



STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

ROY COOPER
GOVERNOR

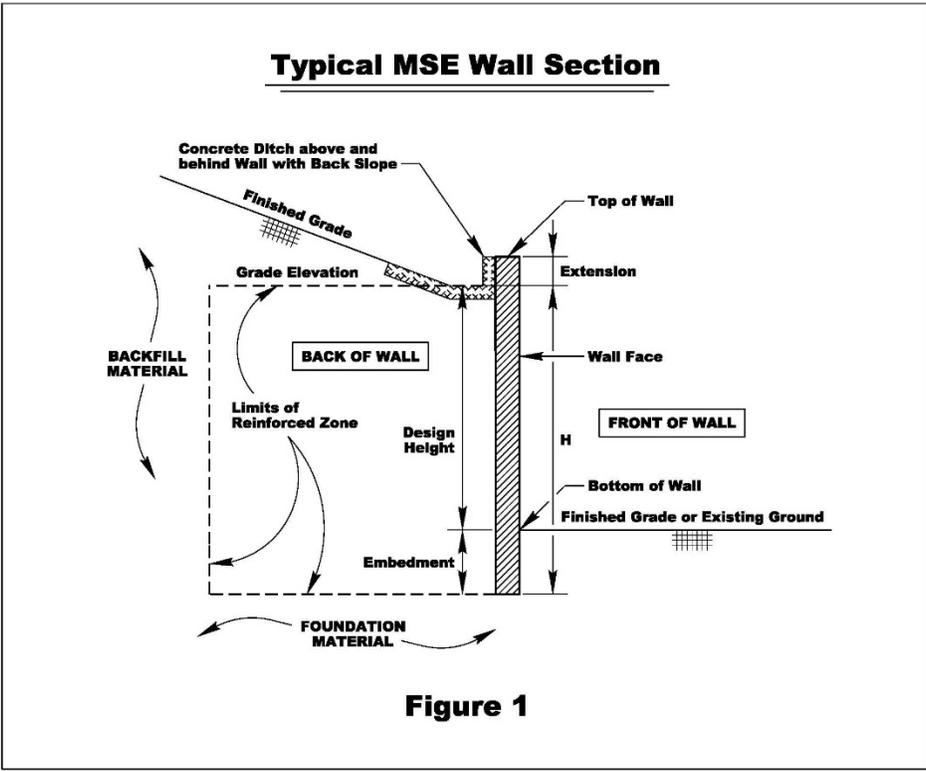
JAMES H. TROGDON, III
SECRETARY

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NCDOT Policy for Mechanically Stabilized Earth Retaining Walls
By: Geotechnical Engineering Unit/Technical Services

A mechanically stabilized earth (MSE) retaining wall for permanent applications is defined as a soil-retaining system with steel or geosynthetic reinforcement in the reinforced zone connected to vertical facing elements. This policy only applies to MSE walls for highways (“mode” as defined by the North Carolina Multimodal Investment Network (NCMIN) unless walls for other modes are supporting or adjacent to highways.

Geosynthetic reinforcement consists of geosynthetic grids (geogrids) or polymer straps (geostrips). Aggregate in the reinforced zone consists of coarse or fine aggregate except fine aggregate is not allowed for MSE walls subject to scour, walls with design heights greater than 35 ft or internal acute corners less than 70° or other MSE walls at the Department’s discretion. Define “design height” as shown in Figure 1 below.



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Vertical facing elements consist of precast concrete panels or segmental retaining wall (SRW) units except SRW units are not allowed for abutment/wing walls for bridges with an average daily traffic (ADT) greater than 5000 or bridges classified as Statewide Tier facilities per NCMIN, walls with internal acute corners less than 70° or other MSE walls at the Department's discretion. Define "abutment wall" as an MSE wall with bridge foundations in any portion of the reinforced zone or an MSE wall connected to an abutment wall.

The list of approved MSE wall systems and the standard NCDOT Mechanically Stabilized Earth Retaining Walls provision are available from:

connect.ncdot.gov/resources/Geological/Pages/Products.aspx

The provision requires the use of an MSE wall system approved by the Geotechnical Engineering Unit (GEU).

The GEU will review MSE wall systems submitted for approval. For first time approvals, an evaluation is required unless a Highway Innovative Technology Evaluation Center (HITEC) report for the MSE wall system is available. After an MSE wall system is approved, a renewal is required if the system changes or every 5 years from the date of the approval letter for the system to stay on the NCDOT list of approved MSE wall systems.

