

MECHANICALLY STABILIZED EARTH RETAINING WALLS

(2-16-10)

1.0 GENERAL**A. Description**

A mechanically stabilized earth (MSE) retaining wall is defined as a soil retaining system with steel or geogrid tensile reinforcements in the reinforced zone and vertical or nearly vertical facing elements. The facing elements may be precast concrete panels or segmental retaining wall (SRW) units unless required otherwise on the plans or the *NCDOT Policy for Mechanically Stabilized Earth Retaining Walls* prohibits the use of SRW units. Design and construct MSE retaining walls based on actual elevations and dimensions in accordance with the contract and accepted submittals. Use an MSE Wall Installer prequalified by the NCDOT Contractual Services Unit for MSE retaining walls work (work code 3015). For this provision, “MSE wall” refers to a mechanically stabilized earth retaining wall and “MSE Wall Vendor” refers to the vendor supplying the chosen MSE wall system. Also, “blocks” refer to SRW units and “panels” refer to precast concrete panels.

B. MSE Wall System

Use an MSE wall system approved by the Department in accordance with any restrictions for the chosen system, the plans and the *NCDOT Policy for Mechanically Stabilized Earth Retaining Walls*. Value engineering proposals for other MSE wall systems will not be considered. Obtain the NCDOT MSE wall policy and the list of approved MSE wall systems from:

<http://www.ncdot.org/doh/preconstruct/highway/geotech/msewalls/>

MSE wall systems with conditional approval are restricted to a design height of 20 ft (6.1 m) and an exposed face area of 5,000 ft² (465 m²) per MSE wall. The design height is defined as the difference between where the finished grade intersects the back and front of an MSE wall.

The conditional status of an MSE wall system will be reevaluated after satisfactorily completing a representative MSE wall meeting the following requirements.

- Design height exceeds 15 ft (4.6 m) for a horizontal distance of at least 150 ft (46 m) along the wall face
- Designed and constructed in accordance with this provision
- Movement monitored during construction to 3 months after wall is subject to surcharge loads or movement stops, whichever is longer, in accordance with the NCDOT MSE wall policy
- MSE wall system evaluation report submitted in accordance with the NCDOT MSE wall policy

When designing an MSE wall with a conditionally approved system, notify the Engineer if the MSE wall will meet the above requirements.

2.0 MSE WALL DESIGN SUBMITTAL

Submit 11 hard copies of working drawings and 3 hard copies of design calculations and an electronic copy (PDF on CD or DVD) of each for the MSE wall design submittal. Provide the submittal at least 30 calendar days before conducting the MSE wall preconstruction meeting. Do not begin MSE wall construction until the design submittal is accepted.

The Retaining Wall Plans show plan views, typical sections, details, notes and elevation or profile views (wall envelope) for each MSE wall. When noted on plans and before beginning MSE wall design, survey existing ground elevations shown on the plans and submit a revised wall envelope for review and acceptance. Use the accepted revised wall envelope for design.

Design MSE walls in accordance with any restrictions for the chosen MSE wall system, the plans and the *AASHTO Standard Specifications for Highway Bridges* unless otherwise required. Either the simplified or Meyerhof coherent gravity approach is acceptable for determining maximum reinforcement loads. Design steel components including reinforcement and connection hardware for non-aggressive backfill with corrosion losses in accordance with the AASHTO specifications. Also, design MSE walls with a minimum reinforcement length of 6 ft (1.8 m) unless shown otherwise on the plans and the reinforcement coefficients and geogrid reduction factors submitted to the Department for the approval of the chosen MSE wall system.

If existing or future obstructions such as foundations, guardrail posts, pavements, pipes, inlets or utilities will interfere with reinforcement, maintain a minimum clearance of 3” (75 mm) between the obstruction and reinforcement unless otherwise approved. Place reinforcement within 3” (75 mm) above the corresponding connection elevation.

Use 6 inch (150 mm) thick cast-in-place unreinforced concrete leveling pads beneath panels and blocks that are continuous at steps and extend a minimum of 6” (150 mm) in front of and behind bottom row of panels and blocks. Unless required otherwise on the plans, embed top of leveling pads in accordance with the following.

