4.1 MECHANICALLY STABILIZED EARTH (MSE) WALLS

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4.1 MECHANICALLY STABILIZED EARTH (MSE) WALLS

4.1.1General

Bridges are not static structures, but are continually in motion. Linear movements of expansion and contraction (translations) are caused by temperature changes. Rotational movement is caused by imbalances in dead loads and live load movements (traffic). Other movements can also be caused by earth pressures and settlement.

This section is designed for the inspector of mechanically stabilized earth walls with a focus on panel systems. Modular Block Wall (MBW) systems will be covered in a more detailed fashion in another section. It will provide general guidelines for the inspector; however, the plans, specifications and special provisions govern and must be read and followed. KDOT allows the contractor to construct a variety of MSE wall systems, but each system shares many common features with the others. Successful wall construction requires a basic understanding of MSE wall construction and carefully following the plans and specifications.

4.1.2 TERMS:

The following is a list of terms that will be used in this chapter. See Figure 1, Wall Components for reference.

Coping- The coping is used to tie in the top of the wall panels and to provide a pleasing finish to the wall top. It can be cast-in-place or made from prefabricated segments.

Extensible Reinforcement – Soil reinforcement made from polymer. These will stretch under a load.

Filter Fabric - A geotextile filter fabric is used to cover the joint between panels. It is placed on the backside of the panels. This keeps the soil from being eroded through the joints (fine migration) and allows any excess water to flow out.

Inextensible Reinforcement – Soil reinforcement made from metallic material (strips, mats, mesh and grids). These materials will not stretch as much under a load as the extensible reinforcement.

Leveling Pad - The leveling pad is a non-reinforced pad of Commercial Grade (AE) concrete. It is used to provide a level, consistent surface at the proper grade to place the panels.
Original Ground - This is the existing ground surface at the site.

Random Backfill (or Retained or Local Backfill) – Fill material placed behind the reinforcing. The backfill allowed in normal embankment construction.

Select Structural Backfill - The fill that meets the gradation, corrosion, unit weight, internal friction angle, electrochemical and any other requirements of the specifications and encapsulates the reinforcement.

Soil Reinforcement - Soil reinforcement holds the wall facing panels in position and provides reinforcement for the soil. It serves to hold the soil, reinforcing, and wall facing panel as a cohesive gravity mass. The soil reinforcement can be strips, grids, or mesh. The reinforcement can be made of steel (inextensible materials) or polymers (extensible materials).

Spacers - Wall panel spacers are typically ribbed elastomeric or polymeric pads. They are inserted between panels to help provide the proper spacing. Maintaining proper spacing keeps the panels from having point contact and spalling the concrete.

Wall Facing Panel - Wall facing panels are used to hold the soil in position at the face of the wall. The panels are typically concrete but they can be metal, wood, block, mesh or other material.

Wall/Reinforcement Connection - This is where the soil reinforcement ties into the wall facing panel.

Water - The water described here is that which may be necessary for bringing the select backfill material up to optimum moisture content. It shall meet the electro-chemical properties of the select backfill.

Wooden Wedges (or Shims) - Wooden wedges are used to help hold the panels at the correct batter during the filling operation. The wedges should be made from hard wood (such as oak, maple or ash).

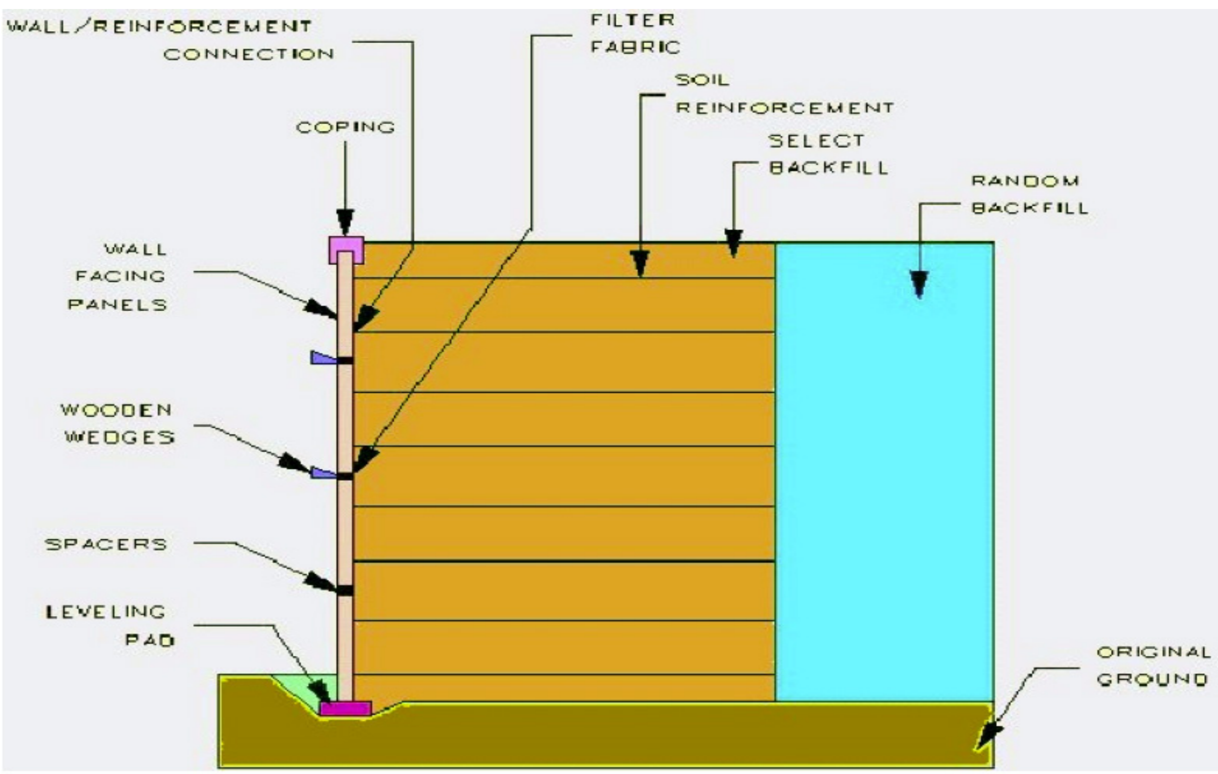

Figure 1, Wall Components

4.1.2MECHANICALLY STABILIZED EARTH WALL SYSTEM:

The wall system consists of the original ground, concrete leveling pad, wall facing panels, coping, soil reinforcement, select backfill and any loads and surcharges. All of these items have an affect on the performance of the MSE wall and are taken into account in the stability analysis. The general concept of the MSE wall system is that the weight of the select backfill “grabs” the soil reinforcement by friction and by directly binding with the granular backfill. The backfill wants to push the facing panels out, but the connection between the facing and the reinforcement prevents this. A change in any of the parts of the system without considering its effect on the design assumptions could have a detrimental effect on the wall.

