bridge.

B-5 NOTATIONS

Ag -ground-contact area, in square inches
b -stringer width, in inches
b_c -cap width, in inches
bft - width of the footer, in inches
bp - plate width
bR -curb-to-curb roadway width, in feet
d -stringer depth, in inches
dc -cap depth, in inches
dco -corbel depth, in inches
D -pile diameter, in inches
Ed - hammer impact energy, in ksi
fbDL -allowable dead-load stress, in ksi
f -soil friction coefficient
fk -safe soil bearing pressure, in ksf
FBf -footing capacity (bearing)
h -height of hammer fall, in feet
hb -bent height, in feet
L -span length, in feet
Lco - corbel length, in feet
Lf -footing length, in feet
Lg -length of pile in the ground or soil layer, in feet
Lm -maximum span length, in feet
Lp -plate length, in inches
m -total bending moment per stringer, in kip-feet
mco -moment capacity per corbel, in kip-feet
mDL -dead-load bending moment per stringer, in kip-feet
mLL -live-load bending moment per stringer, in kip-feet
MDL -dead-load bending moment for entire span, in kip-feet
MLC -military load classification
MLL -live-load bending moment per lane, in kip-feet
MLL1 -live -load bending moment for one-lane traffic
MLL2 -live-load bending moment for two-lane traffic
Nb -number of braces
Nco -number of corbels
Ne -effective number of stringers
Nf -number of footings
NL -number of lanes
Np -number of posts or piles per bent
Npe -equivalent number of posts or piles
Npr -required number of posts or piles
NR -number of rows (bents)
Ns -number of stringers
N1 -effective number of stringers for one-lane traffic
N2 -effective number of stringers for two-lane traffic
P -total design load
Pp -pile penetration, in inches per blow
PLC -provisional load classification
Ppc -post capacity, in ksi
R -rise of the arch, in feet

S   -section modulus, in cubic inches
Sb   -brace spacing, in feet
SBC -soil bearing capacity
Sco -corbel spacing, in inches
Sf   -footing spacing, in inches
Sp   -post or pile spacing, in inches
Spm -maximum post spacing, in inches
Ss   -center-to-center stringer spacing, in feet
tc   -crown thickness, in inches
td   -deck thickness, in inches
teff -effective deck thickness, in inches
tf   -flange thickness, in inches
tft -thickness of footer, in inches
tp   -plate thickness, in inches
tr   -required deck thickness, in inches
tw   -web thickness, in inches
tx   -thickness factor
v   -total live-load shear per stringer, in kips
vco -shear capacity per corbel, in kips
vLL -live-load shear per stringer, in kips
vDL -dead-load shear per stringer, in kips
Vr   -required shear per stringer, in kips
VDL -dead-load shear for entire span, in kips
VDL1 -dead-load shear for one-lane traffic, in kips
VDL2 -dead-load shear for two-lane traffic, in kips
VLL -live-load shear per lane, in kips
Wh   -hammer weight, in kips
Ws   -stringer weight, in kips
XL   -footing length factor
XPL -plate thickness factor
%lam -percent of lamination

Rapid Field Design

Timber-Stringer Superstructure Design

Bridge Dimensions		Stringer Dimensions	
L(ft)	17	Type: Timber	
MLC	70	b (in)	?
NL	2	d (in)	?
bR (ft)	23		
m			

Procedure

Step	Formula	Considerations	Example Calculations
1	$Ns = \frac{bR}{6} + 1$	Minimum of four required	$Ns = \frac{23}{6} + 1 = 4.83$ stringers (Round answer to 5 stringers)
2	$Ss = \frac{bR}{Ns-1}$		$Ss = \frac{23}{5-1} = 5.75$ feet
3	a. One lane $Ne1 = \frac{Ns}{Ss} + 1$ b. Two lane: $Ne2 = \frac{3}{8}(Ns)$		a. One lane: $Ne = \frac{5}{5.75} + 1 = 1.86$ stringers b. Two lane: $Ne2 = \frac{3}{8}(5) = 1.87$ stringers
4	MLL per lane: a. Wheeled b. Tracked	Figures A-1 and A-2 Pg A-17 (Use the larger value for remaining design procedures).	a. Wheeled: 260 kip-feet b. Tracked: 340 kip-feet
5	$mLL = \frac{MLL}{Ns}$		$mLL = \frac{340}{5} = 68$ kip-feet
6	MDL	Table A-1 pg A-14 Estimated. If the bridge is two-lane, determine any width adjustment required.	MDL = 37.36 kip-feet
7	$mDL = \frac{MDL}{Ns}$		$mDL = \frac{37.36}{5} = 7.47$ kip-feet
8	m = mLL + mDL	The required moment capacity must be less than the actual moment capacity of the selected stringer (Table E-2). pg E-4	m = 68 + 7.47 = 75.47 kip-feet m for 12x14 = 78.40>75.47; except span length is to short 16.7' you need 17' 10 x 16 =85.30 > 75.47

Step	Formula	Considerations	Example Calculations
9	VLL per lane a. Wheeled b. Tracked	Figures A-3 and A-4 . pg A-18 Use the **larger** value for remaining design procedures.	a. Wheeled: 71 kips b. Tracked: 77 kips
10	$vLL = \frac{0.1875VLL(Ne+1)}{Ne}$	For one-lane class, use Ne1. For two-lane class, use smaller value of Ne1 and Ne2.	$vLL = \frac{0.1875(77)(1.86+1)}{1.86} = 22.19$ kips example: $\frac{0.1875x77x2.86}{1.86} = 41.29 = \frac{41.29}{1.86} = 22.19$ kips **rd up 22.20**
11	a. One lane: VDL1 = VDL b. Two lane: $VDL2=(VDL)\frac{bR}{24}$	VDL from Table A-1.pg A-14 If the bridge is two-lane, determine any width restriction required.	a. One lane: VDL1 = 5.22 kips b. Two lane: $VDL2=(8.75)\frac{bR}{24} = 8.38$ kips
12	$vDL=\frac{VDL}{Ns}$		$vDL = \frac{8.38}{5} = 1.68$
13	vr = vLL + vDL	The required shear capacity must be less than the actual shear capacity of the selected stringer (Table E-2).pg E-4	vr = 22.20+1.68=23.88 kips 10 x 16 = 16.0; 16 < 23.88 no good 10 x 24 =24.0; 24 > 23.88 and **m** is 192 which is > 75.47 bracing req. 12 X 20 = 24.0: **m** is 160 bracing not req. **12 x 20**
14	Nb= 3 if b > 2d (look at table E-2 pg E-4)	Minimum of 3 required if d>2b	not required b = 20, 2d = 24 20 < 24
15	a. td > 6in: $\%lam = \frac{td}{tr}100\%$ b. td < 6 in: tr = td + 2 in Determine td from fig 3-14 pg 3-23	a. Use a laminated deck. b. Use a plank deck. assume 3 x 10 inch planks are used.	tr > 6 inches; therefore, use a laminated deck $\%lam = \frac{(8)}{10}100\% = 80\%$ Use the lamination pattern from Figure 3-15 (page 3-24) that equals or exceeds the required %lam.
16	Curbs and handrails	Use the standard design in Figure 6-13 pg 6-22	

Rapid Field Design

Steel-Stringer Superstructure Desiign

Bridge Dimensions		Stringer Dimensions	
L(ft)	30	Type:	
MLC	80	b(in)	
NL	2	d (in)	
bR(ft)	28	tf(in)	
		tw(in)	

Procedure

Step	Formula	Considerations	Example Calculations
1	$Ns = \frac{bR}{6} + 1$	Minimum of four required.	$Ns = \frac{28}{6} + 1 = 5.66$ stringers (Round answer to 6 stringers.)
2	$Ss = \frac{bR}{Ns-1}$		$Ss = \frac{28}{6-1} = 5.6$ feet
3	a. One lane: $Ne1 = \frac{5}{Ss}(+1)$ b. Two lane: $Ne2 = \frac{3}{8}(Ns)$		a. One lane: $Ne1 = \frac{5}{5.6}(+1) = 1.89$ stringers b. Two lane: $Ne2 = \frac{3}{8}(6) = 2.25$ stringers
4	MLL per lane a. Wheeled b. Tracked	Figures A-1 and A-2 (pg A-17) Use the larger value for remaining design procedures.	a. Wheeled = 605 kip-feet b. Tracked = 950 kip-feet
5	$mLL = \frac{MLL}{Ne1,2}$	For one-lane class, use Ne1. For two-lane class, use smaller value of Ne1 and Ne2.	$mLL = \frac{950}{1.89} = 502.65$ kip-feet
6	MDL	Table A-1 (pg A-14) Estimated. If the bridge is two-lane, determine any width adjustment required.	MDL = 140.63 kip-feet,
7	$mDL = \frac{MDL}{Ns}$		$mDL = \frac{140.63}{6} = 23.44$ kip-feet

Step	Formula	Considerations	Example Calculations
8	m = mLL +mDL	The required moment capacity must be less than the actual moment capacity of the selected stringer (Table F-10).(pg F-17)	m = 502.65 + 23.44 = 526.09 kip-feet (Try W24x84, where m=534>526.09.) (Try W 21 x 73) = 532 > 526.09
9	VLL per lane: a. Wheeled b. Tracked	Figures A-3 and A-4 (pg A-18) Use the larger value for remaining design procedures.	a. Wheeled = 98 kips. b. Tracked = 114 kips.
10	$vLL = \frac{1.15VLL}{2}$		$vLL = \frac{1.15(114)}{2} = 65.55$ kips
11	a. One lane: VDL = VDL b. Two lane: $VDL = (VDL)\frac{bR}{24}$	VDL from Table A-1. If the bridge is two-lane, determine any width adjustment required.	Two lane: $VDL = (18.75)\frac{28}{24} = 21.88$ kips
12	$vDL = \frac{VDL}{Ns}$		$vDL = \frac{21.88}{6} = 3.65$ kips
13	vr = vLL + vDL	The required shear capacity must be less than the actual shear capacity of the selected stringer (Table F-10).pg F17	vr = 65.55 + 3.65 = 69.20 kips W24x84- = 150>71.49,GO **W21x73** = 188 > 71.49, GO **smaller**
14	$Nb = \frac{L}{Sb} + 1$	Sb from Table F-10 pg F-17 (pgF-17) W21x73 = Sb 20.0	$Nb = \frac{30}{20} + 1 = 2.5$ braces or **3** (if answer is not a whole # Round up to next whole number.)
15	Bearing plate dimensions a. Lp = bc $b.\ bp = \frac{2vr}{Lp}$ $c.\ tp = \frac{(bp - 2.5)}{8.48}$	Assume a 12x12-inch cap. Round bp to nearest inch. Round tp to next 1/8 inch. .125 = 1/8" .875 = 7/8" .250 = 2/8" .375 = 3/8" .500 = 1/2" .626 = 5/8" .750 = 6/8"	a. Lp = 12 inches (**Lp = plate length in inches**) $b.\ bp = 2\frac{(69.20)}{12} = 11.53$ inches (**bp = plate width in inches**) (round answer to 12) $c.\ tp = \frac{12 - 2.5}{8.48} = 1.12$ inches **(tp = plate thickness in inches)** (Round answer to 1.125 inches.) (1 1/8")
16	a. td > 6 in: $\%lam=\frac{(td)}{tr}\ 100\%$ b. td < 6 in: tr = td + 2 in Determine td from fig 3-14 pg 3-23	a. Use a laminated deck. b. Use a plank deck. For the example, assume 3x12-inch planks are used for deck.	td = 8.15>6; therefore, use laminated deck. $\%lam= \frac{(8.15)}{12}\ 100\% =67.9\%$ Use 75% lamination from figure 3-15 (page 3-24).
17	Curbs and handrails	Use the standard design in figure 6-13 pg 6-22.	

Rapid Field Design

Timber-Trestle Bent Substructure Design

Bridge Dimensions		**Post Dimensions**		**Cap Dimensions**		**Sill Dimensions** (normally the same as cap dimensions)	
L1 (ft)	30	Type: 8x8		bc	12	bc	12
L2 (ft)	30	SBC (KSF)	8	dc	18	dc	18
MLC	60	dc (in)	18	Footing Material	4"x8" planks	Footing Material	4"x8" planks
NL	1	tft(in)	4	dc = cap depth in inches tft = thickness of footer in inches bc = cap width			
bR (ft)	16						
hb (ft)	20						

Procedure

Step	Formula	Considerations	Example Calculations
1	Le = L1 + L2		Le = 30 + 30 = 60 feet
2	hb (**bent height in feet**)	Buckling check. hp must be less than or equal to the maximum allowable bent height from Table E-3,pg E-5 or braces are required.	hb = 20 feet$\leq$20 feet Do not need to add bracing.
3	VLL per lane: (**Live load shear per stringer**) a. Wheeled b. Tracked	Figures A-3 and A-4. pg A-18 Use the Le to determine VLL. Use the larger value for remaining design procedures.	a. Wheeled: VLL = 103 kips b. Tracked: VLL = 103 kips
4	a. Span 1: VDL1 b. Span 2: VDL2	Use L1 and L2 from Table A-1. pg A-14	a. Span 1: VDL1= 12.15 kips b. Span 2: VDL2=12.15 kips
5	VDL=VDL1 + VDL2		VDL=12.15 + 12.15 = 24.30 kips
6	a. One lane: VDL = VDL b. Two lane: $VDL = VDL\frac{(bR)}{24}$ $\quad 24.30 \times \frac{16}{24}$	If the bridge is two-lane, determine any width restriction required.	One lane: VDL = 24.30 kips **STEP 5**
7	P = VLL(NL) + VDL	**Total design load**	P = 103(1) + 24.30 = 127.30 kips

Step	Formula	Considerations	Example Calculations
8	Ppc (**Post capacity**)	Table E-3 pg E-5	Ppc = 32 kips
9	Npr = P / Ppc (**Number of posts required**)	Use 0.5P for a two-bent pier.	Npr = 127.30 / 32 = 3.98 **Step 7** / **Step 8** (Round answer to 4 Npr.)
10	Sp = bR(12) / Npr-1 16 x 12 = 192 / 3 = 64 (**Post or Pile spacing in inches**)	Maximum spacing is 5(dc). Add posts or use a larger cap, if necessary. **dc = cap depth**	Sp = 16(12) / 4-1 = 64 inches (5dc = 5 x 18 = 90 inches OK because 64 < 90.)
11	Footing length factor: K	Figure D-1 pg D-3	xL = 23 inches
12	Lf = xL + bc		Lf = 23 + 12 = 35 inches
13	FBf = Lf(bft) / 144 (SBC)		FBf = 35(8) / 144 (8) = 15.55 kips
14	Nf = P / FBf Step 7 / Step 13 (**Number of footings**)	Use 0.5P for a two-bent pier. Minimum Nf equals number of posts per bent.	Nf = 127.30 / 15.55 = 8.18 footers **9** (Round up to next highest whole #)
15	Sf = 12bR / Nf - 1 (**Footing Spacing**)		Sf = 12 (16) / 9 - 1 = 24 inches

REFERENCE(S):

FM 5-446 Military Nonstandard Fixed Bridges

FM 5-34\MCRP 3-17A Engineer Field Data

UNITED STATES MARINE CORPS
COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C-01A32
27 Jun 00
(98 POI)

STUDENT HANDOUT

BRIDGE CLASSIFICATION

PURPOSE: The purpose of this period of instruction is to show you the student an expedient way of classifying bridges in the theater of operation.

LEARNING OBJECTIVE(S):

1. TERMINAL LEARNING OBJECTIVE(S):

a. Given a tactical situation, a map, a bridge and references. Determine the bridge classification with consideration to width and overhead clearance restrictions in accordance with FM 5-446, GTA 5-7-13 and the FM 5-34/MCRP 3-17A. (1302.1.18)

2. ENABLING LEARNING OBJECTIVE(S):

a. Given a bridge to classify, identify the sources of information required to classify the bridge in accordance with FM 5-446. (1302.1.18a)

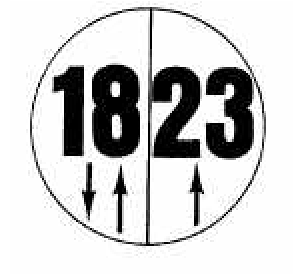
b. Given a bridge to classify, identify the data required to classify the bridge in accordance with FM 5-446, GTA 5-7-13, and FM 5-34\MCRP 3-17A. (1302.1.18b)

OUTLINE:

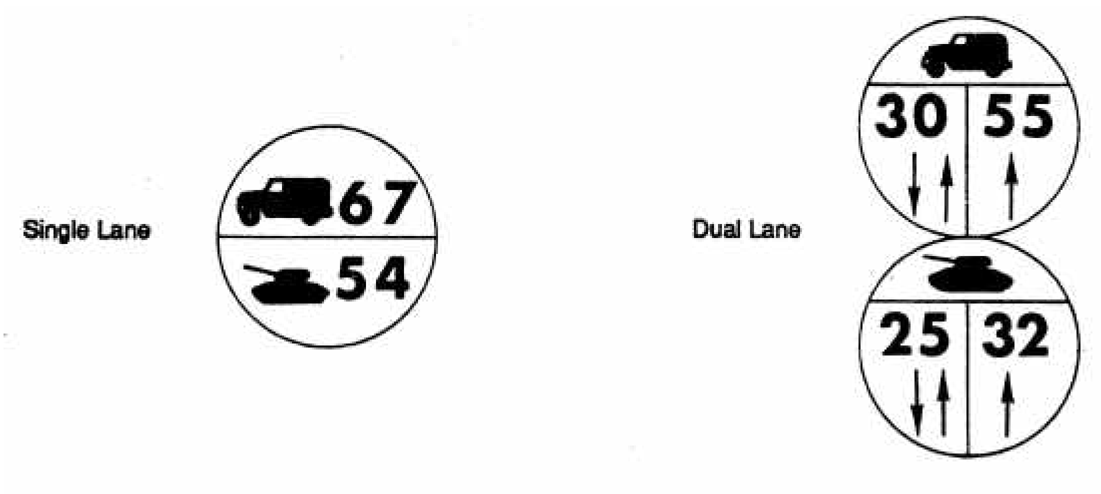
1. BRIDGE CLASSIFICATION:

a. Classifications Systems: Bridge reconnaissance requires a general knowledge of the vehicle military load classification system, and bridge military load classification system, so these elements are discussed before bridge reconnaissance procedures. The bridge and vehicle classification system complies with NATO standardization agreements and provides a way in which a driver can determine whether or not his vehicle can safely cross a specific bridge. The purpose of the system is to protect the bridge, vehicle, load, and driver.

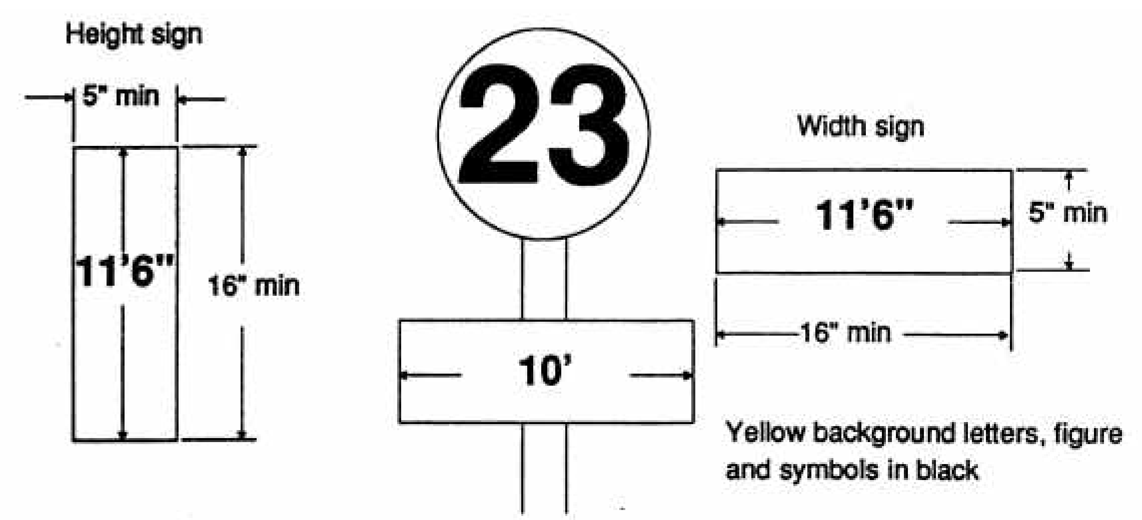
Typical Single-Lane Bridge Classification Sign



Typical Two-Lane-Bridge Classification Sign



Typical Dual-Classification Bridge Signs



Width and Height Signs

b. Vehicle Military Load Classification: Most military vehicles display a vehicle classification sign. This classification number represents the effect a crossing vehicle has on a bridge. The driver compares the vehicle classification number with the bridge classification number. If the vehicle classification number is equal to or less than the bridge classification number, the vehicle can make a normal crossing. All self-propelled vehicles in military use that has a gross weight greater than 3 tons must have a classification number. The mathematical computation of a vehicle's military load classification is beyond the capability of route reconnaissance teams. (For more details see FM 5-446,pg C-22,pg C-23)

(1) Compare the unclassified vehicle to a known vehicle having similar wheel and axle loadings and wheel spacings. Use Figure C-1, pg C13 FM 5-446 or FM-5-36,PG C-9 through C-13, to assign a temporary class number.

(2) Assign a temporary class number. Estimate the gross vehicle weight from the ground contact area and pressure of the tires. To do this use the following procedure:

(a)Figure the gross vehicle weight for all tires of the same size as--

$$w = \frac{AcptN}{1{,}000}$$

where —

w = estimated gross vehicle weight for all tires of the same size, in kips.
Ac = ground contact area of each tire, in square inches.
Pt = tire pressure of each tire, in psi.
N = number of tires of the same size.

If you cannot directly measure the tire pressure, use the maximum allowable pressure printed on the side of the tire or on the vehicle's data plate.

(b)Total the estimate gross vehicle weight for all tires. For example, an unclassified wheeled vehicle has the following ground contact areas and tire pressures:

-Two front wheels, each with a ground contact area of 42 square inches and tire pressure of 72 psi.

-Eight rear wheels, each with a ground contact area of 34 square inches and tire pressure of 74 psi.

Therefore--

$$w = \frac{AcPtN}{1{,}000}$$

$$w = \frac{42(72)2}{1{,}000} + \frac{34(74)8}{1{,}000} = 26.18 \text{ kips}$$

(C-1)

the temporary class is equal to 42.5 percent of the gross vehicle weight, in kips.

$MLC = 0.425w$

$MLC = 0.425(26.18) = 11.13$ *or* 11

where--

MLC = temporary military load classification for a wheeled-vehicle.
w = estimated gross vehicle weight, in kips

(3) Tracked Vehicles. for expedient classification of tracked vehicles, use one of the following methods.

(a) Compare the ground contact area of the unclassified tracked vehicle with that of a known or an appropriate hypothetical vehicle. Use figure C-1 or FM 5-36 to obtain a temporary class number.

(b) Assume that tracked vehicles weigh 2 kips per square foot of ground contact area (most heavy vehicles weight slightly less than this). The MLC is equal to the total ground area, in square feet, which is about twice the gross weight in kips. The total ground contact area of the tracks is--

$$Ac = \frac{2bL}{144}$$

where--

AC = total ground contact area of the tracks, in square feet.
b = track width, in inches.
L = track length, in inches.

(4) Nonstandard Combinations. Temporarily classify nonstandard combinations, such as two single vehicles traveling less than 100 feet apart or one vehicle towing another. Change the lead vehicle's front sign, if necessary, to reflect the combination class. A ***C*** above the numerals indicates that the number represents a combination class. Determine the temporary classification as follow:

--If the sum of the MLC's of the lead and trailing vehicles is less than or equal to 60, the MLC's is 90 percent of the sum of the MLC's.

--If the sum of the MLC's of the lead and trailing vehicles is greater than 60, the MLC is equal to the sum of the MLC's.

(5) Adjustment for Other-Than-Rated Load. Temporarily classify overloaded or underloaded vehicles by adding or subtracting the weight difference in kips from the normally assigned design load. For example, a 5-ton dump truck with a maximum load has an MLC of 20. With an 8-ton load, the MLC is 23 (Figure C-7,pg c24 FM 5-446). Change the front sign to show the overload class.

c. Vehicle Classification Signs.

(1) Categories. Vehicles are divided into two categories, single and combination, for classification purposes.

(a) Single Vehicles. A single vehicle has only one frame or chassis. Examples are trucks, tanks, trailers, and gun carriages. Single vehicles are assigned a class number rounded up to the nearest whole number. All vehicles except trailers have front signs to show their classifications when loaded to rated capacity. For unloaded or overloaded vehicles, adjust the front sign to show the actual load classification.

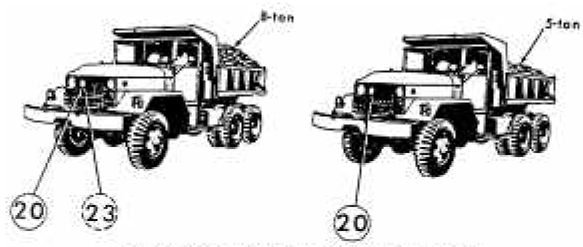
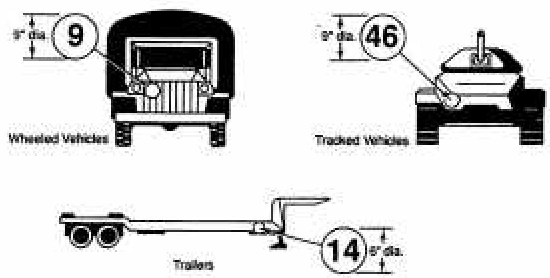


Figure C-7. Example Nonstandard Load Classification

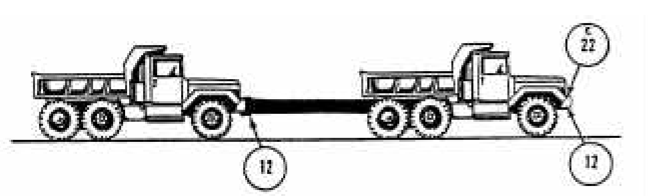


Classification Markings for Single Vehicles

(b) Combination Vehicles. A combination vehicle is two or more single vehicles operating as one unit, such as prime movers pulling semi-trailers. One vehicle towing another less than 100 feet behind is also a combination vehicle (nonstandard). The sign on the front of the combination vehicle (towing vehicle or prime mover) has the letter *C* above the classification number of the combination.

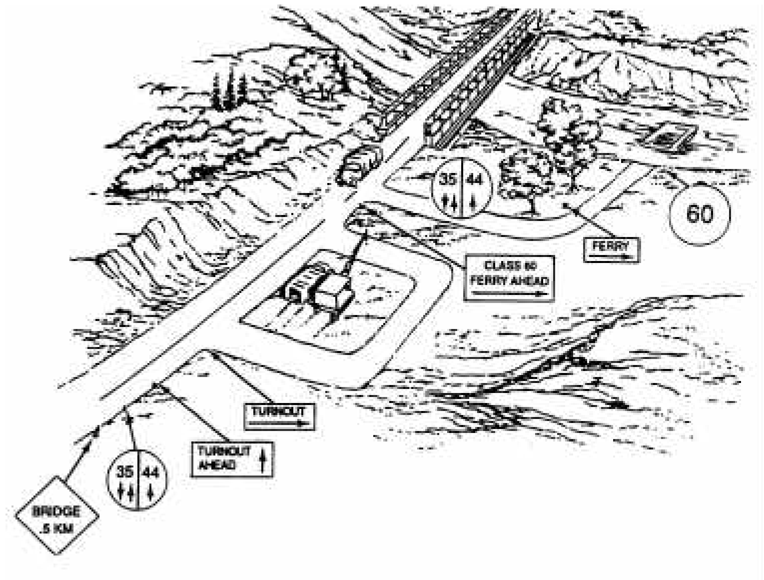
(2) Shape, Color, and Size. Both front and side signs are circular and marked in contrasting colors consistent with camouflage requirements. Black figures on a yellow background are normally used. Front signs are 9 inches in diameter and side signs are 6 inches in diameter. Figures are as large as the sign allows.

(3) Location. Place or paint front signs on or above the bumper, below the driver's line of vision. When possible, place it on the right front (passenger side) of the vehicle. Place or paint side signs on the right side of the vehicle facing outward.



Classification Marking of Nonstandard Combination Vehicles

d. Bridge Military Load Classification: A mobile army must make maximum use of existing bridges, but before any existing bridge can be used to capacity, it needs to be classified in terms of the bridge and military load classification system that has been adopted by the US and allied nations. The class of each bridge indicates the carrying capacity of the bridge and is posted to prevent overloading that may cause failure and hamper future operations. To classify bridges, various methods are available, however, this outline limits discussion to only one of these methods, the GTA 5-7-13 (Bridge Classification Card). For more detailed bridge classifications, see FM 5-446.



Standard Bridge Signs and Supplementary Signs

e. Special Crossings. Under exceptional conditions, the theater commander may authorize vehicles to cross bridges when the bridge classification number is less than the vehicle classification number. These special crossings carry restrictions on vehicle speed and spacing. Special crossings are limited to caution and risk crossings and are not posted on standard bridge signs.

(1) Caution Crossings. Obtain the caution classification for nonstandard, fixed bridges by multiplying the normal one-way class number by 125%. Obtain the caution classification from the published data for standard prefabricated, fixed, and floating bridges. Table outlines restrictions.

NOTE: CONSIDER AFCS BRIDGES AS NONSTANDARD FOR PURPOSES OF SPECIAL CROSSINGS.

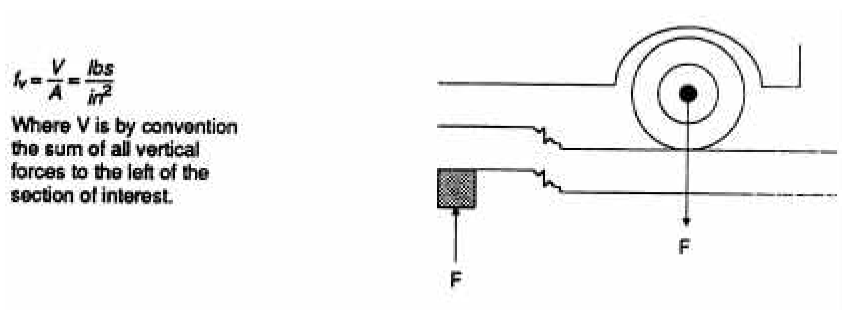
(2) Risk Crossings. Obtain risk classifications from the published data for standard fixed and floating bridges. Risk crossings are not made on nonstandard, fixed bridges. These crossings are made only in emergencies when authorized by the responsible commanders. Table 5-1 outlines restriction on travel under risk conditions. A qualified engineer officer must inspect the bridge for signs of failure after each risk crossing. Damaged parts must be replaced or repaired before the bridge is reopened.

Table 5-1. Special-Crossing Considerations

Considerations	Type of Crossing		
	Normal	Caution	Risk
Classification	As posted	Standard bridges: as published Nonstandard bridges: 125 percent of normal one-way classification	Standard bridges: as published Nonstandard bridges: no crossing
Spacing	100 feet	150 feet	One vehicle on bridge at a time
Speed	25 mph	8 mph	3 mph
Location	In lane	Bridge centerline	Bridge centerline
Other	None	No stopping, breaking, or acceleration	No stopping, breaking, or acceleration Inspect bridge after each crossing

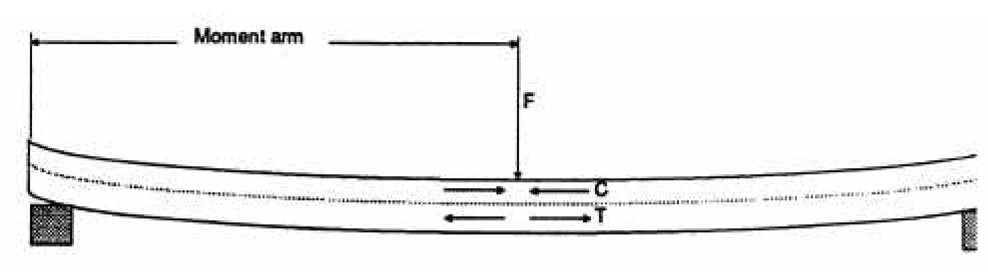
f. Bridge Classification Card: Bridges can be classified quickly by using the Bridge Classification Card (GTA 5-7-13). The card uses a partially graphic method to simplify classification procedures. The card outlines procedures for determining the class of simple steel and timber stringers, masonry arch, concrete T-beam, and concrete slab bridges. Bridge classification with this card is based on the superstructure only since this is considered to be the controlling feature in classification. A balanced design in the substructure is assumed. The bridge classification card is based on many assumptions in arriving at a bridge military load classification. This method is a way to estimate the military load classification of simple structure bridges under field conditions. When time and qualified personnel are available to provide a more detailed analysis, or if the bridge is a complicated design, more precise methods are used (FM 5-446). Before the class of a bridge can be determined, measurements and other data that determine the class of the bridge are taken and noted.

g. Shear Stress: Shear forces act very much like a pair of scissors cutting a piece of paper. When forces of equal magnitude and opposite direction act on a member, internal shear forces are generated as a reaction to external loads see figure below. Shear failures in stringers usually occur close to the supports in members less than 20 ft long. The formula to calculate shear stresses is also in the figure below.



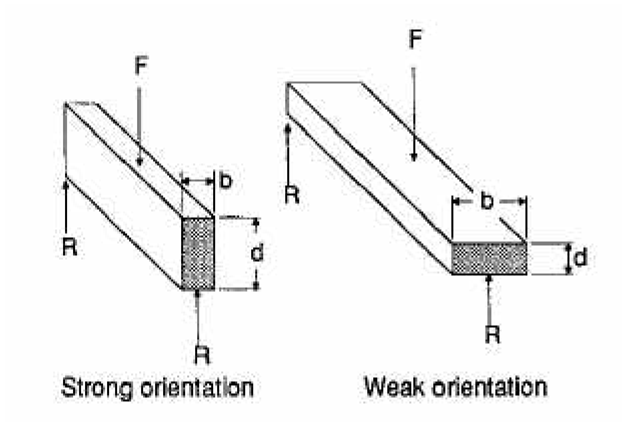
Shear Stress

h. Moment. Moment is the tendency of a body to rotate about an axis as a result of a force acting over a lever arm. Using a wrench to turn a bolt is a good example of moment; the longer the wrench, the less effort required to turn the bolt. Internal moment stresses are generated when members bend, such as when a stringer bends under the load of a vehicle. As shown in the Figure below, compressive and tensile forces are generated inside the stringer as a result of an applied moment.

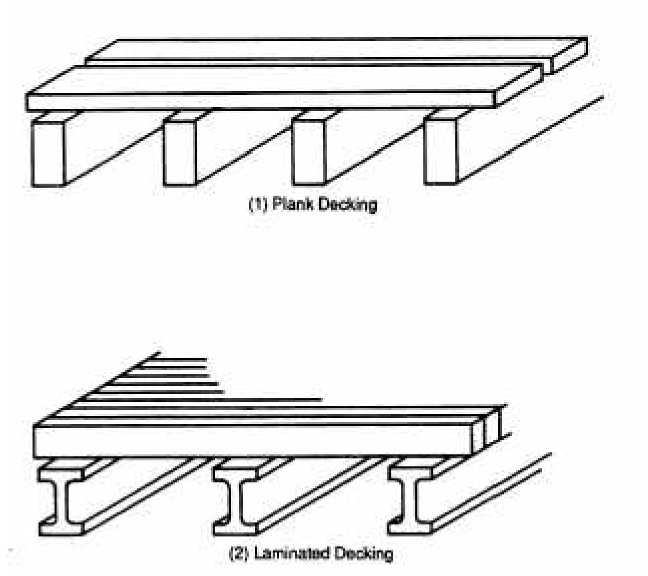


Moment (Bending Stress)

The property of a beam that measures the beam's ability to resist bending is called section modulus. Although expressed in units of volume, section modulus functions as an index of the member size, shape, and orientation with respect to the load. For example, of the two timber orientations shown in above Figure, the one to the left results in less deflection. This orientation is stronger and distributes the stress better because the compressive and tensile stresses generated by the moment in the beam are farther away from each other. Consequently, the section modulus of a stringer in the diagram to the left is greater than the section modulus of a stringer in the diagram to the right.



Stringer Orientations for Section Modulus



Timber Decking

FACTS THAT AFFECT BRIDGE CLASSIFICATION

Superstructure. Consists of the stringer, flooring, curbing, walks, handrails, trusses and other components forming that part of the bridge above the substructure.

Substructure. Consists of the transverse supports for the superstructure. The substructure takes the load directly from the superstructure and transmits it to the ground.

Dead Load. Is assumed to be evenly distributed over the bridge and distributed equally to the main structural members. Dead load consist of:

a. The weight of the main structural members, such as stringers, girders or trusses.

b. The weight of the decking.

c. The weight of all accessories and hardware, such as curbs, handrails, bracing, nails and bolts.

Live Load. Any load not consistent in its application, as moving traffic, which a bridge or structure carries in addition to its own weight (vehicles, snow, ice).

Span Length. A portion of the superstructure between two supports, as the span increases, larger end reactions are delivered to the foundations and more substantial substructures become necessary.

Shearing Stress. A force causing two contacting parts or layers to slide upon each other in opposite direction parallel to the plane of their contact.

Traveled Way Width. Roadway width limits for maximum two-way class, and/or one way width restriction. (See GTA 5-7-13)

Stringers. Rest on and span the distance between the intermediate supports or abutments. Stringers are the main load - carrying members of the superstructure; they receive the load from the flooring and transmit it to the substructure.

BRIDGE RECONNAISSANCE REPORT
For use of this form see FM 5-36; the proponent agency is TRADOC.

DATE: 18 AUG 84
SIGNATURE: Gerald Smith

TO: (Headquarters ordering reconnaissance): CDR, ATTN: S-2, 21st ENGR BN
FROM: (Name, grade, and unit of officer or NCO making the reconnaissance): GERALD SMITH, SFC, Co A, 21ST ENGR BN

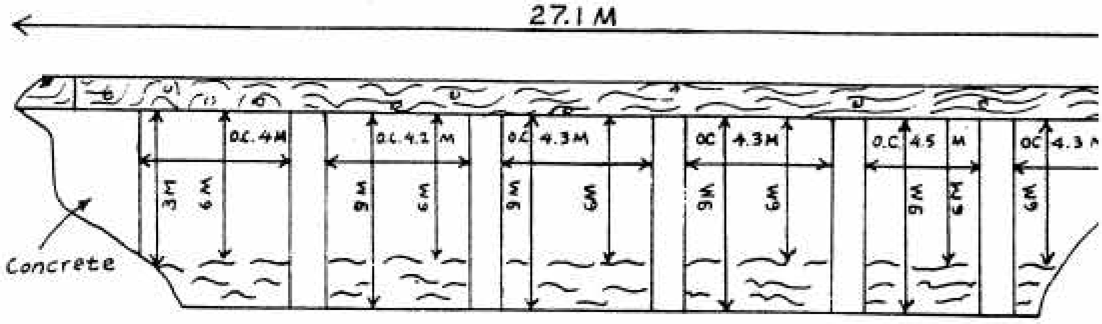
MAPS (Country, scale and sheet number or name): USA 1:50,000 AMS V733 5561 IV QUANTICO
DATE/TIME GROUP (Of signature): 181620 AUG 84

ESSENTIAL BRIDGE INFORMATION								ADDITIONAL BRIDGE INFORMATION (Add columns as needed) (Military load class, overall length, roadway width, vertical clearance, bridge by-pass)				
		CLEARANCE		SPANS								
SERIAL NO. 1	LOCATION 2	HORIZONTAL 3	UNDER-BRIDGE 4	NUMBER 5	TYPE OF CONSTRUCTION 6	TYPE OF CONSTRUCTION MATERIAL 7	LENGTH AND CONDITION 8	MILITARY LOAD CLASS	OVERALL LENGTH	TRAVELED WAY WIDTH	VERTICAL CLEARANCE	BYPASS CONDITIONS
21XYVO	LA 07216874	∞	3m/6m	1	3	h	4m W	16	27.1 m	7.3 m	∞	EASY, FORDING SITE AVAILABLE NEXT TO BRIDGE
			9m/6m	1	3	h	4.2m W					
			9m/6m	1	3	h	4.3m W					
			9m/6m	1	3	h	4.3m W					
			9m/6m	1	3	h	4.5m W					
			2m/6m	1	3	h	4.5m W					

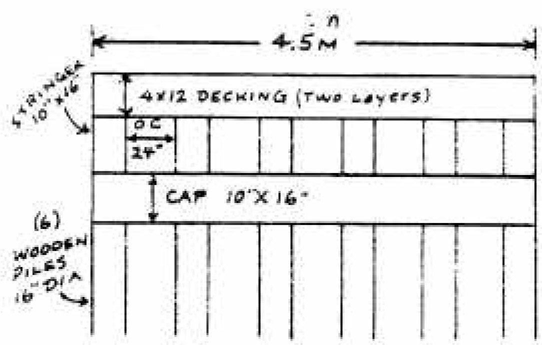
DA FORM 1 JUL 66 1249 PREVIOUS EDITION OF THIS FORM IS OBSOLETE.

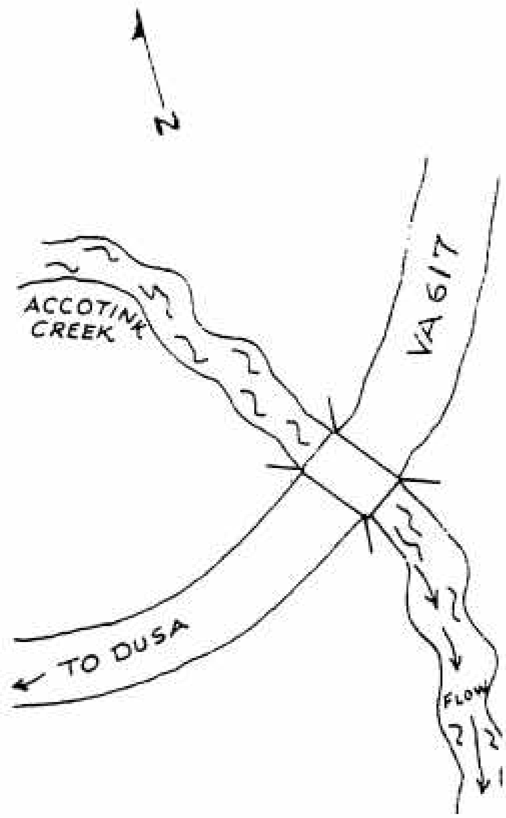
Sample Bridge Reconnaissance report with an abbreviated bridge symbol

NONE

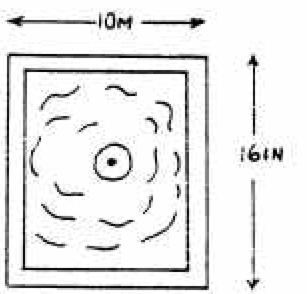


NONE





NONE



TIMBERS SHOW NO DETERIORATION

Sample bridge sketch on a Bridge Reconnaissance Report

<u>STUDENT EXERCISE</u>: Enclosed are (5) five of the most common types of bridges that are encountered. The training information is set up step by step procedures for classification. Your references are the GTA 5-7-13 card and FM 5-446, if you are having problems or would like more information, see FM 5-446 (military fixed bridges). The information that you will be using in the sample

problem(s) is given to you here in this text. In the future you will have to get this information from a bridge reconnaissance report, or other sources.

DETERMINE THE MILITARY LOAD
CLASSIFICATION OF A TIMBER-TRESTLE BRIDGE

CONDITIONS

You are given a sample problem (less the military load classification), GTA 5-7-13, FM 5-446, and a directive to classify the bridge.

STANDARDS

You will determine the one- and two-way military load classifications for wheeled- and tracked-vehicles within $\pm$ three classes. Remember this is a hasty method of classification.

TRAINING

Sample Problem

1. Review the bridge reconnaissance report, and obtain the following information about the bridge, (sample problem);

a. Roadway width, curb to curb in feet (bR). 18 feet

b. Critical span length, in feet (L). 23 feet

c. Type, size, and number of stringer (NS). 8 Timber stringers: 12 x 18 inches

d. Stringer Spacing (SS); 30 inches or 2.5 feet

e. Number of lateral braces(Nb). No lateral braces

f. Deck: Single-plank, Multilayer or Laminated 2 layers of 4 x 12 inch planks

g. Deck thickness (td_______, % lamination______

NOTES:

1. All necessary tables and figures are in your GTA 5-7-13.

2. Carry out all calculations two places to the right of the decimal point and <u>do not round up</u>.

2. Determine the moment class of the bridge span.

a. Obtain the total moment capacity per stringer from Table 2.

m (moment capacity) = kip foot/stringer.

b. Determine the dead-load moment for the span (MDL) from Table 4.

NOTE: If L is not shown in the Table, add the higher and lower L and divide by 2 to determine the MDL.

c. Calculate the dead-load moment per stringer (mDL).

$$mDL = \frac{MDL}{NS}$$

d. Calculate the live-load moment capacity per stringer (mLL).

(1) Steel stringers.

$$mLL = \frac{m - mDL}{1.15}$$

(2) Timber stringers.

$$mLL = m - mDL$$

(3) Check the maximum span length (Lm) on tables 2 or 3 for excess deflection to obtain the safe live-load moment capacity per stringer.

NOTE: If L > Lm, multiply mLL by $\frac{Lm}{L}$

e. Calculate the effective number of stringers for one- and two-way traffic.

One-way $N1 = \frac{5}{SS} + 1$ <u>DO NOT ROUND OFF</u>

Two-way $N2 = 3/8\ (NS)$ <u>DO NOT ROUND OFF</u>

NOTE: Calculate N2 only if the bR $\geq$ 18 because the bridge will have a two-way class.

f. Calculate the live-load moment per lane (MLL) using the effective number of stringers.

NOTE: MLL must be calculated for one- and two-way traffic.

MLL1 = N1 (mLL)

MLL2 = (smaller of N1 or N2 (mLL)

Condition if	For one-way use	For two-way use
N1 > N2	N1	N2
N2 $\geq$ N1	N1	N1

g. Determine the moment class from figures 8 and 9 using MLL for the appropriate modes of traffic. Find both tracked- and wheeled-vehicle classes.

3. Determine the shear class of the bridge span.

a. Obtain the total shear capacity of a stringer v from table 2 or 3.

b. Obtain the dead-load shear VDL from table 4.

NOTE: If L is not shown in GTA card, add the higher and lower VDL together, and divide by 2 to determine VDL.

c. Calculate the dead-load shear per stringer vDL.

$$vDL = \frac{VDL}{NS}$$

d. Calculate the allowable live-load shear per stringer (vLL).

$$vLL = v - vDL$$

e. Calculate the live-load shear capacity per lane (VLL).

(1) Steel stringers.

$$VLL = \frac{2vLL}{1.15}$$

(2) Timber stringers.

One lane / Two lanes

$$VLL = \frac{16}{3}(vLL)\frac{(N1)}{N1 + 1} \quad \text{or} \quad \frac{16}{3}(vLL)\frac{(N2)}{N2 + 1}$$

f. Determine the tracked and wheeled shear class from fig. 10 & 11 using VLL for the appropriate traffic modes.

4. Determine the width restrictions and class from table 1.

NOTE: Use the highest class on the chart.

5. Determine the deck classification.

a. Calculate the effective thickness of the deck (teff).

(1) Laminated deck.

teff = (%Lam)td

(2) Single-layer plank deck.

teff = td

(3) Multi-layer plank deck.

teff = td - 2 inches

b. Determine the deck class from fig. 3.

NOTE: If the class falls on the line for class 50 to 150, use the highest class.

6. Check the lateral bracing requirements. Calculate the number of lateral braces required (Nb).

NOTE: Add bracing, if required, before posting the final bridge classification.

a. Steel stringer.

$$Nb = \frac{L}{Sb} + 1 \text{ (table 3)}$$

b. Timber stringer.

(1) Three lateral braces are required if the stringer is marked by an asterisk (*) in your GTA card, or if d $\geq$ 2b.

NOTE: The total depth of the stringer is d. The width of the stringer is b.

(2) Add bracing to the bridge, if required.

7. Determine the final class.

8. Draw the bridge sign.

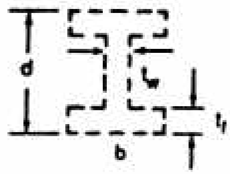
Timber- or Steel-Trestle Bridge with Timber Deck

Map Sheet Grid

Recon Officer/NCO Unit Date

BRIDGE DIMENSIONS

L ____ ft
b_R ____ ft
N_L ____ (2 if $b_R \geq 18$ ft)
N_s ____
S_s ____ in
N_b ____
S_b ____ ft
Deck: Single-layer, Multilayer, or Laminated
t_d ____ in
%lam ____



STRINGER DIMENSIONS

Timber: b ____ in
d ____ in
Steel: Type____(Table 3)
d ____ in
b ____ in
t_w ____ in
t_f ____ in

1. m ____ (Table 2, Timber; or Table 3, Steel)
2. M_{DL} ____ (Table 4)
3. m_{DL} ____ (M_{DL}/N_s)
4. m_{LL} ____
   a. Timber: $m - m_{DL}$
   b. Steel: $(m - m_{DL})/1.15$
5. L_m ____ (Table 2 or 3)
6. Adjust m_{LL} if $L>L_m$: $m_{LL}(L_m/L)$
7. N_1 ____ $(60/S_s) + 1$
8. N_2 ____ $0.375N_s$; calculate only if $b_R \geq 18$ ft
9. M_{LL1} ____ $(N_1)m_{LL}$
10. M_{LL2} ____(smaller of N_1or N_2)m_{LL}
11. Moment Classification (Figures 8 and 9):
    T_1 ____ T_2 ____ W_1 ____ W_2 ____
12. v ____ (Table 2 or 3)
13. V_{DL} ____ (Table 4)
14. v_{DL} ____ (V_{DL}/N_s)
15. v_{LL} ____ ($v - v_{DL}$)
16. V_{LL} ____
    a. Timber: $(16/3)(v_{LL})\dfrac{(N_1 \text{ or } N_2)}{(N_1 \text{ or } N_2) + 1}$
    b. Steel: $(2v_{LL}/1.15)$
17. Shear Classification (Figures 10 and 11):
    T_1 ____ T_2 ____ W_1 ____ W_2 ____
18. Width Classification (Table 1):
    T_1 ____ T_2 ____ W_1 ____ W_2 ____
19. Deck Classification (Figure 3):
    T_1 ____ T_2 ____ W_1 ____ W_2 ____
    a. Single-layer: $t_{eff} = t_d$
    b. Multilayer: $t_{eff} = t_d - 2"$
    c. Laminated: $t_{eff} = t_d(\%lam)$
20. $N_{b(reqd)}$ ____
    a. Timber: 3 required if $d \geq 2_b$
    b. Steel: $(L/L_c)+1$ (L_c in Table 3)
    Add braces if $N_b < N_{b\ (reqd)}$

21. **Final Classification:**

	T_1	T_2	W_1	W_2
Moment (Step 11)				
Shear (Step 17)				
Width (Step 18)				
Deck (Step 19)				
Final				

DETERMINE THE MILITARY LOAD CLASSIFICATION OF A CONCRETE SLAB BRIDGE

Instructions read by instructor the students.

CONDITIONS

You are given a sample problem (less the military load classification), GTA 5-7-13, FM 5-446, and a directive to classify the bridge.

STANDARDS

You will determine the one- and two-way military load classifications for wheeled- and tracked-vehicles within $\pm$ three Classes. Remember this is a hasty method of classification.

TRAINING

1. Review the bridge reconnaissance report, and obtain the following information:

Sample Problem

Given:
- Span length (L) - 20 feet
- Roadway width (bR) - 17 feet
- Width of slab (bd) - 21 feet
- Depth of slab (td) - 14 inches

NOTES:

1. Carry out all calculations two places to the right of the decimal.

2. Calculate be2only if bR $\geq$ 18 feet.

2. Determine the live-load moment, mLL (fig. 8)

a. Enter the table with the span length (L)drawing a vertical line until it intersects the curve representing the depth (td) of the slab, estimating (when necessary) where this point is.

b. From this intersection, draw a horizontal line to read the value of mLL on the left-hand axis.

3. Determine the effective roadway width;

One-way

$$be1 = \frac{L}{\frac{3}{4} + \frac{L}{bd}}$$

Two-way

$$be2 = \frac{L}{\frac{1}{4} + \frac{2L}{bd}}$$

4. Determine the live bending moment (MLL) for the bridge.

a. To determine MLL1 for one-way traffic, use the following formula:

MLL = be1 x mLL

b. To determine MLL2 for two-way traffic, use the following formula:

MLL = smaller of be1 or be2 x mLL

5. Determine the bridge class using figures 8 and 9.

a. To determine the one-way class, enter the Tables on the left-hand side with the value of MLL1 (one-way) and draw a horizontal line across to the right until it intersects with the span length in feet. Read the wheel and track one-way bridge class.

b. To determine the two-way class, enter the Tables on the left-hand side with the value of MLL2 (two-way) and proceed the same as when determining the one-way class explained in step 5a. (**NOTE: THIS STEP IS NOT ALWAYS NEEDED**)

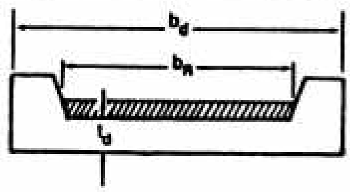
c. Check the class determined for the bridge against the minimum lane widths and overhead clearance table. (Table 1) If the bridge does not meet the minimum width and overhead clearance standards, reduce the class IAW the table located on your GTA 5-7-13.

Concrete-Slab Bridge with Asphalt Wearing Surface

Map Sheet ____ Grid ____
Recon Officer/NCO ____ Unit ____ Date ____

BRIDGE DIMENSIONS

L ____ ft
b_d ____ ft
b_R ____ ft
t_s ____ in (Do not include wearing surface.)



PROCEDURE

1. m_{LL} ____ (Figure 5)
2. b_e ____
   a. One-Lane: $b_{e1} = \dfrac{L}{0.75+(L/b_d)}$
   b. Two-Lane: $b_{e2} = \dfrac{L}{0.25+(2L/b_d)}$
   (Calculate b_{e2} only if $b_R \geq 18$ ft)
3. M_{LL1} ____ $(b_{e1})m_{LL}$
4. M_{LL2} ____ $(b_{e2})m_{LL}$
5. Moment Classification (Figures 8 and 9): T_1 ____ T_2 ____ W_1 ____ W_2 ____
6. Width Classification (Table 1): T_1 ____ T_2 ____ W_1 ____ W_2 ____
7. **Final Classification:**

	T_1	T_2	W_1	W_2
Moment (Step 5)				
Width (Step 6)				
Final				

DETERMINE THE MILITARY LOAD CLASSIFICATION OF A CONCRETE T-BEAM BRIDGE

CONDITIONS

You are given a sample problem (less the military load classification), FM 5-446,GTA 5-7-13, and a directive to classify the bridge.

STANDARDS

You will determine one- and two-way military load classifications for wheeled- and tracked-vehicles within $\pm$ three classes. Remember this is a hasty method of classification.

TRAINING Training Information Outline

1. Review the bridge reconnaissance report, and obtain the following information about the bridge:

a. Span Length (L). Given: L = 30 feet

b. Roadway width (bR). bR = 25 feet

c. Thickness of the slab (td). td = 7 inches

d. Depth of the stringers (d). d = 22 inches

e. Stringer spacing (SS). SS = 60 inches c/c = 5 feet c/c

f. Width of the stringers (b). b = 9 inches

g. Number of stringers (NS). NS = 6

NOTE: Carry out all calculations two places to the right of the decimal point.

2. Determine the total moment capacity of one stringer (m).

m = .0116 (SS x d2)

NOTE: Use SS and D in inches.

3. Calculate the dead load moment per stringer mDL.

$mDL = .00013(L^2)[(b)(d)+(td)(SS)]$

NOTE: Use L in feet; b, d, td, and SS in inches.

4. Determine the load moment per stringer mLL.

$$mLL = \frac{m - mDL}{1.15}$$

5. Calculate the effective number of stringers N1 and/or N2.

$$N1 = \frac{5}{SS} + 1$$ Do not round off

N2 = 3 (NS) <u>Do not round off</u>
8

NOTES:*

***1. Use SS in feet.**

***2. Calculate N2 only if the bR is ≥ 18 feet.**

Condition if	For one-way use	For two-way use
N1 > N2	N1	N2
N2 ≥ N1	N1	N1

6. Calculate the live load moment per lane (MLL).

MLL1 = N1 (mLL) and/or MLL2 = [smaller of N1 or N2](mLL)

NOTE: All necessary tables and figures are on GTA 5-7-13.

7. Determine the moment classes for both tracked- and wheeled-classes from GTA card.

8. Determine the width class from GTA card.

9. Determine the bridge classification.

10. Draw the bridge sign.

Concrete T-Beam Bridge with Asphalt Wearing Surface

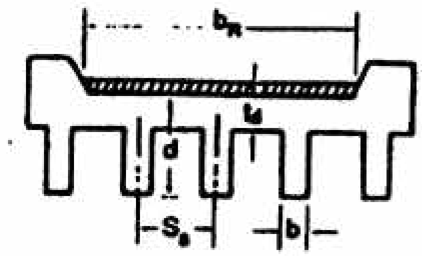
Map Sheet Grid
Recon Officer/NCO Unit Date

BRIDGE DIMENSIONS

L _____ ft
b_R _____ ft
t_d _____ in
S_s _____ in
N_s _____

STRINGER DIMENSIONS

d _____ in
b _____ in



PROCEDURE

1. m _____ $0.0116(S_s)(d^2)$

2. m_{DL} _____ $0.00013\ L^2(bd + (t_d)S_s)$

3. m_{LL} _____ $(m - m_{DL})/1.15$

4. N_1 _____ $(60/S_s) + 1$

5. N_2 _____ $0.375N_1$; calculate only if $b_R \geq 18$ ft

6. M_{LL} _____ $(N_1)m_{LL}$

7. M_{LL} _____(smaller of N_1 or N_2)m_{LL}

8. Moment Classification (Figures 8 and 9):
T_1 ___ T_2 ___ W_1 ___ W_2 ___

9. Width Classification (Table 1):
T_1 ___ T_2 ___ W_1 ___ W_2 ___

10. Final Classification:

	T_1	T_2	W_1	W_2
Moment (Step 8)				
Width (Step 9)				
Final				

DETERMINE THE MILITARY LOAD CLASSIFICATION OF A MASONRY ARCH BRIDGE

CONDITIONS

You are given a sample problem (less the military load classification), GTA 5-7-13, FM 5-446, and a directive to classify the bridge.

STANDARDS

You will determine the one- and two-way military load classification for wheeled and tracked vehicles within ± three classes. Remember this is a hasty method of classification.

TRAINING

Training Information Outline

Sample Problem

Given: Roadway width, bR = 24 feet.

Span length, L = 35 feet.

Depth of fill, df = 15 inches.

Crown thickness, tc = 15 inches.

Rise, R = 6 feet

Materials: Granite.

Joints: Normal joints with up to 1/4 inch of unpointed mortar.

Deformations: None.

Abutments: Minor vertical settlement of the left abutment--good size.

Approaches: Level and good condition.

Fill material: Good granular material.

Cracks: Small lateral and diagonal.

1. Determine the provisional load class(PLC).

a. Calculate the total crown thickness (tc + df).

b. Determine the PLC using figure 6 of your GTA card. Enter column A with the arch span (L) and column B with the total crown thickness. Connect these points with a straight line extending to column C. Read the provisional load class where the line intersects column C.

2. Determine the Arch factors.

a. Calculate the span/rise ratio.

$$\text{Span/rise ratio (SR)} = \frac{L}{R}$$

b. Determine the profile factor from Table 5.

c. Determine the material factor from Table 6.

d. Determine the joint factor from Table 6.

e. Determine the deformation factor from Table 6.

f. Determine the crack factor from Table 6.

g. Determine the abutment size factor from Table 6.

h. Determine abutment fault factor from Table 6.

NOTE: If two different factors are used, multiply one by the other.

i. Determine the abutment fault factor from GTA card. The value used for each type of abutment fault depends on the severity of the fault, the lower values being the more severe faults. The abutment faults should be evaluated by a trained engineer. If there is doubt of how severe a fault may be, use the lowest value for the fault factors.

j. Determine the deformation factor from GTA card. This factor accounts for the structural failure of the crown and is extremely critical because the arch gains most of its strength from the crown. (If no faults are found, use 1.0.)

3. Calculate the one-way tracked class of the bridge by multiplying the provisional class by all of the previous factors.

a. T1 = PLC x Product of factors 2b through 2h.

NOTE: Always round down.

b. Determine the one and two-way width class of the bridge from GTA card.

c. Calculate the two-way tracked class for two-lane bridges.

T2 = .9 T1.

d. Determine the one and two-way wheeled-vehicle classes from figure 7 in your GTA card.

e. Determine the final bridge classification.

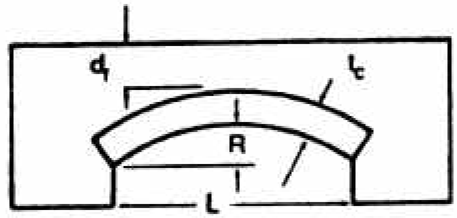
Masonry-Arch Bridge

Map Sheet | Grid
Recon Officer/NCO | Unit | Date

BRIDGE DIMENSIONS

L _____ ft
t_c _____ ft
d_f _____ ft

b_a _____ ft
R _____ ft



PROCEDURE

1. *PLC* _____ (Figure 6)

2. Arch Factors:
   a. Span-to-Rise Ratio (*SR = L/R*) _____
   b. Profile Factors (Table 5) _____
   c. Material Factors (Table 6) _____
   d. Joint Factors (Table 6) _____
   e. Deformations (Table 6) _____
   f. Crack Factors (Table 6) _____
   g. Abutment Size Factors (Table 6) _____
   h. Abutment Fault Factors (Table 6) _____

3. Classification of Arch Factors:
   T_1 _____ (*PLC x Product of Factors 2b through 2h*)
   T_2 _____ ($0.9T_1$)
   W_1 _____ (Figure 7)
   W_2 _____ (Figure 7)

4. Width Classification (Table 1):
   T_1_____ T_2_____ W_1_____ W_2_____

5. **Final Classification:**

	T_1	T_2	W_1	W_2
Factors (Step 3)				
Width (Step 4)				
Final				

REFERENCE (S):

1. FM5-34/MCRP 3-17A   Engineer Field Data
2. FM 5-446   Military Nonstandard Fixed Bridges
3. GTA 5-7-13   Bridge Classification Booklet

UNITED STATES MARINE CORPS

COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C-01B01
27 Jun 00
(98 POI)

STUDENT HANDOUT

ENGINEER RECONNAISSANCE

1. LEARNING OBJECTIVE (S):

a. TERMINAL LEARNING OBJECTIVE (S):

(1) Given a tactical situation, a map, and prioritized information requirements, with the aid of references, plan an engineer reconnaissance mission in accordance with FM 5-36. (1302.1.3)

(2) Given a tactical situation, a map, necessary equipment and a mission order, with the aid of references, perform an engineer reconnaissance mission in accordance with MCWP 3-17.3 (1302.1.4)

b. ENABLING LEARNING OBJECTIVE (S):

(1) Given a tactical situation, a map, and intelligence requirements, with the aid of references, determine the type of engineer reconnaissance mission required in accordance with MCWP 3-17.3. (1302.1.3a)

(2) Given a tactical situation, a map, and intelligence requirements, with the aid of references, write an engineer reconnaissance mission operation order in accordance with MCWP 3-17.3. (1302.1.4a)

(3) Given a mission, maps, and equipment, reconnoiter an area in accordance with MCWP 3-17.3. (1302.1.4b)

(4) Given a mission and reconnaissance forms, with the aid of references, complete the forms in accordance with MCWP 3-17.3. (1302.1.4c)

(5) Given reconnaissance forms, a map, and overlay paper, with the aid of references, complete an overlay in accordance with MCWP 3-17.3. (1302.1.4d)

(6) Given reconnaissance reports, overlays, and maps, with the aid of references, debrief the reconnaissance team in accordance with MCWP 3-17.3. (1302.1.4e)

OUTLINE

1. Definitions:

a. Patrol. A patrol is a detachment of ground forces sent out by a larger unit for the purpose of gathering information or carrying out destructive, harassing, or security type missions. Patrols may range in size from fire team to platoon depending on the type of patrol, its mission, and its distance from the parent unit. Patrols are limited only by the ingenuity, with which they are employed, and the skill and aggressiveness of their members. Extensive patrolling provides one of the most effective information gathering agencies available to the commander of a tactical unit.

b. Reconnaissance. Reconnaissance is a mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy, potential enemy or the geographic characteristics of a particular point/area.

2. Patrolling. Patrolling requires proficiency in many areas and is attained only through carefully planned practical exercises based upon realistic situations. Some of the basic skills/information marines need to conduct a successful patrol are as followers:

a. Leadership

b. Combat Intelligence

c. Map reading and land navigation

d. Team work

e. Small unit tactics

f. Communications

g. Ability to operate at night

h. Camouflage and concealment

i. Knowledge and use of supporting arms

j. Security

3. Types of Patrols. There are two general types of patrols which are classified according to the nature of the mission assigned. They are:

a. Reconnaissance Patrol: The commander needs information about the enemy and the terrain the enemy controls. The information must be accurate and timely to assist him in making tactical decisions. Reconnaissance patrols are one of the most reliable means for obtaining this information. Reconnaissance patrols engage enemy only to accomplish their mission or for protection. In general, they avoid contact and accomplish the mission by stealth. A reconnaissance patrol is capable of carrying the search for information into the area occupied by enemy forces and is capable of examining objects and events at close range. The distance reconnaissance patrols cover varies. The squad is ideally suited for reconnaissance patrol missions.

b. Combat Patrols: Combat patrols provide security, establishes and/or maintains contact with friendly and enemy forces, denies the enemy access to terrain, and harasses, destroys, or captures enemy personnel, equipment and installations. They have a secondary mission to collect and report information. There are six types of combat patrols.

(1) Raid Patrol. A combat patrol whose mission is to attack a position or installation for the purpose of:

(a) Destroying the position or installation.

(b) Destroying or capturing personnel or equipment.

(c) Liberating personnel.

*Surprise, firepower and violence of action are the keys to a successful raid.

(2) Ambush Patrol. A surprise attack from a concealed position upon a moving or temporarily halted target.

(3) Contact Patrol. A combat patrol whose mission is to establish and maintain contact to the front, flanks, or rear, with friendly or enemy forces when their exact locations are not known. Contact patrols do not engage in decisive combat with the enemy forces.

(4) Economy of Force Patrols. A patrol organized to attack a defended or undefended objective, establish roadblocks, seize key terrain, or act as a blocking force.

(5) Security Patrols. A combat patrol whose mission to screen flanks, areas, and routes. In a static situation, they prevent infiltration, detect and destroy infiltrators, and prevent surprise attack. They protect moving units, including convoys, by screening flanks, areas through which units will pass, and the routes units will use.

(6) Search and Attack. A patrol with the general mission of seeking out and attacking targets of opportunity. It is used most often in counter-guerrilla operations.

4. Principles of Patrolling. There are four principles of patrolling.

a. Planning
b. Recon
c. Security
d. Control

5. Patrol Organization.

a. General. The key to successful small unit combat organization is unit cohesion. The nature of reconnaissance patrolling does not always permit long periods of preparation and rehearsal to build a unit specifically for each mission. Organization of a patrol is a two-step process. First, there is the general organization of the entire patrol and second, the task organization of various patrol members.

b. General Organization.

(1) Patrol Headquarters. The headquarters is composed of the patrol leader and the personnel who provided support for the entire patrol, such as a forward observer, corpsmen, and radio operator.

(2) Assault Section. Designate a unit to conduct the attack or assault. This unit engage the enemy at the objective by fire and maneuver.

(3) Support Section. Designate a unit to act as support. This unit will provide the base of fire in the attack or cover withdrawals or advances.

(4) Security Section. Designate a unit to provide security while in route to the objective or at the objective.

c. Task Organization: Organize the reconnaissance patrol so each individual, team, and unit is assigned a specific task or billet, keep in mind the need for individuals and units to know all tasks or billets, not just their own.

6. Reconnaissance Equipment. Patrol members are equipped as necessary for accomplishing the mission. The following are examples of gear that might be required for the completion of the mission: binoculars, compass, maps, watch, Nikonos V, alcohol pens, notebooks, and your map overlay. This list is just a small part of the gear that may be needed. Each mission should be looked at carefully by the unit commander and the appropriate gear taken.

a. Specialized Personnel Support and Equipment. There will be situations when the unit assigned to conduct a patrol does not have the necessary technical skills or equipment organic to it to successfully accomplish the patrol's mission. In these cases, additions (attachments) are made to the unit. Examples are:

(1) Machinegun and/or assault rocket launcher (SMAW) team/squad.

(2) Forward observer (mortar/artillery).

(3) Radio operators.

