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Inspection Guidelines for Construction and Post-Construction of Mechanically Stabilized Earth Wall

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INSPECTION GUIDELINES FOR CONSTRUCTION AND POST-CONSTRUCTION OF MECHANICALLY STABILIZED EARTH WALL

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PREFACE

This manual is primarily intended for use by inspectors who are charged with overseeing the construction of mechanically stabilized earth (MSE) walls. The material presented here is not intended to address design issues but to highlight sound construction methods that will enable the MSE wall to function successfully. The manual also provides guidelines for post-construction inspection.

The majority of information in this document was taken from *Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines*, Publication No. FHWA-NHI 00-043, 2001 and *Mechanically Stabilized Earth Wall Inspector's Handbook* published by Florida Department of Transportation, Geotechnical Engineer Paul D. Passe, P.E., CPM .

MECHANICALLY STABILIZED EARTH (MSE) WALLS

INTRODUCTION

This manual is designed for the inspector of mechanically stabilized earth walls. It will provide general guidelines for the inspector; however, the plans, specifications and special provisions govern and must be read and followed.

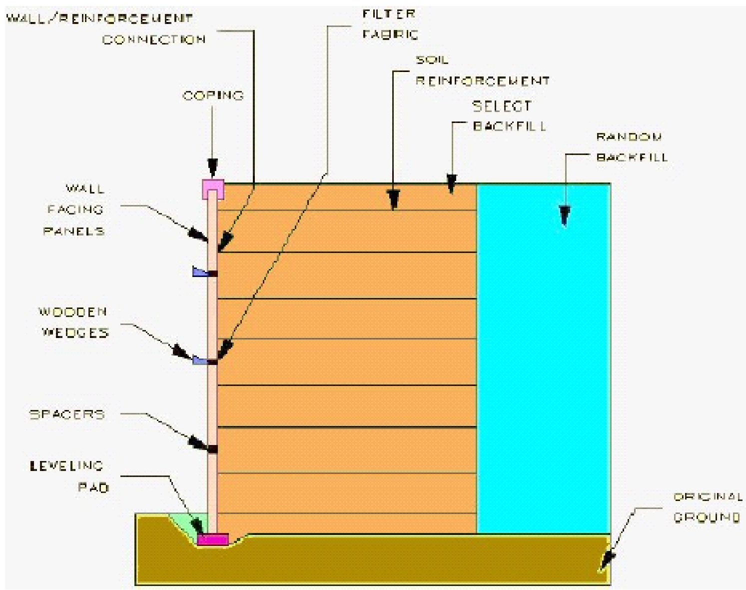

Figure 1. Wall Components

TERMS

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

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). Its deformation characteristics are compatible with those of the backfill soil.

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.

Inextensible Reinforcement - metallic reinforcement material, strips or grids. Its deformations are much smaller than the surrounding soil.

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 panels.

Original Ground - this is the existing ground surface at the site.

Random Backfill - random backfill is the soil is allowed in normal construction.

Select Backfill - select backfill is the fill that meets the gradation, corrosion, unit weight, internal friction angle and any other requirements of the specifications.

Soil Reinforcement - soil reinforcement holds the wall facing panels in position and provides reinforcement for the soil. 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. 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 connection is made between the wall facing panel and the soil reinforcement.

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

DESCRIPTION OF MSE SYSTEMS

a. Systems Differentiation

Since the expiration of the fundamental process and concrete facing panel patents obtained by the Reinforced Earth Co. for MSEW systems and structures, the engineering community has adopted a generic term ***Mechanically Stabilized Earth*** to describe this type of retaining wall construction.

Trademarks, such as Reinforced Earth®, Retained Earth®, Genesis® etc., describe systems with some present or past proprietary features or unique components marketed by nationwide commercial suppliers. Other trademark names appear yearly to differentiate systems marketed by competing commercial entities that may include proprietary or novel components or for special applications.

A system for MSEW structures is defined as a complete supplied package that includes design, specifications and all *prefabricated* materials of construction necessary for the complete construction of a soil-reinforced structure. Often technical assistance during the planning and construction phase is also included. Components marketed by commercial entities for integration by the owner in a coherent system are not classified as systems.

b. Types of Systems

MSE systems can be described by the reinforcement geometry, stress transfer mechanism, reinforcement material, extensibility of the reinforcement material, and the type of facing and connections.

Reinforcement Geometry

Three types of reinforcement geometry can be considered:

- **Linear unidirectional**. Strips, including smooth or ribbed steel strips, or coated geosynthetic strips over a load-carrying fiber.

- **Composite unidirectional**. Grids or bar mats characterized by grid spacing greater than 150 mm (6 inches).

- **Planar bidirectional**. Continuous sheets of geosynthetics, welded wire mesh, and woven wire mesh. The mesh is characterized by element spacing of less than 150 mm (6 inches).

Reinforcement Material

Distinction can be made between the characteristics of metallic and nonmetallic reinforcements:

- **Metallic reinforcements**. Typically of mild steel. The steel is usually galvanized or may be epoxy coated.

- **Nonmetallic reinforcements**. Generally polymeric materials consisting of polypropylene, polyethylene, or polyester.

The performance and durability considerations for these two classes of reinforcement vary considerably.

Reinforcement Extensibility

There are two classes of extensibility:

- **Inextensible**. The deformation of the reinforcement at failure is much less than the deformability of the soil.
- **Extensible**. The deformation of the reinforcement at failure is comparable to or even greater than the deformability of the soil.

c. Facing Systems

The types of facing elements used in the different MSE systems control their aesthetics because they are the only visible parts of the completed structure. A wide range of finishes and colors can be provided in the facing. In addition, the facing provides protection against backfill sloughing and erosion, and provides in certain cases drainage paths. The type of facing influences settlement tolerances. Major facing types are:

- **Segmental precast concrete panels** have a minimum thickness of 140 mm (5-½ inches) and are of a cruciform, square, rectangular, diamond, or hexagonal geometry. Temperature and tensile reinforcement are required but will vary with the size of the panel. Vertically adjacent units are usually connected with shear pins.

- **Dry cast modular block wall (MBW) units**. These are relatively small, squat concrete units that have been specially designed and manufactured for retaining wall applications. The mass of these units commonly ranges from 15 to 50 kg (30 to 110 lbs), with units of 35 to 50 kg (75 to 110 lbs) routinely used for highway projects. Unit heights typically range from 100 to 200 mm (4 to 8 inches) for the various manufacturers. Exposed face length usually varies from 200 to 450 mm (8 to 18 inches). Nominal width (dimension perpendicular to the wall face) of units typically ranges between 200 and 600 mm (8 and 24 inches). Units may be manufactured solid or with cores. Full height cores are filled with aggregate during erection. Units are normally dry-stacked (i.e. without mortar) and in a running bond configuration. Vertically adjacent units may be connected with shear pins, lips, or keys. They are referred to by trademarked names such as Keystone®, Versa-Lok®, Allan Blocks®, etc.