4.1.3PREPARATION OF THE SITE:

The MSE wall footprint area needs to be prepared. The footprint area is the zone of the wall facing, soil reinforcement and select backfill. The foundation for the structure shall be graded level for a width equal to or exceeding the length of soil reinforcement or as shown on the plans. Any soft or loose material that is encountered should be compacted or removed and replaced. The foundation soils for the retaining system must be proof rolled before wall construction begins and after the required excavation is completed. If soils are encountered that do not match the borings performed for the wall they should be brought to the attention of the geotechnical engineers for analysis.

4.1.4LEVELING PAD:

Once the area has been properly prepared, an unreinforced concrete leveling pad is poured in place. The leveling pad concrete must cure for a minimum of 12 hours before placement of the wall panels can begin. Even though the leveling pad is not "structurally" important, it is important to the construction of the wall. The leveling pad sets the horizontal and vertical alignment of the wall. It must be in the correct horizontal position, level and at correct grade. No more than 2 wedges (each 3/16" thick) should be required to level the panels on the leveling pad. If the wall is not level, the panels will bind against each other, causing spalling of the edges and corners. Experience has shown that if the wall is not started correctly, the finished product is seldom satisfactory (see Figure 2, Improper Leveling Pad and Figure 3, Leveling Pad).

Figure 2,Improper Leveling Pad

Figure 3,Leveling Pad

4.1.5 WALL FACING PANELS:

Wall panels come in many shapes and sizes (see Figure 4, Some Panel Finishes and Shapes for a few of the most common shapes). They can be custom built into any configuration that will fit together. The front face can have any type of finish, shape, texture or other surface treatment that can be formed.

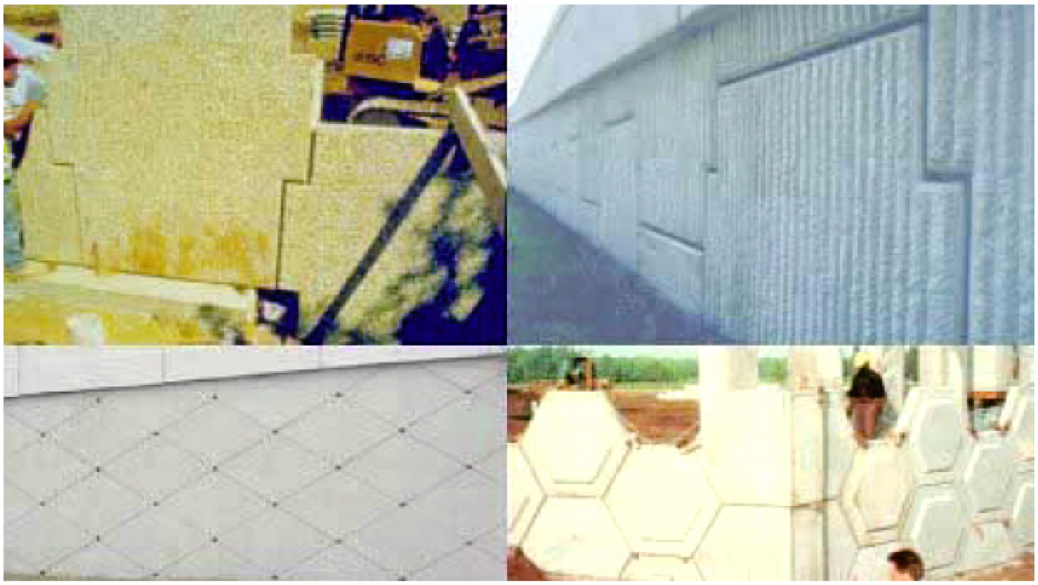

Figure 4, Some Panel Finishes and Shapes

Before the panels are placed, the wall and shop drawings must be checked to ensure that the proper panels are being used. Depending on the wall height, the number of reinforcement connections on the back of the panel may vary. The panels with the most connections will be typically the lower panels of the wall. In the upper portions of the wall, the number of connections may be less. It is important that the panels are used in their proper position. The panels need to be inspected to ensure they meet the plans, specifications, and shop drawings. They also need to be inspected for damage (bent connectors, damaged panels, etc.).

The correct placement of the first row or two of panels is very important (see Figure 5, Placing Panels). A spacer bar should be used to get the correct placement. They need to be on the proper alignment and grade and be level. The correct spacing is also very important. Without the correct spacing, panel corners will crack and spall as they settle. Spacing blocks must be used. Wooden wedges are also used to help hold the vertical alignment of the panels. The contractor should not keep more than three levels of the wooden wedges in the wall. If more than three levels of wedges are used they may become bound in the wall making them very difficult to remove and can cause the panel to spall. The drainage system for the wall must be installed at this early stage of wall construction to prevent ponding of water in the excavation and the subsequent loss of strength of the foundation soils.

Figure 5, Placing Panels

The vertical and horizontal alignments need to be checked periodically to ensure proper alignment. This will also uncover problems early so corrections can be made before the panels get too far out of alignment.

Slip Joints

Typically, a slip joint is created by breaking the pattern of the facing panels. Slip joints are used to handle large differential vertical movement of the wall (Figure 6, Slip Joint).

