Construction Guide for

Reinforced Belowground 40' Milvan Bunker

Developed by:

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Bill of Materials – Structural Steel Assembly

Item Description	Quantity
TS 3x3x3/16” steel frame (min. yield stress=50 ksi) *fabrication details contained herein	20
2”x1/4” flat bar, 20’-3” long (min. yield stress=50 ksi) *fabrication details contained herein	8
2”x1/4” flat bar, 6’-4” long (min. yield stress=50 ksi) *fabrication details contained herein	8
L 3 ½”x3 ½”x1/4”, 19’-6” long (min. yield stress=50 ksi) *fabrication details contained herein	4
3/8” diameter bolts, 4 ½” long, 1 ½” thread length min., w/ self-locking nuts	80
Plate washers, 7/16” I.D., 1 ¼” O.D., 1/8” thickness	16
3/8” diameter lag screws, 1 ½” long	38

Bill of Materials – Revetment Walls & Roof

Item Description	NSN	Quantity
Concertainer – 4.5’ high, 3.5’ wide, 32’ long *exact quantity required will vary with application	5680-99-001-9396 – Green 5680-99-835-7866 – Beige/Sand	4
Concertainer – 2’ high, 2’ wide, 4’ long *exact quantity required will vary with application	5680-99-001-9397 – Green 5680-99-968-1764 – Beige/Sand	4
Composolite panels, 10’ long	5675-01-500-2761	6
Toggle connectors, 10’ long	5675-01-500-2761	5
Sand bags	-	20

Equipment, Personnel and Time Estimate

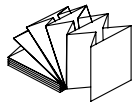
- To assist in planning, provided below are estimates of the necessary equipment and soldier assets and total construction time required to construct this position. Consideration during planning should be given to such issues as equipment and operator availability, topographic and work area limitations, maneuverability, etc., and their impact on the construction effort. Only heavy equipment are listed below. Hand tools such as wrenches, shovels, rakes, pliers, wire cutters, etc. will also be needed.

  The indicated time required for construction does not include fabrication times for the structural steel assemblies. If steel assemblies are not pre-fabricated, appropriate time and resources should be factored into the estimates shown below. Time estimates are given for installing steel assemblies in container. Factors such as threat based urgency, equipment and material availability, soil type, knowledge of construction techniques, etc. can greatly impact time requirements. Therefore the time indicated is an estimate only, and should be utilized when actual performance data for similar positions under similar conditions is not available.

- ***Total Estimated Soldier Asset Requirements – 49 man-hours***

Task	Equipment Req'd.	Soldiers Req'd. (excluding operators)	Time Req'd.
Install steel assemblies in container	-	4	4 hours
Position excavation	HYEX	1	4 hours
Place ISO	crane	2	30 minutes
Erect and fill revetment walls	HYEX	6	3 hours
Place and cover roof panels	HYEX	6	1 hour
Backfill position	HYEX	1	4 hours

Hesco Bastion Concertainer
Site Preparation & Infill Guidelines



General

- Hesco Bastion Concertainer units are primarily utilized in the construction of protective positions in a wide array of environments. Concertainer units are transported in a compressed, "accordion" style, expanded on-site, and filled with infill material to create the desired structure. The Concertainer wire/fabric framework is utilized to create a confinement system for the infill material, which, when properly placed and compacted, will provide the global strength and stability for the structure. Considering that Concertainer structures transmit their loads through the "fill walls" and into the foundation below, proper foundation preparation and infill placement are critical to overall performance. **The following information provides essential guidelines to the proper foundation preparation and infill placement for these structures. Reference should be made to the Engineering Research and Development Center (ERDC) guide titled "Concertainer Construction Techniques" for requirements pertaining to proper layout, connection, modification and durability.**

  Note that Concertainer units are manufactured in green, desert tan, and gray colors. The dyes used to pigment the fabrics impact the Concertainer's resistance to UV degradation, and according to current data the gray color fabric exhibits the fastest deterioration. **Based upon this susceptibility to UV deterioration, the gray colored fabric is not recommended for use.**

Site Preparation & Foundation Construction

- The performance of Concertainer structures, as with any conventional structure, is highly dependent upon proper site selection and preparation. Concertainer structures strongly rely upon the strength of near-surface soil material for overall structural stability. The condition of these near surface materials can be deteriorated by elevated moisture levels, soil erosion, freeze/thaw cycles, decay of organic matter, compression of weak soils, etc. Therefore, the site evaluation process should include consideration of site drainage patterns and existing soil conditions for the purpose of identifying a **well drained, stable site**. Reference FM 5-34, Chapter 8 for procedures to assist in soil evaluation.
- Concertainer structures should be constructed on a relatively **flat, level foundation**. The foundation must exhibit sufficient **strength and stability** to support the structure over the intended life. If construction will not take place on an improved surface (such as concrete paving, asphalt paving, or stabilized soil), the foundation area must be prepared. At a minimum, preparation should consist of:

  1) Blade area to level foundation site and remove organic material and loose surface soils.
  2) Test exposed foundation material to ensure a stable foundation will be provided. FM 5-34, Figure 8-1 provides guidelines for procedures which can be utilized to test foundation soils.
  3) If exposed foundation material will not provide a stable foundation, or if the life of the structure is expected to be greater than 6 months, an improved foundation should be constructed to prevent future settlement and shifting.

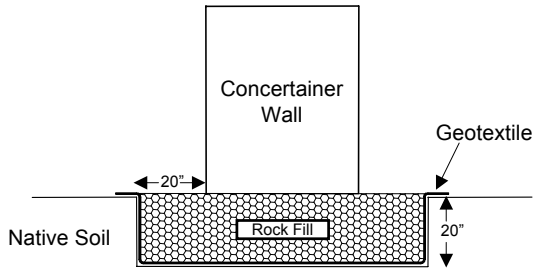
     To construct an improved foundation, excavate a trench 20" deep beneath all structure walls. The width of the trench should extend 20" beyond each edge of the wall.

     After excavation, line the trench with a geotextile cloth (minimum weight 200 g/m^2) and backfill the trench with a **well compacted** layer of coarse graded fill material or crushed rock.