- **Metallic Facings**. The original Reinforced Earth® system had facing elements of galvanized steel sheet formed into half cylinders. Although precast concrete panels are now commonly used in Reinforced Earth walls, metallic facings may be appropriate in structures where difficult access or difficult handling requires lighter facing elements.

- **Welded Wire Grids**. Wire grid can be bent up at the front of the wall to form the wall face. This type of facing is used in the Hilfiker, Tensar, and Reinforced Earth wire retaining wall systems.

- **Gabion Facing**. Gabions (rock-filled wire baskets) can be used as facing with reinforcing elements consisting of welded wire mesh, welded bar-mats, geogrids, geotextiles or the double-twisted woven mesh placed between or connected to the gabion baskets.
- **Geosynthetic Facing.** Various types of geotextile reinforcement are looped around at the facing to form the exposed face of the retaining wall. These faces are susceptible to ultraviolet light degradation, vandalism (e.g. target practice) and damage due to fire. Alternately, a geosynthetic grid used for soil reinforcement can be looped around

to form the face of the completed retaining structure in a similar manner to welded wire mesh and fabric facing. Vegetation can grow through the grid structure and can provide both ultraviolet light protection for the geogrid and a pleasing appearance.

- **Postconstruction Facing**. For wrapped faced walls, the facing – whether geotextile, geogrid, or wire mesh – can be attached after construction of the wall by shotcreting, guniting, cast-in-place concrete or attaching prefabricated facing panels made of concrete, wood, or other materials. This multi-staging facing approach adds cost but is advantageous where significant settlement is anticipated.

Precast elements can be cast in several shapes and provided with facing textures to match environmental requirements and blend aesthetically into the environment. Retaining structures using precast concrete elements as the facings can have surface finishes similar to any reinforced concrete structure.

Retaining structures with metal facings have the disadvantage of shorter life because of corrosion, unless provision is made to compensate for it.

Facings using welded wire or gabions have the disadvantages of an uneven surface, exposed backfill materials, more tendency for erosion of the retained soil, possible shorter life from corrosion of the wires, and more susceptibility to vandalism. These disadvantages can, of course, be countered by providing shotcrete or by hanging facing panels on the exposed face and compensating for possible corrosion. The greatest advantages of such facings are low cost, ease of installation, design flexibility, good drainage (depending on the type of backfill) that provides increased stability, and possible treatment of the face for vegetative and other architectural effects. The facing can easily be adapted and well-blended with natural country environment. These facings, as well as geosynthetic wrapped facings, are especially advantageous for construction of temporary or other structures with a short-term design life.

Dry cast segmental block MBW facings may raise some concerns as to durability in aggressive freeze-thaw environments when produced with water absorption capacity significantly higher than that of wet-cast concrete. Historical data provide little insight as their usage history is less than two decades. Further, because the cement is not completely hydrated during the dry cast process, (as is often evidenced by efflorescence on the surface of units), a highly alkaline regime may establish itself at or near the face area, and may limit the use of some geosynthetic products as reinforcements. Freeze-thaw durability is enhanced for products produced at higher compressive strengths and low water absorption ratios.

INSPECTION AND PERFORMANCE MONITORING

Construction of MSE systems is relatively simple and rapid. The construction sequence consists mainly of preparing the subgrade, placing and compacting backfill in normal lift operations, laying the reinforcing layer into position, and installing the facing elements *(tensioning of the reinforcement may also be require*d). Special skills or equipment are usually not required, and locally available labor can be used. Most material suppliers provide training for construction of their systems. A checklist of general requirements for monitoring and inspecting MSE systems is provided in Appendix A.

There are some special construction considerations that the designer, construction personnel, and inspection team need to be aware of so that potential performance problems can be avoided. These considerations relate to the type of system to be constructed, to specific site conditions, the backfill material used and facing requirements. The following sections review items relating to:

- Section 1- Preconstruction Reviews.
- Section 2 - Prefabricated Materials Inspection.
- Section 3 - Construction Control.
- Section 4 - Performance Monitoring Programs.
- Section 5 – Post Construction

➢ Section 1 - PRECONSTRUCTION REVIEWS

Prior to erection of the structure, personnel responsible for observing the field construction of the retaining structure should become thoroughly familiar with the following items:

- The plans and specifications.
- The site conditions relevant to construction requirements.
- Material requirements.
- Construction sequences for the specific reinforcement system.

a. Plans and Specifications

The owner's field representatives should carefully read the specification requirements for the specific type of system to be constructed, with special attention given to material requirements, construction procedures, soil compaction procedures, alignment tolerances, and acceptance/rejection criteria. Plans should be reviewed and unique and complex project details identified and reviewed with the designer and contractor, if possible. Special attention should be given to the construction sequence, corrosion protection systems for metallic reinforcement, special placement requirements to reduce construction damage for polymeric reinforcement, soil compaction restrictions, details for drainage requirements and utility construction, and construction of the outward slope. The contractor's documents should be checked to make sure that the latest issue of the approved plans, specifications, and contract documents are being used.

b. Review of Site Conditions and Foundation Requirements

The site conditions should be reviewed to determine if there will be any special construction procedures required for preparation of the foundations, site accessibility, excavation for obtaining the required reinforcement length, and construction de-watering and other drainage features.

Foundation preparation involves the removal of unsuitable materials from the area to be occupied by the retaining structure including all organic matter, vegetation, and slide debris, if any. This is most important in the facing area to reduce facing system movements and, therefore, to aid in maintaining facing alignment along the length of the structure. The field personnel should review the borings to determine the anticipated extent of the removal required.

Where construction of reinforced fill will require a side slope cut, a temporary earth support system may be required to maintain stability. The contractor's method and design should be reviewed with respect to safety and the influence of its performance on adjacent structures. Caution is also advised for excavation of utilities or removal of temporary bracing or sheeting in front of the completed MSE structures. Loss of ground from these activities could result in settlement and lateral displacement of the retaining structure.

The groundwater level found in the site investigation should be reviewed along with levels of any nearby bodies of water that might affect drainage requirements. Slopes into which a cut is to be made should be carefully observed, especially following periods of precipitation, for any signs of seeping water (often missed in borings). Construction of de-watering operations should be required for any excavations performed below the water table to prevent a reduction in shear strength due to hydrostatic water pressure.

MSE structures should be designed to permit drainage of any seepage or trapped groundwater in the retained soil. If water levels intersect the structure, it is also likely that a drainage structure behind and beneath the wall will be required. Surface water infiltration into the retained fill and reinforced fill should be minimized by providing an impermeable cap and adequate slopes to nearby surface drain pipes or paved ditches with outlets to storm sewers or to natural drains.

Internal drainage of the reinforced fill can be attained by use of a free-draining granular material that is free of fines (material passing No. 200 sieve should be less than 5 percent). Because of its high permeability, this type of fill will prevent retention of any water in the soil fill as long as a drainage outlet is available. Arrangement is generally provided for drainage to the base of the fill to prevent water exiting the face of the wall and causing erosion and/or face stains. The drains will, of course, require suitable outlets for discharge of seepage away from the reinforced soil structure. Care should be taken to avoid creating planes of weakness within the structure with drainage layers.