(4) Tracked vehicle crewman to assess the trafficability of the terrain.

(5) Corpsman.

(6) Other personnel as requires (snipers, translators, etc.).

7. Patrol Leaders Responsibilities. During planning and preparation, the patrol leader uses the patrol steps, a series of mental and physical processes to ensure that all required events are planned for and all patrol members know their duties. The patrol steps incorporate the troop leading procedures (BAMCIS), but are addressed in greater detail. The 12 patrol steps are:

a. BAMCIS *12 PATROL STEPS*

(1) **Begin planning.**

(2) **Arrange for reconnaissance and coordination.**

(3) **Make reconnaissance and complete the estimate.**

(4) **Complete the plan.**

(5) **Issue the order.**

(6) **Supervise.**

b. The first patrol step is "study the mission."

(1) When receiving the mission, the patrol leader listens carefully to the operation order to ensure that he clearly understands all information, instructions, and guidance. He takes copious notes for later use in his planning. Afterwards, he asks questions if any points are not clear.

(2) Ensure that commander’s intent is understood.

(3) By studying the mission the patrol leader identifies essential tasks to be accomplished in executing the mission. These essential tasks become missions of the patrol's elements and teams. The patrol leader must also consider organization, personnel, and equipment.

c. The second patrol step is "plan use of available time."

(1) Combat situations seldom allow the patrol leader as much time for planning and preparation as he would like. When the patrol leader finishes his study of the mission, he quickly makes a mental or written time schedule that allots time for each action of the patrol.

(2) Use a planning sequence called "Reverse Planning". The patrol leader starts his schedule with the last action for which a time has been specified, and works back to the receipt of the operation order.

(3) In planning the use of time, the patrol leader ensures that subordinate leaders and patrol members are allotted enough time to prepare for the mission. The patrol leader uses the "half rule", the first half is to prepare the warning order and the second is to prepare the patrol order. This gives the subordinate leaders time to prepare their sections for the mission.

d. The third patrol step is "study terrain and situation."

(1) The patrol leader studies the terrain over which the patrol will operate and friendly and enemy situations, relating these considerations to his study of the mission.

(2) When analyzing terrain, the patrol leader makes a detailed study of maps and photos, if available. He studies notes, fields of fire and observation, cover, concealment, obstacles, key terrain features, and avenues of approach and withdrawal. He considers the influence of terrain on the execution of the mission.

(a) The terrain may influence the patrol's size, organization, and equipment.

(b) Patrol formations are influenced by the terrain.

(c) The terrain may affect the patrol's speed of movement.

(d) The terrain in the objective area helps determine the security needed and the positioning of fire support.

(3) The patrol leader studies the situation with respect to strengths, locations, dispositions, and capabilities of both friendly and enemy forces that may affect the patrol's operation.

e. The fourth patrol step is "organize the patrol."

(1) Organization consists of determining the elements and teams required to accomplish essential tasks. It is a two step process. The two steps are general and special organization.

f. The fifth patrol step is "select men, weapons and equipment."

(1) Patrol members are usually selected from the unit commanded by the patrol leader.

(a) The headquarters dispatching the patrol provides specially qualified personnel, such as linguists, guides, scout dog teams, and forward observers.

(b) The patrol leader's company or platoon may provide corpsmen and radio operators.

(2) The patrol leader should ask himself, "What weapons and equipment are needed to accomplish the mission?" The value of the weapons and equipment in accomplishing the mission is weighed against the difficulty in transporting it. Furthermore, personnel handling weapons and equipment need to be proficient in their use.

g. The sixth patrol step is "issue the warning order."

(1) Up to this time, the patrol members have no idea of the patrol's mission or what their individual role will be. The patrol leader issues a warning order to provide the patrol members with the maximum time possible to prepare for the patrol. The warning order format is as follows:

(a) SITUATION: This includes only the information the subordinate leaders needs in order to prepare for the patrol. The complete situation is given in the patrol order.

(b) MISSION: This is a brief and clear statement of what the patrol must accomplish. It must tell who, what, when, where, and why.

(c) GENERAL INSTRUCTIONS: These are instructions for all members of the patrol. It consist of:

1 Organization: This explains the general and special organizations. Men are assigned to either the headquarters or one of the elements or teams.

2 Uniform and equipment common to all.

3 Weapons, Ammunition, and equipment needed for the patrol, and which element is to carry them.

4 Chain Of Command: The patrol leader designates the chain of command within the patrol. Each element leader is assigned a place within the chain of command and they set up a chain of command within their elements.

5 Time Schedule: The patrol leader prepares a time schedule for all upcoming actions. He uses reverse planning sequence to make this schedule. The time schedule helps the patrol and element leaders make the best use of their time in planning and preparing for the mission.

6 Time, place, uniform and equipment for receiving the patrol order. The patrol leader tells his subordinate leaders when and where the order will be given and what to wear, and what equipment to bring.

7 Time and place for inspection and rehearsals.

8 Specific Instructions to subordinate leaders. Instructions are given to special purpose teams and key men for such things as preparing explosives, checking radios, making a map study to point and compass men.

h. The seventh patrol step is "coordinate."

(1) Coordination is continuous throughout the planning, preparation, and conduct of the patrol. The patrol leader may effect coordination with staff members of the unit who can assist him, or with other units or personnel immediately affected by the patrol's operation. The unit commander or his subordinates may have conducted some coordination for the patrol leader. If at all possible, the patrol leader arranges for as much coordination as possible before leaving the area where he received the operation order. Those

interested, knowledgeable personnel who may affect the patrol are centrally located there (S-2, S-3, S-4, CommO, etc.).

(2) Some examples of coordination would be with the friendly unit commander through whose lines you may have to depart or return. If the patrol will be operating in a unit's area of responsibility then they should know about it to prevent endangering or restricting the patrol. And, of course, a patrol leader should plan on fire support if available. Coordination for fire support is enacted with the Fire Support Coordinator (FSC). You may have the opportunity to submit an overlay of your planned route.

i. The eighth patrol step is "make reconnaissance."

(1) The patrol leader makes a reconnaissance while the patrol members prepare for the patrol.

(2) A visual ground reconnaissance confirms, clarifies, and supplements information provided by maps, aerial photos, and other sources. Remember, however, a great deal of time must be available to the patrol leader if he is to conduct a ground reconnaissance, if it's possible at all.

(3) An aerial reconnaissance can be conducted if aircraft are available and the enemy situation is appropriate. An aerial reconnaissance is less time consuming than a ground reconnaissance and fulfills many of the same purposes of a ground reconnaissance.

(4) However, in most cases the patrol leader will conduct a map and aerial photoreconnaissance.

j. The ninth patrol step is "complete detailed plans".

(1) The patrol leader now develops his tentative plan and warning order for accomplishing the mission. This plan is later issued to the patrol in paragraphs 3, 4, and 5 of the patrol order.

(2) The following format may be used when issuing the warning order:

(a) Situation. The minimum information required to allow patrol members to begin preparation.

1 Enemy. (**SALUTE**)

a **S**ize

b **A**ctivity

c **L**ocation

d **U**nit

e **T**ime

f **E**quipment

2 Friendly (Mission and Location). (**HAS**)

a **H**igher unit

b **A**djacent units

c **S**upporting units

3 Mission.

a A brief statement of what the patrol is to accomplish and the location of the area in which it is to be done. Who, What, When, Why and Where.

4 General Instructions.

a Name

b Chain of Command

c Organization - Either a combat patrol or a reconnaissance patrol.

d Weapons, Ammo, and Equipment

e Uniform and Equipment common to all

f Time Schedule

g Specific Instructions

h Fire Support Plan - Which could include planned fires or targets of opportunity. Elements which may be needed with these would be overlays and target lists.

k. The tenth patrol step is "issue patrol order".

(1) There are four keys to success in issuing a patrol order.

(a) After making a detailed map study, a terrain model or sand table can be built. This task can be assigned to a member of the patrol. If at all possible, take the patrol members to a vantage point.

(b) You must insure all patrol members are present, use warning orders to hold muster.

(c) You should instruct the patrol members to break out their maps and note taking materials holding all questions until the order is complete

(d) Conclude the order with a time check.

(2) The patrol order format: (**SMEAC**)

(a) **S**ituation.

1 Enemy Forces.

a Weather.

(1) Sunrise/sunset

(2) Moonrise/moonset/moon phase

(3) BMNT/EENT

(a) Precipitation

(b) State how weather will affect the patrol.

b Terrain.

(1) General description of terrain and how it will affect the patrol's size, organization and equipment.

c Enemy. (**SALUTE**)

2 Friendly Forces. (**HAS**)

a Attachments and detachments. State who or what and effective time.

(b) **M**ission. (Read twice) A brief statement of who, what, when, where, and why. Must also state whether mission or time has priority.

(c) **E**xecution.

1 Commanders Intent.

2 Concept of Operation. A statement of the overall scheme of maneuver of the operation from start to finish is given.

3 Sub-unit missions. During movement and actions on the objective.

4 Detailed instructions.

a Formations and order of movement

b Primary and alternate patrol route.

c Procedures for departure and reentry of friendly lines.

d Actions at danger areas and procedures for crossing danger areas.

e Actions on enemy contact. I/A drills

f Rally points and actions at rally points.

g Actions in the objective area.

h Fire support plan.

5 Coordinating Instructions. Contains instructions common to two or more elements/teams, coordinating details and control measures objective area. Applicable to the patrol as a whole, and time or conditions when order is to be executed.

a Time of departure/time of return.

b Rehearsals/briefback.

c Inspections.

d Debriefing.

e Priority Intelligence Requirements (PIR).

f Annexes. Actions not normally included in other parts of the order, such as stream crossings, aerial insert/extract, resupply and rough terrain procedures.

(d) **A**dministration and Logistics. This would include rations, food and water, equipment and method of handling WIA, KIA, and EPW's. **(5 S's: Search, Silence, Segregate, Safeguard, & Speed)**

(e) **C**ommand and Signal.

1 Signal.

a Signals to be used within the patrol. Standing signals are hand and arm, pyro and audible.

b Communication with higher headquarters. Radio frequencies and call signs, time to report and special codes to be used are disseminated.

2 Command Relationships.

a When operating with other services, to include foreign services, assignment of senior man must be determined.

3 Chain of Command.

4 Location of Leaders. During movement, in danger areas, and at the objective. End the patrol order with a time check.

l. The eleventh patrol step is "supervise, inspect, and rehearse."

(1) The twelfth patrol step is "execute the mission." The first eleven patrol steps are oriented towards reaching this goal.

10. RECONNAISSANCE OPERATIONS. Reconnaissance operations vary within the operational environment and depend on the assigned mission, size, type and composition of the reconnaissance element.

a. Fundamentals of Reconnaissance. Ground reconnaissance operations are performed in conformance with the following fundamentals:

(1) Orient on the Location or Movement of the Intelligence Objectives. Units engaged in reconnaissance operations maneuver according to location or movement of the intelligence objective.

(2) Report All Information Accurately. To be of value, reconnaissance reports must be complete, timely, and accurate.

(3) Avoid Decisive Engagement. The reconnaissance mission must not be jeopardized by unnecessary combat and is most effective when undetected.

(4) Develop the Situation (RAPIDLY). You would deploy and report, reconnoiter, choose a course of action, make the report.

(5) Debrief the Reconnaissance Patrol. Upon return of the patrol, the commander receives the report(s) at a debriefing attended by the reconnaissance leader and all recon members. Necessary information is given with the commander’s needs and patrols mission in mind. The debriefing should be conducted as soon as possible following the patrol's return, while information is still fresh in the minds of the patrol members.

b. Types of Reconnaissance Missions. There are three types of ground reconnaissance mission:

(1) Route reconnaissance: Is directed in order to obtain information on routes. Obstacles including chemical or radiological contamination, route conditions, and critical terrain and man-made features along a specific route. Techniques used are less time consuming, performed more rapidly and use less qualified personnel than other types of reconnaissance.

(2) Zone reconnaissance: Is used to gather information within a zone establish be defined lateral boundaries, (i. e. corridor). It may include but is not limited to information about all routes, obstacles, key terrain and chemical or radiological contamination. This type is used when enemy location is unknown or in doubt.

(3) Area/Point reconnaissance: Is a directed effort to obtain specific and detailed information within any clearly defined area with specified limits of advance, (i.e. a "box"). It may include, but is not limited to routes, obstacles, chemical or radiological contamination, minefields, breach sites, enemy emplacements, and enemy forces.

c. Techniques of Reconnaissance:

(1) Reconnaissance in force: is a limited objective offensive operation by a considerable force to discover and test the enemy's disposition and strength. Route reconnaissance teams are often included in reconnaissance in force operations.

(2) Reconnaissance of Suspect Area: areas along a route that are likely to be defended by enemy detachments. Approach routes are checked for mines, and signs of ambush. Detailed OBSERVATION precedes actual reconnaissance.

(3) Reconnaissance by Fire. Is accomplished by firing on likely or suspected enemy positions in an attempt to remove camouflage and cause an undisciplined enemy to disclose his presence by movement or return fire. Engineer reconnaissance teams may use this type of reconnaissance when time is critical and the loss of surprise is not critical.

(4) Reconnaissance at Night. Night reconnaissance is limited usually to electronic surveillance devices, observation of routes, and use of listening posts. This type of reconnaissance is slower and less effective.

(5) Reconnaissance by Aircraft. Normally employed in fluid situations to obtain general information concerning enemy movements and locations, and the conditions of roads, bridges, airfields, terrain features, and waterways, both enemy and friendly. Reports from photographs provide information on the condition, type, classification, length, width, and construction material of bridges; and information about fording sites, bypasses, and obstacles. Aerial photographic reconnaissance is used to deny or confirm information obtain by visual reconnaissance or other means.

11. REFERENCE MATERIAL

a. MCWP 3-17.3 (Route Reconnaissance And Classification) This manual describes intelligence aspects, fundamentals of Route/Road Reconnaissance, methods of reconnoitering and classifying routes for military use. Also included are procedures for electrical transmission of engineer reconnaissance information and procedures for filling in engineer reconnaissance forms.

b. FM 5-34 (Engineer Field Data). The "Engineer Bible" is one of the most sought after books. It holds formulas and formats for most engineer data.

c. GTA 5-2-5 (Engineer Reconnaissance Card). It is an excerpt from MCWP 3-17.3 used for training.

12. ROUTE RECONNAISSANCE. The ability to carry out a mission depends heavily upon available lines of communication, and in particular, the land routes. There are two types of route reconnaissance:

a. Hasty Route Reconnaissance. Is conducted to determine the immediate military load classification of a specified route when time has priority.

(1) It is limited to critical terrain data necessary for route classification.

(2) The route reconnaissance overlay is accurate, clear, and concise.

b. Deliberate Route Reconnaissance. Is much greater in scope and is made when sufficient time and qualified personnel are available.

(1) Enclosures describe in detail each terrain feature covered by the report.

(2) It differs from hasty route reconnaissance reports only in the degree and completeness of reported information. Deliberate reconnaissance provides a thorough analysis and classification of significant information along a route and considers demolition and repair information that may be necessary.

c. Terrain Considerations. Terrain features are important in route reconnaissance and require consideration. Examples are:

(1) Existing routes and their physical characteristics.

(2) Gradients and radius of curvature.

(3) Bridges.

(4) Vehicular fording, ferrying.

(5) Tunnels, underpasses, and similar obstructions to traffic flow.

(6) Reinforcing obstacles (craters, minefields, roadblocks, NBC).

(7) Rock falls and slide areas.

(8) Drainage.

(9) Other natural or man-made features such as wooded or built up areas that may impact movement.

d. Route Classification System. This is designed to assist in planning and executing military movement. Routes are classified according to the factors of minimum width, worst route type, least bridge military load classification and obstructions to traffic flow. (See GTA Card Pg. 8)

e. Route Types. For the purpose of classification, routes are designated by their ability to withstand the effects of weather. There are three types. (See GTA Card, pg. 8).

(1) Type X. All weather route is any route which with reasonable maintenance, is passable through the year to traffic never appreciably less than maximum capacity.

(2) Type Y. All weather route (limited traffic due to weather) is any route which with reasonable maintenance can be kept open in all weather, but sometimes less than maximum capacity. Bad weather could halt traffic, for a short time, on this type of road.

(3) Type Z. Fair weather route is any route that quickly becomes impassable in adverse weather and cannot be kept open by maintenance short of major construction. (See GTA Card, pg. 8).

f. Military Load Classification. (MLC) Considers vehicle weight and type and its effect on routes and bridges. (See GTA Card, pg. 10).

(1) The classification system is represented by whole numbers assigned to vehicles, bridges, and routes.

(2) Bridges and routes are assigned military load classifications based on their safe load capacity and physical dimensions.

(3) The lowest military load classification number regardless of vehicle type or conditions of traffic flow determines the military load classification of the entire route in question.

g. Obstruction to Traffic Flows. Route obstructions are factors that restrict the type, amount and speed of traffic flow. Obstructions to be reported on are indicated in the route classification formula by the abbreviation (OB). Examples of obstructions are:

(1) Overhead obstructions: Tunnels, underpasses, overhead wires, overhanging buildings, overhead clearance less than 4.3 meters (14 ft)

(2) Reduction in traveled way widths: Single flow 5.5 meters to 7.3 meters (18 to 24 ft), double flow over 7.3 meters (24 ft).

(3) Gradients (slopes) of 7 percent or greater.

(4) Curves with a radius of less than 25 meters (82 ft).

(5) Ferry and/or ford sites.

h. Special Conditions

(1) Snow blockage: Where snow blockage is regular, recurrent, and serious the classification symbol is (T).

(2) Flooding: Where flooding is regular, recurrent, and serious the classification formula is (W).

i. Route Classification Formula. (See GTA 5-2-5 Card, pg. 8). Is developed from notations expressed in the standardized sequence of, minimum traveled way width, route type, lowest military load classification, and obstructions if present.

(1) Example: 20 ft. Z 10 (OB). This describes a fair weather route with a minimum traveled way width of 20 feet and a military load classification of 10 with an obstruction.

(2) Student Problem #1 = 7m Y 50 (OB): A LIMITED ALL WEATHER ROUTE WITH A MINIMUM TRAVELED WAY OF 7 METERS, A MILITARY LOAD CLASSIFICATION OF 50, AND WITH OBSTRUCTION(S).

(3) Student Problem #2 - All weather route with a minimum traveled way width of 10.5 meters, a military load classification of 120 with a grade of 8 percent. 10.5m X 120 (OB)

13. ROAD RECONNAISSANCE: Road reconnaissance is conducted to determine the traffic capabilities of a particular road and to provide more detailed information than that needed for the route classification formula.

a. A road is an open way provided for the convenient passage of vehicles. Road reconnaissance is conducted to determine the traffic capabilities of a particular road and to provide more detailed information than that needed for the route classification formula. To determining the load-bearing capacity of roads, a basic knowledge of road structure and design (as outlined in MCWP 3-17.3 and TM 5-330) is desirable. A road usually consists of a pavement or surface, a base course, a subgrade, and a drainage system(s).

(1) Surfaces - The surface of a road is the top portion of the road structure. Surfaces are made of various materials; natural earth stabilized with oil, bituminous pavement, portland cement, concrete, brick, block and stone.

(2) Base Course and Subgrades - The base course of a road is the intermediate portion of the road. Base courses are usually made from gravel or crushed rock. The subgrade is the foundation. Roads usually have a subgrade made of locally available natural materials.

(3) Drainage Systems - Drainage systems remove surface water, intercepts and disposes of runoff from adjoining areas, and removes harmful groundwater from the road surface or subsurface areas. The entire serviceability of a road depends on the adequacy of the drainage system. In addition, drainage systems are targets for demolition. Reconnaissance personnel should therefore inspect the drainage system to report structures in need of repair or debris which may clog the system and to check likely sites for prepared demolition or acts of sabotage. Components of drainage systems are open channels, embankments, culverts, and dips.

(a) Open channels or ditches are the simplest and most common method of handling surface water. Deep or wide ditches bordering roads are definite traffic hazards. These ditches may reduce the width of the traveled way and require posting with caution signs.

(b) Dikes, berms, or intercepting embankments are used along shoulders of high fill or along the tops of cut slopes to collect runoff. Such runoff may be directed into ditches or natural drainage courses to prevent the erosion of unstable slopes.

(c) Culverts are used under roads and air landing facilities to carry water that cannot be diverted to natural drainage channels by other means. Culverts are relatively short and conform generally to the grade and alignment of the open ditch, stream, or natural drainage course at the inlet and outlet ends. Culverts are particularly good demolition targets.

(d) Dips are portions of a road, normally paved, that may be used as fords for crossing shallow watercourses or washes in semi-arid regions subject to flash floods and in other locations where the construction of a bridge is impractical or too expensive.

b. Road Classification Formula: A series of numbers and symbols express the road classification formula in standardized order. The formula describes the worst section of a road. It is expressed as follows:

(1) The formula is prefixed by the letter "A" if there are no limiting characteristics and letter "B" if there is one or more limiting characteristic.

(2) Limiting characteristics: (On GTA Card, pg. 9.) Each characteristic has its own symbol.

Symbol c - curves with radius less than 25 meters (82 ft)
d - inadequate drainage
f - unstable foundation
g - gradients of 7% or more
j - excessive camber or superelevation
s - rough surface condition

Any unknown characteristic is represented by a question mark, for example, (f?).

(3) The minimum width of the traveled way is expressed in meters and is followed by a slash and the combined width of the traveled way and the shoulders (for example, 14/16m). A description of the shoulders is not reported as part of the formula but as a separate notation which specifies the surface of the shoulders (grass, gravel metaling), condition (unusable, emergency only, capable of improvements), width, vegetation, and critical side slopes. To report a dual road in which the two traveled ways are <u>narrowly</u> separated by a fixed barrier, turf in center , the width of each traveled way is noted first and followed by the combined width including shoulder (for example 7 + 7/21m). If the two traveled ways are <u>significantly</u> divided, each is reported as a separate road.

(4) Next is the type of surface material. Road surface material is expressed by a letter symbol, see GTA Card, pg. 9, in the route classification formula.

(5) The road length in km may be shown in parentheses.

(6) Obstructions along a road are indicated by placing the symbol (OB) at the end of the formula. Details of obstructions affecting the traffic flow of a road are not shown in the formula but are reported separately by appropriate symbols on accompanying maps or overlays or on DA Form 1248 (Road Reconnaissance Report). Reportable obstructions are:

(a) Overhead clearance is less than 4.3 meters (14 feet).

(b) Reductions in Traveled way widths below standards (see GTA card table 3, page 12 or MCWP 3-17.3, page 2-4, table 2-1)

<u>1</u> (OB) Whenever the traveled way width is reduced below the minimum standard for the type of traffic conditions, (less than 5.5 meters for single flow traffic and less than 7 meters for double flow traffic).

<u>2</u> If type of vehicle is not known, use 8 meters (26 ft) as minimum width.

(c) Excessive grades. (OB) When gradient is 7% or greater.

(d) Sharp curves. (OB) Whenever the radius of curvature is less than or equal to 25 meters (82.5 ft).

(e) Fords & Ferries. (OB) When present.

(7) Special Conditions. If road blockage is regular, recurrent, and serious, the effects of snow blockage (T) and flooding (W) are indicated in the road classification formula.

(8) Example: B g s 4/5 l (OB). This formula describes a road with limiting characteristics of steep gradients and rough surface, a minimum traveled way of 4 meters, a combining width of 5 meters, gravel, or lightly metaled surface, and obstruction.

Student Problem. A road with a sharp curve, unknown foundation, a traveled way of 3.2 meters. It has a paving of brick on stone surface, 4.3 kilometers long, and there are signs of heavy snow. Classify this road using the road classification formula.

ANSWER: **B c (f?) 3.2m P (4.3km) (OB) (T)**

14. ROAD RECONNAISSANCE REPORT: DA Form 1248 provides the format required for road classification. When DA forms are not available, short forms or work sheets for fieldwork, may be designed by the unit making the reconnaissance. During deliberate route reconnaissance, each road within the route will be classified and a DA Form 1248 will be completed.

a. The top part of the form consists of standard identification information.

b. Section I. Consists of general road information. Grid references, roadway width, reconnaissance date and time occurred, weather during reconnaissance, road marking, and length of road.

c. Section II. Consists of detailed road information. Alignment, drainage, foundation, surface, and type of surface. You simply check the appropriate blocks.

d. Section III. Obstructions (OB) in the road.

e. The mileage chart on the reverse side reads from the bottom up and is used to show the location of noticeable or prominent features along the road. You can use miles or kilometers to create a scale.

15. BRIDGE RECONNAISSANCE:

a. A bridge is a structure that carries a roadway or railway over a depression or obstacle. A bridge that is completely supported by its two abutments (end supports) is called a single-span bridge. A bridge that has one or more supports between the abutments is a multi-span bridge. From a military standpoint, bridges either already exist in an area of operations or must be constructed for military purposes during the course of a specific operation. Existing bridges vary in size and complexity, and it is these types of bridges that military engineers must most often reconnoiter and classify. Military bridges, on the other hand, which are usually constructed and classified by military engineers, include floating bridges, standard prefabricated bridges, and field-fabricated bridges.

b. Bridge Components: The main components of the bridge are the approaches, substructure, and the superstructure. The approaches (portions of a route leading to a bridge) are often constructed as either fills that rise to the bridge or cuts that slope down to the bridge. Approaches may be mined or boobytrapped and, therefore, require thorough investigation during reconnaissance. The substructure (lower part) of a bridge consists of the abutments and intermediate supports that transfer the load of the bridge to the ground. The superstructure is the upper part of the bridge and consists of the components described below.

(1) Stringers rest on and span the distance between the intermediate supports or abutments. Stringers are the main load-carrying members of the superstructure. They receive the load from the flooring and transfer it to the substructure.

(2) The flooring system often consists of both decking and tread. The decking is laid directly over the stringers at right angles to the centerline of the bridge. The tread is laid parallel to the centerline of the bridge and between the curbs. It acts to strengthen the structure and increase load bearing capacity as well as preventing traffic wear on the decking.

(3) Curbs are usually placed at both edges of the flooring to guide crossing vehicles. A vehicle with an a axle that is wider than the width of the road, will not fit between the curbs and cannot cross the bridge. Most bridges, however, allow for vehicular overhang beyond the wheels or tracks. This allowance is called horizontal clearance above the curbs.

(4) Railings along the bridge are built to guide drivers and to protect vehicular and foot traffic.

(5) Trusses are used in some bridge superstructures, either above or below the traveled way, to increase the load-carrying capacity. A truss is a structural element made of several members joined together to form a series of triangles.

c. Time and qualified personnel, (Engineers), need to be available for detailed analysis, or if the bridge is of a complicated design, more precise methods and better qualified personnel (SEA B'S or Civil Engineers) are used (for the methods see TM 5-312). A bridge reconnaissance must be done before the class of a bridge can be determined, measurements and other data that determine the classification of a bridge are taken and noted.

(1) The number of members in each span is noted, where applicable (stringer bridges and concrete T-beam bridges, for example). Exact and complete dimensions of specific bridge members are taken as outlined later in this lesson.

(2) The span length is measured from center-to-center of supports. The classification of the bridge is usually based on the critical (weakest) span, and if the weakest span is readily apparent, no other spans need be investigated. However, if the weakest span is difficult or impossible to locate by looking, all spans must be classified. Even if several spans look identical, actual measurements are taken to prevent error.

(3) The traveled way width is measured between the inside faces of the curbs. On a truss bridge, however, the horizontal clearance is measured from a point four feet above the roadway, but only one foot for other bridges.

(4) It is essential to note the general condition of the bridge, paying particular attention to evidence of damage from natural causes (rot and rust) or combat action. Classification procedures presume that a bridge is in good condition. If the bridge is in poor condition, the class obtained from

mathematical computations must be reduced in accordance with the classifier's judgement.

(5) Additional Bridge Information: There are several items of bridge information that may be collected and recorded when possible.

(a) Approaches (limiting factors, minimum traveled way width, surface material, and obstructions) my be recorded.

(b) The geographical feature, which the bridge spans, and its width and depth may be recorded. If the crossing is over a water obstacle, additional information includes current conditions, width and depth at mean water level, tidal conditions, flood susceptibility, location of dams and locks, nature and slope of banks, and type stream bottom.

(c) Abutments, including foundation conditions, type and material of construction, and bearing areas, may be recorded (see TM 5-312 or FM 5-34).

(d) Intermediate supports may be recorded. This information could include foundation conditions, type and material of construction, bearing areas, height above ground or mean water level, horizontal clearance between supports at ground or mean water level, special design features such as ice breakers, and critical dimensions required for demolition or classification calculations (see TM 5-312 or FM 5-34).

(e) Bridge structure (including a detailed description of the type and material of construction, wearing surface, deck or flooring, and supporting members) may be recorded. Also included are capacity dimensions, where applicable (Table 11); engines and machinery for swing, lift, , and retractile bridges; supply, utility, or communication lines supported by the bridge; date of construction; and critical dimensions for demolition and calculation of military load classification (see TM 5-312 or FM 5-34).

(f) Repair information may be recorded. This information should include a description of the nature of repair or the reinforcement needed; an estimate of time , labor, and material required; availability of construction material nearby; and results to be expected from repairs or reinforcement (TM 5-312). Extensive repair information is recorded on DA Form 1711-R and attached to the Bridge Reconnaissance Report.

(g) Demolition information may be recorded. This should include a description of the demolition procedures planned and the expected effect, a description of any prior preparation, and an estimate of time, labor, and material required to execute the demolition (FM 5-25) (see target folders).

(h) Alternate crossing sites may be recorded. This could include data concerning the approaches, type of crossing (ferry, ford, or floating bridge), and estimate of the time, labor, and materials needed to construct alternate crossings.

16. Bridge Reconnaissance Report Form. DA Form 1249 is used for each bridge encountered.

a. Standard information along the top of the form.

b. The assigned serial number of the bridge is entered in Column 1. This number corresponds with the number used on the overlay.

c. The bridge location is reported by means of Universal Transverse Mercator (UTM) grid coordinates in Column 2. Standard grid coordinates used on all ground military maps.

d. Horizontal clearance is entered in Column 3. If unlimited clearance, put infinity symbol.

e. Under bridge clearance is entered in Column 4. Both heights are listed in order; height between the underspan and stream bed, back slash, then the height between the underspan and the normal water depth.(12m/10m)

f. The number of spans is listed in Column 5. Each span is listed, form the west to east. In the event a more westerly span cannot be determined, i.e. the bridge run due north/south, the spans are listed north to south in sequence

g. Types of span construction are recorded by corrected number symbol in Column 6. The number symbol are listed on pg. 5-12 in FM 5-34 and pg. 6 of the GTA card 5-2-5 (Engineer Recon).

h. The construction material of each span is recorded by letter symbols in Column 7. The symbols are found on pg. 5-13 in FM 5-34 and pg. 9 in GTA card 5-2-5.

i. The length of each span is recorded in Column 8. This is the center to center distance between bearings, so the sum of all spans will not equal the overall length of the bridge. In this column place a "#" next to the length if the span is damage or unusable and/or a "W" next to the length if the span is over water.

j. For additional bridge information add column as needed, or write on another paper/form.

k. Bridge Sketches. Sketches on the back of DA Form 1249 show as much information as necessary. Several important details must be illustrated in the sketches:

(1) A side elevation (profile) shows general features of the bridge. This should include abutments, piers, spans, with their type and construction material indicated.

(2) The critical span (the span with the least load carrying capacity) should be sketched in cross-section. This is generally the longest span but this depends on the construction of the bridge, (number and size of stringers). Enough detail must be provided to compute military load classification.

(3) Cross sections of critical members should be sketched in detail. Enough detail must be provided to compute military load classification.

(4) Site plan sketch shows location, alignment, gap or obstacles spanned, dimensions, classification, and gradient of approaches.

(5) Bridge photographs if possible.

17. RECONNAISSANCE FOR STREAM CROSSING OPERATIONS: Considerations for stream crossing ops. are depth, width, approaches, velocities, and natural, and man-made obstacles.

a. Stream depths are normally taken every three meters to provide warning for changes. Usually poles or weighted ropes work well for determining depth. Take into consideration high water marks that may indicate the depth of the stream in heavy rainfall or spring thaw. Sluggish streams may turn into raging river in a short notice, especially in tropical, mountain, or desert regions.

b. Stream width determined by compass.

(1) Take an azimuth from a point on the near shore and close to the water's edge to a point on the opposite shore.

(2) On the near shore, establish another point that is on a line and at a right angle (90) to the azimuth selected.

(3) The azimuth to the same point on the far shore is $\pm$ 45 degrees form the previous azimuth. Depending on if you travel 90 degrees to the left or right, will tell you to add or subtract the 45 degrees. (See GTA Card, pg. 14).

(4) Measure the distance between the two points on the near shore.

(5) This distance is equal to the distance across the stream.

c. Stream width by measuring the gap.

(1) Have a member of the reconnaissance team hold an end of a tape or rope on the near bank.

(2) Another member crosses to the opposite bank and pulls the tape tight.

(3) The length of tape that corresponds to the distance across the gap is measured.

(4) This method is particularly useful during darkness when lights are not allowed.

d. Current velocities vary in different parts of a stream. The current is slower near the shore and swifter in the main channel.

(1) To determine velocity of a stream, measure a distance along the riverbank.

(2) Throw a light object that can float into the stream. Record the time required for the object to float the measured distance.

(3) The formula is measured distance in feet (or meters) divided by average time in seconds equals stream velocity in FPS (or MPS).

18. FORDS: A ford is a location in a water barrier where the current, bottom and approaches allow personnel and/or vehicles and other equipment to cross, where suspension systems remain in contact with the bottom. All fords are considered obstructions.

a. Fords are classified according to their crossing potential or trafficability for pedestrians or vehicles.

b. The composition of the stream bottom of a ford determines its trafficability. (See GTA Card, pg. 4).

c. Limited ford information is recorded on maps or overlays by means of symbols.

d. Ford reconnaissance report form: The following details should be entered on the ford reconnaissance report.

(1) Items 1-10: Enter all data that establishes positive identification of the ford.

(2) Item 11: Record the width and depth of the crossing and velocity of the stream. Low, mean, and high water data may be obtain from local records, talking to the locals, or estimated based on the terrain along the site.

(3) Items 12-17: Record composition of the stream bottom, composition and percent of slope of both approaches, usable width of approaches and any known hazards such as flash floods, quicksand, or floating debris.

(4) Item 18: Enter any other pertinent data not recorded elsewhere on the report.

(5) Items 19-20: Draw sketches of the ford showing both a profile and site plan.

(6) Ford signs are used to mark fords. The trace of the ford should also be marked, especially in low light conditions. (See GTA Card, pg. 4).

(7) Vehicle Swimming Operations are related to the ford reconnaissance, in that some fording sites may be to deep for fording but not deep enough for a ferry and should be annotated as such. Most details of ford reconnaissance apply to swimming operations (stream depth and bottom conditions, sandbars and other obstructions, and especially stream entrances and exits. The DA form 1251 and the format for electrically ford data are modified with the notation that the site is appropriate for Swimming vehicles only.

19. FERRIES. A floating vehicle whose construction varies widely and ranges from expedient rafts to ocean-going vessels. Propulsion may be by oars, cable, pulleys, poles, stream current, or by steam, gasoline, or diesel engines. Ferries are obstructions. Limiting features of a ferry site that should be considered are the width of the water barrier, distance and time for the ferry to travel from one bank to bank and the water depth of both slips.

a. Desirable Site Characteristics:

(1) Current velocity between 0 and 1.6 meters per second.

(2) Banks which permit loading without a great deal of preparation.

(3) Approaches that permit easy access and exit.

(4) Strong natural holdfast.

(5) No shoals, sandbars, or snags.

(6) Sites clear of obstacles immediately downstream.

(7) Sites clear of mines and boobytraps.

(8) Enough depth to prevent grounding the raft or ferry during loading and unloading operations, or when crossing.

(9) Holding areas for vehicles awaiting passage.

(10) Limited ferry information is recorded on maps or overlays by means of symbols.

b. Ferry Reconnaissance Report Form (DA 1252).

(1) Items 1-11. Enter all information that identifies the ferry.

(2) Item 12. Enter limiting features that would affect ferry operations. Such as varying depths of water at high and low tide, effects of freezing temperatures, etc....

(3) Items 13-15. Record the depth of the stream or body of water at high/low tides, the crossing times and the length of the course.

(4) Item 16. Record the pertinent design features for the vessels used. Include number of each type, length, beam, max capacity, and draft.

(5) Item 17. Designate the geographic direction of each bank by circling the appropriate abbreviations (N, E, S, W), the dimensions and capacity of each slip, the conditions of any docking facilities and the types and conditions of approaches.

(6) Item 18. Enter facilities for transferring freight.

(7) Items 19-20. Draw a sketch showing the route alignment plan and two sketches showing terminal's accessibility on both sides of the crossing. Pay particular attention to record any obstructions.

20. <u>SLOPES</u>: The rise or fall of the ground is known as slope or gradient (grade).

a. Percent of Slope. The percent is the ratio of change in elevation (vertical distance to horizontal ground distance) multiplied by 100. (See GTA Card, pg. 14)

b. Large-scale maps may be used to approximate the percent of slope.

(1) The <u>difference</u> in elevation between the top and bottom of the slope is found by reading the contour lines (check your contour interval) or spot elevation.

(2) The horizontal distance (usually road distance) is measured and converted to the same unit of measurement as the elevation interval.

(3) The vertical and horizontal distance are substituted in the percent of slope formula and the percent of slope is computed. **<u>This method is not suitable where cuts and fills have been used to reduce the gradient.</u>**

V X 100 = % of slope H

c. Line of sight and pace is a quick method of estimating the percent of slope. See example and pg.3-3 MCWP 3-17.3.

(1) The eye level of the average man is 1.75 meters (5 feet, 7 inches) above ground.

(2) The pace of the average man is .75 meters (30 inches).

(3) Vertical distance is then computed by multiplying the number of eye level height.(If it takes two eye level heights to get to the top of the slope, than: 2 eye level height x 1.75m = 3.5m)

(4) Horizontal distance is computed by totaling the number of paces and converting the meters by multiplying by the factor .75, (If it takes a total of 200 paces to travel to the top of the slope, than: 200 x .75m = 150m).

d. Slope Reconnaissance Symbols. Most vehicles that must negotiate slopes of 7 percent or greater for any significant distance will be slowed down. (See GTA Card, pg. 3).

21. CURVES: The speed at which a vehicle can move along a route is affected by sharp curves. A radius curvature of 25 meters (82.5 feet) or less is an obstruction.

a. There are several ways to measure curves. The easiest method is:

(1) Radius of a curve based on the formula (see fig.3-8, pg.3-7, MCWP 3-17.3)

$$R = \frac{C^2}{8M} + \frac{M}{2}$$

Where R = radius of the circle

C = distance from the centerline of road to the center line of the road at the extremities of the curve.

M = perpendicular distance from center of tape to centerline of road

(2) If c is fixed at a constant of 2 meters, the formula is much easier to calculate.

Example: $\mathbf{R} = \frac{15^2}{16} + \frac{2}{2} = 14.06 + 1 = 15.06 \quad \mathbf{R} = 15$

(3) The result of calculation would be placed in the route classification formula.

(4) Curve symbols: (See GTA Card, pg. 3).

NOTE: Any radius less than or equal to 25 meters is an obstruction. Any radius between 25.1m and 45m are reportable but not considered obstructions.

22. TUNNELS: Tunnels are underground galleries or section of road that has been artificially covered for the passage of a route. Tunnel reconnaissance determines essential information such as serial number, location, type, length, width including sidewalks, alignment, gradient, and cross section.

a. Common shapes of tunnel bores are:

(1) Square with arch ceiling.

(2) Elliptical

(3) Horseshoe

(4) Semicircular

b. Tunnel reconnaissance symbol is recorded on maps or overlays. The tunnel entrance is shown on the map or overlay by an arrow from the symbol to the location of the entrance.

c. The width of the traveled way is shown in meters and is placed below the symbol.

d. Overhead clearances is the least distance between the surface of the traveled way and any obstruction vertically above it. Minimum and maximum overhead clearance is shown in meters to the left of the symbol.

e. Tunnel reconnaissance report form DA 1250:

(1) 1 - 11. Enter all information that identifies the tunnel.

(2) 12 - 17. Enter overall tunnel dimensions.

(3) 18 - 21. Enter the type of lining material, portal material, type of ventilation, and drainage means.

(4) 22 - 29. Enter bypass possibilities, gradient, and passability of approaches, in tunnel restrictions such as curves, any geological information pertinent to maintenance, improvement, or safety.

(5) 30 - 32. Draw a plan, profile, portal view, and a cross section of the bore.

(6) 33. Enter any pertinent information not mentioned above and attach appropriate photographs, if available.

23. ENGINEER RECONNAISSANCE. Is terrain reconnaissance conducted to support engineer activities. General engineer reconnaissance gathers engineer information of a **broad** nature within the operational area to locate and evaluate items, such as construction material, resources, and terrain features, that have engineer implications. General reconnaissance missions may be assigned on a zone, area, or route basis. To ensure that important engineer aspects are not overlooked, a checklist is recommended. A copy of the checklist is located in FM 5-34, pg. 5-17, and MCWP 3-17.3, pg. 7-2.

a. Engineer Reconnaissance Checklist. Consists of the following:

(1) Roads. Classify using symbols.

(2) Bridges, fords, and ferries. Classify using symbols.

(3) Obstacles to movement. Report natural or artificial.

(4) Terrain, nature ridge system, drainage, swamps, forest.

(5) Engineer materials, road material, bridge timber, lumber, steel, concrete

(6) Engineer equipment, sawmills, machine shops, garages.

(7) Errors and omissions on maps used.

(8) Water points. Recommend location.

(9) Barriers to enemy movement. Natural or artificial barriers.

(10) Streams. Description of width, depth, banks, approaches.

(11) Defensive positions.

(12) Bivouac areas. Give data on soil, drainage, entrances, and concealment.

(13) Utilities, water sewage, electricity, gas utilities.

(14) Construction sites, access, earthwork, acreage, power source.

(15) Ports, cargo-handling facilities, storage transportation routes.

(16) Railways, switching stations, off-load capabilities, storage.

(17) Airfields, tower facilities, length of runway , condition of strip.

b. The location of important terrain features is shown on the reconnaissance overlay by conventional military, topographic, and reconnaissance symbols. (See GTA Card, pg. 7).

c. Engineer Reconnaissance Report (DA 1711-R Form) is used to report on engineer activities. (See GTA Card, pg. 1).

(1) The heading. Contains self-explanatory information that identifies who conducted the reconnaissance.

(2) The key. References the item of the report and its corresponding location on the reconnaissance overlay.

(3) The object. To be explained. Is shown in this column by conventional symbol or brief, written description.

(4) If a work estimate is included as part of the report, enter YES; if not, enter NO.

(5) In the additional remarks column: Report the location of the object by grid coordinates followed by explanatory remarks, calculations, and appropriate sketch.

(6) The work estimate. On the reverse side, is used to indicate the amount and type of engineer effort required for construction or repair.

24. OVERLAYS

a. An overlay is a clear sheet of plastic or transparent paper. Information is plotted on it at the same scale as on the map, aerial photograph, or other graphic. When the overlay is placed over one of these, the details plotted on the overlay are shown in their true position.

b. Overlays are used to display military operations with enemy and friendly troop dispositions, and as supplements to orders sent to the field. They show detail that will aid in understanding the orders, displays of communication networks, and so forth. They are also used as annexes to reports made in the field because they can clarify matters that are difficult to explain clearly in writing.

c. Route Reconnaissance Overlays - The route reconnaissance overlay is an accurate and concise report of the conditions affecting traffic flow along a specified route and is the preferred method of preparing a route reconnaissance report. An overlay normally satisfies the requirements of a hasty route reconnaissance. If more detail is required to support the reconnaissance, the overlay is supplemented with written reports describing critical route characteristics in more detail.

d. Preparation of a overlay. There are three steps in making a map overlay; orienting the overlay material, plotting and symbolizing the detail, and adding the required marginal information.

(1) Orienting the overlay

(a) Orient the overlay over the place on the map to be annotated. Then, if possible, attach it to the edges of the map with tape.

(b) Trace the grid intersections nearest the two opposite corners of the overlay and label each with the proper grid coordinates. These register marks show the receiver of the overlay exactly where it fits on his map, without them, the overlay is difficult to orient. It is imperative that absolute accuracy be maintained in plotting the cross hairs, as the smallest mistake will throw off the overlay.

(2) Plotting detail.

(a) Colored pencils or markers in standard colors are used when available to plot any detail (Field Manual 101-5-1). Otherwise plot the positions of the activities or other information you wish to show with a pen or pencil that makes a lasting mark without cutting the overlay. Use standard topographic or military symbols where possible. Nonstandard symbols invented by the author must be identified in a legend on the overlay. Depending on the conditions under which the overlay is made, it may be advisable to plot the positions first on the map, then trace them onto the overlay. Since the overlay is to be used as a supplement to orders or reports and the recipient will have an identical map, show only that detail with which the report is directly concerned.

(b) If you have observed any topographic or cultural features that are not shown on the map, such as a new road or a destroyed bridge, plot the positions as accurately as possible on the overlay and mark with the standard topographic symbol.

(c) If difficulty in seeing through the overlay material is encountered while plotting or tracing detail, lift the overlay from time to time to check orientation of information being added.

(3) Recording marginal information - When all required detail has been plotted or traced on the overly, print information as close to the lower right-hand corner as detail permits. This information includes the following data.

(a) Title and objective - This tells the reader why the overlay was made and may also give the actual location. For example, "Road Reconnaissance" is not as specific as "Route 146 Road Reconnaissance."

(b) Time and date - Any overlay should contain the latest possible information. An overlay received in time is very valuable to the planning staff and may affect the entire situation; an overlay that has been delayed for any reason may be of little use. Therefore, the exact time the information was obtained aids the receivers in determining its reliability and usefulness.

(c) Map reference - The sheet name, sheet number, map series number, and scale must be included. If the reader does not have the map used for the overlay, this provides the information necessary to obtain it.

(d) Author - The name, rank, **SSN**, and organization of the author, supplemented with a date and time of preparation of the overlay, tells the reader if there was a time difference between when the information was obtained and when it was reported.

(e) Legend - If it is necessary to invent nonstandard symbols to show the required information, the legend must show what these symbols mean.

(f) Security classification. This must correspond to the highest classification of either the map or the information placed on the overlay. If the information and map are unclassified, this shall be so stated. The locations of the classification are, top center, bottom center, and near the marginal information block, of the overlay.

(g) Additional information. Any other information that amplifies the overlay shall also be included. Make it as brief as possible.

CONTROLLED PRACTICAL APPLICATION:

1. General Instructions.

a. The class will be divided into three teams. Each team will be assigned a team leader to supervise and delegate sub-tasks to complete that team's mission. Each team will be prepared to brief their reconnaissance finding to the instructor. Team leaders will ensure information for briefing is thoroughly disseminated to all team members enabling each one to deliver the brief and answer pertinent questions from the instructor. The planning, execution and intended use of their recon mission is administrative. All movement will be strictly on foot and at no time will teams deviate from their assigned routes. Team leaders will be issued one (1) Hand held radio for two checkpoints during course of recon and safety needs.

Each Team Leader will sign for:

(1) Hand held radio from the range house
(2) Camp Lejeune Special Maps
(2) Compass/Protractors
(*) MRE's for his team
(1) Ruler
(1) Clipboard
(1) Measuring tape
(*) Required recon forms
Team #1 should carry an extra pair of socks. (Ford Recon)

5 PARAGRAPH ORDER:

ORIENTATION: Use map (Camp Lejeune, Special 1:50,000). Our current location is 848293. Direction of movement varies with each team. Generally, team #1 will move East and South. Team #2 will move East and North. Team #3 will move West and North. Terrain is primarily level, heavily wooded with frequent marshy areas. Control measures are time orientated and the movement and planning will be administrative. Hold all questions until the end of this order.

SITUATION:

A. ENEMY FORCES: Your only enemy is time and human natures tendency to fail to pay attention to detail.

B. FRIENDLY FORCES: Higher - CEIC's mission is to train BCE's, JCE's, EOC's, and CEO's for duty in the FMF. The intent is to continue all published training schedules within existing time constrains.
Adjacent - None
Supporting - None required

C. ATTACHMENTS/DETATCHMENTS: One instructor may be attached to each recon team for observation and critique purposes. Time effective maybe at any time during the course of your recon.

MISSION: ____________________ will conduct engineer recon between and on along designated routes in the vicinity of MCES to determine route conditions for administrative wheeled vehicle traffic. FOME is on the accuracy of all information compiled for briefing.

EXECUTION:

A. COMMANDERS INTENT: My intent is to determine the ability of all routes to permit continuous use by military wheeled vehicles in support of training operations.

B. CONCEPT OF OPS: **(USE MAP)** From the Demo Range the class will separate into three teams and move to their respective start points, initiate their designated recon and return along the same route to the Demo Range.

1. SCHEME OF MANEUVER All movement is on foot, administrative and controlled by the team leader. Team integrity will be maintained to maximize the participation of all team members.

C. FIRE SUPPORT PLAN: N/A

D. TASKS:

TEAM #1: Conduct a route recon and ford recon on the preexisting trails of the following route:

Start Point:	83482885
1st Leg	83482885 - 84602840
2nd Leg	84602840 - 84502916
3rd Leg	84502916 - 85622895
4th Leg	85622880 - 85152815
5th Leg	85152815 - 85352802
Ford Site	85352802 - 85402795

TEAM #2: Conduct a route recon and LZ recon (LZ Dove) on the preexisting trails of the following route:

Start point:	83502955
1st Leg	83502955 - 85622880
2nd Leg	85622880 - 85742912
3rd Leg	85742912 - 85952910
4th Leg	85952910 - 86102915
5th Leg	86102915 - 86403020
6th Leg	86403020 - 85553101
LZ Dove	859308

TEAM #3: Conduct a route recon and designate and admin bivouac site for an infantry company (90 Men) and six supporting HMMWV's for a two day operation.

Start point:	83502955
1st Leg	83502955 - 82403022

2nd Leg 82403022 - 83203045
3rd Leg 83203045 - 83643135
4th Leg 83643135 - 82893156

NOTE: Bivouac site must be on 3rd or 4th leg of route.

E. COORDINATING INSTRUCTIONS:

1. Ensure all information is disseminated to all team members to allow any member to give the brief.

2. Each team will create duplicates (one coy) of all overlays, recon forms and any associated material for the instructor prior to giving briefs.

3. Time will be allocated in the classroom to prepare smooth recon forms and overlays.

4. Report back to the classroom immediately after completing recon mission.

5. Radios will be monitored at all times. Ensure that a radio check is done prior to departure.

ADMINISTRATION & LOGISTICS:

A. RATIONS & WATER: N/A

B. AMMO & FUEL: N/A

C. MEDICAL: In the event of an injury that requires immediate attention, establish contact with the Demo range or BB-13 , report your position, and nature of injury. Remain in place until evacuation vehicle arrives.

D. EPW's: N/A

COMMAND AND SIGNAL:

A. SIGNAL:

CALL SIGN: Higher -Demo Range(primary) BB-13 (alternate)

Team #1 -

Team #2 -

Team #3 -

FREQUENCY: (all teams)

Call in departure from start point and completion of recon.(return to start point) Any other traffic will be in the event of a mishap.

B. COMMAND:

Instructor location will be:

Time on deck is:

Are there any questions?

REFERENCE(S):

FM 5-36 ENGINEER RECONNAISANCE

UNITED STATES MARINE CORPS

COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C-01B02
10 Jul 00
(98 POI)

STUDENT HANDOUT

RIVER CROSSING OPERATIONS

LEARNING OBJECTIVES:

1. TERMINAL LEARNING OBJECTIVE(S):

a. Given a tactical situation and a map, with the aid of references, plan the engineer aspects of a river crossing operations consistent with the commander's intent in accordance with FM 90-13-1/ FMFM 7-26, FM 5-34/MCRP 3-17A, and MCWP 3-17. (1302.1.8)

b. Given a tactical situation, with the aid of references, supervise the engineer aspects of a river crossing operation in accordance with FM 90-13-1/FMFM 7-26, FM 5-34/MCRP 3-17A, and MCWP 3-17. (1302.1.24)

2. ENABLING LEARNING OBJECTIVE(S):

a. Given a tactical situation and an operation order, analyze the mission, enemy, terrain, troops and fire support available, time, space, and logistics (METT-TSL) in accordance with FM 90-13-1/FMFM 7-26, FM 5-34, and MCWP 3-17. (1302.1.8a)

b. Given a tactical situation, a map, and an operational area, evaluate potential river crossing sites in accordance with FM 90-13-1/FMFM 7-26, and MCWP 3-17. (1302.1.8b)

c. Given a list of potential river crossing sites, intelligence reports, a map, and a list of crossing equipment, select the crossing means in accordance with FM 90-13-1/FMFM 7-26, FM 5-34/MCRP 3-17A, and MCWP 3-17. (1302.1.8c)

d. Given a tactical situation and an operation order, identify the engineer tasks in accordance with FM 90-13-1/FMFM 7-26, FM 5-34/MCRP 3-17A, and MCWP 3-17. (1302.1.8d)

e. Given a tactical situation and an operation order, identify the resources required to complete engineer tasks in accordance with FM 90-13-1/FMFM 7-26, FM 5-34/MCRP 3-17A, and MCWP 3-17. (1302.1.8e)

f. Given a tactical situation and an operation order, prioritize the engineer tasks in accordance with FM 90-13-1/FMFM 7-26, FM 5-34/MCRP 3-17A, and MCWP 3-17. (1302.1.8f)

g. Given a tactical situation, an operation order, and a map, complete a crossing area overlay with tactical control measures in accordance with FM 90-13-1/FMFM 7-26, FM 5-34/MCRP 3-17A, and MCWP 3-17. (1302.1.8g)

h. Given a tactical situation, a map, an operation order, a river crossing mission, T/E and T/O of an engineer unit, task organize engineer equipment and personnel in accordance with FM 90-13-1/FMFM 7-26, FM 5-34/MCRP 3-17A, and MCWP 3-17. (1302.1.24a)

i. Given a tactical situation, an operation order, a river crossing mission, T/E and T/O of a MAGTF, identify tactical river crossing control measures in accordance with FM 90-13-1/FMFM 7-26, FM 5-34/MCRP 3-17A, and MCWP 3-17. (1302.1.24b)

BODY:

1. CONCEPTS OF RIVER CROSSING OPERATIONS.

a. River crossing operations are an integral part of land warfare. Rivers are not objectives, they are simply obstacles that must be negotiated in the offense or during retrograde operations. River crossings are special operations that require additional planning. The obstacle may be a river, stream, canal, or lake, but for simplicity we will refer to them all as "rivers". Regardless, the doctrine we use today was developed during hundreds of river crossings conducted by U.S. forces during WW II.

b. The first fundamental you must remember is that momentum should be maintained to some degree in any crossing. An unanticipated stall or time delay could pass the initiative to the enemy and cause all planning to be rendered worthless. Remember the costly lessons learned by the 141st Infantry Regiment on the Rapido River in 1944 (from "Evolution of River Crossing Operations, 1918-1944"). Other fundamentals of river crossing operations must also be considered to the extent required by your METT-TSL analysis:

(1) Surprise
(2) Preparations (training/rehearsals, intelligence)
(3) Flexible Planning
(4) Traffic Control
(5) Task Organization
(6) Speed in Exploitation

Failure to consider these fundamentals can seriously risk the crossing. All of these fundamentals will be covered in greater detail in this lesson.

c. River crossing operations are divided into three categories: hasty, deliberate, and retrograde.

d. **Hasty River Crossings** are characterized by the following:

(1) Speed, surprise and minimal loss of momentum.

(2) Decentralized control and execution of operation with existing or expedient resources already task organized/available at the maneuver unit level.

(3) Weak enemy defenses on both banks.

(4) Quick continuation of the attack.

As you can see, the Marine Corps' limited availability of bridging and rafting assets requires that units be task organized with the appropriate resources in order for hasty river crossing to be conducted.

e. **Deliberate River Crossing Operations** are characterized by:

(1) The failure or lack in feasibility of a hasty crossing.

(2) Detailed planning and centralized control.

(3) A deliberate pause to prepare or acquire additional bridging/rafting assets and concentrate combat power.

(4) Clearance of enemy forces from the far bank.

(5) Usually involves a rehearsal in the planning/preparation stages.

f. **Retrograde River Crossing Operations** are characterized by:

(1) Detailed planning and centralized control.

(2) Enemy control of maneuver initiative if crossing means is fixed.

(3) High risk as delaying forces attempt to cross river.

(4) Forces on exit bank provides covering fires for delaying force.

(5) Crossing means destroyed if time does not allow for recovery.

2. <u>CONSIDERATIONS FOR THE COMMANDER</u>.

a. **Offensive River Crossings-** The force commander and the engineer officer must evaluate and determine courses of action based primarily on the following factors:

(1) Severity and characteristics of the obstacle(s).

(2) Enemy's defense or use of obstacle(s).

(3) Command and control of operation.

(4) Available resources to negotiate obstacle(s).

(5) Ability to rapidly project combat power across the obstacle to continue the mission.

As you can see, river crossings are regarded in much the same way as any other obstacle. Many considerations that apply to breaching operations also factor into river crossing operations. The characteristics of the obstacle and the amount of crossing equipment available will dictate the number of crossing sites. The use of a <u>broad crossing front</u> has the most advantages tactically: less congestion, less vulnerability to enemy fires, easier to deceive enemy as to your main attack, and allows a wider exploitation of the crossing on the enemy side. Crossing on a <u>narrow front</u> has more merit from a supporting (e.g. engineers) standpoint: supporting fires can be mutually supportive and more concentrated, less security required, easier to control and coordinate, supporting engineer resources are less spread out, and traffic waiting to cross can quickly be rerouted from failed/delayed attempts to successful crossing sites. In either case, multiple crossing sites help prevent the crossing force from being defeated piecemeal during the critical period when the crossing force is divided by the obstacle. Command and control during river crossings are perhaps the most difficult functions for the crossing area commander. Centralized control will ideally work best but should not be depended on as communication lines quickly become saturated and enemy action/reaction can never be predicted with certainty. Traffic control, crossing timetables and signals are all critical to success and therefore must be included in the planning stages. We will discuss these aspects in greater detail later. Finally, the vulnerability of forces during crossing operations make <u>deception plans</u> a potentially life-saving option. A deception plan that employs reconnaissance, site preparations, heavy radio traffic and a perceived build-up of forces may be very effective in dividing your enemy's defensive capability.

b. **Retrograde River Crossing Ops**- Conducted with much of the same detailed planning and considerations as offensive crossings. Remember, failure of the retrograde on the ENTRY bank could result in loss of the entire force! Usually, a bridge already exists and has been in use by friendly forces prior to the retrograde. Naturally the bridge should be targeted and prepared for demolition by engineers as soon as the retrograde appears imminent. Unlike offensive operations, the FIRST PRIORITY is to get all non-essential combat and combat-service support elements/equipment across the river and disperse them in locations that can support the operation. Next, a defensive force moves across to establish a defense on the exit bank. Meanwhile, a delaying force is deployed to delay/deceive the enemy forward of an established hold line. Ideally, the hold line should be far enough from the entry bank to allow sufficient time for all other forces to cross the obstacle and establish over-watching defensive positions. Combat engineers should be heavily involved in counter-mobility tasks to aid the delaying force. A common enemy tactic employed in such scenarios is to attempt to seize the crossing means before it is destroyed. This effort is most likely while the delaying force is separated from the defending force by the river and may take the form of a flanking attack. Engineers should anticipate such an attempt and employ obstacles/mines accordingly. At a critical point, the defending force accepts primary responsibility for the defense from the delaying force. The defending force then over watches the crossing of the delaying force. All fixed bridges and rafts will then be destroyed by the defending force. Close coordination must be maintained by every means available to prevent bridges and/or rafts from being destroyed prematurely. Again, retrograde forces should expect the enemy to detect the operation and counter with whatever means available - especially indirect fire and attempts at envelopment of the delaying force. Remember, enemy intelligence will be trying to determine the time and location of any crossing attempt so an elaborate deception plan and solid OPSEC measures are well worth the investment.

3. OBSTACLE RECONNAISSANCE.

The primary factors behind the planning of river crossing operations is the information gathered on the ***river***, the ***terrain*** and the ***enemy***. The sophisticated intelligence gathering capabilities available at division and higher levels allows the opportunity to complete some of the early planning well before the operation begins. The critical link in the intelligence chain is the dissemination. Engineers at all levels must be proactive in seeking the information most needed by the assault and support forces. As a special staff officer, engineers must make known their intelligence requirements and priorities through the intelligence officer and be the driving force behind requests for follow-ups and updates. General characteristics of most of the world's rivers have been studied and recorded. The information must be checked for a date of origination as time and man-made developments (e.g. a dam, new bridges, dredged channels, etc.) can seriously effect your planning. Other sources of intelligence are:

(1) Aerial photographs.

(2) Satellite imagery (including infrared - detects invisible heat by light wavelengths).

(3) UAV's.

(4) Local inhabitants.

(5) EPWs.

(6) Scouts/patrols.

a. **The River**. Physical ground reconnaissance of the actual crossing site is the most preferred and relevant. Circumstances (e.g. enemy control of crossing sites) can often preclude getting all information desired. What is essential, however, is the following:

(1) Existing/proposed crossing sites (location and condition).

(2) Width, depth, velocity of the river.

(3) Bottom condition(s).

(4) Bank height, slope and stability.

NOTE: THERE IS NO STANDARD RECONNAISSANCE FORM THAT COVERS WET OR DRY GAP CROSSINGS IN GENERAL. USEFUL INFORMATION TO ATTAIN CAN BE FOUND IN THE FM 5-34/MCRP 3-17A ON PAGE 5-15.

b. **The Terrain**. The terrain around a river crossing is studied from two perspectives: (1) the impact on fighting the enemy and (2) the conduct of the crossing. Terrain considerations should include:

(1) Avenues of approach to the crossing sites and from the exit points to the objectives.

(2) Combat routes leading to and away from the river.

(3) Covered, concealed and dispersed areas for holding, staging and assembly areas.

(4) Work areas for support engineers.

(5) Fighting positions for forces over-watching the assault or delaying force.

(6) Effects of weather on soil trafficability, obscuration, etc.

c. **The Enemy**. Knowing the capabilities and disposition of the enemy insofar as how they can interfere with the river crossing is vital. Futhermore, the crossing force commander must have an understanding of enemy tactics for defense of a river line. The enemy naturally regards a water obstacle as a significant contribution to a strong defense. The enemy can economize the use of his forces and cover a relatively large amount of terrain. Depending on his strength, resources, the terrain and his knowledge of friendly forces, the enemy will defend in one of three ways; ***forward of the river line***, ***on the river line***, or ***to the rear of the river line***.

(1) **Forward of the River Line** - A strong enemy with sufficient reserves will choose a forward defense. This tactic is **MOST** preferable from the enemy's standpoint. The enemy intends to defeat the crossing force while it is preparing to cross the river but before it reaches the river. The enemy forces are divided into at least two defensive echelons with a mobile counter-attack/envelopment force behind the forward echelons. Depending on the size of the unit and the terrain, the first echelon may be as far as 10-15 km forward of the river line and is employed with economy of force in mind. The second echelon is concentrated on high speed avenues of approach and

located just a few kilometers forward of the river. The second echelon is prepared to reinforce the first, block any breakthroughs or, as a last resort, act as a defending force to cover the retrograde crossing of the first echelon. The counter attack force may be behind of or in front of the second echelon for the purpose of counter attacking (flanking or enveloping) any progress from areas from areas providing good mobility. In any event, the mission is to defeat the attacker before he reaches the river line.

(2) **On the River Line** - In this situation, the enemy's mission is defend as close to the exit bank as possible and defeat the crossing force while it is divided by the river. The enemy's relative strength will be equal to or slightly less than the attacking force. The enemy plans on heavy use of indirect fire to disrupt crossing forces prior to arriving at the river. He evaluates the terrain and concentrates on high speed avenues of approach and likely crossing sites. The arrangements of all defensive belts are similar to that of defenses forward of the river line except that distances between the echelon will most probably be closer. Delaying forces may also be used to deceive and deploy the attacking force prematurely. Existing bridges or crossings sites will be mined and/or destroyed. If necessary, few sites will be left open to allow the delaying forces (ideally amphibious) the opportunity to cross. Any breakthrough of the attacking force can expect all remaining echelons and counterattack forces to envelop and attempt to cut off the lead assault forces.

(3) **Rear of the River Line** - When forces, terrain and time do not appear favorable, the enemy will defend to the rear of the river line; the objective is to delay and disrupt the crossing and buy time for an effective defense at another location. Security/delaying forces will attempt to destroy bridges or rafts from the exit bank and observe and adjust indirect fire. Mines may be heavily employed to disrupt the crossing but time will usually preclude effective concentration at all sites and proper camouflage procedures.

(4) **Other Required Information: The Enemy-** In addition to the above information about enemy tactics, here is a checklist of the other essential pieces of information the crossing commander must attempt to have available on the enemy:

(1) Strength, composition and disposition.

(2) Conventional, nuclear, chemical capabilities (remember indirect fire and air attack).

(3) Previous tactics employed in the defense.

(4) Electronic warfare capabilities.

(5) Ability to reinforce with maneuver, artillery or air assets.

(6) Time available to prepare defenses.

(7) Probable location, type and extent of enemy emplaced obstacles.

(8) Effectiveness of command/control procedures and location.

4. Command and Control.

a. **Command Relationships**.

(1) Forces are divided in a manner similar to breaching operations except there is no breaching force in the task organization.

(a) **Assault Force**: Conducts assault crossing and captures/secures exit bank objectives (EBOs), intermediate objectives (IOs), and applies pressure to push out the bridgehead line.

(b) **Support Force**: Contains the engineers as well as direct and indirect fire weapons needed for the successful crossing.

(c) **Follow-on Forces**: Subsequent combat, combat support and combat service support units that will exploit the crossing.

(2) The appropriate MAGTF commander delegates authority to the ***Crossing Force Commander (CFC)***. Subordinate to the CFC are the ***Assault Force Commanders (AFC)*** and the ***Crossing Area Commander (CAC)***. The CAC is usually an engineer, and is responsible for the crossing area - the space between the release lines and all units within. A Crossing Site Commander (CSC) is an engineer, perhaps a platoon commander, who is responsible for crossing units at his site.

(3) CFC headquarters are centrally located and may be collocated with the central traffic control point and/or engineer headquarters.

5. Phases of River Crossing Operations.

a. **Advance to River**.

(1) **Plan/Arrange/Conduct Detailed Reconnaissance**: Specific areas to be reconnoitered in detail are selected based on any currently available intelligence. The engineers must coordinate their security arrangements for their recon. The reconnaissance must obtain information on the characteristics of the river, potential crossing sites, near shore and far shore characteristics, routes to and from crossing sites, potential staging, assembly and holding areas, equipment parks and existing crossing means (bridge, ferry, or ford). The engineer officer must evaluate the recon reports, select crossing sites, select the means to cross, and brief the plan.

(2) **Secure Near Shore**: The near shore is secured from the enemy to prohibit his influencing the preparations for crossing. This is to include crossing sites and construction site for rafts if necessary. The assault force is responsible for physically seizing the ground and the support forces will occupy and set up positions, as necessary, to support (by fire) the crossing of all forces.

(3) **Engineer Tasks:** During this phase, the staff engineer acting as Crossing Area Commander, must brief his plan to the Crossing Force Commander. Once approved, all external support arrangements must be coordinated; communication assets, manning of tactical control measures, exit bank objectives for the Assault Force Commander, security at the crossing sites, additional motor transport requirements for bridging trains/personnel and many other situationally dependent matters that pertain to any offensive plan.

b. **Assault Crossing**.

(1) **Conduct of Crossing**: The GCE conducts an assault crossing of the river. Supporting fires and obscuration fires are employed by the assault crossing force. Methods for assault crossing include swimming, boat ferrying, AAV/LAV swimming, fording and/or flying.

(2) **Objective**: The objective of the assault crossing is the seizure of the far shore. Security of the crossing sites that will enable the construction of bridging/rafting assets while not under direct fire/observation is the secondary objective.

(3) **Engineer Tasks:** While this phase centers on the assault crossing, engineers have other functions that may occur simultaneously: mobility support to the assault force; mark and establish all tactical control measures in effect; move bridging trains "up" to staging areas; control movement of traffic into holding areas; and provide updates to the CFC. Engineers may also be involved in the ferrying of assault forces across the river using Combat Rubber Reconnaissance Crafts (CRRC or more commonly known as F470 Zodiacs) or Bridge Erection Boats, both of which are T/E items in the bridge company of an engineer support battalion. Such a task requires extensive training and preparation and should not be undertaken by amateurs. See chapter 8 of FM 90-13/FMFM 7-26 for greater details.

c. **Advance from the Exit Bank**.

(1) **Exit Bank Objective (EBO)**: Secures far shore for subsequent crossing operations and orients force for capture of intermediate objectives. EBO is designed to push enemy outside of small arms range from crossing site. The EBO thus corresponds to what is referred to as the O-1 line (outside of small arms range, i.e. less than 20 mm projectiles).