     Prior to construction of structure, test improved foundation to ensure the desired level of foundation strength and stability has been achieved.

Hesco Bastion Concertainer
Site Preparation & Infill Guidelines

- Reference the following detail for a depiction of an improved foundation:



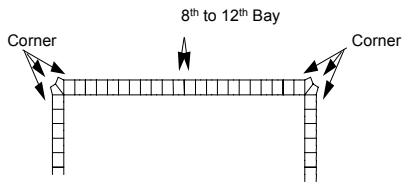
End View of Improved Foundation

Placement of Infill

- **A basic principle behind the usage of Hesco Concertainers is the user's capability to easily create a lightweight wire/fabric "framework" for a given structure, and then fill the framework with infill material to impart structural strength and integrity. Considering that Concertainer structures therefore rely solely upon the "fill walls" for their global strength and stability, the proper placement of infill is critical to the performance of the structure. In all cases possible, the following guidelines to infill placement should be adhered to.**

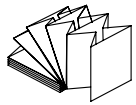
- Prior to filling, connect all units in a single layer together and adjust to the desired layout. Attaching empty units to filled units is difficult.

  In general, filling of a Concertainer layer should begin by first filling corner bays, and every 8th to 12th bay thereafter, with 1' of compacted material placed in two 6" lifts. This will allow the layer to be "anchored" during remaining filling activities.



After anchoring the wall, filling of the remaining bays should progress such that the infill material is uniformly placed throughout the Concertainer layer (e.g. Do not completely fill one bay while the adjacent bay is completely empty).

Hesco Bastion Concertainer
Site Preparation & Infill Guidelines

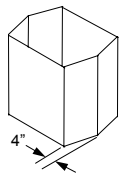


- Concertainer walls largely obtain their load carrying capacity and stability by “bulging” along the sides during the filling process and **allowing the wire/fabric structure to deform to its “maximum state”.** By allowing the bays to reach maximum deformation during filling, the infill material becomes confined within the widest, shortest volume of space available – **which significantly reduces the potential for future structure movement and failure**. “Bulging” also improves structure performance by increasing the width of the Concertainer walls, thereby creating a more stable structure.

  Restraint mechanisms – such as wires and bracing – **must not** be used to prevent “bulging” of the Concertainer. As infill is placed within the bays, the fill material exerts lateral pressures on the walls in an attempt to “push” the walls outward. This outward pressure induces stress concentrations in restrain mechanisms which can lead to failure of the restraint. Upon failure of the restraint, the Concertainer walls move outward to reach the maximum deformed state described above, and the infill material moves outward with the wall. As the infill material moves outward to occupy the void space created by the moving wall, the fill material also moves downward. This outward/downward infill movement will induce wall settlement, wall and load shifting, and potentially an overall failure of the structure.

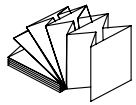
- To accommodate the deformation process previously described, the coil hinges on each side of every bay must be pulled out approximately 4” during initial filling. If coil hinges are not present, as with Mil 2 units, simply pull the sides of each bay outward to create a slightly curved side wall for each bay. This will assist the bay in deforming as necessary during the filling process.

Pull out center of each bay approximately 4” at base during initial fill placement

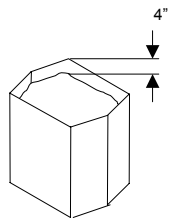


- After adjusting the base, fill the bay with infill material. **Unless otherwise specified, infill should be placed in lifts no greater than 9” in thickness and must be adequately compacted**. Adequate compactive effort can be obtained through foot compaction. During compaction, care must be taken to ensure that all infill material is compacted along the walls and in the corners. **Proper compaction of infill material is critical to prevent future settlement of Concertainer walls.**

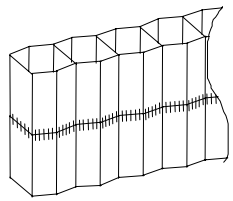
Hesco Bastion Concertainer
Site Preparation & Infill Guidelines



- If a 2nd level of units is to be placed on top of the first**,** halt filling of the first layer approximately 4” from the top of the unit.

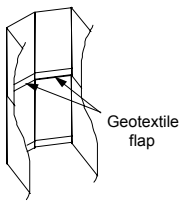


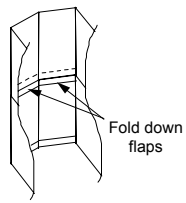
Place the 2nd layer on top of the 1st. **The 2nd layer must be positioned to ensure that it is correctly aligned with the 1st layer**. To achieve this alignment, place the second layer such that the bay corners of the 2nd layer are located directly above the corners of the 1st. This alignment will allow the walls of the 2nd layer to lay directly on top of the walls of the first, and thereby prevent infill leakage and enhance structural stability.

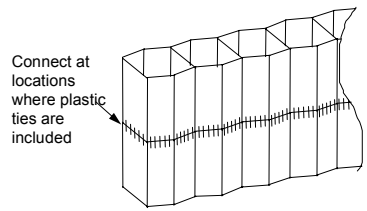


Ensure corners
are properly aligned.

- After correctly positioning the second layer, seal the wall junctions with the geotextile flaps located at the bottom of the second layer, and connect the layers together with the pre-positioned plastic ties.

