Project Special Provisions
Culverts and Walls

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PROJECT SPECIAL PROVISIONS
CULVERTS AND WALLS

PROJECT R-2237C **CALDWELL / WATAUGA COUNTY**

OPTIONAL PRECAST REINFORCED CONCRETE BOX CULVERT AT STATION 523+33.51 –L- **(2-14-04)**

1.0 GENERAL

This Special Provision covers precast reinforced concrete box culverts intended for the construction of culverts and for the conveyance of storm water.

If the option is indicated on the plans, the submittal of a design for a precast reinforced box culvert in lieu of a cast-in-place culvert is permitted. Provide the size and number of barrels as indicated on the plans. Precast wing walls will not be allowed. For culverts with less than 2 feet (0.6 m) of cover, design the precast culvert sections in accordance with AASHTO M273. Detail the culvert with cast in place wings. Provide a precast box culvert that meets the requirements of Section 1077 and any other applicable parts of the Standard Specifications.

The design of the precast members is the responsibility of the Contractor and is subject to review, comments and approval. Submit two sets of detailed plans for review. Include all details in the plans, including the size and spacing of the required reinforcement necessary to build the precast box culvert. Include checked design calculations for the precast members complying with the latest AASHTO Standard Specifications and requirements detailed herein. Have a North Carolina Registered Professional Engineer check and seal the plans and design calculations. After the plans are reviewed and, if necessary, the corrections made, submit one set of reproducible tracings on 22" x 34" sheets to become the revised contract plans.

A pre-installation meeting is required prior to installation. Representatives from the Contractor, the precast box manufacturer, and the Department should attend this meeting. The precast box manufacturer representative shall be on site during installation.

2.0 PRECAST REINFORCED CONCRETE BOX SECTIONS

A. Types

Precast reinforced concrete box sections manufactured in accordance with this Special Provision are designated by span, rise, and design earth cover.

B. Design

1. Design – The box section dimensions and reinforcement details are subject to the provisions of Section F.

2. Placement of Reinforcement – Provide a 1 inch (25 mm) concrete cover over the circumferential reinforcement subject to the provisions of Section F. Extend the inside circumferential reinforcement into the male portion of the joint and the outside circumferential reinforcement into the female portion of the joint. Detail the clear distance of the end circumferential wires so it is not less than 1/2 inch (13 mm) nor more than 2 inches (51 mm) from the ends of the box section. Assemble reinforcement per the requirements of AASHTO M259, Section 7.3. The exposure of the ends of the wires used to position the reinforcement is not a cause for rejection.

3. Laps and Spacing – Use lap splices for the circumferential reinforcement. Detail the circumferential wires so that the center to center spacing is not less than 2 inches (50 mm) nor more than 4 inches (100 mm). Do not detail the longitudinal wires with a center to center spacing of more than 8 inches (200 mm).

4. The design earth cover is reported on the plans as the elevation difference between the point of maximum fill and the top of the top slab.

C. Joints

1. Produce the precast reinforced concrete box section with male and female ends. Design and form these ends of the box section so, when the sections are laid together, they make a continuous line of box sections with a smooth interior free of appreciable irregularities in the flowline, all compatible with the permissible variations given in Section F. The internal joint formed at the male and female ends of the precast units shall be sealed with either bitumen/butyl sealant or closed-cell neoprene material. The internal joint material shall be installed in accordance with the manufacturer's recommendations. The material shall be shown on the shop drawings when they are submitted for review.

2. Seal the external joint with an outside sealer wrap that is at least 12 inches (300 mm) wide and covers the joint on both the sides and the top of the box section. Use ConWrap CS-212 from Concrete Sealants, Inc., EZ-Wrap from Press-Seal Gasket Corporation, Seal Wrap from Mar-Mac Manufacturing Co., Inc., Cadilloc External Pipe Joint from Cadilloc, or an approved equal for the outside sealer wrap. If the outside sealer wrap is not applied in a continuous strip along the entire joint, a 12 inch (300 mm) minimum lap of the outside sealer wrap is permitted. Before placing the outside sealer wrap, clean and prime the area receiving the outside sealer wrap in accordance with the sealer wrap manufacturer recommendations. The joint wrap manufacturer installation recommendations shall be included with shop drawings submitted for review. The external joint wrap shall be installed in three pieces, as indicated on Figure 1 below:

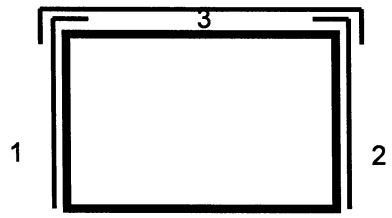

Figure 1

Cover the external joint sealer with a 3 foot (900 mm) strip of filter fabric conforming to Type 4 requirements in Section 1056 of the Standard Specifications.