(2) **Intermediate Objective (IO):** Such objectives are normally selected by the CFC and give direction to the assault force for the attack upon securing the EBOs. For opposed river crossings, IOs should be on or relatively close to the O-2 line. This is important to the engineer because the securing of the O-2 line means that no direct fire weapons or forward observers can target the crossing site. Thus the O-2 line is a control measure for the CAC in that the bridge/raft can be constructed without taking direct fire or observed indirect fire.

(3) **Engineer Tasks**: Ideally, once the assault force declares the EBOs and IOs secured, engineer/crossing equipment is brought to the actual crossing site and construction begins. This includes site preparation, improvement of approaches, construction of standard bridging on site (MGB) or the construction of rafts at separate sites and movement of the rafts to the crossing site. Obscuration fires that mask construction are desirable only to the point that the smoke does not hinder construction or draw enemy attention to the construction site. The establishment of the EBOs and IOs should thus be done in close coordination with the CAC and correspond with the O-1 and O-2 lines.

d. **Secure Bridgehead**.

(1) **Objective**: A bridgehead line is selected to deny enemy the ability to influence crossing operations. The line is outside the enemy's range of indirect fire weapons (0-3 line). Assault crossing units are continually pushing out to the bridgehead line in order to create safe assembly areas for the follow-on forces. This phase is similar to an

amphibious assault in that it includes the rapid buildup of combat power on the far shore in order to exploit the successful crossing.

(2) **Engineer Tasks:** While the bridgehead is being secured and thereafter, the CAC initiates the crossing of all equipment/personnel over whatever means has been constructed. Improvements are made to approaches while assembly areas are created and all routes are clearly marked and if feasible, a crossing means devoted to reverse flow traffic is established.

6. Control Measures.

a. **Release Line (RL)**. Line that delineates the crossing area on the near and far shore and indicates a change of the headquarters controlling movement. Movement within the release lines is controlled by the CAC. Location depends on METT-TSL but is usually 2-4 km from the river and on easily identifiable terrain.

b. **Release Point (RP)**. Physical location where release/return of control takes place between the tactical unit commander and the crossing area commander. Release points are located along a release line.

c. **Engineer Regulation Point (ERP)**. Where technical checks are made on vehicles by engineers to ensure vehicles do not exceed height, width and weight limitations of the crossing means. If vehicles are found to exceed limitations, they must be rerouted to an appropriate crossing site. ERPs can be collocated with the release point or at the traffic control point at the staging area. In any case, they must be located at a site where vehicles can readily be turned around and routed to the proper crossing site.

d. **Traffic Control Point (TCP)**. TCPs are placed to maintain orderly traffic flow, move assigned series and move vehicles to holding areas, staging areas and on to the crossing site as required. TCPs provide control and information to higher headquarters and to vehicles. They are ideally manned by military police personnel and collocated with other control measures and/or at road intersections to provide a smooth flow of traffic.

e. **Staging Areas (SA).** Battalion-sized waiting areas ***outside*** the crossing area where forces wait to enter the crossing area. The CAC controls movement from staging areas into the crossing area.

f. **Call-foward Areas (CFA).** Company-size waiting areas ***within*** the crossing area. Vehicles/units prepare for crossing in the call-forward areas. Activities include formation of serials, preparation of vehicles and equipment, and waiting for their turn to move to the crossing. When leaving the call-forward area, especially in the case of rafting operations, units are not sent across in their tactical formations, e.g. a tank platoon is moved from the call-forward area to the site and across the river as individual vehicles. Call-foward areas are controlled by the CSC at the corresponding crossing site.

g. **Holding Area (HA)**. Designed for dispersing units and/or individual vehicles enroute to the crossing, ***used only if there are delays*** at the crossing point. Holding areas eliminate the lucrative artillery/air target presented by lines of vehicles waiting to cross.

h. **Assembly Area (AA)**. Area on the far shore where "disassembled" units are returned and reorganized into combat formations. Also near these areas are far shore traffic control points and a far shore release line. This allows the unit to leave the assembly area in tactical formations and to be immediately released to the operational control of the maneuver commander.

i. **Engineer Equipment Park (EEP)**. Where engineer equipment is assembled and staged for the movement to construction/crossing points and where vehicles/equipment used in the construction of bridging is conveniently stored. Ideally located in a ***covered and concealed position near the crossing site*** and positioned so as to not interfere with the routes of crossing units.

7. SELECTION OF CROSSING MEANS (STANDARD BRIDGING). Planners use METT-TSL to select the appropriate bridge for the situation. The mission will dictate the type of crossing. The enemy situation and the obstacle will impact on the crossing means selected and the sites for crossing and construction. Troops will include the type and number of vehicles and units to cross, while fire support available will determine the amount of obscuration fires. Terrain and weather will include the characteristics of the river. Time, space and logistics will be the factors that limit or allow for protracted construction operations of standard bridging. A cross section of current standard bridging shows TSL considerations:

BRIDGE	**MAXIMUM LENGTH**	**WORK FORCE**	**LOGISTICS**	**TIME**
MGB	46m	1 Platoon	15 Pallets	3 Hrs
RIBBON	Raft	1 Section	1 Veh per day	>20 min

NOTE: Ribbon bridges are limited in length only by available bridging and river current. Floating bridges require anchoring systems and multiple launch/construction sites. Chapter 7, FM 5-34/MCRP 3-17A contains the required tables for complete estimations.

a. **Platoon Commander Responsibilities**: Platoon commanders will usually be assigned as crossing site commanders or as crossing area commanders, depending of the size of the operation. Required engineer support for a MEU size operation is two platoons; for MEF-FWD two companies; and an ESB(-) and a CEB(-) for a MEF. Bridge company, ESB, will be task-organized according to the scope of the operation. Responsibilities of the senior engineer include, but are not limited to the following:

* Crossing units assault and follow-on forces in the crossing area.
* Security of the crossing sites and crossing area.
* Development and maintenance of crossing sites and support areas.
* Direction and control of movement of units within the area.

REFERENCES:

FM 90-13-1/FMFM 7-26	River Crossing Operations
FM 5-34/MCRP 3-17A	Engineer Field Data
MCWP 3-17	MAGTF Engineer Operations

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STUDENT HANDOUT

DEMOLITION TARGETS

PURPOSE: The purpose of this period of instruction is to provide you with the knowledge and skills necessary to prepare a target folder.

1. TERMINAL LEARNING OBJECTIVE(S):

a. Given a tactical situation, a map, a completed Demolition Reconnaissance Form (D. A. 2203R), and a blank NATO Standardization Agreement (STANAG) 2123 Obstacle Folder complete an obstacle folder in accordance with FM 5-250. (1302.2.4)

b. Given a tactical situation, a map, and a blank Demolition Reconnaissance Report (D.A. 2203 R), perform a demolition reconnaissance in accordance with FM 5-250. (1302.2.4)

BODY:

1. DEMOLITION PLANNING

a. Execution of a demolition project. The execution of a demolition project must be based upon careful planning and reconnaissance.

b. Selection of a demolition project.

2. DEMOLITION RECONNAISSANCE REPORT

a. The Demolition Reconnaissance Report provides information in all areas related to the target. Use DA Form 2203-R together with the appropriate sketches to record and report the reconnaissance of a demolition target. This report will be your primary source to prepare a target folder.

b. The Demolition Reconnaissance Report should contain the following information:

(1) Block 1 (FILE NO.). Leave blank unless a higher headquarters provides this number. Higher headquarters provides this number or enters it after you submit the form.

(2) Block 2 (DML RECON RPT NO.). Leave blank unless a higher headquarters provides this number. Higher headquarters provides this number or enters it after you submit the form. Company SOP may specify the procedures for determining this number.

(3) Block 3 (DATE). Enter the date the reconnaissance was performed.

(4) Block 4 (TIME). Enter the time the reconnaissance party arrived at the target site (local or ZULU time).

(5) Block 5 (RECON ORDERED BY). Enter the command authority authorizing the reconnaissance action.

(6) Block 6 (PARTY LEADER). Enter the name of NCOIC or OIC of the reconnaissance party who was physically at the site when the reconnaissance was performed.

(7) Block 7 (MAP NAME, SCALE, SHEET #, and SERIES #). Obtain this information from a map of the reconnaissance area and enter the information in this block.

(8) Block 8 (TARGET AND LOCATION). Enter a brief description of the target and the distance and direction from an identifiable landmark (railroad, bridge, crossroad, hilltop, etc.). For example "Target is 275 degrees, 300 meters from the railroad bridge, 2 miles east of Hanesville, on Route 2."

(9) Block 9 (TIME OBSERVED). Enter the time you last saw the target as you departed the site.

(10) Block 10 (COORDINATES). Enter the complete 8 digit grid coordinates of the target.

(11) Block 11 (GENERAL DESCRIPTION {attach sketches}). When applicable, include the type of construction, width of the roadway, number of lanes or tracks, type of pavement, number of spans, condition of spans or entire bridge, and bridge categorization and classification. For example, "Pre-stressed concrete T-beam bridge, four simple spans supported by six concrete columns, two lanes; total bridge length is 140 feet; roadway width is 30 feet; overall bridge width is 36 feet; height is 16 feet; Class 80; very good condition."

(12) Block 12 (NATURE OF PROPOSED DEMOLITION {attach sketches}). State the expected amount of destruction and the priority for placing charges, if feasible. Provide a sketch showing the number and type of charges to use (tamped or untamped), where the charges should be placed, and the type of firing system required.

(13) Block 13 (UNUSUAL FEATURES OF SITE). Include any special features of the target or site that might affect the method of demolition (high-tension lines, radar installation, underwater blasting, etc.). Give any details that may affect the security of the target and the demolition work party.

(14) Block 14 (EXPLOSIVES REQUIRED). Indicate the types, quantities, caps, detonators, etc., proposed for the demolition.

(15) Block 15 (EQUIPMENT AND TRANSPORT REQUIRED). Specify the amount and type of transportation required (for example, two 5 ton dump trucks, one ram set with 50 cartridges, two posthole diggers, two demolition sets, 10 pounds of 16d nails, twelve 8-foot 2 by 4s). Comments may be continued on the reverse side of the form.

***** NOTE: Troops may not ride in the vehicles transporting explosives.**

(16) Block 16 (PERSONNEL AND TIME REQUIRED FOR:). Complete subsection a and b, indicating the number of personnel and amount of time necessary for placing the demolitions. The distance between the firing points and firing systems will be a consideration for determining the amount of time necessary to arm and fire the explosives.

(17) Block 17 (TIME, LABOR, AND EQUIPMENT REQUIRED FOR BYPASS; SPECIFY LOCATION AND METHOD). Specify the equipment necessary to clear the site after demolition and the available bypasses that allow units to bypass the site. Comments may be continued on the reverse side of the form.

(18) Block 18 (REMARKS). Include any appropriate remarks that are not covered in Blocks 1 through 17. Comments may be continued on the reverse side of the form.

(19) Block 19 (ADDITIONAL COMMENTS). Use this block as a continuation for Blocks 1 through 18. Identify the block being continued.

INSTRUCTIONS FOR SKETCHES:

a. General Description Sketch. This sketch should include:

(1) The avenues of approach to the target and possible bypasses in the vicinity of the target. Indicate route numbers and the direction of cities or towns.

(2) Rivers or streams including name, direction of flow, and velocity in meters per second.

(3) Terrain features including observation points, cover and concealment, swampy areas, deep valleys, etc.

(4) Compass arrow indicating north (indicate grid or magnetic).

(5) Dimensions of the proposed target.

(6) Number and length of bridge spans.

(7) Height of the bridge from the ground or water.

b. Nature of Proposed Demolition Sketch. This sketch should include:

(1) Dimensions of members to be cut.

(2) Placement of charges.

(3) Charge calculations. Use either the formula or table method, but show your work.

(4) Priming of charges.

(5) Branch lines.

(6) Ring mains.

(7) Firing systems.

(8) Firing points.

3. OBSTACLE FOLDER

a. The following information has been taken from NATO STANDARDIZATION AGREEMENT (STANAG) 2123 OBSTACLE FOLDER (Edition 2). The aim of NATO STANAG 2123 is to standardize the procedures to be used by NATO nations in connection with the preparation in peacetime of preplanned, pre-constructed and/or field-type obstacles.

b. FORMAT: The obstacle folder must have a strong, durable cover and be bound so that pages with maps, stores lists, sleeves, report forms, etc., can be easily removed. It is to be made small enough to fit into a pocket, whose dimensions are approximately 15 cm x 21 cm.

c. COMPOSITION: The obstacle folder consists of five parts:

(1) Location of the target.

(2) Supply of ammunition and stores.

(3) Technical instructions for the preparation.

(4) Handover/takeover procedures.

(5) Demolition report.

NOTE:

The parts are to be in the order indicated above. If additional information is considered to be necessary, it is to be inserted after the above parts in the appropriate place in the folder. If there is sufficient space to enter the information, insert pages can be used. In such cases, the words “see page ...” are to be inserted at the appropriate place. The insert page is to be placed immediately after the page to which it refers.

d. LANGUAGE: Situations could arise where the unit responsible for installing an obstacle is of a different nationality from the unit preparing the folder. It is therefore essential to produce the obstacle folder in a multilingual form. The obstacle folder is to be prepared in the languages of the host nation, and one of the two official NATO languages. All subject matter in the obstacle folder is to be completed in languages agreed for the folder. Notes on the sketches, etc., are to be in one language only, with a translation of relevant items into other languages on the page provided.

e. DETAILS:

(1) List of Explosives, Stores and Mines Required (Part 2.d of the folder). The list given in the format does not cover every possible item. It does indicate, however, a logical order for recording the various items. The list is to include only those items required for a particular target.

(2) Special Technical Instructions (Part 3.a of the folder). In the case of a major task, the size, composition and mission of the various parties employed on preparations are to be noted in the paragraph “Organization of work”.

(3) Mines (Part 3.e of the folder). This part concerns only nuisance or protective minefields laid to protect the demolition target and does not apply in the case of tactical minefields.

(4) Demolition Report (Part 5 of the folder). Paragraphs a. and b. are filled in when the folder is prepared. The sheet at Part (5) can be detached for use as a demolition report form upon completion of the demolition. Graph paper is provided on the back of it for making a sketch.

f. FRONT COVER:

(1) Security classification after completion. This classification will be indicated on all pages of the target folder at the top and bottom of the page.

(2) Class - Preliminary or reserved.

(a) Preliminary - A preliminary demolition target can be executed immediately after preparation.

(b) Reserved - A reserved demolition target must be controlled at a specific level of command because it plays a vital part in the tactical or strategic plan because of the structure itself, or because the demolition may be executed in the face of the enemy.

(3) Serial Number - Serial number of the target.

(4) Assigned target number.

(5) Copy number - This should read # __ of # __.

g. PAGE 2:

(1) Photograph of Target.

(2) Direction of View - (You will shoot an azimuth from center of circle to your target). North will be at direct top of circle.

(3) Description - Describe as complete as space allows, such as “Deliberate Road Crater”.

(4) Map Name and Scale - This block should have series, name, scale, and the sheet name and number.

(5) Grid reference of target - Use eight digit coordinates.

h. Page 3 LOCATION OF TARGET AND PRE-STOCK POINT:

(1) Use the largest scale map section that shows both the target and pre-stock point.

(2) Indicate the primary route with a solid line and the alternate route with a broken line.

(3) Label the target with the appropriate symbol and target number.

(4) Label the pre-stock point with the appropriate symbol and number.

(5) Label the map section with the map series, name, sheet number and sheet name.

(6) If there is no large town on the map section, label the road to the nearest town with an arrow pointing towards the town, put the name of the town, and the distance.

(7) If no grid lines are marked on the map section, fill in the numbers on each grid line.

(8) This page can be detached from the folder and handed to the commander of the party detailed to collect the explosives and stores from the pre-stock point.

i. PAGE 4, ANNEX A, STANAG 2123 IS BLANK.

j. PAGE 5 LOCATION OF TARGET:

(1) Use a large-scale map section showing the target and symbol in red. Center the target on the map section.

(2) Label the road to the nearest town. Include grid references as on page 3.

(3) Place the words: "Artillery Target Reference Number" along with the applicable pre-coordinated Artillery Target Reference Number right above the scale block.

k. PAGE 6 SUPPLY OF EXPLOSIVES AND STORES FOR TARGET:

(1) Name of pre-stock point.

(a) Location: See map pages 3, 5, 7.

(2) Number and size of trucks required to transport the munitions from the pre-stock point to the target.

(3) Route: See maps pages 3, 5, 7.

(4) Approximate travel distance from pre-stock point to target (km).

(5) Explosives and stores required: See page 12, 13, 14, and 15.

(6) Storage location of additional barrier material.

(a) Map Name and Scale.

(b) Grid Reference.

l. PAGE 7 LOCATION OF PRE-STOCK POINT:

(1) Center pre-stock point on map section.

(2) Use a map section, no larger than 1:50,000, showing the pre-stock point (highlighted in yellow) with the name and number written next to it.

(3) Show primary and alternate routes leading into the pre-stock point and label them.

(4) Include information and label the road to the nearest town as on page 5.

(5) Ensure that grid lines are legible.

(6) This page can be detached from the folder and handed to the commander of the party detailed to collect the explosives and stores from the pre-stock point.

m. PAGE 8 LAYOUT PLAN OF PRE-STOCK POINT:

(1) Make a detailed sketch of the pre-stock point showing where each item of munition or equipment is located and each stop the truck must make.

(2) Explain any procedures the driver/squad leader must know to obtain the munitions or equipment.

(3) Use an estimated scale.

(4) This page can be detached from the folder and handed to the commander of the party detailed to collect the explosives and stores from the pre-stock point.

n. PAGE 9 INSTRUCTIONS FOR OPENING AMMUNITION STORAGE VAULT DOOR:

(1) Explain in detail the procedures for opening the ammunition vault door.

o. PAGE 10 INSTRUCTION FOR OPENING AMMUNITION STORAGE VAULT DOOR:

(1) Explain in detail the procedures for opening the ammunition vault door.

(2) This page can be detached from the folder and handed to the commander of the party detailed to collect the explosives and stores from the pre-stock point.

p. PAGE 11 KEYS FOR AMMUNITION STORAGE FACILITY:

(1) The bearer of this document is authorized to enter the ammunition site and to pick up from the bunkers indicated on the document.

(2) This document will contain the bunker number and the target number.

(3) If keys are required to enter the bunker(s) and are not contained in the folder, the location of the keys will be marked here clearly.

(4) This page can be detached from the folder and handed to the commander of the party detailed to collect the explosives and stores from the pre-stock point.

q. PAGE 12 EXPLOSIVES STORES AND MINES REQUIRED:

(1) Target number.

(2) Pre-stock point number.

(3) Nomenclature and quantity of issue of explosives, explosive accessories, tools, and mines to execute the particular target.

r. PAGE 13 TOOLS, STORES, AND MINES:

(1) Nomenclature and quantity of the tools required to execute the particular target.

(2) Include anything else that may not be in your squad/plt tools, (i.e. minefield marking kits, pickets, concertina wire, etc.).

(3) Amount of mines, type, and total weight.

(4) Amount of fuses, type, and total weight.

s. PAGE 14 EXPLOSIVES STORES AND MINES REQUIRED:

(1) This page is the same as page 12.

(2) This page can be detached from the folder and handed to the commander of the party detailed to collect the explosives and stores from the pre-stock point.

t. PAGE 15 TOOLS, STORES, AND MINES:

(1) This page is the same as page 13.

(2) This page can be detached from the folder and handed to the commander of the party detailed to collect the explosives and stores from the pre-stock point.

u. PAGE 16 DEMOLITION ORDER AND/OR MINEFIELD RECORD:

(1) The demolition order is a system to establish complete control of the preparing, charging, and firing of a demolition target.

(2) STANAG 2017 outlines these procedures.

(3) They establish a Chain of Command and responsibility of the Authorized Commander, Demolition Guard Commander and Demolition Firing Party Commander.

(a) Authorized Commander.

1 Has overall control of the demolition target.

2 Determines the requirements and responsibilities for a demolition guard.

3 Assigns the demolition order/guard.

4 Establishes a clearly understood communication channel to fire the demolition.

(b) Demolition Guard Commander.

1 Has command of the demolition firing party.

2 Security of the demolition site from enemy attack or sabotage, and the control of traffic and refugees at the demolition site.

3 Gives the order to the Demolition Firing Party Commander to change the state of readiness and to fire the demolition.

4 Keeps the Authorized Commander informed of the operational situation at the Demo site.

(c) Demolition Firing Party Commander.

1 Is in technical charge of the preparation, charging and firing of the demolition.

2 Consults with Demolition Guard Commander for firing point selection. Firing point should be collocated with the Demolition Guard Commander.

3 Keeps the Demolition Guard Commander aware of status at target site.

4 Contacts Demolition Guard Commander in any case not covered by orders.

v. PAGE 17 SPECIAL TECHNICAL INSTRUCTIONS:

(1) Time required for preparing and charging.

(2) Time required (in minutes) for passing from state of readiness 1 (safe) to 2 (armed).

(3) Personnel required (NCO and below) for preparing and charging.

(4) Personnel required (NCO and below) for firing.

(5) Organization of work. (attach if necessary)

(6) Drawings and sketches. See pages 19, and 21.

w. PAGE 18 NUISANCE MINES OR PROTECTIVE MINEFIELD:

(1) + Strike out words not applicable.

(a) Nuisance mines

1 MUST be laid

2 MUST NOT be laid

3 See sketch page 24

(b) THERE IS

1 (A) large

2 THERE IS + (NO) minefield near (give location and reference of minefield record)

(2) Translation of notes on the sketch page 14

x. PAGE 19 SKETCH OF TARGET:

(1) Sketch includes both the target and the surrounding area. This sketch should tell the individual exactly where the charges are to be placed.

(2) All targets should show plan views. Bridges, tunnels, dams, and buildings should show sections and side views.

(3) A north seeking arrow and the expected enemy avenue of approach must be labeled.

(4) Include other information such as building or house numbers, road types (dirt, concrete), and arrows pointing to nearest town.

y. PAGE 20 TRANSLATION NOTES FOR THE SKETCH ON PAGE 19:

(1) Translation of all notes that are on page 19.

z. PAGE 21 SKETCH OF CHARGES:

(1) This must be a high quality sketch.

(2) Show the placement of every individual charge, to include dual priming and shaped charges.

(3) Include dimensions that describe exact placement of charges, exact amounts, and types of demolitions.

aa. PAGE 22 TRANSLATION NOTES FOR THE SKETCH ON PAGE 21:

(1) Translation of all notes that are on page 21.

bb. PAGE 23 SKETCH OF THE IGNITION SYSTEM:

(1) This sketch should show ignition system to include:

(a) Detonating cord connections.

(b) Time fuse (state quantity used for system).

(c) Fuse igniters.

(d) Blasting caps.

(2) Give description of safe firing points.

(a) Primary and alternate.

cc. PAGE 24 MINEFIELD IF APPLICABLE, OR PROTECTIVE MINES:

(1) Personnel and time required for laying mines.

(2) Sketch of planned minefield. When laid draw sketch on page 24 and fill out minefield record (page 16).

dd. PAGE 25 TURN OVER/TAKE OVER OF TARGET:

(1) Target number.

(2) Type of target.

(3) Grid reference.

(4) Date/Time Group.

(5) State of readiness at time of turn-over/take-over.

(6) Work still required to complete barrier or to prepare demolition target.

ee. PAGE 26 AMMUNITION/EQUIPMENT TO BE TURNED-OVER/TAKEN-OVER:

(1) Barrier documentation will remain at:

(a) Location of the barrier document.

(2) Relieved Commanders last name, rank, unit, and signature.

(3) Relieving Commanders last name, rank, unit, and signature.

ff. PAGE 27 TURN-OVER/TAKE-OVER OF TARGET:

(1) Target number.

(2) Type of target.

(3) Grid reference.

(4) Date/Time Group.

(5) Relieved Commanders last name, rank, unit, and signature.

(6) Relieving Commanders last name, rank, unit, and signature.

(7) THIS COPY IS FOR THE UNIT HANDING OVER.

gg. PAGE 28, ANNEX A, STANAG 2123 IS BLANK.

hh. PAGE 29 DEMOLITION REPORT:

(1) Target number.

(2) Map Reference.

(3) Demolition was fired at: Date-Time.

(4) Extent of damage.

(a) In case of a bridge:

1 Width of gap (meters).

2 Numbers of spans down.

(5) In a road or runway size, depth, and location of craters.

(6) Mines laid, type and number.

(7) Any other details.

ii. PAGE 30 SKETCH OF THE EFFECTS OF DEMOLITION AND LOCATION OF MINES (IF APPLICABLE):

(1) Insert a copy of the sketch used on page 19. Annotate the sketch with damages to the target upon execution.

(2) Date-Time.

(3) Name, rank, and unit of individual completing this sketch.

(4) Designation.

(5) Signature.

jj. PAGE 31 TABLE OF CONTENTS:

(1) This page will contain the table of contents of the obstacle folder.

kk. PAGE 32 NOTES, COMPLETED BY, AND REVIEWED BY:

(1) Pages 3, 7-12, and 14 can be detached from the target folder and handed to the Marine detailed to pick up the barrier material.

(2) The commander of the closing/executing unit will use pages 29 and 30 to report the results to his immediate superior.

(3) Target folder completed by: Name, Rank, Grade, Designation, Signature, and Date.

(4) If more than one individual completes the target folder, the second individual will fill out the same information as above (3).

(5) This section will contain the name, rank, designation, date, and signature of the individuals that review the target folder.

ll. PAGE 33 OF THE TARGET FOLDER IS INTENTIONALLY LEFT BLANK:

<u>REFERENCES</u>:

FM 5-250	Explosives and Demolitions
TC 5-6-14	How to Prepare a Target Folder
MCRP	Engineer Forms and Reports
STANAG 2017	Standard NATO Agreement, Demolition Order

UNITED STATES MARINE CORPS

COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C-01B08
14 Jul 00
(98 POI)

STUDENT HANDOUT

MINEFIELDS

PURPOSE: The purpose of this period of instruction is to provide you with the knowledge and skills needed to effectively use mines.

1. TERMINAL LEARNING OBJECTIVE(S):

a. Given a tactical situation, supervise the construction of an obstacle in accordance with FM 90-7 (1302.1.13)

2. ENABLING LEARNING OBJECTIVES:

a. Given a compass, map, reconnaissance report, protractor, minefield recording form, FM 5-34\MCRP 3-17A and a mission specifying desired density, depth, minefield frontage, and types of mines to be emplaced, lay a minefield in accordance with FM 20-32 and FM 90-7. (1302.1.13a)

b. Given a compass, map, reconnaissance report, protractor, minefield recording form, FM 5-34\MCRP 3-17A and a mission specifying desired density, minefield frontage, and depth, and a percentage of Anti-handling devices, estimate the materials required to lay a minefield in accordance with FM 20-32 and FM 90-7. (1302.1.13b)

c. Given a compass, map, reconnaissance report, protractor, minefield recording form, FM 5-34\MCRP 3-17A and a mission specifying desired density, depth, minefield frontage, and types of mines to be emplaced, record a minefield in accordance with FM 20-32 and FM 90-7. (1302.1.13c)

OUTLINE

1. MINEFIELDS: A minefield may be an area of ground containing mines laid with or without pattern, or it may be an area of ground without any mines (phony minefield). Minefields may be composed of AT or AP mines, or a mixture of both.

a. A minefield provides a reinforcing obstacle, which, though not impassable, will cost the enemy time, casualties and resources. Minefields are used to:

*Delay, disrupt or canalize enemy assault formations.

*Provide protection for unit positions.

*Provide flank protection.

*Lower the enemy's morale.

b. The tactical situation, the terrain, and the location of other obstacles will determine the location of minefields.

c. Minefields can be used to block enemy approaches, fix the enemy in kill zones, turn enemy forces, or disrupt enemy formations. In concert with other obstacles, the enemy will be forced to use a variety of breaching equipment to breach the obstacle complex.

6. MINEFIELD REPORTS AND RECORDS

a. Minefield Report. A minefield report is an oral, electronic, or written communication concerning mining activities, friendly or enemy. This report is submitted by the emplacing unit commander through operational channels to the operations officer (G3/S3) of the authorized headquarters. That headquarters integrates the report with Terrain intelligence and disseminates it with tactical intelligence. The report will by sent by the fastest, most secure means available.

(1) Report of Intention. The report of intention serves as notification to a unit's higher headquarters that the unit intends to emplace a minefield. The report of intention doubles as a request when initiated at levels below those with emplacement authority. Conventional minefields which are part of an organization plan (OPLAN) or General Defense Plan (GDP) approved by the authorizing commander do not require a report of intention. The fact that the minefields are included in such a plan implies an intention to lay. Minefields not authorized in a tactical plan require a separate report of intention. The report includes data regarding the tactical location, the proposed start and completion times, the type of minefield, whether mines are surface laid or buried, whether AH device, and the location and width of lanes and gaps. (TABLE 3-7, FM 5-34)

(2) Report of Initiation. The report of initiation is a mandatory report that informs higher headquarters that emplacement has begun and the area is no longer safe for friendly movement and maneuver. It should specify the time emplacement began, estimated completion time and identify the location and target number of the minefields. (TABLE 3-8, FM 5-34)

(3) Report of completion. The report of completion is usually an oral report to the authorizing commander that the minefield is complete and functional. The report of completion is followed as rapidly as possible by the completed DA Form 1355 (Minefield Record) or DA Form 1355-1-R (Hasty Protective Minefield Record). DA Form 5032-R (Field Artillery Delivered Minefield Planning Sheet). (TABLE 3-10, FM 5-34)

(4) Progress Reports. During the emplacing process, the commander may require periodic reports on the amount of work completed. (TABLE 3-9, FM 5-34)

(5) Report of Transfer. The responsibility of a minefield is transferred from one commander to another in a report of transfer. This report is signed by both the relieved and relieving commanders, and includes a certificate stating that the relieving commander was shown or otherwise informed of all mines within the commander's zone of responsibility. The report states that the relieving commander assumes full responsibility for those mines. The report of transfer is sent to the next higher commander who has authority over both relieved and relieving commanders.

(6) Report of Change. The report of change is made immediately upon any change or alteration made in a previously reported minefield and is sent to the next higher commander. It is then sent through channels to the headquarters that keeps the written mine record. The report of change is made by the commander responsible for surveillance and maintenance of the minefield.

b. Minefield Records

(1) All conventional minefields are recorded on DA Form 1355, except for hasty protective minefields that are recorded on DA Form 1355-1-R. Preparing the standard minefield record form is the responsibility of the laying unit. The OIC of the unit laying the mines must sign and forward the form to the next higher command as soon as possible. Once the information is entered on the form, the form is classified SECRET or NATO SECRET.

(2) The number of copies prepared depends on the type of minefield and local procedures. Unit standing operating procedures (SOPs) should provide advance guidance on how minefield information is to be passed to higher, lower, and adjacent commands. Minefield records are circulated on a "need to know" basis When a record is made, it should be reproduced at the lowest level having the equipment to make copies. When used for training, the record is marked SAMPLE. Large minefields are recorded on two or more DA Forms 1355.

(3) Whenever any changes are made to an existing minefield, a completely new record must be prepared on DA Form 1355. This record is marked REVISED and shows the minefield as it is after the changes. The original minefield number remains unchanged. Some changes that require a new record are:

(a) Relocation of mines in safe lanes

(b) Relocation of safe lanes

(c) Changed lane or minefield markings

(d) Inclusion of the minefield into a large minefield system

(e) Removal or detonation of mines

(f) Addition of mines to the field

(4) Conventional minefield records are forwarded through operational channels to higher headquarters where the G-3 or S-3 will maintain them on file. If a higher head- quarters has not been established, minefield records will be maintained on file with the assistant G-3/S-3 in whose area of operation the minefield is located.

7. HASTY PROTECTIVE MINEFIELD:

a. Characteristics:

(1) Uses

(a) Used as part of a unit's defensive perimeter.

(b) Used in temporary positions to protect forward and rear areas or in isolated locations. Examples: outposts, work sites, roadblocks, patrol bases.

(c) Located within small caliber weapon range, but beyond hand grenade range of defender's position.

(d) Normally laid on short notice.

(e) Must be covered by fire.

(f) Mine locations should cover likely avenues of approach and enhance key weapon systems and dead spaces.

(2) Mines

(a) Mines usually used are from unit's basic load.

(b) Type mines used

1 Metallic antitank and antipersonnel mines

2 Trip flares and improvised flare mines

3 Do NOT use mines detector’s to detect, chemical mines or anti handling devices

(c) If time permits mines should be buried to increase effectiveness, but they may be laid on top of the ground in a random pattern.

(d) The emplacing unit upon leaving the area picks up all mines, unless enemy pressure prevents mine retrieval.

b. Required Authority. The Battalion Commander is authorized to employ a hasty protective minefield. It may be delegated to a Company Commander.

c. Reports required for Hasty Protective Minefield:

(1) Report of Intention

(2) Report of Initiation

(3) Report of Completion

(4) Additional reports when needed:

(5) Progress Report

(6) Report of Transfer

(7) Report of Change

d. Emplace and Record the Minefield:

(1) The first step in emplacing a hasty protective minefield is to conduct a thorough leader's reconnaissance of the proposed minefield area.

(2) After a reconnaissance, emplace the mines but do NOT arm them.

(3) As the mines are being emplaced, establish an easily identifiable reference point (RP) between the minefield and the unit's position. From the RP, mines should run in rows parallel to the unit's position. This procedure simplifies the recording and makes retrieval quicker and safer.

(4) By international agreement, the row closest to the enemy is designated row A, while succeeding rows are B, C, D, and so on.

(5) Indicate the ends of a row by two markers. Label the markers with the letter of the row and the number 1 for one end of the row and 2 for the other end of the row. The marker could be a wooden stake, steel picket, etc.

(6) From the reference point, measure the magnetic azimuth in degrees and pace the distance to a point arbitrarily selected between 15 and 25 paces to the right of the first mine laid. Call this point B-1 (if there are two rows). It will mark the beginning of the second row. Place a marker at B1 and record the azimuth and distance on DA Form 1355-1-R. Always consider that the reference point is located at the center of the circles.

(7) Scale

(a) To determine the scale, use the following formula:

Distance from RP to farthest point in the field + 10 paces/4 = scale.

Example: 90 paces + 10 paces/4 = 25 paces

(b) The 4 is a constant and represents the four concentric rings on the DA Form 1355-1-R.

(c) Add ten to the pace count as a safety margin to ensure that the minefield sketch is entirely contained within the largest ring.

(d) The distance between rings is 2 centimeters, therefore the scale used in the example is 2cm = 25 paces.

(8) Azimuth Block

(a) Always point the magnetic north arrow towards the top of DA Form 1355-1-R.

(b) Indicate the direction of the enemy in relation to magnetic north.

(9) Measure the azimuth and distance to a point 15 to 25 paces from the first mine in row A. Place a marker at this point and record it as A-1.

(10) Measure the distance and azimuth from A-1 to the first mine and record it.

(11) Next, measure the distance and azimuth from the first mine to the second and so on until all mine locations have been recorded. Repeat this procedure for the second (next) row.

(12) As each mine is recorded, assign it a number to identify it in the minefield record.

(13) When the last mine location is recorded, measure an azimuth and distance from that point to another arbitrary point, A2 or B2. Here place a marker in the same manner as at A1 and B1. Next, measure and record the distance and azimuth from the reference point to B2 and from B2 to A1.

(14) Now tie the reference point with a permanent landmark that can be found on the map. The landmark is used to assist others in locating the minefield should it be abandoned. Measure the distance and azimuth from the landmark to the reference point.

(15) Complete tabular and identification blocks.

(16) Upon completion of the recording, arm the mines. Arm the mines nearest the enemy first, allowing the Marines to safely work their way back to the platoon position.

e. Removal of the Minefield

(1) When you retrieve the mines, start at the reference point and move to B1 (if two rows being used) using the azimuth and distances as recorded. Then move from B1 to the mine.

(2) If B1 marker is destroyed, move from reference point to B2, using that azimuth and distance. You will have to shoot the back azimuth from B2 to last mine (add or subtract 180 degrees from the recorded azimuth).

(3) The stakes at A-1, B-1, A-2, B-2 etc. are necessary because it is safer to find a
stake when traversing long distances than to find a mine.

8. STANDARD PATTERN MINEFIELD:

a. General. Standard pattern minefields are minefields laid out and emplaced according to a set of prescribed procedures. The rules governing the emplacement of mines in a standard pattern are specified by Standardization Agreement (STANAG) 2036.Standard pattern installation facilitates clearing and recovering of mines, simplifies planning and logistical computations, and ensures proper mine emplacement. The following procedures must be followed when emplacing standard pattern minefields.

b. Mine Cluster. The basic unit of a minefield is a cluster. There are two types of clusters = LIVE and OMITTED.

(1) A live cluster consists of one to five mines. All mines in a live cluster are emplaced within or on a semi-circle within 2-meter radius. Only one antitank mine is permitted within a single live cluster and it is placed as a base mine. When an antitank mine is not employed in a line cluster, the largest metallic mine is employed as the base mine so the cluster's location is easily identified. All clusters are numbered to facilitate recovery or removal of mines.

(2) Omitted clusters are those that do not contain any mines. They are also numbered to maintain the normal numbering sequence. Omitted clusters and clusters with tripwires and anti handling devices are identified in the NOTES section of (DA) Form 1355 Minefield Record. Cluster are emplaced 6 meters apart from base mine to base mine in rows.

(3) Numbering sequences of mines by type within a cluster or cluster composition. The cluster composition is designated by three sets of number. The first number represents number AT mines. The second number represents number of APF (fragmentation) mines and the third number represents number APB (blast) mines.

Example 1: 1-2-2 cluster composition means the cluster will have: 1 AT mine, 2 APF mines and 2 APB mines.

Example 2: 0-4-1 cluster composition means the cluster will have: 0 AT mine 4 APF mines and 1 APB mine.

Example 3: 1-0-0 cluster composition means the cluster will have 1 AT mine and no antipersonnel mines.

c. Mine Strip. A mine strip consists of two parallel cluster rows offset 3 meters on either side of the strip centerline. There are two types of mine strips: SHORT STRIPS and REGULAR STRIPS. Short strips are located only on the irregular outer edge (IOE) of the minefield. Regular strips are located behind the IOE to form the minefield.

d. <u>The IOE.</u> The IOE is the first part of the minefield normally encountered by the enemy. It consists of a base line from which the short strips are extended. The short strips along the IOE deceive the enemy as to the minefields pattern, spacing, and size. The placement and composition of the IOE is largely dictated by the time allowed for laying the minefield, the terrain conditions at the laying site, and the tactical situation. The IOE baseline extends from an end point marked IOE 1 to another end point marked IOE 2. These end point markers indicate the laying direction; laying always begins at IOE 1. Intermediate or turning points are marked in consecutive order beginning with I1. From that IOE base line, short strips are extended from turning at irregular angles (towards the enemy and only on the enemy side) and are identified by the turning point markers. Turning points should be no greater than 45 degrees from the last azimuth. The length of short strips is not standard. At the end of each short strip an end-marking stake is driven into the ground. For recording purposes, it is marked in consecutive order beginning with I1E. No tripwires are used in the IOE, but anti handling devices may be employed.

e. <u>Clusters on Short Strips.</u> The first live or omitted cluster on the IOE short strips will be a 6 or 8 pace from the base line. The last cluster in these strip will fall on the end point of each strip. Clusters are numbered consecutively with odd numbers on the enemy side and the even numbers on the friendly side. If a short strip is parallel to the enemy approach, the NCO determines which sides of the short strip will be numbered odd and even. The number of live cluster in the IOE is usually one-third the total number of clusters used in the regular strips. The angle between the IOE baseline and the IOE short strips will not be less than 45 degrees at any given point. Turning points are not used on short strips. For ease of calculation mine logistical requirements, the number of mines in each IOE cluster is the same and is reported in the IOE representative cluster composition in the NOTES section of DA Form 1355.

f. <u>Clusters on regular Strips</u>. The front row (1) of a regular strip is the one nearest to the enemy. It is parallel to, and 3 meters from, the strip centerline. The clusters in a row are 6 meters apart with the beginning cluster of each mine strip always located on the enemy side of the strip centerline. The clusters in row 2 are staggered to lie between the clusters in row 1. Clusters are numbered consecutively from right to left, or left to right depending on the direction the minefield is laid. To indicate the direction of laying, the strip end points are marked A1 and A2 (or B1 and B2, and so forth). Each regular strip is assigned a cluster composition by the NCOIC of the laying unit that is recorded in the notes section of DA Form 1355. The minimum distance between adjacent strip centerlines is 15 meters. Strips need not be parallel and may have as many turning points (changes of direction) as desire.

g. <u>Turning Points</u>

(1) The last cluster before the turning point will have a distance of at least 3 meters, 4 paces from the turning point (3 meters/4 paces).

(2) The first cluster after the turning point will be laid on the opposite side of the strip baseline from the last cluster, and 3 meters/4 paces from the last cluster turning point.

(3) The angle of any given turning point must not exceed 45 degrees from the last azimuth. This ensures that there will be a minimum distance of 2 meters between clusters in the same row.

h. Use of Tripwire. Tripwire actuated antipersonnel mines are only placed on the enemy side of each regular strip. No more than one mine per cluster will use tripwires, and no more than two tripwires will extend from the mine. Tripwires should be angled toward the enemy and should be at least 2 meters from a cluster, the border of a minefield lane, or a minefield boundary. Trip wires are only used with antipersonnel fragmentation mines and are not considered anti handling devices. Tripwires may be employed no closer than every third cluster. There are no tripwires on the IOE.

i. General Rules

(1) The farthest extremities of a regular (lettered) strip determines the minefield front. The IOE is not considered in determining the minefield front.

(2) The minefield can be laid left to right or right to left, but consistency among strips is required.

(3) Determine the depth using the IOE.

(4) No back azimuths are used to record the minefield.

(5) The minefield will have two landmarks located to the rear of the minefield (never to the extreme side or front).

(6) Landmarks can be up to 200 meters away from the last regular lettered strip, but must be in direct line of sight. If they are not in direct line of sight or over 200 meters, intermediate markers are used and are placed 75 meters apart.

j. Minefield Lanes

(1) Minefield lanes are left for the use of patrols and sometimes vehicles. When designing minefield lanes, the following points are to be observed:

(a) Lanes are to be sited before laying begins.

(b) The location of lanes is not to be obvious.

(c) Mines are not to be laid within 2 meters of the edges of lanes.

(d) Lanes are not to be straight throughout their length but are to zigzag.

(e) Lanes are to cross the centerline of mine strips at approximately right angles.

(f) Changes of direction are not to exceed 45 degrees, to ensure that long vehicles will be able to negotiate the changes if necessary.

(g) The number of lanes must be sufficient to ensure that no one lane is overused and turned into an obvious track.

(h)Sufficient mines are to be stockpiled to enable the unit responsible for the minefield to seal lanes suspected of having been located by the enemy.

(i) Following are the recommended lane widths in minefields:

1 Footpath 1 meter

2 One-way vehicle lane 8 meters

3 Two-way vehicle lane 16 meters

4 GapsGreater than 100 meters

k. Minefield Gaps.

(1) Minefield gaps are left to enable friendly forces to pass through in tactical formation and are normally not less than 100 meters wide. (Refer to Figure 2-7 of your Reference Text) The location of gaps should be disturbed to the extent necessary, with tracks to represent the passage of mine carrying vehicles. Signs of mine-laying activity, such as digging or scattered spoil, mine crates and other suitable evidence, should be visible.

(2) When designing minefield gaps, the following points should be observed:

(a) Gaps should be sited before laying begins.

(b) Gaps should, where possible, be located along recognizable features, such as fences, tracks or creeks.

(c) Gaps should run straight through minefields (that is, gaps are not to contain bends).

(d) Sufficient mines must be stockpiled to enable the unit responsible for the security of the minefield to seal gaps, when necessary.

l. Platoon Emplacement Procedures.

(1) The platoon is the basic unit used to install a standard pattern minefield. Orders to the officer is charge (OIC) of laying unit specify the minefields type, proposed location, length, and also the mine type and density. The platoon organization and equipment table is shown table on the next page.

(2) Platoon Organization and Equipment:

Personnel	**Off.**	**NCO**	**Troops**	**Equipment**
Supervisory Personnel	1	1		**Officer**: Map, Compass. Notebook & Minefield Record Forms **NCO**: Map, Notebook and Compass
Sitting Party		1	3	Stakes or Pickets, Sledge Hammers, Tracing Tape on Reels and Nails to Peg Tape
Marking Party		1	2	Barbed Wire on Reels, Marking Signs, Lane Signs, Wire Cutters, Gloves, Sledges, Pickets
Recording Party	1	2		Sketching Equipment, Lensatic Compass, Minefield Record Form, Map & Metric Tape
First Laying Party		1	6 to 8	Notebook for Squad Leader, Picks, Shovels and Sandbags
Second Laying Party		1	6 to 8	Same as First Party
Third Laying Party			6 to 8	Same as First Party
TOTAL	1	7	25 to 31	

(3) The OIC. The OIC makes a map study and situation permitting, conduct a ground reconnaissance of the site. The OIC determines the locations for each mine strip, landmarks, fences, mine dumps, and approaches using the Minefield Requirements Computation Form. The OIC determines the required number of mines and other materials arranges for mines to be drawn, and organize the platoon into siting, laying, recording, and marking parties.

(4) The Siting Party. The sitting party places boundary stakes or pickets as strip markers at the beginning and end of each mine strip, and also at points where strips change direction.

(5) Laying Party. One laying party is responsible for installing, arming and camouflaging all mines on a strip or portion of a strip. Upon work completion, each laying party is assigned additional strips.

(6) Recording Party. The recording party obtains the necessary reference data, prepares DA Form 1355, and installs intermediate markers when needed. All distances are recorded in meters, however for hand laid mines along strips, pace measurement is permissible.

(7) Marking Party. The marking party erects fences and signs to mark minefield boundaries and any lanes within the minefield. Upon completion of work, the marking party assists other parties as directed.

(8) Platoon Mine Emplacement Procedures

(a) The OIC arrives at the site with the siting and marking parties, and goes to the rear boundary (either the right-or-left hand boundary of the field). This is the furthest part of the minefield from the direction of the enemy. The OIC indicates the starting point of the rear strip, which, for a three-strip minefield, is strip C, and the sitting party drives a boundary stake to mark the location.

(b) The OIC then designates a starting point for the marking party at least 20 meters to the right of the boundary stake and indicates where the minefield-marking fence should be placed. The marking party immediately begins to install fence pickets, working in a counter clockwise direction.

(c) When all pickets are installed, the marking party encircles the field with single strand of barbed wire followed by the second strand..

(d) From the boundary stake of strip C, the OIC moves in the direction of the enemy and establishes the starting point of B strip. The centerlines of the strips should not be parallel nor less than 15 meters apart. Two members of the siting party drive a strip stake at the starting point of strip B, and the remaining two members begin to lay tape between the two stakes. The tape is fastened to the ground at frequent intervals to prevent its movement. This procedure is followed until the boundary stakes of the three lettered strips (C, B, and A) and the IOE on the right-hand side of the minefield have been installed. At the boundary stake of the IOE the OIC gives a sketch of the minefield and instructions on siting the IOE baseline and the regular mine strip centerline to the siting party. The NCO and one member of the siting party immediately begin setting stakes that indicate the baseline of the IOE. The centerline laying team then lays the tape for the IOE baseline leaving tape rules where tapes run out. Simultaneously, the short strips extending from the IOE baseline are established. Each short strip ends with a stake that is designated as I1E, I2E, and so forth. Turning points are not used in the short strips of the IOE.

(e) On reaching the other boundary of the IOE, the NCO moves away from the enemy side, establishes the left boundary stake of strip A, stakes out this strip, and repeats the same procedures until all strip centerlines are taped. All stakes are driven flush with the ground.

(f) While the IOE is being taped, the recording party begins obtaining reference data for the minefield record. Starting from the landmark designated by the OIC and working behind the siting party. The amount of detail obtained by the recording party depends on the tactical classification of the minefield and any special orders. Aerial photographs are taken of the minefield before the tracing tape is removed, and become valuable supplements to the minefield record.

(g) As soon as the laying parties arrive at the site with mines, they establish mine dumps behind the field. The antitank mines are uncrated and stacked. Other types of mines are left in their crates with the crate lids removed. Fuses and detonators are placed in separate boxes; fuse types are not mixed.

(h) When the siting party completes the staking of centerlines, it installs lane tapes and traffic lines, respectively. Mine laying personnel to assist in camouflage by reducing the amount of traffic on strip centerlines use traffic lines. Traffic tapes are laid approximately perpendicular to the minefield trace at about 100 meters intervals. Tapes to mark safety lanes for tactical vehicles and patrols are also laid out.

TURN TO PAGE 3-17 AND 3-18 OF FM 5-34/MCRP 3-17A.

m. DA Form 1355, Minefield Record

(1) The DA Form 1355 from STANAG 2036 consists of a single, two-sided printed sheet (See Figure 4-10 of your Reference Text). The front contains blocks for the tabular data. The back is a graph consisting of 1-centimeter squares for a scaled sketch of the field. The scale for plotting minefields will depend on the size of the field. To avoid using two sheets for the sketch, adjust the scale so that one form will support the sketch. For very large minefields, two sheets may be required. The system of measurement and scale sizes must be mentioned in the legend block of the form. An additional form may be used to support any additional information in the mandatory note block. Any blocks or lines not used on the form must be crossed out to avoid unauthorized entries on the form.

(2) Enter complete data on authority for laying and on the laying unit. The OIC will include name, rank, and social security account number (SSAN).

(3) Enter date-time group (DTG) for starting and completion times. The RECORDER line will include name, rank, and SSAN.

(4) Enter copy and sheet number. The number of copies prepared will depend upon unit SOP and the classification of the minefield. the laying unit will forward the minefield record. According to STANAG 2036, one copy of the minefield records will be retained at the next higher command, one copy at MAGTF HQ, where appropriate, and one copy at the proper national territorial authority.

(5) Enter minefield number as follows:

Designation of unit authorizing installation

Number of obstacles

Status of obstacles:

E = executed P = proposed U = under construction

(6) Enter map data as stated on map(s) used.

(7) Enter the grid coordinates and description of at least two landmarks. If the landmarks are roads, trails or routes, enter the name or number to make the identification easy for removal.

(8) Also, enter description (s) of any intermediate markers used. When a landmark is more than 200 meters from the minefield, or the strip/row reference stake cannot be seen from the landmark, an intermediate marker must be used. If possible, the intermediate marker should not be closer than 75 meters to the strip/row reference stakes. Cross out any unused blocks.

(9) Enter the word STANDARD when the standard marking fence is used. describe the boundary marking if other than the standard marking fence is used. (Use two sides and rear for tactical, or four sides for protective.)

(10) Enter the number or strips/rows laid other than IOE. Describe the strip/row markers. Cross out words not applicable.

(11) Enter the width, marking, and closing provisions for each lane. When appropriate, give the type and number of mines for closing. The location of these mines is described in the METHOD OF CLOSING.

(12) Enter the type of minefield by crossing out lines not needed. Indicate the method of laying by crossing out the incorrect descriptions. Enter the types of mines as APB, APF, or AT. For each type of mine, enter the number of mines and anti handling devices installed in the IOE and in each strip or row. Strips or rows will be lettered sequentially, starting with the first one laid. Enter the totals.

(13) Enter under NOTES at least the following eight items and any additional information that would be useful in the removal of the minefield.

(a) Mine clusters at ___________ meters/paces spacing.

(b) Number of IOE live clusters (all others numbered except omitted clusters).

(c) Number of omitted clusters in regular strips.

(d) Omitted clusters for lanes or gaps.

(e) Clusters with anti handling devices (what type and where they are located on the mine). When using the M142 multipurpose firing device state the activation mode for each mine.

(f) Clusters with trip wire-actuated antipersonnel mines.

(g) Strip cluster composition.

(h) Location of safety clips/pins (distance and direction from landmarks).

(14) The OIC of the emplacing unit will sign and date the form.

(15) The front side of DA Form 1355 is now completed. The backside of DA Form 1355 and step-by-step instructions are shown on the following pages. When filling out the sketch, enter arrows for the direction of the enemy and magnetic North. The enemy arrow will always point within the top 180^0 of the form; the North arrow will follow one of the lines of the graph.

(16) Enter in the information block what was used if a compass was unavailable. Indicate system of measurement and scale used. The OIC of the emplacing unit will sign in the signature block.

(17) Enter security classification of the form. If the form was used for training, enter the word SAMPLE.

(18) Sketch: FM 5-34/MCRP 3-17A shows the information that will be in the sketch.

9. MINEFIELD CALCULATION AND LOGISTICAL REQUIREMENTS:

a. Minefield Lethality and Density. Minefield density is used as a means of expressing the relationship between the number of mines emplaced and the size of the minefield. It provides an indication of the "lethality" or "difficulty" of the minefield as an obstacle. There are two ways of expressing minefield density: linear density and area density.

b. Linear Density. Linear density is the traditional means of expressing the number of mines in a minefield. Linear density specifies the average number of mines, by type, per meter of minefield front, regardless of the depth. It is the average number of mines that one would expect to encounter when walking along a straight, 1-meter-wide path from the front to the rear of the minefield (Figure 4-11 of your Reference Text). By convention, linear density is written as a three-digit figure that specifies the number of AP mines, APF mines, and APB mines per meter of front. The figure usually consists of whole numbers or large decimals.

EXAMPLE: 0.5 - 1.0 - 0.5

c. Area Density. Area density is used most often with scattered mines. Area density specifies the number of mines per square meter (m2). It is the average number of mines located in a 1 square meter section of a minefield (Figure 4-12 of your Reference Text). A separate area density is specified for each type of mine (AT or AP). It is written as a decimal and is usually a very small number.

EXAMPLE: 0.005 mines/m2

d. Conversion. Linear density can be converted to area density by dividing the linear density by the depth of the minefield. For example, if the linear AT mine density was 1.5, and the minefield was 100 meters deep, the area density would be 0.015 mines/m2. In the same respect, area density can be converted to linear density by multiplying the area density by the depth of the minefield.

e. Planning. There is no simple method for defining the "lethality" of a minefield until it has actually been employed in combat. The overall effectiveness of mines and minefields depend on a variety of factors, all of which are unique to a given circumstance. These factors include the following:

(1) Minefield density.

(2) Lethality and reliability of mines.

(3) Mine encounter rates.

(4) Threat countermine equipment and training.

(5) Effectiveness of friendly covering fires.

(6) Determination of the appropriate size and density of minefields must be based on the normal planning considerations of mission, enemy, terrain and weather, troops and fire support available, time, space and logistics (METT-TS&L). The staff engineer, as the maneuver commander's "counter mobility expert," is usually responsible for recommending the density to be used in a particular tactical situation. There are several sources of guidance to assist in determining the most effective minefield density: experience, standard obstacles, and probability graphs.

(7) Experience. Experience probably provides the best basis for signing minefields. Minefields of a particular size, density, and mix (types of mines and ratio of AT to AP mines) that have been proven effective in past combat situations under similar tactical conditions are very good indicators of what will be successful in future engagements. However, the current situation must be analyzed very closely and adjustments made to reflect any conditions that differ from the original engagement.

(8) As a rule of thumb for conventional minefields, it can be said that an acceptable tradeoff between time and effort and minefield effectiveness is achieved with a linear density of one AT mine per meter of front. Because of their full-width kill capability, tilt-rod and magnetic-influence fused mines have the same effectiveness at half that density. As a benchmark, scattering mines are laid at a linear density equivalent to between 0.4 and 0.8 mines per meter of front, with the higher number being more widely accepted.

f. Probability Graphs. Probability graphs were developed in an attempt to define minefield lethality more precisely. The accompanying graphs show the relationship between AT mine density and the expected encounters or kills that should result. The graphs are based on the fuse-sensing width and the size of the target area. In Figure 4-13 of your Reference Text, the number of expected M-KIlls, based on various densities, is shown for three different attack formations.

g. Minefield Calculations

(1) Given Information. The engineer company commander or the staff engineer will normally determine this information. It will be provided to the officer or NCOIC of the emplacing unit during the mission briefing. In this example, the following guidance is given to the emplacing unit:

GIVEN

(a) Desired density	AT	*1*	APF	*4*	APB	*8*
(b) IOE representative cluster	AT	*1*	APF	*2*	APB	*2*
(c) Front	*200*	meters				
(d) Depth	*300*	meters				

(e) AHD's (percentage of) *5* %

(2) With this given information, the remainder of the form can be completed.

PART 1. NUMBER OF MINES

A. The regular strip has a cluster density of 1 cluster every 3 meters. The IOE has a cluster density of 1/3 that of a regular strip, or 1 cluster every 9 meters. Therefore, to obtain the number of clusters in the IOE, the length of the strip is divided by 9. Decimals are rounded up to the next highest whole number.

PART 1. NUMBER OF MINES

A. Front / 9 = IOE live clusters *200* / 9 = *23* (round up)

B. The representative cluster composition for the IOE clusters is established by the commander based on METT-TS&L and is part of the given information. The number of clusters in the IOE is multiplied by the cluster composition to determine the number of mines by type in the entire IOE.

	AT	APF	APB
B. IOE representative cluster x	*1*	*2*	*2*
number of IOE clusters =	x *23*	x *23*	x *23*
number of mines in IOE	*23*	*46*	*46*

C. The minefield front multiplied by the desired density determines the number
of mines in the minefield.

NOTE: The desired density pertains only to the regular strips and does not take into account the number of mines in the IOE which were calculated in step B.

C. Desired density x	*1*	*4*	*8*
minefield front =	x *200*	x *200*	x *200*
mines in regular lettered strips	*200*	*800*	*1600*

D. The number of mines required for the IOE (step B) is added to the number of mines in the regular lettered strips (step C).

D. Subtotal of mines (lines B + C)	*223*	*846*	*1646*

E. Ten percent is added to the total number of mines required to allow for damaged items and irregularities in terrain and strip length. This is accomplished by multiplying the total number of mines (step D) by 1.10. Decimals are rounded up to next highest whole number.

E. 10% excess factor =	x 1.10	x 1.10	x 1.10
Total number of mines to order	*246*	*931*	*1811*

These figures represent the total number of mines by type required for the entire minefield. When ordering by the case rather than by individual mines, the totals above should be divided by the number of mines per case (refer to the table on Truck Capacity for Carrying Mines, page 3-26 of FM 5-34) and rounded up to the next whole case.

PART 2. NUMBER OF REGULAR LETTERED STRIPS

A. As defined earlier, linear density is the number of mines by type per meter of front. To determine the total density of mines per meter of front, the densities for each type of mine must be added together. Therefore, if the desired density is equal to 1 AT mine, 4 APF mines, and 8 APB mines, the total density is 13 mines per meter of front.

PART 2. NUMBER OF REGULAR LETTERED STRIPS

A. Add desired density AT _1_ + APF _4_ + APB _8_ = _13_

B. Each regular mine strip has a cluster every 3 meters and therefore has a density of 1/3 cluster per meter of front. A total density of 13 mines per meter of front in the previous example would equal 3 x 13 or 39 mines per 3 meters of front. Clusters may contain a maximum of 5 mines (only one of which may be an AT mine) so the resulting figure must be divided by 5. In short, to determine the minimum number of regular strips required, the total density must be multiplied by 3/5 (3 meters between clusters and 5 mines per cluster). For ease of calculation, 3/5 is converted to the decimal 0.6. Decimals are rounded up to the next highest whole number.

B. 0.6 x line A above 0.6 x _12_ = _8_ (round up)

C. The calculations to determine the minimum number of regular strips previously described are not suitable when the ratio of antitank to antipersonnel mines is greater than 1:4. For example, if the desired density is 1 - 1 - 1, the total density is 3. The minimum number is strips then would be 3 x 3/5 = 1.8, rounded up to 2 strips. A minimum of 3 regular strips will be required. The alternative means of determining the number of regular strips is found by multiplying the AT desired density by 3.

C. 3 x AT desired density 3 x _1_ = _3_

D. The number of regular strips calculated by the first method and the alternative method are compared, and the higher figure is used as the minimum number of regular strips. The 8 deter- mined by the "3/5 rule" is larger than the 3 determined by the alternative method. Therefore, the minimum number of regular strips in this example is 8.

D. Number of regular letter strips required = Highest number of lines B or C

PART 3. NUMBER OF AHD's

The percentage of AHD's is established by the company commander or staff engineer during the planning process. The number of AT mines (AP mines are not employed with AHD's in a standard pattern minefield) is multiplied by this percentage to determine the total number of AHD's required. Decimals are rounded up to the next highest whole number.

PART 3. NUMBER OF AHD's % AHD's x total number of AT mines _.05_ x _246_ = _13_ (round up)

PART 4. STRIP CLUSTER COMPOSITION

The Cluster Composition Table is prepared by the OIC of the laying unit to control the allocation of mines to a regular lettered strip. The cluster composition remains constant within a particular lettered strip but it may vary among the different that not more than 1 AT mine can be placed in each representative cluster, and that each cluster may have a maximum of 5 mines.

A. A tabular format is prepared to facilitate the distribution of mines by the emplacement personnel. Note that at the top of the form each component of the desired density is multiplied by 3. Three is always used regardless of the minimum number of regular lettered strips because it is the number of mine strips required to give a minefield density of 1 mine per meter of front when a cluster contains only 1 mine of each type. Each mine strip has a cluster every 3 meters, and therefore has a density of 1/3 mine per meter when a cluster contains 1 of each type of mine.

PART 4. STRIP CLUSTER COMPOSITION

A. Desired density

AT: 3 x *1* = *3* APF: 3 x *4* = *12* APB: 3 x *8* = *24*

The resulting numbers are the maximum amount of mines that the sum of each column in the table cannot exceed. With an APF desired density of 4 for example, 3 x 4 = 12, and therefore the sum of the APF mines in the representative cluster composition for each of the regular strips cannot exceed 12.

B. CLUSTER COMPOSITION TABLE

	STRIP	AT	APF	APB	ROW TOTAL (cannot exceed 5)
	A		*1*	*4*	*5*
	B		*2*	*3*	*5*
	C	*1*	*1*	*3*	*5*
	D		*2*	*3*	*5*
	E	*1*	*1*	*3*	*5*
	F		*2*	*3*	*5*
	G	*1*	*1*	*3*	*5*
	H		*2*	*2*	*4*
COLUMN TOTAL		*3*	*12*	*24*	*39*

(Cannot exceed desired density x 3 as computed in A above)

NOTE: This table represents only one allocation of mine types; many others are possible provided the total columns are not exceeded and the number of mines in any one row does not exceed 5.

PART 5. NUMBER OF MAN-HOURS TO INSTALL MINEFIELD

To determine the approximate number of man-hours required for emplacement, the total number of mines of a particular type are divided by the laying rate figure for the mine type. The laying rate is the number of mines one Marine can emplace in an hour. Note that the total number of mines includes mines in the regular lettered strips as well as those in the IOE short strips. The laying rates for mines per man-hour are:

AT mines: 4 mines per man-hour

APF mines: 8 mines per man-hour

APB mines: 16 mines per man-hour

The number of hours for each mine type is rounded up, summed, and a 20 percent excess factor is included by multiplying the total by 1.2. The resulting figure is the total number of man-hours required for emplacement and represents straight work time only. It does not take into account time for transportation to and from the emplacement site, meals, breaks, and limited visibility or nuclear, biological, chemical (NBC) conditions. The commander's judgment and experience should be exercised in determining the time required for transportation, meals, and breaks. When working under limited visibility or NBC conditions, the total man-hours (after the excess factor has been included) should be multiplied by 1.5.

In this example, a total of 352 man-hours is required as determined below. Note each decimal is rounded **up** to next highest whole number.

PART 5. NUMBER OF MAN-HOURS TO INSTALL MINEFIELD

Number of mines / emplacement rate (mines per man-hour)

Number of AT mines: *246* / 4 = *62* (round up)

Number of APF mines: *931* / 8 = *117* (round up)

Number of APB mines: *1811* / 16 = *114* (round up)

62 + 117 + 114 x 1.2 = 352 man-hours (round up)

PART 6. AMOUNT OF FENCING AND MARKING MATERIAL

A. Standard pattern minefields must be marked and fenced. The amount of fencing required will depend on whether barbed wire (two strands) or concertina is used. The amount of wire for a two-strand barbed wire fence is calculated with the following formula:

[(front x 4) + (depth x 4) + 320] x 1.4

The formula for calculating concertina is:

[(front x 2) + (depth x 2) + 160] x 1.4

PART 6. AMOUNT OF FENCING AND MARKING MATERIAL

Concertina wire

[(front x 2) + (depth x 2) + 160] x 1.4 = meters of concertina required

[(_______x 2) + (_______x 2) + 160] x 1.4 = ________(round up)

Number of pickets = amount of concertina / 15

____/ 15 = ______(round up)

B. The number of pickets required is equal to the total amount of fence divided by 30 if barbed wire is used, or 15 if concertina is used.

The number of minefield marking signs is equal to the number of pickets.

In this example, two-strand barbed wire will be used.

NOTE: These calculations determine the marking and fencing materials required for the minefield perimeter only. Additional materials may be required for lanes and paths.

B. Barbed wire

[(front x 4) + (depth x 4) + 320] x 1.4 = meters of barbed wire required

[(*200* x 4) + (*300* x 4) + 320] x 1.4 = *3,248* (round up)

Number of pickets = amount of barbed wired / 30

3,248 / 30 = *109* (round up)

C. Number of signs = number of pickets *109*

PART 7. NUMBER OF TRUCKLOADS

The number of truckloads required will depend on the type and amount of mines as well as the type of trucks available. The number of cases of mines per truck is shown in the FM 5-34/MCRP 3-17A. The number of cases per truck is multiplied by the number of mines per case to determine the total number of mines per truck. The total mines by type required is divided by the number of mines per truck to determine the number of truckloads required to transport the mines.

In this example, M15 AT mines, M16A2 APF mines, and M14 APB mines will be hauled in 5-ton dump trucks.

PART 7. NUMBER OF TRUCKLOADS

AT mines

204 cases x 1/truck mines = *204* mines truck

246 mines required / 204 mines/truck = *1.21* truckloads of AT mines

APF mines

222 cases/truck x *4* mines/case = *888* mines/truck

931 mines required / *888* mines = *1.05* truckloads of APF mines
truck

APB mines
216 cases x *90* mines = *19,440* mines
truck case truck

1811 mines required / *19,440* mines = *0.09* truckloads of APB mines
truck

Total truckloads

1.21 AT truckloads + *1.05* APF truckloads + *0.09* APB truckloads = *3* total truckloads required (round up)

PART 8. AMOUNT OF ENGINEER TAPE

An extensive amount of engineer tape is used to mark the initial layout of a standard pattern minefield. Engineer tape comes in 170-meter rolls and is used to mark the following portions of the minefield.

NOTE: In this example, only one lane and one traffic line are required.

A. Minefield boundaries depth x 2 = *300* x 2 = *600*

B. Regular letter strips front x number of regular strips = *200* x I8 *1600*

C. IOE front x (number of IOE clusters x 3) = *200* + (*23* x 3) = *269*

D. Lanes and gaps: depth x 2 x number of lanes and gaps =*300* x 2 x *1* = *600*
.

E. Traffic lines: depth x number of traffic lines *300* x *1* = *300*

The total amounts of tape for each portion of the minefield are added together and a 20% excess factor is included by multiplying the total by 1.2.

600 + 1600 + 269 + 600 + 300) x 1.2 = 4043 meters of tape / 170 meters per roll = 24 rolls of tape required.

Subtotal (add line A + B + C + D + E)
600 + *1600* + *269* + *600* + *300* = *3369* meters (round up)

F. Number of rolls to order

line F x 1.2 *3369* x *1.2* = *4043* meters

4043 meters / 170 meters = *24* rolls of tape (round up)

10. MINEFIELD MARKING:

a. Forward-Area Minefields. Minefields forward of positions along the forward line of troops (FLOT) are fenced only on the friendly (rear) side or on the friendly side and the flanks as necessary to protect friendly troops. Forward-area minefields may also be completely enclosed, and part of the fencing removed before the enemy approaches. There are times when higher headquarters may require the field to be completely enclosed in order to influence the enemy to bypass the field. Lanes in forward areas are marked inconspicuously because use of standard methods would expose lane locations to the enemy. Suggested methods of lane marking include placing wire, tape, or closely-spaced objects on the ground on each side of the lane, with the lane entrance made easily-identifiable by markers such as pickets wrapped with tape or piles of stones.

b. Minefield Marking Sets

(1) The Standard Minefield Marking Set #2 contains the necessary components for marking a safe lane 400 meters through a minefield. It also includes means of illumination for night marking.

(2) The M133 Hand Emplaced Minefield Marking Set (HEMMS). The HEMMS is a means of safely guiding friendly forces through or around scattering or conventional minefields. It can also be used in a limited role to mark cleared lanes through enemy minefields. The set consists of lights, signs, tape, wire, poles, pole driver, batteries, and a wooden storage chest. The chest and all components collectively weigh 174 pounds. Each set has enough material to mark a lane 700 to 1000 meters.

