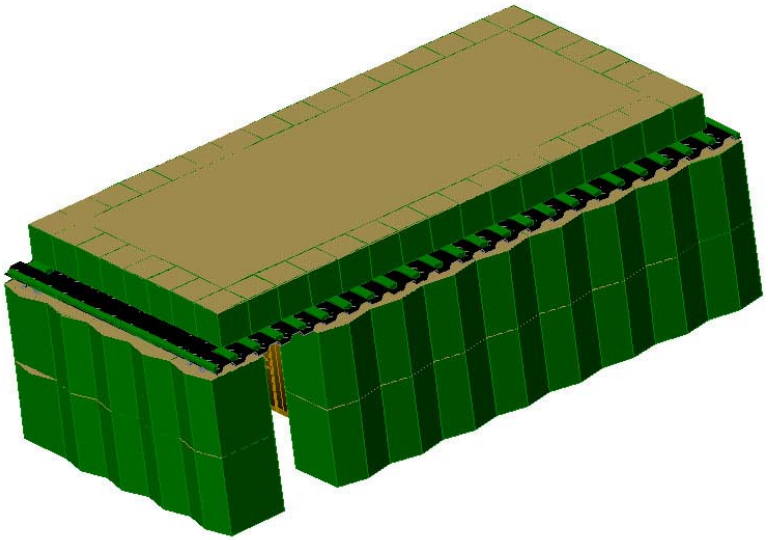
Construction Guide for

Aboveground 20' Milvan Bunker

May, 2003



Developed by:

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U.S. Army Engineer School, Fort Leonard Wood

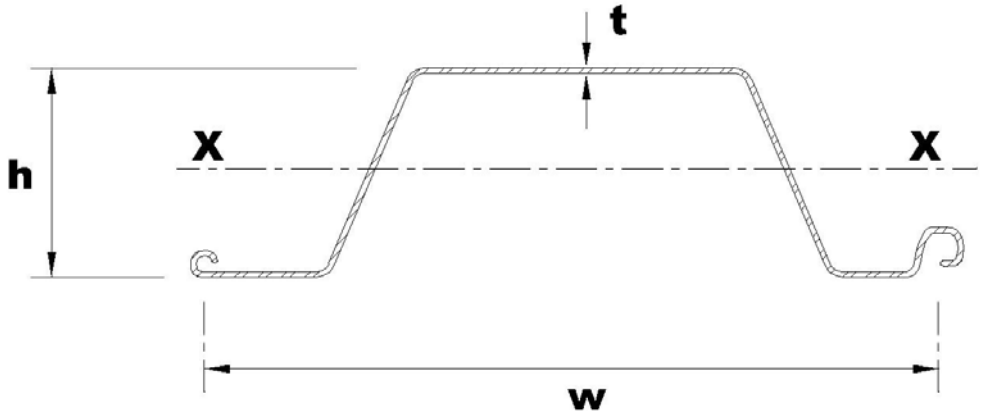
ERDC Engineer Research and Development Center

Geotechnical and Structures Laboratory

Bill of Materials

Item Description	NSN	Quantity
Concertainer – 4.5’ high, 3.5’ wide, 32’ long	5680-99-001-9396 – Green 5680-99-835-7866 – Beige/Sand	6
Concertainer – 2’ high, 2’ wide, 4’ long	5680-99-001-9397 – Green 5680-99-968-1764 – Beige/Sand	22
Sheet piling – 18’ long Skyline Steel CS 55 steel sheet piling, or equal (see “Sheet Piling Properties” on next page for material requirements)	NSN not available	19
Sand bags	-	100
Waterproof membrane (44’ x 18’)	5650-01-504-5373	1
Concertainer infill material, cubic yards	Not applicable	180

Sheet Piling Properties



Skyline Steel CS 55 steel sheet piling, or equal

Material Requirements

ASTM A572, Grade 50 steel

All piling shall be primed and painted as required

Minimum Section Properties

Thickness (t) = 0.2”

Height (h) = 6”