Place multiple lines of a precast reinforced concrete box culvert such that the longitudinal joint between the sections has a minimum width of 3 inches (75 mm). Fill the joint between multiple lines of precast box sections with Class A concrete. Use Class A concrete that meets the requirements listed in the Standard Specifications except that Field Compressive Strength Specimens are not required.

D. Manufacture

Precast box culverts may be manufactured by either the wet cast method or dry cast method.

1. Mixture – In addition to the requirements of Section 1077 of the Standard Specifications, do not proportion the mix with less than 564 lb/yd^3 (335 kg/m^3) of portland cement.

2. Strength – Make sure that all concrete develops a minimum 28-day compressive strength of 5000 psi (34.5 MPa). Movement of the precast sections should be minimized during the initial curing period. Any damage caused by moving or handling during the initial curing phase will be grounds for rejection of that precast section.

3. Air Entrainment – Air entrain the concrete in accordance with Section 1077 - 5(A) of the Standard Specifications. For dry cast manufacturing, air entrainment is not required.

4. Testing – Test the concrete in accordance with the requirements of Section 1077 - 5(B).

5. Handling – Handling devices or holes are permitted in each box section for the purpose of handling and laying. Submit details of handling devices or holes for approval and do not cast any concrete until approval is granted. Remove all handling devices flush with concrete surfaces as directed. Fill holes in a neat and workmanlike manner with an approved non-metallic non-shrink grout, concrete, or hole plug.

E. Physical Requirements

Acceptability of precast culvert sections is based on concrete cylinders made and tested in accordance with AASHTO T22 and AASHTO T23.

F. Permissible Variations

1. Flatness – All external surfaces shall be flat, true, and plumb. Irregularities, depressions, or high spots on all external surfaces shall not exceed 1/2 inch (12 mm) in 8 feet (2.5 meters).

2. Internal Dimensions – Produce sections so that the internal and haunch dimensions do not vary by more than 1/4 inch (6 mm) from the plan dimensions.

3. Adjacent Sections - Internal, external, and haunch dimensions for connecting sections shall not vary by more than 1/2 inch (12 mm).

4. Length of Tongue and Groove – The minimum length of the tongue shall be 4 inches (100 mm). The minimum length of the groove shall be 4 inches (100 mm). The dimensions of the tongue and groove shall not vary by more than 1/4 inch (6 mm) from the plan dimensions.

5. Slab and Wall Thickness – Produce sections so that the slab and wall thickness are not less than that shown on the plans by more than 5% or 3/16 inch (5 mm), whichever is greater. A thickness more than that required on the plans is not a cause for rejection.

6. Length of Opposite Surfaces – Produce sections so that variations in laying lengths of two opposite surfaces of the box section meet the requirements of AASHTO M259, Section 11.3.

7. Length of Section – Produce sections so that the underrun in length of a section is not more than 1/2 inch (13 mm) in any box section.

8. Position of Reinforcement – Produce sections so that the maximum variation in the position of the reinforcement is ±3/8" (±10 mm) for slab and wall thicknesses of 5 inches (125 mm) or less and ±1/2" (±13 mm) for slab and wall thicknesses greater than 5 inches (125 mm). Produce sections so that the concrete cover is never less than 5/8 inch (16 mm) as measured to the internal surface or the external surface. The preceding minimum cover limitations do not apply at the mating surfaces of the joint.

9. Area of Reinforcement – Use the design steel shown on the plans for the steel reinforcement. Steel areas greater than those required are not cause for rejection. The permissible variation in diameter of any wire in finished fabric is prescribed for the wire before fabrication by either AASHTO M32 or M225.

G. Marking

1. Each section shall be match-marked in order of intended installation as indicated on the approved shop drawings. Ensure that pieces fit together neatly and in a workmanlike manner. In order to ensure a good, neat field fit, assemble adjacent sections at the producer's facility and match-mark the pieces. This will require that a minimum of three adjacent sections of the culvert be fitted at the production yard at a time and then match-marked. Once three sections have been match-marked, the first section may be removed for shipment and a fourth section set for marking. Continue in a progressive manner until all sections have been properly match-marked.

2. Clearly mark each section of the box culvert in accordance with AASHTO M259, Section 15.

H. Construction

1. Foundation – Foundation for precast box culvert shall meet the requirements of Section 414 of the Standard Specifications. In addition, Type VI foundation material shall be encapsulated in filter fabric conforming to Type 4 requirements in Section 1056 of the Standard Specifications. The filter fabric shall be placed perpendicular to the culvert barrel. Provide sufficient overhang beyond the excavation to allow a minimum lap of 3 feet (900 mm) when the foundation material is placed and fabric wrapped on top. Perpendicular sections of fabric shall be continuous. A minimum lap of 2 feet (600 mm) shall be provided between sections of fabric.