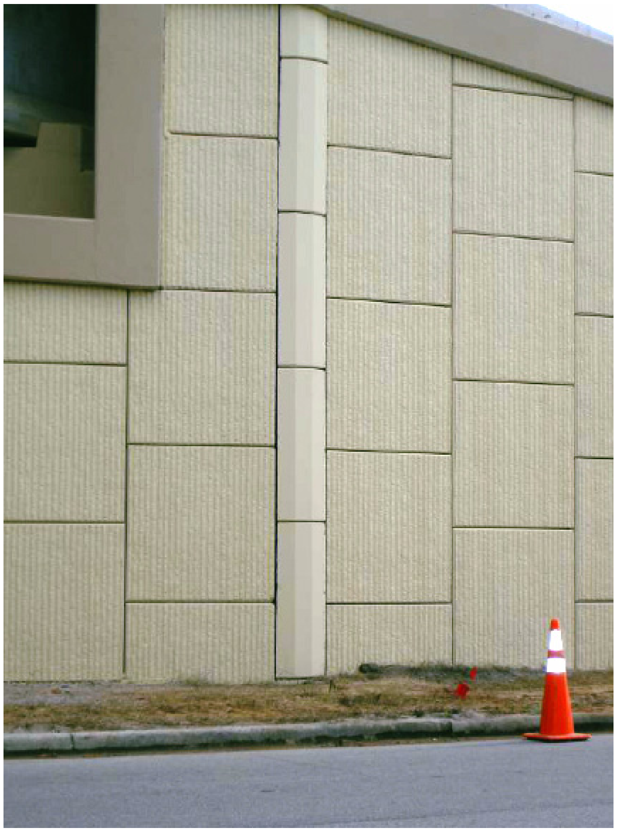

Figure 6, Slip Joint

Corner Panels
Corner panels provide a good connection between the two walls and act like slip joints for the wall, allowing differential movement between the two walls (Figure 7, Corner Panel).

Figure 7, Corner Panel

4.1.6 PANEL STORAGE:

Panels should be stored flat and on dunage (see Figure 8, Proper Panel Storage and Figure 9, Improper Panel Storage). Properly storing panels protects the connections from being bent and damaging the galvanization (see Figure 10, Damaged Tabs). Panels with bent connections will not be used. Panels should be stored out of the mud to avoid staining the panel face.

Figure 8, Proper Panel Storage

Figure 9,Improper Panel Storage

Figure 10, Damaged Tabs

4.1.7 SOIL REINFORCEMENT:

The soil reinforcement is used to make a unified gravity mass consisting of select structural backfill, facing, and the reinforcement and acting like a gravity wall for exterior analysis purposes. Metallic reinforcement should not be bent or torn, and the galvanization should not be damaged. Polymer reinforcement should not be torn, cut, left in the sun or otherwise damaged. The inspector should check the reinforcement to make sure that it is the required length and gauge prior to placement. No equipment should be allowed to operate directly on the reinforcement, with the exception of wheeled equipment on polymeric reinforcement. Reinforcement can be damaged by sharp turns, so it should be checked and replaced prior to backfilling. Typically, the reinforcement is placed perpendicular to the wall face. Slack in the reinforcement should be removed prior to placing the backfill over it, and polymer reinforcement should have some tension placed in the reinforcement. The reinforcement should not be connected to the wall until the compacted fill is at or slightly higher than the facing panel connector.

At vertical obstructions the reinforcement should not be angled more than 15° from perpendicular (see Figure 11, Vertical Obstructions) to the wall. No exceptions to this should be allowed without verifying with the wall supplier and engineer of record.

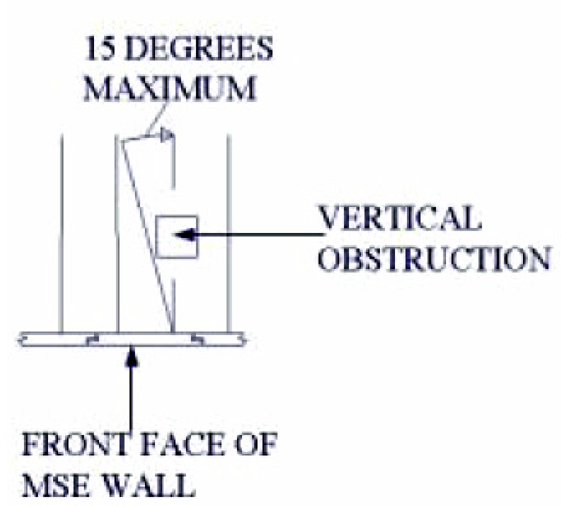

Figure 11, Vertical Obstructions

Ideally, horizontal obstructions consisting of utilities carrying water through the reinforced mass should not be allowed. At horizontal obstructions, if the reinforcement must be more than 15° from horizontal (see Figure 12, Horizontal Obstructions) the supplier and engineer of record should be contacted. It may require additional reinforcement length to meet design. When clearing horizontal obstructions, the reinforcement should be smoothly curved around the obstruction. The reinforcement should not be kinked at any time. There should also be a minimum of 4 inches of compacted soil between the obstruction and the reinforcement. Table 1 shows the recommended transition distance X (see "X" in Figure 14) from the point of connection to provide a smooth curve of the reinforcement with an offset of d (see "d" in Figure 13, Transition Distances). If these distances cannot be achieved the wall supplier should be contacted to check the design.

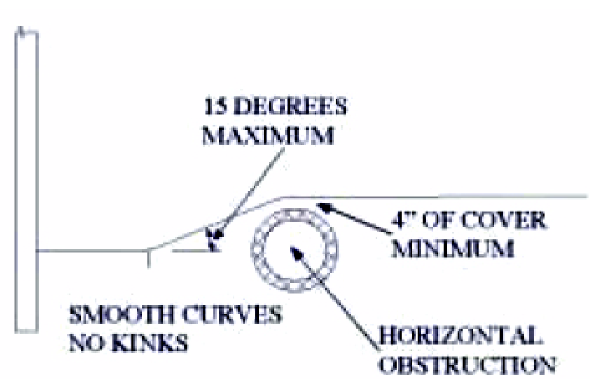

Figure 12, Horizontal Obstructions

Offset Distance "d"	Recommended Transition Distance "X"
0" – 3.99"	2'-0"
4" – 5.99"	2'-3"
6" – 7.99"	2'-7"
8" – 9.99"	3'-3"
10" – 11.99"	4'-0"
12" – 14.99"	5'-0"
15" – 17.00"	6'-0"

Table 4.1.1 Transition Distances

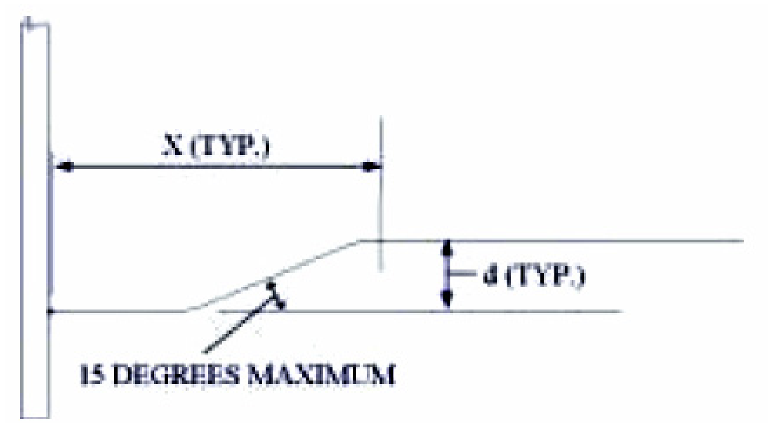

Figure 13, Transition Distances

Reinforcement Storage

Like the panels, the reinforcement should be stored on dunage (see Figure 14, Reinforcement Storage) and carefully handled to prevent damage. Damage may include excessive bending of the reinforcement and damaging the galvanization.