EMBEDMENT DEPTH

Front Slope (H:V)	Minimum Facing Embedment Depth* (whichever is greater)	
6:1 or Flatter (except abutment walls)	H/20	1 ft (0.3 m)
6:1 or Flatter (abutment walls)	H/10	2 ft (0.6 m)
Steeper than 6:1 to 3:1	H/10	2 ft (0.6 m)
Steeper than 3:1 to 2:1	H/7	2 ft (0.6 m)
* H is from the top of leveling pad to the grade elevation		

When a drain is required with a note on plans, extend a continuous drain along the base of the reinforced zone behind the select material. Provide drains meeting the requirements of an aggregate shoulder drain in accordance with Roadway Standard Drawing No. 816.02.

Use select material in the reinforced zone for MSE walls and extend the reinforced zone 6" (150 mm) beyond the end of reinforcement. Regardless of select material type, fill between and behind SRW units for a horizontal distance of 18" (450 mm) and, unless otherwise approved, any block core spaces with stone meeting the requirements of standard size nos. 57, 67 or 78M in accordance with Sections 1005 and 1014 of the *Standard Specifications*. Separation fabric is required between select material and overlying fill or aggregate with the exception of when concrete pavement is placed directly on the select material. Separation fabric may also be required between stone and backfill or natural ground as determined by the Engineer.

Unless shown otherwise on the plans, use reinforced concrete coping at top of walls with dimensions shown on the plans. Extend coping a minimum of 6" (150 mm) above where finished grade intersects the back of MSE walls unless required otherwise on the plans. Cast-in-place concrete coping is required when noted on plans and for MSE walls with SRW units. At the Contractor's option, connect cast-in-place concrete coping to panels and blocks with dowels or extend coping down the back of MSE walls. Also, connect cast-in-place leveling concrete for precast concrete coping to panels with dowels. When barriers are required above MSE walls, use concrete barrier rails with moment slabs in accordance with the plans and design reinforcement for impact loads in accordance with the *AASHTO Standard Specifications for Highway Bridges* unless otherwise required.

Submit working drawings and design calculations for review and acceptance in accordance with Article 105-2 of the *Standard Specifications*. Submit working drawings showing plan views, wall profiles with maximum applied bearing pressures, typical sections with reinforcement connection details, select material type and separation fabric locations and details of leveling pads, facing elements, coping, bin walls, slip joints, etc. If necessary, include details on working drawings for concrete barrier rails with moment slabs, reinforcement connected to end bent caps and obstructions interfering with reinforcement or extending through walls. Submit design calculations for each wall section with different surcharge loads, geometry or material parameters. A minimum of one analysis is required for each wall section with different reinforcement lengths. When using a software program other than MSEW by ADAMA Engineering, Inc. for design, provide a hand calculation verifying the analysis of the section with the longest reinforcement length. Have MSE walls designed, detailed and sealed by a Professional Engineer registered in North Carolina.

3.0 MATERIALS

A. Certifications, Storage and Handling

Provide certifications in accordance with Article 106-3 of the *Standard Specifications*. Provide Type 3 Manufacturer's Certifications for all MSE wall materials with the exception of geogrids, SRW units and precast elements. For each geogrid product,

provide Type 2 Typical Certified Mill Test Reports for tensile strength. For SRW units, provide Type 4 Certified Test Reports for all block properties with the exception of durability. When a note on plans requires freeze-thaw durable blocks, provide Type 5 Typical Certified Test Reports for durability.

Load, transport, unload and store MSE wall materials such that they are kept clean and free of damage. Damaged panels or blocks with excessive discoloration, chips or cracks as determined by the Engineer will be rejected. Do not damage reinforcement connection hardware or mechanisms in handling and storing panels or blocks. Label each pallet of blocks with the information listed in Article 1077-13 of the *Standard Specifications*. Do not transport SRW units away from the casting yard until the concrete strength reaches 4000 psi (27.6 MPa) and a period of at least 5 days elapses after casting unless otherwise approved.

Identify, store and handle geogrids and fabrics in accordance with ASTM D4873. Geogrids and fabrics with defects, flaws, deterioration or damage will be rejected. Do not leave geogrids and fabrics uncovered for more than 7 days.

B. Facing Elements

Provide facing elements produced by a manufacturer approved or licensed by the MSE Wall Vendor.

