MECHANICALLY STABILIZED EARTH WALL INSPECTOR'S HANDBOOK

FDOT – State Construction Office

Revised: November 2020

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1. INTRODUCTION

This handbook is designed for the CEI personnel and inspectors that will be involved and responsible for inspecting the construction of mechanically stabilized earth (MSE) walls. It will provide general guidelines for inspection; however, the plans, specifications and special provisions govern and must be read and followed.

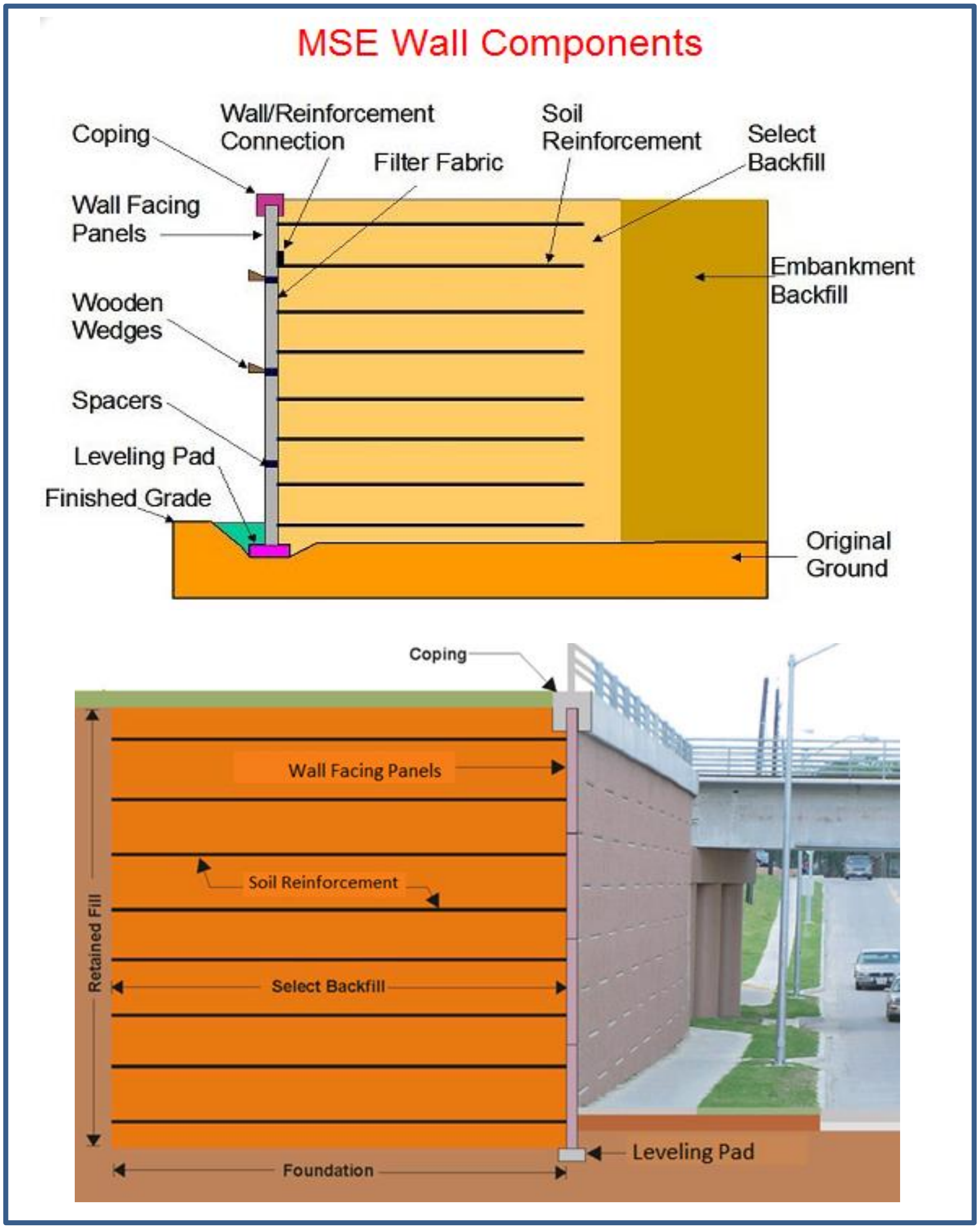

Figure 1-1: MSE Wall Components

2. TERMS

The following is a list of terms that will be used in the handbook, see Figure 1-1 for reference.

CEI
Construction Engineer Inspection. The CEI staff is the Consultant firm or Department group in charge of the administration and responsible for ensuring that the work is performed meeting the Department quality standards. Personnel inspecting MSE walls must complete and pass the CTQP computer-based-training (CBT) course for MSE wall inspector.

Engineer of Record
The Professional Engineer or the Engineering Firm that develops the criteria and the overall concept for the project, performs the analysis and develops the Plans and specifications for the project.

Wall Design Engineer
The Professional Engineer or the Engineering Firm registered in the state of Florida that designs the final details of the MSE walls and prepares the wall shop drawings. He usually works for the proprietary MSE wall supplier and is engaged by the Contractor.

Mechanically Stabilized Earth (MSE) Wall
MSE walls are retaining structures consisting of reinforced soil mass (reinforced backfill) and prefabricated facing elements. The backfill is reinforced with steel or geosynthetic elements. The backfill could be either select backfill or coarse aggregate.

Concrete Panel MSE Walls
MSE walls in which the facing elements consists of reinforced concrete panels (see Figure 6-1).

Segmental Block Walls (SBW)
MSE walls in which the facing elements consists of masonry blocks. They are also known as modular block walls in the industry. See Figure 6-2.

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 prefabricated segments.

Extensible Reinforcement
Polymeric reinforcement materials (exhibits creep characteristics under stress).

Inextensible Reinforcement
Metallic reinforcement material (strips or grids); does not exhibit creep characteristics under stress.

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 and allows any excess water to flow out.

Leveling Pad
The leveling pad is a non-reinforced concrete pad used to provide a level, consistent surface at the proper grade to place the first row of panels.

Original Ground
This is the existing ground surface at the site.

Embankment Backfill
Embankment backfill is the backfill that is allowed in normal embankment construction.

MSE Wall Select Backfill
MSE wall select backfill is the fill that meets the gradation, corrosion, unit weight, internal friction angle, and any other requirements of the construction specifications Section 548.

Coarse Aggregate
Material meeting the size distribution, corrosion properties and any other requirements of sections 548 and 901.

Soil Reinforcement
Soil reinforcement holds the wall facing panels in position and provides reinforcement for the soil. The soil reinforcement can be strips, grids, geogrids, or geotextiles. The reinforcement can be made of steel (inextensible materials) or polymers (extensible materials).

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

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

Wall/Reinforcement Connection
This is where the connection is made between the wall facing panel and the soil reinforcing.

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 required by the specifications.

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

3. MECHANICALLY 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 (Figure 1-1). All these items influence the performance of the MSE wall and are taken into account in the stability analysis. A change in any of these items could have a detrimental effect on the wall.

Certifications: The CEI staff must obtain from the Contractor, the Certificate of Compliance for all materials including fill, panels, soil reinforcement, filter fabric, etc. Signed and sealed certification for MSE wall select backfill must be submitted prior to placement.

4. FOUNDATION PREPARATION (548-8.3)

MSE walls, like any other structure, need a good foundation to build upon. Proper preparation of the site increases the potential for proper performance of the wall. The foundation for the structure shall be graded level for a width equal to or exceeding the length of the soil reinforcement or as shown in the Plans. Prior to beginning fill placement, the area under the MSE wall footprint (the zone of the wall facing, soil reinforcement and MSE wall select backfill) should be prepared and compacted with a minimum of five passes with an appropriate vibratory roller weighing at least 8 tons. Any soft or loose material that is encountered should be compacted or removed-and-replaced. If soils are encountered that do not match the borings performed for the wall, they should be brought to the attention of the Project Administrator and the District Geotechnical Engineer for analysis.

The CEI personnel must confirm foundation has been prepared and compacted properly.

Figure 4-1: Foundation Preparation

5. LEVELING PAD (548-8.3)

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 wall panels can begin. Even though the leveling pad is not considered an element that contributes to the stability and bearing capacity of the wall, it is important for the proper 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 the correct grade. No more than 2 shims (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.

Figure 5-1: Proper Leveling Pad

Figure 5-2: Improper Leveling Pad

The CEI personnel must ensure that leveling pads are properly constructed-and-cured and meet the requirements of the Contract documents.

6. PANELS AND PANEL PLACEMENT

6.1 WALL FACING PANELS

Wall panels come in many shapes and sizes (see Figure 6-1 and Figure 6-2 for a few of the most common shapes). In Figure 6-1, the top left shows square panels, top right shows diamond panels, bottom left shows finish stone panels and bottom right shows cruciform panels. Figure 6-2 shows segmental block panels. 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 treatments that can be formed.

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 for items such as bent connectors, damaged panels, etc. The inspector must notify the Project Administrator of any damaged components observed.

Figure 6-1: Panel Finishes and Shapes

Figure 6-2: Segmental Block Walls

6.2 WALL PANEL SPACERS

Wall panel spacers are typically ribbed elastomeric or polymeric pads. They are placed in all horizontal joints to limit vertical stresses on the pad and prevent concrete to concrete contact.

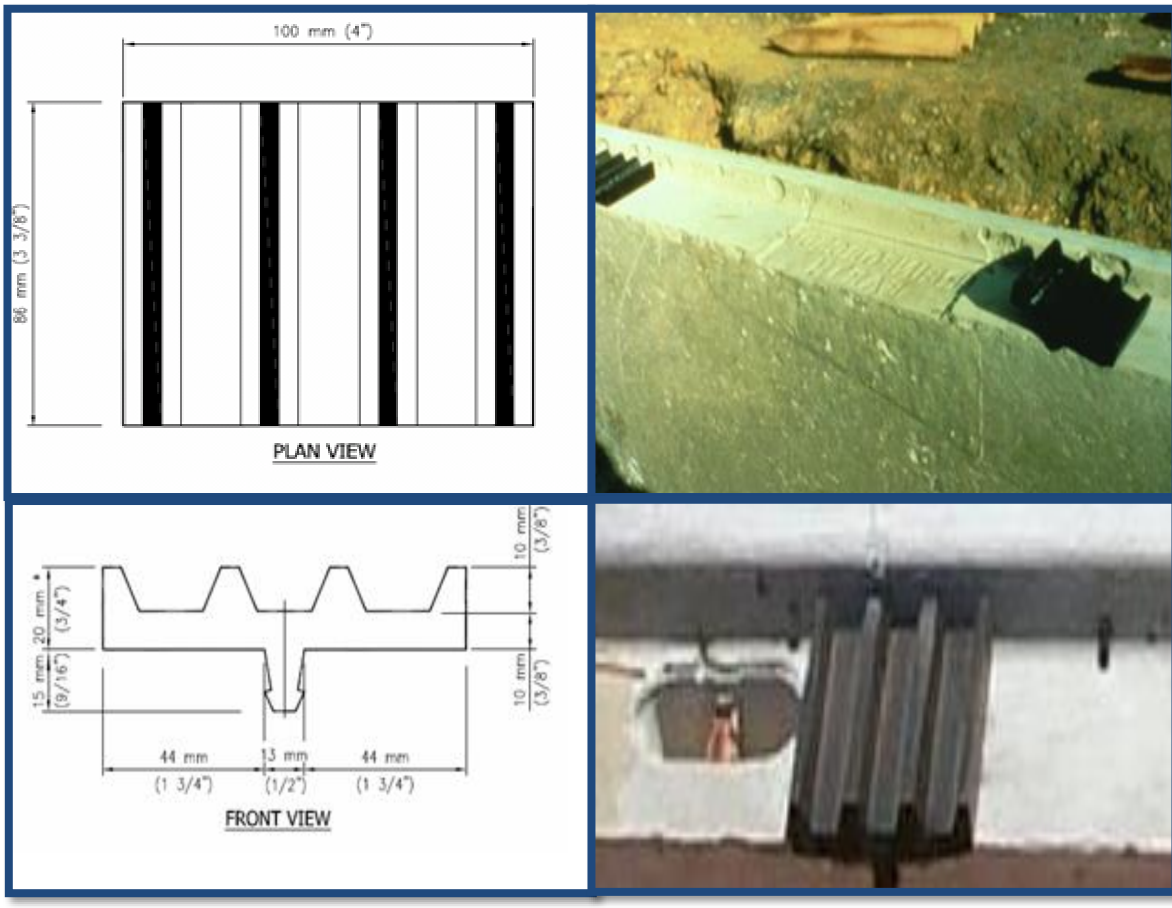

Figure 6-3: Wall Panel Spacers

6.3 PANEL PLACEMENT

The correct placement of the first few rows of the panels are very important (see Figure 6-4). The first row of panels are placed on the leveling pad and braced (Figure 6-4). In some MSE wall systems, a spacer bar should be used to get the correct placement. The panels need to be placed at the proper alignment, grade and level. The correct spacing is also very important, otherwise, the panel corners will crack and spall with settlement. Spacers (bearing pads) 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 wooden wedges in the wall, otherwise, they may become bound in the wall making them very difficult to remove and can cause the panel to spall.