11. ROW MINEFIELDS:

a. Types of Row Minefields. Row mining is the process of laying mines in rows as opposed to laying them in a standard or random pattern. The typical row minefield is composed of several rows of surface-laid mines set out at regular mine spacing. Row minefields are usually directed against a mechanized threat and are made up solely of AT mines. Antipersonnel mines can be added and either laid as separate rows or placed in clusters around the AT mines. Minefields composed entirely of AP mines are also used if the threat is a dismounted force. The specific compositions of row minefields vary depending on the situation and the capabilities of the laying unit. They range anywhere from very simple minefields, with only two or three rows of surface laid mines, to much more complex ones, with buried mines, clusters of AP mines, AHD's, and IOE’s.

b. Mine-Laying Vehicles. Typically row minefields are emplaced from a vehicle, thus speeding emplacement. Any of a variety of tactical and wheeled vehicles may be used for mine laying. Important considerations for selecting a vehicle include the vulnerability of the vehicle, its mine-carrying capacity, and its traffic ability in the minefield area.

c. Categories of Row Minefields. There are two special categories of row minefields: the deliberate row minefield (DRMF) and the hasty row minefield (HRMF). The HRMF is an on-call minefield (HRMF) under the control of the maneuver commander as an obstacle reserve.

(1) The DRMF is simply a procedural guide designed to simplify and standardize the planning, organization, and supervision of row-mining operations. Although it is rigidly structured, it remains more expeditious than the standard pattern minefield.

(2) The HRMF is executed on order, and usually done at the direction and under the direct control of the maneuver commander. It gives the maneuver commander the greatest flexibility by giving him a means to rapidly create obstacles when and where he needs them.

(3) Hasty row mining is usually conducted from a vehicle such as an AAV or a 5-ton truck and is composed of surface-laid AT mines. Generally, an IOE is not employed and there is no change of direction in the rows.

d. Usage

(1) Row mining is not a new concept. It has been used since the beginning of modern warfare and has proven to be very effective, especially in

support of maneuver-oriented doctrines, which require rapid mine-laying techniques.

(2) Row mining is faster then standard pattern mining because the mines are usually not buried and are often laid directly from a slowly moving vehicle.

e. Disadvantages. A major disadvantage of the row mining technique is the abbreviation of the procedures which simplifies the planning and execution of the traditional standard pattern minefield. These standard rules enhance safety and ease the supervision, command, and control of the minefield mission. Eliminating them to expedite the mine-laying process places a greater burden on the leader of the mine-laying party for planning, supervision, and control, and increases the risk to the laying party. Maintaining and removing mines in a row minefield is dangerous, even when the mines are surface laid.

f. Advantage. Although the row minefield is generally not as effective as a standard pattern minefield, the difference is often negligible under battlefield conditions. The advantage of row mining, in terms of speed, efficiency, and protection, make it a desirable option, especially in support of today's Air Land Battle doctrine. If time and resources are not critical, when a very dense minefield is required (as a barrier) or when the minefield must be maintained for a long period of time, the standard pattern minefield is still the best choice.

g. Laying of a Row Minefield. Generally, the rules governing the authority, reporting, recording, and marking are the same for the row minefield as in all other conventional minefields. In fact, row mining simply describes the method for laying the mines. Procedural guidelines governing specific minefield characteristics are few, leaving the laying unit greater flexibility in developing techniques and SOP's which meet their needs and desires.

THE MOST IMPORTANT FACTOR IN ROW MINING IS THE REQUIREMENT FOR STRICT SUPERVISION AND CONTROL.

(1) Rules for Row Mining only a few rules govern the conduct of row mining. Most of these rules are contained in STANAG 2036. The following are the rules that apply to row mining:

(a) The minimum distance between rows of AT mines is 8 meters.

(b) The minimum distance between any rows and a row with AP mines is 15 meters.

(c) Clusters (the same as in standard pattern minefields) are placed on the row centerline directed toward enemy side.

(d) Cluster composition must remain the same throughout the row.

(e) The number of AP mines in each cluster must be the same.

(f) Different types of AP mines may be used in a cluster.

(g) The total number of mines in one cluster will not exceed five, with not more than one being an AT mine.

(h) The type of AT mine may vary from one cluster to another.

(i) AP mines can be laid in a 2-meter semicircle on the enemy side of the base mine in a cluster.

(j) The spacing between mines or clusters in a row can vary between 6 and 10 meters, but it will remain constant within the row.

(k) Mines and clusters will not be closer than 15 meters from the perimeter fence.

(l) Different AT mines may be laid within a row.

(m) The distance between a start row marker and the first mine in a row will be the mine spacing for that row.

(n) If the distance between a mine/cluster and any turning point is less than the mine spacing for that row, that mine/cluster will be omitted. the next mine after a turning point is always located at the mine spacing selected for that row.

(o) All minefields will be recorded on a DA Form 1355, Minefield Record.

(p) Minefield marking, reporting, and approval authority are the same as with any other conventional minefield.

h. Planning Considerations

(1) Initial Planning: Initial planning is done in conjunction with the staff planning process obstacles, including minefields, are planned to support each course of action the obstacles are designed to support the commander's intent and METT-T analysis. When the final plan is selected, the engineer prepares his obstacle plan that includes the location of the minefield, its orientation, and its dimensions. The plan may include also the desired density and the intended effect on the enemy. The engineer should brief the maneuver commander on the relative effectiveness of the minefield using the minefield density. At this point logistics are coordinated, resources are allocated, and the mission is assigned to a unit for execution.

Detailed planning and actual siting of each minefield is done by the engineer emplacing the minefield.

(2) Reconnaissance and Planning. The OIC of the laying party will need to reconnoiter the ground before siting the mine rows. He should prepare a detailed plan using a sketch of the area. maps, aerial photographs, and information from his reconnaissance. The plan should show the following:

* All relevant ground detail such as slopes, ditches, roads, tracks, waterways, soil bearing conditions, weather effects on the area, and vegetation.

* Direction of north and of the enemy.

* The enemy's capabilities and equipment for overcoming the minefield.

The OIC coordinates with the commander of the unit that will be covering the obstacle to ensure that the minefield fits within his plan for the defense. He ensures that the actual siting of the minefield supports the defensive concept, and is in the optimum location and orientation. With the maneuver commander, he makes whatever adjustments are necessary. He then identifies the exact location of:

* Boundary fences.
* Mine rows and row markers.
* Landmarks and intermediate markers.
* Construction routes, gaps, and lanes.
* Mine dumps and re-supply routes.
* Control and rally points.
* Routes for fencing party.
* Location of IOEs (if required).

i. Organization. The labor involved in row mining is relatively easy for trained personnel, but the organization of the task as a whole is intricate, placing great demands on the leader. Without the guidelines to follow as in the standard pattern, and because each situation is different, nothing must be left to chance in the planning and execution. Allowances must be made for the transportation, handling, and control of the considerable tonnage of mines required. The officer and the squad leaders must be able to exercise control throughout the task, under all conditions including nighttime. Safety must be observed at all times.

j. Minefield Layout

(1) The layout is the first step in the actual mine-laying process, and entails the physical establishment of the minefield's landmarks and other control features. The purpose of the layout is for safety and control, and should be conducted under favorable conditions, usually in daylight.

(2) Layout consists of identifying the landmarks; establishing the initial construction routes; and emplacing the start and end row markers, intermediate row markers, and fence location.

(3) The following points should be observed in addition to the standard procedure for siting mine rows:

(a) The layout party starts well in advance of the actual laying. The leader of the emplacing unit will usually direct the layout party with two or three Marines or his subordinate leaders to assist. Usually a single vehicle is employed to assist in the carrying of layout equipment to reduce the amount of traffic in the minefield location.

(b) The layout party sets out all control markers and temporary directional markers for night or day.

(c) The use of sharp turns must be avoided. The distance between intermediate markers in a row should not exceed 100 meters, and is terrain dependent.

(d) Start, change of direction, and end row markers are all the same, and are driven flush (or exposed 1 to 2 inches above the ground). These markers must be used as they are required for the recovery of the minefield.

(e) Safety tapes and any required minefield gaps or lanes should be marked early in the layout.

(f) Mark the routes for mine-laying vehicles to and from the rows.

In order to speed the layout of large minefields, the layout party may proceed from landmark 1 to A1 to A2 to B2 to B1 to C1 and so on until they reach landmark 2.

k. Siting Mine Rows

(1) Rows should be laid to reinforce the terrain. Certain features like thick woods and deep wide streams are natural obstacles. The mine rows should be laid to reinforce these obstacles and increase the effectiveness of the minefield. the distance between rows will be decided by the following factors:

(a) The depth and density of the minefield.

(b) The terrain.

(c) The suitability of the ground for use by the mine-laying vehicle.

(2) Mine rows are always labeled with a letter. Row A is the mine row nearest to the enemy, followed by rows B, C, D, E, and so forth. When vehicles work as teams; two, three, or four rows can be laid simultaneously. This is referred to as a PANEL. Several Panels may be laid together to give the desired depth, width, and density to the minefield.

l. Mine Row

(1) The mine row forms the basic element of a minefield. An AT mine row may be laid with all pressure or with part pressure and tilt rod to increase probable kill or increase coverage of anticipated enemy breach areas. The mine row can be all pressure actuated and then be upgraded to tilt rod and buried, if so desired. Anti handling devices can be installed during the emplacement of the minefield, or after the minefield has been installed as long as no AP mines have been laid.

(2) Tilt-rod activated mines increase the effectiveness of the minefield and decreases the number of mines required to achieve the desired result.

m. Mine Spacing. The OIC of the minefield is responsible for determining the mine spacing. The desired density, the availability of laying vehicles, the number of rows, and the possibility of sympathetic detonation see TM 9-1345-203-12&P) affect the distance between mines. When M21 mines with tilt-rod extensions are surface laid, they must be staked to the ground to prevent the mine from tipping over. The M21 mine is staked on the enemy side using 6-inch nails or steel rods driven through the carrying lugs of the mine.

n. Irregular Outer Edge. A row minefield may contain an IOE designed to deceive the enemy as to the pattern and the extent of the minefield. This may cause the enemy to begin breaching early, using more of his engineer assets and multiplying the effectiveness of the minefield. An IOE consists of short rows and can be laid by hand or vehicle. It may contain AT mines, AP mines, or mixed clusters. An IOE will require extra time, manpower, and supplies.

o. <u>Control Measures</u>

(1) Row mining control measures are essential to the mine-laying vehicles due to the complexity of the indicators. The basic commands, which may be required, are as follows:

(a) Start laying.

(b) Intermediate markers.

(c) Change of direction.

(d) Warning markers (used to alert the vehicle driver that a change of direction, stop laying, or end of row marker is coming up).

(e) Stop laying.

(f) End of row.

(2) Some materials that may be used to construct control measures are:

(a) U-shaped pickets.

(b) HEMMS poles.

(c) Wooden posts.

(d) Steel rods.

(3) Control measures for night laying require lights or infrared equipment such as the following:

(a) Cyalume sticks placed in the U-shape of the picket.

(b) Directional flashlights taped in the U-shape of the picket.

(c) HEMMS lights used with either U-shaped pickets or poles.

(d) BETA lights, if available.

(e) Lights from minefield marking set #2.

(f) Curb lights from a Medium Girder Bridge Set.

(g) Infrared reflectors.

p. <u>Marking</u>. Marking of row minefields is the same as all conventional minefields. In principle, all areas in friendly territories containing mines will be marked by signs and, if possible, be fenced.

12. <u>ROW MINING LOGISTICAL CALCULATIONS</u>:
The following is a method of determining the number of AT mines required for a row minefield:

Step 1. Determine the number of AT mines required. Multiply the given desired density by the minefield frontage.

Density x Frontage = Number of AT mines

Step 2. Determine the number of AT mines per row. Divide the minefield frontage by the desired spacing interval between mines.

NOTE: The resulting number is rounded down to the nearest whole number.

Frontage / Mine spacing = Number of Mines per Row

Step 3. Determine the number of rows. Divide the number of AT mines by the number of mines per row.

NOTE: The resulting number is rounded up to the nearest whole number.

Number of AT mines / Number of Mines per Row = Number of Rows

Step 4. Determine the actual number of AT mines. Multiply the number of AT mines per row by the number of rows.

Number of Mines per Row x Number of Rows = Actual Number of AT mines

Step 5. Determine the number of AT mines to request.

Multiply the actual number of AT mines by the 10% factor for waste.

NOTE: The resulting number is rounded up to the nearest whole number.

Actual Number of AT Mines x Waste Factor = AT Mines to Request

Step 6. Determine the number of vehicle loads by using the same procedure as with the Standard Pattern Minefield.

Step 7. To determine the amount of fencing and marking materials required use the procedure as with the Standard Minefield.

13. ROW MINEFIELD RECORDING: All Conventional minefields are recorded on DA FORM 1355, except for hasty protective minefields, which are recorded on DA FORM 1355-1-R. Row minefields are recorded the same as standard pattern minefields, except that Hasty row will be written on the top portion of Block 1 with minimum information included. The note section will include:

a. Mine clusters at 8-pace spacing.

b. All distance in minefields are measured in paces.

c. Height of the pacer.

d. Mines with AHD- IOE, A, B, C, E, etc.

e. Clips and safeties buried 30-cm rear of end row markers.

SAMPLE PROBLEM #1

Your platoon has been tasked to emplace a 400-meter row minefield with a density of 0.5-0-0. You have decided to space the mines 6 meters apart and your rows will be 15m apart. Determine the number of M15 mines to order, and the number of 5-ton dump trucks required to deliver the crated mines.

Step 1. Density x Frontage = Number of Mines

0.5 mines/meter x 400 meters = 200 mines

Step 2. Frontage / Mine Spacing = Number of Mines per Row

400 meters / 6 meters between mines = 66.6 (round down) 66 mines per row

Step 3. Number of AT Mines/ Number of Mines per Row = Number of Rows

200 mines / 66 mines per row = 3.03 (round up) 4 rows

Step 4. Number of Mines per Rows x Number of Rows = Actual Number of Mines

66 mines per row x 4 rows = 264 mines

Step 5. Actual Number of Mines x Waste Factor = Mines to Request

264 mines x 1.10 = 290.4 mines (round up) 291 mines

Step 6. Mines Requested / Crated M15s per 5 Ton Dump = Number of (see FM 5-34/MCRP 3-17A, page 3-26)

Trucks 291 mines / 204 mines per truck = 1.42 trucks (round up) 2 trucks

Step 7. Barbed Wire = [(Front x 4) + (Depth x 4) + 320] x 1.4

[(Front 400m x 4) + (Depth 60m x 4) + 320] x 1.4 = 3024m

Number of Pickets = Amount of Barbed Wire / 30

3024 m of barbed wire / 30 = 101

Step 8. Amount of Engineer Tape

a. Minefield Boundaries. Depth x 2 60m x 2 = 120

b. Regular Rows. Front x Number of Rows 400m x 4 = 1600 m

c. IOE. Front + (Length of IOE Shortstrip X number of OIE Shortstrip) = NONE

d. Lanes and Gaps. Depth x 2 x Number of Lanes and Gaps.

60m x 2 x 2 lanes = 240m

e. Traffic Lines. Depth x Number of Traffic Lines

60m x 2 = 160m

f. Subtotal (add line A+B+C+D+E) = meters (round up)

120m+1600+0+240+120= 2080m

g. Number of Rolls to Order. Line F x 1.2 = meters

2080m x 1.2 = 2496m

2496 meters / 170 meters per roll = 14.68 rolls 15 rolls

14. FASCAM CHARACTERISTICS:

a. Capabilities

(1) Faster Response

(a) Scatterable mines can be emplaced more rapidly than conventional mines to adjust for a changing battlefield.

(b) Some scatterable mine systems allow emplacement of the mines directly on top of enemy forces, thus allowing emplacement in reaction to, rather than in anticipation of, enemy movement.

(2) Increased Mobility

(a) Upon expiration of the self-destruct time, the minefield is cleared and the commander can move through an area that was previously denied to enemy or friendly forces.

(b) In many cases, the self-destruct period may be set at only a few hours. This feature allows for effective counterattacks to the enemy's flanks and rear areas.

(3) Efficiency

(a) Scatterable mines can be emplaced by a variety of delivery methods. They can be deployed by air, artillery, vehicle, or hand to satisfy the high mobility requirements of modern warfare.

(b) Extensive manpower, equipment, or tonnage is not required for their emplacement.

(4) Increased Lethality

(a) Most scatterable antitank mines utilize a warhead that is designed to kill the crew of the tank (K-Kill) rather than merely breaking a track (M-Mobility-Kill), although an M-Kill is also possible with scatterable mines.

(b) Scatterable antipersonnel mines are trip wire actuated and utilize a blast/fragmentation type kill mechanism.

(c) Scatterable mines are much smaller and lighter than their conventional mine counterparts.

b. Limitations

(1) Extensive Coordination

(a) Because scatterable mines are a very dynamic weapon systems, great care must be taken to ensure that proper coordination is made with all higher, adjacent, and subordinate units.

(b) All affected units must be notified of the location and duration of scatterable mine fields to preclude friendly casualties.

(2) Cost - Due to their sophisticated design, scatterable mines are much more expensive than conventional mines. The efficiency of scatterable mine systems over conventional mines offsets much of their higher cost.

(3) Visibility

(a) Because of their means of delivery, scatterable mines will lay exposed on the surface of the ground. However, given their relatively small size and natural colorings, together with the limited visibility and intense activity on the modern battlefield, this problem does not impose a significant limitation to their effectiveness.

(b) A percentage of all scatterable mines have anti disturbance devices built in at the factory that will prevent them from being manually removed or tampered with.

c. Antitank Mines

(1) Magnetic Influenced Fuse - The large mass of iron in the tank's armor generates a magnetic field as the tank travels. The fuse in scatterable antitank mines is sensitive to this magnetic field and will detonate the mine when the field reaches a certain intensity.

(2) SFF Warhead

(a) The kill mechanism of an SFF warhead (also called a Miznay-Scharden M-S plate) is essentially a directed energy platter charge. The warhead is bi-directional, meaning that it can fire from the top or the bottom.

(b) It is a highly lethal warhead that functions by forming a slug of molten metal which, by the concentrated force of the explosive, punches a hole through the belly of the tank. As the slug penetrates that tank's armor, shrapnel is sprayed throughout the inside and the occupants are killed instantly.

(3) Small Size and Weight - Scatterable antitank mines are cylindrical in shape, measure 4.75 inches in diameter, and are 2.6 inches high. They contain only 1.3 pounds of explosive as compared to over 20 pounds for conventional antitank mines. The total weight of the scatterable antitank mine is 3.8 pounds.

(4) Self-Destruct Times

(a) Each scatterable antitank mine has two or more self-destruct times. The exact times vary among the different systems and are classified information. The following self-destruct times have been established for planning purposes.

1 ADAM/RAAMS (M731/M741) - 4 HOURS

2 ADAM/RAAMS (M692/M718) - 48 HOURS

3 GEMMS (M74/M75) - 5 DAYS -15 DAYS

4 MOPMS (M76/M75) - 4 HOURS

5 GATOR/VOLCANO (M89/M90) - 4 HOURS
-48 HOURS
-15 DAYS

(b) The self-destruct times for the Remote Intramural Mine System (RAAMS) and M56 are factory set and cannot be changed. All others can be changed by the operators.

d. Antipersonnel Mines

(1) Blast Fragmentation Kill Mechanism

(a) Scatterable antipersonnel mines kill enemy soldiers through the combined effects of blast and fragmentation. Each mine contains an explosive that detonates upon actuation and shatters the mine's metal casing to produce shrapnel.

(b) The shrapnel is propelled upward and outward from the mine and produces fatal casualties out to a distance of 10 to 15 meters.

(2) Trip Wire Actuated

(a) Each mine has eight trip wires, four on the top and four on the bottom. This feature gives the mine a bi-directional capability, meaning that no matter what side the mine lands on, some of the trip wires will deploy.

(b) After the mine is deployed and has impacted on the ground, there is a short delay period before it arms.

(c) After arming, the trip wires are propelled out 20 to 40 feet. The trip wires are similar in appearance to very fine fish line and are weighted at one end. Tension of 0.9 pounds applied to one of the trip wires is enough to create a break in an electrical circuit that causes the mine to detonate.

(3) Small Size and Weight - Scatterable antipersonnel mines have the same cylindrical shape and size (4.75 inches by 2.6 inches) as the antitank mines. they contain 1.2 pounds of explosive and have a total weight of approximately 3.2 pounds. There are four holes on both the top and bottom of the mines from which the trip wires are released.

(4) Self-Destruct Times

(a) All the scatterable antipersonnel mines will self-destruct. The exact self-destruct times vary among the different systems and are classified. Some systems have two or three self-destruct times.

(b) For planning purposes, the same time periods used for antitank mines are used for antipersonnel mines.

15. FASCAM SYSTEMS:

a. ADAM/RAAMS Artillery Delivered Mine Systems

(1) Description

(a) Both the ADAM and RAAMS mines are delivered by a standard 155-millimeter howitzer. No special modifications or adaptations for the firing system are required. The mines are contained within a 155-millimeter projectile and dispensed while in flight. The effective range is 17 kilometers.

(b) The ADAM mine is an antipersonnel mine only. Each ADAM artillery round contains 36 mines.

1 There are two different rounds based on the self-destruct time: the M731 round contains all short self destruct time mines and the M692 round contains all long self-destruct time mines.

2 The self-destruct times are preset during the manufacturing process and cannot be changed.

(c) The RAAMS mine is an antitank mine only. Each RAAMS artillery round contains nine mines.

1 There are two different rounds based on the self-destruct time: the M741 rounds contain all short self-destruct time mines and the M718 rounds contain all long self- destruct time mines.

2 The self-destruct times are preset during the manufacturing process and cannot be changed. The RAAMS mine follows the standard design characteristics for scatterable antitank mines.

(2) Emplacement

(a) The ADAM and RAAMS mining missions are requested through normal channels for artillery support.

(b) Once the proper authorization has been received to employ the mines, requests for ADAM and RAAMS are processed in the same way as normal requests for fire support, including targets of opportunity.

(c) The use of ADAM and RAAMS for pre planned fires requires close coordination among the G3/S3, engineer, and Fire Support Coordinator (FSCOORD) sections. The G3/S3 has primary responsibility for the employment of obstacles in support of the tactical plan. The FSCOORD and engineer sections provide technical expertise and advice on details concerning the execution of the mission.

(3) Employment

(a) The ADAM and RAAMS systems were designed to provide a flexible, and rapid response mining capability.

(b) They are ideally suited for emplacing interdiction and point mine fields, re-seeding (not relaying) breached minefields, and providing counter battery fires.

(c) The greatest advantage of these systems is that they provide the tactical commander with the capability to emplace mines directly on top of, in front of, or behind enemy forces. Their responsiveness allows the emission to be executed quickly, thus allowing the commander to effectively influence a rapidly changing battlefield.

(d) Their employment does not involve sending friendly forces beyond their own lines, nor committing an entire company for an extended period of time to emplace the mine field.

(e) Scatterable mines will force an enemy to disperse and will deny the use of terrain for a long period of time.

(f) In addition to the counterbattery and normal mine field missions, ADAM and RAAMS may also be used for the following special purposes.

1 Disrupt enemy follow-on echelons.

2 Harass rear-area command and support activities.

3 Fix enemy forces for attack (hammer and anvil).

4 Supplement final protective fires.

5 Re-seed other obstacles and close lanes and gaps.

6 Mine river-crossing operations.

(g) The main limitation of ADAM/RAAMS is their range of 17,000 meters. Many of the deep interdiction missions in support of Air Land Battle will require an extension of this distance.

(h) Accuracy of the delivery system is also a potential limitation. Although ADAM/RAAMS are no less accurate than a normal 155-millimeter artillery mission, care must be exercised when they are employed near the location of friendly forces because of the potential for short rounds or firing data calculation errors.

b. M56 Helicopter Delivered Antitank Mine Dispensing System.

(1) Description

(a) The dispensing system consists of a control panel, two dispensing pods, and mounting hardware. The system is installed externally on the UH-1H utility helicopter. Each pod contains 40 canisters having two mines inside, giving the system a 160 mine per sortie capability.

(b) Each mine utilizes an electrical/mechanical pressure fuse and a high explosive blast warhead. Pressure between 49 and 200 pounds is required for actuation, and the mine will function under water as long as the water pressure does not exceed the actuation pressure.

(c) The mine has only one self-destruct time that is preset at the time of manufacture and cannot be changed. A percentage of the mines have anti disturbance and/or roller defeating devices. The M56 is an exception to the standard design for scatterable antitank mines discussed earlier.

(2) Emplacement

(a) When the pods are drawn from the ammunition supply point (ASP),a preflight inspection of the system must be conducted. Once the batteries have been installed and a complete system check has been made, the pods are installed on the aircraft.

(b) The pilot then flies to the designated area and locates the target. the recommended mine field size for each sortie is 200 by 300 meters. The minefield density is established through the selection of the proper release settings on the control panel in conjunction with the aircraft's speed and altitude.

(3) Employment

(a) Due to its limited payload size, the M56 mine system is designed for the rapid emplacement of smaller size minefields.

(b) Because of the system's vulnerability, its use is normally restricted to areas controlled by friendly forces. It is ideally suited for emplacing point mine fields and small size tactical mine fields; reinforcing other obstacles; and closing gaps and lanes in existing mine fields.

(c) The M56 system is an antitank system only and does not have an antipersonnel system to supplement it; however, other scatterable systems may be used to provide antipersonnel mines.

(d) Although the M56 provides maneuver forces with a rapid response and self- clearing capability, it does have several limitations that must be considered when deciding how it should be employed. The aircraft required for emplacement are vulnerable to enemy small caliber fire that precludes the system from offering a true interdiction capability.

c. Air Delivered Scatterable Mines (GATOR)

(1) Description

(a) The Gator mine dispensing system is produced in two versions: the US Navy MK7 dispenser, which contains 60 mines; and the US Air Force SUU-66 dispenser, which contains 94 mines. The mix for each dispenser is approximately three antitank mines to one antipersonnel mine.

(b) The mines are contained inside of a bomblet type dispenser attached under the wing of a high-performance, fixed-wing aircraft.

(c) While airborne, the dispenser is released and allowed to fall free.

(d) The area of minefield coverage depends upon the terrain, weather, and aircraft speed and altitude.

(2) Emplacement - The Gator mine system will most likely be a corps or theater asset. Once the proper authorization has been received to employ the mines, requests for Gator should be initiated and processed in the same manner as normal Tactical Air Command (TAC) support requests.

(3) Employment

(a) The Gator mine system was designed to provide a deep interdiction mining capability. It is ideally suited for the interdiction of threat follow-on forces. While the Gator has the capability to provide close combat support, deep interdiction mining is expected to be its primary mission.

(b) Typical mining missions include the following:

1 Isolate objectives.

2 Counter air defense artillery (ADA)/artillery fires.

3 Deny terrain.

4 Disrupt and disorganize support activities.

5 Inflict personnel and equipment losses.

d. M128 Ground Emplaced Mine Scattering System (GEMSS)

(1) Description

(a) The GEMSS is a trailer-mounted system that may be towed by several type vehicles including a 5-ton dump truck.

(b) The dispenser consists of two magazines that hold up to 400 mines each. Mines are fed from the magazines into the ejector that propels them out 30 meters from the centerline of travel.

(c) Various options exist for the pattern of mine dispersion. The mines may be thrown all to one side of the dispenser or to both sides. When the mines are dispensed to both sides, a 60-meter wide belt will be produced.

(d) The dispenser has an emplacement speed of 5 to 8 miles per hour that allows the entire 800 mines to be dispensed in about 15 minutes.

(e) The GEMSS M75 antipersonnel mines possess the scatterable mine design characteristics described earlier.

(f) The flipper is a manual, auxiliary dispenser designed to supplement the M128 GEMSS. It weighs about 100 pounds and can be mounted to several type vehicles.

(g) The Flipper uses the electrical power system of the host vehicle and launches the standard GEMSS mine 35 meters out from the vehicle. It performs all the functions of the GEMSS dispenser (arms, selects the self-destruct time, and emplaced) and is the only alternative means of employing the GEMSS mines. It can dispense mines at a rate of six per minute.

(h) In addition to its primary mission of providing a backup means for the GEMSS, the Flipper may also be used to emplace small mine fields by itself.

(2) Emplacement

(a) The GEMSS (and/or Flipper) missions will be tasked to engineer units in the same manner as conventional mine field missions.

(b) The type of minefield to be emplaced and the self-destruct period will determine the authorization required for employment. Once a unit has authorization to emplace GEMSS mines, the G3/S3 and the staff engineer will plan the minefield. As a minimum, the following items should be addressed in the plan:

1 Location and proposed frontage of the mine field.

2 Self-destruct time setting.

3 Antitank to antipersonnel mine ratio.

4 Number and width of belts.

5 Mine density.

(c) FM 20-32 (MINE/COUNTERMINE OPERATIONS) gives exact details in emplacing a minefield with GEMSS.

(3) Employment

(a) The GEMSS system was designed primarily to provide a capability for rapid emplacement of large tactical mine fields in areas controlled by friendly forces, but can also be used for point and protective minefields.

(b) Key advantages of the GEMSS are the 800-mine capacity of the dispenser and the speed of emplacement. These characteristics give the GEMSS the capability to rapidly emplace large-scale tactical mine fields with minimal stops for reloading.

(c) The major limitations of the system include its vulnerability to small caliber fire, the support assets required to conduct the mission, and the mine arming initiation sequence. Because of its limitations, GEMSS should not be used for interdiction minefields in areas involving direct contact with combat activity.

(d) Possible mining missions well suited for the GEMSS are listed below. With all missions, the commander must consider the temporary nature of the mines due to their inherent self-destruct feature.

1 Large tactical mine fields.

2 Large point mine fields to protect the flanks of an attacking or advancing force.

3 Re-seed breached mine fields or close gaps left in friendly mine fields.

4 Reinforce existing minefields or obstacles.

5 Mine potential drop zones (DZ) or landing zones (LZ).

e. XM133 Modular Pack Mine System (MOPMS)

(1) Description

(a) The concept of MOPMS is a "mine field in a suitcase." It consists of a storage container which weighs approximately 150 pounds and contains 21 mines - 17 antitank mines and 4 antipersonnel mines. The mines are similar in appearance and functioning to the standard scatterable mines discussed earlier.

(b) The mines are located inside seven tubes (three mines per tube) within the container. An explosive propelling charge at the bottom of each tube expels the mines through the roof of the container when they are dispensed. The mines are propelled 35 meters out from the container in an approximate 180-degree semicircle. The resulting density is 0.01 mines per square meter.

(c) The mines are dispensed by either a radio control unit (RCU) or the M34 hand-blasting machine connected to the container by WD-1 field wire. Once the mines are dispensed, they cannot be recovered or reused. If the mines are not dispensed, the container may be disarmed and recovered for use at a later time.

(2) Emplacement

(a) Because of the weight of the system, it will normally be transported by vehicle as close as possible to the emplacement site. It can then be hand emplaced by two soldiers utilizing the carrying handles.

(b) The container should be carefully sited by the NCOIC to ensure the minefield will be dispensed in the proper location. Several containers can be used together to provide a greater area of coverage or higher mine density, if desired.

(c) If the mines are not to be dispensed immediately, the containers should be camouflaged and possibly buried. A firing point should be designated that will give the operator a clear field of observation over the area to be mined.

(d) Firing systems must be checked out per the MOPMS operating instructions.

(e) If the mines are to be dispensed immediately, the empty containers should be removed to avoid giving away the minefield location.

(3) Employment

(a) With its unique characteristics, the MOPMS is ideally suited for the following mine field missions:

1 Close gaps or lanes in existing mine field.

2 Hasty protective mine fields.

3 Deliberate protective mine fields (cases emplaced but mines not dispensed).

4 Point mine fields (trails, crossing sites, LZs/DZs, and road junctions).

5 Ambushes and booby-traps.

(b) The 150-pound container is too heavy to make it a practical system to support many light infantry or special forces operations. The small area of coverage may also pose a problem in some cases, but this can usually be overcome through the use of several overlapping MOPMS or with conventional mines emplaced prior to the MOPMS mines being dispensed.

16. RECORDING AND REPORTING FASCAM:

a. Since the locations of individual scatterable mines are unknown, they cannot be recorded in as great a detail as conventional mines. For most systems, a safety zone is calculated from one or more aim points.

b. For example, a RAAMS minefield would be recorded based on the target location (the grid coordinates given to the firing battery). The size of the minefield would depend on the number of rounds fired, the number of aim points, and the angle of fire.

c. A GEMSS minefield can be recorded more accurately by plotting each of the minefield corner points rather than an aim point.

d. To facilitate the reporting and recording of scatterable mine fields, a simple uniform procedure is used. This procedure combines the report and the record into one document - the Scatterable Mine Field Report and Record - for all delivery systems.

e. The information contained on the Scatterable Mine Field Report and Record is as follows:

(1) Line 1 Approving Authority. Enter approving authority. CDR 3AD

(2) Line 2 Target/Obstacle Number. If the minefield is part of an obstacle plan, enter the obstacle number 2XXX0157. This number represents II

Corps, target number 157. If the minefield is not a part of an obstacle plan or does not have a number, then leave blank or enter NA.

(3) Line 3 Type Emplacing Systems. Enter the type system that emplaced the mine field, such as GEMSS, ARTY, Volcano.

(4) Line 4 Type mines. Enter AP for antipersonnel mines, AT for antitank mines. If both, enter AP/AT.

(5) Line 5 Self-Destruct Period. Enter the time period in which the minefield will self-destruct.

(6) Lines 6 - 14 Aim Point/Corner Points of the MineField. If the system used to emplace the minefield uses a single aim point to deliver the mines, enter that aim point MB 10102935. If the system has distinct corner points such as GEMSS, enter those corner points MB 17954790, MB 18604860, MB 18504890, MB 18054895, MB 17804850.

(7) Line 15 Size Safety Zone from Aim Point. If an aim point is given in Line 6, enter the size safety zone from that aim point. Example: Artillery emplaced a mine field from aim point MB 10102935 and the safety zone is 1000m x1000m, enter 500m so that personnel plotting or receiving the information can plot the safety zone.

(8) Line 16 Unit Emplacing Mines and Report Number. BCO 23ENGR BN 4 Reports should be numbered consecutively. This would be the fourth minefield that B Company has emplaced.

(9) Line 17 Person Completing the Report. Sgt. Hollins

(10) Line 18 Date-Time Group of Report. 160735ZOCT82

(11) Line 19 Remarks. Any other items the reporting unit may feel are important.

f. In addition to the Scatterable Mine Field Report and Record, a separate report, the SCATMINWARN, is used to notify selected units that scatterable mines will be emplaced. These two reports are the only reports used with scatterable mines.

g. The report is sent by voice, digital or hard copy means, either prior to or immediately after the mines have been emplaced. A sample SCATMINWARN report is shown below, followed by a completed SCATMINWARN report for an artillery mission.

SCATMINWARN

LINE	MESSAGE
ALPHA	Emplacing System
BRAVO	AT YES/NO
CHARLIE	AP YES/NO
DELTA	# aim points/corners points
ECHO	Grid coordinates of aim points/corner points and size of the safety zone
FOXTROT	DTG of self-destruct period

SCATMINWARN for Artillery Mission

ALPHA	ARTY
BRAVO	Yes
CHARLIE	Yes
DELTA	One
ECHO	MB 10102935 500M
FOXTROT	081610Z-081900ZOCT82

17. PLANNING ARTILLERY DELIVERED MINE FIELDS:

a. Once it has been determined that a RAAMS/ADAM will be used as a method of emplacing a mine field, close coordination is required between the engineer and the Fire Support Coordinator (FSC).

b. During the planning process, the proposed minefield is plotted on a map to locate the minefield centerline end points. This is done by determining the center point of the right and left mine field boundaries.

c. Planning Modules

(1) The RAAMS/ADAM minefield is based upon a 400 x 400-meter planning module. The only exception to this is when RAAMS is delivered at low angle for which a 200 x 200-meter module is used. The planner must therefore select a depth of 400 meters, unless he intends to employ RAAMS ONLY using low angle delivery.

(2) The FSC is instrumental in providing advice on the delivery systems posture.

d. Selection of Mines

(1) RAAMS (AT) minefields are employed against enemy armored vehicles. When intelligence sources indicate that the enemy has a dismounted breaching capability, ADAM (AP) mines should be delivered directly on top of the RAAMS minefield. Always deliver ADAM as the last rounds fired when used in conjunction with RAAMS or other munitions.

(2) ADAM (AP) mines are employed with AT mines when the primary target is dismounted personnel. ADAM mines can also be delivered onto existing AT obstacles to hinder dismounted breaching. As a general rule, AT mines are employed together.

e. Mine field Density

(1) The density of the proposed mine field is based on the purpose of the minefield.

(2) Refer to your student handout (FASCAM), page 17 for density or page 3-36 in FM 5-34/MCRP 3-17A.

(3) The density is "Area Density". Area density specifies the number of mines located in a 1 square meter section of a minefield.

f. Number of Aim Points

(1) Prior to determining the number of aim points, you must coordinate with the FSC to determine:

(a) Delivery techniques (Transfer of MET+VE or observer adjust)

(b) Type of shell (RAAMS or ADAM)

(c) Trajectory (low angle or high angle)

(d) Battery Mine Field Angle (BMA) - The BMA is the smaller angle formed by the intersection of the minefield centerline with a line drawn from the battery center to the center point of the minefield. The BMA is determined as either less than or equal to 800 mils or larger than 800 mils. (800 mils is approximately 45 degrees).

(2) Once this information is known, the tables located on pages C-2 through C-7 of your FASCAM Reference Text will be used to determine the number of aim points required to assure the emplacement of a given size mine field.

(3) The number of aim points on the table is based on the range to the minefield center (expressed to the nearest 2000 meters) and the desired width of the minefield.

(4) Page 3-36 in FM 5-34/MCRP 3-17A can be used as a ready reference to determine the number of aim points under the given conditions stated.

g. The location of aim points

(1) Once the number of aim points has been determined, the next step is to determine the location of aim points.

(2) Odd number aim points (400 x 400 module)

(a) Place the first aim point at the center point of the minefield.

(b) Place the others at intervals of 400 meters left and right of the center point along the centerline.

(3) Even number aim points (400 x 400 module)

(a) Place aim points 200 meters left and right of the center point along the centerline.

(b) Place the others at intervals of 400 meters.

(4) Module size 200 x 200 meters, odd number aim points

(a) Place aim points 100 meters left and right of the center point along the centerline.

(b) Place the others at intervals of 200 meters.

(5) Number of projectile type, trajectory, and desired density

(a) The number of projectiles required to achieve the desired density within each aim point is based on the projectile type, trajectory, and desired density.

(b) Page A-4 in your student handout or page 3-36 in FM 5-34/MCRP 3-17A has the tables to determine number of projectiles per aim point.

REFERENCES:

1.	FM 5-34/MCRP 3-17A	ENGINEER FIELD DATA
2.	FM 20-32	MINE/COUNTERMINE OPERATIONS

UNITED STATES MARINE CORPS

COMBAT ENGINEER INSTRUCTION COMPANY
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STUDENT HANDOUT

FOREIGN MINES

1. LESSON PURPOSE: As a Combat Engineer, you will be called upon during breaching operations, road sweeps, etc, to identify and destroy foreign mines. You must have a basic understanding of the type of mines the enemy may use against you in combat.

OUTLINE

1. CHARACTERISTICS:

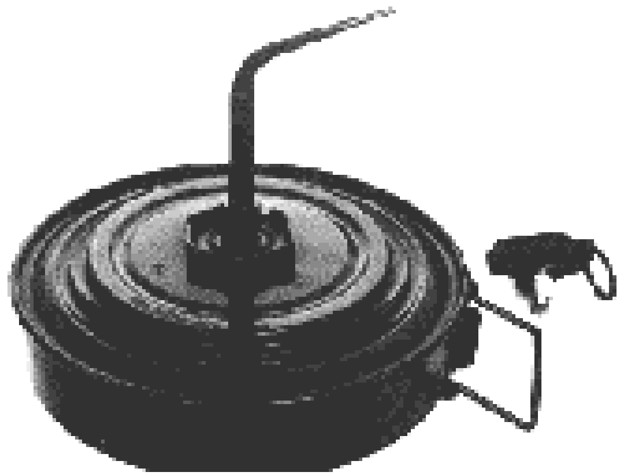
a. Definition. A foreign mine is any mine used in combat not employed by U. S. Personnel. During Operation Desert Storm, we discovered that Iraq was using US mines in their minefields. Though these mines are familiar to you, you still must treat them as foreign mines

b. Characteristics of Anti-Tank Mines and Anti Personnel nines:

(1) General: Most foreign Mines are designed similar to US mines. Some Mines are being produced with electronic or mercury switches built into the mine and once armed, the slightest movement may activate the mine.

(2) Anti Tank Mines: are designed to produce either M-Kill (Mobility Kill) or K-Kill (Personnel and Vehicle Kill). Foreign anti-tank mines are metal. More modern anti-tank mines use a plastic body to make detection difficult or impossible.

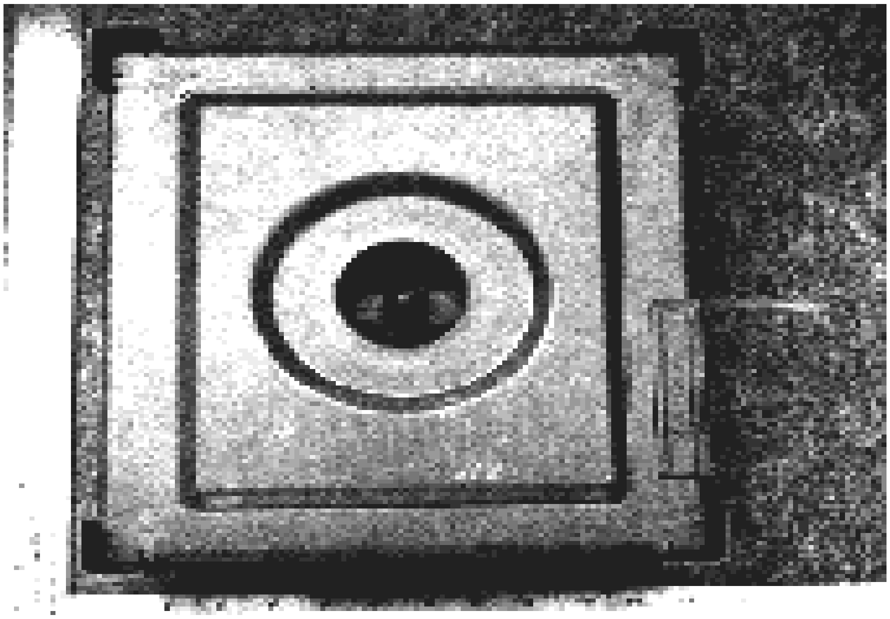
(a) Metal: Normally an older type mine, the body is made completely of metal and will have one or two secondary fuse wells. These type of mines are easily detectable with metallic mine detectors. An example of this type is the TM 46 Anti-tank Mine.



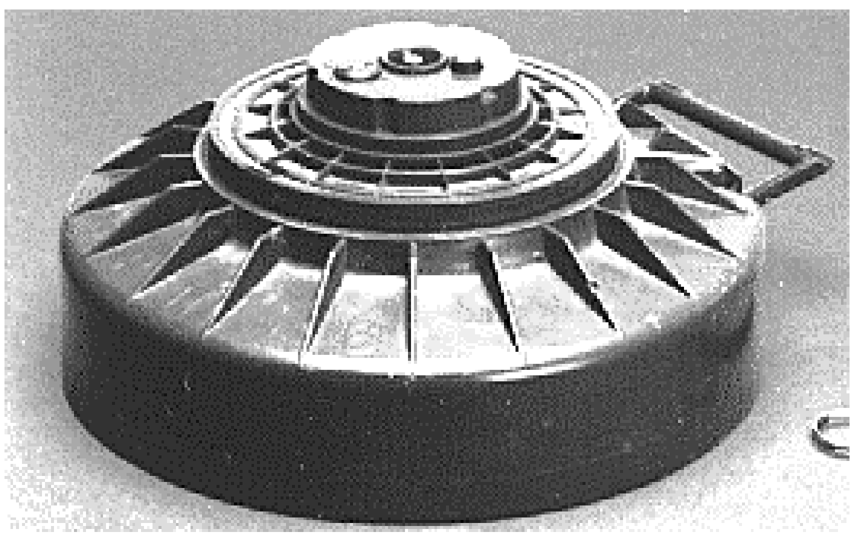
TM 46 \ TMN 46 (has secondary fuse well)
Origin: **Former Soviet Union**
Type: **Blast**
Initiating action: **pressure**
Main charge: **TNT**
Casing: **sheet metal**

(b) Plastic. These type of mines were designed to make it difficult to detect them with metallic mine detectors. Several plastic mines contain small amounts of metal (normally the firing pin) and may still, though difficult, be detected with metallic mine detectors. An example of this is the VS-2.2 Anti-tank Mine. Some plastic mines, like the TMA-5 Anti-tank Mine contains no metal and is **impossible** to detect with metallic mine detectors.

VS-2.2
Origin: **Italian**
Type: **Blast**
Initiating action: **Blast resistant pressure**
Main charge: **TNT**
Casing: **Plastic**

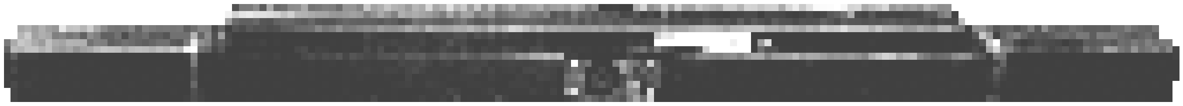


TMA- 5
Origin: **Former Yugoslavia**
Type: **Blast**
Initiating action: **Pressure**
Main charge: **TNT**
Casing: **Plastic**



TMRP- 6
Origin: **Former Yugoslavia**
Type: **Platter charge**
Initiating action: **pressure or tilt rod**
Main charge: **TNT**
Casing: **Plastic**

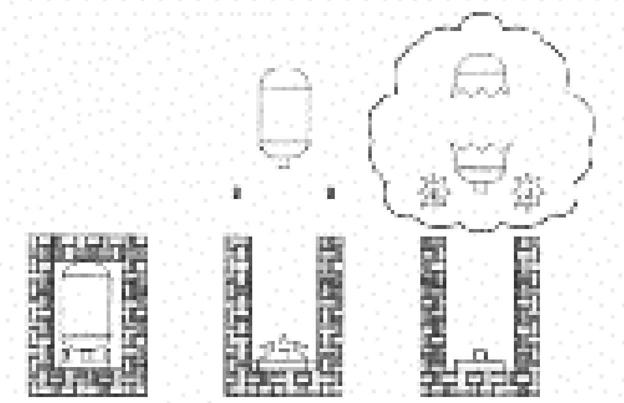
(3) Style. Most anti-tank mines are round or square. There are a few that are odd shaped One mine that is not round or square is the British L-9 (Bar Mine). This long narrow mine was designed to cover a larger area with a single mine. Because of its length, this mine proved difficult to remove with a mine plow and rakes.



L-9 (Bar Mine)
Origin: **British**
Type: **Blast**
Initiating action: **Pressure or magnetic influence**
Main charge: **Hexogen**
Casing: **plastic**

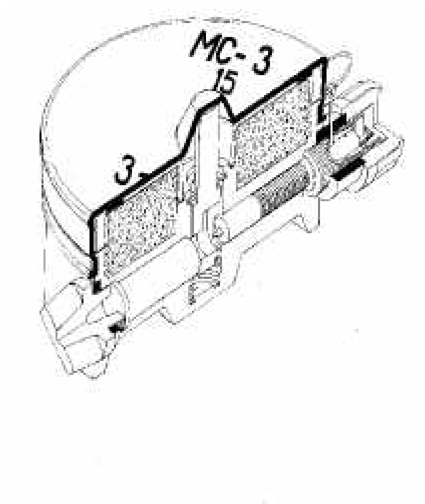
c. ANTI-PERSONNEL MINES

(1) Anti-personnel mines are designed to kill or wound personnel. There are three types, horizontal spray, blast and fragmentation. One other type of AP mine is the blast overpressure of which only one mine is known to function in this manner the UDAR



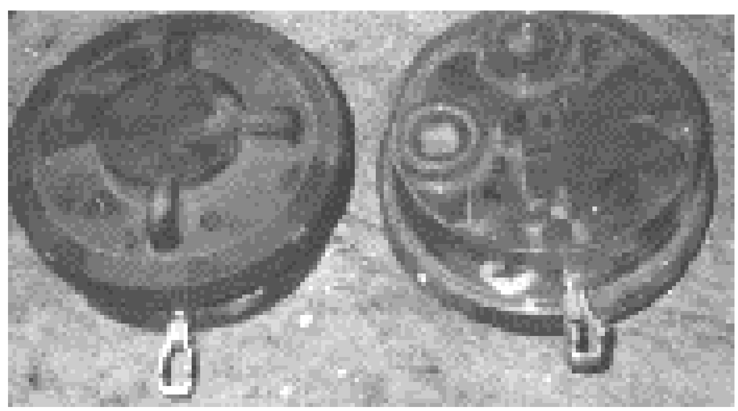
UDAR
Origin: **Former Yugoslavia**
Type: **Blast Overpressure**
Initiating action: **Pressure or command**
Main charge: **Fuel Air Explosive**
Casing: **Metal**

(2) Blast Type. Designed to cripple the foot or leg of the person who steps on it. It can also burst the tires of a wheeled vehicle, which passes over it.



MS-3
Origin: **Former Soviet Union**
Type: **Blast**
Initiating action: **Pressure release**

PMN



PMN-2

PMN \ PMN-2
Origin: **Former Soviet Union**
Type: **Blast**
Initiating action: **Pressure**
Main charge: **TNT**
Casing: **Plastic, Rubber, and Metal**

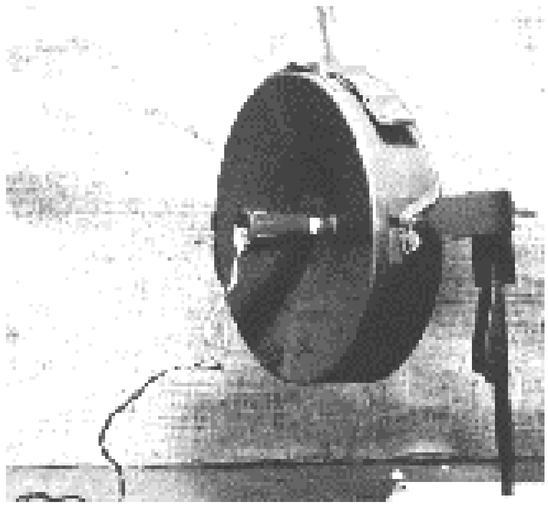
(3) Fragmentation

(a) Bounding Fragmentation. When activated by pressure or trip wire it throws a canister into the air which burst and scatters shrapnel throughout the immediate area. The Valamara 69 is a bounding fragmentation type anti-personnel mine.

Valamara 69
Origin: **Italian**
Type: **Bounding Fragmentation**
Initiating action: **Pressure, Tension**
Main charge: **TNT with 1200 steel cubes**
Casing: **Plastic, Valamara 59 has Metal casing**

PROM- 1
Origin: **Former Yugoslavia**
Type: **Bounding Fragmentation**
Initiating action: **Pressure, Tension**
Main charge: **TNT**
Casing: **Steel**

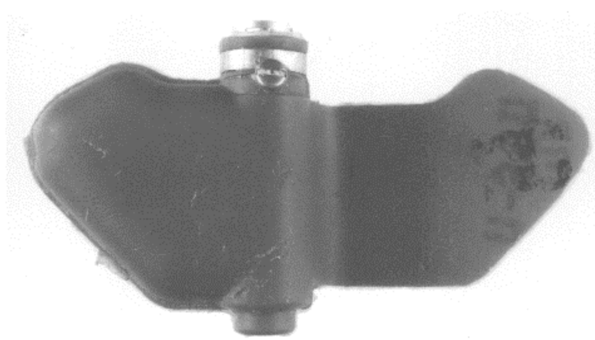
(b) Horizontal Spray or Fixed Directional. When activated, throws shrapnel towards personnel. Normally command detonated but may be booby-trapped with trip wire. Claymore type mines. The MON 100 is a Claymore type Mine.



MON 100
Origin: **Former Soviet Union**
Type: **fixed directional**
Initiating action: **trip wire, break wire, and command detonation**
Main charge: **TNT** has 400 steel fragments
Casing: **Metal**

(c) Some anti-personnel fragmentation mines, like the POMZ-2 mine, are like grenades on a stick. When activated, throw shrapnel 360 degrees. These type mines are trip wire activated.

POMZ- 2
Origin: **Former Yugoslavia**
Type: **horizontal spray**
Initiating action: **Tripwire Pull**
Main charge: **TNT**
Casing: **Cast Iron**



PFM- 1
Origin: **Former Soviet Union**
Type: **Blast**
Initiating action: **Hydrostatic pressure**
Main charge: **Liquid Explosive**
Casing: **Plastic**

(d) Anti-personnel Mine Fuses. Fuses for anti-personnel mines are normally pressure activated or from pull on a trip wire. Anti-personnel mines with their fuses are very sensitive and require small amounts or pressure or pull (normally under 20 pounds) to activate. Mine clearing devices like the line charge, mine plows, and mine rollers easily defeat most anti-personnel mines.

REFERENCES:

FM 20-32	Mine\Countermine Operations
DOD-1540-17-96	Bosnia Country Handbook
	Engineer Contingency Handbook

UNITED STATES MARINE CORPS

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STUDENT HANDOUT

OBSTACLE CONSTRUCTION

LEARNING OBJECTIVE (S)

1. TERMINAL LEARNING OBJECTIVE (S):

a. Given a tactical situation, an obstacle plan overlay, personnel, equipment, and references, supervise construction of an obstacle to meet the requirements of the obstacle plan per the references. FM 90-7, FM 5-34/MCRP 3-17A, FM 5-102 and FM 20-32. (1302.1.13)

2. ENABLING LEARNING OBJECTIVE (S)

a. Given a tactical situation, determine the requirements needed to complete an obstacle plan that supplements the commander's intent per the references. FM 90-7, FM 5-34/MCRP 3-17A, FM 5-102 and FM 20-32. (1302.1.13a)

b. Given a tactical situation, area of operation, identify logistical requirements to construct obstacles per the references. FM 90-7, FM 5-34/MCRP 3-17A, FM 5-102 and FM 20-32. (1302.1.13b)

c. Provided materials and equipment, as a member of a team, construct obstacles per the references. FM 90-7, FM 5-34/MCRP 3-17A, FM 5-102 and FM 20-32. (1302.1.13c)

1. CONSTRUCTED OBSTACLES. Constructed obstacles are those that are built by Marines and machinery, generally without the use of explosives.

a. Types

(1) Wire

(2) Tank ditches

(3) Other obstacles (Hedgehogs and tetrahedrons, Rubble, Fires, and Flooding)

(4) Log Obstacles

b. Constructed obstacles generally require extensive amounts of manpower, equipment, material and/or time.

c. Marines and construction equipment can be exposed to all types of enemy fire when employing constructed obstacles. They should be employed prior to the start of the battle, or on a terrain feature away from direct engagement areas, so that observed fire cannot disrupt the emplacement process.

2. EXPEDIENT OBSTACLES. The potential of expedient obstacles is almost unlimited. They place a great premium on imagination in the use of available materials and other resources, thus avoiding the logistical burden associated with all other types of obstacles. These may include:

a. Nonstandard log obstacles

b. Junked vehicles or other debris spread to block an open area.

c. Selected trees pushed over to make an abatis or to strengthen a wooded area where tree spacing may otherwise allow armored vehicles to pass.

d. Short ditches cut in lieu of craters.

e. Equipment used to steepen or deepen stream banks, gullies or other breaks in the terrain to make expedient tank ditches.

3. WIRE OBSTACLE EMPLOYMENT

a. Purpose. Barbed wire entanglements are artificial obstacles designed to impede the movement of foot troops and, in some cases, tracked and wheeled vehicles. The materials used in constructing barbed wire entanglements are relatively lightweight and inexpensive, considering the protection they afford. Barbed wire entanglements can be breached by fire, wire obstacles are built rapidly, repaired, and reinforced rapidly.

b. Siting and Layout. To be effective, barbed wire entanglements are sited and laid out to meet the following requirements:

(1) Under friendly observation, covered by fire, and where practicable, protected by antipersonnel mines, flame mines, trip flares, and warning devices.

(2) Concealed from enemy observation as far as practicable by incorporating terrain features such as reverse slopes, hedges, woods, paths and fence lines.

(3) Erected in irregular and non-geometrical traces.

(4) Employed in bands or zones wherever practicable.

(5) Coordinated with other elements of the defense.

c. Classification. Entanglements are classified according their use and their depth and whether fixed or portable.

(1) Use. Entanglements are classified by use as tactical, protective, or supplementary. The employment of these types in a defensive area is shown schematically in Figure 3-3 in your FM 5-34.

(a) Tactical. Tactical wire entanglements are sited parallel to and along the friendly side of the final protective line. They are used to break up enemy attack formations and to hold the enemy in areas covered by the most intense defensive fire. Tactical entanglements extend across the entire front of a position but are not necessarily continuous.

(b) Protective. Protective wire entanglements are located to prevent surprise assaults from points close to the defense area. As in the case of all antipersonnel obstacles, they are close enough to the defense area for day and night observation and far enough away to prevent the enemy from using effectively from points just beyond the obstacle, normally 40 to 100 meters (131 to 328 ft). Protective wire surrounds the individual units of a command, usually the platoons, to enclose entire defensive positions. Protective entanglements are erected around rear area installations in the same manner and to serve the same purpose as protective wire around defensive positions in forward areas. Protective wire also includes the entanglements that should be installed over the tops of installations provided with overhead cover.

(c) Supplementary. Supplementary wire entanglements in front of the forward edge of the battle area are used to conceal the exact line of the tactical wire. To the rear of the FEBA, supplementary wire is used to enclose the entire defensive position by connecting the protective wire entanglements. Supplementary wire entanglements used to break up the line of tactical wire should be identical to the tactical wire entanglements and constructed simultaneously with them whenever possible.

(2) Depth. Entanglements are classified by depth as belts, bands, or zones.

(a) Belt. A belt is an entanglement one fence in depth.

(b) Band. A band consists of two or more belts in depth, with no interval between them. The belts may be fences of the same type, or the band may be composed to two or more fences of different types.

(c) Zone. A zone consists of two or more bands or belts in depth, with intervals between them.

(3) Equivalent effectiveness. Entanglement depths are also described or specified in terms of comparative effectiveness. Tactical wire entanglements should be equivalent in effectiveness to three belts of 4 and 2 pace double apron fence whenever possible. Protective wire may employ any type of entanglement provided its effectiveness is at least the equivalent of that of the 4 and 2 pace double apron fence. Supplementary wire should have an effectiveness equivalent to that of the type of wire it supplements. It should be equivalent to tactical wire or equivalent to the type of protective wire being used if it connects the outer perimeters of protective wire at the flanks and rear.

(4) Portability.

(a) Fixed entanglements are those types which must be erected in place and which cannot be moved unless completely disassembled.

(b) Portable entanglements are those types that can be moved without complete disassembly. Portable entanglements have been developed for one of the following reasons: To permit assembly in rear areas, with ease of transportation and rapid installation in forward positions, and for the temporary closing of gaps or lanes which can be reopened quickly for patrols or counterattacking forces.

d. Lanes and Gaps. Lanes and gaps are provided for the passage of patrols, working parties, and attacking or counterattacking forces. When not in use they are kept closed by the use of portable obstacles covered by fire. In barbed wire zones lanes and gaps are staggered on a zigzag pattern.

e. Uses

(1) Outpost area. The combat outpost should be surrounded with wire entanglements. These entanglements should be carefully sited to serve as both protective and tactical wire and must be covered by small arms fire. Antipersonnel mines, warning devices, and booby traps should supplement the wire obstacle.

(2) Battle position. In the battle area, each company defense position is normally surrounded by a wire entanglement that is connected laterally across the front to the entanglements surrounding the other units in the position.

(3) Artillery and reserve area. Wire entanglements are used in the outer protection of howitzer positions. Heavier weapons, and shelters or other installations in the reserve area, are similarly protected if justified by the situation.

(4) Antipersonnel obstacles. Barbed wire entanglements, trip flares, noisemakers, and antipersonnel mines are sited to warn against enemy patrol action or infiltration at night, to prevent the enemy from delivering a surprise attack from positions close to the defenders, and to hold, fix or delay the enemy in the most effective killing ground. Such obstacles should be near enough to defensive positions for adequate surveillance by the defenders by night and day, and far enough away to prevent the enemy from using hand grenades against the defender from points just beyond the obstacles.

f. As Roadblocks. A series of barbed wire concertina can stop wheeled vehicles. A series of these blocks placed about 10 meters apart should be used. The ends of adjacent coils are wired together and the obstacle lightly anchored at the sides of the road. The block should be sited to achieve surprise.

g. To Strengthen Natural Obstacles. Deep rivers, canals, swamps, and cliffs which form effective delaying obstacles to infantry, and thick hedgerows, fences, and woods, which are only partial obstacles, can be improved by lacing with barbed wire, by the addition of pats of standard fences on one or both sides, or by entangling with loose wire.

4. WIRE OBSTACLE CONSTRUCTION PROCEDURES.

a. Table 3-4 in FM 5-34 give the materials and man-hours required for entanglements of the various types. The normal sizes of work crews are given in the descriptions of the entanglements. For each construction project, the senior noncommissioned officer divides his crew into groups of approximately equal size, based on his knowledge of the skill and speed of each man. He organizes them in such a way the construction proceeds in proper order and at a uniform rate. Each individual must know exactly what his group is to do and his job in the group. Each man should have barbed wire gauntlets. The sequence of operations for each fence is given in the paragraph describing the erection of the fence. The sequence that is outlined should be followed, and as experience is gained, the size and composition of the groups may vary. For each section of entanglement, all fence-building operations normally proceed from right to left, as one faces the enemy. It may, however, be necessary to work from left to right, and men should, if time permits, be taught to work in either direction. In case of heavy casualties, the senior officer or NCO will decide what wires, if any, are to be omitted.

b. Construction at Night. For night construction the following additional preparations are made.

(1) Tracing tape should be laid from the materials dump to the site of work and then along the line of fence where possible.

(2) Materials should be tied together in man loads and pickets bundled tightly to prevent rattling.

(3) Wire fastenings or wire coils and pickets should be removed and replaced with string which can be broken easily.

(4) A piece of tape should be tied to the ends of the wire on each reel or bobbin.

c. Supervision. Proper supervision of entanglement construction includes the following:

(1) Proper organization of the work into tasks.

(2) Ensure the tasks are carried out in the proper sequence.

(3) Prevention of bunching and overcrowding of personnel.

(4) Ensure the wires are tightened properly and spaced correctly.

(5) Checking ties to see that they are being made correctly and at the right points.

d. Construction in Combat Areas. When working in close proximity to the enemy, the necessary precautions include:

(1) Provision of security around the work party.

(2) Silence.

(3) No working on enemy side of fence unless absolutely necessary.

(4) Use of screw pickets, if available.

(5) Men not working should lie down near start of work until they can continue their work.

(6) Individual weapons must be kept nearby at all times.

e. Four Strand Cattle Fence.

(1) Description. The four-strand center section of a double apron fence can be installed rapidly to obtain some obstacle effect, and aprons can be added later to develop it into a double apron fence. In country where wire fences are used by farmers, obstacles in the form of four strand cattle fences (Figure 3-9 in FM 5-34) will blend with the landscape. Their design should follow as closely as possible the local custom, usually wooden pickets at about 2 to 4 pace intervals with four horizontal strands of barbed wire fixed to them. They should be sited along footpaths and edges of fields or crops, where they will not look out of place. If conditions permit, this fence may be improved by installing guy wires in the same manner as the diagonal wires of the double apron fence. All longitudinal wires of this fence must start and end at an anchor picket.

(2) Construction. Eight men may be employed on short sections of this fence and up to 16 men on 300-meter (984 ft) sections. The two operations are laying out and installing pickets and installing wire.

(a) First operation. The working party is divided into two groups of approximately equal size. The first group carries and lays out long pickets at 3 meter (9.8 ft) intervals along the centerline of the fence, beginning and ending the section with an anchor picket and including anchor pickets for guys if needed. The second group installs the pickets.

(b) Second operation. As the first task is completed, men move individually to the head of the fence and are organized into teams of two or four men to install wires. For four man teams, two men carry the reel and two men make ties and pull the wire tight. For two man teams, the wire must first be unrolled for 50 to 100 meters (164 to 328 ft), then the men come back to the head of the work and make the ties, or the wire may first be made up into bobbins to be carried and unwound by one man while the other man makes the ties. The first team installs the bottom fence wire, and draws it tight and close to the ground. Succeeding teams install the next wires in order.

f. Double-Apron Fence

(1) Types. There are two types of double apron fence, the 4 and 2 pace fence and the 6 and 3 pace fence. The 4 and 2 pace fence (Figure 3-5, FM 5-34) is the better obstacle of the two and is the type more commonly used. In this fence the center pickets are 4 paces apart and the anchor pickets are 2 paces from the line of the center pickets and opposite the midpoint of the space between center pickets. The 6 and 3 pace fence follows the same pattern with pickets at 6 and 3 pace intervals. For this fence, less material and construction time are required, but the obstacle effect is substantially reduced, since the longer wire spans makes it easier to raise the lower wires and crawl under them. Except for picket spacing, the 4 and 2 pace and the 6 and 3 pace fences are identical. Only the 4 and 2 pace fence is discussed in detail.

(2) Construction. A 300-meter (984-ft) section of either type of double apron fence is a platoon task normally requiring 1 1/2 hours, assuming 36 productive men per platoon. There are two operations in building a double apron fence: the first operation is nearly completed prior to starting the second. The second operation is started as men become available and the first operation has moved far enough ahead to avoid congestion. A platoon is normally assigned to build a 300-meter (984-ft) section.

(a) First operation. The working party, if not organized in three squads, is divided into three groups of approximately equal size. One squad lays out the long pickets along the centerline of the fence at 4 pace intervals at the spots where they are to be installed and with their points toward the enemy, another squad lays out the anchor pickets, with points toward the enemy and positioned 2 paces each way from the centerline and midway between the long pickets. The spacing is readily checked with a long picket. The third squad installs all the pickets, with the help of the two other squads as the latter finish the work of laying out the pickets. When installed, the lower notch or bottom eye of the long pickets should be approximately 10.

(b) Second operation. As the groups complete the first operation, they return to the head of the fence and begin installing wire. The order in which the wires are installed is shown in Figure 3-5 (FM5-34). Care must be taken to avoid having any of the men cut off between the fence and the enemy. The men are divided into two or four man groups and proceed to install the wires in numerical order; that is, as soon as the men installing one wire have moved away from the beginning of the fence and are out of the way, the next wire is started. Installations is as follows:

1. The # 1 wire is the diagonal wire on the enemy side and is secured with a top eye tie to all pickets. It is important to keep this wire tight.

2. The # 2 wire is the tripwire on the enemy side of the fence and is secured to both diagonals just above the anchor picket with the apron tie. This wire must be tight enough and close enough to the ground to make passage over or under the wire difficult.

3. The #3 wire is an apron wire on the enemy side of the fence. It is secured to the first diagonal wire, and thereafter to each alternate diagonal, and then to the last diagonal wire (#1), thereafter to the diagonal wires which are not tied to the # 3 wire, and then to the last diagonal wire. Apron wires #3 and #4 are equally spaced along the diagonal wire.

4. The #5 wire is the first one which is not started from the end anchor picket. It is started at the first long picket, and ended at the last long picket. It is secured with the intermediate eye tie and is stretched tightly to prevent passage over or under it.

5. Wires #6,#7, and #8 complete the center portion of the fence and are secured to the long picket #6 and #7 with the intermediate eye tie. They also start at the first end at the last long picket. #8 is secured with the top eye tie. These wires (#6,#7 and #8) form the backbone of the fence and are drawn up tightly hold the pickets in position.

6. #9 is the diagonal apron wire on the friendly side of the fence and is secured with the top eye tie to all pickets. #10 and #11 are apron wires and #12 is the tripwire on the friendly side of the fence. Wire # 12 is installed in the same manner as wire #2 above.

g. Triple Standard Concertina Fence

(1) Description. This consists of two lines of concertinas serving as a base, with a third line resting on top, as shown in Figure 3-6 (FM 5-34). All lines are installed with staggered joints. Each line is completed before the next is started so that a partially completed concertina entanglement presents some obstruction. It is erected quickly and is difficult to cross, cut, or crawl through.

(2) Detail. A 300-meter (984-ft) section of this fence is a platoon task normally requiring less than 1 hour. There are two operations, carrying and laying out pickets and concertina rolls and installing pickets, and opening and installing concertinas.

(3) First Operation. For the first operation, the working party is divided into three groups of approximately equal size: one to lay out all pickets, one to install all pickets, and one to lay out all concertina rolls.