1. Precast Concrete Panels

Provide precast concrete panels meeting the requirements of Sections 1000 and 1077 of the *Standard Specifications* and reinforcing steel meeting the requirements of Section 1070 of the *Standard Specifications*. Accurately locate and secure reinforcement connection hardware and maintain a minimum 2" (50 mm) clearance to the reinforcing steel. Produce panels within 1/4 inch (6 mm) of the panel dimensions shown in the accepted submittals.

A minimum compressive strength of 4000 psi (27.6 MPa) at 28 days is required. For testing panels for compressive strength, 4 cylinders are required per 2000 ft² (186 m²) of panel face area or a single day's production, whichever is less.

Unless required otherwise on the plans, provide a final finish in accordance with Article 1077-11 of the *Standard Specifications*.

2. Segmental Retaining Wall (SRW) Units

Unless required otherwise on the plans, provide SRW units with a vertical split face and a concrete gray color with no tints, dyes or pigments. Before beginning block production, obtain approval of sample blocks of the type, face and color proposed for the project.

Use blocks meeting the requirements of ASTM C1372 with the exception of absorption, compressive strength and durability requirements. Test blocks in

accordance with ASTM C140 with the exception of the number of units in a lot. For testing blocks, a lot is defined as 5000 units or a single day's production, whichever is less, and 6 blocks are required per lot. Provide blocks with a maximum absorption of 5%.

A minimum compressive strength of 4000 psi (27.6 MPa) at 28 days is required for blocks with the exception of freeze-thaw durable blocks. When a note on plans requires freeze-thaw durable SRW units, a minimum compressive strength of 5500 psi (37.9 MPa) at 28 days is required.

Test freeze-thaw durable blocks in accordance with ASTM C1262. Test specimens in water. Freeze-thaw durable blocks are acceptable if the weight loss of each of 4 of the 5 specimens after 150 cycles does not exceed 1% of its initial weight.

C. Reinforcement

Provide reinforcement supplied by the MSE Wall Vendor or a manufacturer approved or licensed by the vendor.

1. Steel (Inextensible) Reinforcement

Use welded wire reinforcement mesh and mats meeting the requirements of AASHTO M55 or M221 and steel strips or straps meeting the requirements of ASTM A572 or A1011 with a grade as specified in the accepted submittals. Galvanize steel reinforcement in accordance with Section 1076 of the *Standard Specifications*.

2. Geogrid (Extensible) Reinforcement

Use geogrids approved by the Department for the chosen MSE wall system. Obtain the list of approved geogrids for each MSE wall system from the website shown elsewhere in this provision.

Test geogrids in accordance with ASTM D6637. Provide minimum average roll values (MARV) as defined by ASTM D4439 for tensile strength of geogrids. For testing geogrids, a lot is defined as a single day's production.

D. Select Material

Provide select material meeting the requirements of standard size nos. 2S, 2MS, 57, 67 or 78M in accordance with Sections 1005 and 1014 of the *Standard Specifications* with the following exception. Do not use nos. 2S or 2MS when prohibited by a note on plans or when SRW units are not allowed.

When using steel reinforcement with nos. 2S or 2MS, provide select material meeting the electrochemical requirements of Section 7.3.6.3 of the *AASHTO LRFD Bridge Construction Specifications* tested in accordance with the following methods:

Property	AASHTO Test Method
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pH	T289
Resistivity	T288
Chlorides	T291
Sulfates	T290

Use select material free of deleterious materials with a maximum organic content of 1% tested in accordance with AASHTO T267.

E. Miscellaneous Components

Miscellaneous components may include attachment devices, connectors (e.g., pins, bars, plates, etc.), bearing pads, dowels, fasteners (e.g., bolts, nuts, etc.), filter fabric and any other wall components not included above. Galvanize steel components in accordance with Section 1076 of the *Standard Specifications*. Provide miscellaneous components approved by the Department for the chosen MSE wall system. Obtain the list of approved miscellaneous components for each MSE wall system from the website shown elsewhere in this provision.

F. Coping, Leveling Concrete and Pads

Provide concrete coping and leveling pads meeting the requirements of Section 1000 of the *Standard Specifications* and reinforcing steel meeting the requirements of Section 1070 of the *Standard Specifications*. Provide precast coping meeting the requirements of Section 1077 of the *Standard Specifications* and leveling concrete for precast coping meeting the requirements of Section 1000 of the *Standard Specifications*.