Figure 6-4: Placing and Bracing Panels

The vertical and horizontal alignments need to be checked periodically to ensure proper alignment. This will also allow problems to be spotted early on and make corrections before the panels get too far out of alignment (Figure 6-5).

Figure 6-5: Checking Vertical Alignment

The CEI personnel must measure and verify at regular intervals that the batter of each MSE wall panels and the overall batter of the MSE wall batter are within tolerance. This is important because the vertical alignment of the panels being installed may be affected by the compaction of the soil behind the panels being installed.

6.4 SPECIAL PANELS

A slip joint is panel used to handle large differential vertical movement of the wall (see Figure 6-6). Corner panels provide a good connection between two adjacent walls and act like slip joints for the wall allowing differential movement between the two walls (see Figure 6-6). Corner panels shall be used at all corners. If corner panels are not indicated in the shop drawings, the CEI shall contact the wall supplier and Wall Design Engineer immediately.

Figure 6-6: Slip Joints and Corner Panels

6.5 WOODEN WEDGES

Wooden wedges are used to help hold the panels at the correct batter during the backfill placement as shown in Figure 6-7. The wooden wedges should be made from hard wood such as oak, maple, or ash. Wooden wedges should be removed as soon as the panel above the wedged panel is completely erected and backfilled.

Figure 6-7: Wooden Wedges

6.6 PANEL STORAGE

Wall panels should be stored flat on dunnage as shown in Figure 6-8. Figure 6-9 is an example of improperly stored panels. Proper storage is required as it protects the connections from being bent and damaging the galvanization (see Figure 6-10) and they should be stored out of the mud to avoid staining the panel face.

Figure 6-8: Proper Panel Storage

Figure 6-9: Improper Panel Storage

CEI inspectors must verify that all components (panels and reinforcement) are handled, stored, and shipped in a manner that prevents, chipping, cracking, fracturing, and excessive bending stresses.

The Department has the right to reject panels with damaged connectors. If the inspector sees bent tabs like those in Figure 6-10**,** he should contact his Project Administrator/Engineer immediately. Also, the inspector should point out to the Contractor when the panel storage is not being done properly.

Figure 6-10: Damaged Panel Tabs

7. SOIL REINFORCEMENT

The soil reinforcement is used to tie the wall to the soil (see Figure 7-1). There are two types of reinforcement, which are metallic and polymeric reinforcements. The metallic reinforcement should not be bent, torn, galvanization chipped off or otherwise damaged. The polymer reinforcement should not be torn, cut, left in the sun, or otherwise damaged. The inspector should check the reinforcement for the required length, size, and supplier's product designation. No equipment should be allowed to run directly on the reinforcement. Typically, the reinforcement is placed perpendicular to the wall face. Any slack in the reinforcement should be removed.

The CEI personnel must inspect soil reinforcement for compliance with design drawings and shop drawings (i.e. size, length, type of material, etc.). The CEI staff must inspect the proper placement of soil reinforcement. Soil reinforcement should not be skewed more than 15 degrees from normal. If reinforcement needs to be skewed more than 15 degrees, notify the Wall Design Engineer, unless the shop drawings clearly indicates such deviation. Soil reinforcement near the top of the wall shall be parallel to the lifts of fill unless a slight bending (within 15 degrees) is indicated in the shop drawings to accommodate a structure. Soil reinforcement shall not extend into stabilized subgrade that may require mechanical mixing operation. Soil reinforcement shall not be cut unless shown in the contract documents or approved by the Engineer.

7.1 METALLIC REINFORCEMENT (INEXTENSIBLE)

Inextensible or metallic reinforcement is the most commonly used reinforcement in permanent MSE wall applications for the Department. Its use is limited when the environmental conditions are highly corrosive. They are made of galvanized steel. The most common are ribbed strips and metallic grid as shown in Figure 7-2.

Figure 7-1: Soil Reinforcement

Figure 7-2: Metallic Grid (Left) and Ribbed Strips Reinforcement/Inextensible (Right)

7.2 POLYMERIC (GEOSYNTHETICS) – EXTENSIBLE REINFORCEMENT

Geosynthetic reinforcement could be geogrids or geotextiles. They are typically used in temporary walls, permanent walls in corrosive environments, and in segmental block (modular block) walls. The polymeric reinforcement should have some tension placed in the reinforcement during fill placement to remove slack. The reinforcement should not be connected to the wall until the compacted fill is at or slightly higher than the facing panel connector.

The CEI personnel must ensure polymeric reinforcements are properly stored to prevent damage, promptly installed and covered to minimize exposure to degradation from sunlight.

Figure 7-3: Geosynthetic Reinforcement (Extensible)

7.3 VERTICAL AND HORIZONTAL OBSTRUCTIONS

At vertical obstruction, the reinforcement should not be angled more than 15 degrees perpendicular to the wall as illustrated in Figure 7-4. No reinforcement may be left unconnected to the wall face or arbitrarily cut/bent in the field to avoid the obstruction**.** No exceptions should be allowed without verifying with the wall supplier and the Wall Design Engineer.

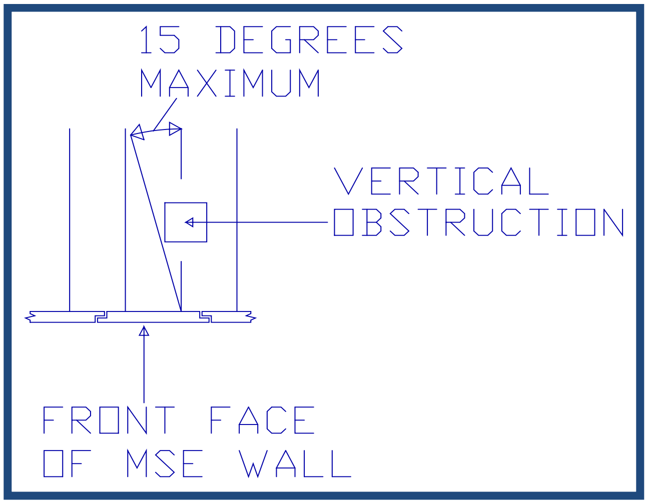

Figure 7-4: Vertical Obstructions

At horizontal obstructions, if the reinforcement must be more than 15 degrees from horizontal (see Figure 7-4), the Wall Design Engineer must be contacted. It may need additional reinforcement length to meet design requirements. 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 cover between the obstruction and the reinforcement. Table 7-1 shows the recommended transition distance X (see "X" in Figure 7-5) from the point of connection to provide a smooth curve of the reinforcement with an offset of d (see "d" in Figure 7-5). If these distances cannot be achieved the wall supplier should be contacted to check the design.

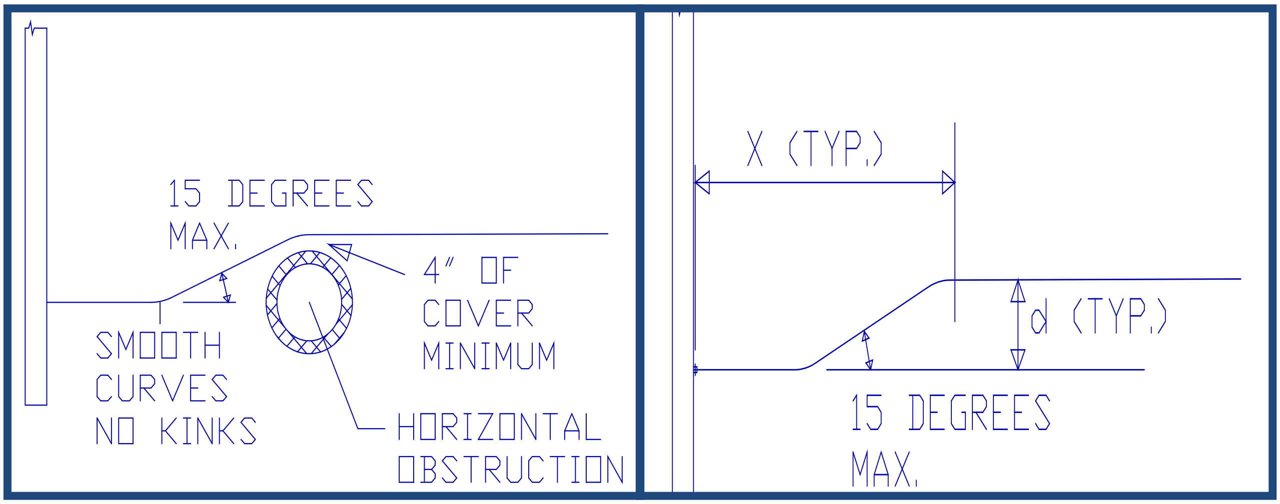

Figure 7-5: Horizontal Obstructions and Transition Distances

Table 7-1: Transition Distances

Additional depth (d) required (in)	Required minimum distance (X) to achieve smooth (in)
3	27
6	39
9	48
12	60
15	72

The CEI staff must verify the soil reinforcement straps are not cut and that the 15 degree skew angle is not exceeded. The CEI staff must ensure that the Contractor submit shop drawings approved by the Wall Design Engineer detailing any cutting of soil reinforcement. No cutting in the reinforcement may be allowed until these shop drawings are submitted and approved. The CEI must also ensure that the Contractor submit shop drawings approved by the Wall Design Engineer which detail construction of the wall around obstructions including details addressing conflicts between the soil reinforcement and any obstructions within the wall volume. The CEI must contact the Wall Design Engineer immediately if cutting of reinforcement, excessive transition angles, or details around obstructions are not properly addressed in the shop drawings.

7.4 REINFORCEMENT STORAGE

Like the panels the reinforcement should be stored on dunnage (see Figure 7-6) and carefully handled to prevent damage. Damage may include bending of the reinforcement and damaging the galvanization.

Figure 7-6: Reinforcement Storage

7.5 WALL/REINFORCEMENT CONNECTION

Connection devices (Figure 7-7) are incorporated into the panels to attach the soil reinforcement. In tab connection devices, the nut should be placed on top (with the head of the bolt underneath) to make sure it is going to be placed and tightened.