➢ Section 2 - PREFABRICATED MATERIALS INSPECTION

Material components should be examined at the casting yard (for systems with precast elements) and on site. Typical casting operations are shown in Figure 2 below. Material acceptance should be based on a combination of material testing, certification, and visual observations.

Figure 2. Casting yard for precast facing elements

When delivered to the project site, the inspector should carefully inspect all material (precast facing elements, reinforcing elements, bearing pads, facing joint materials, and reinforced backfill). On site, all system components should be satisfactorily stored and handled to avoid damage (See Figures 3 and 4). The material supplier's construction manual should contain additional information on this matter.

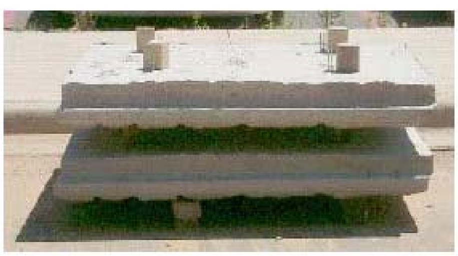

Figure 3. Proper panel storage

Figure 4. Improper panel storage

a. Precast Concrete Elements. At the casting yard, the inspector should assure the facing elements are being fabricated in accordance with the agency's standard specifications. For example, precast concrete facing panels should be cast on a flat surface. To minimize corrosion, it is especially important that coil embeds, tie strip guides, and other connection devices do not contact or attach to the facing element reinforcing steel.

Facing elements delivered to the project site should be examined prior to erection. Panels should be rejected on the basis of the following deficiencies or defects:

- Insufficient compressive strength.

- Imperfect molding.

- Honey-combing.

- Severe cracking, chipping, or spalling.

- Color of finish variation on the front face.

- Out-of-tolerance dimensions.

- Misalignment of connections.

The following maximum facing element dimension tolerances are usually specified for precast concrete:

- Overall dimensions - 13 mm (½-inch).

- Connection device locations - 25 mm (1-inch).

- Element squareness - 13 mm (½-inch) difference between diagonals.

- Surface finish - 2 mm in 1 m (1/8-inch in 5 ft) (smooth surface).

- Surface finish - 5 mm in 1 m (5/16-inch in 5 ft) (textured surface).

In cases where repair to damaged facing elements is possible, it should be accomplished to the satisfaction of the inspector.

For drycast modular blocks, it is essential that compressive strengths and water absorption be carefully checked on a lot basis. The following dimensional tolerances are usually specified:

- Overall dimensions - ± 3.2 mm (1/8-inch)

- Height of each block - ± 1.6 mm (1/16-inch)

b. **Reinforcing Elements**. Reinforcing elements (strips, mesh, sheets) should arrive at the project site securely bundled or packaged to avoid damage (see Figure 5). These materials are available in a variety of types, configurations, and sizes (gauge, length, product styles), and even a simple structure may have different reinforcement elements at different locations. The inspector should verify that the material is properly identified and the specified designation (AASHTO, ASTM, or agency specifications) is checked. Material verification is especially important for geotextiles and geogrids where many product styles look similar but have different properties. Mesh reinforcement should be checked for gross area and length, width, and spacing of transverse members. For strip reinforcements, the length and thickness should be checked. Geogrids or geotextile samples should be sent to the laboratory for verification testing.

Figure 5. Inspect reinforcing elements

Protective coatings, i.e., galvanization (thickness 610 gm/m) or epoxy (thickness 18 mils [457 μm]), should be verified by certification or agency conducted tests and checked for defects.

c. **Facing Joint Materials**. Bearing pads (cork, neoprene, SBR rubber), joint filler and joint cover (geotextile) should be properly packaged to minimize damage in unloading and handling. For example, polymer filler material and geotextiles must be protected from sunlight during storage.

Although these items are often considered as miscellaneous, it is important for the inspector to recognize that use of the wrong material or its incorrect placement can result in significant structure distress.

d. **Reinforced Backfill**. The backfill in MSE structures is the key element in satisfactory performance. Use of the appropriate material and its correct placement are important factors. Reinforced backfill is normally specified to meet certain gradation, plasticity, soundness, and electrochemical requirements. Depending on the type of contract, tests to ensure compliance may be performed by either the contractor or the owner. The tests conducted prior to construction and periodically during construction for quality assurance form the basis for approval. During construction these tests include gradation and plasticity index testing at the rate of one test per 1500 m^3 (2000 yd^3) of material placed and whenever the appearance and behavior of the backfill changes noticeably.

➢ Section 3 - CONSTRUCTION CONTROL

Each of the steps in the sequential construction of MSE systems is controlled by certain method requirements and tolerances. Construction manuals for proprietary MSE systems should be obtained from the contractor to provide guidance during construction monitoring and inspection. A detailed description of general construction requirements follows.

a. Leveling Pad

Figure 6. Leveling pad

Figure 7. Improper leveling pad

A concrete leveling pad should have minimum dimensions of 150 mm (6 inches) thick by 300 mm (1 ft) wide and should have a minimum 13.8 MPa (2,000 psi) compressive strength. Cast-in-place pads should cure for a minimum of 12 hours before facing panels are placed. Careful inspection of the leveling pad to assure correct line, grade, and offset is important. A vertical tolerance of 3 mm (1/8 inch) to the design elevation is recommended. If the leveling pad is not at the correct elevation, the top of the wall will not be at the correct elevation. An improperly placed leveling pad can result in subsequent panel misalignment, cracking, and spalling. Full height precast facing elements may require a larger leveling pad to maintain alignment and provide temporary foundation support. Gravel pads of suitable dimensions may be used with modular block wall construction. Typical installations are shown in Figures 8 and 9 below.

Figure 8. Concrete leveling pad

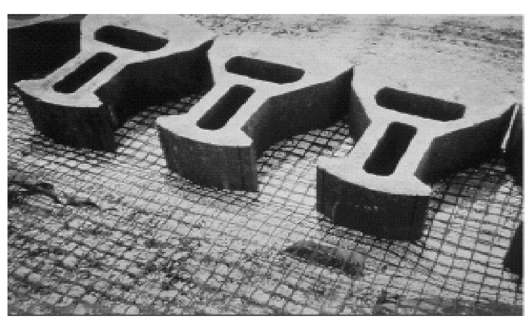

Figure 9. Compacted gravel leveling pad

b. Erection of Facing Elements

Precast facing panels are purposely set at a slight backward batter (toward the reinforced fill) in order to assure correct final vertical alignment after backfill placement as shown on Figure 10. Minor outward movement of the facing elements from wall fill placement and compaction cannot be avoided and is expected as the interaction between the reinforcement and reinforced backfill occurs. Most systems with segmental precast panels also have some form of construction alignment dowels between adjacent elements that aid in proper erection. Typical backward batter for segmental precast panels is 20 mm per meter (¼-inch per foot) of panel height.