***Width (w) = 27.5”**

X-axis section modulus = 6.3 in^3/ft

X-axis moment of inertia = 18.7 in^4/ft

***Note – The width requirement is based on the number of sheet piling required to construct the roof. If piling of a different width is used, the required number of pieces shown on BOM may change.**

Equipment, Personnel and Time Estimate

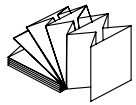
- **To assist in planning, provided below are estimates of the necessary equipment and soldier assets and total construction time required to construct this position. In many cases multiple types of equipment are capable of performing the same task, and are listed as alternatives. Consideration during 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. Note that based upon parameters such as foundation type and source of fill material, certain tasks – and their associated equipment – may be unnecessary. Only heavy equipment are listed below. Hand tools such as shovels, rakes, pliers, wire cutters, etc. will also be needed.**

  The indicated time required for construction includes the time associated with basic foundation preparation and construction of the position. Factors such as threat based urgency, equipment and material availability, poor foundation soils, 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 – 70 man-hours***

Task	Equipment Req'd.	Soldiers Req'd. (excluding operators)	Time Req'd.
Site preparation & foundation leveling	bulldozer, DEUCE, ACE, front-end loader, HMEE	2	1 hour
Foundation compaction	vibratory roller (smooth drum or pad feet), HSC	2	30 minutes
Haul infill material to site	dump trucks	varies	varies
Position ISO	crane, forklift	2	30 minutes
Erect walls & place infill	front-end loader, HMEE	6	5 hours
Construct roof & place infill	forklift, crane (w/ clamshell bucket for infill), HYEX	6	6 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.

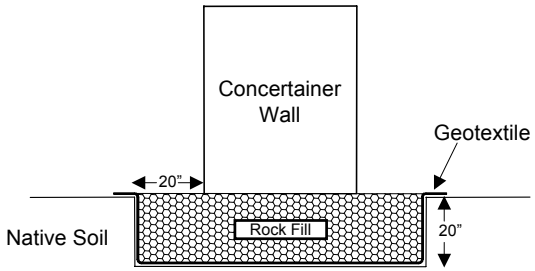
  To construct an improved foundation, excavate a trench 20" deep beneath all structure walls. The width of the trench should extend 20" beyond each edge of the wall.

  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:



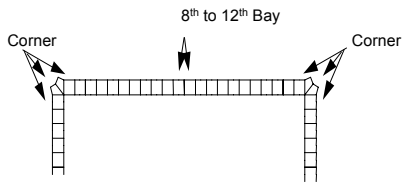
End View of Improved Foundation

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.**

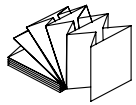
- Prior to filling, connect all units in a single layer together and adjust to the desired layout. Attaching empty units to filled units is difficult.

  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

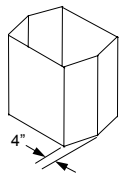


- Concertainer walls largely obtain their load carrying capacity and stability by “bulging” along the sides during the filling process and **allowing the wire/fabric structure to deform to its “maximum state”.** By allowing the bays to reach maximum deformation during filling, the infill material becomes 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.

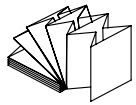
- To accommodate the deformation process previously described, the coil hinges on each side of every bay must be pulled out approximately 4” during initial filling. If coil hinges are not present, as with Mil 2 units, simply pull the sides of each bay outward to create a slightly curved side wall for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

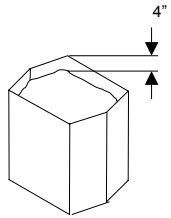


- After adjusting the base, fill the bay with infill material. **Unless otherwise specified, infill should be placed in lifts no greater than 9” in thickness and must be adequately compacted**. Adequate compactive effort can be obtained through foot compaction. During compaction, care must be taken to 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.**

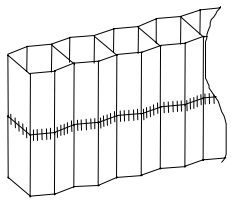
Hesco Bastion Concertainer
Site Preparation & Infill Guidelines



- 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.