Figure 7-7: Reinforcement Connections

8. FILTER FABRIC AND JOINTS

All joints and wall openings must be covered with a geotextile filter fabric. See Figure 8-1.

Figure 8-1: Filter Fabric Installation

There are two types of fabrics used for joint covers which are Type D-2 and Type D-3. Refer to the FDOT Standard Specifications for the requirements regarding the types of geotextile. In addition to section 548, geotextiles must meet the requirements of section 985 of the Standard Specifications.

Type D-2 is a woven geotextile stronger than Type D-3. Type D-2 geotextile is required where an abutment is founded on spread footings and in wall portions where coarse aggregate has been used in lieu of select fill (section 12 of this handbook). For walls supporting bridge abutments on spread footings, Type D-2 is required in all the joints and other wall openings within a horizontal distance equal to the larger of:

1. the length of the reinforcement under the footing plus 25 feet, or
2. twice the maximum height of the footing above the leveling pad, measured from the nearest edge of the footing, surrounding the reinforced backfill for the abutment with geotextile fabric.

When there is no spread footing behind the wall supporting abutments, or the wall does not require the use of coarse aggregate, either Type D-3 or D-2 may be used. Type D-5 is a weaker geotextile and is not acceptable as a joint cover. Type D-5 is only acceptable as a separation geotextile between the coarse aggregate and the select backfill/embankment at the bottom, top and sides of the coarse aggregate

- Projects Technical support for districts
- Review of auger cast piles logs on I-395
- Review of I95 3C submittals
- Presentation for September
- CBT class for pile driving
- CBT class for drilled shafts
- MSE wall manual update
- SPW additional load implementing
- Post grouting factors implementation.
- Research Review
- Preparing for D6 Process Review
- Spec changes preparation

It is important that the joint opening widths be within specifications and to place the filter fabric properly. Significant loss of backfill after few years of service may occur if the fabric and joint system are not built properly. Figure 8-2 shows loss of backfill through improperly constructed joint and filter fabric. The left photo shows backfill washed through joint deposited next to the slip panel and the right photo shows a void as observed from the top of wall.

CEI personnel must ensure that the filter fabric and the panel spacers are acceptable and that the filter fabric is properly placed in all joints.

Figure 8-2: Loss of Backfill Through Improperly Constructed Joint and Filter Fabric

9. COMPRESSIBLE FREE DRAINING SEAL (548-8.6)

In Florida, vegetation may develop easily in the MSE wall openings from seeds and spores transported by wind and rain (See Figure 9-1). FDOT Specifications require that all the concrete panel joints be sealed with a compressible free draining material (open cell). The seal is a cylindrical foam element that allows water to drain preventing any vegetation growth (see Figure 9-2). The seal must be at least 1 1/2-inches from both the front and rear faces of the panel.

The Contractor must protect the free draining seal during the application of coatings and sealants. The seal must be replaced if it becomes coated or clogged. The installation must be secure and free draining to keep the seal securely in place until uninstalled and to prevent hydrostatic forces from building up behind the panel.

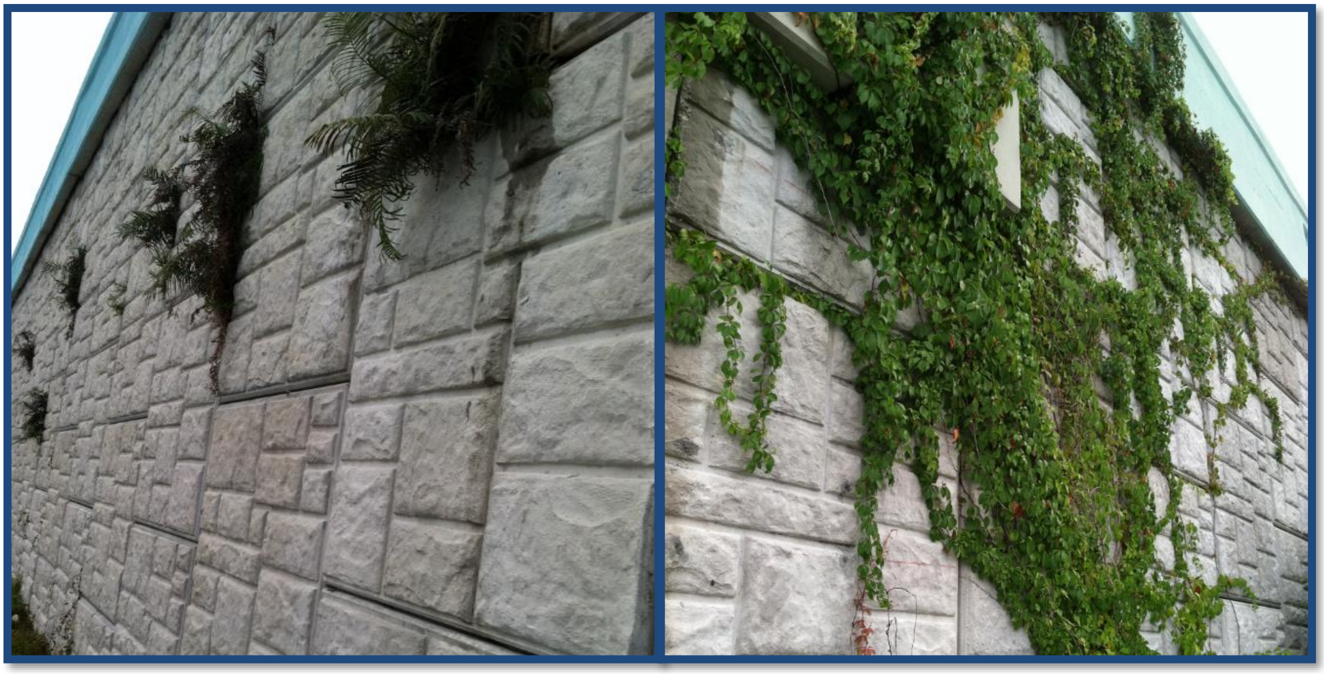

Figure 9-1: Vegetation Growth in Joint Openings

Figure 9-2: Joint Compressible Free Draining Seal to Prevent Vegetation Growth

10. COPING/BARRIER

Coping is used to tie in the top of the wall panels and to provide a smooth pleasing finish to the wall top. Coping/barriers can be cast-in-place or prefabricated segments. For precast units, a leveling course of concrete is placed prior to setting the units in place (see Figure 10-3) as this provides the vertical control needed. Barriers are tied together and strengthened against vehicle impact by a junction (moment) slab (see **Error! Reference source not found.**).

Figure 10-1: Coping

Figure 10-2: Precast Barrier (Leveling Concrete Indicated in Red)

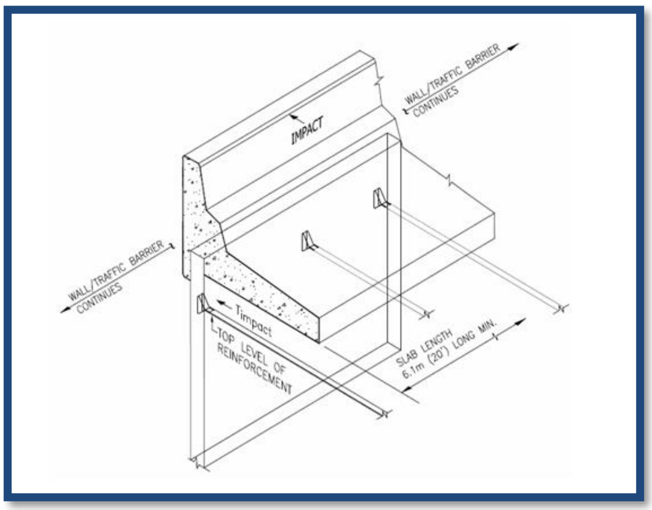

Figure 10-3: Cast-in-Place Barrier with Slab

When precast coping is used, CEI personnel must verify that top panels have dowels that will extend into the cast-in-place buildup concrete (refer to the wall coping Design Standard indices).

When cast-in-place coping is used, the CEI personnel must verify that a minimum ½-inch preformed expansion material between wall panels and cast-in-place concrete is placed (refer to the wall coping Design Standard indices).

11. 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
). If this is not done, when the wall settles and the abutment doesn't settle, it will create a tension load in the cheek wall and the panel. This eventually will lead to one or both to crack (see
). When rough panel finishes are used as one shown

, 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. With smooth panel finishes a paper bond breaker would usually be sufficient.

Figure 11-1: Bond Breaker (Left) and Cracked Panel/Cheek Wall (Right)

12. MSE Wall Backfill

12.1 SELECT BACKFILL

The select backfill must meet the specification requirements for gradation, electro-chemical, soil plasticity properties and organic content. It must be free draining material, having therefore a limited amount of fines (material passing sieve #200). Refer to the specification section 548 for the current gradation limits and the maximum amount of fines permissible. Typical acceptable material will fall within the AASHTO classification of A-1, A-3, or A-2-4 with less than 12% fines.

In special cases, the Plans and/or shop drawings may require higher soil friction angles to meet stability requirements. In these cases, the Contractor is required to perform direct shear tests to prove that the material supplied meets the design requirements. As a minimum, the Contractor needs to supply three (3) direct shear tests per soil type in accordance with FM-3-D3080. The lowest soil friction angle obtained from the three direct shear tests must be equal or exceeding the value indicated in the Plans/shop drawings. These special testing will be required in the following cases:

- **For A-3 and A-2-4 materials**: When the assumed or required design soil friction angle is greater than 30 degrees.
- **For limerock material** (which may be used in some projects in South Florida): When the assumed or required design soil friction angle is greater than 34 degrees.

12.2 OTHER BACKFILL MATERIALS

There are other backfill materials that may be required or specified in the Plans: coarse aggregate and flowable fill.

For permanent walls, when the walls can be partially underwater (i.e. when the lowest adjacent ground is below the Design High Water (DHW) elevation), the Contractor must provide coarse aggregate backfill in lieu of select backfill to an elevation of at least 1-foot above the DHW as shown in the Plans. Coarse aggregate sizes number 57 through 89 are acceptable (refer to section 901 of the Standard Specifications).

Flowable fill may be used instead of select backfill or coarse aggregate backfill, when the option for flowable fill is indicated in the Plans (548-2.6).

12.3 PLACING BACKFILL

The backfill lift should be placed parallel to the wall and starting approximately three (3) feet from the back of the wall panels. The backfill should be placed in 6" compacted lifts (it may be helpful to mark your lifts on the back side of the wall panels). Ensure the compacted lifts are no more than 10 inches, if the thick lift option is approved. The backfill is then leveled by machinery moving parallel to the wall and 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, backfill is then placed within 3 feet behind the wall by windrowing the material except for the initial layer, for which the backfill must be brought up uniformly for the whole layer.

13. COMPACTION (548-8.5.1)

13.1 GENERAL

Backfill compaction shall be performed in such a way that the roller (up to 8 tons in weight) 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 13-1). 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 on the dry side of the optimum moisture content as determined by the lab Proctor density test. If additional water is required for the material, the water must meet the specification requirements.

Figure 13-1: Compaction Equipment

13.2 SELECT BACKFILL

The Contractor must compact the backfill within three (3) feet of the wall using a power operated roller or plate weighing less than 1,000 pounds. Beyond three (3) feet of the wall facing panels a vibratory roller may be used provided that the frequency and amplitude combined with bulk weight of the roller has performed satisfactorily at a trial section of the same type of wall. A smooth wheel or rubber tire roller is considered adequate (see Figure 13-1). Compactors, which employ a foot such as a sheepsfoot (see Figure 13-1) or grid rollers, are not acceptable. For walls using geosynthetic reinforcement, the weight of the compaction equipment shall be limited to 25,000 pounds.