Evaluation reports are required to include MSE wall system limitations and any proposed deviations from or exceptions to the NCDOT MSE wall provision or *AASHTO LRFD Bridge Design Specifications*. Submit all items listed under the "Submittal Requirements" in this policy except precast concrete panel calculations to one of the following consultants to perform an evaluation:

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After receiving a complete submittal and provided no additional information is required during the review, the GEU will approve or approve for provisional use the MSE wall system with or without restrictions or reject the system within 60 days. MSE wall systems will be assigned an “approved for provisional use” or “unapproved” status code if the system has been used on 5 or fewer state Department of Transportation (DOT) projects in the U.S. with design heights exceeding 20 ft within the last 5 years (see Figure 1 for definition of design height). After the system has been successfully used on at least 6 DOT projects with design heights greater than 20 ft within the last 5 years, the status of an MSE wall system may be reevaluated.

Connection strength (ASTM D6638) and seam strength (ASTM D4884) testing for connections with SRW units and pullout resistance (ASTM D6706) and direct shear (ASTM D5321) testing for reinforcement must be performed by a laboratory accredited by the Geosynthetic Accreditation Institute (GAI) to perform these test methods.

Submittal Requirements

Provide submittals in accordance with the standard NCDOT MSE retaining walls provision. All testing data must be for the exact components submitted and a National Transportation Product Evaluation Program (NTPEP) report is required for geosynthetic reinforcement.

Use geosynthetic reinforcement with an “approved” status code in accordance with the NCDOT Geosynthetic Reinforcement Evaluation Program. Use long-term design strengths, pullout resistance factors and soil-geosynthetic friction angles from the Geosynthetic Reinforcement Evaluation Program approval letters. The list of approved geosynthetic reinforcement with current approval letters is available from:

connect.ncdot.gov/resources/Geological/Pages/Products.aspx

Submit the following items for first time approvals:

1. HITEC evaluation report with changes to the MSE wall system since the HITEC report or the following:
 - Consultant evaluation report with changes to the MSE wall system since the consultant report;
 - Precast concrete panel dimensions, tolerances, textures, colors and compressive strength, slump and air content requirements;
 - Precast concrete panel LRFD calculations and anchor testing for standard size panels and anchors to be used on NCDOT projects;
 - Joint sizes, details and materials (spacer and filter materials) including bearing pad requirements, calculations and compression testing curves for wall heights of 30 and 40 ft in accordance with Section 3.6.1.a of the FHWA MSE Wall Manual and Section 9.1 of AASHTO M 251;
 - Connection strength analysis including connection strength testing data (for SRW units with geosynthetic reinforcement, CR_u from short-term testing and CR_{cr} from long-term or short-term testing in accordance with Section 4.4.7.i of the FHWA MSE Wall Manual);
 - SRW unit dimensions, tolerances, textures, colors and compressive strength, absorption and durability requirements;
 - Any shear strength between SRW units testing data;

- Connectors (e.g., anchors, bars, clamps, pins, plates, ties, etc.), fasteners (e.g., bolts, nuts, washers, etc.) and dowels including attachment details and materials (cast-in-place concrete, grout or epoxy);
 - Steel reinforcement type, sizes, tolerances, grades, corrosion protection and design parameters for aggregate;
 - Steel component corrosion calculations for 75 and 100-year design life in accordance with carbon steel corrosion rates (3 corrosion loss rates) in the NCDOT MSE wall provision;
 - Geosynthetic reinforcement manufacturer, product lines, types, classes, grades, categories and design parameters for aggregate;
 - Geosynthetic reinforcement splice details and testing data;
 - Any reinforcement pullout resistance and direct shear testing data;
 - Wall drainage system, separation geotextile, leveling pad and coping details including coping reinforcement and connection methods;
 - Obstruction details and/or calculations including those for a 4 ft square drainage box in the reinforced zone 2 ft behind panels or SRW units and foundations in the reinforced zone for abutment walls;
 - Any other miscellaneous materials and components such as corner and slip joint elements;
 - Quality control (QC) program information;
 - Material suppliers and MSE wall vendor approved or licensed precasters covering North Carolina; and
 - Plan sheets (11" x 17") showing all standard and alternate MSE retaining wall typical details including those for wall elements, connections and construction.
2. Design parameters for reinforcement to be used for NCDOT projects provided in one of the following tables (provide separate tables for coarse and fine aggregate and add rows for more reinforcement types or product lines):

- Steel reinforcement (for coarse and fine aggregate),

Reinforcement (Name & Type, e.g., grid, strip, etc.)	Abutment? (Yes or No for Fine Aggregate, N/A for Coarse Aggregate)	F _y (ksi)	E _n (inches)	b (inches)	S _h (inches)	A _c ¹ (square inches)	R _c	F* _{top} p	F* _{20 ft}	α	Connection ¹ (Name & Type)	CR ¹

¹For 75 and 100-year design life; see NCDOT MSE wall provision for carbon steel corrosion rates.