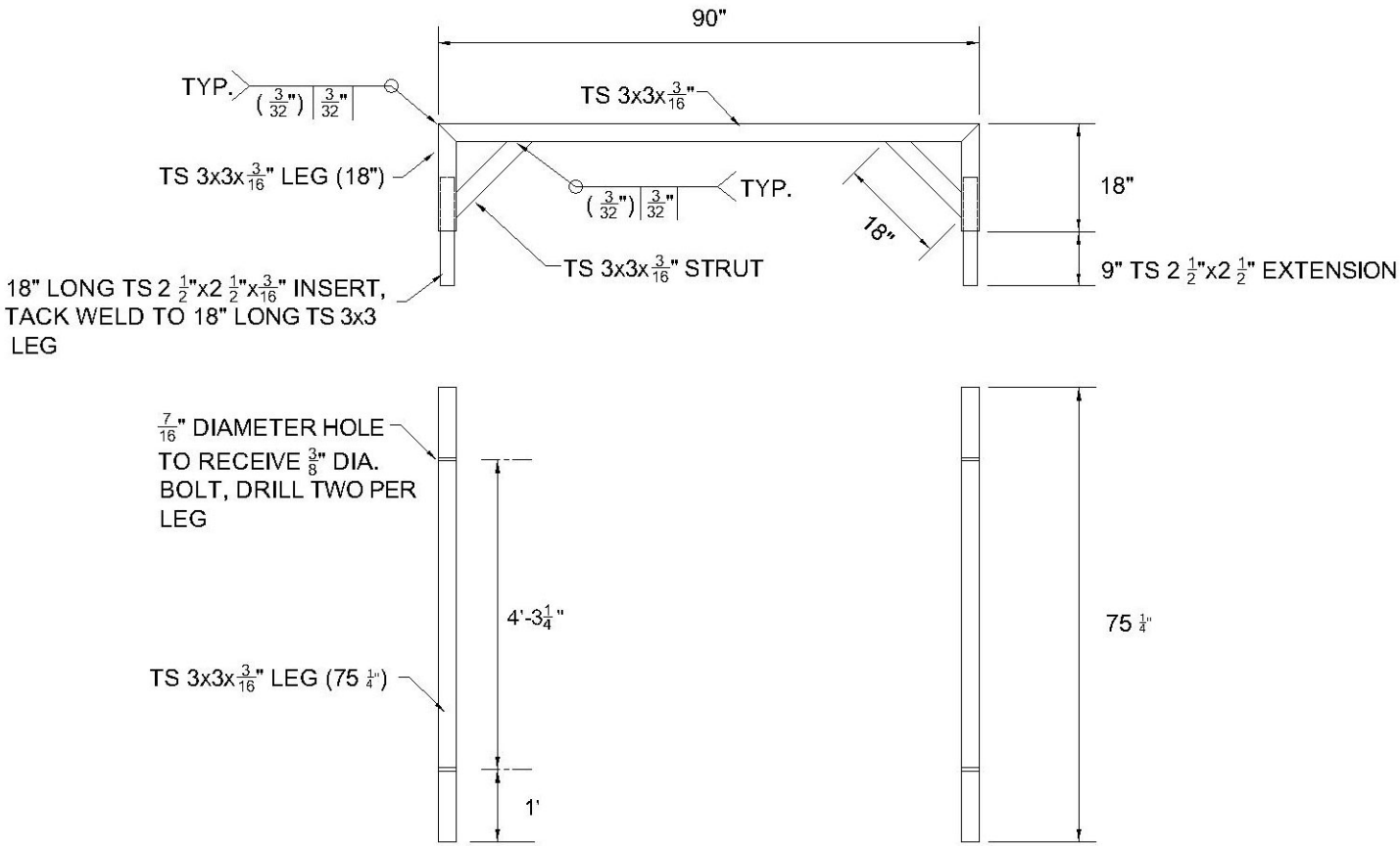






- Continue to fill the second layer in the same manner as the first layer.

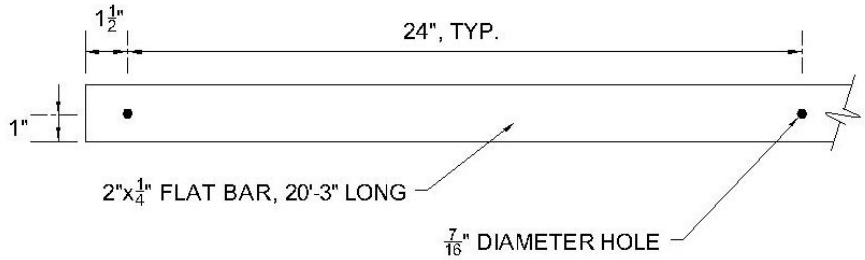
Step 1 – Fabrication Details



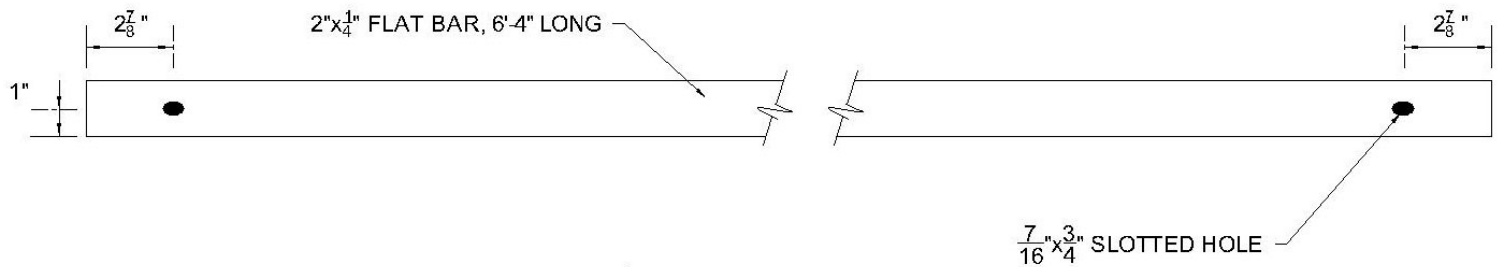
FRAME FABRICATION DETAIL
nts

- **Steel frames are fabricated in 3 pieces, and can either be assembled in the container before shipping, or assembled upon arrival to final destination.**
- **Reference detail above for frame fabrication requirements. Note that this frame configuration is based upon a standard 8’ wide, 8’ tall container.**