13.3 COARSE AGGREGATE

Coarse aggregate backfill must be compacted with a minimum of three passes of a vibratory compactor weighing between 600 and 1000 pounds or two passes of vibratory compactor weighing over 1000 lbs. However, the compaction equipment shall not exceed 1000 lbs. within three (3) feet from the back of the wall. If necessary, additional compaction may be needed until there is no additional movement. For walls using geosynthetic reinforcement, the weight of compaction equipment shall be limited to 25,000 pounds.

13.4 DAYS END

At the end of each day's operation, the Contractor shall shape the last level of backfill as 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. Failure to do this could result in wall damage due to hydrostatic pressure or the erosion of material from around the soil reinforcement (see Figure 13-2).

Figure 13-2: Wash Out from Around Reinforcement

13.5 BACKFILL INFRONT 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 (Figure 13-3).

Figure 13-3: Undermining Leveling Pad

14. FLOWABLE FILL

The FDOT specifications allow the use of flowable fill as MSE wall backfill material when it is specified in the Plans. Flowable fill is a mixture of Portland cement, fly ash, fine aggregate, admixture, and water. Flowable fill contains a low cementitious content for reduced strength development. Refer to Section 121 of the FDOT Standard Specifications for the flowable fill material and construction requirements. The metallic wall components (including metallic soil reinforcements) must not be in partial contact when flowable fill is used, but it must be fully encapsulated by the flowable fill in accordance the sub-article 548-8.5.3 of the standard specification. Metallic elements partially embedded in cementitious material have been found to be susceptible to corrosion.

A type of low density flowable fill called cellular concrete is also allowed by the specifications. A cellular flowable fill is a low-density concrete made with cement, water, and preformed foam to form a hardened closed cell foam material. Cellular concrete flowable fill may also contain fine aggregate, fly ash, slag, and admixtures. The use of cellular concrete may be very convenient when there is a need for relatively narrow widenings in front of an existing retaining wall. Figure 14-1 illustrates a wall constructed with full height panels (known as tilt panels) using cellular concrete as backfill next to an existing cantilever concrete retaining wall.

Figure 14-1: Cellular Concrete Wall

15. TEMPORARY WALLS AND TEMPORARY WALL FACING

Temporary walls with temporary wall facings are typically used in phased construction to allow traffic above it while a permanent embankment or other structures is constructed in front of it. In this particular wall type, the reinforcement used is typically geogrids but other approved systems exist. See Figure 15-1**.**

Figure 15-1: Temporary Facing during Phased Construction

When large settlements are expected, temporary wall facings are used at times to handle large settlements that the permanent wall facings could not handle. The wall is built using a temporary facing such as fabric wrapping with tabs sticking out for eventual connection of a permanent facing (see Figure 15-2). The permanent facing is not attached until most of the settlement has occurred. This type of wall construction is known as a two-phased wall system.

Figure 15-2: Temporary and Permanent Wall Facings

16. MISCELLANEOUS POINTS

16.1 CONSTRUCTION LOADS

Before the actual start of construction of the wall, the various parts of the Plans (shop drawings, drainage, lighting, etc.) needs 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 and the shop drawings do not indicate it, the wall supplier should be contacted. The wall supplier may not have seen a full set of Plans. Due to this, he may have missed loadings from various types of structures. If he did not take these loads into consideration, the wall could fail. This also can be temporary loads that the contractor may have imposed which may not have been accounted for by the wall supplier (see Figure 16-1).

Figure 16-1: Construction Load

Loads placed near the bottom of an MSE wall may impact the wall; particularly when there are compressible soils in the foundation. In some cases, a temporary wall is used to preload and surcharge compressible sols to pre-induce settlements and prevent long-term settlements after MSE wall installation. The permanent final facing is constructed after the observational period and settlement has been determined to be completed. However, if a load is placed in front of the stabilized area of the wall, there will be potential additional settlements (see Figure 16-2) creating both horizontal and vertical movements on the wall.

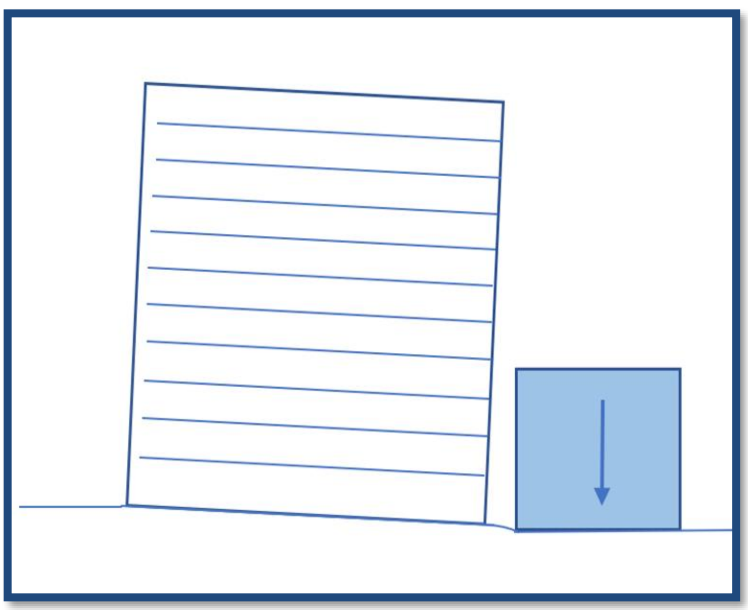

Figure 16-2: Illustration of Settlements Underneath the Load and the Adjacent MSE Wall

Figure 16-3: Distortion created by a load placed at the bottom

In Figure 16-3, some material was stockpiled in front of the wall. There was significant movement and cracking in the roadway which lead to the wall being rebuilt. It was determined that some materials stockpiled at the bottom the wall created this issue.

The CEI personnel should warn the Contractor to avoid materials or equipment to be stored adjacently to temporary and permanent MSE walls since this may create settlements and deflections that may render the wall unacceptable. This is critical in areas where settlements have been pre-induced with a pre-load and surcharge. Additional loads outside the pre-loaded area will create additional settlements as indicated in Figure 16-2. Tolerance requirements will be covered in section 18.6 of this handbook.

16.2 DRAINAGE STRUCTURES

Design for drainage structures in the wall mass are also sometimes missed by the wall supplier. It is not acceptable to just cut the reinforcement (see Figure 16-4). Sometimes it is necessary to angle the reinforcement, but never angle them more than 15 degrees from the perpendicular to the wall without verifying adequacy with the wall supplier and the Wall Design Engineer. Sometimes a special design to relocate the reinforcement around the obstruction may be necessary (see Figure 16-5). If the space between the drainage structure and the wall panel is very limited to allow proper compaction, consideration may be given for using flowable fill in such confined areas. Metallic elements must be fully encapsulated when using flowable fill.

Figure 16-4: Improper Avoidance of Drainage Structure

Figure 16-5: Special Design to properly avoid a structure

Retention ponds located next to MSE walls need to be checked. Check that the wall is protected from scour by the drainage pipes. It has happened on projects where the drainage and wall Plans were not coordinated.

16.3 EXCAVATIONS ADJACENT TO MSE WALLS

An MSE wall is a large spread footing and when excavations occur close to the wall, a bearing capacity failure could occur. This is especially true when excavating below the existing water table. Excavations next to existing MSE Walls can cause settlement and failure of the wall. As the area is excavated in front of the wall, the material under the wall moves into the excavation. Consequently, the wall settles leaving a large gap at the panel joints (see Figure 16-6 and Figure 16-7). This can also happen if a trench is dug before erecting the wall without properly compacting the trench backfill. In the case illustrated in Figure 16-8**,** a drainage pipe was installed prior to erecting the wall. Once the rains came and soften up the soils, the material under the wall moved into the pipe trench that was not properly compacted.

Inspectors should document and report any contractor excavation operations. There have been bad experiences of existing walls being affected by Contractor's temporary excavations. This could particularly occur on phased construction in vicinity of temporary walls. Any excavation not indicated in the Plans, whether supported or unsupported, close to an existing wall needs to be analyzed and checked by the Engineer of Record (EOR) and reviewed by the District Geotechnical Engineer (DGE). Also, if dewatering is planned near the wall, it should be analyzed by the EOR and reviewed by the DGE.

The CEI shall not allow excavations in close proximity in front of the wall once the wall construction has started without the EOR's approval. Also, excavations in front of a wall should not be allowed without protection to the wall (i.e. sheet piles, seawall, etc.).

Figure 16-6: Settlement from Excavation

Figure 16-7: Joints Opening from Settlement

Figure 16-8: Wall Failure from Exterior Excavation

17. CONSTRUCTION

The construction sequence is typically as follows:

First, the site is cut to grade and all unsuitable material is removed. The site is proof rolled to delineate any loose and/or unsuitable materials. Compact any loose material and remove-and-replace any unsuitable material found. The proof rolling is accomplished by at least 5 passes of a vibratory roller weighing a minimum of eight tons.

1. The leveling pad excavation is dug (see Figure 17-1)

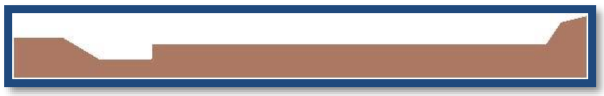

Figure 17-1: Preparing Site, Proof Roll & Excavate Footing

2. The leveling pad is placed (see Figure 17-2**Error! Reference source not found.**). The concrete is allowed to cure a minimum of 12 hours before any panels are placed.

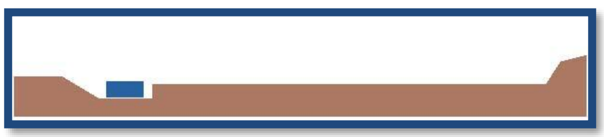

Figure 17-2: Concrete Leveling Pad

3. The first row of panels is placed on the leveling pad and braced (see Figure 17-3). Adjacent panels should be clamped together to prevent individual panel displacement. The panels should be set with a backward batter, typically $\underline{+}$1/8 inch per foot. This may allow the panel to be vertical once fill is placed and compacted against it. The batter is adjusted for the site conditions such as backfill properties. For example, the finer sand may require a larger batter.

Figure 17-3: Install and Brace First Row of Panels

4. Attach filter fabric over the joints (See Figure 17-4). An adhesive is used to hold the filter fabric across all the panel joints. The adhesive should be applied on the panel next to the joints then the filter fabric is placed over the joint, because applying adhesive on the filter fabric tends to clog the filter fabric.

Figure 17-4: Attach Filter Fabric

5. 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 17-5). 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 has 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.

Figure 17-5: Fill in 6" lifts to reinforcement

6. The reinforcement is then placed typically perpendicular to the wall panel and the connection (see Figure 17-6). Any slack in the reinforcement should be removed to avoid excessive panel movement. With polymeric reinforcement some tension should be applied to the reinforcement by means of a kicker tension device or a rod (see Figure 17-7).

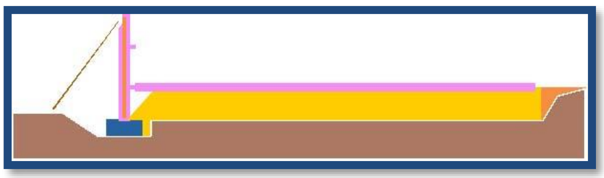

Figure 17-6: Connect and tighten reinforcement

Figure 17-7: Tightening Polymer Reinforcement

7. Then another row of wall panels are placed with the proper batter.

8. The select backfill is then placed (see Figure 17-8 left picture) in 6-inch compacted 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 three (3) feet from the back of the panels. The fill is then windrowed toward the reinforcement ends (see Figure 17-8 right picture). Once this is complete, the fill is windrowed from the three (3) foot point back toward the panels (see Figure 17-9).