Where,

- F_y = yield strength of steel (ksi),
- E_n = nominal thickness of steel reinforcement, strip thickness or wire/bar dia. (inches),
- b = unit width of steel reinforcement (inches),
- A_c = design cross-sectional area (square inches),
- S_h = center-to-center horizontal spacing (inches),
- R_c = coverage ratio,
- F*_{top} = pullout resistance factor @ top, Z = 0 ft,
- F*_{20 ft} = pullout resistance factor @ 20 ft, Z = 20 ft,
- α = scale effect correction factor and
- CR = connection strength reduction factor (CR_u in MSEW).

- Geosynthetic reinforcement (for coarse and fine aggregate),

Reinforcement (Product Label & Type, e.g., grid, strip, etc.)	T _{ult} (lb/ft)	RF _{CR} for 75 and 100-year design life	RF _D	RF _{ID}	T _{al} for 75 and 100- year design life (lb/ft)	F*	α	ρ (degrees)	CR _u	CR _{cr} for 75 and 100-year design life	T _{ac} for 75 and 100- year design life (lb/ft)

Where,

- T_{ult} = ultimate tensile strength of geogrid/geostrip (lb/ft),
- RF_{CR} = creep reduction factor,
- RF_D = durability (degradation) reduction factor,
- RF_{ID} = installation damage reduction factor,
- T_{al} = long-term geosynthetic design strength (lb/ft),
- F* = pullout resistance factor,
- α = scale effect correction factor,
- ρ = soil-geosynthetic reinforcement friction angle (degrees),
- CR_u = short-term ultimate connection strength reduction factor (CR_{ult} in MSEW),
- CR_{cr} = long-term connection strength reduction factor and
- T_{ac} = long-term connection design strength (lb/ft).

3. MSEW* AASHTO LRFD analyses and design calculations for each steel reinforcement type (e.g., grid, strip, etc.) and geosynthetic reinforcement product line sealed by a professional engineer for 4 MSE wall design cases with a 100-year design life in accordance with the following (see Figure 1 for descriptions of H, design height, embedment, reinforced zone and backfill and foundation material):

Design Case	2:1 (H:V) Back Slope (slope rise \geq 50 ft) or Traffic Surcharge (q = 250 psf)	Coarse or Fine Aggregate in Reinforced Zone
1	Back Slope	Coarse
2	Back Slope	Fine
3	Surcharge (no abutment wall)	Coarse
4	Surcharge (no abutment wall)	Fine

- Seismic not applicable
- H = 30 ft (Design Height) + 2 ft (Embedment) = 32 ft
- Level front slope
- Reinforced zone aggregate parameters:

Aggregate Type	Unit Weight (γ) pcf	Friction Angle (ϕ) degrees	Cohesion (c) psf
Coarse	110	38	0
Fine	115	34	0

- In-situ assumed material parameters:

Material Type	Unit Weight (γ) pcf	Friction Angle (ϕ) degrees	Cohesion (c) psf
Backfill and Foundation	120	30	0

4. MSEW* FHWA traffic barrier impact analyses for each reinforcement type (e.g., grid, strip, etc.) and geosynthetic reinforcement product line sealed by a professional engineer for Design Cases 3 and 4 in accordance with Section 7.2.1 of the FHWA MSE Wall Manual (see NCDOT MSE wall provision for exception to FHWA for geosynthetic rupture analysis).
5. MSE wall system construction manual.
6. MSE wall system history including design heights, dates and current contact information for any state DOT projects within the last 5 years.
7. Reports of any case histories, problems, failures, studies, research or additional testing for the MSE wall system.
8. Any other miscellaneous information requested by the GEU.

*Computer software MSEW version 3.0 with update 14.96 or later, manufactured by ADAMA Engineering, Inc. is required.

For renewals, submit items from above that have changed since the most recent approval including changes to the MSE wall system since the current HITEC/consultant evaluation report. Revised consultant evaluation reports are not required for renewals. All submissions are subject to the North Carolina Public Records Law, Chapter 132 of the North Carolina General Statutes. Submit all information electronically by email to the State Geotechnical Engineer at jpilipchuk@ncdot.gov and carbon copy shidden@ncdot.gov. For questions about this policy, contact Scott Hidden of the Geotechnical Engineering Unit at (919) 707-6856.