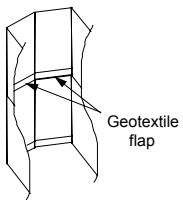


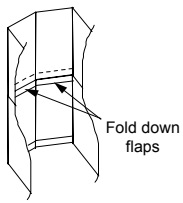
Place the 2nd layer on top of the 1st. **The 2nd layer must be positioned to ensure that it is correctly aligned with the 1st layer**. To achieve this alignment, place the second layer such that the bay corners of the 2nd layer are located directly above the corners of the 1st. This alignment will allow 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.

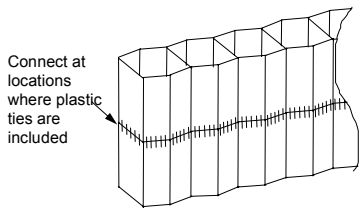


Ensure corners
are properly aligned.

- 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.

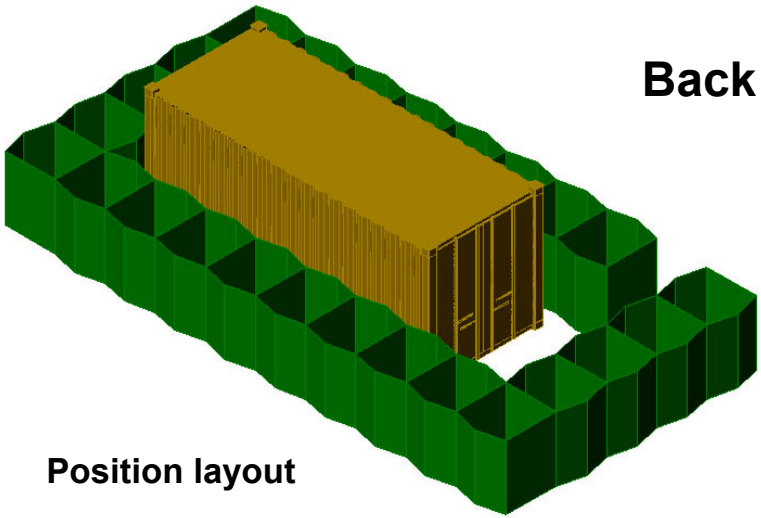




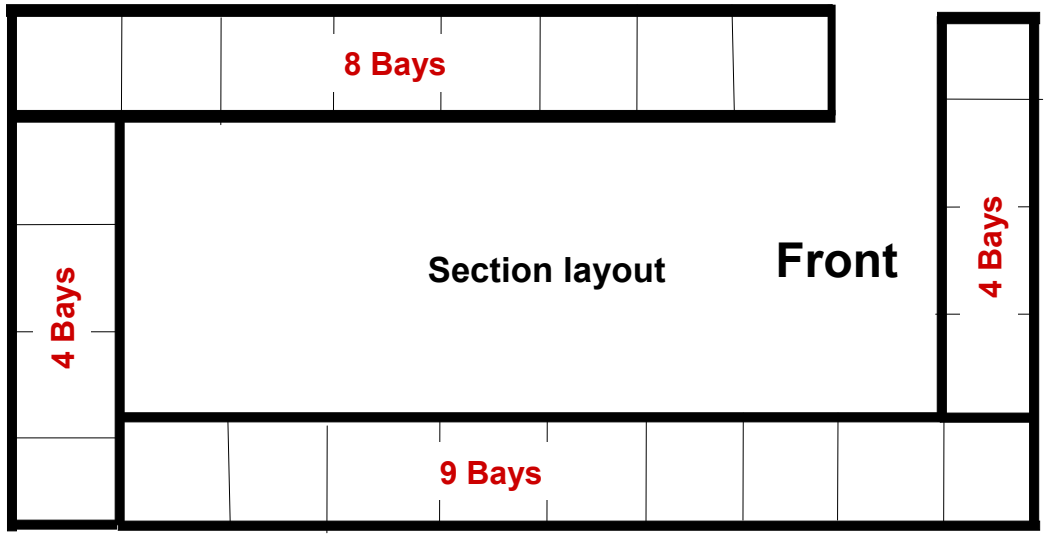


- Continue to fill the second layer in the same manner as the first layer.