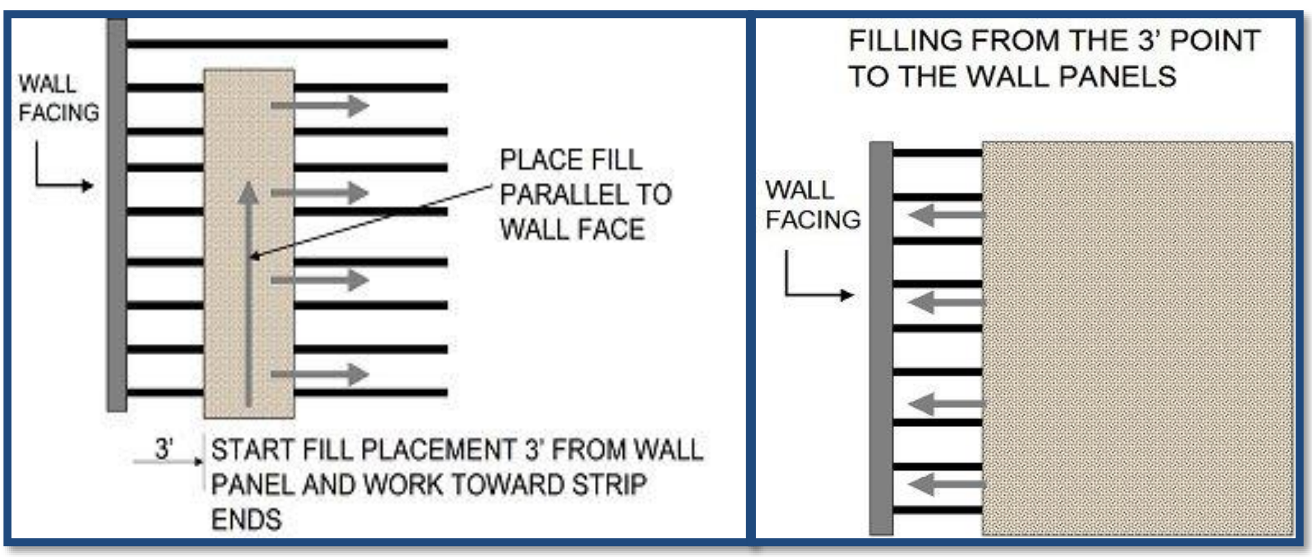

Figure 17-8: Typical Edge Fill Placement (Plan View)

9. The compaction equipment rolls parallel to the wall facing. Compaction starts at least three (3) feet from the wall and works toward the end of the reinforcement (see Figure 17-9).

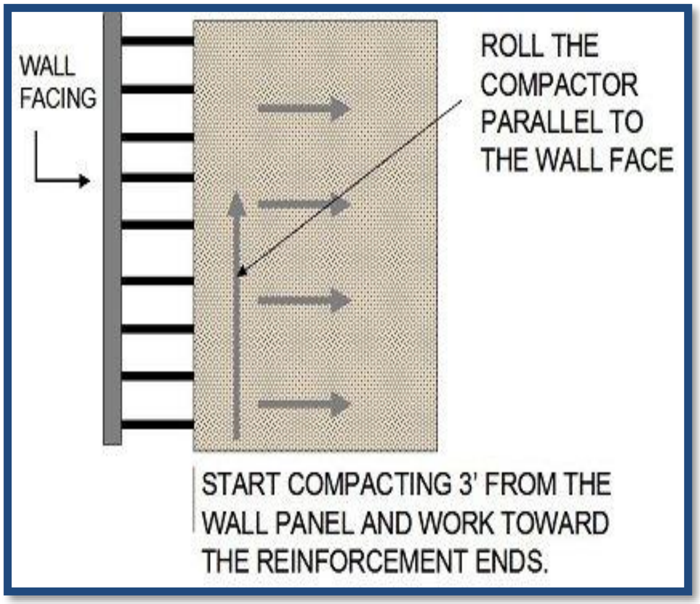

Figure 17-9: Initial Compaction

10. Compacting the remaining three (3) feet next to the wall face then completes the compaction (see Figure 17-10). This compaction is accomplished with compaction equipment weighing 1,000 lbs. or less (see Figure 17-11).

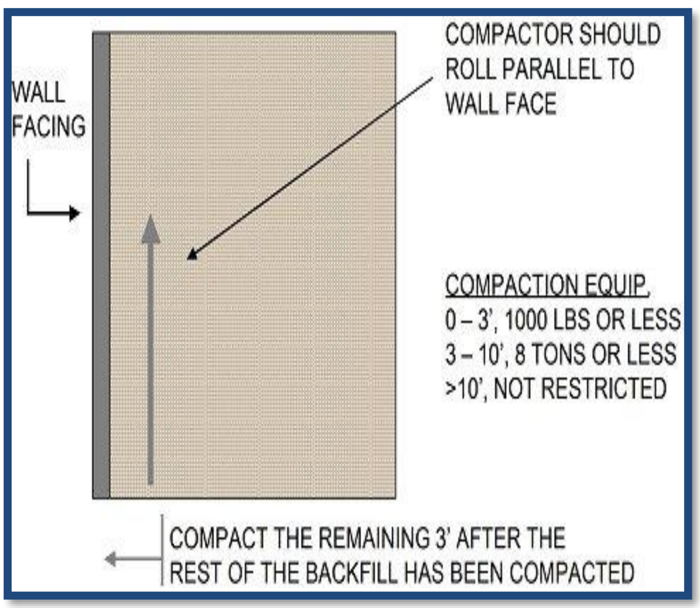

Figure 17-10: Final Compaction

Figure 17-11: Typical Compaction Equipment Used Within 3 feet from the Panel

11. Remove wooden wedges as soon as the above precast component is completely erected and backfilled (see Figure 17-12). 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.

Figure 17-12: Wooden Wedges

12. Repeat steps 8 through 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 17-13).

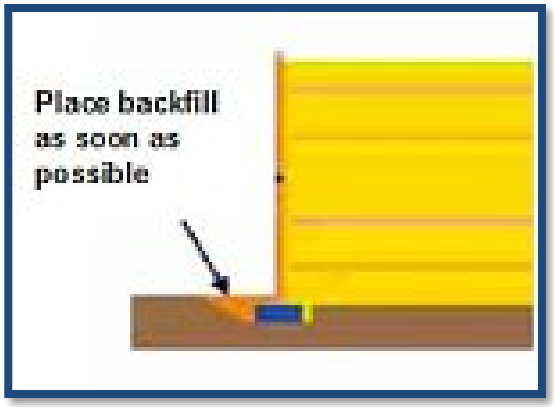

Figure 17-13: Backfill In Front of the Wall

13. 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.

18. BACKFILL TESTING AND ACCEPTANCE

The quality control (QC) of the backfill is performed through laboratory and field testing. Lab testing is performed on soil material proposed to be used as a MSE wall select backfill material to determine the grain size distribution properties, the electro-chemical (corrosion potential) properties, the organic content, the plasticity indices, and the compaction properties. Refer to specification 548 for test frequency and acceptable ranges in test results.

From the compaction properties testing, a maximum dry density is determined in the lab. The specifications dictate the minimum percentage of compaction in relation to the maximum density determined in the lab, that is required for the retaining wall volume (reinforced mass). In the field densities will be determined by the contractor QC personnel. The Engineer/CEI staff will perform verification testing (VT) to accept QC's test results at a reduced frequency.

18.1 FIELD DENSITY REQUIREMENTS (548-9.4)

The CEI staff must verify that the backfill is placed and compacted in accordance with the Plans and specifications and that the Earth Density books are properly prepared. Check that water used for soil compaction is in compliance with section 923 (no salt or brackish water). Unless approved by the Engineer, compacted lifts thicker than 6" are not allowed (548-8.5.1). Refer to section 18.5 for the thick lift option.

The MSE wall backfill shall have the following minimum dry densities:

- The material beyond 3 ft from the back of the panels shall have a minimum dry density of 95% of the maximum density determined in the Modified Proctor test, in accordance with the FM 1-T 180 modified Proctor test.
- The material within 3 ft from the back of the panels shall have a minimum dry density of 90% of the maximum density determined in the Modified Proctor test, in accordance with the FM 1-T 180 modified Proctor test.

If the Material classifies as A-2-4 or A-3 at the Contractor's option, the MSE wall backfill may be compacted to the following alternative criteria:

- Material beyond 3 ft from the back of the panels: minimum dry density of 100% of the maximum density determined in the standard Proctor test, in accordance with the FM1-T-099 procedure standard Proctor test.
- The material within 3 ft from the back of the panels shall have a minimum dry density of 95% of the maximum density determined in the standard Proctor test, in accordance with the FM1-T-099 standard Proctor test.

In the 3-foot zone within the back of the panels the compactor equipment weight cannot exceed 1000 lbs. The reason to limit the weight of the equipment and a lower density requirement in this zone is to minimize movement of the panels.

Note: For pipe backfill within the MSE wall reinforcement volume, the compaction requirements for the MSE wall backfill described above will apply.

18.2 LOTS (548-8.5.1)

A LOT is defined as a single lift of finished backfill not to exceed 500 feet in length. The maximum thickness of compacted material allowed by the specifications in a lift is 6 inches. If the Contractor requests and performs a successful test wall, the Engineer may allow up to 10" compacted lifts (see section 18.5 of this handbook). The contractor is required to perform at least 1 QC field density test per LOT. The Department will perform 1 VT field density test every 4 LOTs.

Since the material within 3 feet from the wall has a different compaction requirement (less) than the rest of the reinforced volume and the equipment is different, there will be two LOTS in any given 500 feet of wall: One for the MSE wall select backfill within 3 feet from the wall and another for the MSE walls select backfill material beyond 3 feet from the panels (see Figure *18-1*). Therefore in any given 500-foot length of wall of Figure *18-1*, the Contractor's QC inspector is to perform 1 field density test for every lift in the zone within 3 ft of the panels and 1 field density test for every lift in the zone beyond the 3 ft from the panels.

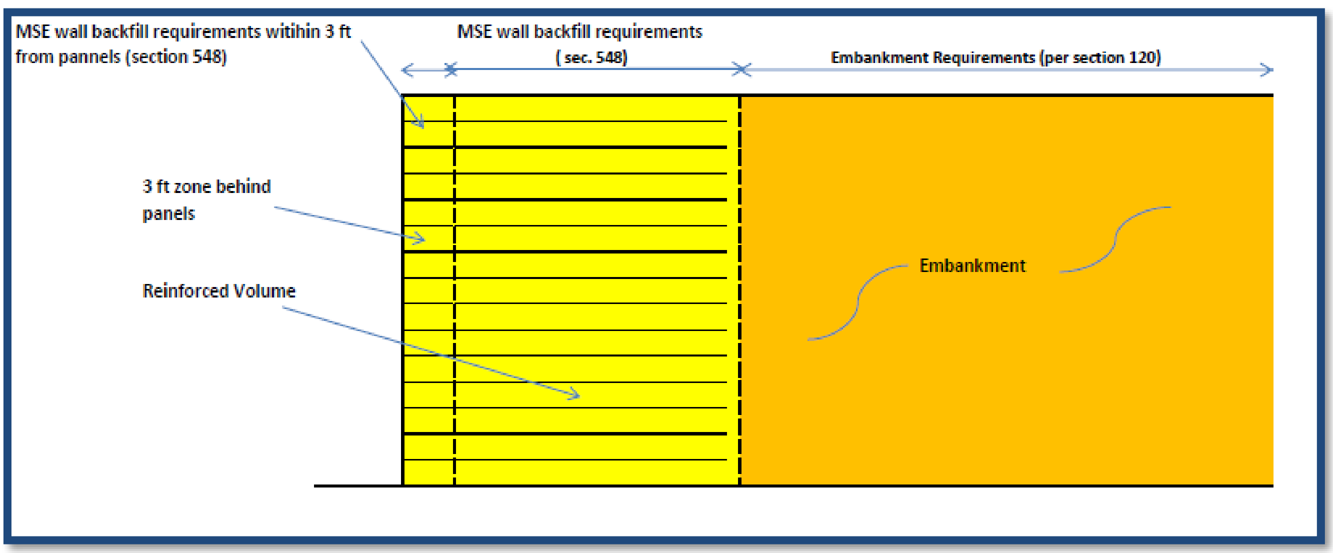

Figure 18-1*: LOT Illustration for the Three Zones*

In the case of parallel walls where the reinforcement overlaps, only one LOT is necessary if the two adjacent areas are compacted in the same operation following the same procedures and using the same backfill material (see Figure 18-2).