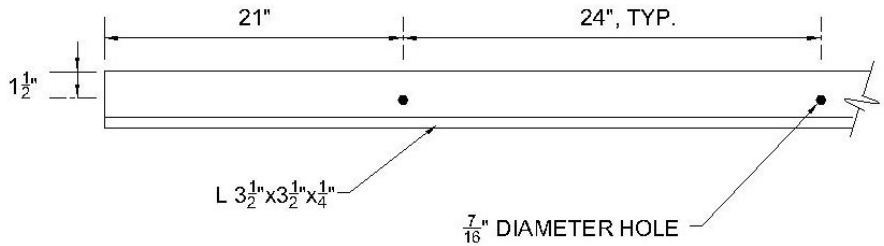
Step 1 – Fabrication Details



2"x¼" FLAT BAR DETAIL (20'-3")
nts



2"x¼" FLAT BAR DETAIL (6'-4")
nts



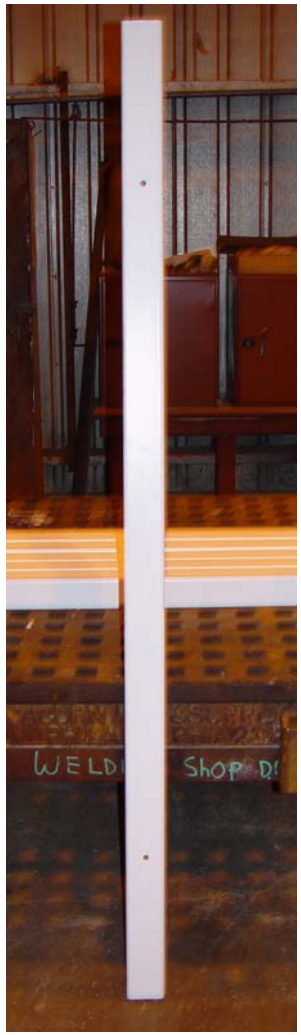
L 3½"x3½"x¼" DETAIL
nts

- **Reference detail above for flat bar and angle fabrication requirements.**

Step 1 – Fabrication Details

Upper portion of frame – TS 3 tubing & TS 2 ½ extensions

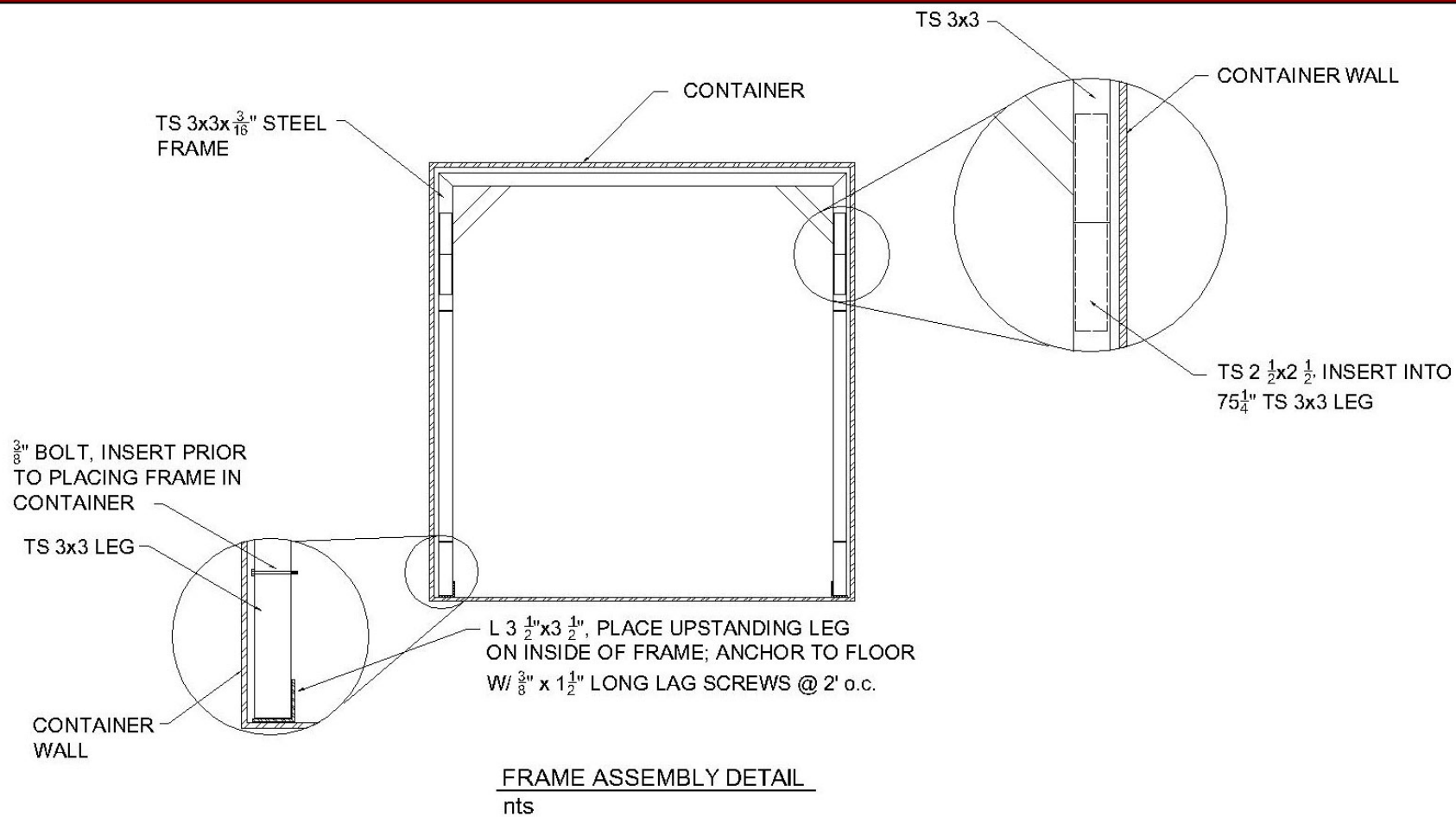
18” TS 3x3 leg & 9” TS 2 ½ x 2 ½ extension



75 ¼” TS 3 leg

6’-4” flat bar with slotted holes

Step 2 – Steel Frame Assembly and Installation



- **Place two L3 ½” angles end-to-end on floor along each wall. Place angle with upstanding leg on inside of frame. Anchor angle to floor with 3/8” lag screws at 2’ o.c. (Ensure anchor placement will not interfere with frames)**
- **Assemble steel frame by inserting 9” long TS 2 ½x2 ½ extensions into 75 ¼” long TS 3x3 legs. Place legs of frame into track formed between L3 ½” angle and container wall. (Note that 3/8” bolts must be inserted into frame legs prior to placing frame in container)**