Use Class A Concrete for coping, leveling concrete and pads in accordance with Article 1000-4 of the *Standard Specifications*. For testing precast coping for compressive strength, 4 cylinders are required per 40 yd³ (31 m³) of concrete or a single day's production, whichever is less.

G. Wall Drainage Systems

Wall drainage systems consist of drains and outlet components. Use shoulder drain materials meeting the requirements of Section 816 of the *Standard Specifications*.

H. Separation Fabrics

Use separation fabrics meeting the requirements of Type 2 Engineering Fabric in accordance with Section 1056 of the *Standard Specifications*.

I. Concrete Barrier Rails with Moment Slabs

Provide concrete barrier rails with moment slabs meeting the requirements of Section 1000 of the *Standard Specifications* and reinforcing steel meeting the requirements of Section 1070 of the *Standard Specifications*.

Use Class A Concrete for moment slabs and Class AA Concrete for concrete barrier rails in accordance with Article 1000-4 of the *Standard Specifications*.

J. Joint Materials

Use joint materials in accordance with Section 1028 of the *Standard Specifications*.

4.0 CORROSION MONITORING

Corrosion monitoring is required for MSE walls with steel reinforcement. The Engineer will determine the number of monitoring locations and where to install the instrumentation. Contact the NCDOT Materials & Tests (M&T) Unit before beginning wall construction. M&T will provide the corrosion monitoring instrumentation kits and assistance with installation, if necessary.

5.0 MSE WALL PRECONSTRUCTION MEETING

Before starting MSE wall construction, conduct a preconstruction meeting to discuss the construction and inspection of the MSE walls. Schedule this meeting after all MSE wall submittals have been accepted. The Resident or Bridge Maintenance Engineer, Bridge Construction Engineer, Geotechnical Operations Engineer, Contractor and MSE Wall Installer Superintendent will attend this preconstruction meeting.

6.0 MSE WALL VENDOR SITE ASSISTANCE

Provide a representative employed by the MSE Wall Vendor to assist and guide the MSE Wall Installer on-site for at least 8 hours when the first panels or blocks are set and the first reinforcement layer is placed unless otherwise approved. If problems are encountered during construction, the Engineer may require the vendor representative to return to the site for a time period determined by the Engineer at no additional cost to the Department.

7.0 CONSTRUCTION METHODS

Control drainage during construction in the vicinity of MSE walls. Direct run off away from MSE walls, select material and backfill. Contain and maintain select material and backfill and protect material from erosion.

Perform necessary clearing and grubbing in accordance with Section 200 of the *Standard Specifications*. Excavate as necessary for MSE walls in accordance with the accepted submittals. If applicable and at the Contractor's option, "temporary shoring for wall construction" may be used in lieu of temporary slopes to construct MSE walls. For this provision, temporary shoring for wall construction is defined as temporary shoring not shown on the plans or required by the Engineer including shoring for OSHA reasons or the Contractor's convenience.

Unless prohibited by a note on plans, install foundations located in the reinforced zone before placing select material or the first reinforcement layer. Notify the Engineer when

foundation excavation is complete. Do not place leveling pad concrete, select material or reinforcement until obtaining approval of the excavation depth and foundation material.

Construct cast-in-place concrete leveling pads at elevations and with dimensions shown in the accepted submittals and in accordance with Section 420 of the *Standard Specifications*. Cure leveling pads a minimum of 24 hours before placing panels or blocks.

Erect and support panels or blocks with no negative batter (wall face leaning forward) such that the final position is as shown in the accepted submittals. Stagger vertical block joints to create a running bond when possible unless shown otherwise in the accepted submittals. Place blocks with a maximum joint width of 3/8 inch (10 mm) and set panels with a joint width of 1/2 to 1 inch (13 to 25 mm). Construct MSE walls with a vertical and horizontal tolerance of 3/4 inch (19 mm) when measured with a 10 ft (3 m) straight edge and a final overall vertical plumbness (batter) of less than 1/2 inch per 10 ft (13 mm per 3 m) of wall height.