Full height precast panels as shown on Figure 11 are more susceptible to misalignment difficulties than segmental panels. When using full-height panels, the construction procedure should be carefully controlled to maintain tolerances. Special construction procedures such as additional bracing and larger face panel batter may be necessary.

First Row of Facing Elements. Setting the first row of facing elements is a key detail as shown on Figure 12. Construction should always begin adjacent to any existing structure and proceed toward the open end of the wall. The panels should be set directly on the concrete leveling pad. Horizontal joint material or wooden shims should not be permitted between the first course of panels and the leveling pad. Temporary wood wedges may be used between the first course of panels and the leveling pad to set panel batter, but they must be removed during subsequent construction. Some additional important details are:

- For segmental panel walls, panel spacing bars (sets horizontal spacing between panels), should be used so that subsequent panel rows will fit correctly.

- The first row of panels must be continuously braced until several layers of reinforcement and backfill have been placed. Adjacent panels should be clamped together to prevent individual panel displacement.

- After setting the battering for the first row of panels, horizontal alignment should be visually checked with survey instruments or with a stringline.

- When using full-height panels, initial bracing alignment and clamping are even more critical because small misalignments cannot be easily corrected as construction continues.

- Most MSE systems use a variety of panel types on the same project to accommodate geometric and design requirements (geometric shape, size, finish, connection points). The facing element types must be checked to make sure that they are installed exactly as shown on the plans.

Figure 10. Checking facing element batter and alignment

Figure 11. Setting first row of precast facing elements

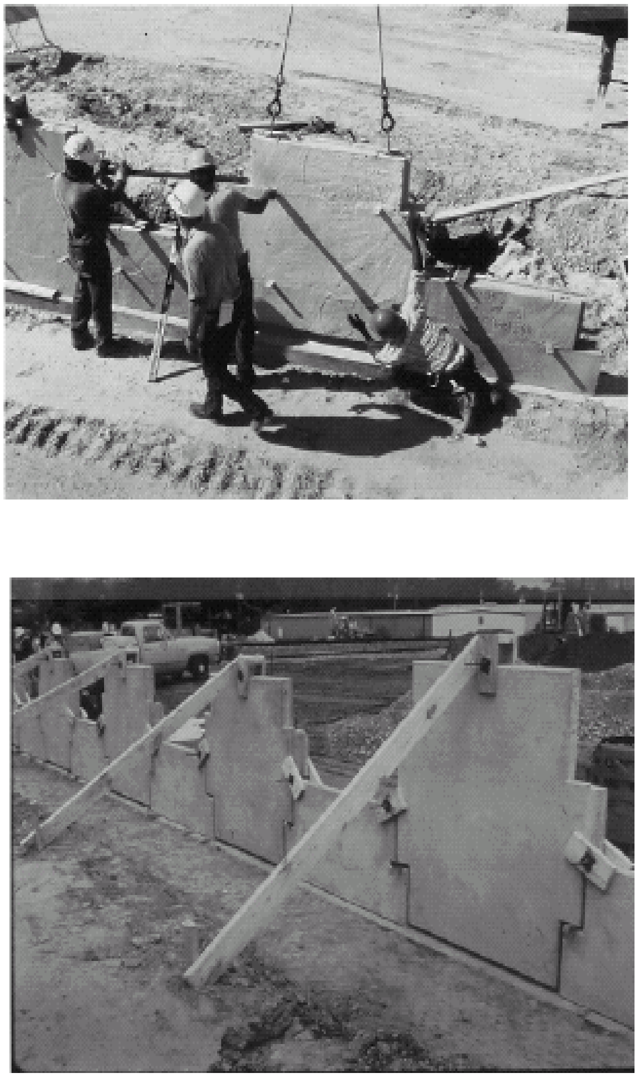

Figure 12. Setting first row of precast facing elements

c. Reinforced Fill Placement, Compaction

Moisture and density control is imperative for construction of MSE systems. Even when using high-quality granular materials, problems can occur if compaction control is not exercised. Reinforced wall fill material should be placed and compacted at or within 2 percent dry of the optimum moisture content. If the reinforced fill is free draining with less than 5 percent passing a No. 200 U.S. Sieve, water content of the fill may be within ±3 percentage points of the optimum. The moisture content of the fill during placement can have a significant effect on reinforcement-soil interaction. Moisture content wet of optimum makes it increasingly difficult to maintain an acceptable facing alignment, especially if the fines content is high. Moisture contents that are too dry could result in significant settlement during periods of precipitation.

A relative compaction of 95 percent of T-99 maximum dry density value is recommended for retaining walls and slopes, and 100 percent of T-99 is recommended for abutments and walls or slopes supporting structural foundation abutments. A procedural specification is preferable where a significant percentage of coarse material, generally 30 percent or greater retained on the 19 mm (¾-inch) sieve, prevents the use of the AASHTO T-99 or T-180 test methods. In this situation, typically three to five passes with conventional vibratory roller compaction equipment is adequate to attain the maximum practical density. The actual requirements should be determined based on field trials.

Reinforced backfill should be dumped onto or parallel to the rear and middle of the reinforcements and bladed toward the front face as shown on Figure 13. At no time should any construction equipment be in direct contact with the reinforcements because protective coatings and reinforcements can be damaged. Soil layers should be compacted up to or even slightly above the elevation of each level of reinforcement connections prior to placing that layer of reinforcing elements.

Figure 13. Placement of reinforced backfill

Compaction Equipment - With the exception of the 1-m zone directly behind the facing elements or slope face, large, smooth-drum, vibratory rollers should generally be used to obtain the desired compaction as shown on Figure 14. Sheepsfoot rollers (Figure 15) should not be permitted because of possible damage to the reinforcements. When compacting uniform medium to fine sands (in excess of 60 percent passing a No. 40 sieve), use a smooth-drum static roller or lightweight (walk behind) vibratory roller. The use of large vibratory compaction equipment with this type of backfill material will make wall alignment control difficult. Within 1 m (3 ft) of the wall or slope face, use small single or double drum, walk-behind vibratory rollers or vibratory plate compactors as shown on Figure 16. Placement of the reinforced backfill near the front should not lag behind the remainder of the structure by more than one lift. Poor fill placement and compaction in this area has in some cases resulted in a chimney-shaped vertical void immediately behind the facing elements.

Figure 14. Compaction equipment roller **Figure 15. No sheepsfoot**

Within this 1 m (3 ft) zone, quality control should be maintained by a method's specification such as three passes of a light drum compactor. Higher quality fill is sometimes used in this zone so that the desired properties can be achieved with less compactive effort. Excessive compactive effort or use of too heavy equipment near the wall face could result in excessive face panel movement (modular panels) or structural damage (full-height, precast panels), and overstressing of reinforcement layers.