Figure 14, Reinforcement Storage

Coping/Barrier

Precast or cast-in-place coping/barriers may be used. For precast units, a leveling course of concrete is placed prior to setting the units in place (see Figure 15, Leveling Course for Coping/Barrier). This provides the vertical control needed. Precast barriers are tied together and strengthened against vehicle impact by a slab cast typically in 30-foot sections (see Figure 16, Barrier with Slab).

Figure 15, Leveling Course for Coping/Barrier

Figure 16, Barrier with Slab

Abutment Cheek Walls

When abutments are on a deep foundation, a bond breaker is needed between the MSE Wall panel and the cheek wall (see Figure 17, Bond Breaker). If this is not done, when the wall settles and the abutment does not, it creates a tension load in the cheek wall and the panel. This eventually causes one or both to crack (see Figure 18, Cracked Panel and Cheek Wall and Figure 19, Tension Break in Cheek Wall). When rough panel finishes are used (such as shown Figure 18, Cracked Panel and Cheek Wall) a heavy/thick bond breaker is required. In cases such as this a thin paper bond breaker forms to the panel irregularities and the panel locks into the poured concrete, whereas with smooth panel finishes, a paper bond breaker would usually be sufficient.

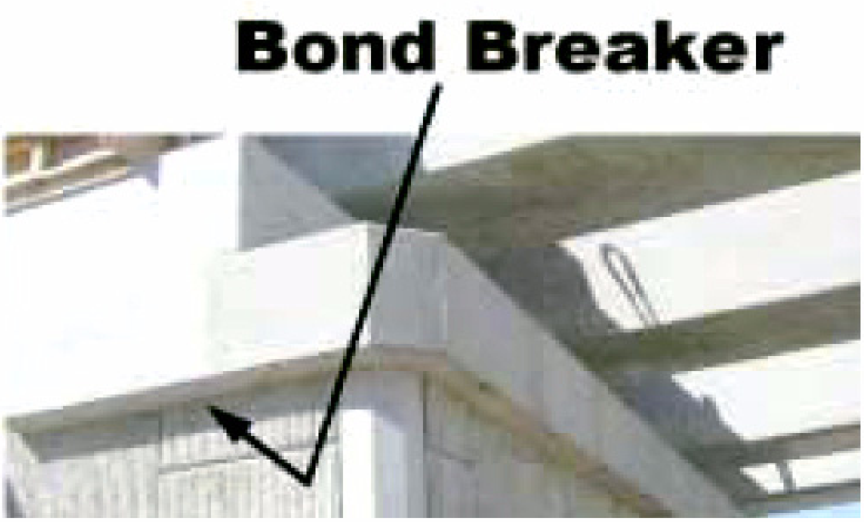

Figure 17, Bond Breaker

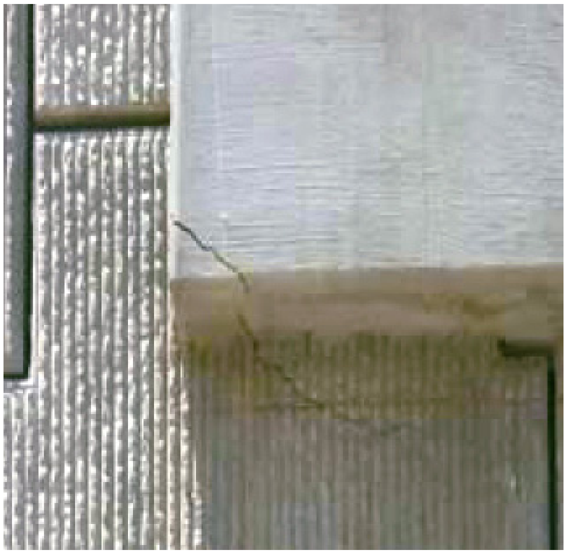

Figure 18, Cracked Panel and Cheek Wall

Figure 19, Tension Break in Cheek Wall

4.1.8 SELECT BACKFILL:

The select backfill must meet the specification requirements for gradation, electro-chemical properties, soil properties and organic content.

Placing Backfill

The select backfill lift should be placed parallel to the wall and starting approximately 3 feet from the back of the wall panels. The backfill should be placed in 10 inch loose lifts (it may be helpful to mark your lifts on the back side of the wall panels). The fill is then leveled by machinery moving parallel to the wall, windrowing the material toward the reinforcement ends. This action works out any slack in the reinforcement then locking the reinforcement and the panels in position. Once this has been accomplished, fill is then placed within 3 feet behind the wall by windrowing the material.

Except for the initial layer, the fill must be brought up uniformly for the whole layer.

4.1.9COMPACTION:

Compaction equipment used within 3 feet of the wall should be a vibratory roller or plate weighing less than 1,000 pounds. From beyond 3 feet of the wall facing panels, a roller up to 8 tons may be used, subject to satisfactory performance (see Figure 20, Compaction Equipment). A rubber-tired roller may also be acceptable. Compactors which employ a foot such as a sheepsfoot (see Figure 21, Sheepsfoot Rollers Not Allowed) or grid rollers, are not acceptable for compacting select structural backfill.

Figure 20, Compaction Equipment

Figure 21, Sheepsfoot Rollers Not Allowed

Backfill compaction shall be performed in such a way that the compactor shall move in a direction parallel to the wall facing panels and proceed from a distance not less than three feet behind the wall facing panels and work toward the end of the soil reinforcement away from the wall facing (see Figure 41, Initial Compaction).