(a) The first group lays out front row long pickets at 5 pace intervals on the line of the fence with points of pickets on line and pointing toward the enemy. The rear row long pickets are then laid out on a line .9 meters (3 ft) to the rear and opposite the center of interval between the front row long pickets. An anchor picket is laid out at each end of each line, 1.5 meters (5 ft) from the end long picket.

(b) The second group installs pickets beginning with the front row. As in other fences, eyes of screw pickets are to the right. Concave faces of "U" shaped pickets are toward the enemy.

(c) The third group lays out concertinas along the rows of pickets. In the front row, one roll is placed at the third picket and one at every fourth picket thereafter. Sixteen staples accompany each front row concertina. In the second row, two rolls are placed at the third picket and two at every fourth picket thereafter. As each roll is place in position, its binding wires are unfastened but are left attached to the hoop at one end of the roll.

(4) Second Operation. As they complete the first operation, all men are organized in four man parties to open and install concertinas, beginning at the head of the fence.

(a) Open the front row concertinas in front of the double line of pickets and the other two in its rear.

(b) Lift each front row concertina in turn and drop it over the long pickets, then join concertina ends.

(c) Fasten the bottom of the concertina to the ground by driving a staple over each pair of end hoops, one over the bottom of a coil at each long picket, and one at the 1/2 and 1/4 points of the 3.8 meter (12.5 ft) picket spacing. Securing the front concertina to the ground is essential and must be done before installing another concertina in its rear unless the enemy side of the entanglement is sure to be accessible later.

(d) Stretch a barbed wire strand along the top of each front row and fasten it to the tops of the long pickets, using the top eye tie for screw pickets. These wires are stretched as tightly as possible to improve the resistance of the fence against crushing.

(e) Install the rear row concertina in the top row fastening the end hoops of 15-meter (50-ft) sections with plain steel wire ties. Begin this row at a point between the ends of the front and rear of the lower rows, thus breaking all end joints.

(f) Rack the top concertina to the rear horizontal wire at points halfway between the long pickets. If there is safe access to the enemy side of the fence, similarly rack the top concertina to the forward horizontal wire.

5. MATERIAL AND LABOR ESTIMATES FOR WIRE OBSTACLES

a. Basic Considerations. Barbed wire obstacles are constructed primarily from issue materials, thus, both logistical and construction estimates are involved. Table 3-3 (FM 5-34) gives weights, lengths, and other data required for estimating truck transportation and carrying party mating truck transportation and carrying party requirements. Table 3-4 (FM 5-34) gives the material and labor requirements for construction of various wire entanglements. This table is based on daylight work; for night work the man-hours must be increased 50 percent.

b. Requirements for a Defensive Position

(1) Method of Estimating. Table 3-4 (FM 5-34) gives estimates for 300-meter section of entanglements and weights of material per linear meter of entanglement. If a layout to scale can be developed, the lengths of the various types of entanglements are scaled and the quantities and weights are computed. If a scaled layout cannot be prepared, rules of thumb may be used for estimating the required lengths of tactical and protective wire entanglements. If the length of front is taken as the straight line distance between limiting points, the rules are:

(a) Length of tactical wire entanglement is 1 1/4 times the length of front, times the number of belts regardless of the size of the unit involved.

(b) Length of protective wire entanglement for a defensive position is 5 times the length of the front being defended times the number of belts. Since protective wire encircles each platoon area of a command, the protective wire entanglement for units is 2.5 times the average platoon frontage times the number of platoons involved.

(c) Supplementary wire in front of the FEBA is used to break up the line of tactical entanglements. Its length is 1 1/4 times the unit's frontage times the number of belts. The length of the supplementary wire entanglement behind the FEBA is approximately equal to 2 1/2 times the distance from the FEBA to the rearmost reserve unit times the number of belts. This rule of thumb is adequate for all units.

Example: You are given a defensive position with a frontage of 1,800 meters (5,904 ft) and a depth of 900 meters (2,952 ft). The tactical wire entanglement is a band consisting of three belts of triple stand concertina fence. The protective entanglement is a band consisting of two belts of 4 and 2 pace double apron fence. The supplementary entanglements are the same type and depth as the entanglements they supplement. Only "U" shaped pickets are available. The work is done during daylight hours with inexperienced personnel.

REQUIRED:

1. Material to be requisitioned.

2. Man hours to construct.

3. Number of 5 ton truck-loads (to permit cross-country travel, each truck will carry only 5 tons).

SOLUTION: Tactical (Triple Standard Concertina)

1. Length of trace of entanglement:
   1.25 x 1800 (5904 ft) x 3 = 6,750 meters
   (rule of thumb constant) x (frontage) x (# of belts) = length of trace

2. Sections of fence:
   $\frac{6,750}{300}$ $\frac{\text{(length of trace)}}{\text{(fence is estimated in 300m increments)}}$ = 22.5 or 23

3. Short pickets: 23 x 4 = 92
   (# of sections) x (# of short pickets)

4. Long pickets: 23 x 160 = 3,680
   (# of sections) x (# of long pickets)

5. Concertina: 23 x 59 = 1,357 rolls
   (# of sections) x (# of concertinas per 300m section on chart)

6. Staples: 23 x 317 = 7,291
   (# of sections) x (# of staples per 300m section on chart)

7. 400m (1,320 ft) reels: 23 x 3 = 69
   (# of sections) x (# of reels)

8. Man-hours to construct: 23 x 30 = 690
(# of sections) x (# of man hours to construct)

NOTE IF AN EXPERIENCED CREW IS USED, YOU MUST MULTIPLY 30 x .67 DURING DAYLIGHT AND 30 x 1.5 IF CONSTRUCTED AT NIGHT. SUBSTITUTE THAT NUMBER INSTEAD OF 71 MAN-HOURS.

NOTE IF AN EXPERIENCED CREW IS USED, YOU MUST MULTIPLY THE CONSTANT TIMES (.67). DURING NIGHT HOURS, YOU MUST MULTIPLY THE CONSTANT TIMES (1.5). SUBSTITUTE THAT NUMBER INSTEAD OF THE CONSTANT FOR MAN-HOURS. IF EXPERIENCED CREW AND AT NIGHT, YOU MUST MULTIPLY THE CONSTANT BY BOTH (.67) AND (1.5) TO GET THE CORRECT AMOUNT OF MAN HOURS TO CONSTRUCT THE WIRE ENTANGLEMENT. SUBSTITUTE THAT NUMBER INSTEAD OF THE CONSTANT FOR MAN-HOURS.

9. 5-ton truck loads:

$$\frac{6{,}750 \times 8.2}{5 \times 2{,}000 \times .4536}$$

(length of trace) x (Kilograms of materials per linear meter)
(5 ton truck) x (ton in pounds) x (1 pound converted into kilograms)
(1 pound = 0.4536 kilogram)

$$\frac{55{,}350}{4{,}536} = 12.20 \text{ OR } 13 \text{ trucks}$$

SOLUTION: Protective (4 and 2 pace double apron)

1. Length of trace of entanglement:
5 x 1,800 x 2 = 18,000 meters
(rule of thumb constant) x (frontage) x (# of belts) = length of trace
2. Sections of fence:

$$\frac{18{,}000}{300} \quad \frac{\text{(length of trace)}}{\text{(fence is estimated in 300m increments)}} = 60$$

3. Short pickets: 60 x 200 = 12,000
(# of sections) x (# of short pickets)

4. Long pickets: 60 x 100 = 6,000
(# of sections) x (# of long pickets)

5. 400m (1,320 ft) reels: 60 x 15 = 900
(# of sections) x (# of reels)

6. Man-hours to construct: 60 x 71 = 4,260
(# of sections) x (# of man hours to construct)

NOTE IF AN EXPERIENCED CREW IS USED, YOU MUST MULTIPLY 71 x .67 DURING DAYLIGHT AND 71 x 1.5 IF CONSTRUCTED AT NIGHT. SUBSTITUTE THAT NUMBER INSTEAD OF 71 MAN-HOURS.

NOTE IF AN EXPERIENCED CREW IS USED, YOU MUST MULTIPLY THE CONSTANT TIMES (.67). DURING NIGHT HOURS, YOU MUST MULTIPLY THE CONSTANT TIMES (1.5). SUBSTITUTE THAT NUMBER INSTEAD OF THE CONSTANT FOR MAN HOURS. IF EXPERIENCED CREW AND AT NIGHT, YOU MUST MULTIPLY THE CONSTANT BY BOTH (.67) AND (1.5) TO GET THE CORRECT AMOUNT OF MAN HOURS TO CONSTRUCT THE WIRE ENTANGLEMENT. SUBSTITUTE THAT NUMBER INSTEAD OF THE CONSTANT FOR MAN HOURS.

7. 5-ton truck loads:

18,000 x 4.6 (length of trace) x (Kilograms of materials per linear meter)
5 x 2,000 x .4536 (5 ton truck) x (ton in pounds) x (1 pound convert into kilo)
(1 pound = 0.4536 kilogram)

$$\frac{82{,}800}{4{,}536} = 18.25 \text{ OR } 19 \text{ trucks}$$

SOLUTION: Supplementary (in front of FEBA) Same as tactical.

SOLUTION: Supplementary (behind FEBA)

1. Length of trace of entanglement:
2.5 x 900 x 2 = 4,500 meters
(rule of thumb constant) x (depth) x (# of belts) = length of trace

2. Sections of fence:

4,500 (length of trace)
300 (fence is estimated in 300m increments) = 15

3. Short pickets: 15 x 200 = 3,000
(# of sections) x (# of short pickets)

4. Long pickets: 15 x 100 = 1,500
(# of sections) x (# of long pickets)

5. 400-meter reels: 15 x 15 = 225
(# of sections) x (# of reels)

6. Man-hours to construct: 15 x 71 = 1,065
(# of sections) x (# of man hours to construct)

NOTE IF AN EXPERIENCED CREW IS USED, YOU MUST MULTIPLY 71 x .67 DURING DAYLIGHT AND 71 x 1.5 IF CONSTRUCTED AT NIGHT. SUBSTITUTE THAT NUMBER INSTEAD OF 71 MAN-HOURS.

NOTE IF AN EXPERIENCED CREW IS USED, YOU MUST MULTIPLY THE CONSTANT TIMES (.67). DURING NIGHT HOURS, YOU MUST MULTIPLY THE CONSTANT TIMES (1.5). SUBSTITUTE THAT NUMBER INSTEAD OF THE CONSTANT FOR MAN-HOURS. IF EXPERIENCED CREW AND AT NIGHT, YOU MUST MULTIPLY THE CONSTANT BY BOTH (.67) AND (1.5) TO GET THE CORRECT AMOUNT OF MAN HOURS TO CONSTRUCT THE WIRE ENTANGLEMENT. SUBSTITUTE THAT NUMBER INSTEAD OF THE CONSTANT FOR MAN-HOURS.

7. 5-ton truck loads:

4,500 x 4.6 (length of trace) x (Kilograms of materials per linear meter)
5 x 2,000 x .4536 (5 ton truck) x (ton in pounds) x (1 pound convert into kilos)
(1 pound = 0.4536 kilogram) 20,000 ? 4,536= 4.56 or 5 trucks

6. ANTITANK DITCHES. Tank ditches are one way to degrade an attacking force's speed and mobility. They impede the advance by slowing vehicles and confusing the crews.

a. Employment. Tank ditches should complement existing obstacles to include:

(1) Slopes greater than 35 degrees.

(2) Steps over 1.5 meter high.

(3) Ravines, gullies, and ditches wider than 3 meters.

(4) Swamps and marshes over 1 meter deep.

(5) Forests having trees over 8 inches in diameter.

(6) Forests having 15 degree slopes and trees over 4 inches in diameter.

(7) Built-up areas.

(8) Construction of antitank ditches is time and equipment intensive. Maximum use should be made of the terrain. Also, the shortest antitank ditch or ditch system possible should be used.

(9) A tank ditch alone is not an adequate obstacle and will not stop a determined attacker. Additional procedures to increase ditch effectiveness are to:

(a) Locate the tank ditch within the optimum effective range of antitank weapons from covered and concealed firing positions.

(b) Preplan artillery and air strikes in antitank ditch area. Artillery and air strikes force the enemy to button up while attempting to breach the ditch, making him more vulnerable to direct fire weapons.

(c) Place antitank mines on both friendly and enemy sides of the ditch, especially in the loose soil material and the ditch bottom, to multiply effectiveness. Even the smallest ditch will strip mine plows and rollers from the front of the attacking force, thus making the enemy more vulnerable to mines on the friendly side of the tank ditch.

(d) Place concertina wire, water, or antipersonnel mines in the ditch to keep dismounted troops from working in the ditch and creating gaps by hand. The wire and water also improve the ditch's effectiveness against attacking tanks.

(e) Tie ends of tank ditches into existing obstacles such as steep slopes, wooded areas, and manmade structures. Ramps used in entering the ditch should be cut off and denied enemy access after completion of the ditch. This can be done with additional "dressing-up", using equipment or mine and wire obstacles. Mines should be used at the ends of the ditch to preclude being easily bypassed.

(10) When planning emplacement of tank ditches, keep this in mind: Threat commanders rely on carefully rehearsed tactical formations for control in the attack. You can disrupt the momentum of the attack and force directional changes in attacking vehicles, thus exposing their vulnerable flanks. This is done by imaginative placement of ditches with other obstacles. Tank ditches should be placed in a series or, if time is available, in a random pattern. Placing the ditch or ditches at 90 degree angles to enemy's avenue of approach may not always be the best tactical use. Consider the terrain and assets available, and construct ditches in a pattern

that will confuse, present good targets, and force the enemy to use resources to breach.

b. Design. The configuration of the most effective tank ditch has been a subject of much discussion and field testing with such constraints as time and equipment available, and soil conditions. The most efficient ditch is either a **rectangular** or **triangular** ditch.

(1) Rectangular ditches.

(a) Construction.

1 A ditch 3.3 meters wide **cannot** be "bridged" by tanks alone.

2 A ditch 1.5 metered deep in consolidated, firm soil **cannot** be crossed by tanks or other vehicles without the aid of bridging or earth moving equipment.

3 A ditch 1.2 meters deep in firm soil should be considered **"expedient"** and capable of only a few minutes delay on the attacker.

4 Rectangular ditches in sand must be greater than 1.6 meters deep to be considered more than just an expedient ditch.

5 Rectangular ditches should have a 1 to 2 meter berm on their friendly side which serves to increase the obstacle height, decrease traction to crossing tanks, greatly impede breaching with scissors type bridges, and keep the enemy from pushing the soil back into the ditch without exposing their dozers or tanks with plows.

(b) Effect and results. The effectiveness of tank ditches is measured by the delay time imposed and targets presented. It is a function of soil type and condition, and ditch width and depth. The rectangular ditch has proven to be the most effective in imposing delays in both directions. Results of tests on crossing rectangular ditches in various soil types are shown below. The ditch must be wide enough to prevent the tank from simply running over it, and narrow enough to force the tank to expose itself to our defensive firepower. A 3.3 meter width (equivalent to a D7 dozers' blade) satisfies this criteria.

(2) Triangular ditches.

(a) Construction. Entrance slope is not critical in determining the effectiveness of triangular ditches.

1. Subjective estimates suggest "the steeper the wall the better".

2. A ditch 1.5 meters deep in hard clay soils cannot be breached tanks alone except under unusual conditions.

3. A ditch 1.2 meters deep in hard soil should be considered "expedient" and capable of imposing only a few minutes delay on the attacker.

4. Triangular ditches in sand must be greater than 1.8 meters deep to be considered more than just an expedient ditch.

5. To deny the use of the triangular tank ditch as a fighting position for the attacking armor, the spoil should be spread loosely

on the enemy side rather than used as a berm. This will also reduce tank traction when approaching the ditch.

c. Equipment. Earth moving equipment such as the M9 Armored Combat Earth mover (ACE), dozers, scrapers, and bucket loaders can all be used for tank ditching. Generally, the equipment is much more effective if used in teams rather than alone. The M9s, dozers, and scrapers are most effective, while bucket loaders are used as a last resort. Various combinations can be used. Some typical team configurations could be:

(1) Two M9s or dozers.

(2) One M9 and two scoop loaders.

(3) Two or more scrapers used in tandem.

(4) One M9, dozer, and scraper used in tandem. (Generally, one M9 or dozer for two scrapers works best.)

(5) Scrapers only. This list is not inclusive. Units should practice and experiment using various equipment and operator combinations to determine what works best for their area and what equipment is available. Frozen or extremely hard soils will most likely have to be ripped with dozer mounted rippers prior to digging.

d. Methods. Following are four proven methods for tank ditch construction using organic engineer equipment.

(1) Two dozers or two M9s (ACE) as a team. In step 1, vehicle #1 will start the ditch and push a load up to 9 to 10 meters (29 to 33 feet) from the start point, and then back up to start the cut again. In step 2, vehicle #2 will push the load away from the ditch to form a berm as vehicle #1 is backing up. The team continues performing in this manner to construct the ditch. This "T" push method is suitable for construction of tank ditches in all soil types.

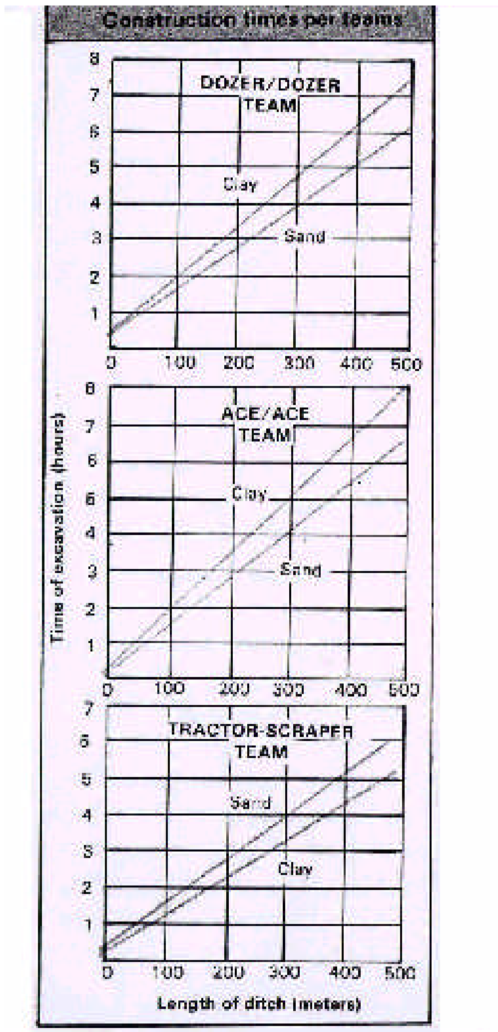
(2) One dozer and one scoop loader and grader as a team. This step is performed the same as the previous method except that the loader is used in place of vehicle #2. The grader is available to keep the berm straight and built up. After the ditch is constructed, and if time permits, the berm can then be further shaped. Normally, this method would be less productive than the first method. Again, more than one team may be used to construct the ditch.

(3) Scrapers in tandem as a team. Using scrapers in tandem as a team is an excellent method of tank ditch construction. Each loaded scraper travels the full length of the tank ditch and exits toward the friendly side of the ditch to spread the load and form the berm. A grader can also be used to shape and smooth the berm that will reduce scraper operator fatigue. "Bean bag" lights can assist during night operation to guide operators and particularly to mark the turn out point. This method may free other diggers such as M9s, dozers, and bucket loaders to perform other missions.

(4) Scraper and M9s or dozers in tandem as a team. This method uses scrapers as earth movers and generally requires a pusher (such as an M9 or dozer) to assist loading of the scrapers. As the pusher and scraper exit the ditch, the scraper will turn toward the friendly side to dump the load along the berm; the pusher will exit on the enemy side and proceed back to the beginning of the ditch to pick up another scraper. This method produces excellent results, but requires training to reduce idle equipment time spent waiting for a pusher or scraper.

(5) Operator training is an absolute must to attain maximum production. Experimenting with various equipment combinations and soil conditions is valuable to determine the best production for a specific area of operations and given equipment availability.

e. Production Time. Basic production data of estimated construction times is shown for a 1.5 meter by 3.3 meter ditch using the teams indicated. The production rates are based upon field tests. No significant differences exist between construction of a triangular or a rectangular ditch. Valid test data does not exist for equipment combinations other than those listed.



f. Construction at Night. Tank ditching can be accomplished under blackout conditions. However, production will not be as great, and certain precautions need to be taken. Equipment operators need an object such as a "bean bag" light or flashlight with red lens to focus upon to assist in digging a straight ditch. Also, night vision devices, if available, are excellent for operators to use. Scraper operators particularly need to have a guide or light to lead them out of the ditch and prevent turning out early and overturning. Night operations will be a must in order to employ the number of tank ditches that will probably be necessary. Commanders should recognize this fact and train under conditions of darkness.

g. Construction by Demolition. The utilization and effectiveness of explosives for tank ditching are still being studied. Considerable effort has been devoted to the subject. The concept of using liquid bulk explosive and buried pipes is currently being tested and evaluated. This concept has significant advantages; for example, the pipes are buried during peacetime and, when a tank ditch is required, the pipes are filled with explosive and detonated. The cratering methods described earlier can also be used to explosively create tank ditches. Some clearing and shaping of the ditch will normally be required to increase its effectiveness.

h. Construction Using Equipment and Explosives. When encountering hard soils or rocky ground to be excavated, rippers used to loosen and break the soil aid in excavation and are the most economical. Should the rippers be unable to loosen the material for excavation, "pre-blasting", or the use of demolition's could be employed using shaped, cratering, line, or buried tamped explosive charges to break up the ground. This technique will shatter the material sufficiently to make excavation easier and thereby raising production rates. An advantage to be considered is that pre-blasting allows less powerful pieces of equipment, like the scraper, to dig ditches out of previously hard material. Should the tactical situation dictate that dozers be used for other tasks, pre-blasting may make it possible to excavate with scoop loaders. With dozers, pre-blasting may substantially increase production rates and decrease "downtime". Pre-blasting will surely decrease wear and tear on machines and operators. For the combat engineer who has limited types and number of equipment, limited capability, and large number of tasks, equipment utilization in conjunction with pre-blasting may turn an impossible tank ditch mission into merely a difficult one.

7. HEDGEHOGS AND TETRAHEDRONS

a. Hedgehogs. Steel hedgehogs are relatively lightweight for the obstacle effect they provide, and they are quickly installed or removed. They are designed to revolve under wheeled vehicles and puncture them or to belly up tracked vehicles. Unless kept under observation and covered with fire, the enemy can readily move them. They are well adapted for use in vegetation enough to afford complete or partial concealment. Exposed parts should be painted to blend with the background.

b. Steel Tetrahedrons. Steel tetrahedrons are employed in a manner similar to that of hedgehogs. They are usually made of 4 in. by 4 in. by 6 in. angles, the base and sides in the shape of equilateral triangles, 5 feet on a side. Their finished height is approximately 4 feet.

c. Concrete Tetrahedrons. Concrete tetrahedrons are pyramids with base and sides of equilateral triangles 5 feet on a side. They are set in irregular rows. A tetrahedron of this size has a vertical height of about 4 feet, requires 1.05 cubic yards of concrete, and weighs about 1.1 tons. They may be pre-cast in trough shaped forms between triangular divisions, with a lifting ring embedded in the center of the top surface of each tetrahedron.

8. Log Obstacles. There are many different types of log obstacles that can be constructed using local materials. Log obstacles are most effective when the lack of a bypass forces the enemy to breach them. Although they are time and labor intensive, and locations for their employment are limited, they do not require much logistic support. Log obstacles can be constructed entirely by hand. The availability of chain saws and bucket loaders or back-hoes will significantly reduce construction time. Log obstacles can and should be used in conjunction with other obstacles to increase their stopping power.

a. **Log Hurdles**

(1) Log hurdles can be constructed using logs greater than 10 inches in diameter. The size of the logs will dictate if the hurdles should be constructed of single logs or multiple logs tied together. On level ground, log hurdles will not stop tanks, but will cause them to slow down. Hurdles will improve the effectiveness of other obstacles by slowing enemy vehicles and making them more vulnerable to direct weapon fire.

(2) Log hurdles can stop tanks on uphill grades. The significant factor is determining how high to construct the hurdle. A field expedient method to determine the height of the hurdle is to use a stick about 12 feet long, stick the uphill end in the ground, and depress the stick until it is level. The distance between the downhill end of the sick and the ground is how high to construct the hurdle. The hurdle should be sited on the steepest part of the slope and as near to the top as possible.

(3) Figure 3-19 (FM 5-34) shows different types of log hurdles.

b. **Log Wall**

(1) Log walls are used effectively as roadblocks where standing timber is available, and where such an obstacle cannot be easily bypassed. Obstacles of this type are not effective against heavy-tracked vehicles. Log hurdles in front of a log wall will force vehicles to reduce speed and add to the effectiveness of the roadblock.

c. **Log Cribs**

(1) **Rectangular** or **triangular** log cribs are used effectively as roadblocks where standing timber is available, and where such an obstacle cannot be readily bypassed. Unless substantially built, obstacles of this type are not effective against heavy tracked vehicles. Cribs are strengthened by filling them with earth. It is preferable to obtain the earth by digging a shallow ditch in front of the obstacle. Log hurdles in front of a log crib will force vehicles to reduce speed and add to the effectiveness of the roadblock.

(2) Figures 3-16 and 3-17 (FM 5-34) and table (3-5) (FM 5-34) can be used as a planning guide for constructing log cribs.

d. **Log Posts**

(a) Posts are among the best anti-vehicular obstacles because each post presents breaching problems to the attacker. There are no fast methods of breaching a belt of posts. Normally, the attacker will try to bypass such an obstacle. Therefore, post obstacles should be placed where bypass requires much time and effort. Posts should be hardwoods with a minimum diameter of 40 centimeters (15.8 inches).

(b) All posts are buried 1.5 meters (5 feet) in the ground, either vertically or at a slight angle toward the enemy, and project between 75 to 120 centimeters (30 to 48 inches) above ground level. The height should vary from post to post. The minimum acceptable density for posts is 200 per 100 meters (328 feet) of front. The spacing should be irregular, with at least 1 meter (3.3 feet), and not more than 2 meters (6.6 feet), between posts.

(c) The effect of post type obstacles can be improved, and the obstacles made more difficult to breach, by weaving spirals of barbed wire among the post. Mines can be used to make the obstacle more difficult to breach.

(d) Figure 3-20 (FM 5-34) can be used as a planning guide in constructing post obstacles.

REFERENCES:

FM 5-34/MCRP 3-17A	ENGINEER FIELD DATA
FM 5-102	COUNTER-MOBILITY
FM 5-103	SURVIVABILITY
FM 90-7	JOINT DOCTRINE FOR CIVIL ENGINEERING SUPPORT

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STUDENT HANDOUT

OBSTACLE PLANNING

LEARNING OBJECTIVE (S):

1. TERMINAL LEARNING OBJECTIVE:

a. Given a tactical situation, a map, and assigned obstacle zone and/or belts, and references, prepare an obstacle plan, consistent with the commander's intent, to best support the concept of operations per the references. (1302.2.4)

2. ENABLING LEARNING OBJECTIVE (S):

a. Given a tactical situation, a map, and assigned obstacle zone and/or belts, and references, identify the additional intelligence required to prepare an obstacle plan consistent with the commander's intent and concept of operations per the references. (1302.2.4a)

b. Given a tactical situation, a map, and assigned obstacle zone and/ or belts, and references, plan the employment of obstacles consistent with the commander's intent and concept of operations per the references. (1302.2.4b)

c. Given a tactical situation, a map, and assigned obstacle zone or/belts, a unit's fire support capability, and references, identify the fire support requirements of an obstacle plan per the references. (1302.2.4c)

OUTLINE:

1. FUNDAMENTALS. Defensive fundamentals center around the focus of the defense. This focus ranges from the possession to the retention of key terrain. The focus can be found in the mission statement and in the commander's intent. There are then two classifications of the defense:

a. Area Defense. The area defense is used when mobility for friendly forces is lacking, when the terrain is not suitable for mechanized movement and air cover does not prevail, or when retaining specific terrain is vital to the accomplishment of the mission. Examples of this type of defense are the Beirut presence of Marines in the early 1980's, and the NAVY/MARINE mission in Guantanamo Bay, Cuba. Generally, the focus is on key terrain.

b. Mobile Defense. This defense of an area or position in which maneuver is used with the organization of fires and the use of terrain to seize the initiative from the enemy. A mobile defense is characterized by the employment of smaller numbers of the forces in the MAIN BATTLE AREA. Forward units hold terrain, channelize the enemy, and destroy him within their capability, while uncommitted forces take offensive action against the enemy. Due to the significant amount of combat power required, Marine units of division size and larger will a conduct a mobile defense. Subordinate battalions conduct a mobile defense only as part of the division. The focus of a mobile defense rests upon the destruction of the enemy.

2. DEFENSIVE TECHNIQUES. In broad terms, there are four basic techniques:

a. Focused. Is where you intend to fight the enemy in one place within the defensive area. You may decide that the terrain, vegetation, habits of your enemy, etc., will lead him to a certain place where you can engage him advantageously. You then focus all your combat power on that area. For example, you may plan to hit him in that area from the front and both flanks with fire, then counterattack into his rear.

b. Dispersed. In a dispersed defense, you decide to engage the enemy throughout the defensive area. To do this, you disperse part or all of your force in small ambushes and/or positions (which of course should be concealed). You may also use a counterattack, or a number of small counterattacks in the defense. This is a typical light infantry defense.

c. Perimeter. Is used where you must defend something such as a fuel farm, or some fixed target that is valuable. A perimeter defense surrounds the object you must protect, defending it from all sides. It must be dispersed to some extent. However, depending on the situation, you may decide to focus it in sectors.

d. Linear This is the weakest form of defense; because once the line is penetrated, it is useless. The enemy will push most of its forces through the penetration; driving on into your depth and rolling out behind your forces that remain in the line.

3. DEFINITION.

a. An obstacle is any obstruction that disrupts, turns, or blocks movement or maneuver.

b. Obstacles can exist naturally such as a river or cliff, or can be man made, such as a minefield, road crater, tank ditch, etc.

c. Through the use of obstacles, a commander can enhance the capabilities of his anti-tank (AT) weapons by gaining target acquisition time for his Marines employing the Tow and Dragon. Additionally, obstacles placed beyond the battle area confuse the enemy of his location of the FEBA.

(1) This anti-mech orientation of the obstacles allows the commander to focus his obstacle effort. He can readily identify the areas that are obstacles to the cross-country movement of the tank and concentrate obstacle construction effort on those areas where no natural anti-mech obstacles exist or to reinforce natural obstacles.

(2) Tactically, the effort to disrupt, turn, block or fix on today's battlefield is one of combined arms units, which are built around mechanized units. The obstacles to be used are primarily those that fix, turn, block, or disrupt the threat tank. While anti-tank obstacles are used to discourage

armor, anti-personnel obstacles may be employed around positions to defeat dismounted infantry.

4. TYPES OF OBSTACLES. The need exists for a clear distinction between what is already -- the terrain consisting of both natural and cultural features-- and what can be done to build on or strengthen existing obstacles, whether natural or cultural. Obstacles are therefore divided into two categories, existing and reinforcing.

a. Existing Obstacles. Existing obstacles are already present on the battlefield. Natural obstacles are bodies of water and other terrain features that restrict movement. Man-made or cultural obstacles include any man-made terrain feature.

(1) The commander's course of action will largely depend on the characteristics of the terrain and intended use of it. All ground movement will be dictated by existing obstacles.

(2) When conducting an analysis of the terrain remember to use the acronym KOCOA.

(a) KEY TERRAIN

(b) OBSTACLES

(c) COVER AND CONCEALMENT

(d) OBSERVATION/FIELDS OF FIRE

(e) AVENUES OF APPROACH

(3) Determining existing obstacle locations is a key element in terrain analysis. The most critical question is how and where do we get information concerning terrain and existing obstacles. The best source is an air/ground reconnaissance.

(4) Analysis of terrain and existing obstacles should focus on the threat and its capabilities. When tanks are part of threat they become the primary vehicles to disrupt, turn, fix, or block.

b. Reinforcing Obstacles. Reinforcing obstacles improve the effectiveness of existing obstacles. Reinforcing obstacles can be broadly categorized by the following types:

* Demolitions

* Constructed

* Landmines

* Contamination

* Expedient

(1) Demolition Obstacle. Are those reinforcing obstacles that are created by the detonation of explosives. There are two types of demolition obstacles:

(a) Reserved Demolitions. Reserve demolitions are critical to the commander's tactical plan. Normally, they will be located astride high-speed avenues of approach, and are blown on order.

(b) Preliminary Demolitions. Preliminary demolitions can be detonated as soon as they are prepared.

(c) Some typical uses of demolition obstacles are:

* Craters.

* Destroying bridges or tunnels.

* Abatis.

(2) Constructed Obstacles. Constructed obstacles are those reinforcing obstacles that are built without explosives. Constructed obstacles fall into two broad categories, anti-personnel and anti-vehicle.

(a) Anti-personnel. These obstacles include, but are not limited to wire obstacles: (DOUBLE AND SINGLE APRON FENCE, TANGLEFOOT, ETC.).

(b) Anti-Vehicle. Log obstacles (hurdles, cribs, and posts) concrete and steel obstacles (tetrahedrons, hedgehogs), and ditches.

(3) Landmines. Mines are an effective obstacle in that they have the capability to destroy enemy vehicles and personnel.

(a) There are five types of minefields:

1 Protective. A protective minefield is used to aid a unit in its local, close-in protection. They add temporary strength to manned weapons, position security and existing obstacles.

2 Point. This minefield is used to delay and disrupt the enemy and to hinder his use of an area or route.

3 Tactical. A tactical minefield is used as part of a barrier plan when there is an imminent threat of enemy ground attack or when such an attack is in progress.

4 Interdiction. These minefields are used beyond the range of division weapons. Like point minefields, they delay, disrupt, and hinder the enemy's use of an area or route.

5 Phony. A phony minefield is a simulated minefield with the objective of deceiving the enemy. They can be used to tie in existing, live minefields and/or conceal gaps in live fields. Also commonly used due to time constraints.

(b) Minefields are placed using the principles applied to other obstacles. Extensive planning is required to preclude friendly casualties. They are graphically depicted in the obstacle plan appendix to the operation order.

(c) FASCAM minefield emplacement can be much more responsive to the tactical situation. FASCAM minefields should be pre-planned and included in the overall obstacle plan.

(4) Contamination. Contamination can be nuclear, chemical or biological in nature. However, the U.S. has renounced the first use of chemical weapons, but the presence of contamination and its effects on the battlefield must be anticipated.

(5) Expedient. Expedient obstacles offer an almost unlimited potential for use. Some examples of expedient obstacles are:

(a) Roadblocks made from cars and trucks.

(b) Pushing trees, rocks, and other material.

(c) Flooding areas to make soil untrafficable.

5. REINFORCING OBSTACLE EMPLOYMENT. Terrain reinforcement techniques must be employed along the entire depth of the main battle area and avenues of approach where existing terrain places the enemy at the greatest disadvantage.

a. Enhance the effectiveness of friendly fires.

b. Delay the enemy's advance, disrupt and channelize his formations, and delay or destroy follow-on echelons.

c. Enhance friendly economy of force measures.

(1) Regardless of the type defense employed by the tactical commander, there are **five** basic employment principles for reinforcing obstacles:

(a) Reinforcing obstacles must support the maneuver commander’s plan. Obstacles other than mines emplaced outside the range of friendly weapons are of little use.

(b) Reinforcing obstacles are integrated with observed fires. Obstacles are used to develop engagement areas in which enemy maneuver is restricted and slowed, thereby increasing the hit probability of direct and indirect fires.

(c) Reinforcing obstacles are integrated with existing obstacles and with other reinforcing obstacles. They are placed where they can close the gaps or openings between existing obstacles and/or close any passage through them. However, when channelizing the enemy you must leave an exit or else the enemy will go around if they feel they cannot get through the obstacle safely.

(d) Reinforcing obstacles are employed in depth.

NOTE: A SERIES OF OBSTACLES PLACED ONE BEHIND THE OTHER, BUT FAR ENOUGH APART WHERE HE CANNOT DESTROY ALL THE OBSTACLES WITH A SINGLE COUNTER-OBSTACLE SYSTEM. MAKE HIM RE-DEPLOY HIS COUNTER OBSTACLE SYSTEM EACH TIME. THIS WEARS DOWN THE ENEMY AND MAKES HIS BREACHING SYSTEMS MORE VULNERABLE TO DESTRUCTION.

(e) Reinforcing obstacles are employed for surprise. Scatterable mines (FASCAM) permits rapid mining anywhere in the battlefield, confronting the enemy with a completely new situation almost instantly. Conventional ways include the sudden detonation of concealed obstacles such as prechambered explosives in roads, bridges, or dikes and dams to cause flooding. Also, the use of phony obstacles can be employed to mislead the enemy as to the pattern and extent of an obstacle system.

6. COUNTERING THE THREAT. By deploying a strong combined arms force well forward and in depth throughout the defensive section, the defender continuously wears the attacker down by confronting him early and successively from prepared positions. Our combined arms force must engage the enemy from battle positions and, when appropriate, move to other battle positions or establish strong points around which the battle can pivot.

a. Threat Limitations: The type and density of threat equipment and its peculiarities can be used to our advantage. Knowledge of enemy equipment limitations will help in identifying existing obstacles and in determining the type of reinforcing obstacles to utilize.

b. When faced with a threat combined arms force, we should try to force the enemy to separate tanks from other Armored Fighting Vehicles (AFVs). This may be done in many ways, here are two examples:

(1) By destroying bridges MLC 50 capability, we will force the enemy to stop until the gap can be spanned by other means or continue the attack with amphibious tanks while preparing the bridge to handle larger tanks.

(2) By mining all shallow ford sites we will force the enemy into deeper water. Only tanks with deep water fording equipment would be able to cross at deep water fording sites, while armored personnel carriers would be able to cross.

c. The threat has a great number of specialized engineer related equipment to cross obstacles. We must develop our obstacles in depth and in various combinations to force them to commit as much of their equipment as soon as possible, in order to destroy it.

(1) The gap breaching capability of tanks with rollers/plows can be greatly reduced by utilizing craters and or tank ditches with minefields:

(2) A ditch on the enemy side will require a Tank Launch Bridge such as a (MTU-20) or (MT-55) to be utilized before the plow/roller tank can even reach the minefield.

(3) A ditch on the friendly side will require a Tank Launch Bridge to be utilized after the plow/roller tank has breached the minefield.

NOTE: EITHER OF THESE TWO SITUATIONS WILL SLOW THE ADVANCE, FORCES THE ENEMY TO EMPLOY SPECIALIZED EQUIPMENT, AND COMPLICATE COMMAND AND CONTROL AT A CRITICAL TIME; HOWEVER, THE BEST USE OF AN AT DITCH IS IN THE CENTER OF A MINEFIELD.

d. Since the pace of the battle will be rapid, we must reduce the time required to construct hasty obstacles. Additionally, we must develop simple obstacles to overcome the threat breaching capability. The following types of obstacles offer some approaches:

(1) We can reduce the loss of attack aircraft by using them with obstacles. By running a single strike against a threat tank column, we might force the enemy off the road into simple minefields laid next to a road.

(2) Inverted shaped charges can be placed in ditches to protect them from mine rollers and plows and command detonated under the belly of the tank.

7. OBSTACLE PLANNING CONSIDERATIONS: The obstacle planning process must be systematic, coordinated, and fully integrated with the tactical plan. Some important factors to be considered are listed below:

a. Mission. The mission is the primary consideration in obstacle planning. The obstacle plan should be tailored to support the mission of the organization and accomplish the objectives of the command.

b. Directed and reserve obstacles. Directed and reserve obstacles are of prime importance to the overall mission and should be planned first. They are those obstacles the commander deems critical to the tactical plan. The demolition of a bridge is a good example of a directed or reserve obstacle.

c. Future plans. While obstacle employment is supporting the current mission, it should not impede future plans of missions.

d. Enemy strengths and weaknesses. The obstacle plan should exploit the weaknesses of the enemy. If the enemy is short of rapid bridging capability, a tank ditch may be a more effective obstacle plan than a minefield.

e. Terrain and weather. These factors and their effects are critical in answering the following questions: Where are good existing obstacles? Are they within the enemy's avenue of approach? Are they effective when tied in with reinforcing obstacles? Are they within range and fields of fire of friendly weapons? What are the anticipated weather conditions? Is the soil frozen? Is digging possible? Can mines be buried?

f. Available time, materials, manpower, and equipment. Answers to these questions will dictate to a large degree the type and extent of the obstacle system, and also provide information on additional resources required and task organization. How much time is available to spend on battlefield preparation? Have the required materials been ordered? Are they on hand? Is the manpower available for labor intensive obstacles? Is earthmoving equipment available for tank ditches and other equipment-intensive obstacles? Has the high diesel fuel consumption rate been planned for?

g. Effects on the local population. Cultural features are not destroyed unless the mission makes it absolutely necessary, as deemed so by higher authority. Always ask if not stated!

8. PLANNING SEQUENCE: Developing an obstacle plan that is effective and supports the tactical plan requires coordinated sequential planning. The following sequence should be used to develop such an obstacle plan:

a. Analyze the mission. Know the commander’s intent. It expands on the **WHO, WHAT, WHEN, WHERE, AND WHY** of the mission order.

b. Analyze avenues of approach. Terrain analysis techniques and existing obstacle evaluation are performed.

c. Analyze engagement areas, battle positions, and locations of weapon. Existing obstacles, fields of fire, and natural cover are all considered in determining where to best engage the enemy.

d. Determine possible obstacle locations and types. Once the engagement areas have been determined then you may select what reinforcing obstacles will be used and where they will be placed.

e. Determine the commander's obstacle priorities. Once again the mission, commander’s intent, and resources are considered to determine obstacle priority.

f. Determine resources. The engineer takes the commander's priorities and makes an estimate based upon time, manpower, equipment, and logistics. The engineer must know how much of each resource is required to emplace and execute a given obstacle. This estimate is based upon type of obstacle, experience, state of training, and condition of equipment. Some examples of resources that need to be considered are Class IV available, Engineer Equipment hours, Dump Truck loads, Etc.

g. Determine actual work sequence. Considering the time available, work force, and logistical assets, they identify those obstacles that can realistically be completed within the allotted time. The commander's obstacle plan will usually develop through the answers to such questions as:

(1) How much time does the unit have?

(2) What obstacle logistic assets are available?

(3) Are engineer attachments available?

(4) Are other supporting arms attachments available?

h. Determine task organization required. The tactical commander and the engineer must balance the comprehensives of the obstacle plan with realities of limited assets. It is important to divide up your work force into units; such as squads with attachments and assign them sectors of the obstacle zone.

i. Determine coordination required. Obstacle planning and employment requires coordination to accomplish its purpose. The G4/S4 must receive a materials estimate as early as possible in order to plan logistic support of the obstacle system. The artillery fire support coordinator and air liaison officer must also be consulted to integrate scatterable mines with the obstacle plan. Obstacles must also be coordinated with the follow-on and adjacent units to insure the location and extent of the obstacle system are known.

9. DEFENSIVE PLANNING TERMS.

a. The following key terms outline the requirements for a successful defense at any level.

(1) Initiative: Seize the tactical initiative locally, then throughout the main battle area (MBA) as the battle progresses.

(2) Depth: Fight the enemy throughout the depth of its formations, to delay and disorganize, and to create opportunities for offensive operations.

(3) Agility: Set the terms of the battle through flexible use of firepower, maneuver, and electronic warfare.

(4) Synchronization: Are all the available tools of battle in well-coordinated combat actions.

REFERENCE(S):

1. FM 5-100, ENGINEER COMBAT OPERATIONS
2. FM 5-102, COUNTERMOBILITY
3. FM 20-32, MINE/COUNTERMINE OPERATIONS
4. FM 90-7, COMBINED ARMS OBSTACLE INTEGRATION1
5. MCDP 1, WARFIGHTING
6. MCDP 1-3, TACTICS
7. MCWP 3-1, GROUND COMBAT OPERATIONS
8. MCWP 3-17, MAGTF ENGINEER OPERATIONS
9. MCRP, 3-17B, ENGINEER FORMS AND REPORTS

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STUDENT HANDOUT

OBSTACLE BREACHING

1. PURPOSE. The purpose of this period of instruction is to provide you with the basic knowledge in the tactics, techniques, procedures and equipment for breaching simple and complex obstacles.

2. INTRODUCE LEARNING OBJECTIVES

a. TERMINAL LEARNING OBJECTIVE (S): Given a tactical situation, supervise the breaching of the obstacles in accordance with FM 5-250, FM 5-101, FM 90-13-1, and FM 20-32. (1302.1.10)

b. ENABLING LEARNING OBJECTIVE(S):

(1) Given a tactical situation, describe the procedures to breach obstacles in accordance with FM 5-250, FM 5-101, FM 90-13-1 and FM 20-312. (1302.1.10a)

(2) Given a tactical situation, identify the quality control measures necessary to breach obstacles in accordance with FM 5-250, FM 5-101, FM 90-13-1 and FM 20-312. (1302.1.10b)

(3) Given a tactical situation, identify the equipment necessary to breach obstacles in accordance with FM 5-250, FM 5-101, FM 90-13-1 and FM 20-312. (1302.1.10c)

(4) Given a tactical situation, organize personnel for sweep teams in accordance with FM 5-250, FM 5-101, FM 90-13-1 and FM 20-312. (1302.1.10d)

(5) Given a tactical situation and a map, with the aid of references, evaluate potential breach sites in accordance with FM 90-13-1. (1302.1.10e)

(6) Given a tactical situation and a map, with the aid of references, identify the intelligence requirements in accordance with FM 90-13-1. (1302.1.10f)

c. I will do this by lecture and demonstration. There will be an examination at the end of this period of instruction.

BODY

1. COMPLEX OBSTACLES

a. A complex obstacle is a combination of single explosive and/or nonexplosive obstacles. While the breach of a single obstacle may be rather simple, the breach of a complex obstacle is a much more formidable task and requires extensive planning and coordination.

b. Complex obstacle systems combine the use of mines along with nonexplosive obstacles such as wire, antitank ditches, sand berms/walls, tetrahedrons, etc. The result is a belt of obstacles. These belts of obstacles may also be duplicated in depth to present an even greater obstacle system.

c. Where possible, the enemy will enhance these complex obstacles by tying them into natural obstacles such as wet or dry gaps, wooded areas, wet lands and elevated areas. Also, the use of cultural or man made features such as above ground pipelines may be used to add to the effectiveness of the system.

d. Complex obstacle systems are closely integrated with a fire plan. Integrating obstacles with supporting arms fire provides a combination of potential kills that is far greater than either could get alone. Preplanned fires can arrive on target within minutes from the time the fire is called and can be adjusted on the breaching location rapidly. Artillery will cover both obstacles and bypasses to create fire sacks and kill zones.

e. Although the complex obstacles encountered on the battlefield may differ in size and composition, the basic employment concepts remain the same and require a well-planned and integrated combined arms operation to breach.

f. It must be realized that successful breaching of a complex obstacle system is a combined arms operation, using all combat support assets available to the ground combat element (GCE) commander. Successful accomplishment will be contingent upon the degree of preparation, planning, and rehearsal accomplished prior to the operation.

g. Due to the fact that complex obstacle systems are relatively inexpensive to construct, quick to emplace, and very effective in delaying, disrupting and channelizing movement, it is therefore likely we will be challenged by them more frequently in the future.

2. BREACHING OPERATIONS TERMINOLOGY

a. "BULLING THROUGH:"

(1) NOT A BREACH, rather a desperate act taken to extricate oneself from the combined grip of an obstacle and/or decisive engagement.

(2) Not an option a commander considers during planning.

(3) Executing a "Bull Through" is a sure sign that something went drastically wrong.

b. "OBSTACLE REDUCTION:" Making a lane or finding a path in which forces and/or equipment can advance through an obstacle.

c. "PROOFING:" Verifying the lane is free of mines; based on the commander's "acceptable risk." Done in concert with obstacle reduction!

d. "BYPASS:" An alternate route that avoids an obstacle.

e. "BREACHING ACTIONS:" Actions taken on the chance of obstacle contact. Includes all aspects in planning, coordinating, and executing breaching operations.

3. COMBINED ARMS BREACHING DOCTRINE

a. BREACHING TENETS

(1) Intelligence (OBSTINTEL)
(2) Breaching Fundamentals
(3) Breach Organization
(4) Mass
(5) Synchronization

b. INTELLIGENCE (OBSTINTEL)

(1) Mission Success: depends largely on how well you see the battlefield. The commander must identify how the enemy is using the ground in order to minimize the risk of surprise. The locations and types of obstacles encountered are an excellent indicator of enemy intentions. For example, rapid mining across an enemy front may indicate a shift to a hasty defense. Surface-laid minefields may indicate that the enemy intends to resume the offensive through the minefields. Antipersonnel and antihandling devices may suggest that the enemy intends to remain in a defensive position for more than a few hours. A commander determines such situations by intelligence preparation of the battlespace.

(a) Intelligence, provides information on how we attack and/or how we will breach, attacking with an unverified enemy template sacrifices the initiative to the enemy.

(b) IPB (Intelligence Preparation of the Battlefield, FM 34-130), focuses the intel collection effort; OBSTINTEL is critical component to all offensive and subsequent breaching operations.

(2) IPB (Intelligence Preparation of the Battlefield) Process:

(a) Why IPB?

1. Used to determine the impact of METT-TSL on operation: and presents this information graphically.

2. Continuous process which supports planning and execution for all operations.

3. Helps determine and evaluate enemy capabilities, vulnerabilities and feasibility of enemy courses of action.

4. Assists in situation and target development, showing where the enemy can most effectively engage by fire and maneuver. The commander can, therefore, identify the following:

HVT: High Value Targets
HPT: High Price Targets
Breach Points
Bypass Point
Overwatch Areas

(b) A thorough OBSTINTEL provides the following:

1. Location, Orientation, and types of obstacles.

2. Minefields: Composition, density and depth

Types of mines (AT and AP)

Types of fuses (Single, double impulse, tilt-rod,) magnetic

Buried or surface laid

3. Lanes gaps or proposed breaching points

4. Presence of wire (tactical, supplementary, or protective)

5. Location of enemy direct-fire weapon;

6. Nonexplosive obstacles (AT ditches, berms, log cribs, etc.)

c. Breaching Fundamentals. The fundamentals listed below must be applied to ensure success when conducting an opposed breach.

(1) Suppress

(a) Suppression is the focus of all available fires on enemy personnel, weapons, or equipment to prevent effective fire or the observation of fires on friendly forces. Oppressive fires can include the full range of weapons from direct and indirect fires, electronic countermeasures (ECM), air support, and naval gunfire. The purpose of suppression is to protect those forces reducing and maneuvering through the obstacles. Also serves to soften the gain fire superiority and thus initial foothold (assault force objective).

(b) Effective suppression is the mission-critical task during any opposed breaching operation. Suppressive fires in sufficient volume (3:1minimum) serve to isolate the breaching site. Successful suppression generally triggers the rest of the required combat actions at an obstacle. Fire control measures are used to ensure that all fires are massed, lifted, and shift-synchronized with other actions at the breach site.

(2) Obscure

(a) Obstruction hampers enemy observation and target acquisition and conceals friendly activities and movement. Obscurities deployed on or near the enemy position minimize their vision. Screening smoke employed in the breaching area or between the breaching area and the enemy conceals movement and obstacle-reduction activities. It also" degrades enemy ground and aerial observation. Obscuration must be employed to protect obstacle reduction, passage of assault forces, and deployment of forces in assault formations.

(b) Obscuration must be carefully planned to provide maximum degradation of enemy observation and fires, but it must not significantly degrade friendly fires and control. Terrain masking that obscures the breaching site is usually the only form of obscuration that is not a double-edge sword.

(3) Secure

(a) The force secures the breaching operation site to prevent the enemy-from interfering with obstacle reduction and passage of the assault force through the lanes created during the reduction. Security must be effective against outpost and fighting positions near the obstacle and against overwatching units and counterattack forces. In general, enemy tactical obstacles are secured by force.

(b) Once the breach site is selected, the appropriate breaching technique and types of support equipment can then be chosen.

(4) Reduce

(a) Reduction is the creation of lanes through or over the obstacle to allow the assault force to pass. The number and width of lanes created varies with the situation and type of breaching operation. The lanes must be sufficient to allow the force to cross rapidly and accomplish the mission. Lanes are handed over to follow-on forces. The unit reducing the obstacle will mark and report obstacle and lane locations and conditions to higher headquarters. Follow-on units will further reduce or clear the obstacle when possible and may improve marking of lanes.

(b) Reduction cannot be accomplished until the other breaching fundamentals (suppress, obscure, and secure) are applied and become effective. The force must isolate the breaching site and overwhelm the defender before reduction can proceed and the breach can be exploited.

(5) Resupply

(a) Breaching operations are logistic-intensive.

(b) Resupply of Class V materials such as demolitions, line charges, smoke, artillery and mortar rounds, and small arms ammunition must be planned.

(c) Equipment such as mine detectors, mine rollers, and plows may need to be staged for resupply of advancing forces

d. Breaching Organization

(1) Support Force

(a) The support force usually consists of combat and combat support elements. The support force includes all units providing or coordinating overwatch fires and other support (electronic warfare, close air, indirect fire support, including counter battery fire and smoke) to support the entire breaching operation. The mission of the support force is to win the direct and indirect fire battle in order to prohibit the enemy from influencing the breaching operation. Among the most crucial tasks, the support force tries to:

<u>1</u> Eliminate enemy interference with the breach

<u>2</u> Isolate battlefield, soften foothold

<u>3</u> Fix enemy repositioning

<u>4</u> Mass direct and indirect fires

<u>5</u> Controls fires and smoke placement

<u>6</u> Suppression is the mission critical task (3:1 Ratio)

(b) Reserve breaching and assault assets are included in this force (line charges, track width mine plows, gap crossing assets, mechanized infantry), and must be prepared to fulfill the mission of these elements should they become ineffective.

(2) Breach Force

(a) Primary mission of the breach force is to maneuver to and make the breaches at selected breach sites. Initially, the breach force travels with or directly behind the assault force. When obstacles are encountered the breach force will move forward after SOS has been accomplished (if opposed). During reduction, lanes are made, proofed, marked, and maintained until the breach force moves ahead or is relieved by support elements that will improve the lanes and begin additional reduction tasks, if required. Breach force responsibilities include:

1 Suppress, obscures, secures at a local level: integrated into a task organized combined arms team.

2 Responsible for creating lanes

3 Marks and reports lane location/status

4 Assists in passage of assault force

(b) The breach force may be composed of engineers, tanks, AAV's, and infantry.

1 Engineers. Engineers are tasked with the reduction of obstacles. The breach force should be lead by an Engineer. Engineers may be further broken down into Obstacle Clearing Detachments (OCD) and Support Breach Teams (SBT) within the breach force.

2 Tanks. Tank assets are used to employ the Track Width Mine Plow, Track Width Mine Roller, line charges, CLAMMS, and Towed Assault Bridge, AVLB, as well as providing direct fire.

3 AAV's. AAV assets maybe required to move the Engineers and Infantry to, through and from the breached lanes. They may also employ the MK 154 (3 shot) and MK 155 (trailer mounted) line charges along with their weapons station (MK 19 and M-2 .50 cal) can provide vital suppressive fires.

4 Infantry. Provide the security element of the Breaching Force and additional engineer assistance if necessary.

(c) Obstacle Clearing Detachments (OCD). OCDs are comprised of a combined arms team that is task organized to conduct obstacle reduction missions. OCDs, commanded by the senior engineer assigned to the team, can be responsible for conducting the following task:

1 Location of the forward edge of obstacle belt/minefields (unless assault force is leading w/organic or attached devices e.g. TWMP)

2 Reduction of obstacles/minefields

3 Creating lanes for the advancement of assault forces

4 Employ assault-bridging assets

5 Proofing of lanes as required based on, "commander's acceptable risk"

6 Conducting "hasty marking" of lanes (at a minimum; entrance and exits must be marked)

7 Making the following reports and/or signals:

a Location of "forward edge" of minefield/obstacle

b Initiation of the breach

c Location of entrance and exit of each lane

d Lane open and ready for travel

(d) (Support Breach Teams SBT). SBTs are comprised of a combined arms team which are task organized to support OCDs. SBTs, commanded by the senior engineer assigned, are responsible for the following tasks:

1 Be prepared to take over the primary mission of supported OCDs (duplication of assets of primary is necessary).

2 Provide immediate resupply to OCDs as required

3 Provide assault-bridging assets forward to OCDs as required

4 Create and mark additional lanes for follow on forces as required

5 On all lanes, make necessary improvements to travel way and lane markings as required

6 Proof all lanes as required

(3) Assault Force

(a) The assault force may consist of infantry, armor, AAV and engineers. Primary responsibilities of the assault force are to provide close-in security of the breach force, to exploit gaps in the obstacle by maneuvering through the lanes created by the breach force, deploy in attack formations to defeat the enemy and secure the enemy side of the obstacle.

1 Destroys or dislodges enemy

2 Secures initial foothold on objective

3 May be committed to secure by force occupation

4 Assists support force in SOS

(4) Follow on Forces

(a) After initial lanes have been breached, follow on forces will be used to create additional lanes, expand lanes, and improve marking systems. This task can be accomplished by the Engineer Support Battalions (ESB) utilizing equipment designed to accomplish this mission, (i.e. full width mine plow with D8 Dozer).

(b) Additional breaching assets are included in this force in the event they encounter obstacles not cleared by the breaching force, or the breach element suffers losses to equipment and personnel which render it ineffective or incapable of completing its mission.

(c) Also contain CS assets and additional assault asset for expansion, exploitation of the breach head and sustainment of forward forces.

(5) Breaching Assets

(a) Each force (Breach, Assault and Support) must be equipped with breaching assets. The type and quantity of breaching assets is dependent upon (METT-TSL) and available equipment.

(b) Units should allow a minimum of 50% (ideally 75% to 100%) redundancy in breaching equipment for all 3 forces due to losses that are expected to occur in breaching operations (especially opposed breaching operations).

e. Mass

(1) Massing Suppression and Obscuration Fire: Breaching is conducted by rapidly applying concentrated force at a point to crack the obstacle and rupture the defense. Massed combat power is directed against an enemy weakness. The location selected for breaching depends largely on a weakness in the enemy defense, where its covering fires are minimized, and where suitable terrain is located in order to conduct the breach. If the attacker cannot find a natural weakness, he creates one by fixing the majority of the defending force and isolating a small portion of it for attack. The isolated portion is then suppressed to eliminate effective fires on the breach forces. Smoke and terrain are used to assist in isolating the force under attack. Suppression requires the commander to mass sufficient firepower, overwatching direct fires to achieve at least a 3:1 firepower ratio. The old maxim, "Hit 'em where they ain't", applies.

(2) Massing the Breach Force: The commander also masses his engineers and breaching equipment to reduce the obstacle (recommended general support of GCE). The breach force is organized and equipped to use several different reduction techniques should the primary technique fail (a key vehicle is destroyed or casualties render dismounted engineers ineffective). Additional reduction assets are present to handle the unexpected. At least 100 percent redundancy is required and is positioned with the breach force.

(3) Massing the Assault Force: Achieving necessary mass for the assault requires the breach force to open sufficient lanes through the obstacle to permit rapid passage and the buildup of forces on the far side. A mounted BLT requires a minimum two lanes to allow two companies to pass simultaneously in column while minimizing lateral movement. A dismounted assault force requires one lane for each leading assault platoon. A mounted BLT requires at least two lanes. However, more lanes will speed passage and provide additional security measures while traveling through the danger zone. The breach force will attempt as many simultaneous breaches as possible to ensure that at least two are successful and will continue to create more lanes within its capability.

This normally results in the breach force simultaneously using a combination of mechanical and manual techniques. The tactical situation may require additional lanes to quickly pass a large assault force through the obstacle to achieve a sufficient combat power ratio.

(4) Mass (Impact on planning)

(a) Focuses on concentrating of combat power.

(b) Directed against enemy weakness or creates a weakness.

(c) Mass considered in:

1 Direct/Indirect Fires

2 Obstacle Reduction Assets

3 Assault Force

(5) Task Organization (Integration of maneuver and engineer units)

(6) Scheme of Maneuver

(7) Level/Type of Breach

(8) Centralized/Decentralized Command and Control

f. Synchronization

(1) Breaching operations require precise synchronization of the SOSR breaching fundamentals by support, breach, and assault forces. Failure to synchronize effective suppression and obscuration with the obstacle reduction and assault can result in rapid, devastating losses of friendly troops in the obstacle or in the enemy's fire sack.

(a) Synchronization ties the breach tenets together

1 INTEL DRIVES BREACH PLANNING

2 Intel collection supports maneuver planning

3 Breach organizations apply fundamentals

4 Mass Achieved: Right place, right time, right assets

(b) Synchronization means:

1 Breach plan supports maneuver plan

2 Unity of effort

(2) The commander ensures synchronization through proper planning and force preparation. Fundamentals to achieve synchronization are:

* Detailed reverse planning. * Clear sub-unit instructions.

* Effective command and control.

* A well-rehearsed force.

(3) Command and Control. Effective command and control is paramount to synchronization. Command and control is integrated into the plan through the use of maneuver control measures and the positioning of key leaders.

(4) Proficiency. Proficiency is achieved through repeated rehearsals. Rehearsals should be done numerous times and be graded by independent evaluators. Commanders must ensure they are thoroughly debriefed by and that this information is disseminated to all participants. This will enable them to make the necessary corrections that will increase the probability of mission accomplishment. Rehearsals should be paced (crawl, walk, run philosophy) with night and NBC conditions considered.

3. TYPES OF BREACHING OPERATIONS

a. In-Stride Breach/Hasty Breaches.

(1) Characteristics.

(a) Conducted without loss of momentum over simple obstacles where intelligence may indicate a weak or weakly defended obstacle

(b) Actual breaches are conducted on the subordinate levels, however, this does not mean the force executes a spontaneous, unsynchronized breaching operation. Capability to breach is organic with subordinate elements. No joint/concentrated effort needed to force a change in task organizations in order to conduct a breach.

(c) Breaches are executed through immediate action drills that are planned for and rehearsed in advanced. Combat units should have a decentralized breaching SOP detailing the performance of hasty breaches.

(d) Subordinate ground commanders are responsible for designating specific support, breach and assault forces based on his task organization. He is also responsible for synchronizing the SOSR breaching fundamentals through his own detailed planning or well-rehearsed immediate action drills.

(e) In-stride breach tactics enables a TF to seize and maintain the initiative through simple, decentralized, independent breaching operations conducted under the responsive command and control of the company team commanders.

b. Deliberate Breaches

(1) Characteristics

(a) Designed specifically when units must cross an obstacle in order to continue the mission to another objective.

(b) Conducted when a unit fails an attempt of an in-stride breach on enemy tactical obstacles and/or when force allocation ratio: indicate that a confirmed enemy situation is beyond the capabilities of a subordinate unit.

(c) Requires detailed reconnaissance, exhaustive combined arms rehearsals, and overwhelming suppression of the enemy's overwatch direct fire weapons.

(d) Unlike the in-stride breach, the support, breach and assault forces for a deliberate breach are given specific objectives and detailed control measures for the attack against the obstacle system.

(e) Reduction of the obstacles normally a mission of an engineer-heavy breach force. It masses reduction efforts, attempting large number of lanes simultaneously to overload defensive fires.

c. Assault Breach

(1) Characteristics

(a) Conducted when a subordinate unit has been assigned the mission to assault an enemy's defense as part of a larger force's action so on the objective.

(b) Conducted when the enemy has had time to prepare protective obstacles around or within its positions.

(c) The assault breach is characterized as the most dangerous and confusing phase of the attack.

(d) Extensive protective obstacles and fortifications are covered by interlocking small arms fires and close-range anti-armor weapons while other close-in obstacles are a combination of wire, AP and AT mines, fortifications, and entrenchment's.

d. Covert Breach

(1) Characteristics

(a) Covert breaches are used by dismounted forces during limited visibility. They are silently executed to achieve surprise and to minimize casualties.

(b) Relies on stealth, quiet manual lane reduction techniques, and dismounted maneuver. Commanders must understand that the need for surprise weighs the need for overwhelming suppression.

(c) Allows the assault force to bypass enemy resistance or to assault at an unexpected time and place.

(d) Surprise is essential for breaching enemy tactical obstacles to support a follow-on mounted attack.

(2) Fundamentals

(a) Suppress. Suppression is always planned for during the covert breach however, remains "on order" if or when it is needed. Suppressive fires are executed when:

<u>1</u> Lanes are open and the assault is initiated.

<u>2</u> Covert breach is discovered in mid-breach.

<u>3</u> Covert breach force completes lane reduction and detonates the charges to clear mines and obstacles in the lanes, signaling direct and indirect suppressive fires for the assault through the obstacle.

(b) Obscure. Obscuration is a necessary condition for covert breaching. Overt breaches are best conducted during naturally reduced visibility such as darkness, snowfall, rain, or fog.

(c) Secure.

<u>1</u> Provided by a portion of the breach force that is organized into a security team that will cover the movement of the reduction team if discovered.

<u>2</u> Achieved through deception operations.

4. <u>PHASE OF BREACH OPERATIONS</u>. Upon receipt of a mission to conduct a deliberate breach, a battalion task force, if not already task organized to do so, must immediately reorganize based on all current enemy intelligence in regards to METT-TSL. The breach location, azimuth of lanes, maneuver coordination measures (phase and coordination lines), any deception plan which may be initiated, and the specific mission of each element within the task

force will be determined. The stages of action necessary to perform a successful breach operation will then be initiated.

a. Approach. The task force will cross the line of departure at the prescribed time in the proper formation as dictated by the threat level, changing tactics and formation to meet changing situations. The sequence of travel is as follows:

(1) Screening or reconnaissance force:

(a) Prevents premature contact with the enemy and ensures the breach force does not become decisively engaged.

(b) Verifies intelligence information.

(2) Breach force:

(a) Must be in a position to immediately deploy upon contact with the obstacle belt.

(b) Prepare to begin obstacle reduction.

(3) Assault force:

(a) Follows in trace of BF (when combat heavy must lead).

(b) Prepared to assault through lanes created by the BF.

(4) Support force:

(a) Provides flank security during movement to contact;

(b) Prepared to deploy to overwatch positions and provide suppressive fires.

b. Deployment. Upon contact with the enemy obstacle, or at a predetermined phase line, the task force will immediately deploy into attack positions.

(1) Support force:

(a) Will assume overwatch positions

(b) Commences suppressive direct/indirect fires and smoke on the enemy positions providing site security for the breach force:

(2) Breach force:

(a) Deploys to predetermined lane sites.

(b) Necessary, breach equipment moves forward.

(3) Assault force:

(a) Deploys to predetermined location.

(b) Assists with site security by providing suppressive fires.

c. Breach. Prior to initiating the breach, the BF commander must ensure his unit is properly oriented to the breach azimuth. Bear in mind that the 50% redundancy in breaching assets within the AF and SF is to be utilized if the

BF becomes unable to complete its mission due to casualties or exhausting essential assets. (e.g. line charges, mine plows, etc.).

(1) Breach force:

(a) Battle hand-over from the GCE/Assault Commander to Breach Force Commander;

(b) Necessary assets move forward to mechanically, explosively, or manually reduce obstacles:, or use explosive and mechanical means concurrently;

(c) Mark the lane entrance and lane as the force moves forward

(d) Adjust supporting fires when needed

(e) Provide organic direct fire support;

(f) Report cleared obstacle status and keep the task force commander informed of progress

(g) Mark lane exit

(h) Develop a bridgehead on the enemy side of the obstacle and defend against counterattack;

(2) Assault force:

(a) Battle hand-over from the GCE/Assault Force Commander to the Breach Force Commander.

(b) Continue to provide suppressive fires.

(c) Deploys to positions in which it can quickly explode breached lanes.

(d) Assumes BF's role if it becomes incapable due to losses.

(3) Support force:

(a) Continues to provide suppressive/counterbattery fires.

(b) May deploy additional breach assets forward if necessary.

d. Assault. The assault stage is the rapid exploitation of lanes created by the BF to close with and destroy the enemy on the far side.

(1) Breach force:

(a) Battle hand-over from the Breach Force Commander to the GCE/Assault Force Commander.

(b) Provides direct fire on the enemy objective enabling the AF to advance forward.

(c) Coordinates or shifts indirect fires on the objective.

(d) Allows the AF to pass through its lines and assault the enemy objective.

(e) If required assists the AF in capturing the objective.

(2) Assault force:

(a) Battle hand-over from the Breach Force Commander to the GCE/Assault Force Commander.

(b) Moves rapidly through breached lanes and assume attack positions on the enemy side.

(c) Utilizes fire, maneuver and reduction techniques to overcome the enemy.

(3) Support force:

(a) Shifts/lifts suppressive fires enabling AF to attack enemy positions

(b) Provides protective fires against possible enemy counterattack

(c) May provide a reserve force if it becomes necessary to overcome the enemy (exploit success, reinforce weak areas and start fresh elsewhere).