Figure 16. Lightweight equipment @ 1 m from face

Inconsistent compaction and undercompaction caused by insufficient compactive effort or allowing the contractor to "compact" backfill with trucks and dozers will lead to gross misalignments and settlement problems and should not be permitted. Flooding of the backfill to facilitate compaction should not be permitted. Compaction control testing of the reinforced backfill should be performed on a regular basis during the entire construction project. A minimum frequency of one test within the reinforced soil zone per every 1.5 m (5 ft) of wall height for every 30 m (100 ft) of wall is recommended.

d. Placement of Reinforcing Elements

Reinforcing elements for MSE systems should be installed in strict compliance with spacing and length requirements shown on the plans. Reinforcements should generally be placed perpendicular to the back of the facing panel. In specific situations involving, for example, abutments and curved walls, it may be permissible to skew the reinforcements from their design location in either the horizontal or vertical direction. In all cases, overlapping layers of reinforcements should be separated by a 75 mm (3-inch) minimum thickness of fill.

Curved walls create special problems with MSE panel and reinforcement details. Different placement procedures are generally required for convex and concave curves. For reinforced fill systems with precast panels, joints will either be further closed or opened by normal facing movements depending on whether the curve is concave or convex.

Other difficulties arise when constructing MSE structures around deep foundation elements or drainage structures. For deep foundations, either drive piles prior to face construction or use hollow sleeves at proposed pile locations during reinforced fill erection. The latter method is generally preferred. Predrilling for pile installation through the reinforced soil structure between reinforcements can also be performed but is risky and may damage reinforcing elements.

Connections. Each MSE system has a unique facing connection detail. Several types of connections are shown on Figure 17. All connections must be made in accordance with the manufacturer's recommendations. For example, on Reinforced Earth structures, bolts must fit and be located between tie strips, be perpendicular to the steel surfaces, and be seated flush against the flange to have full bearing of the bolt head. Nuts are to be securely tightened.

Flexible reinforcements, such as geotextiles and geogrids, usually require pretensioning to remove any slack in the reinforcement or in the panel. The tension is then maintained by staking or by placing fill during tensioning. Tensioning and staking will reduce subsequent horizontal movements of the panel as the wall fill is placed.

e. Placement of Subsequent Facing Courses (Segmental Facings)

Throughout construction of segmental panel walls, facing panels should only be set at grade. Placement of a panel on top of one not completely backfilled should not be permitted.

Alignment Tolerances. The key to a satisfactory end product is maintaining reasonable horizontal and vertical alignments during construction. Generally, the degree of difficulty in maintaining vertical and horizontal alignment increases as the vertical distance between reinforcement layers increases.

The following alignment tolerances are recommended:

- Adjacent facing panel joint gaps (all reinforcements) - 19 mm ± 6 mm (¾-inch ± ¼-inch).

- Precast face panel (all reinforcements) - 6 mm per m (horizontal and vertical directions) (3/8 inch per 5 ft).

- Wrapped face walls and slopes (e.g., welded wire or geosynthetic facing) - 15 mm per m (horizontal and vertical directions) (1-inch per 5 ft).

- Wrapped face walls and slopes (e.g., welded wire or geosynthetic facing) overall vertical –8 mm per m (½-inch per 5 ft).

- Wrapped face walls and slopes (e.g., welded wire or geosynthetic facing) bulging - 25 to 50 mm (1 to 2 inches) maximum.

- Reinforcement placement elevations - 25 mm (1-inch) of connection elevation.

Failure to attain these tolerances when following suggested construction practices indicates that changes in the contractor's procedures are necessary. These might include changes in reinforced backfill placement and compaction techniques, construction equipment, and facing panel batter.

Facing elements that are out of alignment should not be pulled back into place because this may damage the panels and reinforcements and, hence, weaken the system. Appropriate measures to correct an alignment problem are the removal of reinforced fill and reinforcing elements, followed by the resetting of the panels. Decisions to reject structure sections that are out of alignment should be made rapidly because panel resetting and reinforced fill handling are time consuming and expensive. Occasionally, lower modular panels may experience some movement after several lifts of panels have been placed. This could be due to foundation settlement, excess moisture content following heavy rain, or excessive compaction. Construction should be stopped immediately and the situation evaluated by qualified geotechnical specialists when these "post erection" deformations occur.

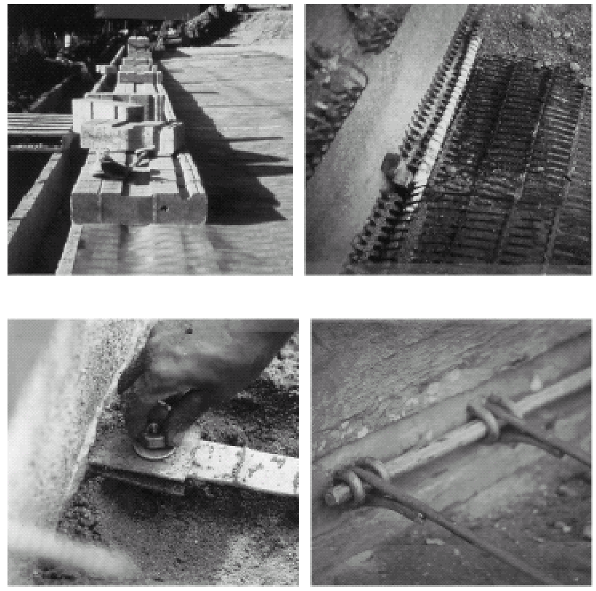

Figure 17. Facing connection examples

Improper horizontal and vertical joint openings can result in face panel misalignment, and cracking and spalling due to point stresses. Wedging of stones or concrete pieces to level face panels should not be permitted. All material suppliers use bearing pads on horizontal joints between segmental facing panels to prevent point stresses (cork, neoprene, or rubber are typically used). These materials should be installed in strict accordance with the plans and specifications, especially with regard to thickness and quantity. Other joint materials are used to prevent point stresses and erosion of fill through the facing joints (synthetic foam and geotextiles details are typically used). Excessively large panel joint spacings or joint openings that are highly variable result in a very unattractive end product. Geotextile joint covers (Figure 18) and neoprene pads (Figure 19) are shown here.

Wooden wedges placed during erection to aid in alignment should remain in place until the third layer of modular panels are set, at which time the bottom layer of wedges should be removed. Each succeeding layer of wedges should be removed as the succeeding panel layer is placed. When the wall is completed, all temporary wedges should be removed.

Figure 18. Geotextile joint cover

Figure 19. Neoprene bearing pad

At the completion of each day's work, the contractor should grade the wall fill away from the face and lightly compact the surface to reduce the infiltration of surface water from precipitation. At the beginning of the next day's work, the contractor should scarify the backfill surface. Table 1 gives a summary of several out-of-tolerance conditions and their possible causes.

MSEW 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.

Table 1. Out-of-Tolerance conditions and possible causes.