The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer of material. Backfill material shall have placement moisture content within 3 percent of the optimum moisture content.

If additional water is required for the material, the water must meet the specification requirements.

4.1.10 DAY'S END:

At the end of each day's operation, the Contractor shall shape the last level of backfill to permit runoff of rainwater away from the wall face or shall provide a positive means of controlling runoff away from the wall such as temporary pipes, etc. Failure to do this could result in the erosion of material from around the soil reinforcement wall or damage to the wall directly due to water pressure building up behind the wall (see Figure 22, Wash Out From Around Reinforcement).

Figure 22, Wash Out From Around Reinforcement

4.1.11 BACKFILL IN FRONT OF WALL:

The area in front of the wall and around the leveling pad should be backfilled as soon as practically possible. A strong rainstorm could cause heavy flow along the wall. This could cause soil erosion and undermining of the leveling pad and the wall.

4.1.12 MISCELLANEOUS POINTS:

Before the actual start of construction of the wall, the various parts of the plans (shop drawings, drainage, lighting, etc.) need to be compared to the contract wall plans to check for conflicts. A conflict may not have been noticed in the design stage.

If the plans show heavy loads on the wall, such as temporary construction loads, but the shop drawings do not indicate them, the wall supplier should be questioned. The wall supplier may not have seen a full set of plans and may have missed loadings from various types of equipment. If the wall supplier did not take these loads into consideration, the wall could fail (see Figure 23, Construction load and Figure 24, Not properly avoiding drainage structure).

Figure 23, Construction load

Figure 24, Not properly avoiding drainage structure

Design for drainage structures in the wall mass are also sometimes missed by the wall supplier. Sometimes it is necessary to angle the reinforcement, but never angle them more than 15° from the perpendicular to the wall without verifying adequacy with the wall supplier and engineer of record.

Retention ponds located next to MSE walls need to be checked. Check that the wall is protected from scour by the drainage pipes.

Excavations next to existing MSE walls can trigger settlement, global stability, and bearing capacity failures (see Figure 25, Settlement from Excavation and Figure 26, Joints Opening from Settlement).

Figure 25, Settlement from Excavation

Figure 26, Joints Opening from Settlement

This can also happen if a trench is dug before erecting a wall, and the trench back fill is not properly compacted As can be seen in Figure 27 a drainage pipe was installed prior to erecting the wall. Once the rains came and softened up the soils, a lateral squeeze or local bearing capacity failure was triggered caused by the pipe backfill not being properly compacted.

Figure 27, Wall Failure from Exterior Excavation

Settlement can also happen if the wall is built over an existing drainage pipe. Figure 28, Settlement from a leak in a pipe joint shows this when after several years of wall service some of the pipe joints started leaking allowing soil from under the wall to migrate into the pipe. This resulted in the wall settling.

Figure 28, Settlement from a leak in a pipe joint

Temporary Wall Facing

Temporary wall facings are used at times to handle large settlements that the permanent wall facings could not handle. These applications typically utilize geosynthetic reinforcement.

The wall is built using a temporary facing such as fabric wrapping with tabs sticking out for the eventual connection of a permanent facing (see Figure 29, Temporary and Permanent Wall Facings). The permanent facing is not attached until the majority of the settlement has been occurred.

Figure 29, Temporary and Permanent Wall Facings

One problem that has occurred with the extensible reinforcement is that fire can damage the material that is at the face of the wall (see Figure 30, Fire Damaged Reinforcement). This can be repaired by connecting new reinforcement from the undamaged reinforcement in the embankment mass out to the wall face.

Figure 30, Fire Damaged Reinforcement

4.1.13 CONSTRUCTION:

The construction sequence is typically as follows:

1. The site is cut to grade and all unsuitable material is removed.

2. The site is proof-rolled to show any loose and/or unsuitable materials. Remove and replace any unsuitable material found and compact any loose material. Use a roller with a minimum static weight of 8 tons.

3.The leveling pad excavation is dug (see Figure 31, Prepaire Site, Proof Roll & Excavate Footing).

4. The leveling pad is placed (see Figure 32, Place Concrete Leveling Pad). The concrete is allowed to cure a minimum of 12 hours before any panels are placed.

5. The first row of panels are placed on the leveling pad and braced (see Figure 33, Install and brace first row of panels). If ½ panels are used they are placed at the correct spacing using a spacing guide; then the second row is set and braced. The panels should be set with a backward batter, typically 1/8 inch per foot. The batter is adjusted for the backfill properties. Finer sands may require a larger batter.

Figure 31, Prepaire Site, Proof Roll & Excavate Footing

Figure 32, Place Concrete Leveling Pad

Figure 33, Install and brace first row of panels

6. An adhesive is used to hold the filter fabric across all of the panel joints. The adhesive should be applied on the panel next to the joints, since applying adhesive on the filter fabric tends to clog the filter fabric. Then the filter fabric is placed over the joint (see Figure 34, Attach Filter Fabric).

Figure 34, Attach Filter Fabric

7.The select backfill is then placed and compacted to the level of the first row of connections. The compacted fill should be at or slightly higher than the panel connections (see Figure 36). On the initial row of panels (and only the initial row of panels) the backfill is not placed against the panel until the first row of reinforcement have been connected and the initial 6 inch layer of compacted fill is placed on the reinforcement. This is to keep the bottom of the panels from "kicking out". From that point, the backfill is brought up uniformly from the back of the panels to the end of the reinforcement.
8. The reinforcement is then placed perpendicular to the wall panel and the connection (see Figure 36, Connect and Tighten Reinforcement). Any slack in the reinforcement should be removed to avoid excessive panel movement. Maximum loose lift thickness is 10 inches.

Figure 35, Fill in 10" Lifts to Reinforcement

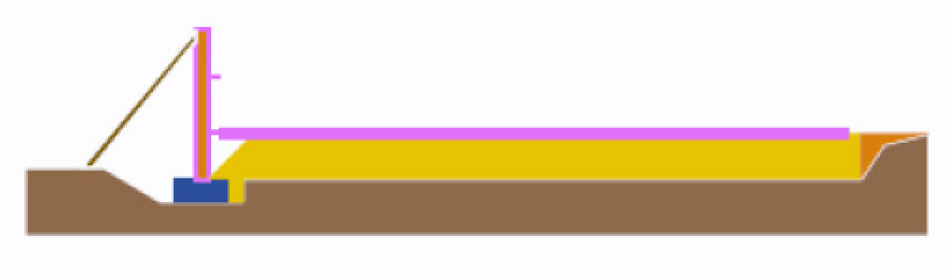

Figure 36, Connect and Tighten Reinforcement

With extensible reinforcement, some tension should be applied to the reinforcement by means of a kicker tension device or a rod (see Figure 37, Tensioning Polymer Reinforcement).