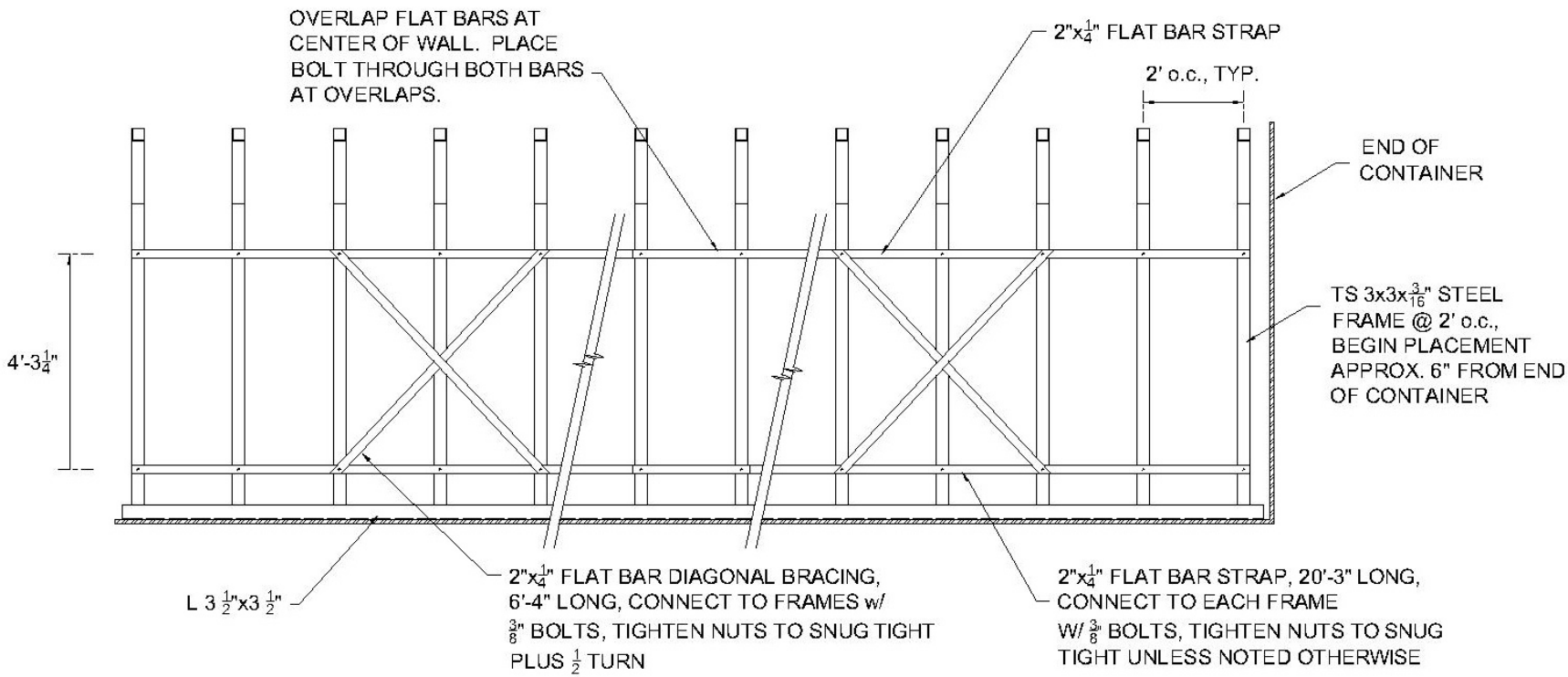
Step 2 – Steel Frame Assembly and Installation

3 ½” angle anchored to floor – upstanding leg to inside of frame

TS 3x3 leg placed in track

Assembled frame

Step 2 –Steel Frame Assembly and Installation



FRAME INSTALLATION DETAIL
nts

- **Install assembled frames at 2’ o.c. Begin frame placement approximately 6” from end of container.**
- **Connect (2) 20’-3” long flat bar straps to each frame with 3/8” bolts and self-locking nuts. Bolts must be inserted into frame legs prior to placing frame into container. Adjust frame placement as necessary to connect each frame to straps. Overlap straps 2’-3” at center of wall.**
- **Place 2 sets of 6’-4” flat bar diagonal bracing on each wall. Connect bracing to frames with 3/8” bolts, plate washers, and self-locking nuts.**

Step 2 –Steel Frame Assembly and Installation

Frames installed at 2’ o.c.