(d) Prepares for displacement forward for consolidation on the objective.

e. Consolidation. Upon seizing the enemy objective the task force will:

(1) Consolidate on the objective ensuring all-around security and defense.

(2) Arrange for supporting fires throughout the task force.

(3) Reconstitute supplies and forces.

(4) Ensure the treatment and evacuation of personnel and disabled equipment.

(5) If designated to do so, elements will create additional lanes, improve upon existing lanes by widening and marking, as well as provide lane guides for follow-on forces.

(6) Begin planning, make reconnaissance, issue necessary orders and continue mission if capable of doing so.

5. MINEFIELD BREACHING

a. General

(1) Minefield breaching is the creation of lanes and paths through a minefield to allow attacking forces to pass through it. The basic procedures are to create the lane(s), proof the lane(s) and mark the lane(s).

(2) Although mission, enemy, terrain and weather, troops and fire support, time space, logistics (METT-TSL) and varying conditions will determine specifics, the preferred techniques and equipment to be used are discussed in this lesson.

b. Lane Requirements

(1) Number of lanes. The number of lanes to be breached simultaneously will be based on the size of unit conducting the breach along with METT-TSL.

Recommended number of lanes are:

COMPANY TASK FORCE - 1

BATTALION TASK FORCE - 2 to 3

(2) Width of lanes. Lanes for one-way travel will normally require a minimum of 4 meters, ideally 5-5 1/2 meters (based on equipment that created the lane). Lane width must be large enough to safely pass through all equipment negotiating the lane(s). Plans for lane improvement must be addressed in the overall breach plan.

(3) Separation between lanes. Parallel lanes should usually be no closer than approximately 250 meters because of artillery effects, and should be far enough apart to force the enemy to engage each breach separately. Certain terrain conditions and the enemy situation may require lanes to be closer or further apart. However, commanders must exercise extreme caution when performing simultaneously breached lanes in close proximity and must ensure mutual supportability of his force when increasing distance between lanes.

(4) Follow-on breaching efforts. Follow-on breaching efforts ensure that lanes are breached and proofed in minefields up to about 5 to 5 1/2 meters wide.

(5) Follow-on lanes/lane expansion. After the breach forces create initial lanes, additional lanes will have to be created by follow-on forces to enable additional combat and combat support forces to flow through the obstacle. Ideally, lanes will be created parallel to initial lanes to allow for two-way traffic.

(6) Lane guides. Guides may be required at the entrances of lanes to preclude follow-on equipment going forward along both lanes, clogging up the lane, and hindering traffic returning to the rear. They also prevent vehicles from entering the lanes before proper lane expansion, proofing and marking efforts are complete.

15. CONTROL MEASURES

a. General

(1) Once an enemy minefield has been breached, friendly forces must move through the lanes as rapidly as possible. To avoid the concentration of possible targets for enemy weapons, extensive planning and control are essential. The control measures and procedures described may also apply to the passage of friendly forces through their own minefields, such as the withdrawal of a covering force.

(2) Traffic control through minefields must be carefully organized to ensure proper support of the operation. Vehicles move from rear holding areas into the minefield lanes along marked traffic routes designated for the particular units. Guides meet the units at forward holding areas and lead them to forward positions.

(3) Markers having letters, symbols or colors are used to designate each route and minefield lane through which traffic must pass. The route markers are placed on posts at least 1.5 meters high, and firmly fixed in the ground at regular intervals in the edges of the lanes and routes. Markers are clearly illuminated at night and must be easily distinguished from the minefield lane marking lights. Each unit is assigned a specific route and lane for its movement through the minefield.

(4) Switch routes between adjacent traffic routes are established and marked so traffic may be quickly diverted from one route to the other, should a minefield lane become blocked. Control teams with radios are positioned at each switch to direct traffic.

b. Control Points/Areas

(1) Release Line. A line located prior to and after a obstacle belt that the Assault, Support, and Follow-on Forces release control of their forces to the Breach Force Commander for movement though a cleared lane or across a gap.

(2) Release Point. Physical location where release/return of control takes place between the tactical unit commander and the Breach Force Commander. Release points are located along a release line.

(3) Traffic Control Point. TCPs are placed to maintain orderly traffic flow and move assigned units and vehicles to holding areas as required. TCPs are manned by MPs and provide control and information to higher headquarters and to vehicles moving to assigned holding areas.

(4) Holding Areas. Area is designed for dispersing units and/or vehicles in route to the lane, but used only if there are delays at the breach site. Holding areas help to eliminate the lucrative artillery/air targets presented by lines of vehicles waiting to cross.

e. Procedures

(1) Traffic priorities through the minefields are established in accordance with the operation plan (OPLAN). Although the priority is announced before the operation, the plan must be flexible enough to meet the tactical situation. Arrangements must be made for rearward movement of casualties and supply vehicles. Traffic control points are staffed by military police (MP) and established at critical locations to control and direct traffic. Holding areas are dispersed as widely as possible to avoid presenting a concentrated target. Local security is established at the far end of each minefield lane to prevent enemy infiltration. Engineers clear, mark, and maintain vehicle lanes and switch routes. They mark the front and rear boundaries of minefields to prevent vehicles and personnel from straying into the mined areas, and they also assist with removing damaged vehicles from minefield lanes. Recovery vehicles should be available near lanes for this purpose.

(2) Well organized, efficient communications are essential for traffic control through minefields. When great distances are involved, the primary system of communication is by radio, supplemented by telephone and messenger. Traffic control through a minefield or obstacle system is similar to the control of traffic during a well-conducted river-crossing operation. FM 90-13 contains additional guidance on command and control for river crossing operations that may also be applied to minefield passage operations.

16. MINEFIELD BREACHING EQUIPMENT (EXPLOSIVE SYSTEMS). Explosive systems (MK1/MK2 Linear Demolition Charges) are used to explosively breach a lane through a minefield. Linear charges will not destroy 100% of the mines in its path. It has limited effect on mines that have magnetic, blast hardened or multiple pulse fuses. Therefore, the lanes cleared by linear charges must also be breached by a mechanical system.

a. M58/MK 155 Trailer Mounted Linear Demolition Charge (LDC)/MK 2 MOD 0 Mine Clearance System

(1) Description

(a) The MK2 system is a trailer mounted, rocket deployed, linear explosive charge.

(b) The M58 linear explosive charge contains 1750 pounds of composition C-4 explosive and is 105 meters long. The explosive charge is anchored to the original container on the trailer by the arresting cable and offers a tethered standoff distance of 205 feet (62 meters). The electrical detonating system is contained within the arresting cable and permits detonation of the linear explosive charge seconds after deployment from the storage tub.

(c) The trailer, launcher, charge and rocket are separate items and are ordered as such.

(2) Employment

(a) The trailer mounted linear demolition charge is used to breach both antitank and antipersonnel minefields.

(b) The linear demolition charge is also very effective in the breaching of wire obstacles. However, it should only be used on wire obstacles employed in depth or in conjunction with minefields.

(c) The system must be ready to deploy prior to reaching a complex obstacle or minefield. The time required for preload and inspection is approximately 30 minutes and requires a 7.5-ton crane or a 6000-pound forklift.

NOTE: PROPER CONTINUITY AND PRE-FIRING INSPECTIONS OF THE LAUNCHER AND CHARGE WILL GREATLY INCREASE THE RELIABILITY OF THIS VALUABLE ASSET.

(d) The trailer mounted linear demolition charge can be towed by a number of combat vehicles such as tanks, amphibious assault vehicles (AAV's), light armored vehicles (LAV's), military 5-ton trucks, and other selected items of engineer equipment.

(e) Due to the extreme exhaust heat of the M1A1 tank, it should not be used to tow the MK2 system.

(f) A technique exists to tow the MK2 in Tandem. When using this technique, if one charge fails, the other can be used. Also you can breach minefields over 90 meters in depth using one host vehicle. When firing charges in tandem, the rear charge should be fired first.

(3) Effectiveness

(a) The M58 linear demolition charge will create a lane approximately 90 meters long and 16 meters wide. (Dependent on soil conditions and types of mines.)

(b) It is effective against single impulse pressure activated antitank mines and mechanically activated antipersonnel mines. The M58 is approximately 95% effective on surface laid and 80% effective against buried single impulse pressure activated antitank mines.

(c) The M58 has a very limited effect on mines that have magnetic, blast hardened or multiple pulse fuses unless it is essentially touching the mine prior to detonation.

NOTE: WARNING, WARNING, WARNING

1. NEVER, EVER USE A LINE CHARGE TO SYMPATHETICALLY DETONATE ANOTHER LINE CHARGE THAT HAS FAILED TO EXPLODE IN PEACETIME TRAINING. (ONLY UNDER COMBAT CONDITIONS)

2. VOLITILITY OF BOOSTERS AND PETN WHEN EXPOSED TO FIRE/HEAT WHICH IS LIABLE TO CAUSE UNINTENDED DETONATION OF LINE CHARGE.

3. NEVER FIRE LINE CHARGE INTO AREA WHERE BRUSH, ETC. IS AFLAME.

b. M59/MK154 Amphibious Assault Vehicle Mounted Linear Demolition Charge/MK1 MOD 0 Mine Clearance System

(1) Description

(a) The MK 1 system contains three M59 linear demolition charges and three MK 22, 5-inch rocket motors inside a dedicated amphibious assault vehicle hull.

(b) Although the M59 linear demolition charge is packed in a vertical vice horizontal container, the explosive charge composition is identical to the M58 and both utilize the MK 22, 5-inch rocket motor to propel the charge into firing position.

(2) Employment

(a) The MK 1 (Three Shot) was principally designed for deployment during amphibious assault operations through mined surf and beach areas.

(b) Currently under development is a track width mine plow for the AAV MK1 system that can be used for proofing. Until procured, the MK1 must be used in conjunction with tank track-width mine plows or full-width mine rakes.

(c) Though an AAV hull has obvious survivability deficiencies in comparison to a hardened tank hull, the MK 1 does offer the advantage of providing 3 linear demolition charges deployed from a single vehicle, enabling it to breach several belts and/or minefields over 90 meters.

(d) When firing on land the rear charge should be fired first to permit rapid reload, when firing in the water the forward charge should be fired first due to buoyancy factors.

(3) Effectiveness. The effectiveness of the M59 is the same as the M58 previously discussed.

NOTE: WARNING, WARNING, WARNING-

1. NEVER, EVER USE A LINE CHARGE TO SYMPATHETICALLY DETONATE ANOTHER LINE CHARGE THAT HAS FAILED TO EXPLODE IN PEACETIME TRAINING. (ONLY UNDER COMBAT CONDITIONS)

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3. NEVER FIRE LINE CHARGE INTO AREA WHERE BRUSH, ETC. IS AFLAME.

c. M1A1/M1A2 Bangalore Torpedo

(1) Description

(a) The bangalore torpedo is a manually placed explosive-filled pipe that creates a footpath for personnel through antipersonnel mines and wire.

(b) It is issued in a demolition kit consisting of 10 sections (tubes). Each section is 5 feet long weighing 15 lbs. (11.5 LBS Explosive)

(2) Employment

(a) The bangalore torpedo was designed for use by dismounted infantry or engineers for breaching antipersonnel mines or wire obstacles.

(b) The bangalore torpedo is not effective in breaching antitank mines.

(3) Effectiveness. The Bangalore torpedo will create a path approximately 1 meter wide and as long as the number of sections employed against antipersonnel mines. It will create a path 3-4 meters wide through wire obstacles.

d. Antipersonnel Obstacle Breaching System (APOBS)

(1) Description

(a) The APOBS is a small linear type charge designed to breach a path in antipersonnel minefields and wire obstacles.

(b) It is a two man portable system weighing approximately 120-lbs.

(c) Has a 25-meter standoff and can be manually or command detonated.

(2) Employment. Is used by dismounted personnel to breach antipersonnel mines and wire obstacles. Due to its effective length, weight, standoff capability, and employment time it is more effective in breaching these type obstacles than its predecessor, the bangalore torpedo breaches.

(3) Effectiveness. The APOBS will create a path 45 meters long by 0.6 meters wide through antipersonnel mines, and 45 meters by 3-4 meters wide, through wire.

7. MINEFIELD BREACHING EQUIPMENT (MECHANICAL SYSTEMS)

a. Tank-mounted Track-width Mine Plow (TWMP)

(1) Description

(a) The tank-mounted, track-width mine-clearing plow is used to extract and remove land mines from the minefield.

(b) It consists of a plow arrangement with 6 scarifying teeth to extract mines, a mold-board to cast them aside, and a leveling skid to control the depth of the plow.

(c) The plow can be mounted to the front of the M60 and M1 series tanks.

(d) The plows lift and push mines that are surfaced laid or buried up to six inches deep to the side of the track-width lanes. The plow creates a 68 inch cleared path in front of each track. The plow can be set to depths of 8", 10" or 12" depending on soil and depth of mines.

(e) It has an improved dog bone assembly centered between the plows to defeat tilt rod fused mines and magnetically influenced mines.

(f) Once mounted, the plow is raised and lowered by an electric motor, and is equipped with an emergency quick disconnect.

(2) Employment

(a) Track width mine plows are used to "breach" lanes that have been explosively breached by a linear demolition charge.

(b) Plows can also be used as a primary breaching device when no linear demolition charges are available, the linear demolition charge does not function or it deploys SUB-OPTIMALLY, or in a hasty breach.

(c) The plow weighs about 3.5 tons and when in the raised position, has little impact on a tank's maneuverability.

(d) When plowing, the tank is restricted to less than 5 mph depending on soil conditions. It cannot maneuver and must continue in a straight path through the minefield or it will damage the plow. The main gun must be traversed to the side during plowing operations since a mine detonation under the plow may cause debris to be thrown violently into the air damaging the tube. The area selected for the lane must be relatively flat and free of large rocks or other obstacles.

(e) The mine plow requires lift capability for mounting and takes up to an hour. It must be mounted well in advance of the mission. It cannot be easily mounted or transferred to another tank under battlefield conditions.

(f) In the center of the cleared lane there is a distance between the plow blades of 64 inches that cannot be cleared of pressure fused mines. Subsequent vehicles traveling on the cleared track lanes may eventually "belly out" detonating the remaining pressure fused mines.

(g) The cleared path created by the track width mine plow restricts the maneuverability of the vehicles following in trace. Follow on vehicles must have an inside wheel base of no less than 66 inches until a full width path has been provided. Lane widening and improvements must be accomplished as soon as possible after securing the opposite side of the obstacle.

(h) Mines armed with antihandling/disturbance devices, or magnetic and seismic fuses may be activated when lifted by the plow, and may disable the plow. Further, long rectangular mines (e.g. the British Bar/Mine) may not spoil to the sides of the plow and may detonate and destroy the plow. Each track width mine plow can sustain 1-2 heavy mine detonations. Mines lifted by the plow are left in the spoil on each side of the furrowed path and remain a hazard until removed.

b. ANTITANK MAGNETIC MINE ACTUATING DEVICE (AMMAD)

(1) Description

(a) The AMMAD (Improved Dog Bone Assembly) is a large, heavy, magnet device mounted between the inside tynes or rollers of the TWMPs or TWMRs.

(b) The AMMAD replaces the old dog bone chain assembly normally supplied with the TWMPs and TWMRs.

(c) When in use the AMMAD rolls along the surface of the ground, generating a magnetic field, causing the denotation of magnetically fused and tilt rod actuated mines harmlessly in front of the tank. Dependent upon mine type and proximity, it may become ineffective upon striking a single mine.

(2) Employment

(a) The AMMAD should be used during breaching operations on all tanks equipped with TWMPs or TWMRs.

(b) The removal of the dog bone chain assembly and installation of the AMMAD can be accomplished by the tank's crew in the field.

c. Tank-mounted, Track-width Mine Roller (TWMR)

(1) Description

(a) The tank-mounted, track-width mine roller consists of a roller assembly, mounting kit, and a hand winch kit. The roller assembly weighs approximately 10 tons and consists of two push beams mounted to the front of the tank.

(b) The rollers are designed to defeat most antitank and antipersonnel mines that are single-impulse, pressure activated. The roller will create a 44-inch path in front of each track, with a 72" uncleared area in between.

(c) An antimagnetic mine actuating device (AMMAD) assembly, like the one used with the mine plow, is centered between the rollers to defeat magnetic influenced mines and tilt rod mines.

(2) Employment

(a) The track width mine roller is designed to detect mines. The system can be used to proof lanes that have been explosively breached if no track width mine plows are available. They may also be used as a secondary proofing device used in trace of a mine plow or rake.

(b) The track width mine roller is not intended to be a primary means of breaching minefields

(c) Because the track width mine roller system weighs approximately 10 tons, it has a great impact on a tank's maneuverability.

(d) When a tank equipped with a track width mine roller intends to cross an armored vehicle launched bridge (AVLB), the AMMAD assembly must be lifted and the AVLB curbing must be removed The additional weight may severely limit the crossing of some fixed and floating bridges.

(e) The M-1 tank track width mine roller system's quick disconnect could be prematurely activated by a roller detonating a mine and will require time for reinstallation.

(f) As with the mine plow, the main gun must be traversed to prevent damage from mine detonations. When employed in a suspected minefield, the roller tank must travel in a relativity straight path because tight turns may cause the roller to deviate from the paths of the track leaving the tank vulnerable to mines. Ground fluctuations, bumps and berms may cause the rollers to lift from the ground and miss mines.

NOTE: MINE ROLLERS ARE NOT A FIELDED T/E ITEM AND ARE TO BE KEPT IN MARINE CORPS INVENTORY AS CONTINGENCY ASSETS.

c. Full Width Mine Rake

(1) Description

(a) The full width mine rake is mounted to the M9 blade on the M60 tank and weighs approximately 4,000 pounds.

(b) The rake tines lift and push aside surface laid mines and mines buried up to 12" deep while sifting through sand or loose soil. It will proof a lane approximately 15 feet wide.

(c) Antipersonnel mines may not be defeated as they may slip through the full width rake's tines.

(2) Employment

(a) The full width mine rake should only be used to proof explosively breached lanes.

(b) The full width mine rake can be used to breach when linear demolition charges are not available or when linear demolition charges fail to function properly.

(c) The full width mine rake has little impact on a tank's maneuverability when stowed for transportation. The raking speed is 3-5 mph.

NOTE: FULL WIDTH MINE RAKES ARE NOT A FIELDED T/E ITEM AND ARE TO BE KEPT IN MARINE CORPS INVENTORY AS CONTINGENCY ASSETS.

d. Full Width Mine Plows (FWMP) (PLANNED TO BE FIELDED)

(1) Counter Mobility Vehicle (CMV) with full width mine plow.

(a) Under consideration for fielding is a countermobility vehicle (M60 hull) equipped with a full width mine plow to be used by the Combat Engineer Battalion (CEB), Marine Division.

(b) When fielded, this full width mine plow will be considered the primary equipment to be used on all proofing operations.

(2) Full Width Mine Plow w/D8 Dozer.

(a) Under development is a full width mine plow to be equipped with the D8 Dozer, with a tractor protection kit.

(b) When fielded, this system will be used for deliberate follow on proofing operations and lane improvements, conducted by the Engineer Support Battalions (ESB), FSSG.

9. PROOFING

a. Definition. Proofing is verifying that a lane is free of mines after explosive, mechanical and magnetic breaching efforts. This should always be accomplished immediately after the lane has been explosively breached.

b. Proofing Equipment

(1) When fielded, the CMV with FWMP should be considered as the primary piece of proofing equipment.

(2) Track width mine plow. Should be considered primary piece of proofing equipment.

(3) Track width mine roller. Used when plows or rakes not available.

(4) Full width mine rake. Is ideally suited for proofing antitank mines in sandy or loose soils.

(5) D8 Dozer with armored protective kit and full width mine plow, will be used for deliberate follow-on proofing and lane improvement.

(6) D7G Dozer with armored protective kit, or the M9 ACE. This type of equipment is not designed as proofing equipment and should be used only as a last resort when plows, rakes or rollers are not available.

10. PROOFING WITH THE TRACK WIDTH MINE PLOW (TWMP)

a. There are three basic methods listed below to proof lanes with track width mine plow. Unit breaching SOP's/plans should indicate how the lanes ill be proofed.

b. Offset Proof

(1) The first track width mine plow proofs one meter to the right side of the trough created by the linecharge. The skip zone between the plows of the first proofed lane is proofed by a second plow producing a full width proofed lane. This lane is tight for subsequent vehicles to negotiate so a third proofing vehicle can be used to make the lane wider when time permits.

(2) This method allows an additional lane to be created on the left side of the trough. Additionally, with this method, keeping the left plow out of the trough created by the linecharge can control the depth of the plow. If the left side of the plow goes into the trough the right side will raise up allowing an unplowed/unproofed area.

(3) This method should be used when troughs are deep (greater than 4-6 inches) and follow on lanes must be created quickly.

(4) This method takes more time than the centerline proof and should be conducted when enemy fire is well suppressed.

NOTE: OFFSET PROOFING IS TIME CONSUMING AND NOT ALWAYS EFFECTIVE. (DEPENDENT ON SOILS AND MINE TYPES ENCOUNTERED.)

c. Centerline Proof

(1) With this method, the track width mine plow drives directly over the linecharge trough. A second proofing tank offsets to the right to expand the lane by about 1/2 of a track width mine plow.

(2) This method allows proofing to be conducted faster than the offset method but should only be used if the trough is shallow and fairly straight.

(3) Follow on lanes cannot be made as quickly with this method. d. If the offset or Centerline methods can not be done because of time and difficulty, making several separate lanes is an alternative.

(4) With this method, subsequent vehicles will follow the one path cleared by the plow(s). When the lane(s) become rutted and too deep, additional separate lanes are created by other plows.

(5) Consideration must be given to the restrictions of a single-track width lane and that subsequent vehicles could eventually "belly out". Also, as more lanes are created, they get further away from the lane created by the line charge and are more vulnerable to mines.

11. PROOFING WITH DOZERS OR THE M9 ACE

a. As mentioned previously, proofing with the D7G Dozer or M9 ACE is to be used as a last resort and it is strongly recommend not to use them for proofing. These types of vehicles are not effective for minefield breaching or proofing because:

(1) It is difficult to control the depth of the blade, and as a result, mines that are dozed will roll or tumble in front of the blade along with accumulated soil. Mines can be easily activated in this situation if they go under the blade.

(2) Blades can only push dirt for short distances before it must back up and go around the accumulated dirt pile (and collected mines).

b. If these types of vehicles are used for proofing they should utilize the curved path or herringbone skimming technique. The operator makes multiple overlapping passes, stripping away about six inches of soil each time. The operator should skim no more than 15 meters at a time.

12. FIRING WITH MULTIPLE LINE CHARGES. When an encountered minefield is greater than 90-100 meters in depth, multiple linear charges must be used. This is accomplished as follows:

a. The first charge is fired from a distance of approximately 60 meters (200 feet) from the edge of the known minefield.

b. Once the charge has been detonated, the proofing vehicle will begin to proof. Begin proofing where the charge was fired from and advance forward the effective length of the charge (approx. 90-100 meters), using either the offset or centerline method. This will place the vehicle approx. 30 meters into the lane created by the line charge.

c. The second linecharge will then be positioned immediately behind the first proofing vehicle and fired over the top of it. Once detonated, the initial proofing vehicle will again continue to proof.

13. EMERGENCY BREACHING AND PROOFING PROCEDURES FOR LINE CHARGE MALFUNCTIONS

a. Units must have "immediate action" plans in the event that the linear charge (MK 1 or MK 2 system) malfunctions or does not deploy properly.

b. Line charge deploys but will not fire remotely.

(1) Attempt to fire line charge at least twice.

(2) After attempting to fire twice electrically, disconnect wire from the control switch/box. Proceed down to the end of the line charge and dual prime, non-electrically, the second to last block of the linear charge (fuse end of the line charge). The length of time fuse used should allow the Marine enough time to reach a safe area prior to denotation. (2 to 3 minutes). If blocks of explosives (TNT or C4) are available, its recommended to have 2 blocks of TNT or C4 dual primed, non-electrically and place them on the linear charge vice attempting to create a cap well in the linear charge. The explosive used to INITIATE a "failed to detonate" line charge should be completely pre-primed.

WARNING: THE EXPLOSIVE OVER PRESSURE FROM AN EXPLODING LINE CHARGE TRAVELS PERPENDICULARLY AWAY FROM THE LINE CHARGE LINE. THE DANGER AREA IS GREATEST O THE SIDES, OUT TO SEVERAL HUNDRED METERS. FRAGMENTS AND DEBRIS MAY BE BLOWN IN ANY DIRECTION, REQUIRING THE FIRING PARTY TO BE A SAFE DISTANCE AWAY OR INSIDE AN ARMORED VEHICLE TO THE REAR OF THE CHARGE. A TWO TO THREE (2-3) MINUTE TIME FUSE WILL ALLOW AMPLE TIME FOR THE FIRING PARTY TO TAKE COVER BACK AT THE ARMORED VEHICLE.

(3) A second method to employ when the line charge deploys but does not fire remote is to fire another line charge along the path and detonate that second one, creating a sympathetic detonation of the first charge.

c. Line charge will not deploy or deploys incorrectly: If the line charge does not deploy or deploys incorrectly, immediate action procedures must be taken to mechanically breach and proof a lane in the minefield It must be remembered that if the line charge veers left or right more than about 25 degrees off the desired breaching azimuth (outside of a 10 to 2 o'clock orientation), using that lane will provide the enemy a flanking shot to vehicles using the lane. Under these circumstances, the following procedures are employed:

(1) Conduct mechanical breach. This requires two plow tanks.

(a) Plow tank #1 breaches and proofs the initial lane.

(b) Plow tank #2 conducts a breach and proof to remove mines left between the inboard tines of the first plow.

(2) Conduct proof procedures (later) using a third plow tank.

(3) When FWMP is available, the breaching and proofing effort will be accomplished in one pass of the host vehicle.

14. MARKING

a. Marking of breached lanes is necessary to define the location and lateral limits of the breaching lane, and the minefield boundary. This activity is critical to the safe and swift movement of the force, particularly if the breached obstacle is under fire. As a minimum, the entrance and exit of safe lanes must be marked. When feasible, the sides of the lane should also be marked to prevent vehicle operators from straying into the minefield. Temporary markings begin upon the completion of proofing and are improved using the standard markings systems as soon as the tactical situation permits. If adequate cover is available, personnel may act as guides at the entrance and exits of the safe lanes to ensure safe passage of vehicles. **ALL UNITS NEED TO KNOW HOW LANES ARE MARKED** as part of breaching procedures. Standard procedures must be part of Command SOP.

b. Equipment

(1) Cleared Lane Marking Systems (CLMS).

(a) The CLMS allows rapid, remote marking of the breached lane, which can be seen at night. CLMS marks centerlines only.

(b) It can be mounted on the rear of the M60 or M1 series tank.
NOTE: If utilized on the rear of an M1 series tank a heat deflector shield must be emplaced to protect the CLMS from the extremely high temperatures generated by this vehicle.

(c) The lane marked using CLMS is only adequate for the initial assault and must be replaced and improved as soon as possible with a two-sided marking using standard marking kits or by unit standard operating procedures.
NOTE: THE CLMS IS NOT CURRENTLY IN THE USMC INVENTORY. DURING OPERATION DESERT STORM, THE CLMS WAS BORROWED FROM THE ARMY.

(2) Pathfinder. (Planned To Be Fielded.) The Pathfinder is a mechanical marking system that marks the side of a lane. The Pathfinder can be mounted on either the tank or AAV.

(3) Minefield Marking Sets

(a) The standard minefield marking set and/or the Hand Emplaced Minefield Marking set (HEMMS) contain the equipment necessary to mark a safe passage 400m through a minefield.

(b) These sets should be used as soon as the tactical situation permits.

(4) Expedient Marking

(a) Expedients such as road flares, chemillums or engineer stakes w/eng. tape can be used to initially mark the centerline or flanks of the cleared lane.

(b) Engineer stakes, engineer tape, chemillums, and panel markers can be used to mark the entrance and exits and the lateral limits of the cleared lane.

NOTE: UNIT SOP SHOULD DICTATE WHAT SYSTEM(S) WILL BE USED.

c. Procedures

(1) Traffic priorities through the minefields are established in accordance with the operation plan (OPLAN). Although the priority is announced before the operation, the plan must be flexible enough to meet the tactical situation. Arrangements must be made for rearward movement of casualties and supply vehicles. Traffic control points are staffed by military police (MP) and established at critical locations to control and direct traffic. Holding areas are dispersed as widely as possible to avoid

presenting a concentrated target. Local security is established at the far end of each minefield lane to prevent enemy infiltration. Engineers clear, mark, and maintain vehicle lanes and switch routes. They mark the front and rear boundaries of minefields to prevent vehicles and personnel from straying into the mined areas, and they also assist with removing damaged vehicles from minefield lanes. Recovery vehicles should be available near lanes for this purpose.

(2) Well organized, efficient communications are essential for traffic control through minefields. When great distances are involved, the primary system of communication is by radio, supplemented by telephone and messenger. Traffic control through a minefield or obstacle system is similar to the control of traffic during a well-conducted river-crossing operation. FM 90-13 contains additional guidance on command and control for river crossing operations that may also be applied to minefield passage operations.

16. MANUAL TECHNIQUES

a. When advanced mechanical equipment is available, manual reduction procedures provide a backup to these systems. Manual obstacle reduction is also the only method that works in all situations and under all conditions. Some types of terrain, weather, and sophisticated fuses can severely degrade the effectiveness of rollers, plows, and line charges. Engineers reducing obstacles manually use hand-emplaced explosives, grapnel hooks attached to ropes, probes, mine detectors, and hand-placed marking equipment.

b. Manual Reduction of Surface-Laid Minefield. Although the Threat does possess a significant mechanical mine burying capability, and have a capacity and propensity for the labor-intensive effort required to hand-bury mines, they often surface lay their mines. Buried mines will usually be found in a more prepared defense requiring a deliberate breach operation. Training and execution of surface and buried minefield breaches should always assume the presence of antihandling devices and trip wires until proven otherwise.

c. From covered positions, the engineers first use grapnel hooks to check for trip wires in the desired lane. The limited range of the tossed hook requires the procedure to be repeated through the estimated depth of the obstacle. The demolition teams then move through the desired lane, placing blocks of explosives next to the surface-laid mines. A minimum of two pounds of TNT or C4 should be placed as close to the mine as possible without touching it. After the mines are blown, the team makes a visual check to ensure all of the mines were cleared before directing a proofing effort or other traffic through the lane.

d. A variation of this procedure is that the blocks of explosives are pre-primed with a fixed length of time fuse set for an SOP time, such as 5 minutes. The team moves through the surface-laid obstacle igniting the time fuse on the blocks of demolitions, setting it next to a surface-laid mine, then moving to the next mine. This procedure is much faster than the trunk line method, but does have drawbacks. A higher chance of misfire exists with individually primed demolitions. Possible injuries in the minefield containing initiated firing devices can defeat the closely timed breach, and detonations occurring at different times can possibly dislodge charges placed next to other mines.

e. Use this technique only when speed and mission necessitate such risks. The manual procedures, often called "manual breach battle drills" by the engineers who use them, must be extremely well practiced no matter what the details of technique are. Marines in the demolitions team are assigned special tasks such as grappler, detonating cord man, and demolitions man, but all of the engineers in the team should be cross-trained on all of the tasks breach site. For clearing a lane for a company team, an engineer platoon will use squads in series through the minefield. The platoon must rehearse the reduction procedure until execution is flawless, quick, and technically safe. The engineer platoon will be exposed in the lane during this breach for 5 to 30 minutes or more depending on the mission, minefield depth and engineers' level of training.

f. Manual Reduction of Buried Minefields. Manually reducing a buried minefield is extremely difficult to perform as part of a hasty breach operation and is usually part of a deliberate breach. If the burrows of the mines are not easily seen (as after moisture falls on a recently buried and poorly compacted hole), mine detectors and probes must be used to locate the mines. The mines are then destroyed by hand-emplaced charges as described above for surface-laid mines. As an alternative, the mines can be removed by use of a grappling hook (and tripod, if necessary).

g. The engineer platoon commander organizes his Marines into teams with distinct, rehearsed missions including grappling, detecting, marking, probing, and demolitions. The platoon conducting a manual reduction of a buried minefield will be exposed in the obstacle for long periods of time.

h. Grappling Hook (Grapnel). The grappling hook is a multi-purpose tool with important uses in manual obstacle reduction. Marines use this device to detonate mines from a standoff position by activating trip wires and antihandling devices. After the grappling hook is used to clear the trip wires in a lane, dismounted engineers can move through the minefield, visually locate surface-laid mines, and prepare these mines for demolition. In buried minefields, Marines will grapple, then enter the minefield with mine detectors and probes.

i. A length of light rope (60 meters or more) is attached to the grapnel for hand throwing. The range for throwing the hook attached to a cord is usually no more than 25 meters. The excess rope is used for standoff distance when the thrower begins grappling. The thrower tosses the hook and seeks cover before the grapnel and rope touch the ground in case their impact detonates a mine. He then moves rearward, reaches the end of the excess rope, takes cover and begins grappling. Once the grapnel is recovered, the thrower moves forward to the original position, tosses the hook, and repeats the procedure at least two more times. He then moves to the end of the grappling area and repeats this sequence through the depth of the minefield. Multiple grapplers can more quickly and thoroughly clear a lane of trip wires, but they must time their efforts and follow the above procedures as simultaneously as possible.

j. A hit on a trip wire or pressure fuze may destroy the hook and cord. An engineer using this technique must carry extra hooks and cord.

17. OTHER MEANS OF BREACHING MINEFIELDS

a. Methods

(1) Artillery and mortar fire - utilizing a successive or rolling barrage to walk a lane through a minefield.

(2) Naval gunfire.

(3) Low altitude B-52 strikes.

(4) Fuel Air Explosives (FAE).

(5) Direct fire -heavy caliber organic weapons.

b. The philosophy of neutralizing mines through sympathetic detonation, (i.e. direct/ indirect fires), or overpressure (FAE) is feasible, however, due to the following reasons they are impractical. Therefore they are **not** recommended!

(1) Significantly decreases trafficability - craters created by the exploding munitions will not allow vehicular traffic without extensive engineer work. Craters also make proofing with plows impossible due to undulations in the ground.

(2) Inaccuracy of munitions delivery systems - does not provide an easily identifiable path or lane to follow, and the accuracy of the breaching azimuth is greatly diminished.

(3) Numerous mine types and fusing methods - blast resistant, or hardened, dual-impulse, and magnetically influenced mines are unaffected unless there is direct impact of the munition upon, or impact in extremely close proximity to the mines. This merely scatters unexploded mines about the area, increasing their sensitivity and creates an additional hazard for those tasked with clearing a lane.

(4) Dud Ammo - Rounds not detonating as desired will add to the minefield by the presence of sensitive fused mortar, artillery or air delivered munitions.

c. Prior to and throughout Operation Desert Shield/Storm various governmental agencies have conducted extensive testing on these methods and they have proven to be ineffective in breaching minefields. They are much more effective in a supporting arms role, delivered as counter-battery fire, on enemy defensive positions, forward observers, assembly areas, avenues of approach, or as tactical denial of the battlefield and to provide obscurants. At present, our best available means for creating vehicle lanes through a minefield is a combination of explosive and mechanical breaching utilizing the full-width mine plow (when fielded) and the M-58 or M-59, Linear Demolition charge.

18. BREACHING NONEXPLOSIVE OBSTACLES

a. General. Nonexplosive obstacles are normally emplaced with minefields to add to the complexity of an obstacle system. Some examples of nonexplosive obstacles include; antitank ditches, sand walls/berms, wire obstacles, log post obstacles, log cribs, and steel obstacles such as tetrahedrons. Though this lesson does not discuss the breaching of natural obstacles such as rivers, streams, wet lands, etc, the enemy may incorporate them into his complex obstacle system.

b. Breaching Antitank Ditches

(1) Towed Assault Bridge

(a) The 12 meter Towed Assault Bridge, is a Military Load Class (MLC) 70 bridge, emplaced by pushing or towing, and designed to breach man-made ditches and escarpments.

(b) It is effective in breaching ditches 3-10 meters in width with escarpments up to 4-5 meters in height.

(c) The TAB is an engineer item and is towed in the supported unit's combat train.

(d) When required for employment, in close proximity to mines, it is connected to the front of a tank (using tank adapter) and is pushed until launched over the antitank ditch. It also can be towed to the vicinity of the ditch and backed into the ditch when mines are not adjacent to the ditch.

(e) The TAB tow bar is equipped with a quick disconnect mechanism. The TAB can be emplaced in 30-60 seconds. If time and mission allow, the TAB can be retrieved from the gap and be reused in about 20 minutes.

(f) The TAB can sustain 2 antitank mine detonations and loss of 50% of its girders and still retain a class 70 rating. Even the loss of its wheels will not prevent its being pushed into place.

(2) Armored Vehicle Launched Bridge (AVLB)

(a) A scissors type bridge deployed from an M60 tank hull which is designed to breach Natural Gaps and destroyed bridges up to 17 meters in width.

(b) The AVLB is an MLC 60 bridge.

(c) The AVLB can be launched and emplaced by a 2-man crew in 2-5 minutes.

(d) Though not designed to breach antitank ditches with escarpments, it can be deployed by an experienced crew to breach an antitank ditch when no other assets are available. Some factors that must be considered when using the AVLB for breaching antitank ditches in a breaching operation are:

1 Tanks equipped with plows and rollers may exceed the MLC rating and must make a risk crossing.

2 Positioning the 17-meter bridge over a 3-8 meter ditch, with a 2-3 meter soil escarpment- especially at night or under smoke conditions may result in the bridge protruding across the spoil escarpment, like a "diving board". Tanks may literally drive off the bridge.

3 During launching, the AVLB presents a target approximately 11 meters high and four meters wide.

4 If the bridge is placed at an angle across the ditch, the AVLB may be bent (deflected). Once bent, the bridge may be unrepairable.

5 While moving to the ditch, the AVLB chassis may hit an unremoved mine in the breached lane and render this valuable asset useless.

(e) It is best to use the AVLB for what it was designed for.

(3) Fascines

(a) Fascines are large bundles of PVC type pipe loosely bound together and designed to be dropped into gaps by a launch vehicle to create a lane. The material used must have enough width and load-being capacity to handle the crossing traffic. Fascine systems are best used on ditches without escarpments.

(b) Expedient fascine systems can be constructed in the field. An expedient fascine system constructed during operation Desert Storm consisted of fascines mounted to the sides of an AAV. A cradle was designed to support the fascines. The cable that releases the fascines is cut by a small command detonated C4 explosive charge.

(c) One cautionary note. This method of employing expedient facines requires the host vehicle turning sideways to the enemy twice (one each side) to release its fascine bundles, creating two vulnerable "flank shots" on for the vehicle.

(d) As with other expedient systems, trial and error will prove its effectiveness

(4) Armored Combat EarthMover (ACE), M9

(a) The M9 ACE is a highly mobile, armored earth-moving system. It is lightly armored and has a chemical-biological overpressure system to protect the operator.

NOTE: ARMOR PROTECTS OPERATOR FROM SMALL ARMS. (7.62 mm ON THE FLANKS: 12.7 mm TO THE FRONT WHEN BOWL IS FILLED WITH EARTH.)

(b) The M9 ACE can scrape, doze, and haul material. It should primarily be used to construct survivability positions or reduce nonexplosive obstacles.

(c) The M9 ACE is also useful in mobility and countermobility efforts in support of mechanized forces. The M9 ACE is capable of removing obstacles such as roadblocks, trees, and rubble while maintaining combat roads and trails.

(d) It can be used to breach antitank ditches and berms. It requires approximately 15 minutes to breach an antitank ditch.

(e) The M9 ACE is also useful in reducing shallow water non-explosive obstacles.

(5) D7G Dozer

(a) The D7G Dozer is a medium size tractor designed as a basic earthmover.

(b) Similar to that of the M9 ACE the D7G Dozer could be used to breach antitank ditches. Unless equipped with a tractor protection kit, the operator is not protected against small arms fire and fragmentation from indirect fires.

(c) The D7G Dozer requires transportation to the site, as it cannot maintain the speed normally associated with mechanized movements.

(6) Manual Antitank Ditch Breach

(a) The manual reduction of antitank ditches by dismounted troops is the slowest and most dangerous method. It is rarely desired because the working party is exposed to enemy direct and observed indirect fire and because explosive reduction of ditches is generally not effective.

(b) One method of manual breaching is an engineer squad (obstacle clearing detachment) using hand tools such as shovels, and demolitions. The OCD uses satchel charges preconnected to detonating cord branch lines. They dismount as close to the ditch as possible and move to the ditch using dismounted movement techniques. On arrival, the team quickly digs four holes in the sidewalls (two in each side) near the ditch bottom for the satchel charges. The holes should be approximately 5 feet apart in each wall and directly opposite each other. After the holes are approximately 2 feet deep, the satchel charges are placed, connected to the prefabricated ring main, and tamped with loose earth. The squad leaves the ditch, takes cover, and detonates the charge. Then they manually cut down the remaining loose soil as rapidly as possible to allow vehicles to pass.

c. Breaching Wire Obstacles

(1) Linear Demolition Charges

(a) The MK 1 or MK 2 Linear Demolition Charge systems as discussed in earlier are very effective in breaching wire obstacles.

(b) Line charges should be used when wire obstacles are used in conjunction with minefields, in great depth, or the risk of dismounted personnel is too great to use other techniques.

(c) Consideration must be given to employing this valuable asset on single/simple wire obstacles.

(2) Antipersonnel Obstacle Breaching System (APOBS)

(a) The APOBS, as discussed in chapter 2, was designed for the breaching of antipersonnel mines and wire obstacles by dismounted troops.

(b) The APOBS will create a 45-meter in length by 3-4 meters wide path in wire obstacles and .6 meters by 45 meters through AP minefield giving the troops a 25-meter standoff from the obstacle.

(3) Bangalore Torpedo

(a) The bangalore torpedo, as discussed in chapter 2 will create a path 3-4 meters wide in wire obstacles.

(b) Caution must be given when pushing the bangalore through the wire obstacle because it may be booby-trapped. A dummy or inert section should always be utilized.

(c) Normally the bangalore torpedo is primed non-electrically since electric firing systems are too complex and time consuming to use in an assault breach. Because the bangalore torpedo throws lethal fragments of wire for long distances, the breach team must ensure that all personnel within range have sought cover before the detonation.

d. Breaching Timber Obstacles. Heavily wooded areas provide an effective obstacle to vehicular movement. Log obstacles, such as abatis across roads and trails and earth filled cribs can further decrease trafficability.

(1) Earth Filled Log Cribs

(a) The 83mm Shoulder Launched multipurpose Assault Weapon (SMAW) can be used by firing low at the center of the mass. Then a M9 ACE, or D-7 Dozer pushes the remaining debris from the breached lane. (Figure 3-7)

(b) Dismounted troops can manually reduce the log crib by the use of explosives. Forty-pound cratering charges are placed in the center of the crib at 2/3 the depth and tamped. Charges are placed on 8-foot centers across the length of the crib.

(c) If under enemy control or fire, log cribs can also be severely damaged by the main gun of the tank.

(2) Abatis

(a) The removal and clearance of log abatis depends on the characteristics of the fallen trees and the total depth of the timber obstacle. An abatis consisting of only several trees or trees of small diameter can generally be forced through with a dozer's pushing effort.

(b) When this is not possible, a combination of manual or explosive breaching and mechanical force is recommended. First the fallen trunk of the tree should be separated from its base with saws or explosive charges. The remaining timber is then pushed by an ACE or dozer or winched from the roadway.

(3) Log Post Obstacle

(a) Log Post Obstacles consisting of small diameter trees or posts can be generally forced through with a mechanical pushing effort.

(b) If this is not possible, saws or explosive charges should be used.

(c) The following formula should be used for cutting trees, piles, posts, beams or other timber with explosives as an untamped external charge:

$$P = \frac{D^2}{40} \quad \text{or} \quad P = .025\, D^2$$

P = Pounds of TNT required
D = Diameter of round timber, or least dimension of dressed timber, in inches.
40 or .025 constant

Charges are placed as close as possible to the surface of the timber and at ground level.

e. Low Water and Beach Obstacles

(1) As an amphibious assault force, one of the Corps' primary missions as part of an amphibious task force will be to assault over beaches employing landing ships, landing craft, and amphibious vehicles in order to seize, occupy, and defend a beachhead in the amphibious objective area (AOA).

(2) A major deterrent which must be overcome in order to ensure a successful amphibious assault operation is the reduction of all obstacles (natural or man-made) throughout the AOA. Navy support elements are responsible for tasks associated with ship-to-shore movement in support of amphibious operations. Current Navy/Marine Corps doctrine dictates that the Navy has the responsibility of obstacle reduction from the high water mark seaward. The Commander of the Amphibious Task Force (CAFT) may assign naval personnel, primarily SEALS or Under Water Demolition Teams (UDT), to neutralize obstacles in shallower water or the surf zone.

(3) Landing force preparation of the beach area initially includes the breaching of minefields and other obstacles from the high water mark, inland. Engineer elements of the landing force breach initial lanes utilizing explosive, mechanical, and manual means to allow the passage of the assault force and prepare the beach area to support the scope of operations. This eases the landing and movement ashore of the Ground Combat Element. Upon reaching the beach the landing team will deploy according to the deliberate

combined arms breaching doctrine discussed previously. The question this poses is how we as engineers breach obstacles in the surf zone? Before we answer this, let's examine threat doctrine for the defense against amphibious operations.

(a) Threat doctrine emphasizes four principles for the defense of the beach. They are:

1 Engagement of the ATF and landing forces at the maximum possible weapons range.

2 Provide for dense overlapping sectors of fire in the beach area.

3 Extensive use of obstacles and barriers both underwater and surface types.

4 Use of back beach area for maneuver elements to rapidly respond to assaulting forces.

(4) Obstacle employment: normally constructed in three belts utilizing explosive and non-explosive obstacles.

(a) First belt: 5-15 meters in water depth.

1 naval mines.

2 antisubmarine nets.

3 large sunken craft.

(b) Second belt: 5-1.5 meters in water depth, designed to slow down or stop amphibious vehicles, tanks, and personnel in the surf.

1 concrete blocks.

2 metal hedgehogs or tetrahedrons.

3 inverted logs.

4 barbed wire entanglements.

(c) Third belt: 1.5 meters deep - inland as appropriate to support the enemy's defense.

1 AP and A.T. mines.

2 barbed wire entanglements.

3 various log, concrete and steel barriers.

4 antitank ditches.

(5) Bangalore torpedoes can be used to destroy submerged obstacles and sandbars. The MK 1 (3 shot AAV) line charge can also be used to destroy these type obstacles.

(6) Floating obstacles should be reduced by destroying the anchorage only, allowing the obstacle to float or be hauled down stream. When possible, the obstacle may be removed by sinking it in place.

(7) Although our doctrine contained in FMFM-1 seeks the avoidance of such heavily defended areas, there are times when a forcible entry by amphibious assault is necessary. From this combination of obstacles and integrated fire plan we can see that this would be a formidable task to breach from the sea. As is the case in a combined arms deliberate breach, the fundamentals of SOSR, massing of combat power, synchronization, and the utilization of all direct/indirect fires available to the commander, also apply in an amphibious assault.

(8) Currently under testing are several systems which will enable us a greater counter-obstacle capability in the shallow water. At present our best hope lies with the M59/MK-154 3-shot line charge and a TWMP for the AAV. Proven to be effective on land, further testing is necessary to validate its effectiveness in the surf. Until such a time that these systems have proven reliable and are adopted into the Corps' inventory we must rely on our proven, time-tested, MAGTF doctrine and the innovation of the engineers.

19. ROUTE CLEARANCE

a. Mine Sweep Operations. Organizing a sweep team will vary according to the mission. There are three types of mine sweep operations: deliberate, hasty and combination.

(1) Deliberate sweep. A deliberate sweep includes a complete electronic and visual sweep on the entire road to include the shoulders, all culverts, ditches, and bridges. A proper deliberate sweep is thorough. The sweep is made before the road is open to traffic. There is no time limit set. An average of one to three kilometers can be covered in one hour during a deliberate sweep.

(2) Hasty sweep. A hasty sweep consists of both visual inspection and search, and the use of mine detectors. Inspect and search the road surface, culverts, ditches, and bridges. Look for mines, wire, or any other signs of recent mining activity, such as disturbed earth and obstacles. Use electronic detectors to check all suspected areas. Use a hasty sweep when the mission does not permit a deliberate sweep or the road urgently needs to be opened. Time / distance factors may be imposed. An average of three to five kilometers can be covered in one hour during a hasty sweep. Remember that when conducting a hasty sweep there is greater danger of bypassing a well emplaced mine or other explosive device.

(3) Combination sweep. A combination sweep consists of a hasty sweep with a deliberate sweep made on selected parts of the route where there is high likelihood of enemy mining. The time / distance factors are determined by the amount of deliberate sweep conducted.

b. Organization and Equipment of a Sweep Team. A sweep team is a trained detection team that does the actual search for mines and explosive devices. The organization of the sweep team depends on the type of sweep mission and the length and difficulty of the road to be swept. Typical organization and equipment for a sweep teams is as follows:

(1) Organization

* NCOIC
* Two detector operators/probers
* Four probers/detector operators
* One radio operator

* One corpsman

* Two demolition men

* Vehicle drivers

(2) Equipment

* One panel marker

* One map

* Four smoke grenades, minimum

* Four detectors (includes two back up detectors) and extra batteries

* Two grappling hooks with 60 meters of rope.

* One demolition kit or demolition bag per demo man.

* Four probes

* Two proof vehicles (sandbagged and loaded with earth)

(3) Security Element. A security element is an escort for the sweep teams that provides security against the enemy. The composition of the security element is dictated by the tactical situation. The enemy often mines or remines areas recently cleared by sweep teams. Rear security elements must be alert to this technique and be prepared to react.

(4) Emergency situations. If a mine-sweep team is attacked, immediate action must be taken to deploy the men into cleared areas and return fire. Normally the security element will assume command on enemy attack. The commander of the security element will organize the defense or counterattack and request support as needed.

c. Typical mine locations. Experience has shown that enemy mines are likely to be placed in the following locations:

(1) Frequently used roadways leading to and from construction sites.

(2) Brush and other traffic obstructions placed on roadways.

(3) Bridge bypasses.

(4) Obvious turnarounds and shoulders.

(5) The enemy normally places more than one mine in each mined area.

d. Conduct of Mine-sweep Search. Organization of a sweep team will vary, depending on the mission. For route clearing, the normal configuration is eight Marines in a column:

(1) The number one Marine (mine detector operator) leads. Approximately 25 meters (34 paces) to the rear are the number two Marine (marker/prober) and the number three Marine (NCOIC). Twenty-five meters to their rear are the number four and five Marines (demolition team). Number six (relief mine detector operator) and number seven Marine (radio operator) are 25 meters behind the demolition team. The number eight Marine follows and

serves as rear security.

(2) If the sweep team is assigned the mission of clearing an entire minefield rather than a single lane or a road, it is organized with several detector operators working in echelon, spaced 25 meters behind each other. This configuration would decrease the amount of time required to clear the area.

(3) The actual distance between team members and the location of the security element will depend on the tactical situation, terrain, and visibility.

(4) Experience has shown that a number of detection methods used together make the most effective sweep. These methods include:

(a) Visual detection.

(b) Electronic mine detectors.

(c) Probing. This is done by protruding the earth with a sharp instrument such as a pointed stake made of wood or plastic probes. All jewelry is removed, sleeves are rolled up, palm placed at a 45-degree angle or less. Probe every 2 inches on a one-meter front.

(d) Proof rollers. Tank rollers may be used as a final check. The rollers are designed to defeat most antitank and antipersonnel mines, which are single impulse, pressure, activated.

e. Disposition of Suspected Mines. The sweep team will take the following actions when a suspected mine is found.

(1) Pinpoint and mark the location of the mine. Leave no mine unmarked.

(2) Search the immediate area for wire. Trace any wires found in both directions to determine if any electric current producing items are attached. Once this procedure has been accomplished and there are no items attached, have the prober cut all loose trip wires.
NOTE: Never cut taught trip wires. Alert the security element to search for an enemy manning a command detonated mine. Keep all troops away from the mine until all wires are cut and traced out. Men doing the cutting and tracing must be alert for booby traps and ambush.

(3) Probe to the suspected location and uncover the object for identification. Expose enough of the object to see whether it is a mine or debris. All other men stay at least 25 meters away while this is being done.

(4) If the object is debris, carefully remove it with grappling hooks and rope from a protected position. Be alert for booby traps or antihandling devices wired to the debris.

(5) If the object is a mine, the prober withdraws and notifies the OIC who decides whether to:

(a) Destroy the mine in place.

(b) Remove the mine with grappling hook and rope.

(c) Notify EOD for hand removal (this action is seldom taken).

f. Safety Precautions

(1) All sweep team members wear helmets and flak jackets to protect them against fragmentation.

(2) Sandbag the floorboards of all vehicles taking part in a mine sweep.

(3) While enroute to and from a mine sweep area, disperse vehicles. Minimum intervals should be 50 meters. If any one vehicle sets off a mine, it will not cause personnel casualties in any other vehicle.

(4) Allow only one person to be at the location of a suspected mine at any time.

(5) Assume that all mines and explosive devices are equipped with antihandling devices until proven otherwise.

(6) Caution all troops in the area not to run and to move only in areas previously cleared.

g. Mine Removal Techniques

(1) After a mine has been located, it may be clearly marked and bypassed, detonated in place, pulled out by rope or wire, or neutralized and removed by hand. The decision as to which of these methods to employ depends upon the location of the mine, the identity of the mine and fuze, and the tactical situation.

(2) Detonation in place may be accomplished by several methods:

(a) Trip wire and tilt-rod fused mines can be detonated by throwing a grapnel with a rope attached past the trip wire or tilt rods and pulling it back to actuate the mine. Grapnels may be improvised from any available material such as a bent drift pin or scrap. A 60-meter length of rope is attached to the grapnel for hand throwing. Cover should be sought before the grapnel and rope touch the ground in the event their impact detonates a mine.

(b) A one-pound block of explosive placed next to the mine is sufficient to detonate the mine. A group of charges placed next to the mines may be connected with detonating cord and fired simultaneously.

(3) Removal by rope or wire is accomplished by pulling mines out of their installed position. This eliminates the potential hazard to mine clearing personnel for mines fitted with antihandling devices. This method requires uncovering as much of the mine as necessary to expose the handle or other projection to which a rope or wire may be tied or a grapnel engaged. Care must be taken while uncovering or attaching a wire or rope not to move the mine that might activate the antihandling device. This method is safe and only detonates those mines equipped with antihandling devices, thus reducing noise and cratering. An expedient A-frame can assist in pulling the mine out of the hole with ease on the first attempt. The procedures for rope removal of mines is as follows:

(a) Uncover only enough of the mine to expose a suitable part. A 60-meter- long-rope or wire is tied to the mine or a grapnel is engaged without disturbing it. If there is no such projection, engage a hook of the grapnel under the bottom side of the mine opposite the direction of pull.

(b) After ensuring that the area to be used for cover is not mined, take cover or lie in a prone position at least 50 meters from the mine and pull it from the hole.

(c) Wait 30 seconds before leaving cover and approaching the mine to guard against the possibility of a delay-firing mechanism if the mine type is unknown.

(4) Hand neutralization. Foreign mines and booby traps should only be neutralized by EOD personnel. Mines are neutralized by hand in the following unique circumstances:

(a) When a silent breach of a mined area is a tactical necessity.

(b) When the mine is located on a bridge, building, or other facility required for use by friendly forces.

(c) When the mine is positively known to be one that can be hand neutralized and is required for reuse.

(d) When the mine is of an unknown type and its recovery for intelligence purposes must be attempted.

(e) When chemical mines are located in areas where subsequent contamination would restrict the use of the area by friendly troops.

h. Reports. There are three types of reports that the NCOIC of the sweep team must submit:

(1) Spot report. The spot report is sent to the higher headquarters when any enemy explosive device or mine is discovered or detonated. A spot report will be made on any enemy activity in the mine-sweep area.

(2) Status of progress and completion report. These reports are sent until the sweep team has completed the sweep of the road. Progress reports must be timely and accurate for two reasons: to permit effective movement by a reacting force if needed and to speed notification to the parent unit of road clearance.

(3) Mine booby trap incident report. This report is given to the commander so that each mine and booby trap incident is documented. These reports are forwarded through intelligence channels at the end of the mine-sweep operation.

(4) The post-operation procedure is a critique of the operation to discuss unsafe acts or possible improvements to the operation.

i. Equipment. Equipment used in the mine sweep should be cared for. Actions to be taken include:

(1) Immediate repair or turn-in for repair all damaged or malfunctioning equipment.

(2) Maintain and frequently check mine detectors for proper operation.

(3) Safely store demolitions and blasting caps.

Reference(s):

FM 20-32	Mine Countermine Operations
FMFM 13-7	MAGTF Breaching Operations

UNITED STATES MARINE CORPS

COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

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STUDENT HANDOUT

SURVIVABILITY POSITIONS

1. TERMINAL LEARNING OBJECTIVES:

a. Given a tactical situation, survivability positions to be revetted and references, plan construction of a revetment to provide adequate protection in a tactical situation per the references. FM 5-103 and FM 5-34/MCRP 3-17A. (1302.1.15)

b. Given a survivability plan, overlays, and references, supervise construction of survivability positions so the survivability positions are constructed per the survivability plan and per the references. FM 5-103 and FM 5-34/MCRP 3-17A. (1302.1.16)

2. ENABLING LEARNING OBJECTIVES.

a. Given a survivability position, equipment and personnel with aid of references, plan revetment construction to supplement the commander's intent per the references. FM 5-103 and FM 5-34/MCRP 3-17A. (1302.1.15a)

b. Given a survivability position, equipment and personnel with the aid of references, determine the need to revet the positions per the references. FM 5-103 and FM 5-34/MCRP 3-17A. (1302.1.15b)

c. Given a survivability position, revetted specifications, equipment and personnel with the aid of references, determine the materials required per the references. FM 5-103 and FM 5-34/MCRP 3-17A. (1302.1.15c)

d. Given a survivability position, equipment and personnel with aid of references, determine the equipment/materials required to construct a survivability position per the references. FM 5-103 and FM 5-34/MCRP 3-17A. (1302.1.16a)

e. Given a survivability position, equipment and personnel with aid of references, use natural cover and concealment per the references. FM 5-103 and FM 5-34/MCRP 3-17A. (1302.1.16b)

OUTLINE

1. COMMANDER'S RESPONSIBILITIES

a. Protect troops

b. Plan and select location of survivability positions (fighting positions and protective positions or bunkers).

c. Improve and maintain unit survivability.

d. Provide materials.

e. Supervise construction.

f. Inspect survivability positions.

g. Obtain technical advice from engineer, as required.

DO-	**DON'T-**
Ensure adequate material is available.	Fail to supervise.
	Use sand for structural support.
Dig down as much as possible. Maintain, repair, and improve positions continuously.	Use sandbags for structural support.
Inspect and test positions safety daily, after heavy rain, and after receiving direct and indirect fires.	Forget to camouflage. Drive Vehicles within 6 feet of a position.
Revet excavations in sandy soil.	Overfill sandbags.
Interlock sandbags for double wall construction and corners.	Take shortcuts.
Check stabilization of wall bases.	Build above ground unless absolutely necessary.
Fill sandbags approximately 75 percent	Forget lateral bracing on stringers.
Construct to standard.	
Use common sense.	

2. <u>POSITIONS CATEGORIES, FIGHTING AND PROTECTIVE POSITIONS THAT ARE USED TOGETHER OR SEPARATELY:</u>

a. <u>Holes and simple excavations</u>:

(1) <u>Advantages</u>

(a) Provides good protection from direct fire.

(b) Permits 360 degrees observation and fire.

(c) Provides good protection from the effects of nuclear weapons.

(2) <u>Disadvantages</u>

(a) Provides limited protection from direct fire when the occupant is firing.

(b) Provides relatively no protection from fragments from overhead burst of artillery.

(c) Provides limited protection from chemical effects. In some cases chemicals concentrate in low holes and excavations.

b. <u>Trenches</u>:

(1) <u>Advantages</u>

(a) Used in defensive area's.

(b) Provides same protection as Holes and Simple Excavations.

(2) <u>Disadvantages</u>

(a) Difficult to camouflage.

(b) Easily detected from the air.

c. <u>Tunnels</u>: Not frequently constructed due to time, effort, and technicalities. Decision to build greatly depends on type of soil.

d. <u>Earth Parapets</u>: Excavations and Trenches are usually modified to include front, side and rear parapets. Parapets of protection.

e. <u>Overhead Cover and Roof Structures</u>: Primarily to defeat in direct fire projectiles. Must consider 3 types of burst, Overhead, Contact, and Delayed Fuse.

f. <u>Triggering Screen</u>: Built separately or added to existing structures. Used to activate the fuse of incoming shell at a standoff distance.

g. Shelters and Bunkers: Protective Shelters and Fighting Bunkers are usually a combination of the positions mentioned up to this point.

(1) <u>Shelters</u>: Command Posts
Observation Posts
Medical Aid Stations
Supply and Ammo Storage
Sleeping Shelters

(2) <u>Fighting Bunkers</u>: Fighting Bunkers are enlarged fighting position built above or below ground.

3. <u>BASIC REQUIREMENTS</u>

a. <u>Weapon Employment</u>

(1) It is desirable for fighting positions to give maximum protection to personnel and equipment.

(2) In defensive combat operations, weapons are sited wherever natural and existing positions are available.

b. <u>Cover</u>

(1) Cover is protection from enemy fire.

(2) The overall purpose of cover is to defeat any possible threat.

(3) Cover designed for one type of enemy fire is not necessarily effective against another.

(a) <u>Frontal</u>: Cover provides protection from small caliber direct fire. Natural frontal protection such as large trees, rocks, logs and rubble is best because enemy detection of fighting positions becomes more difficult.

(b) Overhead: Cover provides protection from indirect fire fragmentation. When possible, overhead cover is always constructed to enhance protection against air burst artillery shells.

(c) Flank and Rear: Cover ensures complete protection for fighting positions. It protects personnel against the effects of indirect fire bursts to the flanks or rear of the position.

c. Camouflage

(1) Camouflage is to change or modify so far as to prevent recognition of the true identity or character of a position or person by blending in with the natural environment or terrain.

(a) Camouflage activities are continual during position siting and preparation.

(b) Offers friendly forces the advantage to fire just before being detected.

d. Concealment

(1) Concealment is to provide protection from enemy observation

e. Simplicity and Economy. The position is usually uncomplicated and strong, requires as little digging as possible, and is constructed from immediately available materials whenever possible.

f. Ingenuity. A high degree of imagination is essential to ensure the best use of available materials. Many different materials that exist on the battlefield, and prefabricated materials found in industrial and urban areas can be used for position construction.

g. Progressive Development

(1) Position should allow for progressive development to insure flexibility, security, and protection in depth. Development in progressive phases, with highest prioritized tasks accomplished first.

(2) Hasty positions are continuously improved into deliberate positions to provide maximum protection from enemy fire.

4. TYPES OF POSITIONS

a. Dragon Position

(1) The operator must consider the dragon's extensive back and muzzle blast, as well as a clear field of fire.

(2) When the dragon is fired, the muzzle extends 6 inches beyond the front of the position, and the rear of the launcher extends out over the rear of the position.

(3) The weapon should be at least six inches above the ground when fired to leave room for the fins to extend out.

(a) A waist deep position will allow the gunner to move while tracking a target.

(b) The frontal cover should be high enough to conceal the Marine's head and, if possible the dragon's back blast.

(c) A hole must be dug in front of the position for the bipod legs.

(d) If cover is built on the flanks of a dragon position, it must extend above the tracker, missiles and the gunner.

(e) Overhead cover for dragon position requires the backblast area be cleared.

(f) The danger zone for the dragon is 45 meters to the rear and a width of 90 meters. The caution area is 30 meters behind the danger zone.

(g) The estimated construction time for the dragon position is 4.0 man hours with the use of hand tools and 0.5 man hours with the use of a SEE Tractor.

b. <u>Machine Gun Position</u>

(1) The hole is shaped so both the gunner and assistant gunner can get to the gun and fire it to either side of the frontal protection.

(2) The position is dug chest high in the center to serve as the gun platform, and 2 feet wide along the rear and side of the platform.

(3) Digging the tripod platform down as much as possible reduces the gun’s height.

(4) The platform is dug in a manner that keeps the gun transferable across the entire sector of fire.

(5) The tripod is used on the primary sector of fire, and the bipod legs are used on the secondary sector.

(6) The ammunition bearer digs a one man fighting position to the flank.

(7) The ammunition bearer's position is connected to the gun position by a crawl trench so the bearer can transport ammunition or replace one of the gunners.

(8) The position also includes a grenade sump, which is dug at the bottom of the front wall 3 feet long and 6 inches wide at a 30-degree angle.

c. <u>Machine Gun Position with Overhead Cover</u>

(1) Cover is constructed as described for the one man fighting position with overhead cover.

(2) To construct this position with the use of hand tools the estimated time is 7.0 hours for the three-man gun crew.

(3) The equipment used, other than hand tools is a SEE Tractor, and the estimated time to construct the position with this is 0.5 hours.

d. <u>Mortar Position</u>

(1) A fighting position for a mortar is a circular shaped hole.

(2) The position is dug to a depth sufficient to shield the weapon and crew but does not restrict the weapon's operation.

(3) The mortar pit should be about 2 to 3 feet deep and 8 feet in diameter, and its bottom should be flat to enable the mortar crew to fire in any direction, but with a 1 to 4 inch slope towards a drainage sump. The drainage sump minimum depth is 20 inches, but it can be deeper depending on the weather. On frozen, hard or rocky surfaces the mortar crew places sandbags in the center of the gun pit to seat the baseplate. In soft soil, mud, sand, or snow, the ground under the base plate will require preparation to keep the base plate from sinking into the ground. The baseplate should be placed over a 12 inch cushion of sandbags, earth and small stones and a backstop (log, tree trunk or ammo canister filled with sand) place behind it to keep the baseplate from sliding back or sinking too deep into the ground.

(4) The pit must not be dug any deeper into the ground than the sight unit. The sight unit has to be above ground level in order to enable the gunner to see the aiming posts. Grenade sumps should have an opening wide enough to allow a man on the opposite side of the gun to pitch a grenade in with ease.

(5) The ready ammunition niche is used for final protective fire ammunition or other preset ammunition and should be wide enough to provide protection from direct sunlight and wet weather. The connecting trench is turned approximately 45 to 90 degrees just prior to the squad ammunition pit to prevent an explosion in the gun pit from spreading to the ammunition stored in the squad ammunition pit and to present a more irregular pattern from the air. The connecting trench should be a minimum of three feet deep. The deeper, the better to protect personnel from indirect fire. If the situation and time permits, the trench and ammunition pit should be bunkered or dug underground.

(6) The estimated construction time for the mortar position is 14 man hours when dug with hand tools and 0.5 man hours when dug with a SEE Tractor.

e. Table 1 below depicts characteristics and construction times.

<u>CHARACTERISTICS OF CREW-SERVED WEAPONS FIGHTING POSITIONS</u>

Type of Position	Estimated Construction Time (Hand Tools)	Estimated Construction Time (See Tractor)	Direct Small Caliber Fire	Indirect Fire Blast and Fragmentation (Direct hit)
Dragon Position	4.0	0.5	12.7mm	NONE
Machine gun Position	7.0	0.8	12.7mm	NONE
Machine gun Position with 1 1/2 overhead cover	12.0	0.8	12.7mm	NONE
Mortar Position	14.0	1.0	12.7mm	NONE

f. Logistical Vehicles Positions

(1) A deep cut vehicle position is prepared to provide protection for support vehicles, such as cargo trucks, maintenance and communication vans.

(2) The position is usually open on each end for drive-through access.

(3) The top of vehicles are at least 1 foot below the top of the surrounding walls.

(4) Camouflage netting is placed across the position if possible.

(5) The deep cut protective position is not used as a fighting position.

g. Tank Positions

(1) Deliberate positions. Deliberate fighting positions are required to protect a vehicle from kinetic energy hypervelocity projectiles. The position is constructed in four parts: hull defilade, concealed access ramp or route, hide area, and turret defilade. Positions formed by natural terrain are best because of easy modification; however, if preparation is necessary, extensive engineer support is required. Each position is camouflaged with either natural vegetation or a camouflaged net. The spoil is flattened out or hauled away. All fighting positions for fighting vehicles (tanks, LAV's, and AAV's) are planned as deliberate positions. If the lack of time does not allow the full construction of a deliberate position, then only some parts of the position's construction are prepared. For example, the complete fighting position for a tank requires the construction of a hull defilade, turret defilade, concealed access ramp or route, and hide area all within the same fighting position. The maneuver commander uses organic and engineer earthmoving equipment in the following order:

(a) Hull defilade

(b) Concealed access ramp or route

(c) Hide area

(d) Turret defilade

(2) Developing deliberate fighting positions. Digging hide areas and concealed routes between fighting positions is not practical due to the lack of engineer assets and time. Engineer assets are required to dig the hull and turret defilade positions only. The ramps and concealed routes should require only partial clearing and leveling with blade tanks or engineer equipment because natural concealed routes and hide areas are used. If time permits, the commander has the preceding fighting position expanded into a fighting position with all four parts, as shown, including a hide and turret defilade location. The access ramp from the hide area to the hull defilade position usually provides turret defilade for a vehicle at some point on the ramp. This location is marked with engineer tape and a chem light so the vehicle driver can see the mark and drive to it. This fighting position affords maximum protection and maneuver for the tank.

h. MOUNTED TOW POSITIONS

(1) Mounted TOW firing positions are most often provided by pre-existing or natural defilade positions.