Figure 37,Tensioning Polymer Reinforcement

1.Then another row of wall panels is placed with the proper batter.

Figure 38, Continuation of fill placement

2.The select backfill is then placed (see Figure 38, Continuation of fill placement) in 10 inch loose lifts until the fill is at or slightly above the next set of connections.

Any additional water needed for compaction must meet the specification requirements. The backfill is placed parallel to the wall starting approximately 3 feet from the back of the panels. The fill is then windrowed toward the reinforcement ends (see Figure 39, Typical fill layer placement (Plan View)). Once this is complete, the fill is windrowed from the 3 feet point back toward the panels (see Figure 40, Typical fill layer placement (Plan View)).

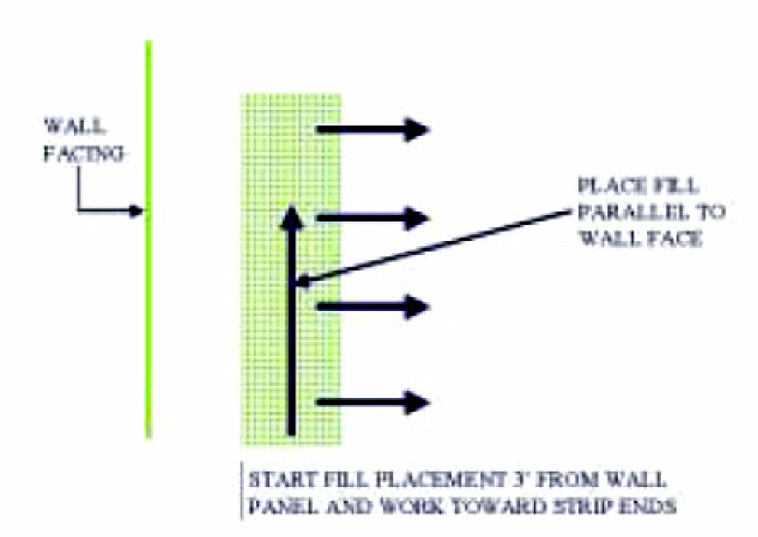

Figure 39, Typical fill layer placement (Plan View)

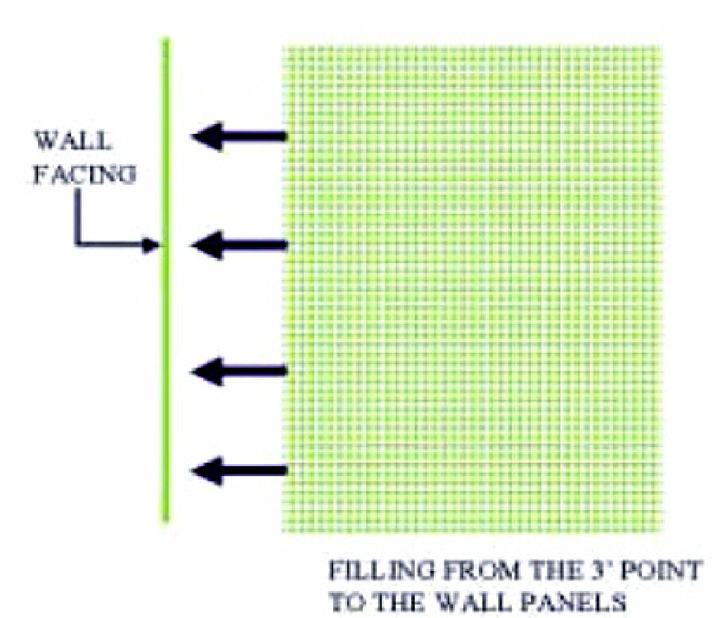

Figure 40, Typical fill layer placement (Plan View)

11. The compaction equipment rolls parallel to the wall facing. Compaction starts at least 3 feet from the wall and works toward the end of the reinforcement (see Figure 41, Initial Compaction

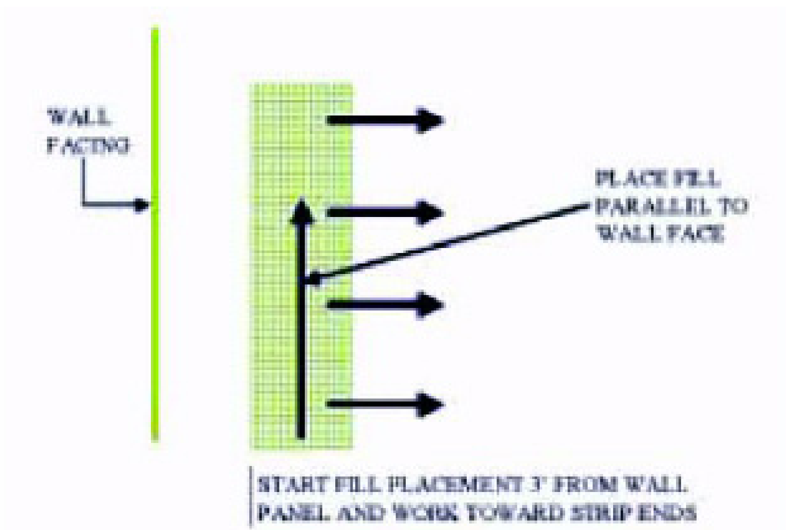

Figure 41, Initial Compaction

12.Compact the remaining 3 feet next to the wall (see Figure 42, Final Compaction). This compaction is accomplished with compaction equipment of 1,000 lbs. or less.