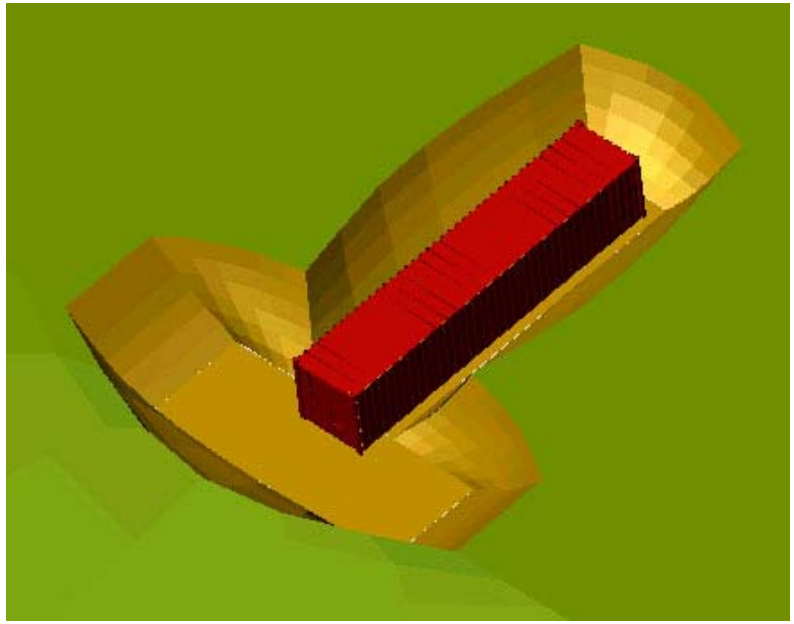
Flat bar straps attached to frames

Flat bar connected to frame with bolt;
Note head of bolt is on outside of frame

Diagonal bracing in place

Step 3 – Site Excavation & Container Placement

Excavating position

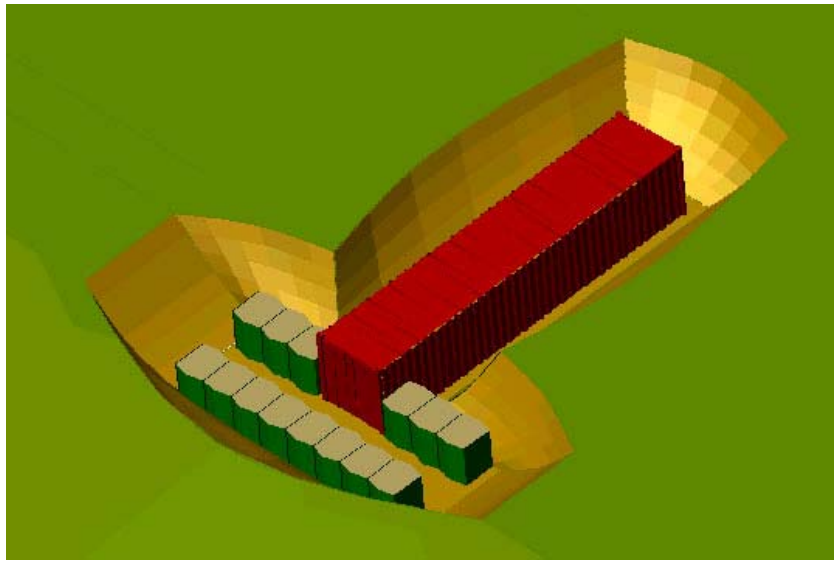


Container placed in excavation

- **Make "container excavation" by digging a hole approximately 8' deep, 38' long and 10' wide. The container will be placed in this excavation. Slope hole such that when container is placed, the floor will slope slightly towards the doors to promote drainage.**
- **At the end of the "container excavation" where the doors will be placed, excavate a hole approximately 8' deep, 12' wide and 32' long perpendicular to container. This will be the "entrance excavation", and will be used to provide an entryway to the position. At ends of excavation, taper to natural ground to provide access.**
- **Place ISO container in "container excavation". After placement, the container should extend approximately 3.5' into the "entrance excavation" (see picture above).**
- **When making excavations, ensure sides are adequately sloped to prevent cave-in while soldiers are working in excavation.**

Step 4 – Concertainer Revetment (1st Layer)

Compact fill into the sides and corner

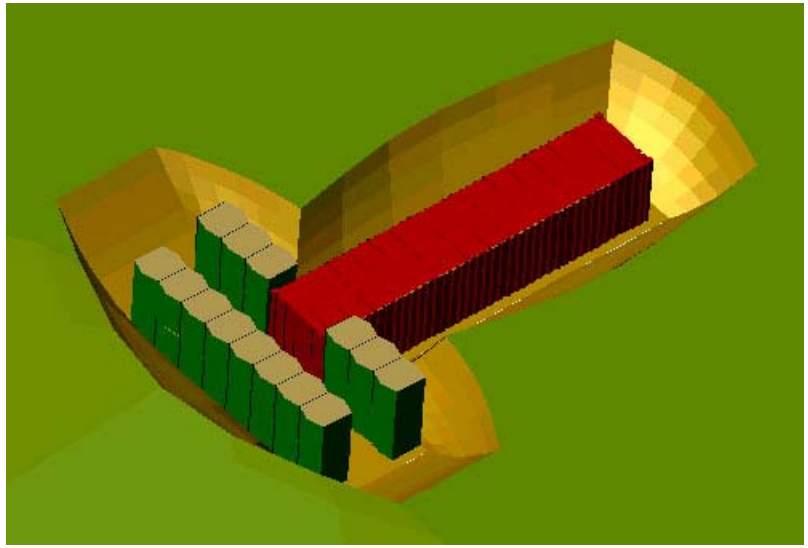


1st layer of Concertainer revetment placed and filled

- **Materials required: 2 sections of Concertainer - 4.5' high x 3.5' wide x 32' long (9 bays per section)**
- **Refer to "Site Preparation & Infill Guidelines" and "Concertainer Construction Techniques" for detailed information on Concertainer construction**
- **Collapse one bay to make a section 8 bays long**
- **Break one 9-bay section into two 3-bay sections**
- **Arrange Concertainer as shown in drawing. Ensure revetment walls are placed 5' apart.**
- **Fill Concertainer with infill material**
- **MAKE SURE FILL IS VERY WELL COMPACTED**

Step 5 – Concertainer Revetment (2nd Layer)

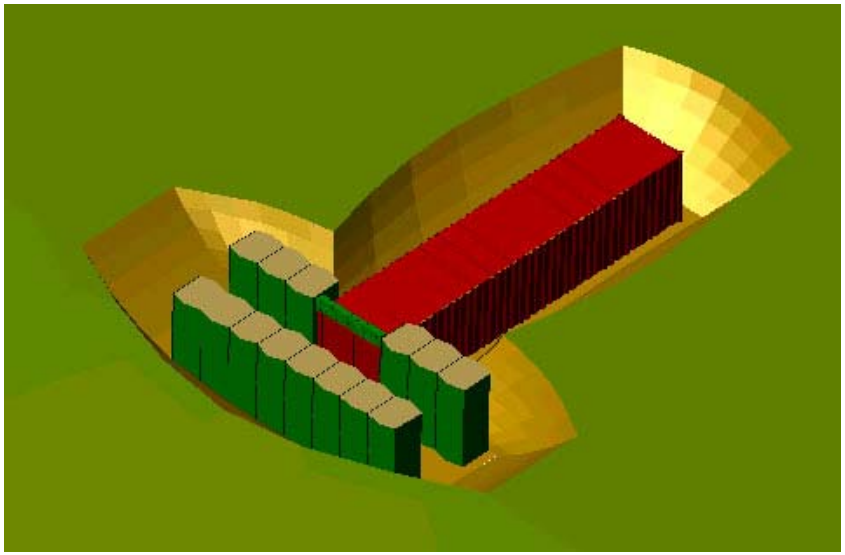
Connecting second layer to first using plastic wire ties