(2) Improved frontal and overhead construction usually characterize defensive positions.

(3) Cover and Concealment

(a) Positions need concealment from ground and aerial observation.

(b) Positions must have good observation and fields of fire into the assigned sector of fire or engagement areas (EA).

(c) Positions must have mutual support between squad positions and other elements.

(4) Primary, Alternate, and Supplementary Positions:

(a) Primary position is the most important position because it is from this position the mission can be accomplished

(b) Alternate position is one that replaces the primary position.

(c) Supplementary position is one that replaces both the primary and alternate positions however cannot accomplish the primary mission.

(d) Primary and Alternate positions are used in the offense and defense, while supplementary positions are only used in the defense. An alternate position carries the same mission as the position but is physically located in a different area. Whenever possible, an alternate position should be 300 meters or more from the primary or other alternate positions. This reduces the possibility of indirect fire suppressing both the primary and alternate positions at the same time. A supplementary position is a position that fulfills a different mission and is physically located away from both the primary and alternate position. These positions all contribute to effective fire control. Where feasible, all TOW weapon systems should be assigned primary, alternate, and supplementary positions. Good covered and concealed routes between positions are essential to ensure rapid displacement and to prevent detection of movement.

(5) Mounted Position Characteristics. Mounted firing positions are characterized by hull defilade positions where the TOW vehicle is behind either natural or constructed cover with only the TOW launcher exposed. Hull defilade positions should be selected or constructed so that the TOW vehicle can move quickly to complete defilade if enemy fire is encountered.

i. <u>LAV Positions</u>

(1) A light armor vehicle is considered in turret defilade position when the entire vehicle is behind cover, but the commander can still observe to the front from the turret. The turret defilade position is used for protection while observing. When ready to engage the target, it moves into a hull defilade position. Turret defilade positions should be 8'6" deep x 25' long x 10' wide.

(2) A light armor vehicle is in a hull defilade position when the muzzle of the gun/launcher is the lowest part of the vehicle exposed to the front. Use hull defilade for maximum protection when engaging targets with direct fire. Hull defilade should be 5' deep x 25' long x 10' wide.

(3) A light armor vehicle is in a hide position when no part of the vehicle or commander is exposed to the front. This is often used in ambush positions in conjunction with dismounted observers. The vehicle would move forward into a hull defilade on the signal of the observer for the target engagement.

(4) Table 2 below shows the dimensions required for various types of vehicles positions and equipment hours required to construct by mechanical means.

TABLE 2 DIMENSION OF VEHICLE POSITIONS AND ENGINEER EQUIPMENT BEST SUITED FOR PREPARATION OF THESE POSITIONS

Vehicle Type	Position Dimension			Equip Hrs (Approx)			
-Deliberate (Hull Defilade)	Length	Width	Depth	Heavy Dozer	ACE	Light Dozer	TRAM
HUMMV TOW CARRIER	22	14	5	.6	.6	.8	.9
AAV	27	17	9	.8	.8	1	1.1
LAV	27	15	6	.8	.8	1	1.1
M1 MAIN BATTLE TANK	32	18	5.5	.9	.9	1.1	1.2
M60 MAIN BATTLE TANK	30	18	6	.9	.9	1.1	1.2

NOTES:

-Deliberate (access route) - Each access route between position or hide location must have the same width as the Hull Defilade. Production time is determined by calculating the volume of soil needed to be moved (cubic yd.) and divide by 100 bank cubic yards per .75 hours.

-Deliberate (Hide Area) - Hide locations are made using natural terrain and concealment. The min. width of the hide location is the same as the deliberate hull defilade. The hide position depth requirement is calculated by increasing the depth given in the deliberate turret defilade position by 15%.

-Deliberate (Turret Defilade)	Length	Width	Depth	Heavy Dozer	ACE	Light Dozer	TRAM
HUMMV TOW CARRIER	22	14	8	.8	.8	1	1.1
AAV	27	17	10	1.2	1.2	1.4	1.5
LAV	27	15	10	1.2	1.2	1.4	1.5
M1 MAIN BATTLE TANK	32	18	9	1.5	1.5	1.7	1.8
M60 MAIN BATTLE TANK	30	18	10	1.5	1.5	1.7	1.8

NOTES:

-Position dimensions provide an approximate 3-foot clearance around vehicle for movement and maintenance.

-Use of natural terrain features will reduce construction time.

-All depths and times are approximate and will need adjustment for surrounding terrain, soil and fields of fire and operator efficiency.

5. DEFINITION OF REVETMENT. A revetment is a facing to sustain an embankment or a barricade to provide protection against bombs, splinters, strafing and fragmentation. It serves mainly to support excavated surfaces from the effects of weather and occupation. There are 5 types of revetments:

(1) Brushwood Hurdle. A brushwood hurdle is a woven revetment unit usually 6 1/2 feet long and as high as the revetted wall. Pieces of brushwood about 1 inch in diameter are weaved on a framework of sharpened pickets driven into the ground at 20 inch intervals. When completed, the 6 1/2-foot lengths are carried to the position where the pickets are driven in place. The tops of the pickets are tied back t o stakes or holdfasts and the ends of the hurdles are wired together.

(2) Continuous Brush. A continuous brush revetment is constructed in place. Sharpened pickets 3 inches in diameter are driven into the bottom of the trench at 30-inch intervals and about 4 inches from the revetted earth face. The space behind the picket is packed with small, straight brushwood laid horizontally. The tops of the pickets are anchored to stakes or holdfast.

(3) Pole revetment. A pole revetment is similar to the continuous brush revetment except, small poles are placed horizontally and cut to length. For faster construction, boards, or planks are used if available Pickets are held in place by holdfasts, or struts.

(4) Corrugated Metal Sheets or Plywood. A revetment of corrugated metal sheets or plywood is durable, rapidly deployed, and is easy to adapt to the size job, It can be overlapped to obtain any height or length.

(5) Sandbag Revetment. The bags are filled about three-fourths full with earth and the choke cords are tied. The bottom corners of the bags are tucked in after filling. The bottom row of the revetment is constructed by placing all bags as headers. The wall is built using alternate rows of stretchers and headers with the joints broken between courses. The top row of the revetment wall consists of headers. Sandbags are positioned so that the planes between the layers have the same pitch as the base at right angles to the slope of the revetment. All bags are placed so that side seams are on stretchers and choked ends on headers are turned toward the revetted face. As the revetment is built, it is backfield to shape the revetted face to this slope.

(6) If water is allowed to stand in the bottom of an excavation, the position is eventually undermined and becomes useless. Sumps and drains are kept clear of silt and refuse. When wire and pickets are used to support revetment material, the picket may become loose, especially after rain. Improvised braces are wedged across the excavation, at or near floor level, between two opposite pickets. Further twisting tightens anchors. Periodic inspections of sandbags are made.

(7) Repairs. If walls crumble at ground level, the soil is removed where it is crumbling, or until firm soil is reached. Sandbags or sod blocks are used to build up the damaged area. If walls are wearing away at the floor level, a plank is placed on its edge and held in with stakes.

6. SHELTER/BUNKER: Timber framed shelters/bunkers are the most commonly used structures because they are easy to construct and materials can be obtained through the supply system, open market or woods/forests.

a. <u>Components</u>.

(1) Sill:

(a) The sill is the first component part of a shelter to be laid out.

(b) Sills are normally of 3" x 12" material, but any three-inch material can be used provided it is at least the same width as the post.

(c) Sills distribute the weight from the post to the ground.

(2) Post:

(a) Connect the posts to the sill forming a butt joint.

(b) The minimum size lumber required is 6" x 6".

(c) Methods of connecting

(d) The post supports the weight of the cap and distributes it to the sill.

(3) Cap:

(a) The minimum size lumber required is 6" x 6".

(b) Attach the caps to the posts by the same means as the posts are attached to the sills, except that scabs may also be used. Scabbing will be discussed later during this period of instruction.

(c) Caps should be the same width as the posts.

(4) Diagonal Bracing:

(a) 3" x 12" material is preferred, but lumber 3" x 6" or larger is acceptable for use.

(b) Run the braces from the top of the post to the sill, not from the top of the post to the bottom of the post.

(5) Sheathing:

(a) Normally use 3" x 12" lumber, but any three-inch material is acceptable for use.

(b) Place the sheathing parallel to the ground.

(c) Put the sheathing on the exterior of the shelter.

(6) <u>Roof</u>: There are two types of roofs, laminated and stringer.

(a) Laminated is the strongest and most economical. Laminated roofs are stronger because the timber is layered with all the grains crisscrossed:

<u>1</u> When using 3" x 12" material, use three layers.

<u>2</u> Run the first layer across the shortest span.

<u>3</u> Run the second layer across the longest span.

4 Run the third layer the same as the first layer.

5 When using one inch material, use seven layers

6 When using two-inch material, use five layers.

7 When using one inch or two inch material, run the layers the same as when using 3" x 12"'s.

(b) The stringer roof is the weaker of the two roofs:

1 Use a minimum size material of 6" x 6".

2 Lay the material side by side in one layer across the shortest span.

8. ASSEMBLY METHODS.

a. Drift pinning

(1) Drift pins vary in length and diameter. The most commonly used size is 1/2 inch in diameter and 16 inches long.

(2) Drill a pilot hole prior to driving the drift pin into the timber. This will prevent the timber from splitting.

(3) Drill the pilot hole 1/16" to 1/8" of an inch smaller than the diameter of the driftpin. (If the drift pin is 1/2" diameter, drill a 7/16" or 3/8" diameter pilot hole.)

b. Toenailing

(1) Toenailing is the fastest method for attaching timber.

(2) Drive the nails at a 45-degree angle through one timber into another timber.

c. Scabbing

(1) The scab should be 18" to 24" inches long; 3" inched thick and the same width as the timber being scabbed.

(2) Place the scab on the inside of the shelter.

(3) Use five to six 60d nails to hold the scab in place.

9. TRENCHES

a. General Information:

(1) Trenches are excavated to connect individual fighting positions and weapons positions.

(2) They provide protection and concealment for personnel moving between fighting positions or in and out of the area.

(3) Excavating trenches involves considerable time, effort and materials, and is only justified when an area is occupied for a long time.

(4) They are difficult to camouflage and are easily detected, especially from the air.

(5) Trenches, as other positions, are progressively developed.

b. Crawl Trench

(1) Usually dug 2 to 2 1/2 feet deep and as narrow as possible.

(2) The spoil is placed on both sides of the trench to form a parapet.

(3) Trenches should have a zigzag or winding pattern.

(4) If the trench runs across a forward slope, all the spoil is placed on the enemy side.

(5) All the spoil needs to be concealed from enemy direct observation.

c. Standard Fighting Trench

(1) This trench is developed from the crawl trench to a depth of at least 5 1/2 feet.

(2) Fighting bays or fighting steps are sometimes constructed and must be built into both sides of the trench to provide alternate positions to fight to the rear.

(3) Step off areas for foot traffic are also constructed. These areas provide protection against lengthwise firing into the trench.

(4) While it is primarily used as a fighting position, this trench is also used for communication, supply, evacuation and troop movements.

d. Patterns

(1) General

(a) Trenches are constructed to the length required and follow either an octagonal or zigzag pattern.

(b) Special combinations and modifications are made to meet battlefield demands.

(2) Octagonal Trace

(a) Affords easy communication and provides excellent protection.

(b) Is economical to construct, both in labor and material and can be built with a continuous firing step.

(3) Zigzag Trace

(a) Provides protection from lengthwise fire.

(b) Simple and easy to construct.

(c) Permits both frontal and flanking fire.

REFERENCES:

FM 5-103	SURVIVABILITY
FM 5-34/MCRP 3-17A	ENGINEER FIELD DATA

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STUDENT HANDOUT

SURVIVABILITY PLANNING

LEARNING OBJECTIVE(S):

1. **TERMINAL LEARNING OBJECTIVE**: Given a tactical situation, a map, a unit's survivability requirements, and references, prepare a survivability plan consistent with the commander's intent and concept of operations per the references. (1302.2.10)

2. **ENABLING LEARNING OBJECTIVES**:

a. Given a tactical situation, a map, a unit's survivability requirements, and references, recommend the employment of survivability positions consistent with the commander's intent and concept of operations per the references. (1302.2.10a)

b. Given a tactical situation, a unit's survivability requirement and references determine the priority of survivability positions consistent with the commander's intent and concept of operations per the references. (1302.2.10b)

c. Given a tactical situation, a map, a survivability mission, and references, create a survivability operation order consistent with the commander's intent and concept of operations per the references. (1302.2.10c)

OUTLINE:

1. SURVIVABILITY ANALYSIS

a. General: Combat engineer support for survivability missions is often limited since priorities are established in combination with mobility and countermobility missions. Fighting and protective positions are constructed with and without engineer assistance; therefore, critical protection requirements are carefully analyzed in order to establish priorities. By collecting and analyzing pertinent data, courses of action and options are developed, evaluated, and planned. The analysis provides engineer and maneuver commanders with a clear, mental picture of what is necessary to implement a survivability plan.

b. The Planning Process:

(1) SHIFT IN PRIORITY: Decision made by maneuver commander to shift priorities toward survivability operations. Must be done because:

(a) Mobility, Countermobility, Survivability, and General Engineering requirements compete for the same engineer assets.

(b) The situation dictates the tactical need for mobility and countermobility is outweighed by the need for sustainment and protection.

(2) PERFORMANCE STEPS:

(a) Step 1: Analyze the mission, enemy, terrain, troops and fire support available, time, space, and logistics (METT-TSL) in relation to the preparation of the survivability plan.

1 Three elements of an ANALYSIS are:

a State the facts.

b State the significance of those facts.

c State the conclusion drawn.

2 Mission: Specified and implied task.

3 Enemy: SALUTE, DRAW-D.

4 Terrain and Weather: OCOKAW, Weather's effect.

5 Troops and Fire Support Available: Organic, attached, supporting.

6 Time and Space: Distance vs Time (time establishes priorities).

7 Logistics: Combat Service Support, Classes of supply.

(b) Step 2: Identify intelligence requirements to the S-2/G-2 for action.

(c) Step 3: Recommend the location of possible survivability positions based on your evaluation of terrain. (i.e.; cover, concealment, camouflage).

(d) Step 4: Identify and prioritize survivability requirements, to include: Personnel, weapons systems, facilities, equipment, supplies that will require engineer equipment, operations and combat engineer personnel.

(e) Step 5: Determine coordination required to execute the survivability plan.

1 Command relationships.

a General support, Direct support, Attached?

b OPCON/ADCON?

c Responsibilities of your parent command?

d Responsibilities of supported command?

2 Operational requirements.

a Operation/mission.

b Key expertise.

_c_ Personnel.

_d_ Equipment.

_e_ Priorities.

_3_ Logistical requirements.

_a_ Life sustaining essentials.

_b_ Transportation.

_c_ POL.

_d_ Medical/dental.

_e_ Classes of supply.

(f) Step 6: Determine Class IV (BOM) and other pertinent supply requirements.

(g) Step 7: Task organize engineers to execute survivability plan.

(h) Step 8: Inspect and supervise construction of positions. Check for structural soundness.

2. DETERMINATION OF PROTECTION NEEDS: Although the decision on what is to be protected depends on the tactical situation, the following criteria can be used as a guide:

a. Exposure to direct and/or indirect fires.

b. Vulnerability to discovery due to electronic emissions (communications and radar), firing signature, tractable projectiles, and the need to operate in the open.

c. Capability to move to avoid detection, or to displace before counter-fire arrives.

d. Armor suitable to cover direct, small caliber fire; indirect artillery and mortar fire; and direct fire antitank weapons.

e. Distance from the FEBA which affects the likelihood of acquisition as a target, vulnerability to artillery and air bombardment, and chance of direct contact with the enemy.

f. Availability of natural cover.

g. Any unique equipment item, the loss of which would make other equipment worthless.

h. Enemy's engagement priority to include which forces most likely to engage first.

i. Ability to establish positions with organic equipment.

3. PROTECTION PRIORITIES: Setting survivability priorities is a maneuver commander's decision based on the engineer's advice.

a. Offensive Halts (Mobile Defense): In offensive operations, fighting and protective positions are developed whenever time is adequate, such as during a temporary halt for resupply, regrouping and/or consolidation. Recommended priorities for protection in a mobile defense are:

(1) Antitank weapons and vehicle mounted weapons systems.

(2) Direct fire, crew-served weapons systems.

(3) Indirect fire weapons.

(4) Command and control centers.

(5) Critical supplies, such as ammunition and POL, as well as ground vehicles and aircraft.

(6) Self-protected, armored, shock weapons (i.e. tanks).

(7) Individual fighting positions.

b. Offensive Halts (Mobile Defense) Considerations:

(1) Usually expedient.

(2) Prefabricated or pre-hardened.

(3) Offers frontal and flank protection.

(4) Makes maximum use of terrain.

c. Deliberate Defensive Operations: In defensive operations, substantial effort for fighting and protective positions construction is required. General priorities for protective construction in a defensive battle position are:

(1) Antitank weapons positions development.

(2) Direct fire, crew-served weapons positions development.

(3) Indirect fire weapon positions development.

(4) Command post hardening.

(5) Tank position development.

(6) Individual fighting positions and covered routes between battle postions.

d. Deliberate Defensive Considerations:

(1) Primary, alternate, and supplementary positions are developed in stages.

(2) Requires large logistical support.

(3) Time intensive.

(4) Offers protection stationary in nature.

4. COMMAND AND CONTROL: Operation Orders (OPORDs)/Operation Plans (OPPLANs) are used by the commander to carry out decisions made following the estimation and planning process. Survivability missions are prescribed in the OPORD/PLAN for all units, including both engineers and non engineers. Survivability

priorities will be specifically defined in the unit commander's OPORD/PLAN and in each unit leader's OPORD.

a. Survivability Operation Order/Plan. An operation order is defined as a directive, usually formal, issued by a commander to his subordinate leaders in order to coordinate execution of an operation. It carries with it the obligation of immediate execution or execution at a specified time or date. An operation plan, on the other hand, would be used in a situation such as an amphibious operation where planning takes place well in advance of the execution phase. Its execution depends on the existence of certain assumed conditions called assumptions that cannot be known as a certainty at the time the plan is written. Although the operation plan may indicate a tentative time to execute, this in itself does not constitute an obligation to execute. Once the order to execute is received, the operation plan becomes an operation order and must be executed at the specified time. Plans and orders employ the same basic format, however, the operations plan uses the subparagraphs 1a GENERAL and 1e ASSUMPTIONS in paragraph 1. The following is a break down of the basic requirements of a survivability operation plan:

(1) **SITUATION.** (PARAGRAPH 1)

(a) **General** (Paragraph 1a) is used for operation plans only. It describes the political military climate that would establish the probable conditions for execution.

(b) **Enemy** (Paragraph 1b) lists information only; there are no orders here. This should be limited to that information that is vital to the command, or is likely to affect survivability mission accomplishment. Information should be presented in the following sequence:

1 Enemy Situation.	**S.A.L.U.T.E**
2 Enemy Capabilities.	**D.R.A.W.D.**
3 Enemy Indications.	**E.M.P.C.O.A.**

(c) **Friendly Forces** (Paragraph 1c) provides information on non-organic forces having a bearing on the operation. Information should be presented in the following order:

1 **Higher.** The mission statement and commander's intent of the next higher unit in the operational chain. Enables the subordinate commanders to understand the mission and intent of his commanders two levels up. This picture provides the foundation from which he can exercise initiative when unexpected opportunities arise on the battlefield.

2 **Adjacent.** The mission statement or a summary statement of the units adjacent to your unit.

3 **Supporting.** Artillery is always listed as the first supporting unit, followed by others listed alphabetically. Each unit is followed by a brief description of the mission it will perform.

(d) **Attachments and Detachments** (Paragraph 1d) lists all non-organic units attached to or detached from the issuing headquarters. Time when all attachments and detachments are effective must be shown here and in the coordinating instructions. Internal attachments and detachments within the organization are never shown here.

(e) **Assumptions** (Paragraph 1e) list all assumed conditions which have a direct impact on mission execution and/or accomplishment.

(2) **MISSION.** (PARAGRAPH 2) The mission paragraph tells the WHO, WHAT, WHERE, WHEN, and WHY of the order. Remember that this mission statement is from you to your subordinates!

(3) **EXECUTION.** (PARAGRAPH 3)

Note: Both the Final Result Desired (FRD) and the Concept of Operations are contained in paragraph 3a.

(a) **Commander's Intent (Final Result Desired).** (Paragraph 3a) A paragraph describing the analysis of the enemy capability, intent, and center of gravity. Describes how the commander sees the operation unfolding and what he intends to accomplish from the "Big Picture" perspective.

(b) **Concept of Operations.** (Paragraph 3a) Includes the overview statement, main effort, supporting effort, reserve forces, and priority of support. It should, at the same time, communicate the following information:

1 **Scheme of maneuver.** Basic synopsis of how the mission will be executed. For example:

Two combat engineer platoons (REIN) will be dedicated forward to construct survivability positions for 2nd and 3rd Battalions (REIN), 7th Marines, who are operating along the FEBA. In reserve, one combat engineer platoon with its support attachments will be dedicated to the rear area to advise and construct survivability positions for 1st Battalion, 7th Marines, who is protecting the 7th Marine Regiment Command Post.

2 **Sequence of events.** Basic synopsis of the order that the mission will be carried out. The sequence of events is usually best expressed in terms of phases. For example:

Phase I. (D+1 - D+2) Phase I will consist of digging individual fighting positions; Primary/Hull defilade positions for tanks, AAV's, TOWs and other vehicle mounted weapons systems; Primary and supplementary positions for crew-served weapons systems.

Phase II. (D+3 - D+7) Phase II will consist of constructing TSFC bunkers for Regiment and Battalion command posts; Developing primary, alternate, and supplementary positions for tanks, AAVs, TOWs, and other vehicle mounted weapons systems; Vehicle protective positions for critical Logistical carriers; Protective positions for critical supplies.

Phase III. etc.........

3 **Employment of supporting arms.** Basic synopsis of units providing support to mission accomplishment. Remember when conducting engineering missions that there are usually other units with engineering capabilities operating in the area (i.e. CSSD engineers, artillery units, tanks, civilians, etc.).

4 **Plan for landing** (helicopter or amphibious operations only).

(c) **Tasks to Subordinate Units.** (Paragraph 3b) Tasks your subordinates and tells them where and how they fit into the Concept of

Operations that was explained earlier. Tasking paragraph should direct your subordinates.

1 Command relationships and with whom: DS, GS, Attached, Detached, OPCON, ADCON.

2 Where and how they fit into the scheme of maneuver.

3 Where and how they fit into sequence of events.

4 Where and how they will employ supporting forces.

5 Directing the accomplishment of specified tasks {their mission(s)}.

6 Identify personnel and/or equipment particular to a specified task and how they are to be directed.

(d) **Reserve.** (Paragraph 3c) Contains the same tasking requirements as paragraph 3b.

(e) **Coordinating Instructions**. (Paragraph 3d) Contains instructions common to two or more units. For an engineer operation order, the following areas should be covered.

1 Engineer equipment common to all.

2 Coordination with supported unit commanders.

3 Submission of reports and overlays.

4 Priority of the survivability effort.

5 Coordination of supporting engineer efforts.

6 Rules of Engagement (ROE).

(4) **ADMINISTRATION AND LOGISTICS.** (PARAGRAPH 4) This is where the four B's {beans, bullets, band-aids, and bad guys (EPW's)} are discussed. For an engineering operation order, the following areas should be covered in paragraph 4:

(a) Concept of Combat Service Support to include engineering support.

(b) Supply/Resupply with particular attention paid to class III (POL), IV (construction materials), V (ammunition/demolitions) and IX (repair parts).

(c) Maintenance.

(d) Transportation.

(5) **COMMAND AND SIGNAL.** (PARAGRAPH 5)

(a) **Command Relationships.** (Paragraph 5a) Details how the command relationship will function. Used only in large operations or when command relationships are unusual.

(b) **Signal.** (Paragraph 5b) Sets forth information on communications and electronics, recognition and identification instructions, and other pertinent information unique to the command post.

(c) **Command Posts.** (Paragraph 5c) State the current location of an issuing unit's CP and the next higher unit's CP and instructions for reporting locations, relocation's of CPs.

b. Maneuver Commander Responsibilities:

(1) Responsible for organizing, planning, coordinating, and effectively using engineer resources to accomplish the survivability mission.

(2) Relies on the engineer staff officer or supporting engineer commander to provide analyses and recommendations for protective and fighting positions construction/employment.

(3) Implements decisions by setting priorities and further defining the constraints of the mission to the engineer.

c. Engineer Commander Responsibilities:

(1) Ensures timely reports concerning survivability tasks are made to engineer staff officer or the operations officer (S-3/G-3).

(2) Develops survivability operational plans.

(3) Ensures the engineer tasks are supervised whether or not they are performed using engineering forces.

(4) Inspects fighting and protective positions for structural soundness.

(5) Provides advice and repair estimates for fighting and protective positions built or occupied by supported units.

(6) Recommends and identifies uses for engineer support in survivability operations through the sequence of command and staff actions.

(7) Evaluates terrain to determine the best areas for construction of survivability systems.

(8) Interfaces between the staff sections (S-2, S-3, S-4, etc.) and coordinates specific requirements.

d. OPORD Engineer Requirements and Information: Key Annexes to the Operations Order of interest to the Engineer operations:

(1) ANNEX A (Task Organization): Tells the WHO and with WHAT.

(2) ANNEX B (Intelligence): Enemy situation; Weather and terrain.

(3) ANNEX C (Operations): Tells HOW.

(a) Engineer appendixes talk specifically about combat engineer operations. They should cover all aspects of engineering (i.e., Mobility, Countermobility, Survivability, and General Engineering).

(4) ANNEX D (Logistics/Combat Service Support):

(a) Combat Service Support Appendixes talk specifically about Combat Service Support Operations.

REFERENCES:

FM 20-3	CAMOUFLAGE
FM 20-32	MINE/COUNTERMINE OPERATIONS
FM 34-130	INTELLIGENCE PREPARATION OF THE BATTLEFIELD
FM 5-102	COUNTERMOBILITY
FM 1-103	SURVIVABILITY
MCRP 3-17A	ENGINEER FIELD DATA
MCRP 3-17B	ENGINEER FORMS AND REPORTS
MWCP 3-1	GROUND COMBAT OPERATIONS
MCWP 3-17	MAGTF ENGINEER OPERATIONS

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STUDENT HANDOUT

ORGANIZATIONAL MAINTENANCE PROGRAM

1. TERMINAL LEARNING OBJECTIVE:

(1) Provided with MCO P4790.2C, TM 08917A-14/1, SL-3-00456A, an Engineer Equipment Operational Record (NAVMC 10523), a Consolidated Engineer Equipment Log (NAVMC 10524), a Preventive Maintenance Roster (NAVMC 10561), and Table of Organization (T/O), and Table of Equipment (T/E), with the aid of references, supervise an organizational maintenance program in accordance with MCO P4790.2C, TM 08917A-14/1, SL-3-08917A, TM 4700-15/1H and TM-11275-15/4. (1371.5.2)

2. ENABLING LEARNING OBJECTIVE(S):

(1) Given a list of maintenance echelons and a list of maintenance categories, with the aid of references, match each echelon to its category in accordance with MCO P4790.2C. (1371.5.2a)

(2) Given TM 08602A-14/1 and list of services, with the aid of references, list of intervals at which the services are to be performed in accordance with TM 08602A-14/1. (1371.5.2b)

(3) Given an SL-3 and a National Stock Number (NSN), with the aid of references, validate the quantity required to make the item complete in accordance with MCO P4790.2C. (1371.5.2e)

(4) With the aid of references, identify the required to be contained in the Maintenance Management Standar Operating Procedure (MMSOP) in accordance with TM 4700-15/1H. (1371.5.2f)

OUTLINE

1. MARINE CORPS INTEGRATED MAINTENANCE MANAGEMENT SYSTEM (MIMMS).

a. POLICIES OF MAINTENANCE. MCO P4790.2C establishes MIMMS and maintenance production policy. The following are excerpts of the policies concerning organizational and intermediate maintenance.

(1) The commander is responsible for the successful accomplishment of the maintenance functions within the unit. The planning directing, and controlling of the maintenance operations will receive the personal attention of commanders at all levels.

(2) A commander is responsible for the operational readiness of T/E items and for maintaining T/E items within the units authorized EOM. The units authorized level of maintenance is normally stated in the logistics capabilities statement of the unit table of organization (T/O). MCO P4790.2c. Request to exceed that authority must be similarly based and may be granted only per the provisions of MCO P4790.2.

b. MIMMS BACKGROUND. MIMMS was developed in 1970 in an effort to standardize maintenance management throughout the Marine Corps. MIMMS was implemented to produce an effective unified approach throughout the Marine Corps. MIMMS is a set of manual procedures by which the effective use of personnel, money, facilities, and material as applied to the maintenance of ground equipment is controlled. It is supported by an automated information system (AIS) which functions as a stand alone class I system that interfaces with existing Marine Corps systems and programs.

c. MIMMS and MIMMS/AIS apply to all command levels and maintenance echelons. They provide management visibility to the user level while simultaneously collating maintenance engineering analysis (MEA) information for item management.

d. MAINTENANCE LEVELS. Maintenance is divided into field and depot level maintenance. Field and depot level maintenance are divided into maintenance categories and echelons as follows.

e. MAINTENANCE CATEGORIES. The Department of Defense (DoD) categories of maintenance production are Organizational, (First and Second Echelons), Intermediate, (Third and Fourth Echelons) and Depot maintenance (Fifth Echelon).

(1) Organizational Maintenance. That maintenance production, scheduled or unscheduled, which is the responsibility of and performed by the using unit on its table of equipment (T/E) and special allowance assigned equipment.

(2) Intermediate Maintenance. Intermediate maintenance is that performed by designated activities in direct support of using organizations.

(a) It includes calibration and repair/replacement of damaged or parts and provides technical assistance, support through a secondary repairable float and/or contact team support to using organizations.

(b) Intermediate maintenance normally includes third and fourth echelon maintenance and in instances when supporting overflow requirements, may include second echelon as well.

(3) Depot Maintenance. That maintenance requiring major overhaul or complete rebuild of parts, subassemblies, assemblies or end items.

(a) Including the manufacture of parts and performance of required modifications, testing.

(b) Depot maintenance serves to support lower categories of maintenance by providing technical assistance and performing maintenance beyond their responsibility.

(c) Depot maintenance provides stocks of serviceable equipment by using more extensive repair facilities then are available in lower level maintenance activities. Fifth echelon maintenance is normally associated with this category and is scheduled to employ production and assembly line methods whenever practicable.

(d) Depot maintenance located at two places, Albany, GA, east coast and Barstow, CA, west coast.

f. MAINTENANCE ECHELONS. The Marine Corps further subdivides the maintenance categories into echelons of maintenance (EOM) to more accurately identify capabilities. In this way tasks most appropriate to the units available commodity personnel, tools, equipment, and parts can be identified.

(1) First Echelon. That maintenance performed by the user or operator of the equipment. It includes the proper care, use, operation, cleaning, preservation, lubrication and such adjustment, minor repair, testing, and parts replacement as may be prescribed by pertinent technical publications, tools and parts allowances. There is no requirement to collect MIMMS data at first echelon.

(2) Second Echelon. Second echelon maintenance is that work performed by specially trained personnel in the organization. Appropriate publications authorize the second echelon of maintenance, and skilled personnel to perform maintenance beyond the capabilities and facilities of "first echelon".

(3) Third Echelon. Third echelon maintenance is that authorized by appropriate publications to be performed by specially trained personnel either in an intermediate or organizational role.

(a) Third echelon includes diagnosis and isolation of equipment/modular malfunctions; adjustment and alignment of modules using test, measurement, and diagnostic equipment (TMDE); repair by replacement of modular components and piece parts which do not require extensive post maintenance testing or adjustment.

(b) Limited repair of modular components requiring cleaning, seal replacement application of external parts, and repair kits; accomplishment of minor body work and evaluation of emissions of internal combustion engines.

(4) Fourth Echelon. That maintenance normally associated to semi-fixed or permanent shops of intermediate maintenance activities and frequently associated to organizational shops of units with a commodity peculiar mission.

(a) Fourth echelon maintenance includes diagnosis, isolation, adjustment, calibration, alignment, and repair of malfunctions to the internal piece part level; replacement of defective modular components not authorized at lower echelons.

(b) Repair of major modular components by grinding, adjusting, items such as valves, tappets, seats; replacing internal and external piece parts to include solid state integrated circuits and printed circuit boards/cards; and performance of heavy body, hull turret, and frame repair.

(5) Fifth Echelon. That maintenance normally performed by depot maintenance activities and at intermediate maintenance activities when specially authorized by the CMC (LPP).

(a) It includes overhaul/rebuild of end item/modular components; repairs which exceed the capability of lower echelon units where special environmental facilities or specific tolerances are required.

(b) Testing, special inspection/modification requiring extensive disassembly, or elaborate test equipment; manufacturing items not provided or available, and provision of wholesale level direct exchange support.

g. REPORTABLE EQUIPMENT. Marine Corps Automated Readiness Evaluation System (MARES) reportable equipment is defined as an item of equipment which is contained in a Marine Corps bulletin (MCBul) in the 3000 series. Before items can be included in this Bulletin, they must be principal end items that are 85 percent fielded Marine Corps-wide, to include the Reserves.

2. **PUBLICATIONS**

a. Types:

(1) Technical Manuals (TM) furnish technical information, instructions, and procedures of a permanent nature on the operation, maintenance, and handling of equipment or material.

(2) Lubrications Instructions (LI) Lubrication Orders (LO) furnish technical information and instructions on the service, lubrication, and related preventive maintenance checks and services requirements for equipment or material.

(3) Modifications Instructions (MI) authorize the modification of equipment or material and furnish technical instructions on how to accomplish the modification.

(4) Technical Instructions (TI) furnish technical advice or information on equipment or material.

(5) Stock Lists (SL) provide all levels of the Marine Corps supply and maintenance operations with essential, up to date information for Marine Corps-managed items.

(6) Users Manual (UM) provide procedures for formatting and entering information into the AIS.

(7) Marine Corps Orders (MCO) are directives that are permanent in nature.

(8) Marine Corps Bulletins (MCBul) are temporary in nature.

b. TECHNICAL PUBLICATION IDENTIFICATIONS. A technical publication is identified by letters and numbers. The number will consist of four elements.

(1) Type of publication. The first two letters are the abbreviation of the publication; for example TM.

(2) Basic number. One of three kinds of basic numbers will be assigned as described below:

(a) Item designator (ID) Number - The equipment ID number, consisting of five digits suffixed by a letter of the alphabet (excluding O and I) assigned to a system, major item, or multiple - use major components. (Example TM - 06709)

(b) National Supply Classification (NSC) number. The four digit NSC number assigned to the material based on the group and class of material rather than the ID number; for example, 6115, 6665.

(c) Standard subject identification codes (SSIC). The four or five digit SSIC is used when the publication provides general information on a wide range of equipment; for example electronics and motor transport. SSIC codes are listed in SECNAVINST 5210.11 and NAVMC 2761.

(3) Maintenance echelon number. The EOM indicator is a significant information provided to show the user the echelon of maintenance covered.

(a) 10 - First EOM only (operator or crew).

(b) 20 - Second EOM only (organizational maintenance).

(c) 30 - Third EOM only (direct support, intermediate maintenance).

(d) 40 - Fourth EOM only (general maintenance support, intermediate maintenance).

(e) Fifth EOM only (depot maintenance).

(f) Any combination of these echelons to which a publication would apply:

1 12 - First through second EOM.

2 15 - First through fifth EOM.

3 23 - Second through third EOM.

4 34 - Third through fourth EOM.

5 45 - Fourth through fifth EOM.

(4) Sequence Number - The sequence number follows the basic number or maintenance echelon indicator, as appropriate. The maintenance echelon indicator is not consider as part of the assigned sequence number. A Virgule (/) separates the sequence number from the preceding element. The sequence indicates a manual as being one of a series for a specific equipment.

(5) Edition Designator - The edition designator if applicable, is on alphabetic number, starting with the suffix "A" that indicates each revision of a publication after its initial printing. The edition designator immediately follows the EOM or sequence number, as appropriate.

c. Publication Library. Utilizing the SL 1-2/SL 1-3 or Publication Library Management System (PLMS) and your units T/E cmr identify which pubs are required or non-required.

d. Marine Corps Publications Distribution System (MCPDS). MCPDS is a system that provides services in support of the initial issuance of publications by Marine Corps publications sponsors and supports publications management by field commanders including the Reserve component. MCPDS provides distribution of Marine Corps publications to other government agencies and non-government entities with a bona fide reason for receiving them.

e. Distribution. Distribution can be defined as the process of getting the required publication, in the right quantity, to the user of the publication. This process consist of two phases:

(1) Marine Corps Publication Distribution. From the publications stock control point, to the activity.

(2) Activity Internal Distribution. From the receiving point in the activity to the technical library.

(3) In addition to the two phases of distribution, which describe the flow of an incoming publication there are two types of distribution.

(a) “Push” or Automatic Distribution. When a publication change or revision is published will be automatically distributed to match those quantites reflected on the PL.

(b) “Pull” or Requisitioning. Result of activity submitting a requisition to the publications stock comtrol point.

f. Internal Publication Control. Determine PCN’s your section requires, and then contact your unit’s publication control point.

3. MOTOR VEHICLE AND ENGINEER RECORD FOLDER.

a. Purpose. The purpose of NAVMC 696D is to maintain a historical record of the equipment's transfer, receipts, modifications, and major assembly replacements; and to serve as a file folder for completed forms and records per the form filing and disposition instructions.

b. Responsibilities. Maintain a NAVMC 696D on each item of motor transport, engineer, and garrison mobile equipment. In cases where items of equipment are under one TAM control number but are associated with standard items of other commodity equipment, maintain a separate record folder for that specific commodity item per applicable chapters of this Manual. However, both records will reflect the Marine Corps registration number, chassis serial number, TAM control number, NSN, and ID number of the TAM as a single entity.

(1) The MCLB that first receives the item of equipment will establish the NAVMC 696D. MCLB will enter the descriptive data and any modifications accomplished while the equipment is under their cognizance and control.

(a) When units other than the MCLB receives the item of equipment direct from the manufacturer of the NAVMC 696D is lost, that unit will be responsible for establishing the NAVMC 696D.

(b) When establishing or reconstructing a NAVMC 696D, use the establishment or reconstruction date in a five digit Julian date. (YYDDD)

(2) The custodian is responsible for keeping the entries in the NAVMC 696D up-to-date while the item of equipment is in the custodian's custody. When engineer equipment has more than one power plant, maintain NAVMC 10523 and 10524 on each power plant.

c. Preparation Instructions. The descriptive data of the item of equipment will appear on the top of the NAVMC 696D when it is received by the using unit. Make entries in the "transfer, modification, and major unit assembly replacement record" portion of the NAVMC 696D each time the item is received, transferred from one RUAF to another RUAF, modified, or a major assembly was replaced. The "Account Serial Number" column refers to the owning unit activity Code of the unit having custody of the item of equipment when the entry is made. Tactical wreckers and garrison mobile equipment (GME) wreckers require an annual condition inspection per MCO P11262.2, and the results must be filed inside the NAVMC 696D. Make entries on the face of the NAVMC 6956D as follows:

(1) MC Registration No. The Marine Corps registration number appearing on the item of equipment's data plate.

(2) Complete Nomenclature and Vehicle Code. The complete nomenclature, as shown on the item of equipment's data plate. When the information is not listed on the data plate or the item of equipment does not have a data plate use the information listed on the parts manual. In the upper right hand corner of this block enter the item of equipment's TAM control number, NSN, and ID number. The vehicle code is not applicable.

(3) Chassis Serial No. The chassis serial number appearing on the item of equipment's data plate.

(4) Date. The five digit Julian date (YYDDD) when the item of equipment is transferred or received from one unit (AC) to another, a modification is completed, or a major assembly replaced. This entry is not required for tactical equipment.

(5) Account Serial No. The AC of the organization accountable for the item of equipment each time an entry is made in the adjoining columns. This entry is not required for tactical equipment.

(6) Voucher No. The document number of the accountable transaction assigned by the custodian when the item of equipment is transferred from one RUAF to another RUAF. This entry is not required for tactical equipment.

(7) MI/TI No. The number of the MI directing the modification to be made to the item of equipment upon completion of the modification. This entry is not required for tactical equipment.

(8) Description of modification completed or Major Unit Assembly Replaced. When an MI is completed enter a brief description of the MI. When a serialized major unit assembly is replaced, enter brief description and the serial number of the new major unit assembly. When the item of equipment is transferred or received enter "transferred" or "received." This entry is not required for tactical equipment.

(9) Remarks. When the Equipment Operational Time Indicator is replaced; that is, odometer/hour meter enter the date changed and the miles/kilometers/hours from the unserviceable and replacement odometer/kilometer/hour meter to permit proper rescheduling of scheduled preventive maintenance checks and services (PMCS). When the item of equipment is load tested, enter the hook throat base dimension measurement. When the item of equipment has anti-freeze changed, enter the type anti-freeze used and the date changed. temporary entries may be entered in pencil; for example, load tested, antifreeze changed.

d. Filing. Maintain the NAVMC 696D in the administrative office of the custodian of the item of equipment concerned or as designated by the commanding officer. When the face of the NAVMC 696D inside the new NAVMC 696D.

e. Disposition. When the item of equipment is transferred, forward the NAVMC 696D by certified mail with the invoice (not forwarded with the item of equipment) upon each change of custody of the item of equipment. When both shipping and receiving units are in the same vicinity, the NAVMC 696D may be hand-delivered. When the item of equipment is determined unserviceable and a Letter of Unserviceable Property (LUP) is received, destroy all records.

4. NAVMC 10524, CONSOLIDATED ENGINEER EQUIPMENT OPERATIONAL LOG AND SERVICE RECORD.

a. Purpose.

(1) The NAVMC 10524 provides the authority for an operator to operate engineer equipment on an assigned mission. A duplicate NAVMC 10524 may be prepared and issued to the operator instead of a daily NAVMC 10523 (Engineer Equipment Operational Record) when equipment is operated at a project site for extended periods - for example, a well drill, generator, air compressor.

(2) The NAVMC 10524 provides the operator with checklist for conducting BEFORE, DURING, and AFTER preventive maintenance checks and services (PMCS) checklist.

(3) The NAVMC 10524 provides a means for recording mileage and hours for equipment operation so that PMCS may be scheduled and petroleum, oil, and lubrications (POL) consumption determined.

(4) The NAVMC 10524 provides a template for indicating required operator daily PMCS listed on the NAVMC 10523.

(5) The NAVMC 10524 need not be prepared on equipment when an ERO/SRO has been submitted and equipment is operated from local equipment pool area to the maintenance shop.

5. NAVMC 10523, ENGINEER EQUIPMENT OPERATIONAL RECORD.

a. Purpose:

(1) The NAVMC 10523 provides the authority for an operator to operate engineer equipment on an assigned mission. NAVMC 10524 (Engineer Equipment Operation Log and Service Record) may be prepared and issued to the operator instead of a daily NAVMC 10523 when equipment is operated at a project site for extended periods; for example, a well drill, generator, air compressor.

(2) The NAMMC 10523 provides the operator with checklist for conducting daily preventive maintenance checks and services (PMCS) checklist.

(3) The NAVMC 10523 provides a means for recording mileage and hours for equipment operation so that PMCS may be scheduled and petroleum, oil, and lubrications (POL) consumption determined.

(4) The NAVMC 10523 need not e prepared on equipment when an ERO/SRO has been submitted and equipment is operated from local equipment pool area to the maintenance shop.

6. NAVMC 10561, PREVENTIVE MAINTENANCE ROSTER.

a. Purpose. The purpose of NAVMC 10561 is to systematically schedule and record second EOM and higher preventive maintenance checks and services (PMCS) on Marine Corps ground equipment. Units are authorized to schedule PMCS via locally developed automated programs, providing the information duplicates the NAVMC 10561.

b. Responsibilities. The responsibility for scheduling all required second EOM and higher PMCS rests with the equipment officer, equipment chief, or appointed individual or individuals.

(1) Commanders will establish an interval of no less frequently than annually, when the equipment's appropriate equipment technical publications list a requirement to conduct second EOM or higher PMCS, but no interval is recommended.

(2) PMCS beyond first echelon need not be accomplished or scheduled, when no requirement to conduct second EOM or higher PMCS is listed in the appropriate equipment technical publications or no equipment technical publication exists.

(3) Schedule second EOM and higher PMCS per the equipment commodity chapter of this Manual. This does not relieve the unit from its responsibility to conduct first EOM PMCS. In preparing rosters, care must be taken to ensure that the workload is staggered so that all items of one type of equipment are not scheduled for PMCS at the same time.

(4) Schedule PMCS's on NAVMC 10561 no less frequently than monthly.

(5) For multiple commodity equipment, the equipment from each commodity area is considered as an individual item for scheduling and performing the required maintenance. The end item responsible officer will ensure that the PMCS coordination between the various commodity maintenance activities is accomplished allowing operational availability for the unit commander.

(6) Maintain at least one active scheduled interval and one interval under preparation (used to schedule the next PMCS). Upon completion of a PMCS schedule the next PMCS. Schedules for current and upcoming year may be maintained.

c. Preparation Instructions.

(1) In the "MODEL/USMC NO." block, enter the type of equipment and serial number.

(a) Schedule and conduct PMCS on items of equipment with more than one TAMCN concurrently; for example, end item and attachment. The attachment being scheduled one line below the end item.

(b) Skip a line between different types of equipment.

NOTE: TO ALLOW AN END ITEM AND ITS ATTACHMENT; FOR EXAMPLE, END ITEM (LVS MK48) AND ATTACHMENT (LVS MK14) TO MAINTAIN A MATCHED SCHEDULE, AN END ITEM MAY HAVE ITS ATTACHMENT LISTED ON THE FOLLOWING LINE.

(2) In the YEAR block, enter the calendar year.

(3) In the MONTH block, enter appropriate symbol listing completed PMCS and reschedule the next PMCS. Use ink for completed PMCS and pencil for scheduled PMCS. Do not erase pencil entries made before the completion PMCS. For PMCS completed during the month scheduled trace over the symbol in ink and schedule the next PMCS in pencil. For PMCS completed during a month other than that originally scheduled, enter the symbol in ink for the month the PMCS was actually completed and schedule the next PMCS in pencil.

(4) ln the REMARKS block, enter justification for any PMCS completed during a month other than that originally scheduled.

d. Filing. Maintain. current (active) copies of NAVMC 10561 in the administrative office of the equipment custodian or as directed by the commanding officer.

e. Disposition. Retain the NAVMC 10561 that has all required PMCS completed for a minimum of 1 year. For equipment requiring a biennial PMCS retain the NAVMC 10561 for two years. Units possessing a limited quantity of equipment may list items for subsequent years on the same NAVMC 10561. Units using an automated system may retain printouts in place of the NAVMC 10561.

7. NAVMC 10560, WORKSHEET FOR PREVENTIVE MAINTENANCE AND TECHNICAL INSPECTION FOR ENGINEER EQUIPMENT.

a. PURPOSE. The purpose of the NAVMC 10560 is to provide a checklist for performing and recording preventive maintenance checks and services (PMCS) and LTI's (limited technical inspections), to include acceptance LTI'S, LTI's prior to major repair, and LTI's at the discretion of the Engineer Equipment officer/chief on Tactical Engineer Equipment and GME Fleet Manager on Garrison Mobile Engineer Equipment. The NAVMC 10560 is also used as a guide when performing an annual safety/condition check.

NOTE: AN LTI IS PERFORMED BY MAINTENANCE PERSONNEL UPON RECEIPT OF EQUIPMENT PRIOR TO THE UNIT PLACING THE EQUIPMENT IN SERVICE TO DETERMINE THE OVERALL CONDITION. THIS LTI IS CALLED THE ACCEPTANCE LTI.

b. Responsibilities for Tactical Engineer Equipment. The equipment chief is responsible for preparing the worksheet for the PMCS. Prepare a template indicating the required PMCS for each item of equipment to facilitate the preparation of the worksheet. In preparing the template, refer to the appropriate services listed in the TM's, Army technical bulletins, and other publications applicable to the equipment. By laying the template for a specific item of equipment on a blank NAVMC 10560, nonapplicable portions of the form may be readily blanked out. The worksheet, which indicates the required services, is then transmitted to the maintenance unit. The maintenance unit, with the assistance of the operator, performs the required services and signs the worksheet indicating that the service has been completed. The equipment chief will also ensure that equipment requiring repairs is inspected and the results of the inspection are recorded on the NAVMC 10560 before the equipment is repaired.

c. Preparation Instructions. The preparing activity may be the equipment owner, the equipment user; for example, the equipment is on temporary loan, or the equipment custodian as in the. case of the maintenance section evacuating to the next higher EOM. The preparing activity is responsible for initial preparation of the NAVMC 10560. The preparing activity completes the items marked with a pound sign (#).

d. Filing and Disposition. When the maintenance officer/chief has verified that all requirements listed in section B of the worksheet have been transferred to an ERO/SRO, the NAVMC 10560 will be destroyed. Retain any NAVMC 10560 used in conjunction with an investigation until released from investigation. Treat a NAVMC 10560 released from investigation as CM.

REFERENCE(S):

MCO P4790.2C	MMIMS (AIS) FMSS
TM-4700-15/1H	Equipment Record Procedures

UNITED STATES MARINE CORPS

COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C-01B24
16 Jul 00
(98 POI)

STUDENT HANDOUT

INPUT TRANSACTIONS

LEARNING OBJECTIVE (S):

1. TERMINAL LEARNING OBJECTIVE:

a. Provided a Daily Process report (DPR), Daily Transaction Listing (DTL), an Equipment Repair Order (NAVMC 10245), and an ERO Shopping/Transaction List (NAVMC 10925), with the aid of references, the above forms and reports will be completed, analyzed, and maintained using the (MIMMS) Marine Corps Integrated Maintenance Management System in accordance with TM 4700-15/1, UM 4790-5, and MCO P4790.2C. (1371.5.1)

2. ENABLING LEARNING OBJECTIVE (S):

a. Given a completed Equipment Repair Order (NAVMC 10245), with the aid of references, identify all items requiring corrective action in accordance with TM 4700-15/1H. (1371.5.1a)

b. Given a completed ERO Shopping/Transaction List (NAVMC 10925), with the aid of references, identify all items requiring corrective action in accordance with UM 4790-5, AND TM-4700-15/1H. (1371.5.1b)

c. Given a Daily Process Report (DPR) and a list of ERO numbers, with the aid of references, identify all items requiring corrective action in accordance with UM 4790-5. (1371.5.1c)

d. Given a Daily Process Report (DPR) and a list of discrepancies, with the aid of references, list corrective action required in accordance with UM 4790-5. (1371.5.1d)

e. Given a Daily Transaction Listing (DTL), with the aid of references, identify the corrective action required for each transaction that did not process in accordance with UM 4790-5. (1371.5.1e)

f. Given a Daily Transaction Listing (DTL), with the aid of references, identify the corrective action required for each transaction that processed with non-critical errors in accordance with UM 4790-5. (1371.5.1f)

OUTLINE:

1. **Form NAVMC 10245, ERO (Equipment Repair Order).**

(REF: TM 4700-15/1H PG. 2-2-1)

a. Purpose. The purpose of an ERO is to request the performance of equipment maintenance to include modification, calibration, and LTI's on all tactical ground equipment within the unit's organic maintenance capability. It is used for transmitting work to higher levels of support and for recording and reporting the services performed in its accomplishment. Maintenance personnel will use an ERO in all instances where either repair parts or resources are required in the performance of requested maintenance. This form is not used to request or record either operator maintenance (first echelon) or depot level maintenance (fifth echelon). However, the ERO will be used to evacuate equipment to subsequent levels of support for the performance of maintenance (second echelon or higher) beyond those levels authorized by the requester. It may also be used by first echelon maintenance personnel in conjunction with the EROSL (equipment repair order shopping/transaction list) to order SL-3 components in accordance with prescribed procedures. Preparation of a second echelon ERO for induction of Test Measurement Diagnostic Equipment (TMDE) into the calibration lab is optional. However, the FMSS supported units, whether or not they are preparing a second echelon ERO for calibration/evacuation of items from first echelon, are required to establish a second echelon record on their Daily Process Report (DPR). Units opting to not open an ERO, must outline procedures to evacuate calibration/first echelon items in their maintenance management Standard Operating Procedures (SOP). Non-FMSS users will prepare a second echelon ERO as a control document when physically evacuating calibration/first echelon items.

b. Responsibilities.

(1) Preparing Activity. The preparing activity may be the equipment owner, the equipment user, (e.g., the equipment is on temporary loan), of the equipment custodian as in the case of the maintenance shop evacuating equipment to the next higher level of support. The preparing activity is responsible for the initial preparation of an ERO to include completion of the heading and description of work to be performed. Those items marked with an asterisk (*) will be completed by the preparing activity during initial preparation of the ERO. The "Description of Work" block requires entries by both the preparing and maintenance activity.

(2) Maintenance Activity. A maintenance activity will receipt for the equipment by completing the "Accepted By", "Date" (DRIS), and "ERO No." blocks, and will complete those other blocks as indicated in the preparation instructions. A maintenance activity will enter information on work performed as maintenance actions are completed and will close out the ERO. If it becomes necessary for a maintenance activity to evacuate the equipment to the next higher level of support, the maintenance activity will initiate a new ERO, completing those items required of the preparing activity and using its ERO number as a request number.

c. ERO Composition. An ERO consists of sheets of self-carbonizing paper of four different colors: white, pink, green, and yellow.

(1) The white copy is the original.

(2) The yellow copy, after it is signed by the authorized individual of the maintenance activity, is an owning unit's receipt for the equipment while the equipment is in the maintenance activity.

(3) The pink copy is the administrative copy. It should be utilized to directly input the required information into the FMSS required for the "O", "T", "3" and "9" cards. After the "O" card information is entered, the pink copy will be married to the original for the remaining entries during the repair cycle. The pink copy also may be used to input "O/C" transactions. After the "9" card information is entered, the pink copy may be used for local processes.

(4) The green copy is the shop copy. It contains the original signature of the individual drawing the equipment from the maintenance shop and thus becomes the shop's receipt for return of the equipment.

d. Preparation Instructions. An ERO will be completed as follows. The printed numbers in the blocks of an ERO heading correspond to CC's (card columns) for the "O" card except for the last line of the heading where the numbers correspond to CC's for the "T" or "3" card. Additionally, Various ERO blocks have been shaded to indicate those data elements required for "O/T" and "T" transactions. The printed numbers in the blocks at the bottom of an ERO correspond to CC's for the "9" card. The "Description of Work" block requires entries by both the preparing and maintenance activity. Entries preceded by an asterisk (*) are completed by the preparing organization.

(1) ERO No. The maintenance section enters the ERO number.

*(2) Serial No. Turned In If Different From Below. This item pertains to category C,D,F,H and K ERO's. For category K ERO's that apply to a component of an end item, enter the component serial number. Enter the serial number of the item turned in if different from the serial number entered in the SERIAL NUMBER block. Enter N/A, if not applicable.

(3) Accepted By (Signature). Enter the signature of the person accepting the equipment for the maintenance activity performing the repairs. The signature acknowledges the transfer of custody for the equipment. No entry is required for deferred ERO's until the equipment is actually delivered to the maintenance activity. If the individual accepting the equipment for work is also the person having the authority to authorize the work, this entry is optional.

(4) DRIS (Date Received In Shop). Enter the Julian date on which the equipment is accepted by the maintenance activity performing the repairs.

*(5) ORF (Operational Readiness Float). **LEAVE THIS FIELD BLANK.**

*(6) Organization Doing Repairs. The preparing activity enters the noun name of the organization doing repairs. This field may be left blank when the:

(a) Unit performing the maintenance action is also the equipment owner.

(b) Equipment is evacuated to a higher EOM and the AC is entered on the ERO.

*(7) DEST. AC (Destination Activity). The preparing activity enters the Activity Address Code (AC) of the unit that is conducting the maintenance only when equipment is being evacuated to a supporting maintenance section; otherwise, leave blank.

*(8) Request No. The preparing activity enters the ERO number assigned to its ERO when equipment is being evacuated beyond its authorized EOM.

*(9) DCD (Deadline Control Date). Enter the DCD (the Julian date on which the equipment was actually deadline). An entry is not required if the equipment is not actually deadlined. However a DCD will be assigned when Category Code P items are deadlined. An entry is required for Category Code M ERO's.

*(10) ECH (Echelon). Enter the echelon of maintenance (1,2,3 or 4) to indicate which echelon is performing the repairs. First echelon (1) will only be used when ordering SL-3 components.

NOTE: UPON DETERMINATION THAT MAINTENANCE IS REQUIRED AT 2ND ECHELON OR HIGHER, A 2ND ECHELON ERO WILL BE INITIATED BY THE EQUIPMENT HOLDER TO THE ORGANIC MAINTENANCE SHOP. THE ORGANIC MAINTENANCE SHOP WILL EFFECT ALL REPAIRS WITHIN AUTHORIZED ECHELONS OF MAINTENANCE (EOM) AND RECORD THOSE ACTIONS ON THE 2ND ECHELON ERO. IF THE ORGANIC MAINTENANCE SHOP SUBSEQUENTLY DETERMINES THAT THE ITEM REQUIRES REPAIR BEYOND ITS AUTHORIZED EOM IT WILL EVACUATE THE END ITEM TO THE ACTIVITY PROVIDING THE NEXT HIGHER LEVEL OF SUPPORT VIA A 3RD ECHELON ERO, EVEN IF THAT ACTIVITY IS WITHIN THE SAME ORGANIZATION (E.G., EVACUATED FROM A COMPANY MAINTENANCE SHOP TO A BATTALION MAINTENANCE SHOP WITHIN THE SAME BATTALION). ALL MAINTENANCE PERFORMED AT THAT LEVEL WOULD BE RECORDED AGAINST THAT 3RD ECHELON ERO. IF THE ITEM IS DISCOVERED TO REQUIRE EVACUATION TO A STILL HIGHER LEVEL OF SUPPORT, IT WILL BE EVACUATED ON A 4TH ECHELON ERO TO THAT NEXT LEVEL AND ALL MAINTENANCE PERFORMED THERE WILL BE RECORDED AGAINST THAT 4TH ECHELON ERO. IN THOSE INSTANCES WHERE THE UNIT DOES NOT POSSESS 2ND ECHELON CAPABILITY, A 2ND ECHELON ERO WILL BE INITIATED BY THE OWNING UNIT TO EVACUATE THE ITEM TO THE ORGANIZATION PROVIDING 2ND ECHELON SUPPORT. SECONDARY REPAIRABLE EVACUATED VIA THE MAINTENANCE FLOAT FOR REPAIR WILL BE EVACUATED ON A 3RD ECHELON ERO.

*(11) Serial Number. Enter the serial number of the equipment, if assigned. The serial number is obtained from the equipment data plate. As an example, the serial number from communication vehicles is taken from the data plate, not the registration number of the vehicle. When the serial number is placed on an ERO, the last ten characters of the serial number will be utilized, including symbols, exactly as on the equipment. The serial number will be right justified (i.e., the last number of the serial number will always appear in CC 35). Spaces, however, will not be depicted. Rather, the serial number will be closed up to eliminate spaces. For example, equipment serial number 2109 8A 421-8 will appear on the ERO as 21098A421-8. The serial number of equipment entered on the ERO will correspond with one on the RUAF (Reporting Unit Allowance File). In those cases where a USMC serial number has not been assigned, a local serial number must be assigned to the end item per instructions contained in UM 4400-124. Secondary repairable floats entering components into maintenance activities will enter the serial number of the component. If more than one item is being batch entered for repairs or LTI's, enter a zero (O) in this block; and list the serial numbers for custody control purposes, if applicable, in the "Description of Work" block. For Category Code C ERO's, the serial number of the end item will be placed in this block. The serial number of the component. turned in for repair will be entered in the block marked "Serial No. Turned In If Different From Below". If the item has no serial number, enter a zero (0). For calibration ERO's enter the end item serial number.

NOTE: THE BASIC SOURCE FOR THE MIMMS AIS SERIALIZED RECORD IS THE SASSY (SUPPORTED ACTIVITIES SUPPLY SYSTEM) CMR (CONSOLIDATED MEMORANDUM RECEIPT) RUAF. THE CMR'S LIST SHOULD ACCURATELY PORTRAY THE SERIAL NUMBERS OF EQUIPMENT IN THE RUAF. OTHERWISE, THE ERO'S FORM NAVMC 10245, OPENED FOR EQUIPMENT SERIAL NUMBERS NOT IN THE RUAF ARE UNABLE TO POST DATA TO THE MIMMS AIS.

*(12) Job ID. **LEAVE THIS FIELD BLANK.**

*(13) Qty. Enter the number of items to be repaired under this ERO number. Ensure that the field is filled; e.g., a quantity of "1" is entered as "01" and a quantity of "10" is entered as "10".

*(14) RDD (Required Delivery Date). Enter the Julian date the equipment is required by the owner. Entry of an RDD is optional unless yes (Y) is indicated for an ORF exchange.

*(15) Owning Organization. If an ERO is being prepared by the using unit, enter the designation (short noun) of the activity (may be the parent the ERO is being prepared by a supporting service unit, enter the designation of the using unit.

*(16) Owner AC (Activity Code). Enter the AC of the unit accountable for the equipment.

*(17) Authorized By (Signature) Date. Enter the signature of the individual authorizing the work and the Julian date on which the ERO is signed. Ensure that the individual has the authority to sign an ERO for the command and that the authority extends to the priority assigned. If the commander has authorized a repair with a priority based on Urgency of Need Designator (UND) "A", he may delegate in writing authority to sign Category Code "C" ERO's of similar priority which support that repair. In those cases where the priority is upgraded (e.g., Priority 13 to Priority 06), a new priority signature and date will be required if the original signer did not have the authority to assign the upgraded priority in accordance with the current edition of MCO 4400.16. The priority will be entered in the "Description of Work" block and the signature in the "Mechanics Signature" block.

*(18) Defect. Enter the defect code found in UM 4790-5 which best describes the nature of the equipment defect. This entry is optional for units not supported by the FMSS.

*(19) PRI (Priority). Enter the priority assigned to the ERO. The priority is established in accordance with MCO 4400.16.

*(20) ID Number. Enter the system ID (Item Designator) number of the end item undergoing repair. Ensure the alpha character of the ID number (06533A) is the correct designation for the specific item of equipment. For Category C,F,H and D ERO's enter the secondary repairable ID number (if it exists). For all other Category Codes, as well as calibration ERO's, enter the end item ID number.

NOTE: FOR CATEGORY CODES F,H AND D A "3" TRANSACTION WILL BE SUBMITTED INDICATING THE NOMENCLATURE, NSN AND WEAPON SYSTEM CODE (WSC), OF THE ACTUAL COMPONENT. TURNED IN. THIS WILL APPEAR ON THE DAILY PROCESS REPORT TO ASSIST IN DETERMINING THE ITEM UNDER REPAIR.

*(21) Nomenclature. Enter the short noun nomenclature and/or model number of the equipment being submitted for repair.

*(22) Category Code. Circle the applicable code.

Code	Definition
M	Readiness-reportable equipment, unit, critical repairs which deadline the item.
N	Non critical maintenance to readiness or non readiness reportable end items.
P	Non readiness reportable, critical repairs which deadline or degrade its operational capability.
X	Readiness reportable, requiring critical repairs that do not deadline the item but degrade its operational capability.

C Component of an end item which deadlines or precludes the end item from operating at its full capacity. Category Code C ERO's are primarily for inter shop use. The status of the end item (deadlined or operational/ readiness or non readiness reportable) must be reported through the use of Category Code M,N,P or X ERO's. Category Code C is used to distinguish between repair for return to the end item/user as opposed to return to the supply system of a repairable (maintenance float) as is the case of Category Code F,H or D. There are cases when the Category Code C will apply to the inter shop of end items.

D Depot repairable as indicated by the item recoverability code.

F,H Secondary repairable as indicated by the end item's recoverability code.

K Calibration only.

O Shop overhead, pre-expended bin items.

S SL-3 components for end items.

(a) The number of ERO's which may be opened on a specific item of equipment and the procedures for upgrading and downgrading Category Codes will be subject to the following procedures.

1 When an end item is deadlined, a Category Code M or P will be assigned as required. When an item has been repaired to the extent that it is no longer deadlined the category code of the ERO will be changed or the ERO closed.

2 When an end item requires critical repairs which do not deadline the item but degrade its operational capability, a Category Code X or P will be assigned as required.

3 Only one ERO (Category Code M,X or P) may be opened on a specific item at one time at each echelon of maintenance.

4 More then one category code ERO other then M, X or P may be opened on a specific item of equipment within the same level of maintenance or for evacuation. However, since an ERO is basically a control document, care should be exercised in opening multiple ERO's. Under no circumstances will more then one ERO serve as a receipt for an item opened to evacuate the equipment.

5 Active Category Code N or X ERO's applicable to a deadlined item may be upgraded only if Category Code M has not previously been used on that particular ERO and at least one task data field for recording major defects remain open. Active Category Code N or X ERO's resulting from a previous downgrade from Category Code M will not be upgraded a second time. Any ERO for which all three-task data fields for recording critical defects have been used may not be further upgraded or downgraded.

6 If a Category Code M ERO is required on an item of equipment for which there is an existing Category Code X ERO, the Category Code X ERO must be upgraded to Category Code M, closed or downgraded to Category Code N. If downgraded to Category Code N, all outstanding requirements for critical parts will be transferred to the new Category Code M ERO. Outstanding requirements for non critical parts will remain on the

downgraded ERO.

<u>7</u> Upon correction of the dead lining condition, Category Code M ERO's must be either closed or downgraded to Category Code N or X if additional repair action is still required. If, however, downgrading will result in the loss of maintenance data because of the correction of more then three major defects, it is desired that the ERO be closed and a new ERO with appropriate category code be opened. This does not restrict the option of upgrading Category Code N ERO's to either Category Code X or P as applicable providing that all pertinent defects can be reported upon closure of the ERO.

(b) Category Code O ERO's are to establish an ERO base in the FMSS which will allow the requisition of pre-expended bin and shop overhead materials. When such materials are associated with a specific type of equipment, the ID number of the equipment type will be used. When such material is applicable to more then one equipment type, the dummy ID numbers shown in the MIMMS AIS ID Standards File as shop overhead will be used.

(c) Category Code S ERO's may be used to establish an ERO base in the FMSS which will allow the requisitioning of operator/crew materials (SL-3 components). When such materials are requisitioned, the ID and serial number of the equipment end item will be used. If the end item serial number cannot be determined, then a local serial number will be assigned to the end item in accordance with UM 4400-124. If the ERO is opened against a multiple quantity of end items of the same type, (a batch ERO), a single right justified zero (0) will be used in lieu of a serial number. However, the use of category code "S" ERO's to requisition all SL-3 deficiencies of a given commodity, e.g., motor transport, under a dummy TAM number is not authorized. Category code "S" ERO's should only reflect current demands and will not be used as a pending/pest record of items procurable from non-system sources such as Direct Stock Service Center (DSSC), Self Service, etc. Accordingly, there is no requirement to record non-system demands/receipts with the "SC","PB" or "99" advice codes as the listing is already passed to the system on a monthly update. When the lack of an SL-3 component. deadlines the item, the SL-3 component shall be ordered under the ERO that deadlines the equipment.

(d) Category Code C allows to inter shop major components of an end item to maintenance shops at the same echelon or evacuate to a higher echelon of maintenance. Additionally, it allows maintenance shops to inter-shop end items at the same echelon due to restraint of one Category Code M, P or X ERO's at the same echelon.

(e) Equipment is considered deadlined if it is not mission capable (i.e., can not perform its designed combat mission due to the need for critical repairs). Routine modifications, scheduled maintenance, or lack of non-critical repair parts (e.g., fenders and windshields will not in themselves cause a reportable deadline condition). It is the responsibility of the organization that owns an item to determine its deadline status and to ADD the item to deadline, if appropriate. It is also the responsibility of the organization that owns an item to DELETE the item from deadline, if it previously had been in a deadline status. It is the responsibility of the organization which is repairing the deadline item to report any changes in the condition of that item (e.g., NMCM to NMCS).