CONDITION	POSSIBLE CAUSE
1. Distress in wall ♦ differential settlement or low spot in wall ♦ overall wall leaning beyond vertical alignment tolerance ♦ panel contact, resulting in spalling/chipping	♦ 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 spalls/chips.	Leveling pad not within tolerance.
3. Wall out of vertical alignment tolerance (plumbness), or leaning out.	♦ Panel not battered sufficiently. ♦ Oversized backfill or compaction equipment working within 1 m (3 ft) zone of back of wall facing panels ♦ Backfill material placed wet of optimum moisture content. Backfill contains excessive fine materials (beyond specs for % passing No. 200 sieve ♦ Backfill material pushed against back of facing panel before being compacted above reinforcing elements. ♦ Excessive or vibratory compaction of uniform, medium fine sand (more than 60% passing No. 40 sieve). ♦ Backfill material dumped close to free end of reinforcing elements, then spread toward back of wall, causing displacement of reinforcements and pushing panels out. ♦ Shoulder wedges not seated securely. ♦ Shoulder clamps not tight. ♦ Slack in reinforcement to facing connections. ♦ Inconsistent tensioning of geosynthetic reinforcement to MBW unit. ♦ Localized over-compaction adjacent to MBW unit.
4. Wall out of vertical alignment tolerance	♦ Excessive batter set in panels for select

(plumbness), or leaning in.	granular backfill material being used. ♦ Inadequate compaction of backfill. ♦ Possible bearing capacity failure. ♦ MBW unit manufactured out of vertical tolerance.
5. Wall out of horizontal alignment tolerance, or bulging.	♦ 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.	♦ Panels not level. Differential settlement. See cause 1. ♦ Panel cast beyond tolerance. ♦ Failure to use space bar.
7. Large variations in movement of adjacent panels.	♦ Backfill material not uniform ♦ Backfill compaction not uniform. ♦ Inconsistent setting of facing panels.

➢ Section 4 - PERFORMANCE MONITORING PROGRAMS

Since MSE technology is well established, the need for monitoring programs should be limited to cases in which new features or materials have been incorporated in the design, when substantial post construction settlements are anticipated, when construction rates require control, where degradation/corrosion rates of reinforcements require monitoring because of the use of marginal fills or when there are anticipated changes in the in-situ regime. Under the outlined conditions the monitoring can be used to:

- Confirm design stress levels and monitor safety during construction.
- Allow construction procedures to be modified for safety or economy.
- Control construction rates.
- Enhance knowledge of the behavior of MSEW structures to provide a base reference for future designs, with the possibility of improving design procedures and/or reducing costs.
- Provide insight into maintenance requirements by long-term performance monitoring.

a. Purpose of Monitoring Program

The first step in planning a monitoring program is to define the purpose of the measurements. Every instrument on a project should be selected and placed to assist in answering a specific question.

If there is no question, there should be no instrumentation. Both the questions that need to be answered and the clear purpose of the instrumentation in answering those questions should be established.

The most significant parameters of interest should be selected, with care taken to identify secondary parameters that should be measured if they may influence primary parameters.

For all structures, important parameters that should be considered include:

- Horizontal movements of the face (for MSEW structures).
- Vertical movements of the surface of the overall structure.
- Local movements or deterioration of the facing elements.
- Drainage behavior of the backfill.

- Performance of any structure supported by the reinforced soil, such as approach slabs for bridge abutments or footings.

- Horizontal movements within the overall structure.

- Vertical movements within the overall structure.

- Lateral earth pressure at the back of facing elements.

- Vertical stress distribution at the base of the structure.

- Stresses in the reinforcement, with special attention to the magnitude and location of the maximum stress.

- Stress distribution in the reinforcement due to surcharge loads.

- Relationship between settlement and stress-strain distribution.

- Stress relaxation in the reinforcement with time.

- Total horizontal stress within the backfill and at the back of the reinforced wall section.

- Aging condition of reinforcement such as corrosion losses or degradation of polymeric reinforcements.

- Pore pressure response below structure.

- Temperature, which often is a cause of real changes in other parameters and also may affect instrument readings.

- Rainfall, which often is a cause of real changes in other parameters.

- Barometric pressure, which may affect readings of earth pressure and pore pressure-measuring instruments.

The characteristics of the subsurface, backfill material, reinforcement, and facing elements in relation to their effects on the behavior of the structure must be assessed prior to developing the instrumentation program. It should be remembered that foundation settlement would affect stress distribution within the structure. Also, the stiffness of the reinforcement will affect the anticipated lateral stress conditions within the retained soil mass.

b. Limited Monitoring Program

Limited observations and monitoring will typically include:

- Horizontal movements of the face (for MSEW structures).
- Vertical movements of the surface of the overall structure.
- Local movements or deterioration of the facing elements.
- Performance of any structure supported by the reinforced soil, such as approach slabs for bridge abutments or footings.

Horizontal and vertical movements can be monitored by surveying methods, using suitable measuring points on the retaining wall facing elements or on the pavement or surface of the retained soil. Permanent benchmarks are required for vertical control. For horizontal control, one horizontal control station should be provided at each end of the structure. The *maximum* lateral movement of the wall face during construction is anticipated to be on the order of H/250 for rigid reinforcement and H/75 for flexible reinforcement. Tilting due to differential lateral movement from the bottom to the top of the wall would be anticipated to be less than 4 mm per m (¼-inch per 5 ft) of wall height for either system. Postconstruction horizontal movements are anticipated to be very small. Post construction vertical movements should be estimated from foundation settlement analyses, and measurements of actual foundation settlement during and after construction should be made.

c. Comprehensive Monitoring Program

Comprehensive studies involve monitoring of surface behavior as well as internal behavior of the reinforced soil. A comprehensive program may involve the measurement of nearly all of the parameters enumerated above and the prediction of the magnitude of each parameter at working stress to establish the range of accuracy for each instrument.

Whenever measurements are made for construction control or safety purposes, or when used to support less conservative designs, a predetermination of warning levels should be made. An action plan must be established, including notification of key personnel and design alternatives so that remedial action can be discussed or implemented at any time.

A comprehensive program may involve all or some of the following key purposes:

- Deflection monitoring to establish gross structure performance and as an indicator of the location and magnitude of potential local distress to be more fully investigated.

- Structural performance monitoring to primarily establish tensile stress levels in the reinforcement and/or connections. A second type of structural performance monitoring would measure or establish degradation rates of the reinforcements.

- Pullout resistance proof testing to establish the level of pullout resistance within a reinforced mass as a function of depth and elongation.

The possible instruments for monitoring are outlined in Table 2.

d. Program Implementation

Selection of instrument locations involves three steps. First, sections containing unique design features are identified such as sections with surcharge or sections with the highest stress. Appropriate instrumentation is located at these sections. Second, a selection is made of cross sections where predicted behavior is considered representative of behavior as a whole. These cross sections are then regarded as primary instrumented sections, and instruments are located to provide comprehensive performance data. There should be at least two "primary instrumented sections." Third, because the selection of representative zones may not be representative of all points in the structure, simple instrumentation should be installed at a number of "secondary instrumented sections" to serve as indices of comparative behavior. For example, surveying the face of the wall in secondary cross sections would examine whether comprehensive survey and inclinometer measurements at primary sections are representative of the behavior of the wall.