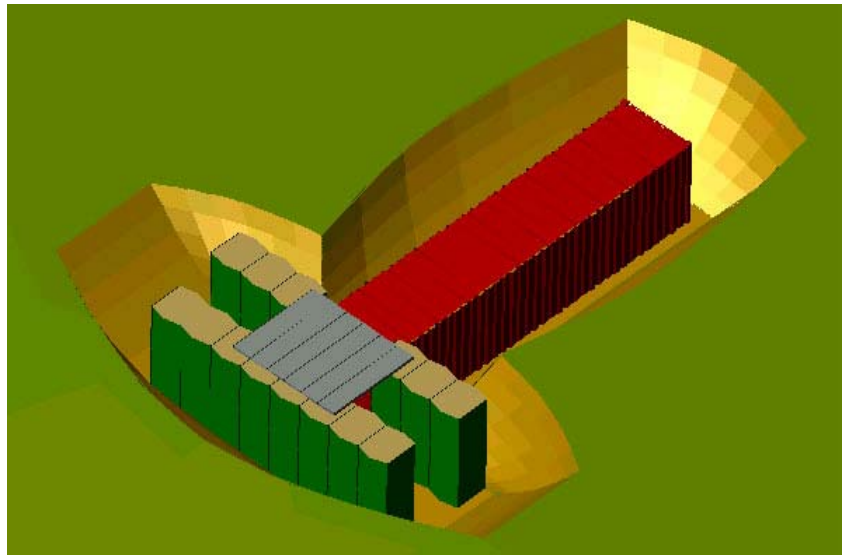
2nd layer of Concertainer revetment placed and filled

- Materials required: 2 sections of Concertainer - 4.5’ high x 3.5’ wide x 32’ long (9 bays per section)
- Collapse one bay to make a section 8 bays long
- Break one 9-bay section into two 3-bay sections
- Arrange Concertainer as shown in drawing. Connect second layer to first using plastic wire ties as shown
- Fill Concertainer with infill material
- MAKE SURE FILL IS VERY WELL COMPACTED

Step 6 – Fiberglass Roof



Place sandbags over container entrance to level roof support surface

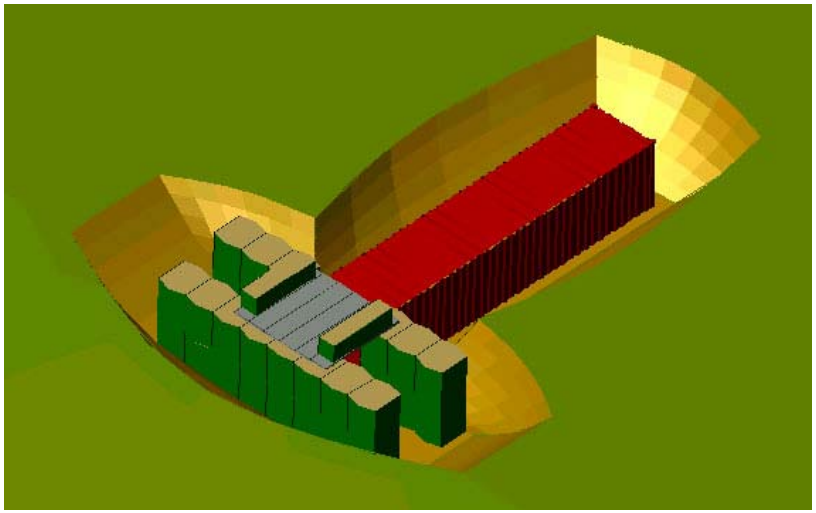


Place Composolite panels on revetment walls

Connecting panels with 10’ toggle connectors

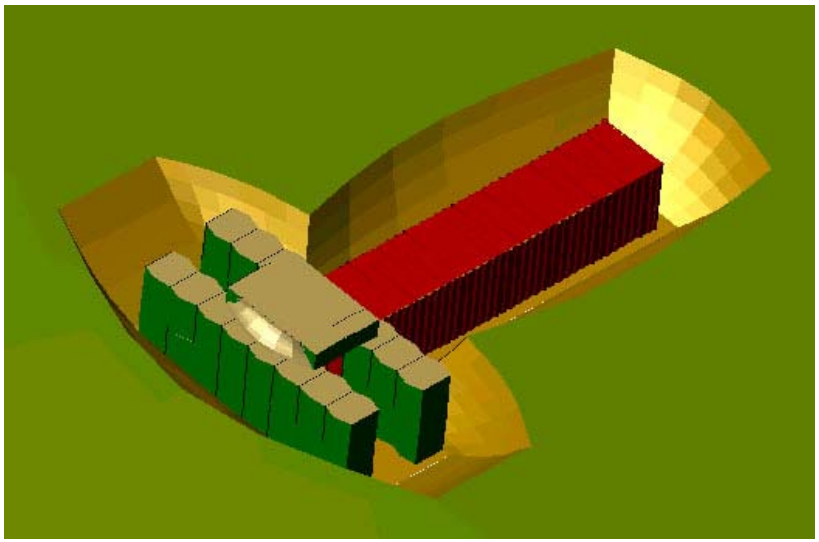
- **Materials required:**
  (6) - 10’ long Composolite panels
  (5) - 10’ long toggle connectors
  (20) – sand bags
- **Place sand bags over container entrance to provide level bearing surface for roof panels**
- **Place Composolite panels on top of revetment walls. Center roof on entrance to container.**
- **Connect panels using toggle connectors. Drive toggle connectors in as far as possible then cut flush. Repeat from opposite end as necessary to provide connection along full 10’ length.**