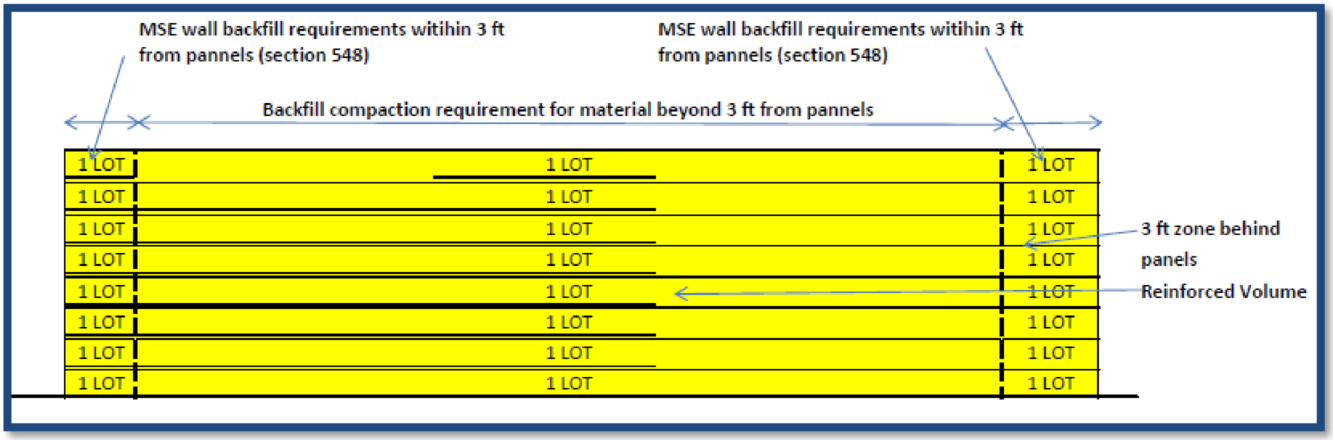

Figure 18-2: Parallel Wall (Overlapping Reinforcement)

In the case of Figure 18-2 for every 500 ft of length, if the same material and same procedures are used, then for every 500 ft, 3 density tests will be required per lift: 2 for the two separate areas within 3 ft from the panels and 1 for the middle area.

If there is a gap between reinforcements, and this gap is not greater than 8 ft, and it is built with the same material, and compacted in the same manner, the two adjacent MSE wall backfills (excluding the 3 ft within the panels) and the gap may be considered as one LOT (see Figure 18-3).

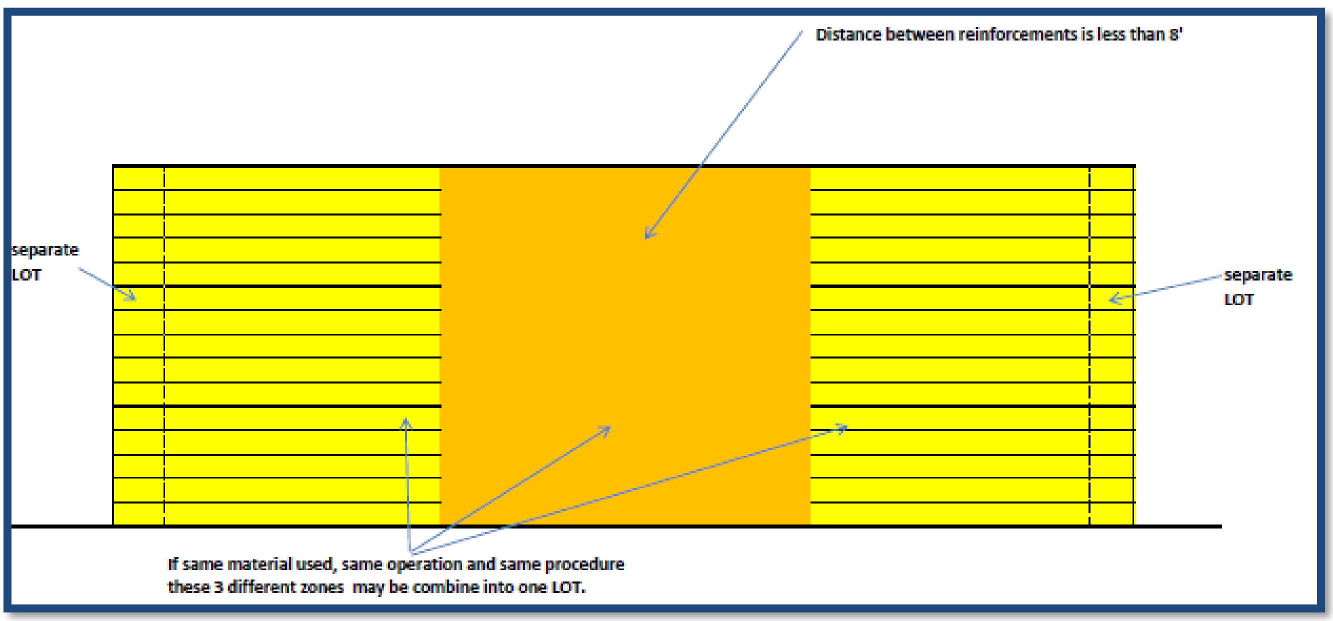

Figure 18-3: Parallel Walls with Narrow Gap Between Reinforcements

In bridge approaches the number of LOTS may be optimized by considering contiguous walls as one continuous "horseshoe" shaped wall. See Figure 18-4 for a plan view:

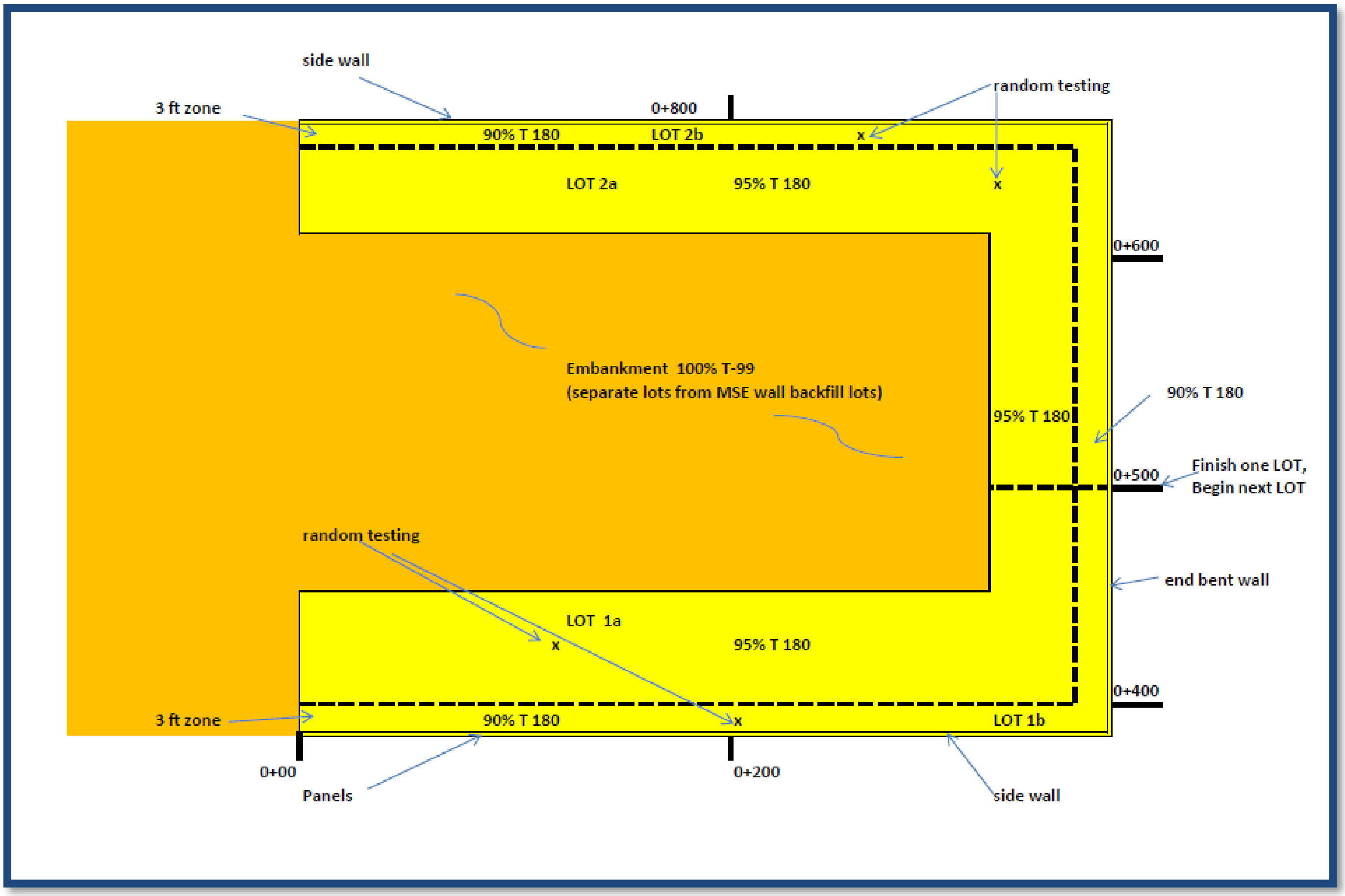

Figure 18-4: Horseshoe Shaped Walls at Bridge Approaches

18.3 SHALLOW FOUNDATIONS BEHIND MSE WALLS

The Plans may call for shallow foundations (spread footings) as the foundation type for the bridge end bents. In this case, to prevent different stiffness underneath the footing, the specifications require the following:

- At least 1 distance equal to the footing width below the foundation level must be compacted at a minimum dry density of 95% of the modified Proctor Test (FM 1-T 180). This includes the 3 ft zone within the panels.
- Within the zone 3 ft from the panels, extend laterally the higher compaction requirement (95% modified Proctor, or 100 % standard Proctor) to 3 ft at each side of the spread footing.
- For A-3 or A-2-4 materials, if the alternative acceptance criteria is used (standard Proctor), at least 1 distance equal to reinforcement length below the foundation level must be compacted at a minimum dry density 100% of the standard Proctor Test (FM1-T-099) within the limits described above. Outside the limits defined above, the density acceptance criteria remain as per the normal MSE backfill compaction requirements.