Step 1 - First Layer



Position layout



Compact fill into the sides and corner

- Materials required: 3 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 section into two units, 4-bays each
- Arrange Concertainer as shown in drawing – Ensure flaps at bottom of units are folded <u>out</u>
- Fill Concertainer with infill material
- MAKE SURE FILL IS VERY WELL COMPACTED

Step 2 - Second Layer

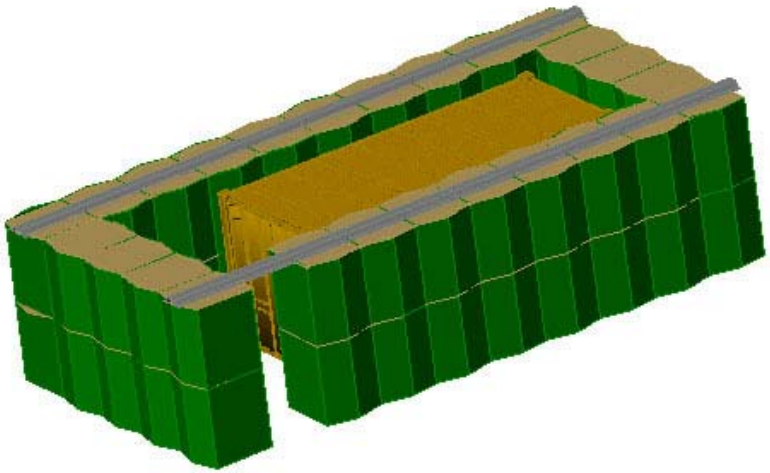
Placing second layer

Connecting second layer to first using plastic wire ties

Second layer in place and filled

- Materials required: 3 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 section into two units, 4-bays each
- Arrange Concertainer as shown in Step 1
- Connect second layer to first using plastic wire ties as shown
- Fill Concertainer with infill material
- MAKE SURE FILL IS VERY WELL COMPACTED

Step 3 – Sheet Piling Roof Support



Sheet piling placed on side walls for roof support

Sheet piling in place on side walls

- **Materials required:**
  (4) – 18’ long pieces of sheet piling
- **Place 2 pieces of sheet piling end-to-end on top of each side wall as shown**
- **Ensure piling is centered on side walls**