Step 7 – Roof Overhead Cover



Concertainer retaining walls in place and filled

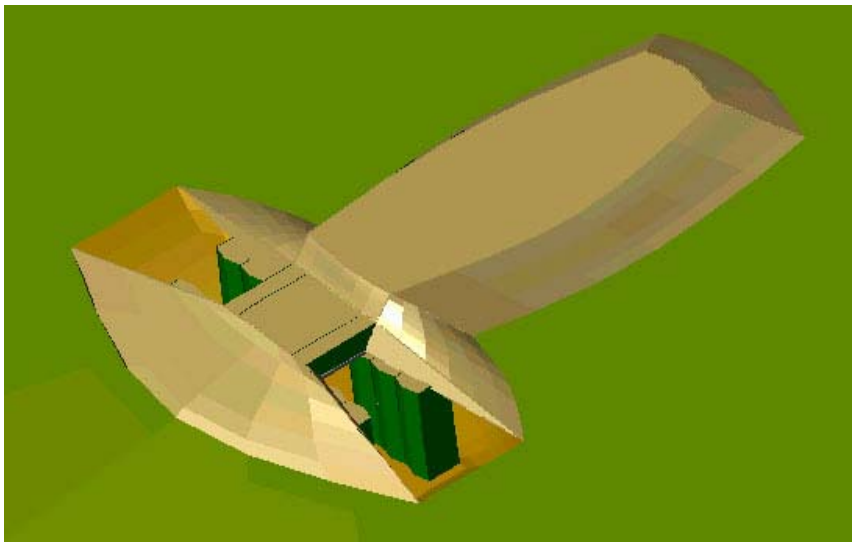
Concertainer retaining walls in place



Fiberglass roof covered with 2’ of fill material

- Materials required: 4 sections of Concertainer - 2’ high x 2’ wide x 4’ long
- Place Concertainer along edge of roof panels as shown in drawing
- Fill Concertainer with loose fill material and lightly compact
- Fill center of fiberglass roof with 2’ of infill material

Step 8 – Backfill Bunker

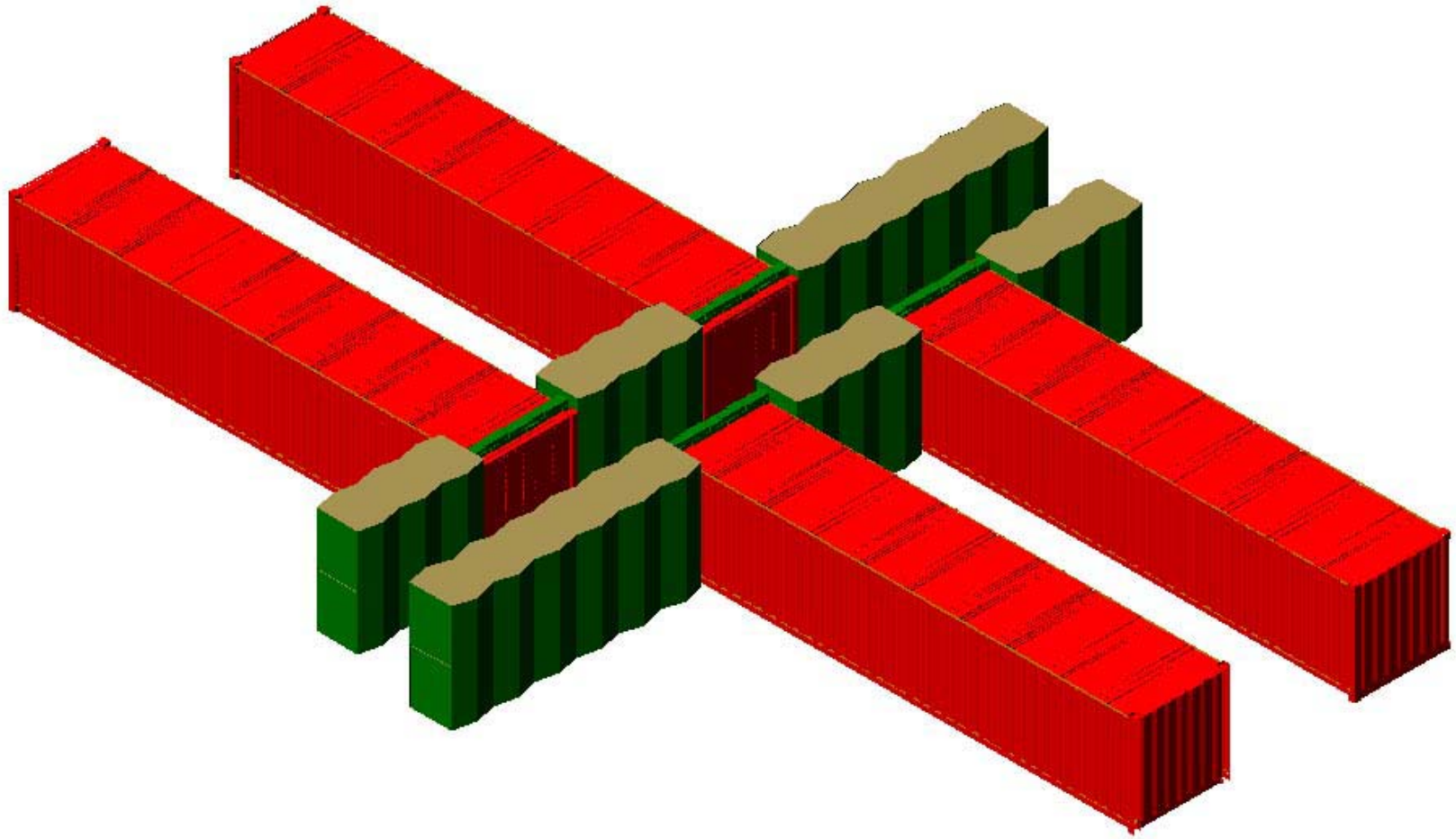


Completed bunker

Entrance way to completed bunker

- Complete bunker by backfilling void space around container, and placing 4’ of soil on top of container. Ensure internal steel framework is properly installed prior to backfilling.
- When placing fill, ensure only 2’ of cover is placed on fiberglass roof.
- Camouflage position as appropriate
- Ensure adequate air supply for personnel in shelter.
- Due to carbon monoxide poisoning, no open flames allowed inside of bunker

Bunker Complex



- **In the event it is necessary to provide multiple bunkers in close proximity, a “bunker complex” can be established in the fashion indicated above. Note that the roof panels and soil cover are not shown for clarity.**