Refer to Figure 18-5, Figure 18-6, and Figure 18-7. In these figures the typical dry density acceptance case when modified Proctor is used is illustrated. Figure 18-5 indicates a plan view of a bridge approach in which a spread footing will be used to support the abutment of the bridge. This plan view illustrates the LOTs that would be required for a specific lift. The combined length of the three sections of the “horseshoe” wall is 1000 ft. There will be two LOTs for the main reinforced volume (beyond 3 ft from the wall panels) that will require compaction at a minimum dry density of 95% of FM1-T180: LOTs 1a and 2b. Within the 3 ft zone from the panels, there will be two LOTs that will require compaction at a minimum dry density of 90% of FM1-T180: LOTs 1b and 2b. In addition, there will be a separate LOT in the spread footing area, LOT 3 b, in which compaction at a minimum dry density of 95% of FM1-T180 is required. Same compaction zones and LOTs definitions will result if the optional standard Proctor acceptance case is used for A-3 or A-2-4 materials as indicated between the parentheses in Figure 18-5.

Figure 18-6 shows a cross-section that illustrates the compaction requirements in elevation within the footing zone. Note how below the footing and for at least one footing width, the density requirement within the 3-foot zone from the panels is the same as the density requirement beyond the 3 feet.

Figure 18-7 shows a front elevation that illustrates the density requirements, within the 3-foot zone of the wall, along the footing. The separate LOT in a particular lift extends to at least 3 feet at each side of the footing.

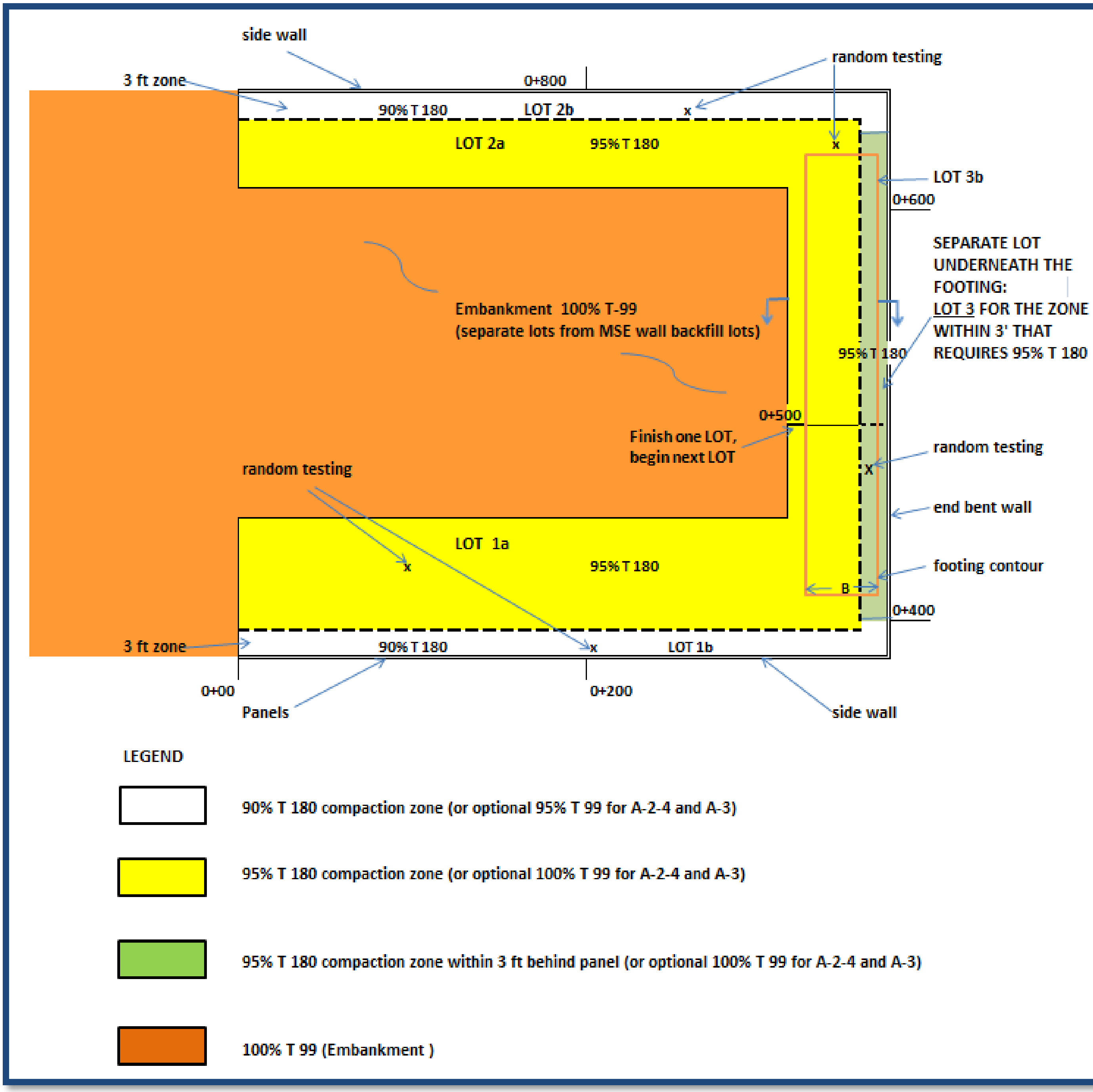

Figure 18-5: Typical Lot Definitions

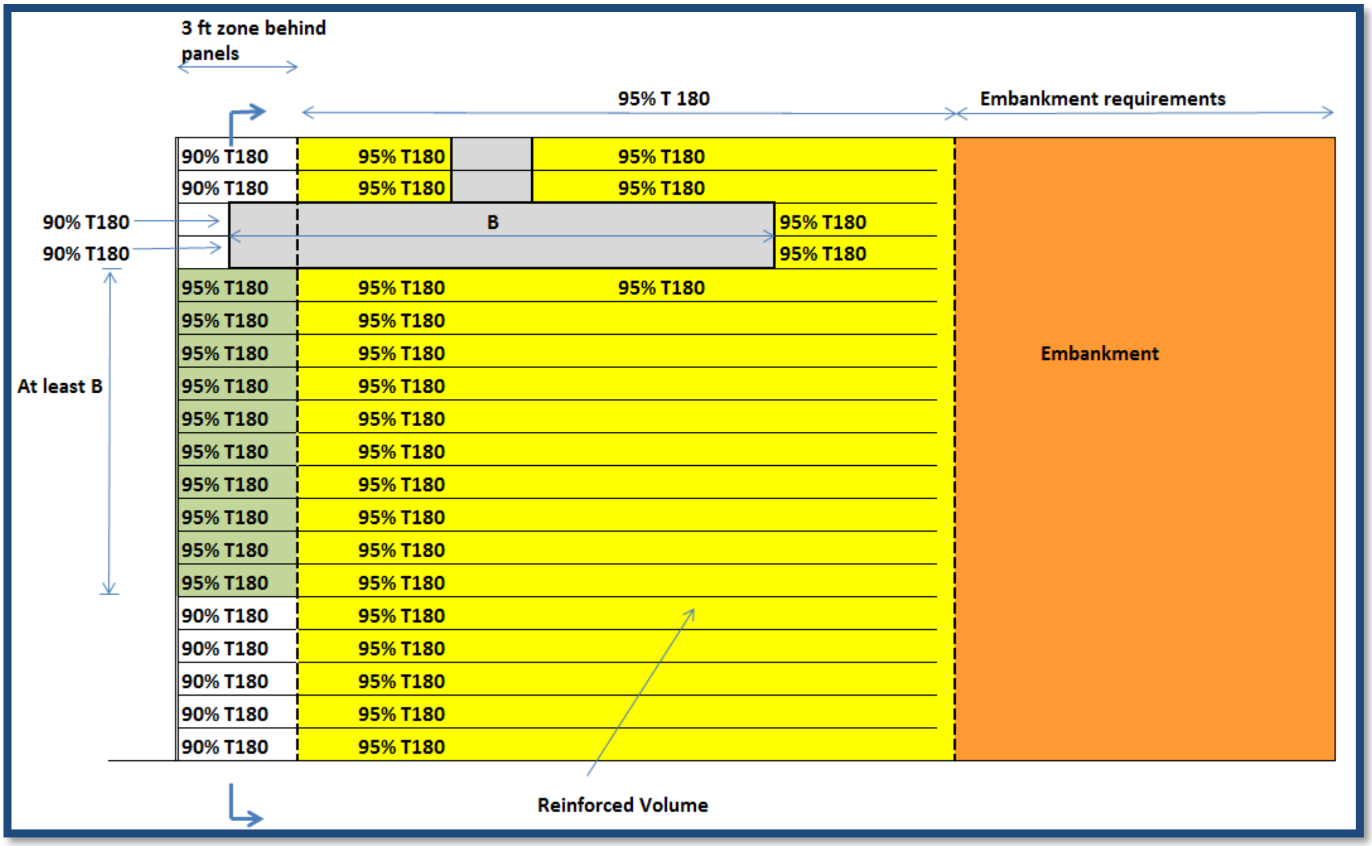

Figure 18-6: Shallow Foundation Behind MSE Wall (Section View)

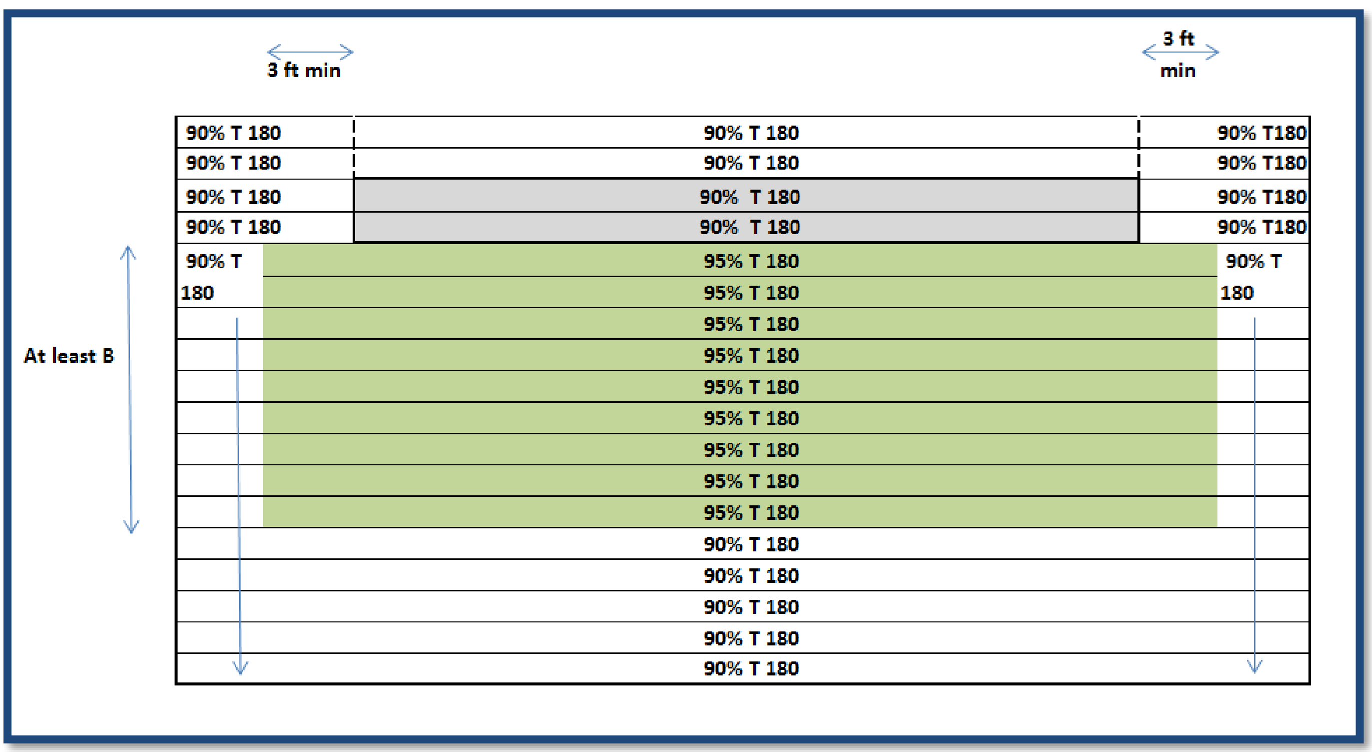

Figure 18-7: Shallow Foundation Behind MSE Wall (Front Section View within 3 ft from Panels)

18.4 ACCEPTANCE OF COARSE AGGREGATE

Coarse aggregate backfill must be compacted with a minimum of 3 passes of a vibratory compactor weighing between 600 and 1000 lbs. or 2 passes of a vibratory compactor weighing over 1000 lbs. The Contractor must use the highest vibration level that does not cause excessive fracture of the aggregate in the opinion of the Engineer. Additional compaction passes must be applied until there is no additional movement.