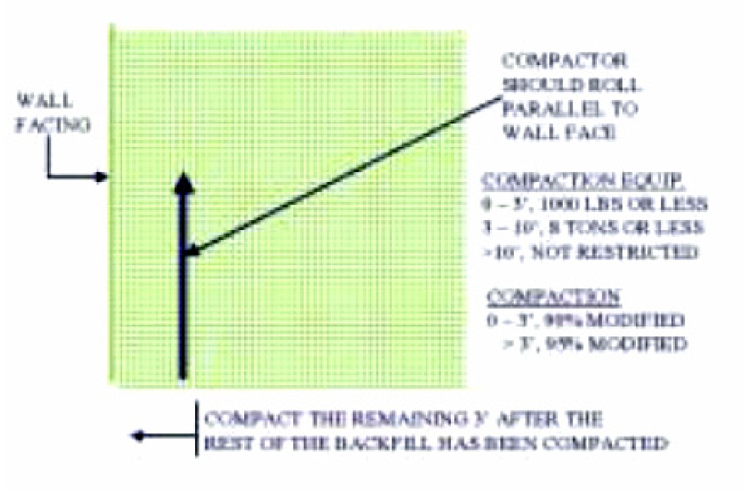

Figure 42, Final Compaction

13. Remove wooden wedges as soon as the precast component above the wedged precast component is completely erected and backfilled (see Figures 43 and 44, Wooden Wedges). In no case should there be more than three rows of wooden wedges in place. Failure to remove the wooden wedges can cause the panels to crack or spall.

Figures 43 and 44, Wooden Wedges

14. Repeat steps 8, 9, 10, 11 and 12 until the top of the wall is reached. As soon as practical the front of the wall should be backfilled. This should occur prior to reaching the top of the wall (see Figure 45, Place Backfill in Front of the Wall as Soon as Practical).

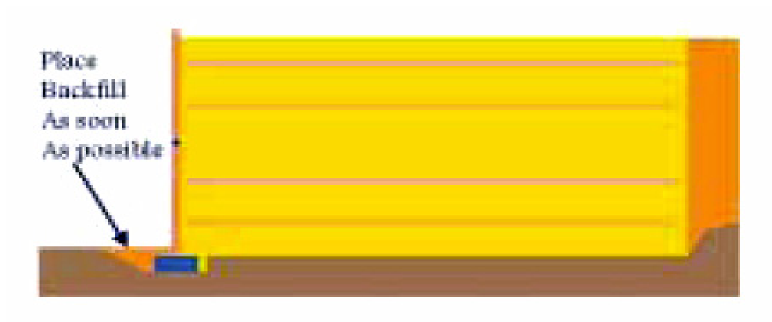

Figure 45,Place Backfill in Front of the Wall as Soon as Practical

15. The coping is then placed on the top of the wall. The wall is completed when the coping is properly installed on top of the wall.

4.1.14POST CONSTRUCTION:

Once the wall construction has begun care must be taken when excavating near it. An MSE wall is a large spread footing. When excavations occur close to the wall, a bearing capacity failure could occur.

This is especially true when excavating below the existing water table. Any excavations within a few feet of the toe of the wall need to be analyzed and checked by KDOT Geotechnical Unit. Also, if dewatering is planned near the wall, it should be analyzed and checked by the KDOT Geotechnical Unit.

Measurement and Payment

MSE walls are bid as “Retaining Wall (*)”, where the “*” is the type of wall used. The MSE wall will be measured by the square foot (square meter). The Engineer will use the neat lines shown in the Contract Documents to compute the quantities. The materials, fabrication, and construction required to install the wall are included in this pay item. See the Special Provision for your project for a list of items that are subsidiary to this item.

4.1.15 Appendix A - CHECK LIST:

The following is a minimum checklist to follow when constructing a Mechanically Stabilized Earth (MSE) wall. The answer to each of these should be yes unless plans, specifications or specific approval has been given otherwise.

YES NO
1. ☐ ☐ Has the contractor submitted wall shop drawings?
2. ☐ ☐ Has the contractor submitted select backfill certification showing that it meets the gradation, density and corrosion and other soil requirements?
3. ☐ ☐ Has the contractor supplied a Certificate of Compliance certifying that the wall materials comply with the applicable sections of the specifications?
4. ☐ ☐ Has the contractor supplied a copy of all test results performed by the Contractor or his supplier, which are necessary to assure compliance with the specifications?
4. ☐ ☐ Has the Contractor furnished a copy of any instructions the wall supplier may have furnished?
5. ☐ ☐ Have the shop drawings been approved?
6. ☐ ☐ Did the contractor receive the correct panels (shape, size and soil reinforcement connection layout) per the approved shop drawings?
7. ☐ ☐ Did the contractor receive the correct reinforcement (proper length and size)?
8. ☐ ☐ Have the panels and the reinforcement been inspected for damage as outlined in the specifications?
9. ☐ ☐ If any panels or soil reinforcement were found damaged have they been rejected or repaired in accordance with the specifications?
10. ☐ ☐ Are the panels and the soil reinforcement properly stored to prevent damage?
11. ☐ ☐ Has the MSE wall area been excavated to the proper elevation?
12. ☐ ☐ Has the area been proof-rolled per the specifications (a minimum of 4 passes by a roller weighing a minimum of 8 tons?
13. ☐ ☐ Has all soft or unsuitable materials been compacted or removed and replaced?
14. ☐ ☐ If the contractor is using any water in the MSE wall area does it meet the requirements shown in the specifications?
15. ☐ ☐ Has the leveling pad area been properly excavated?
16. ☐ ☐ Has the leveling pad been set to the proper vertical and horizontal alignment?
17. ☐ ☐ Has the leveling pad cured for a minimum of 12 hours before any panels are set?
18. ☐ ☐ Is the first row of panels properly placed? Do they have proper spacing, bracing, tilt and where required, do they have the spacers installed?
19. ☐ ☐ Has the proper filter fabric and adhesive been supplied?
20. ☐ ☐ Is the filter fabric being properly placed over the joints?
21. ☐ ☐ Is the adhesive being applied to the panel, than the filter fabric being placed?