Access to instrumentation locations and considerations for survivability during construction are also important. Locations should be selected, when possible, to provide cross checks between instrument types. For example, when multipoint extensometers (multiple telltales) are installed on reinforcement to provide indications of global (macro) strains, and strain gauges are installed to monitor local (micro) strains, strain gauges should be located midway between adjacent extensometer attachment points.

Most instruments measure conditions at a point. In most cases, however, parameters are of interest over an entire section of the structure. Therefore, a large number of measurement points may be required to evaluate such parameters as distribution of stresses in the reinforcement and stress levels below the retaining structure. For example, accurate location of the locus of the maximum stress in the reinforced soil mass will require a significant number of gauge points, usually spaced on the order of 30 cm apart in the critical zone. Reduction in the number of gauge points will make interpretation difficult, if not impossible, and may compromise the objectives of the program.

In preparing the installation plan, consideration should be given to the compatibility of the installation schedule and the construction schedule. If possible, the construction contractor should be consulted concerning details that might affect his operation or schedule.

Step-by-step installation procedures should be prepared well in advance of scheduled installation dates for installing all instruments. Detailed guidelines for choosing instrument types, locations and installation procedures are given in FHWA RD89-043.

Table 2. Possible instruments for monitoring reinforced soil structures.

PARAMETERS	POSSIBLE INSTRUMENTS
1. Horizontal movement of face	♦ Visual observation ♦ Surveying methods ♦ Horizontal control stations ♦ Tiltmeters
2. Vertical movements of overall structure	♦ Visual observations ♦ Surveying methods ♦ Benchmarks ♦ Tiltmeters
3. Local movement or deterioration of facing elements	♦ Visual observations ♦ Crack gauges
4. Drainage behavior of soil	♦ Visual observations at outflow points ♦ Open standpipe piezometers
5. Horizontal movements within overall structure	♦ Surveying methods (e.g., transit) ♦ Horizontal control stations ♦ Probe extensometers ♦ Fixed embankment extensometers ♦ Inclinometers ♦ Tiltmeters
6. Vertical movements within overall structure	♦ Surveying methods ♦ Benchmarks ♦ Probe extensometers ♦ Horizontal inclinometers ♦ Liquid level gauges
7. Performance of structure supported by reinforced soil	♦ Numerous possible instruments depending on structure details

8. Lateral earth pressure at the back of facing elements	♦ Earth pressure cells ♦ Strain gauges at connections ♦ Load cells at connections
9. Stress distribution at structure base	♦ Earth pressure cells
10. Stress in reinforcement or Stress distribution in reinforcement due to surcharge loads	♦ Resistance strain gauges ♦ Induction coil gauges ♦ Hydraulic strain gauges ♦ Vibrating wire strain gauges ♦ Multiple telltales
11. Relationship between settlement and stress distribution	♦ Same instrumentation as for # 2, 6 and 10. ♦ Earth pressure cells
12. Stress relaxation in reinforcement	♦ Same instrumentation as for # 10
13. Total stress within backfill and at back of reinforcement wall section	♦ Earth pressure cells
14. Temperature	♦ Ambient temperature recorder ♦ Thermocouples ♦ Thermistors ♦ Resistance temperature devices ♦ Frost gauges
15. Rainfall	♦ Rainfall gauges
16. Barometric pressure	♦ Barometric pressure gauge

e. Data Interpretation

Monitoring programs have failed because the data generated was never used. If there is a clear sense of purpose for a monitoring program, the method of data interpretation will be guided by that sense of purpose. Without a purpose, there can be no interpretation.

When collecting data during the construction phase, communication channels between design and field personnel should remain open so that discussions can be held between design engineers who planned the monitoring program and field engineers who provide the data.

Early data interpretation steps should have already been taken, including evaluation of data, to determine reading correctness and also to detect changes requiring immediate action. The essence of subsequent data interpretation steps is to correlate the instrument readings with other factors (cause and effect relationships) and to study the deviation of the readings from the predicted behavior.

After each set of data has been interpreted, conclusions should be reported in the form of an interim monitoring report and submitted to personnel responsible for implementation of action. The report should include updated summary plots, a brief commentary that draws attention to all significant changes that have occurred in the measured parameters since the previous interim monitoring report, probable causes of these changes, and recommended action.

A final report is often prepared to document key aspects of the monitoring program and to support any remedial actions. The report also forms a valuable bank of experience and should be distributed to the owner and design consultant so that any lessons may be incorporated into subsequent designs.

➢ Section 5 - POST CONSTRUCTION INSPECTION

Despite the efforts of construction/inspection personnel to build a MSE wall that meets the requirements established in the plans and specifications, problems may surface after the wall construction has been completed. Following is a photo essay on what to look for in post construction inspection.

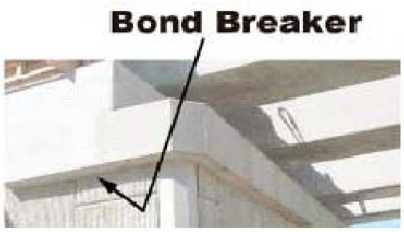

Figure 20. Bond breaker

If the abutments are on a deep foundation, a bond breaker is needed between the MSE wall panel and the cheek wall as seen in Figure 20. If a bond breaker is not present, when the wall settles and the abutment does not, it creates a tension load in the cheek wall and panel. The tension loading eventually leads to one or both to crack as seen in Figures 21 and 22 below.

Figure 21. Cracked panel and cheek wall

Figure 22. Tension break in cheek wall

As stated above, a differential settlement has occurred (pile supported abutment remains stationary and the wall settles) causing tension cracking. The primary reason for the settlement of the wall can be traced to the foundation (subgrade) material being too soft (cohesive) or wet to properly resist settlement.

Problems may arise long after the project has been completed. What can happen, for instance, if trees are planted near the top of the wall? They certainly will become an increasing weight factor in the years to come that probably was not included in design calculations and the root system can have a significant impact on the verticality (plumbness) of the wall panels. Also, structures built within a horizontal distance H (wall height) of the wall face can contribute undesirable impacts to the MSEW's integrity. It is wise to verify that the wall supplier has seen both the construction plans and shop drawings and that all loadings, whether temporary construction equipment loading or permanent structural loading near the wall face, are taken into account.

Figure 23. Settlement from excavation

Excavations next to existing MSEW's can cause, again, settlement problems with the structure. As the area is excavated in front of the wall, the material under the leveling pad sloughs off into the excavation and the wall settles, usually leaving gaps at the panel joints as seen in Figures 23 and 24. Excavation activities after the building of the MSEW can have a negative impact, both aesthetically and structurally.

Figure 24. Joints opening from settlement

This can also happen if a trench that was dug before erecting a wall and not properly compacted with backfill. As seen below, a drainage pipe was installed prior to erecting the wall. Rain after construction softened up the soil and the material under the wall moved into the improperly compacted pipe trench with results shown in Figure 25. In addition to the effects of gravity, water has affects most the structure.