NOTE: "CRITICAL PARTS" ARE DEFINED AS THOSE PARTS OR SECONDARY REPAIRABLE WHICH PRECLUDE AN ITEM FROM PERFORMING ITS INTENDED MISSION OF SHOOTING, MOVING, OR COMMUNICATING AND WHICH REQUIRE SECOND THROUGH FIFTH ECHELON EXPENDITURE OF MAINTENANCE HOURS. "NON CRITICAL PARTS" ARE THOSE PARTS OR ACCESSORIES WHICH AFFECT AN ITEMS ABILITY TO DO ITS INTENDED MISSION BUT DO NOT PRECLUDE IT FROM SHOOTING, MOVING, OR COMMUNICATING.

(23) Job STAT (Status). Enter the appropriate code from the UM 4790-5, which represents the present status of the equipment (e.g., 00 for awaiting inspection, 12 for repairs in progress, etc.). This entry is optional for units not supported by the FMSS.

*(24) JON (Job Order Number). **LEAVE THIS FIELD BLANK**

(25) Shop Sect (Section). Enter the appropriate shop section code as indicated in UM 4790-5. This entry is optional for units not supported by the FMSS.

*(26) Release From Investigation (Signature). **LEAVE THIS FIELD BLANK**

(27) Disposition-Reference. Enter the reference documentation if the item has been declared unserviceable. If the ERO has been opened for more then one item (batching), the reference documentation will be indicated in the "Description of Work" block by serial number, unless the disposition instructions apply to all of the batched items.

*(28) Owners Phone No. Enter the telephone number of the individual/ section to be notified upon completion of the requested services.

*(29) Sec Rep (Secondary Repairable) NSN. **LEAVE THIS FIELD BLANK**

(30) Remarks. Enter any other information considered appropriate by the originator or maintenance activity. Items to be entered:

(a) Old and new meter readings when odometers or hour meters are replaced.

(b) End item ID number for Category Code D items.

(31) Card Type. Circle either T for "T" transaction or 3 for "3" transaction to indicate the desired transaction. When the T is circled, a "Y" may be placed in either the P or LP block if "parts" or "later parts" is required. The MAU block is used only by West PAC units to enter the appropriate MAU indicated on the "T" transaction.

(32) NSN of Item. Enter the NSN of the item to be repaired for "3" transaction submission. The NSN will be left blank for Cat Code C ERO's. For Category Code F, H or D ERO's, if the ID number block is blank or the SEC REP ID is not on the ID Standards File, the SEC REP NSN is a required entry

(33) T-DRIS. Enter the Julian date on which the equipment was received in the shop performing the repairs.

(34) WSC. For the "3" transaction, enter the weapon system code of the item to be repaired if applicable. Weapon system codes for readiness reportable items are found in the current Marine Corps Bulletin in the 3000 series. The WSC of the end item will be used for Category Code C ERO's.

(35) Nomenclature. For the "3" transaction, enter the nomenclature of the item being repaired. For calibration ERO's on components ensure a "3" transaction is submitted to change the nomenclature. For Category Code F, H or D ERO's when the ID number block is blank or the SEC REP ID is not on the ID Standards File, the SEC REP nomenclature is a required entry.

(36) TAM CN/ID No. For the "3" transaction, enter the TAM number of the item being repaired. For Category Code C ERO's, enter the TAM of the end

item from which the component was removed. Intermediate maintenance facilities will enter the end item ID for secondary repairable. Entry will be right justified; i.e., ID number 04078C will be entered as 4078C. For F, H or D coded SEC REPs enter the last five digits of the actual end item ID number.

NOTE: WEST PAC UNITS ONLY WILL ENTER THE JOB ORDER NUMBER TO WHICH PARTS ARE TO BE BILLED IN CARD COLUMNS 27 THROUGH 40 ON THE SIXTH LINE OF THE ERO WHEN SUBMITTING A "T" TRANSACTION.

(37) Item No. Enter the number of each task performed in numerical sequence. This number may correspond to the task number in a TM (technical manual); if so the TM must be referenced in the "Description of Work" block one time. When utilizing task numbers from a TM during the performance of scheduled maintenance, only list in chronological order those tasks where actual work is performed (i.e., tighten, adjust, test, lubricate, remove, replace). If the TM does not indicate task numbers, list only those where actual work is performed. However, if during a task which calls for observation, a work task is performed (i.e., replace air filter if unserviceable), this work task should be indicated in the ERO.

(38) Description of Work. The preparing activity will enter a brief description of each task or symptoms of the failure. Units supported by the FMSS will also enter the primary and secondary defect codes in accordance with UM 4790-5 (e.g., Perform APM (b52), replace hour meter (X34), replace R22 in R/T front panel (T40), etc.). The maintenance activity will indicate the tasks as performed. These will correspond to the defects listed in the lower portion of the ERO. When all available parts are placed on the equipment and this does not complete the task, this will be indicated in general terms with labor hours in the appropriate column (e.g., replaced R-1, replaced door handle, etc.). Although procedures for a scheduled maintenance may require actions such as lubricate, replace oil/air/fuel filter(s), adjust brakes, etc., which may be identified as defects, these actions will be included in the PM defect code and listed under the PM defect as separate tasks performed. If during the PM, an area is found to be defective, such as bad break linings, these defects will be listed after the PM task, and defect code(s) and labor hours will be indicated. When entering a priority upgrade, ensure the new priority and date are entered in the Description of Work column and the new authorization, when required, in the Mechanics Signature block. Line out the original signature and the original priority when a new signature is entered.

NOTE: WHEN AN ENTRY FOR PM SERVICES IS LISTED IN THE DESCRIPTION OF WORK BLOCK ON THE ERO, AND THE PM HAS BEEN COMPLETED, THE DATE THE PM WAS PERFORMED MUST BE ENTERED. THIS DATE IS REQUIRED FOR COMPLETION OF THE NAVMC 10561.

(39) Labor (Hours). Enter the total labor hours to the nearest one-tenth of an hour required to repair each defect listed in the "Description of Work" block (e.g., Perform APM (b52) 6.3, replace hour meter (X34) 3.1, etc).

(40) Mechanic (Signature). Enter the signature of the mechanic/ repairer performing the repair of the defect. If more then one mechanic/ repairer performs the repair, the senior supervisor will affix his/her signature as the responsible individual. Enter the signature of the person authorized to upgrade the priority when required.

(41) Status. Enter changes to equipment and/or ERO status as they occur; e.g., short tech, repairs in progress, and repairs complete. This will provide a history of the equipment on the ERO and also a vehicle from which "O/C" cards may be entered into the FMSS. It is not necessary to indicate all of the changes of status that occur the same day but only the last change that

occurs on that day.

(42) Code. Enter the job status code that corresponds to the job status entered in the status column as described in the preceding. Entries in this column are mandatory/optional as established in the major command maintenance management SOP and optional for units not supported by the FMSS.

(43) Status Date. Enter the Julian date the change in status occurred.

(44) Non-SASSY Parts, Nomen, NSN or Part No. **LEAVE THIS FIELD BLANK.**

(45) QTY. **LEAVE THIS FIELD BLANK.**

(46) Cost. **LEAVE THIS FIELD BLANK.**

(47) Civ. Labor Chg. (Civilian Labor Charge). Enter the total civilian labor charge to the nearest cent. Enter the cents in 18 and 19.

(48) Non -SASSY Parts Chg. **LEAVE THIS FIELD BLANK**

(49) Date Closed. Enter the Julian date the ERO was returned to the owning unit.

(50) Mil Labor Hr (Military Labor Hours). Enter the total military labor hours used during the repair of the equipment to include Q.C. inspection time to the nearest one-tenth of an hour. Enter tenths of an hour in column 36.

(51) Close Stat (Status). Enter the completion job status code from UM 4790-5. This entry is optional for units not supported by the FMSS.

(52) NO. Unser. Enter the number of secondary repairable items which were washed out during the repair cycle. If the quantity washed out was "1", it will be entered as "01". This entry is made by fourth echelon capable units. This entry is optional for units not supported by the FMSS.

(53) EOTC (Equipment Operating Time Code). Enter the appropriate EOTC for the equipment repaired. The valid entries are "D" for days, "R" for rounds, "H" for hours and "M" for miles. To use hours, the equipment must have an hour meter from which to get a reading. In order to use miles, the equipment must have an odometer from which to get the reading. The EOTC may be obtained from the ID Standards File or the Daily Process Report. No entry is required for secondary repairable or items not on the ID Standards File. This entry is optional for units not supported by the FMSS.

(54) Primary Meter Reading. Enter the primary meter reading at the time the equipment was repaired. The meter reading must be compatible with the primary EOTC. The meter reading is taken to the nearest whole mile/hour. An entry is required for items with a primary EOTC of "H" or "M". If the primary meter is replaced during the repair cycle, enter the new meter reading and ensure that one of the defect codes in the task data fields reflects the fact that the meter was changed. The old and new meter readings are entered in the remark block.

(55) Task Data Fields.

(a) If the second position of the "Job ID" is "3" or "$", refer to the procedures for completing the 9 transaction in the UM 4790-5.

(b) The "Task Data Fields" provide for the entry of defects with attendant tasks and work hours to effect repair of the defects into the FMSS.

(c) If three or less defects have been repaired/corrected, they will be entered in "Defect 1, 2 or 3", as appropriate.

(d) If more then three defects have been repaired/corrected, the three most prominent defects will be entered. This will include any PM and hour meter or odometer changes.

(e) Entries in this area are optional for units not supported by the FMSS.

1 Defect1, Defect 2, and Defect 3. Enter the appropriate defect code from UM 4790-5.

2 Tasks. Enter the number of tasks associated with the defect code. This block must be completely filled. "2" tasks are entered as "002".

3 Work Hours. Enter the total number of labor hours it takes to repair/correct the defect to the nearest one-tenth of an hour. Enter the tenths of an hour in columns 57,67 or 77 as applicable.

(56) Inspected By (Signature) Date. Enter the signature of the individual performing the quality control inspection of the repaired equipment and the Julian date the item was inspected.

(57) Owner Notified-Name Date. Enter the name of the individual in the owning unit who was notified to pick up their equipment/ERO due to work completion. Also, enter the date notified. If the unit is notified more then once, make additional entries under the first entry. If the unit performing the maintenance actions is also the owner, this entry is optional.

(58) Delivered to (Signature) Date. Enter the signature of the individual authorized by the owning unit to receipt for the equipment upon completion of work. Enter the date of the signature as proof of return of equipment, the copies of the ERO will be arranged in such a manner so as to obtain the original signature on the green copy (shop copy) of the ERO.

e. Disposition. Upon acceptance of an ERO and the equipment by the maintenance activity, the yellow copy of an ERO is returned to the originator as a receipt. Upon completion of the required maintenance services, the yellow copy is returned to the maintenance activity and, the original (white copy) will be returned to the using/owning unit (with the original copy of the EROSL for Non-FMSS units) for filing in the equipment record jacket/folder, and retention for a minimum of 1 year. If the interval between maintenance actions exceeds one year, then the most recent completed maintenance ERO will be retained in the equipment record jacket/folder. Upon return of the equipment to the using/owning unit, the yellow copy will be destroyed by the maintenance activity. In the case of deferred/unit recall ERO's, careful local procedures must be established to ensure proper accountability of the equipment and use of the yellow copy as a receipt after the maintenance activity signs the "Accepted By" block of the ERO. The green copy of the ERO will be retained in the files of the maintenance activity for a minimum of 1 year unless the maintenance activity also is the unit that has custody of the equipment records, in which case retention of the green copy is not mandatory. After the pink copy is used to close out the ERO in the FMSS, it may be disposed of in accordance with local procedures.

(1) When equipment is evacuated to a higher level of maintenance, an open ERO must exist at both the evacuating level (2nd or higher) and the level to which the item was evacuated, even if they are within the same unit. The one exception is calibration where only a record of the evacuation on the DPR is required.

(2) An ERO initiated to authorize PM service will normally be closed when the PM has been completed. However, if during the accomplishment of the PM, it is determined that the equipment requires CM, the PM service will be completed as far as possible and practicable; and CM action may be continued on the same ERO. If the nature of the CM action and type of equipment requires an upgrade of priority or change of mission essentially, changes will be made by crossing through the original entry; entering a new priority, as appropriate; and recording a new authorization signature from the ERO originator, if required in the Description of Work/Mechanics Signature block. The authorizer will initial the changes. If a change of category code is required by CM, it will be accomplished in accordance with the procedures in paragraph 2-2d(22)(a). Priority upgrades in support of Category Code changes will be in accordance with the guidance in Table 2-1 and MCO P4400.16

(3) When scheduled PM services requiring an ERO become due while an item is undergoing CM, the PM services and date accomplished will be recorded on the CM ERO, thus providing a record for upgrading PM schedules and precluding the necessity for opening another ERO.

(4) Required CM on equipment for which a deferred ERO has been submitted may be performed using the deferred ERO as the authorizing document.

NOTE: A DEFERRED ERO IS ONE WHICH HAS BEEN ACCEPTED BY A MAINTENANCE UNIT TO ALLOW IT TO OBTAIN THE NECESSARY PARTS AND/OR SCHEDULE THE EQUIPMENT FOR MODIFICATION, CALIBRATION, ROUTINE CM AND/OR PM. WHEN PROPERLY USED, IT ALLOWS BETTER SCHEDULING OF SCARCE MAINTENANCE RESOURCES AND UTILIZATION/ UPKEEP OF EQUIPMENT ITEMS. THE USE OF JOB STATUS "UNIT RECALL" SHOULD NOT BE CONFUSED AND USED INTERCHANGEABLY WITH "SHORT PARTS".

(5) An ERO will be prepared for each end item requiring maintenance, except in those instances where equipment is normally in "batched" or large quantities; i.e., 782 gear, brake shoes, rifles, pistols, non-depot secondary repairable, LTI's, and pre fire range checks. All items in the batch must have the same ID number. Individual serial numbers, where applicable, of those items submitted in a batch will be listed as set forth in paragraph 2-2d(11). Principal end items (Class VII) of equipment will not be batched for either modification application of PM, nor will mission-essential items (readiness-reportable) be batched for CM. TAM Type II items may be batched for PM. Units may optionally use a batch ERO to obtain modification kits and/or materials required to apply the modification. However, upon receipt of all kits/materials required to apply the modification, an ERO will be opened for each item of equipment requiring modification. Appropriate "4" and/or "8" transactions will be processed for each ERO.

(6) Either a copy of the maintenance forms utilized by other services/fifth echelon (depot) maintenance such as U.S.Army DA-2407, in the accomplishment of maintenance services under an ISSA (inter service support agreement), or a transcription on an ERO must be filed in the equipment record jacket or folder and maintained there the same length of time as an ERO. The transcription should contain all information available that is required on an ERO/EROSL.

(7) Certain key entries on the ERO are transposed from the ERO into the AIS through various means for units supported by the MIMMS AIS.

(8) When a NAVMC 10925, ERO Shopping/Transaction List (EROSL), is properly completed in accordance with paragraph 2-3, it will constitute authorization for the requisition of any parts for an associated ERO.

(9) When the quantity of information recorded on an ERO exceeds available space, another form NAVMC 10245 will be attached as an addendum page. Required information on addendum pages will be the ERO number and the associated serial number reflected on the first page of the ERO. When closing the ERO, the bottom portion of the first page will be completed.

2. **Form NAVMC 10925, EROSL (ERO Shopping/Transaction List).**

(REF: TM 4700-15/1H PG.2-3-1, UM 4790-5 PG.4-1)

a. Purpose.

(1) Use. The EROSL is a dual purpose form. It serves as the ERO shopping list and as a MIMMS data input form. The EROSL will be used in conjunction with the ERO to requisition, receipt for, cancel, and record partial issues and credits of repair parts and secondary repairable associated with ground equipment undergoing repair. Additionally, to simplify data input, all required MIMMS input transactions may be placed on the EROSL.

NOTE: USE OF THE EROSL IS OPTIONAL FOR NON-FMSS SUPPORTED UNITS UNTIL CONVERTED TO AN AUTOMATED SYSTEM. IF LOCAL FORMS (DD 1348-1.ECT.) ARE USED IN LIEU OF THE EROSL, DISPOSITION INSTRUCTIONS WILL BE THE SAME AS FOR THE EROSL.

(2) Configuration. The EROSL is configured in a pad of 100 sheets. The forms are self-carbonizing to permit their preparation in the desired number of copies. The front and back covers of the pad are printed with instructions and may be used as templates for completing the actual EROSL, however, the current edition of UM-4790-5 is the preferred reference for completing the EROSL data elements for all MIMMS input transactions.

b. Preparation Instructions (4 Transaction).

(1) Responsibilities.

(a) ERO Holder. The ERO holder is responsible for the initial preparation of the EROSL, to include the ERO number, Unit, Date, circling the Material Usage Code ("6" is for SL-3 components, "7" is for CM and secondary repairable, "8" is for modification, and "9" is for PM), annotating the shop section and entering the reference source in the letter blank "A"; the remaining letter blanks may be used as specified in local SOP's to provide additional information.

(b) Maintenance Shop. The maintenance shop will complete the "Maint Date/Init" fields on the header portion of the EROSL and will fill in information for the requisition of parts as indicated in the current edition of UM 4790-5 except for the document number and the SASSY Advice Code. Additionally, the maintenance shop will fill in the required information for requesting secondary repairable as instructed by the current edition of the UM 4790-5, except for the document number, secondary repairable NSN, supplementary address, unit of issue, JON, Demand Code, and Advice Code.

(c) Issue Point. For issues of backorders, the issue point is responsible for completing the document number and the SASSY Advice Code, researching parts information to ensure accuracy, issuing parts on hand "over-the-counter", backordering required items, and preparation of receipt transactions. In addition, the issue point is responsible for initialing the

"Supply-Ip Date/Init" fields on the header portion of the EROSL and will complete the information for the requisition/receipt of parts as indicated in the current editions of UM 4790-5 and UM 4400-124.

(2) Parts Information.

(a) CC 1 Transaction Code/Card Type. Enter a 4. This is a required entry.

(b) CC 2-6 ERO Number. Enter the ERO number to which the parts information applies. This is a required entry.

(c) CC 11-23 Repair Part/Sec Rep NSN. Enter the NSN of the repair part to be added. This is a required entry.

(d) CC 24-25 Quantity. Enter the quantity of repair parts to be added. This entry must be numeric and right justified. The field must be filled (e.g., a quantity of one would be entered as 001).

(e) CC 28-40 Document Number. Enter the document number of the part to be added. This is a required entry, completed by the supply section. CC-37 must contain a valid material usage code.

(f) CC 42-43 Priority. Enter the priority of the parts to be added. The priority should not be higher then the priority of the ERO. This is a required entry.

(g) CC 44-48 Supplementary Address. Enter the supplementary Unit Account Code. This field may be left blank, however, when ordering Sec Reps this is a required entry, completed by the issuer.

(h) CC 49-50 Unit of Issue. Enter the Unit of Issue of the parts. This is a required entry and must match the SASSY MHIF for the NSN.

(i) CC 51-64 Job Order Number. Enter the JON to which parts charge is to be billed. This is a required entry.

(j) CC 66 Demand Code. Enter the code that reflects if the demand code is recurring (R) or nonrecurring (N).

(k) CC 67 Non Mission Capable Supply. Enter the NMCS indicator (N) for NMCS requisitions, (E) for anticipated NMCS requisitions, or (9) for expedite handling. This field may be left blank.

(l) CC 68-69 Advice Code. Enter the advice code that best suits the parts being added. This will be completed by the supply section.

(m) CC 70-79 Part Name. Enter the nomenclature of the part(s) to be added, left justified. This field may be left blank. If left blank, the nomenclature will automatically appear if it is resident in the SASSY files.

(n) CC 80 Transaction Type. Enter an "A" to indicate a 4 Add (parts) transaction. This is a required entry.

c. Special Instructions.

(1) Pre-Expended Bin (PEB) Items. All PEB items will be requisitioned under a shop overhead ERO in accordance with paragraph 2-2d(22)(b) of TM 4700-15/1f and UM 4790-5. Additionally, parts usage for PEB items applied in quantities equal to or in multiples of the Unit of Issue will

be reported via the EROSL with MIMMS Advice Code "PB" and attached to the associated ERO.

(2) Scrounged Repair Parts. All repair parts obtained through scrounge action will be reported via the EROSL with MIMMS Advice Code "SC" and attached to the associated ERO.

(3) ERO Parts Bin. An ERO Parts Bin is an area where the parts ordered on an ERO are stored, waiting to be placed on the equipment. The area can be a shelf, box, or something similar. All small parts for the same ERO are kept together in the same ERO bin, the location of which is normally indicated by the ERO number. Large parts, by virtue of their size, require a larger area and are normally stored together, regardless of the ERO to which they belong.

(a) Upon receipt of parts which will not be immediately installed on the equipment, the EROSL will be annotated as to the date/quantity of items received and ERO bin location, if the location is designated by other then an ERO number.

(b) If parts are removed from the ERO bin for installation, the shop copy of the EROSL will be annotated by the mechanic or shop chief accordingly.

(c) The method of annotation may be by circling, checkmarks, use of blanks in the heading of the EROSL, use of unused card columns, or written information on the EROSL. The annotation procedures must be contained in the unit's Maintenance Management SOP.

d. Disposition. Upon completion of the required requisition information by the using unit, the EROSL is taken to the issue point where issues are made, if possible. The issue point completes its required information for repair parts/secondary repairable and returns the second copy of the EROSL to the requisitioner. The issue point maintains the first copy for local use while parts/secondary repairable are outstanding. The issue point forwards the original EROSL to the keypunch center for processing. The keypunch center returns the original to the issue point when the required information has been automated. When all part transactions reflected on the EROSL have been accepted on the Daily Transaction Listing/Daily Process Report, the original EROSL is returned to the originator who will join it with the original ERO. FMSS supported units are not required to retain the EROSL after the ERO has been closed. Non-FMSS supported units will file the completed original (or its commercial equivalent) ERO and EROSL together and retain them for a minimum of one year. If the interval between maintenance actions exceeds one year, then the most recent completed ERO and EROSL will be retained in the equipment record jacket/folder.

3. **DAILY PROCESS REPORT.**

(NOTE: FOUND IN UM 4790-5 PG.17-19)

a. Description. This report provides maintenance managers at all levels visibility of active EROs in their shops.

(1) EROs which have had action taken will be indicated by two asterisks (**) to the left of the ERO number.

(2) The parts charge is cumulative, increasing whenever an 8 card (receipt) is processed.

(3) The job status field is capable of presenting up to ten history entries. Any quantity over ten will cause the oldest status to drop from the record.

(4) Supply status on this report is normally entered automatically from SASSY and MILSTRIP input. The ability to enter manual status is available using the MIMMS 7 transaction.

b. Use. The information on this report provides the complete history of an item in the maintenance cycle.

(1) Distribution of this report should be to the shop section level and the unit MMO.

(2) Information for each open ERO is presented in ERO sequence.

(3) The first two lines of each ERO present basic identification data and current maintenance status.

(4) The third line for each ERO is a listing of repair parts requirements and the supply action to date on these requirements. The MMO can quickly see the outstanding requirements and their current status's. This information can also be used to verify that priorities of maintenance are in agreement with repair parts requirements.

(5) Situations can also be spotted where maintenance activities have added on parts, which may indicate poor initial inspection. Repeat parts can be identified which may indicate that parts previously received have been applied elsewhere, the initial inspection was faulty, parts previously received were faulty or damaged, or that the mechanic lost the part during installation.

(6) Additionally, the misuse of category codes, priorities, and NMCS/ANMCS indicators is recognizable. The MMO can identify parts which have long lead-times based on current status and take action to expedite

(7) This report is a tool which maintenance management personnel can use to conduct the sassy additional demand reconciliation.

(8) For specific information on reconciliation, refer to the current editions of MCO P4790.2 and UM 4400-124.

(9) Via submissions of a T transaction, the MMO can identify the parts on requisition at a different echelon of maintenance for an item of equipment.

(10) Finally, upon closeout, the MMO can see the labor and material resources expanded for a given ERO.

c. Legend:

(1) First Line.

(a) ERO - This column displays the equipment repair order number.

(b) TAM - This column displays the table of authorized material control number of the equipment undergoing maintenance.

(c) ID - This column displays the identification number of the equipment undergoing maintenance.

(d) SERIAL # - This column displays the USMC/manufacturer's serial number of the equipment undergoing maintenance.

(e) JON - This column displays the account number to which the cost of maintenance is to be charged.

(f) CAT - This column displays a code which identifies the category of the equipment undergoing maintenance. This code is used in the production of equipment readiness transactions.

(g) RDD - This column displays the required delivery date. A date entered in this field indicates the equipment's criticality to the unit and will specify the date on which the unit requires the equipment. If this date cannot be met, an ORF exchange may be required or requested.

(h) PRI - This column displays the priority of need of the equipment having maintenance performed.

(i) NSN - This column displays the national stock number (NSN) of the equipment having maintenance performed.

(j) NOMEN - This column displays the noun name of the equipment having maintenance performed.

(k) DCD - This column displays the deadline control date. The date on which the equipment was actually deadlined.

(l) DRIS - This column displays the date received in shop. The date on which the equipment was received in the shop performing the maintenance.

(m) JOB-ID - This column displays the job identification code. A code which best describes the maintenance action being performed.

(n) ORF - This column displays the operational readiness float indicator. A code of Y in this field indicates that an ORF replacement item is desired by the unit. If an ORF exchange is required, the RDD must also have been entered. A code of N indicates an ORF replacement item is not desired.

(o) EOTC - This column displays the equipment operational time code. The code, extracted from the ID standards file, identifies the primary operating mode for the item of equipment such as miles, hours, days, or rounds.

(p) CLOS - This column displays the close flag. A code of NO indicates that the ID number/serial number of the record did not match an NSN/serial number on the SASSY reporting unit allowance file (RUAF). The record cannot be closed until this flag is removed by corrective action. Blank indicates either a match or no edit.

(2) Second Line:

(a) AWTG-STAT - This column indicates the status of the equipment prior to being inducted into the maintenance cycle or once maintenance has been completed.

(b) DEST-AAC - This column displays the destination ACC to which the equipment is being evacuated for repairs.

(c) JOB-STATUS - This column reflects the actions which have occurred on the equipment and the date each action was initiated.

(d) PARTS CHARGE - This column displays the accumulated parts charge for those parts that have been obtained. Non-system parts charges are input via the 9 transaction. SASSY parts charges are computed during system processing.

(e) ECH - This column displays the echelon of maintenance. These codes indicate the echelon performing the required maintenance such as 1 or 2 (organic), 3 or 4 (intermediate).

(f) QTY - This column displays the quantity of equipment undergoing maintenance.

(g) X-EROS - This column displays the two intershop/interechelon EROs for an item of equipment. These ERO numbers reference EROs of different maintenance activities.

(h) MARES/DATE - This column displays the MARES logistics readiness indicator. A machine-generated code which identifies the type of LM2 readiness transaction that has been prepared for an ERO and the date of that transaction.

(i) DEFECT - This column displays the interpretation of the defect code used in the input transaction. The first part of the interpretation relates to the first character of the defect code, and the second part of the interpretation relates to the second and third characters of the defect code.

(j) DDL - This column displays days deadlined. The total number of days the equipment has been deadlined. This is the sum of the current processing date minus the DCD or the accumulated category M-days deadlined.

(k) DIS - This column displays days in shop. The total number of days the equipment has been in the maintenance shop. This is the sum of the current processing date minus the DRIS.

(L) OWNER - This column displays the activity address code of the unit which owns the equipment.

(3) Third Line.

(a) RCVD - This column serves two purposes. First, when an item has been received and the receipt processed, the date of receipt will be posted. Second, when a cancellation request has been inducted for an item, The letter C will be posted. If the column is blank, it indicates the parts record is open.

(b) DOCUMENT # - This column displays the unit document number used for repair parts requisitioned or the applicable modification instruction number. When a secondary repairable is issued over the counter to the customer by the maintenance float, the document number of the maintenance float will be reflected. When a secondary repairable is back ordered to the customer by the maintenance float, the document number of the using unit will be reflected.

(c) U/I - This column displays the unit of issue of the item requested.

(d) QTY - This column displays the quantity of material requisitioned.

(e) PRI - This column displays the priority of the requisition. The priority of the requisition. may not exceed the priority of the ERO; however, parts may be requisitioned. on a lower priority. In other words, If the priority of the ERO is 06 and parts are on order, there should be at least one priority 06 part on requisition. This does not preclude the requisitioning of lower priority parts on a priority 06 ERO.

(f) PART-NSN - This column displays the national stock number (NSN) or local stock number (LSN) of the part requisitioned.

(g) PART-NAME - This column displays the nomenclature of the part requisitioned.

(h) STAT - This column displays the current status on the requisition. The status code is a two digit code that indicates the status of the requisition. at the supply source. When shipping status has been provided to the unit, the mode of shipment code will be reflected. The mode of shipment code is a one-digit code that identifies the means by which the item is being shipped to the unit.

(i) DIC/EXC - This column displays the type of status being provided. The type of status is identified by a document identifier code (DIC). DICs in the AE series identify the status as automatic supply status. DICs in the AS series identify the status as automatic shipment status. Codes in the B series will also appear. These are SASSY exception codes. An exception is generated when a transaction processes against the units loaded unit balance file (LUBF) and conditions were present which caused the exception to be created. When a transaction fails to pass the master edit process in SASSY and is rejected from processing, the letters REJ are entered.

(j) NMCS - This column displays the not mission capable supply indicator which is a code that indicates that the material requisitioned. is for a mission-essential item which is deadlined for lack of the specific material or is anticipated to be deadlined in the near future if the material is not received. An N indicates NMCS, E indicates anticipated NMCS, and 9 indicates items requiring expedited handling.

(k) LKH - This column identifies the last known holder of the transaction. The routing identifier codes for last known holders are contained in the current edition of UM 4400-71. When the LKH is identified as FLT, it indicates that the maintenance float is the supply source for the item.

(l) ADV - This column displays the advice code. MIMMS advice codes identify information relative to the processing of the requisition. and are not input to the supply system. MIMMS advice codes are contained in the legend for the 4 (parts) transaction contained in chapter 6 of UM 4790-5. SASSY advice codes are contained in UM 4400-124.

4. **DAILY TRANSACTION LISTING.**

(NOTE: FOUND IN UM 4790-5 PG.17-7)

a. Description. This report will provide visibility of input transactions that were accepted into the MIMMS daily cycle or rejected because of errors.

(1) The transactions will be presented on the report in the identical format that they were entered into the system. Additionally, the report will display transactions which were system generated in response to other MIMMS or SASSY related input.

(2) This report is divided into three sections:

(a) Transactions processed with no errors.

(b) Transactions processed with non-critical errors.

(c) Transactions that did not process.

(3) When input, transactions will print in the applicable section. For transactions which did not process correctly, an Error Code will be printed to the immediate right of the reflected input. The Error Code will provide you with the specific element(s) in which the error exists and indicates the type of error within that field.

(a) Any associated transaction submitted with an O, T, or O/T transaction will be rejected if a fatal error appears on the O, T, or O/T transaction.

(b) A 4 transaction rejected for a document number or ERO number will cause rejections for the associated 5, 7, and/or 8 transactions.

b. Use. The Daily Transaction Listing is used to validate the unit's input to MIMMS.

(1) This is accomplished by matching the previous day's input data to the transaction on the Daily Transaction Listing.

(2) The unit's MMO will monitor this report to ensure that prompt resubmission of corrected transactions is accomplished by the Maintenance or Supply Section.

(3) Transaction listed under "Transactions That Did Not Process" must be corrected prior to subsequent transactions for that ERO being entered into

(4) The MMO should look for common rejects and conduct appropriate training within commodities/units.

(5) Every effort should be made to ensure that the Daily Transaction Listings are promptly forwarded to the cognizant supply and/or maintenance sections responsible for resubmission of the corrected input. When possible, corrected resubmission's should be made to the next day's cycle.

c. Legend. The Daily Transaction Listing contains each input transaction. Refer to Chapter 6 of UM-4790-5 for an explanation of each transaction.

REFERENCE(S):

TM 4700-15/1H
UM 4790-5

UNITED STATES MARINE CORPS
COMBAT ENGINEER INSTRUCTION COMPANY
MARINE CORPS ENGINEER SCHOOL
PSC BOX 20069
CAMP LEJEUNE, NORTH CAROLINA 28542-0069

C-01B26
16 Jul 00
(98 POI)

STUDENT HANDOUT

DECEPTION OPERATIONS

LEARNING OBJECTIVES:

1. TERMINAL LEARNING OBJECTIVE:

a. Given a tactical situation, a map, a deception task, objective, and story, and references, advise the commander on the engineer role in deceptions operations to support the commander's intent and concept of operations per the references. (1302.2.9)

2. ENABLING LEARNING OBJECTIVE (S):

a. Given a tactical situation, a map, a deception mission, and references determine engineer tasks for deception measures per the references. (1302.2.9a)

b. Given a tactical situation, a map, a deception mission, and references employ engineer assets to fulfill required tasks per the references. (1302.2.9b)

OUTLINE

1. DEFINITION OF TACTICAL DECEPTION. Tactical deception is action taken to mislead the enemy to induce them to do something counter to their interests. Deception is an element of surprise, one of the principles of war.

a. It includes manipulating, distorting or falsifying evidence available to the enemy in order to insure security of real plans, operations or activities.

b. In terms of surfaces or gaps, deception hides or distorts them. It allows the commander to hide weaknesses, or in the case of trying to sucker punch the enemy, allows the commander to hide strengths.

2. OBJECTIVE OF TACTICAL DECEPTION. The objective is expressed as what the enemy will do or not do at a critical time or place. The objective of the deception can be geared toward any part of an enemy's organization, to include intelligence, reserves, fire support, communication, etc.

3. DECEPTION STORY: Is false information provided to the enemy to lead him to an incorrect estimate. It involves a believable intent or capability, so the enemy makes a decision that puts him at a disadvantage. Must be realistic and plausible. Successful deception ends up in the hands of a enemy commander as what he accepts to be real or an estimate of our capabilities and intentions:

a. Successful deception methods are determined by analyzing the battlefield conditions in relation to the deception objective.

b. All options except the one selected for the true operation are evaluated against the following four criteria:

(1) Is it consistent with our way of war?

(2) Is it simple or does it cause more confusion to our own forces?

(3) Is it plausible? (Will the enemy believe it is within our capability?) (Is it?)

(4) Will it cause the desired reaction? Who is most likely influenced?

4. TARGET: The enemy commander with the authority to make the decision that will achieve our deception objective.

a. EXAMPLE: If the deception objective concerns the enemy's first echelon reserve, the target is not the reserve commander, but rather the force commander who controls the unit in the battle area.

5. INTELLIGENCE. The decision to use deception, the story selected, and the means to project it are based upon knowledge of the enemy provided by the unit's intelligence system. AT a minimum, commanders must:

a. Know the characteristics, capabilities, and employment of the enemy's information-gathering system;

b. Know the enemy's collection system being used in the battle area, enemy intelligence organizations, enemy surveillance doctrine;

c. Know which enemy systems are susceptible to the deception story, enemy systems to be neutralized, measures to depict the deception story.

6. MEANS OF DECEPTION: Deception is controlled by the highest level headquarters conducting the deception. Each subordinate command, however, may play a part or be responsible for its own deception within the overall projection of the deception story.

a. There are four deception tasks that can be issued to a unit in a deception plan. They are:

(1) FEINT. A feint is an offensive action involving contact with the enemy. Examples of feints include:

(a) Limited Objective Attack

(b) Supporting Attack

(c) The goal of a feint is to present an offensive action as the main attack. It must take place at a time and location that concerns the enemy, and is consistent with previous operations. In addition to hiding the main attack, a successful feint can cause the enemy to shift critical supporting fires, cause early employment of reserves and reveal defensive positions and defensive lines.

(2) DEMONSTRATIONS. A demonstration is a show of force not involving contact with the enemy. The demonstration is also presented to the enemy as the main attack and must adhere to the same criteria as the feint. Marine Corps history is replete with examples of demonstrations. Some notable

examples are the actions of the 4th MEB in the Persian Gulf (1991) and the actions of the Okinawa invasion fleet (1945).

(a) ADVANTAGES:

1 Absence of physical contact with the enemy, facilitates employment of forces elsewhere.

2 Full force is not always necessary, because no contact is made with the enemy.

3 It permits the use of simulation devices, when available, in place of real items to deceive enemy's visual capabilities.

(b) DISADVANTAGES:

1 Difficult to portray the deception story convincingly without contact with the enemy.

2 More likely to be identified earlier in the operation because of the attempt to avoid enemy contact.

(3) RUSE. A ruse is a trick of war, ranging from individual actions by Marines on a tactical level to the strategic tricks of a nation. The ruse is based on misinformation. It is the deliberate placing of false information in the hands of the enemy. The only limitation to the ruse is the imagination of the perpetrator.

(4) DISPLAY. A display is a physical, tangible deception that is a static production aimed at enemy surveillance systems. Displays can be:

(a) SIMULATION. A simulation is an object or system depicted where one does not exist. Simulations range from simple shallow excavations that appear as fighting positions, to elaborate life size 3-D type photographs or mockups.

(b) DISGUISE. A disguise is the alteration of an object to make it look like something else. The goal is to make high value targets appear low in value or low value targets to appear high in value.

(c) PORTRAYAL. A portrayal a depicted unit or facility that does not exist. An example is the use of empty drums and containers to portray a supply dump. Displays can be a combination of simulations, disguises, and portrayals.

7. DECEPTION MEASURES. Provide notional information to the enemy that causes him to reach the conclusion we want him to draw. The measure employed usually take the form of visual, sonic, olfactory, and electronic indicators, or some combination of the above.

a. VISUAL. If the enemy is to believe something is there, he must be able to see it. The axiom "hide the real and reveal the false" is the essence of deception. Eyes are the most numerous and among the most responsive sensors on the battlefield. Therefore, visual deception must defeat the eye. Decoys and camouflage are well known examples.

(1) CAMOUFLAGE. Is an important protective measure and a fundamental element of deception. Used to project the visual evidence of a deception story and deny observation of the true operation. Camouflage has a two-part mission: active and passive; i.e., depending on military needs it can conceal (passive) from the enemy the true picture, or mislead (active) him into

accepting a false one. Camouflage methods cover four categories:

(a) HIDING. Denies electronic signals and emissions, as well as equipment, personnel, and supplies. (anything that can be "out of sight, out of mind")

(b) BLENDING. Reduces the contrast between an item or system and it's background.

(c) DISGUISING. Denies recognition by creating a false appearance.

(d) DECOYING. Denies the validity of the situation and is differentiated from disguise by the creation of signals or items that give the enemy a false target and induce him to attack it.

b. SONIC. What the enemy sees should be reinforced by what he hears. It is the projection of sounds to produce battlefield noises. Sonic measures should compliment visual deception, for the enemy will seek to confirm what has been seen. Use sonic measures to convey to the enemy the identifiable sounds of a specific activity in accordance with the deception story.

(1) CONFUSE AND MISLEAD. Specially prepared recordings can mislead and confuse the enemy, although the sound is emanating from a fixed location. An individual with normal hearing can recognize several separate sounds that arrive simultaneously, his estimate of the distance from the source is unreliable and therefore may not realize the source is singular.

(2) MIX REAL WITH THE FALSE. A false sound by itself will seldom be successful on the battlefield; it is necessary to blend true sounds with those reproduced artificially.

(3) CONSIDER ENEMY OBSERVATION. The less effective the enemy's visual observation, the more effective the projection of sonic deception measures. Therefore, their effectiveness is increased at night or when the point of origin is obscured by artificial means such as smoke.

(4) ENVIRONMENTAL EFFECTS. Range of sound signals depends on climate conditions, vegetation, topography, temperature, humidity, etc, although distances cannot be predicted, cool, humid, still atmosphere and water surfaces carry sound best.

c. OLFACTORY. Simulated battlefield odors can be used for deception. Pending the development and standardization of olfactory agents, munitions, and devices, it is left to the ingenuity and resourcefulness of the commanders in the field to improvise means in simulating battlefield odors. The smells being projected during deception must be consistent with the visual, sonic, and electromagnetic measures being used.

(1) DISTANCE. One factor affecting the use of olfactory is proximity to the enemy. The enemy must be close enough to friendly units to smell our simulated battlefield odors if it is to be useful.

(2) ENVIROMENTAL EFFECT. Will depend on climatic conditions. Therefore, planning must take into account wind patterns, temperature, etc.

(3) IMAGINATION. Cooking smells, medical odors, gunpowder smells, can be used by an individual or small patrol, or larger unit to assist in adding credence to a deception. Certain smells might suggest the size of a

unit by indicating whether or not that facility or unit is in operation.

d. ELECTRONIC. Is the deliberate radiation, re-radiation, alteration, absorption, or reflection of electromagnetic radiation to mislead an enemy when interpreting data received by his electronic equipment and to present false indications of electronic systems. Among the types of electronic deception are:

(1) MANIPULATIVE. Use of friendly electromagnetic radiation to falsify information an enemy can obtain from analyzing electromagnetic radiation. (Example: Engr SitRep)

(2) IMITATIVE. Intrusions on the enemy's channels and introduction of matter in imitation of his own electromagnetic radiation to deceive or confuse him.

8. DECEPTION TECHNIQUES. Actual deception techniques are wide and varied. They are limited only by the imagination of the delivers. Attention to all details, so that no part of the story is left untold, is the key to successful deception tasks, which in turn could arouse enemy suspicions. Some details, such as the use of supporting fires in deception areas, add credence to the overall picture. In all deception activities, maintaining normal activities and appearances aid in selling the plan to the enemy.

a. Deception techniques do not appear overnight. As with anything else requiring a level of proficiency, regular training in deception must be conducted. Deception tasks are manpower and equipment intensive, and must be planned accordingly.

9. DECEPTION PLAN. The most difficult aspect of deception planning is converting the concept and story into a set of instructions to subordinate units. It is basically the same as the planning for any military activity. Deception planning results in a deception plan, which may or may not be a formal document. An elaborate deception appendix or a series of written or verbal fragmentary orders.

10. DECEPTION PLAN AND RELATED PLANS AND ORDERS. To conduct a deception plan, there must be at least three plans:

a. PLAN TO ACCOMPLISH MISSION. Plan to accomplish the mission of deception's originator.

b. NOTIONAL PLAN. Plan that the friendly force desires to make the enemy accept as real.

c. DECEPTION PLAN. Plan to cause the enemy to accept the notional plan.

(1) To conduct an operation, there must be an operation order. It is "a directive issued by a commander to subordinate commander's for the purpose of effecting the coordinated execution of an operation".

(2) An operation order can have one of several relationships to the three plans. Three of these relationships are:

(a) Operation order includes three plans with (1) the notional plan and the deception plan in the deception appendix and (2) the deception appendix issued with the rest of the operation order. This promotes a wide understanding of the mission to be accomplished.

(b) Operation order states only the plan for accomplishing the mission, with the deception plan and the notional being issued in a separate document. This provides better security than explaining all three plans in the operation order.

(c) Operation order states only the notional plan, with the plan to accomplish the mission and the deception plan being stated in a separate order. This provides good security, but elements whose mission is changed have lost the planning time available they would of had, if they would have known their ultimate mission from the start of planning.

11. STAFF ORGANIZATION. There are four ways a commander can organize his staff for planning and conducting a deception:

a. NORMAL ORGANIZATION. Deception is planned by the commander and his staff much as they would any activity.

b. COMMANDER ONLY. Commander plans the deception without any assistance from his staff. This provides good OPSEC. However, since the staff is unaware of the deception, they may inadvertently undermine it.

c. CLOSE HOLD. Commander uses selected subordinates only. This provides better security than normal organization. This also provides a greater chance that one of the commander's subordinates will not inadvertently undermine the deception.

d. AD HOC STAFF. A special staff is established to plan and/or implement the deception. Personnel for this staff may be drawn from within the unit, from outside the unit, or a combination of both.

12. STAFF RESPONSIBILITIES.

a. Responsibilities of the commander, G/S-2, and G/S-3 have already been discussed. Other staff officers and logistics (G/S-4) officers for example, can have a critical role in the planning and executing of deception operations. Many of the deception measures will be planted in the activities planned and supervised by staff officers other than the G/S-3. For example, the G/S-4 can do much to ensure that the enemy believes we are going to attack instead of defend by having dummy logistics reports passed over the radios while the genuine logistics reports are delivered by courier, thus hiding the true disposition of our supplies.

b. As in all tactical operations, close coordination among all staff officers, unit commanders, and supporting functions is the best means to ensure execution of the deception plan.

13. FORMAT. There is no single format that must apply. These forms take the traditional orders and annexes for convenience. A command should use whatever is clear, secure, and appropriate to the conditions of the battlefield and the operation to be conducted.

a. The deception plan is the basic document, although it may be a supporting directive to an operations order or plan. Using an annex or other supporting directives in preparing a deception plan is optional. The type and number depend on the deception, the enemy, and the amount of detail that must be provided.

14. DECEPTION ANNEX TO OPERATION ORDER.

a. Listing of Notes for Operation Order:

(1) This is used when there is a requirement for special organizational changes in order to conduct deception. If the existing task

organization (the one established in OPORD for true operation) is used, only a Cross-reference is needed. Often the deception directives is a contingency plan to be put into effect if an opportunity perceived by the commander during his analysis actually presents itself. Having the plan ready with an adjusted task organization, allows immediate reaction for adjusted command and control on implementation.

(2) Included if necessary for understanding of plan or if information needed by units in order to execute deception is not available in other documents.

(3) FRIENDLY FORCES. Information of friendly forces that may influence deception actions. Attachments are listed when they are attached to your unit for the deception.

(4) This is not the assigned tactical mission. The mission of the forces used in a deception is to project the deception story which is given in this paragraph. The "why" of the deception (i.e. the deception objective) is included in the mission.

(5) Subparagraphs 3b to 3j are the tasks assigned for the conduct of the deception. Include, when necessary, critical activities to be concealed. When referring to units attached to brigades, the unit designated should be identified through coordination with the brigade before the plan is published to preclude an unexpected (to the brigade) rearrangement of the battle area. If a unit in the command is not effected by the conduct of a deception, it is not listed and it continues to prepare and act in accordance with the orders for the TRUE operation.

(6) CONCEPT OF OPERATION. The overall concept. Include the action that will be the main vehicle for the projection of the story and the purpose of the operation (i.e., deception objective).

(7) COORDINATING INSTRUCTIONS. Final subparagraph contains instructions applicable to two or more units taking part in the deception.

(8) If no special support is needed to conduct the deception, all that is required is a reference to the OPORD paragraph or annex. If the deception will need service support other than that provided to the TRUE operation, it is placed in this paragraph; if the extensive, an appendix may be used.

(9) This paragraph covers any command and control instruction peculiar to the deception. In fast-moving situations, when separate communication actions are not established, only a reference to the OPORD or CEOI is needed. Instructions for MCD and ICD are in paragraph 3 or in separate EW instructions (e.g., appendix to annex).

(10) Distribution is normally limited to those units tasked to conduct deception and/or specific information denial and to those units whose operations may also be affected by enemy reaction to the deception. The criteria for determining distribution on a deception plan is "WHO NEEDS TO KNOW" plus a realistic appraisal of own unit's OPSEC posture.

15. NOTIONAL ORDER OF BATTLE.

16. DECEPTION SCHEDULE.

17. DECEPTION OVERLAY.

REFERENCES:

FM 90-2	BATTLEFIELD DECEPTION
MCWP 3-17	MAGTF ENGINEER OPERATIONS
OH 7-3	DECEPTION
MCRP 3-17A	ENGINEER FIELD DATA

UNITED STATES MARINE CORPS

MARINE CORPS ENGINEER SCHOOL
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C-01B28
16 Jul 00
(98 POI)

STUDENT OUTLINE

ENGINEER TRAINING

LEARNING OBJECTIVES:

1. TERMINAL LEARNING OBJECTIVE:

a. Given an engineer unit, training requirements and references develop an engineer training plan to meet all training requirements and to enhance the ability of Marines to operate in combat, per the references. (1302.03.02)

2. ENABLING LEARNING OBJECTIVE (S):

a. Given training records, training requirements and references prepare specific training objectives per the references. (1302.3.2a)

b. Given training requirements, training objectives and references determine the coordination required to accomplish the training per the references. (1302.3.2b)

c. Given training requirements, training objectives, a unit Training Standing Operating Procedures (SOP), and references develop a training schedule per unit SOP and the references. (1302.3.2c)

d. Given training requirements, training objectives, a training schedule, and references, develop evaluation procedures per the references. (1302.3.2d)

0UTLINE:

1. TRAINING BASICS. The first step to learning the "basics" of training is to understand what makes people want to learn. The key word to bear in mind is interest: interest to learn on the part of the student and interest to teach by the instructor. The second part of the "interest" factor lies in the demonstrated interest the trainer and those in command have in training. A command, for example, showing little interest in training by routinely canceling scheduled training events, will lose the interest of its Marines, who will soon cease to care. If training is not important to commanders, why should it be important to their Marines? Commanders and their staffs must display an interest in training by giving it top priority at all times, not only when under scrutiny or inspection. A commander who regularly appears at training sites demonstrates training is important. As small unit leaders, platoon commanders should make every effort to schedule their administrative work around key training times and get out of their offices to observe training.

2. ESSENTIAL ELEMENTS OF TRAINING. For virtually any type of training, there are four essential elements: Marines, equipment, area(s) and imagination.

a. Personnel. You will have Marines, if you didn't, we wouldn't need you. Do not despair when only half of your T/O strength falls out for training or is able. Train whoever is present and treat them with the same level of interest as you would your entire unit. Remember lack of Marines is a poor excuse for inadequate training, after all, how many battles have been won by platoons at full strength?

b. Equipment. Break out your equipment at every opportunity. Every Marine in your unit should, for example, know how to assemble and use mine detectors, blind folded! Use imagination and conduct training on different items simultaneously. This type of training is called "incidental training" and can be extremely realistic, e.g. conduct a road sweep in MOPP 4 while your gun teams set up covering fires. Avoid the tendency, however, to take everything you own to the field. Take only what you might realistically need and train to the situation.

c. Area. Some units have better training areas than others dependent upon location. The key is to use what you have. Sharpen your powers of observation and scan your immediate area in garrison for ideal real estate requiring no requests and is within walking distance for convenience.   Get out of the classroom setting at every opportunity.

d. Imagination. Use all of the above elements to create challenging training for your unit. Marines enter the Corps because they seek challenge. If training isn't challenging, they will seek it elsewhere. Get out at night, in the mud when it's cold. Your Marines will learn and so will you.

3. <u>INDIVIDUAL AND COLLECTIVE TRAINING</u>. The Marine Corps training system consists of both individual and collective training.

a. <u>Individual Training</u>. Individual training develops the technical proficiency of both the Marine and the leader.

(1) Marine training focuses on mastery of mission-essential skills and tasks using:

(a) Sustainment training

(b) Train-up training

(c) Cross Training

(d) On-the -job training

(e) Individual training evaluation

(2) Sustainment Training.

(a) Sustainment training is the repetitive execution of essential tasks throughout the unit training program. It keeps skill and task performance at the required level of proficiency.

(b) Sustainment training corrects identified weaknesses and reinforces strengths.

(c) The amount and frequency of sustainment training is determined by the difficulty of the tasks, personnel turnover, feedback of evaluation, results through the chain of command, and the personnel observations and evaluations of the commander.

(3) Train-up training. Provides opportunities for Marines to train at higher skill levels in their career field once they have become proficient in their MOS. These Marines provide the unit with a broad base of expertise during periods of high personnel turnover.

(4) Cross-training. Cross training is another important method. It is normally done within a squad, section, etc. to train Marines on other jobs and MOSs within the team. This allows the small unit to operate, despite personnel shortages, and continues the Marines' professional development. Example: A combat engineer cross-trained to be a radio operator.

(5) On-the-job-training (OJT). An effective technique for many types of training. It may be used to complete a Marine's individual training and/or to sustain skills. It may also be used for train-up or cross training.

(6) Individual training evaluation program. A unit training program must include year round individual training and evaluation. Some ways to do this include:

(a) Individual OJT

(b) Battle Skills Training (BST)/Essential subjects training and evaluation.

(c) Integrating individual tasks in collective training and evaluation.

(d) Requiring subordinates to train and evaluate individual tasks. Individual tasks that are MOS related are evaluated using Individual Training Standards (ITSs).

b. Collective Training. Collective training builds combat teams that can accomplish their wartime mission. Training programs stress collective training because:

(1) Marines fight best as members of a unit. Collective training develops the critical confidence and teamwork units need for success.

(2) It is efficient. Marines can practice individual skills while developing collective skills under proper supervision.

(3) Leaders can assess the strengths and weaknesses of the Marines and units during training exercises.

(4) Leaders can exercise leadership skills.

(5) Units at various echelons can train concurrently for MAGTF operations as combined arms teams in a challenging and realistic environment. Example: A Combined Arms Exercise (CAX).

4. TRAINING STANDARDS. A training standard is a measure of performance. Uniform standards based upon projected combat needs ensure training activities focus on defeating the enemy. Training standards are measures of performance used to determine if Marines can or cannot perform satisfactorily. Individual Training Standards (ITSs) apply to an MOS (MCO 1510.95-Engineer Occupational Field) or by grade (MCO 1510.89 and MCO 1510.90-"Battle Skills Training Book 4" - Pvt through Gysgt). There are also collective training standards that apply to units by occupational field (MCO 3501.12- Mission Performance Standards). For the scope of this class, we will focus on Occupational Field ITSs and Mission Performance Standards only. As far as the

BST Handbook: Volume 1 deals with general military subjects from Pvt through GySgt, Volumes 2-4 deal with individual combat basic tasks by grade (LCpl and below, NCO, SNCO), Volume 5 covers the implementation of BST training and is called the "Users Guide".

a. Individual Training Standards (ITSs).

(1) ITSs provide guidance concerning the tasks a Marine should be able to accomplish within a given grade for a particular MOS.

(2) ITSs provide training objectives common for all Marines within a given MOS, by grade and a listing of training references and support requirements for each objective.

(3) ITSs are intended to assist a unit commander in developing individual training programs and should be made available to those Marines who are expected to plan and conduct training.

(4) The components of an ITS are:

(a) Task. A unit of work usually performed over a short period of time, which has a specific beginning and ending, can be measured, and is a logical and necessary unit of performance.

(b) Condition(s). Equipment, manuals, assistance/supervision, special physical demands, environmental conditions, and locations effecting how the Marine performs the task.

(c) Standard(s). Accuracy, time limits, sequencing, quality, product, process, restrictions, etc., indicating how well a behavior should be performed.

(d) Performance Steps. Steps that must be performed in order to accomplish the training objective.

(e) Reference(s). Manuals, job aids, Fleet Marine Force Manuals (FMFMs), etc., that will guide trainers, instructors, or performers.

(5) ITS INDEX OF TASKS. Identifies training location, required sustainment and required proficiency.

b. Collective Training Standards.

(1) Collective training standards are measures of mission performance. The standards are detailed and explain what the team, crew, or other Marine unit is expected to do.

(2) The Marine Corps Combat Readiness Evaluation System (MCCRES) provides a means for standardized evaluations of unit operational strengths and weaknesses measured against Mission Performance Standards (MPS).

(3) MPSs describe the capability organizations should have in order to successfully accomplish the assigned mission.

(4) The leader of a unit is evaluated based on the performance of his unit.

c. How to Use Training Standards. Training standards should be used to guide the training program of the unit. They are obviously the test, and as such they can be used in several different ways. At the unit level, training standards should be used to:

(1) Determine individual or team proficiencies and deficiencies.

(2) Determine training objectives.

(3) Determine instructional settings, methods, and media.

(4) Specify training resources.

(5) Evaluate proficiencies as a result of training.

5. A UNIT TRAINING SYSTEM. The Unit Training System is based on the Systems Approach to Training (SAT). This system is divided into five phases: Analyze, Design, Develop, Implement, and Evaluate.

a. ANALYZE. The analysis phase concentrates on defining where the unit is going and where it currently stands in terms of training. This phase is primarily the responsibility of a unit commander and the training manager.

(1) **Step 1: Analyze unit mission requirements.**

(a) Attention is focused on the mission(s), assigned and implied, in the operations and contingency plans for which a unit is, or will become responsible for. This action initiates the prioritization of a training program.

(b) A comprehensive list of unit missions, planned/scheduled training exercises and deployment schedules should be prepared. The Marine Corps Tactical Exercise and Employment Plan (MCTEEP), prepared annually and quarterly by an S-3, should be examined to identify training evolutions to which a unit or a unit to be supported is committed.

(c) Recurring/individual training requirements directed by the Commandant in Marine Corps Orders (MCOs), such as marksmanship training, NBC, BST, AND PFT, etc. are also identified.

(2) **Step 2: Determine unit training goals.**

(a) A commander determines training goals from the list of long and short-term missions, and CMC directed training requirements generated in Step 1.

(b) These goals are prioritized and will become the basis for selecting the training objectives used for each training event or activity.

(3) **Step 3: Analyze the current unit training status.**

(a) Unit commanders evaluate the current state of training in their own units. Input from the enlisted leadership of the unit is critical.

(b) One way to determine unit proficiency is to conduct pretests. Individual and collective performance should be measured using individual and collective training standards appropriate for the selected goals. These standards can be found in the ITSs, MCIs, BST, the MCCRES, and the Training Handbook (MCO 1510.89 and MCO 1510.90). Pretests will show the strengths and weaknesses of a unit.

(4) **Step 4: Inventory available training resources.**

(a) A training manager should inventory all internal and external resources available for training so the unit program uses resources in the best possible way.

(b) Internal resources: Include trainer availability and capabilities, unit equipment, unit property, and existing documents on the current training program and tables of organizations (T/O).

(c) External resources: Include elements outside the direct control of the unit. For example; training areas, training devices from TAVSC or additional funding controlled by higher headquarters.

(5) **Step 5: Analyze impact of external influences.**

(a) External influences, such as operational tempo, personnel problems, environmental considerations, time available, maintenance and administrative requirements can effect a unit training program.

(b) Unit Standing Operating Procedures (SOPs) and prior training plans provide helpful information on external influences.

b. <u>DESIGN</u>. The design phase at the unit level concentrates on deciding how to reach the training goals specified by a unit commander, i.e., determining what must be trained.

(1) **Step 1: Select training objectives.**

(a) With the results of the Analysis phase, a training manager selects training objectives to be covered in the unit training program. These objectives, or training tasks, consist of the MPSs/ITSs and are listed in order of criticality and complexity.

(b) Emphasis is placed on tasks necessary to prepare a unit for mission(s) most likely to be assigned.

(c) In this regard, priority is given to correcting previously identified training deficiencies related to anticipated mission(s).

(2) **Step 2: Identify individuals/units to be trained.** An analysis of current unit training status portrays an accurate picture of the information Marines know when they join a unit. Prior training, schools attended, civilian experience, SRBs and other information maintained on file by a unit can be examined to enhance the overall picture of the individuals/units to be trained.

c. <u>DEVELOP</u>. The development phase builds on information gathered in the Analysis and Design phases. In this phase the training program is written or modified to fit the requirements identified during the first two phases.

(1) **Step 1: Review and select training settings, methods, and media.**

(a) A training manager must select appropriate settings, methods and media for meeting unit training objectives. Many training methods and media are available to provide training to individuals or teams. They range from lectures to field exercises.

(b) The inventory of internal and external resources generated during the Analysis phase will provide information on the unit resources available.

(c) Selection of the setting, method, and media is also dependent on available facilities, resource costs, available time, and trainer qualifications.

(d) Additionally, training materials may already be available at the unit or from MCI. These should be reviewed and used if appropriate for the training tasks.

(2) **Step 2: Define and allocate resources required for training.**

(a) With the training settings, methods, and media selected, a training manager can determine the actual resources required. In addition, a training manager ensures the necessary administrative and management support is available.

(b) If training standards are available, the condition statement in the training objectives will identify required resources. If standards are not available, a training manager will have to specify the resources required.

(3) **Step 3: Gather, prepare, and confirm resources.**

(a) More valuable training time is lost as a result of poor planning and coordination of the essential resources to support training than to any other cause.

(b) Late arrival of ammunition, failure to coordinate the transportation, forgetting to check out the range, etc., are all examples of problems leading to “down” time for trainees.

(c) As an engineer platoon commander, you will play a very important roll in the coordination of training resources. Local SOPs will guide you in coordinating resources in your unit (what's required, request procedures, lead time, etc.). Here are some considerations for coordinating resources:

1 CORPSMAN - NORMALLY REQUESTED THROUGH S-4/BAS, REQUIRED FOR ALL TRNG WHERE CHANCES OF INJURY POSSIBLE.

2 SAFETY VEHICLE - IF YOU HAVE A CORPSMAN, YOU NEED A SAFETY VEHICLE. WHAT TYPE?

3 WATER - ALWAYS. 5 GAL WATER CANS (SMALL UNIT T/E OR UNIT SUPPLY). HOW ARE THEY GOING TO GET FILLED?

4 TRANSPORTATION - NORMALLY REQUESTED THROUGH S-4/MT. KNOW CAPABILITIES OF MT VEHICLES, (I.E. HOW MANY TROOPS CAN THEY CARRY). PRECISE PICK-UP/DROP-OFF POINTS AND TIMES.

5 AMMO - NORMALLY REQUESTED THROUGH S-4 VIA S-3. UNDERSTAND MCO P8011/KNOW UNIT ALLOCATION. USE PROPER DODIC AND UNITS OF ISSUE. DROP OFF LOCATION/TIMES (PLAN FOR DELAYS AT ASP). IF POSSIBLE, PRESTAGE PRIOR TO REQUIRED TIME/DATE. WHAT ABOUT THE RETURN OF UN-USED AMMO?

6 RANGES AND TRAINING AREAS - NORMALLY REQUESTED THROUGH RANGE CONTROL VIA S-3. KNOW THE RANGE (WHAT ARE THE CAPABILITIES AND LIMITATIONS). KNOW RANGE REGULATIONS.

7 CHOW – MREs/HOT CHOW/BAG NASTIES REQUESTED THROUGH S-4. PROPER DOCUMENTATION (MEAL CARD #'S, MONEY FROM MARINES ON COMRATS)

8 HEAVY EQUIPMENT - NORMALLY REQUESTED THROUGH HE SECTION VIA S-4. KNOW ITS CAPABILITIES, FUEL REQUIREMENTS & TRANSPORTATION REQUIREMENTS.

9 COMMUNICATIONS - NORMALLY REQUESTED THROUGH COMM. VIA S-3. USE IN ALL TRAINING. BACK-UP RADIOS/BATTERIES. COMM SECURITY EQUIPMENT (KY 57,KYK/13) & ANTENNAS (RC 292). FREQUENCY REQUEST SHOULD ACCOMPANY COMM REQUEST.

10 WEAPONS – KNOW ARMORY REQUIREMENTS. EARLY DRAW/LATE TURN-IN.PRE-FIRING INSPECTIONS.

(4) **Step 4: Prepare the training outline.** The training outline is a brief, informal guide for a trainer to use to conduct training, whether classroom oriented or field training.

(5) **Step 5: Rehearse and qualify.** A trainer must be qualified to conduct the specific training event (usually dictated by local SOP) and should rehearse the event if practical.

(6) **Step 6: Revise, update, modify.** As a result of the rehearsal/ preparation of the training outline, certain changes or modifications may be necessary. The idea is to continue to polish, enhance, and improve the training through detailed preparation and past experience. This action provides for efficient use of resources and employment of the most effective training methods to accomplish the training objectives.

d. IMPLEMENT. The implementation Phase of the Unit Training System is the culmination of the preceding phases. During implementation, training is scheduled and conducted.

(1) **Step 1: Schedule and announce the training.** The training schedule is produced and the training is announced to the unit. A training schedule is a near term projection outlining the training activities to be conducted by a unit.

(2) **Step 2: Inspect the training schedule.** Using the information in a training plan, training bulletin and a unit SOP, a training manager inspects the training schedule to ensure the training activities can be performed as planned. In checking the schedule, the following items apply:

(a) Time - Ensure time is well spent and sufficient time is allotted to cover the material.

(b) Progression - Verify the training is logical, orderly, and the sequence of training activities is appropriate.

(c) Location - Is the location appropriate for the activity scheduled?

(d) Methods - Ensure the methods emphasize performance-oriented training as much as possible.

(e) References - Ensure the references are doctrinally correct and local regulations and applicable safety regulations are cited.

(3) **Step 3: Conduct training.** The training outline developed in Steps 1 and 2 provide the foundation for conducting meaningful training. In addition to being prepared and knowing the subject matter, conducting training requires knowledge and application of fundamental principles of training:

(a) Ensure the Marines being trained are motivated and understand what is expected of them.

(b) Emphasize performance oriented training.

(c) Make sure training is clear and organized.

(d) Vary the training method. Use demonstrations whenever possible.

(e) Plan adequate practice time.

(f) Conclude all training with an evaluation.

(g) Make sure training is at Marines' pace.

(h) Pay attention to training conditions.

(i) Serve as a role model. Be present!

e. EVALUATE. During the evaluation phase, individuals involved in training look for ways to improve the efficiency and effectiveness of training. Training effectiveness is determined by how well personnel meet or exceed established the performance standards specified in the training objective(s). Training efficiency is concerned with how well the trainer used what was available to train the Marines.

(1) **Step 1: Evaluate the conduct of training.**

(a) The training manager, trainer, and the Marines being trained evaluate the conduct of training. The manager will evaluate training by observing the activity and completing a training evaluation report. The training manager is concerned with evaluating the adequacy of instruction, the administration of performance tests, and the performance of Marines in relation to the training goals and objectives previously defined.

(b) The trainer can evaluate the conduct of training by closely observing performance tests and/or drills and should be alert to errors in performance of individuals and teams.

(c) The Marines being trained can evaluate the conduct of training by providing clear and objective feedback.

(2) **Step 2: Evaluate training results.** The training manager and the trainer will work together to evaluate the results of training as soon as possible after the conduct of the activity. The initial evaluation of training results comes from testing performance of individuals and teams. No other indicator is as important as this one.

(3) **Step 3: Identify the cause of the training problems.** The most difficult part of the Evaluation Phase is to correctly identify the cause of the training problem. Usually, failure during performance can be attributed to one of the following factors:

(a) Individual Failure

(b) Team Failure

(c) Trainer Failure

(d) Training Program Failure

(4) **Step 4: Recommended solution to the training program.** The training manager and trainer will use common sense and all information generated in the Analyze Phase of the unit training system to find a solution to the training problem. Results of activities in the evaluation phase should be discussed in training meetings so all training personnel can be kept aware of changes or alterations to the training program.

6. SMALL UNIT TRAINING MANAGEMENT. Training management is a vital, yet often time-consuming task. This lesson outlines a concise technique of managing individual and collective training on a platoon or section level; the purpose of which is threefold; first, to document past training; second, to determine current individual and collective skill proficiency; third, to determine future training requirements. Used properly, it reveals the training status of individuals, teams, sections, squads, and platoons. The management of individual/collective training is normally the exclusive duty of a platoon training NCO. The demands of the job are heavy and meticulous so the Marine chosen for the task should be intelligent, cooperative and a self-starter.

a. Individual Training Record (ITR). The ITR is kept on each individual in the unit. It contains essential training data, to include weapons qualification, BST, PFT, MCI courses completed, swim qualification, military schools attended, and is supplemented by a platoon proficiency chart showing MOS-specific tasks.

b. Platoon Proficiency Chart (PPC). A platoon proficiency chart is a compilation of all ITRs and displays platoon proficiency in, weapons qualification, swim qualification, and most importantly, individual and collective skills at a glance. Entries should be color coded to indicate satisfactory or unsatisfactory performance. A PPC content is up to the discretion of the users.

7. TRAINING MANAGEMENT TIPS. Much lip service is given to our instant readiness, but this requirement is not always reflected by our training schedules. The training schedule you create should be a reflection of your priorities. Small unit training exercises should be frequent, short, thoroughly critiqued, and understandable for the most junior Marine. The trainer must stress drills and reaction oriented field problems whenever feasible. German officers have always been taught to make a checklist every time they wrote a training schedule. The checklist covered key areas:

CHECKLIST	EXAMPLE
1. MAJOR SUBJECT AREA	-DISMOUNTED BREACHING
2. LEVEL OF TRAINING	-SQUAD
3. SEGMENT OF TRAINING	-RECON/SECURITY OF BREACH SITE
4. LESSON	-EXPLAIN 5 "Ws" OF RECON/SECURITY
5. EXERCISE	-SAND TABLE AT SQUAD LEVEL WALK, THEN RUN THROUGH ACTUAL RECON AND EST. OF SECURITY OF SITE

As your can, see this technique leaves little doubt as to what and how you intend to conduct the training and emphasizes actual practical application. With this information, a list of supporting resources needed for the training can be roughly constructed. However, for detailed support planning, several questions must be presented to the training planner: number of personnel to be trained; duration/time (day or night) of training; location (or desired location), live or simulated fires, and, any incidental training involved. After gathering all available details from the training planner (e.g.. training officer, platoon commander, company commander, etc.). A training manger must coordinate all technical support resources (instructors, reference material) and logistical resources.

REFERENCE(S):

1. MCI (SPD) 1520, COMPANY COMMANDER’S HANDBOOK
2. MCRP 3-0A, UNIT TRAINING MANAGEMENT GUIDE
3. COMMON SENSE TRAINING
4. SYSTEMS APPROACH TO TRAINING GUIDE