Place reinforcement at the locations and elevations shown in the accepted submittals. Do not splice reinforcement. Contact the Engineer when unanticipated existing or future obstructions such as foundations, guardrail posts, pavements, pipes, inlets or utilities will interfere with reinforcement. To avoid obstructions, deflect, skew and modify reinforcement as shown in the accepted submittals. Place reinforcement in slight tension free of kinks, folds, wrinkles or creases.

Place select material in the reinforced zone in 8 to 10 inch (200 to 250 mm) thick lifts. Compact standard size nos. 2S and 2MS select material in accordance with Subarticle 235-4(C) of the *Standard Specifications*. Use only hand operated compaction equipment within 3 ft (1 m) of the wall face. At a distance greater than 3 ft (1 m), compact select material with at least 4 passes of an 8 – 10 ton (7.3 - 9.1 metric ton) vibratory roller. Smooth wheeled or rubber tired rollers are also acceptable for compacting select material. Do not use sheepsfoot, grid rollers or other types of compaction equipment with feet. Compact select material in a direction parallel to the wall face. Do not damage reinforcement when placing and compacting select material. End dumping directly on the reinforcement is not permitted. Do not operate heavy equipment on the reinforcement until it is covered with at least 10" (250 mm) of select material. Replace any damaged reinforcement to the satisfaction of the Engineer. Backfill for wall construction outside the reinforced zone in accordance with Article 410-8 of the *Standard Specifications*.

If a drain is required, install wall drainage systems as shown in the accepted submittals and in accordance with Section 816 of the *Standard Specifications*. Provide drains with positive drainage towards outlets.

Place and construct coping and leveling concrete as shown in the accepted submittals. Construct cast-in-place concrete coping, leveling concrete and moment slabs in accordance with Section 420 of the *Standard Specifications*. Do not remove forms until concrete achieves a minimum compressive strength of 2400 psi (16.5 MPa). Provide a Class 2 Surface Finish for cast-in-place concrete coping in accordance with Article 420-17 of the *Standard Specifications*. Construct concrete barrier rails with moment slabs in accordance

with the plans and concrete barrier rails in accordance with Subarticle 460-3(C) of the *Standard Specifications*.

Construct cast-in-place concrete coping joints at a maximum spacing of 10 ft (3 m) to coincide with vertical joints between panels or blocks. Half-inch (13 mm) thick expansion joints in accordance with Article 420-10 of the *Standard Specifications* are required every third joint. Half-inch (13 mm) deep grooved contraction joints in accordance with Subarticle 825-10(B) of the *Standard Specifications* are required for the remaining joints. Stop coping reinforcement 2" (50 mm) from either side of expansion joints.

When separation fabric is required, overlap fabric a minimum of 18" (450 mm) with seams oriented parallel to the wall face. Seal joints above and behind MSE walls between coping and ditches with joint sealer as shown on the plans.

8.0 MEASUREMENT AND PAYMENT

MSE Retaining Walls will be measured and paid for in square feet (meters). MSE walls will be measured as the exposed face area with the wall height equal to the difference between the top and bottom of wall elevation. The top of wall elevation is defined as the top of coping unless shown otherwise on the plans. The bottom of wall elevation is defined as where the finished grade intersects the front face of the MSE wall. No payment will be made for portions of MSE walls below bottom of wall elevations.

The contract unit price bid for *MSE Retaining Walls* will be full compensation for design, submittals, furnishing labor, tools, equipment and MSE wall materials, excavating, backfilling, hauling and removing excavated materials and providing site assistance, leveling pads, facing elements, reinforcement, select material, wall drainage systems, fabrics, coping, miscellaneous components and any incidentals necessary to design and construct MSE walls in accordance with this provision. If necessary, the contract unit price bid for *MSE Retaining Walls* will also be full compensation for reinforcement connected to and select material behind end bent caps in the reinforced zone in accordance with the contract.

No separate payment will be made for temporary shoring for wall construction. Temporary shoring for wall construction will be considered incidental to the contract unit price bid for *MSE Retaining Walls*.

Concrete Barrier Rail will be measured and paid for in accordance with Article 460-4 of the *Standard Specifications*. The contract unit price bid for *Concrete Barrier Rail* will be full compensation for providing concrete barrier rails with moment slabs in accordance with the contract and no separate payment for moments slabs will be made.

Payment will be made under:

Pay Item	Pay Unit
MSE Retaining Walls	Square Foot (Meter)