CHECK LIST continued

YES NO

22. ☐ ☐ Is the filter fabric being stored properly (stored out of the sunlight and protected from UV radiation)?
23. ☐ ☐ Is the contractor using the correct panels (correct size, shape and with the proper number of connections) for that panel's wall location and elevation?
24. ☐ ☐ Is the fill being placed and compacted in loose 10 inch lifts?
25. ☐ ☐ Is the equipment being kept off of the soil reinforcement until a minimum of 6 inches of fill is placed?
26. ☐ ☐ Are the lifts being placed by the proper method and sequence?
27. ☐ ☐ Is the fill being compacted by the correct equipment and in the correct pattern?
28. ☐ ☐ Is the proper compaction being met? A minimum of 95 percent of maximum density must be met 3 feet or greater from the wall.
29. ☐ ☐ Is the fill being brought up to or slightly above the soil reinforcement elevation before the reinforcement are connected?
30. ☐ ☐ Is the soil reinforcement being properly connected (connections tight and all of the slack in the soil reinforcement removed)?
31. ☐ ☐ Is the soil reinforcement in the proper alignment?
32. ☐ ☐ Is the vertical and horizontal alignment being checked periodically and adjusted as needed?
33. ☐ ☐ Is the contractor removing the wooden wedges as per the specifications? (The wooden wedges shall be removed as soon as the panel above the wedged panel is completely erected and backfilled.)
34. ☐ ☐ At the end of each day's operation is the contractor shaping the last level of backfill as to permit runoff of rainwater away from the wall face or providing a positive means of controlling runoff away from the wall such as temporary pipe, etc?
35. ☐ ☐ Has the contractor backfilled the front of the wall?
36. ☐ ☐ Is the correct coping being installed?

4.1.16 Appendix B - MSE WALL CONSTRUCTION DO'S AND DON'TS:

1. Review approved shop drawings.

2. Review the Mechanically Stabilized Earth (MSE) Wall section of the KDOT Bridge Construction Manual.

3. Confirm foundation has been compacted properly in accordance to the specifications.

4. Verify leveling pad elevations.

5. Confirm receipt of Certificate of Compliance from the wall company.

6. Confirm fill material has been tested and approved before it is brought to the job site.

7. Inspect panels.

8. Inspect soil reinforcement for damage.

9. Reject all panels that are not in compliance with the plans and specifications.

10. Ensure panels, soil reinforcement and filter fabrics are properly stored to prevent damage.

11. Ensure all piles in the reinforced fill are isolated from the settlement of the fill as shown on the plans.

12. Install panels in accordance to plans and specifications.

13. Place and properly compact fill in accordance with plans and specifications.

14. DO NOT use thick fill lifts. Lifts thicker than 10 inches of loose material require more energy to compact and may move the panels out of alignment.

15. Use corner panels at all corners. If corner panels are not indicated on the plans, the designer should be notified.

16. Soil reinforcement should not be skewed more than 15° from normal. If reinforcement needs to be skewed more than 15° and it is not shown on the plans, notify the designer.

17. Check the batter of the panels often. Adjust accordingly. The vertical alignment of the panels below the panels being installed may be affected by the compaction of the soil behind the panels being installed.

18. Check overall batter regularly.

19. Water for soil compaction shall be in compliance with Section (2401?). Brackish water is NOT to be used.

20. When attaching filter fabric to the back of the panels, the adhesive shall be applied to the panel NOT the filter fabric.

21. Remove wooden wedges as soon as practical.

22. If precast coping is used, ensure top panels have dowels that will extend into the cast-in-place leveling fillet.

23. DO NOT allow excavations in close proximity in front of the wall once the wall construction has started. If excavations are required in front of the wall, the designer's approval will be obtained before the excavation is started. Also, excavations in front of the wall should not be allowed without protection to the wall (i.e. sheet piles, etc.)

24. Soil reinforcement near the top of the wall shall be parallel to the lifts of fill. Soil reinforcement shall not extend into the sub-base that may require mechanical mixing.

25. DO NOT CUT soil reinforcement without the designer's approval.

26. Place ½ inch minimum preformed expansion material between wall panels and cast-in-place concrete.

4.1.17 Appendix C - OUT-OF-TOLERANCE CONDITIONS AND POSSIBLE CAUSES CRITERIA

The following is taken out of FHWA's Publication .MECHANICALLY STABILIZED EARTH WALLS AND REINFORCED SOIL SLOPES DESIGN & CONSTRUCTION GUIDELINES. Publication No. FHWA-DP.82-1.

Table 4.1.2 Out-of-Tolerance Conditions and Possible Causes

MSE structures are to be erected in strict compliance with the structural and aesthetic requirements of the plans, specifications, and contract documents. The desired results can generally be achieved through the use of quality materials, correct construction/erection procedures, and proper inspection. However, there may be occasions when dimensional tolerances and/or aesthetic limits are exceeded.
Corrective measures should quickly be taken to bring the work within acceptable limits.

Presented below are several out-of-tolerance conditions and their possible causes.

1. Distress in wall:
   - A. Differential settlement or low spot in wall.
   - B. Overall wall leaning beyond vertical alignment tolerance.
   - C. Panel contact, resulting in spalling/chipping.

1.a. Foundation (subgrade) material too soft or wet for proper bearing. Fill material of poor quality or not properly compacted.

2. First panel course difficult (impossible) to set and/or maintain level. Panel-to-panel contact resulting in spalling and/or chipping.

2.a. Leveling pad not within tolerance.

3. a. Panel not battered sufficiently.

3. Wall out of vertical alignment tolerance (plumbness), or leaning out. b. Large backfill placing and/or compaction equipment working within 3-foot zone of back of wall facing panels.

c. Backfill material placed wet of optimum moisture content. Backfill contains excessive fine materials (beyond the specifications for percent of materials passing a No. 200 sieve).

d. Backfill material pushed against back of facing panel before being compacted above reinforcing elements.

e. Excessive or vibratory compaction of uniform, medium-fine sand (more than 60 percent passing a No. 40 sieve).

f. Backfill material dumped to close to free end of reinforcing elements,then spread toward back of wall, causing displacement of reinforcements and pushing panel out.

g. Shoulder wedges not seated properly.

h. Shoulder clamps not tight.
i. Slack in reinforcement to facing connections.

4. Wall out of vertical alignment tolerance (plumbness) or leaning in.

4.a. Excessive batter set in panels for select granular backfill material being used.

5. Wall out of horizontal alignment tolerance, or bulging.

5.a. See Causes 3c, 3d, 3e. Backfill saturated by heavy rain or improper grading of backfill after each day's operations.

6. Panels do not fit properly in their intended locations.

6.a. Panels are not level. Differential settlement (see Cause 1).
b. Panel cast beyond tolerances.
c. Failure to use spacer bar.

7.a. Backfill material not uniform.

7.b. Backfill compaction not uniform.

7. Large variations in movement of adjacent panels.
c. Inconsistent setting of facing panels.

Appendix EMSE Wall Specification

KDOT Construction Specification and current Special Provisions can be found at:
http://www.ksdot.org/burconsmain/specprov/2007SSDefault.asp#800