19. THICK LIFT (548-8.5.2)

The Standard Specification allows under certain conditions the compaction of lifts up to 10-inch compacted thickness.

To be approved for the thick lift procedure, the Contractor needs to successfully demonstrate on a test wall that he can achieve the density requirements for the full depth of the thicker lift. In addition, to verify the contractor can achieve the required density, the purpose of the test wall is to determine what percentage of compaction should be targeted for the 10 inches thickness to ensure the bottom 6 inches will have the required compaction (see section 18.1 of this handbook and article 548-9.4 of the Standard Specifications). The following conditions should be met:

- A test wall will be required for every separate MSE wall contractor or subcontractor involved in the project.

- Notify the Engineer prior to beginning construction of a test wall.

- The test wall is valid only for the backfill material used in the test wall. If a different backfill is used, a separate test wall will be required.

- The test wall length shall be the length required to produce a LOT of 500 feet at the top of the wall.

- If none of the walls in the project are 500 ft or more, the test wall may be broken into two segments comprising separate LOTs. Both segments must be accepted to determine the required % compaction for the remaining walls

- The height of the test wall shall be 20 feet or the highest wall, whichever is less. Lower height walls may be constructed using these procedures until a full height test wall is constructed.

- The Contractor must perform QC density test sets per thick lift. Each QC set consists of a density of the full 10" lift and the density of the bottom 6" of the lift. The latter is performed by performing a local excavation (dig down) to test for density from 4 to 10 inches depth. QC density test sets must be performed for both scenarios: within 3-foot from the back of the panels and outside the 3-foot from the back of the panels.

- The Department will perform verification testing of density for the bottom 6 inches and the entire lift thickness at the frequency indicated in 548-9.6 (one VT set per every 4 thick lifts). **All QC tests and a Department Verification test must** meet the density required by 548-9.4 (see section 18.1 above).

When the Contractor fails to achieve the required density (6 inches or 10 inches lift) he must remove and replace or repair the test wall to comply with the specifications at no additional expense to the Department. It is important to verify the wall tolerances during the installation of the test wall since the additional energy required for a thick lift may move panels out of alignment.

During regular production wall compaction, the thick lift density must meet or exceed the minimum thick lift density result obtained during the test wall. Otherwise, the Contractor must perform dig-down density tests to verify whether the density of the bottom 6 inches of the lift meets the density requirements for 6-inch lift. The Engineer/CEI can periodically verify the density of the bottom 6 inches during thick lift operations, particularly in marginal cases, through IV testing.

The Engineer/CEI may terminate the use of thick lift construction and instruct the Contractor to revert to the 6 inches maximum lift thickness if the Contractor fails to achieve satisfactory results.

20. TOLERANCES (548-8.4)

Vertical and lateral displacements as well as plumbness issues may occur during and after the MSE wall installation if proper erection procedures are not followed. The specifications clearly indicate that the maximum allowable tolerances regarding vertical alignment, horizontal alignment and joint gaps or openings. Inspectors should frequently monitor, measure, and document any tolerance non-compliances.

It is also important to monitor sometime after completing the wall these tolerances. There have been frequent cases in which the walls meet requirements right at the end of wall construction, but have alignment issues post construction. This type of problems could occur especially in areas where the Contractor has attempted to stabilize compressible materials in the foundation. The Department should not accept walls without meeting the specifications at the end of the project.

The specifications require the following tolerances:

20.1 PERMANENT WALLS (548-8.4.1)

Reinforced Concrete MSE Wall Systems:

- Vertical tolerances (plumbness): Maximum deviation: ¾ inch per 10 foot per 10-ft straightedge.
- Horizontal alignment tolerance: Maximum deviation: ¾ inch per 10 foot per 10-ft straightedge.
- Vertical tolerance of the completed wall (plumbness from top to bottom): Maximum deviation: ½-inch per 10 feet of wall height.
- Offset in the joint between precast concrete elements: Maximum ¾-inch.
- Joints Opening (Horizontal and vertical joints): Minimum ½-inch; Maximum 1-1/4 inches.

SBW Systems:

- Vertical tolerance per 10-ft of straightedge: Not specified.
- Vertical tolerance of the completed wall (plumbness from top to bottom or batter shown in the Plans): Maximum deviation: ½-inch per 10 feet of wall height.
- Horizontal alignment tolerance Maximum deviation: ¾ inch per 10 foot per 10-ft wall length.
- Gap between segmental retaining wall blocks above the first course: Maximum 1/16 inch. The final overall vertical tolerance of the completed wall (deviation from plumbness from top to bottom or batter shown in the Plans) must not exceed ½-inch per 10 feet of wall height

Figure 20-1: Vertical Alignment Requirements for Permanent Concrete Panel Walls

Figure 20-2: Joint Opening Measurement

Figure 20-2 is an example of a specification violation of joint opening that is greater than 1.25-inches.

20.2 TEMPORARY WALLS (548-8.4.1)

- Vertical tolerances (plumbness): Maximum deviation: 3 inches per 10 foot per 10-ft straightedge.
- Horizontal alignment tolerance: Maximum deviation: 3 inches per 10 foot per 10-ft straightedge.
- Vertical tolerance of the completed wall (plumbness from top to bottom): Maximum deviation: 1 inch per 3 feet of wall height, without exceeding 6 inches per full wall height.

APPENDIX A: CHECKLIST

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

#	Yes	No	Description
1.	☐	☐	Has the contractor submitted wall shop drawings?
2.	☐	☐	Has the contractor submitted signed and sealed 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? 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, size, and proper product designation)?
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 five (5) 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?

#	Yes	No	Description
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 all the panel joints?
21.	☐	☐	Is the adhesive being applied to the panel, and then the filter fabric being placed?
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 6-inch thick 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.	☐	☐	Are the proper compaction requirements being met? Are the minimum percentage compaction achieved within 3 feet from the panels and beyond three feet from the panels?
29.	☐	☐	Are separate densities (separate LOTs) being taken for the 3 ft from the panels and beyond 3 ft from the panels?
30.	☐	☐	Is the fill being brought up to or slightly above the soil reinforcement elevation before the reinforcement is connected?
31.	☐	☐	Is the soil reinforcement being properly connected (connections tight and all of the slack in the soil reinforcement removed)?

#	Yes	No	Description
32.	☐	☐	Are the soil reinforcements in the proper alignment?
33.	☐	☐	Is the vertical and horizontal alignment being checked periodically and adjusted as needed?
34.	☐	☐	Are the correct reinforced length and sizes installed per shop drawings?
35.	☐	☐	Are the constructed panel joints being checked periodically to verify the specification limits are met?
36.	☐	☐	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.)
37.	☐	☐	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.?
38.	☐	☐	Has the contractor backfilled the front of the wall?
39.	☐	☐	Is the correct coping being installed?

APPENDIX B: MSE WALL CONSTRUCTION DO'S AND DON'TS

1. Review approved shop drawings.
2. Review Mechanically Stabilized Earth (MSE) Wall Inspector's Handbook.
3. Confirm foundation has been compacted properly in accordance to the specifications.
4. Verify leveling pad elevations.
5. Ensure Contractor has submitted certificates of compliance for all the wall components used in the project.
6. Ensure Contractor has submitted a signed and sealed letter certifying the proposed select backfill and coarse aggregate materials met the requirements of 548-2. Ensure backfill materials have been tested and approved before they are 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 wrapped with two independent layers of 6 mil plastic with lubricating oil between the layers.
12. Install panels in accordance to shop drawings, plans and specifications.
13. Place and properly compact fill in accordance with plans and specifications.
14. Ensure the nuclear density gauges are properly calibrated. DO NOT use gauges which calibration has expired (gauges to be calibrated every year)
15. Unless approved by the Engineer after a successful test wall, DO NOT use thick lifts thicker than 6”. With a successful test wall, thick lifts up to 10” compacted lifts may be used.
16. Use corner panels at all corners. If corner panels are not indicated on the plans, the wall supplier and the Wall Design Engineer should be notified.
17. Verify installed reinforcement lengths behind panel.
18. Soil reinforcement should not be skewed more than 15 degrees from normal. If reinforcement needs to be skewed more than 15 degrees, notify the wall supplier and the Wall Design Engineer.
19. 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.
20. Check overall batter regularly. Check alignment and join opening regularly.
21. Water for soil compaction shall be in compliance with Section 923. NO saltwater or brackish water is to be used.
22. When attaching filter fabric to the back of the panels, the adhesive shall be applied to the panel NOT the filter fabric.
23. Remove wooden wedges as soon as possible.
24. If precast coping is used, ensure top panels have dowels that will extend into the cast-in-place Buildup concrete.
25. 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 Engineer of Record'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.)

26. Soil reinforcement near the top of the wall shall be parallel to the lifts of fill. Soil reinforcement shall not extend into the stabilized subgrade that may require mechanical mixing.
27. DO NOT CUT soil reinforcement to avoid obstructions without the approval of the Wall Design Engineer.
28. Place one-half inch minimum preformed expansion material between wall panels and cast-in-place concrete.

APPENDIX C: OUT-OF-TOLERANCE CONDITIONS AND POSSIBLE CAUSES CRITERIA

The following is taken out of FHWA's Publication — DESIGN AND CONSTRUCTION OF MECHANICALLY STABILIZED EARTH WALLS AND REINFORCED SOIL SLOPES- Publication No. FHWA-NHII-10-025, November 2009.

Table 11.4. 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.

CONDITION	**POSSIBLE CAUSE**
1. Distress in wall: a. Differential settlement or low spot in wall (Cause 1a & b apply) b. Overall wall leaning beyond vertical alignment tolerance (Cause 1 a & b). c. Spalling, chipping, or cracking of facing units (Cause 1 a – e apply) (e.g., from panel to panel contact or differential movement of modular block facing units).	a. Foundation (subgrade) material too soft or wet for proper bearing. b. Fill material of poor quality or not properly compacted c. Inadequate spacing in horizontal and vertical joints. d. Use of improper bearing pads e. Stones or concrete pieces between facing units (e.g. units not clean or used to face units)
2. First panel course difficult (impossible) to set and/or maintain level.	2.a. Leveling pad not level
3. Wall out of vertical alignment tolerance (plumbness) or leaning out.	3.a. Panel not battered sufficiently. b. Oversized 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 placed and compacted above reinforcing elements. e. Excessive compaction of uniform, medium-fine sand (more than 60 percent passing a No. 40 sieve). f. Backfill material dumped 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. i. Shoulder clamps not tight. j. Slack in reinforcement to facing connections. k. Inconsistent tensioning of geosynthetic reinforcement to facing l. Localized over-compaction adjacent to MBW unit.
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.	5a. See Causes 3c, 3d, 3e, 3j, 3k. 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.
7. Large variations in movement of adjacent panels.	7.a. Backfill material not uniform. b. Backfill compaction not uniform. c. Inconsistent setting of facing panels.