Step 4 – Sheet Piling and Sand Bag Roof

Interlock sheet piling

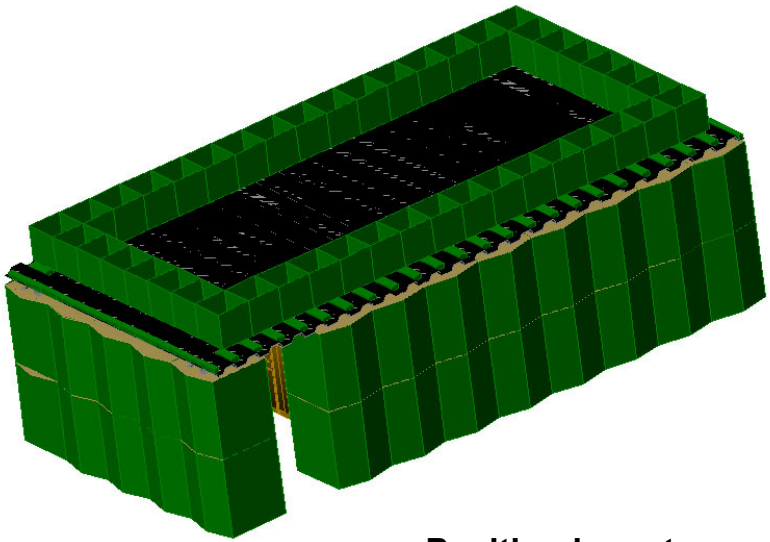
Place sheet piling roof

Place waterproof membrane

Sand bags used to level perimeter of roof

- **Materials required:**
  (15) – 18’ long pieces of sheet piling
  (100) - Sand bags
  (1) – 44’x18’ waterproof membrane
- **Place sheet piling on top of roof supports as shown. When placing sheet piling, utilize the built-in interlocking system to interlock piling. Interlocking is achieved by sliding the pieces together from the ends.**
- **Place waterproof membrane on top of sheet piling. Ensure membrane conforms to shape of sheet piling.**
- **Use sand bags to level perimeter of roof**

Step 5 - Overhead Cover



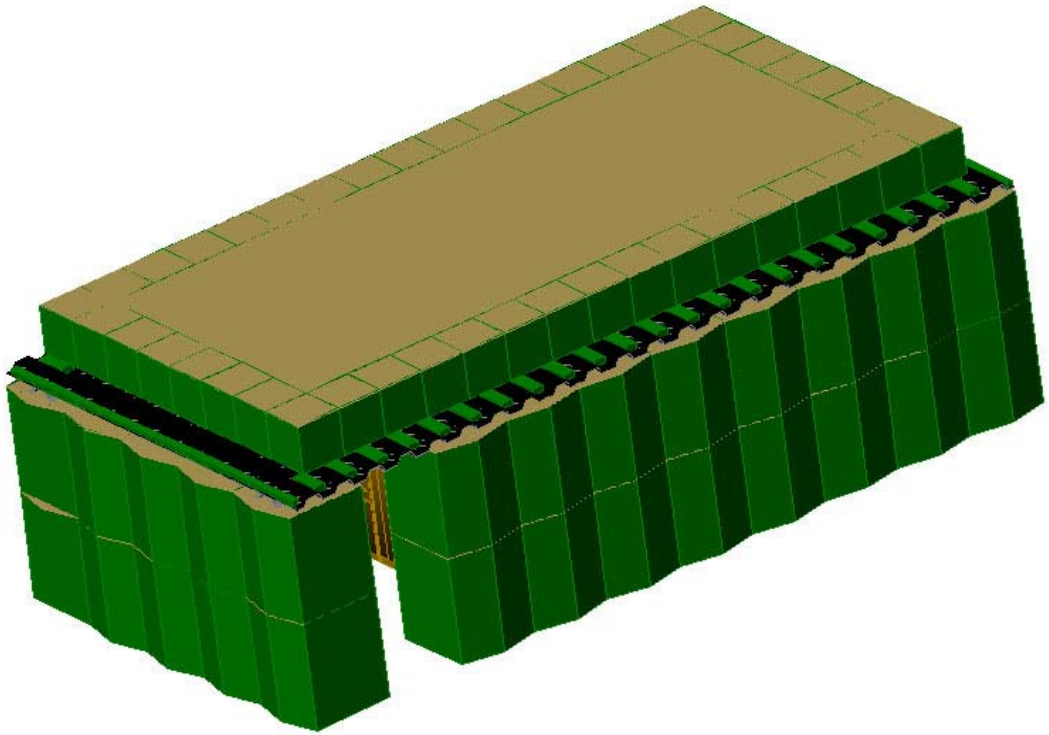
Position layout

Place Concertainer along roof perimeter

Fill Concertainer and center of roof

- Materials required: 22 sections of Concertainer - 2’ high x 2’ wide x 4’ long
- Place Concertainer as shown in drawing. Ensure sand bags are located beneath edge of Concertainer to prevent soil from leaking between Concertainer and roof.
- Fill Concertainer with loose fill and lightly compact
- Fill center of roof with 2’ of fill

Step 6 - Bunker Checklist



Check completed bunker to ensure:

- **No excessive deflection of roof (up to 0.75” is acceptable)**
- **Roof supports centered on side walls**
- **Sheet piling roof fully supported by roof supports**
- **Walls straight**
- **No excessive settlement of walls**