Figure 25. Failure from exterior excavation

Settlement can also happen if the wall is built over an old drainage pipe. Figure 26 shows a case where this scenario came to be. After several years in service, some of the joints started leaking which initiated the migration of soil from beneath the wall into the pipe. Settlement of the wall panels resulted.

Figure 26. Settlement from pipe leakage

As seen in the Figures 23, 24 and 26, settlement of the MSEW can result when soil migration, external excavation, or excessive water infiltration occurs. It should be noted that all failures occurred after the structure had been completed. Other causes of various undesirable conditions are mentioned in Table 1.

Figure 27. Staining on panels

Another sign to look for is staining on the face of the wall (Figure 27). This can indicate that soil is washing out from behind the structure. The reason for soil washing must be investigated. The staining can also be due to oxidation (rusting) of metallic reinforcement material and subsequent seepage between wall panel joints. The cause and extent of rust must be investigated.

If water is ponding over the select backfill although it has a proper drainage system (as shown in Figure 28), it is likely that the drainage is clogged. This may lead to catastrophic failure of the wall. The reason for the ponding water must be investigated.

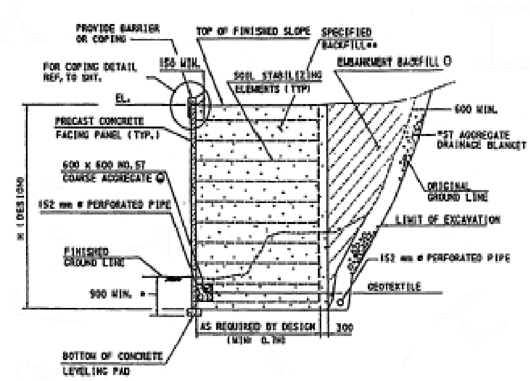

Figure 28. Drainage blanket detail

Poor drainage possibly combined with deicing salt can cause an accelerated corrosion of metallic reinforcement. This corrosion typically occurs near the back of the facing panel. If close examination of the front panels reveals rust discoloration, the reinforcement is likely undergoing accelerated corrosion. In such a case, further investigation to verify the extent of corrosion is needed.

Figure 29. Corroded reinforcement

Figure 30. Cracks on crest **Figure 31. Tension cracks in backfill**

Cracks tend to develop near catch basins or other drainage elements as seen in Figure 30. In this case, the crack resulted from a non-functional drainage system causing backfill settlement and wall face movement (not shown). Such face movement may result in collapse. Tension cracks can also develop in the backfill soil typically due to improper drainage (Figure 31). These cracks are parallel to the wall face and may become visible over the reinforced soil or over the retained soil. Signs of tension cracks need to be inspected up to a distance of twice the height of the wall (2H), away from the face. Also, inspection for cracks at a distance of 2H from the toe should be performed. The reason for such cracks must be investigated.

APPENDIX A

Del DOT to select desired checklist for Inspector's Manual.

Check list # 1 is reproduced from FHWA's Publication "Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines", Publication No. FHWA-NHI-00-043. FHWA does not include post-construction inspection; the writers added it.

Check list # 2 is reproduced from "Mechanically Stabilized Earth Wall Inspector's Handbook" by Paul D. Passe, P.E., CPM, Florida Department of Transportation. No post-construction inspection is included.

#1
MSE Field Inspection Checklist – Construction

✓ 1. Read the specifications and become familiar with:
- material requirements
- construction procedures
- soil compaction procedures
- alignment tolerances
- acceptance/rejection criteria

✓ 2. Review the construction plans and become familiar with:
- construction sequence
- corrosion protections systems
- special placement to reduce damage
- soil compaction restrictions
- details for drainage requirements
- details for utility construction
- construction of slope face
- contractor's documents

✓ 3. Review material requirements and approval submittals.
Review construction sequence for the reinforcement system.

✓ 4. Check site conditions and foundation requirements. Observe:
- preparation of foundations
- facing pad construction (check level and alignment)
- site accessibility
- limits of excavation
- construction dewatering
- drainage features; seeps, adjacent streams, lakes, etc.

✓ 5. On site, check reinforcements and prefabricated units. Perform inspection of prefabricated elements (i.e. casting yard) as required. Reject precast facing elements if:
- compressive strength < specification requirements
- imperfect molding
- honey-combing
- severe cracking, chipping or spalling
- color of finish variation
- out-of-tolerance dimensions
- misaligned connections

✓ 6. Check reinforcement labels to verify whether they match certification documents.

- ✓ 7. Observe materials in batch of reinforcements to make sure they are the same. Observe reinforcements for flaws and non-uniformity.

- ✓ 8. Obtain test samples according to specification requirements from randomly selected reinforcements.

- ✓ 9. Observe construction to see that the contractor complies with specification requirements for installation.

- ✓ 10. If possible, check reinforcements after aggregate or riprap placement for possible damage. This can be done either by constructing a trial installation, or by removing a small section of aggregate or riprap and observing the reinforcement after placement and compaction of the aggregate, at the beginning of the project. If damaged, contact the design engineer.

- ✓ 11. Check all reinforcement and prefabricated facing units against the initial approved shipment and collect additional test samples.

- ✓ 12. Monitor facing alignment:
  - adjacent facing panel joints (typically 19 mm ± 6 mm)
  - precast face panels: (6 mm per m horizontal and vertical; 4 mm per m overall vertical)
  - wrapped face walls: (15 mm per m horizontal and vertical; 8 mm overall vertical)
  - line and grade

MSE Field Inspection Checklist – Post-Construction

- ✓ 1. Report any distress signs such cracks in the soil on the crest or away from the toe (up to a distance of 2H in each direction where H is the height of the wall).

- ✓ 2. Report any cracks, bulging, and differential settlement at the facing.

- ✓ 3. Report any sign of staining of the facing due to backfill washout. Look for rust markings on the facing in case of metallic reinforcement.

- ✓ 4. Report the presence of large trees or structures on the wall not considered as part of the design.

- ✓ 5. Report any signs of ponding waters on the crest or near the toe.

- ✓ 6. Examine and report any signs of clogging of the drainage system.

CHECK LIST # 2

The following is a general checklist to follow when constructing a Mechanically Stabilized Earth 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? Has the contractor supplied a copy of all test results performed by the contractor or his supplier, which are necessary to assure compliance of the specification?

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 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?

YES NO

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 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 before placement of filter fabric?

22. □ □ Is the filter fabric being stored properly (stored out of 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 lifts?

25. □ □ Is the equipment being kept off the wall 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?

29. □ □ Is the fill being brought up to or slightly above the soil reinforcement elevation before connection of the reinforcement?

YES NO

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 right 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?

APPENDIX B

Do’s and Don’t’s
Paul D. Passe, Florida DOT

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. 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 wrapped with two independent layers of 6 mil plastic with lubricating oil between the layers.

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. Fill lifts thicker than 6" compacted lifts 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 degrees from normal. If reinforcement needs to be skewed more than 15 degrees, 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 923. NO saltwater or brackish water is 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 possible.

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 to avoid obstructions without the designer's approval.

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

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