2. Installation – Sections shall be placed at the beginning of the outlet end of the culvert with the groove end being laid upgrade. Tongue sections shall be laid into the groove sections. Positive means shall be provided to pull each section firmly into the previously placed section so that the joints are tightly homed. Use a "come-along", box pullers or other approved methods to create a positive means of joining box sections. Construction equipment shall not have direct contact with the box section. The load of the box shall be suspended by lifting device during joining procedure.

3. Backfill – Complete backfill in accordance with Section 414 of the Standard Specifications.

3.0 BASIS OF PAYMENT

Any additional cost of redesigning will be paid for by the Contractor if Precast Reinforced Concrete Culvert is used in lieu of the cast-in-place culvert shown on the plans. Except for Foundation Conditioning Material and Culvert Excavation, payment for the Precast Box Culvert will be a lump sum amount equal to the payment that would be allowed for construction of a Cast-in-Place Box Culvert. Plan quantities and unit bid prices will be used to compute the lump sum amount. Such price and payment will be full compensation for all work covered by this Special Provision, the plans and applicable parts of the Standard Specifications and will include, but not be limited to, furnishing all labor, materials (including all filter fabric), equipment and other incidentals necessary to complete this work. Such price and payment will also be full compensation for concrete, reinforcing steel, labor, equipment and all other related materials necessary for the completion of the barrel section, and the construction of the headwalls, leveling pad, end curtain walls, wings and wing footings.

FALSEWORK AND FORMWORK (8-4-09)

1.0 DESCRIPTION

Use this Special Provision as a guide to develop temporary works submittals required by the Standard Specifications or other provisions; no additional submittals are required herein. Such temporary works include, but are not limited to, falsework and formwork.

Falsework is any temporary construction used to support the permanent structure until it becomes self-supporting. Formwork is the temporary structure or mold used to retain plastic or fluid concrete in its designated shape until it hardens. Access scaffolding is a temporary structure that functions as a work platform that supports construction personnel, materials, and tools, but is not intended to support the structure. Scaffolding systems that are used to temporarily support permanent structures (as opposed to functioning as work platforms) are considered to be falsework under the definitions given. Shoring is a component of falsework such as horizontal, vertical, or inclined support members. Where the term "temporary works" is used, it includes all of the temporary facilities used in bridge construction that do not become part of the permanent structure.

Design and construct safe and adequate temporary works that will support all loads imposed and provide the necessary rigidity to achieve the lines and grades shown on the plans in the final structure.

2.0 MATERIALS

Select materials suitable for temporary works; however, select materials that also ensure the safety and quality required by the design assumptions. The Engineer has authority to reject material on the basis of its condition, inappropriate use, safety, or nonconformance with the plans. Clearly identify allowable loads or stresses for all materials or manufactured devices on the plans. Revise the plan and notify the Engineer if any change to materials or material strengths is required.

3.0 DESIGN REQUIREMENTS

A. Working Drawings

Provide working drawings for items as specified in the contract, or as required by the Engineer, with design calculations and supporting data in sufficient detail to permit a structural and safety review of the proposed design of the temporary work.

When concrete placement is involved, include data such as the drawings of proposed sequence, rate of placement, direction of placement, and location of all construction joints. Submit the number of copies as called for by the contract.

When required, have the drawings and calculations prepared under the guidance of, and sealed by, a North Carolina Registered Professional Engineer who is knowledgeable in temporary works design.

Design falsework and formwork requiring submittals in accordance with the 1995 AASHTO *Guide Design Specifications for Bridge Temporary Works* except as noted herein.

1. Wind Loads

   Table 2.2 of Article 2.2.5.1 is modified to include wind velocities up to 110 mph (177 km/hr). In addition, Table 2.2A is included to provide the maximum wind speeds by county in North Carolina.

Table 2.2 - Wind Pressure Values

Height Zone feet (m) above ground	Pressure, lb/ft^2 (kPa) for Indicated Wind Velocity, mph (km/hr)				
	70 (112.7)	80 (128.7)	90 (144.8)	100 (160.9)	110 (177.0)
0 to 30 (0 to 9.1)	15 (0.72)	20 (0.96)	25 (1.20)	30 (1.44)	35 (1.68)
30 to 50 (9.1 to 15.2)	20 (0.96)	25 (1.20)	30 (1.44)	35 (1.68)	40 (1.92)
50 to 100 (15.2 to 30.5)	25 (1.20)	30 (1.44)	35 (1.68)	40 (1.92)	45 (2.15)
over 100 (30.5)	30 (1.44)	35 (1.68)	40 (1.92)	45 (2.15)	50 (2.39)

2. Time of Removal

   The following requirements replace those of Article 3.4.8.2.

   Do not remove forms until the concrete has attained strengths required in Article 420-16 of the Standard Specifications and these Special Provisions.

   Do not remove forms until the concrete has sufficient strength to prevent damage to the surface.

Table 2.2A - Steady State Maximum Wind Speeds by Counties in North Carolina

COUNTY	25 YR (mph) (km/hr)	COUNTY	25 YR (mph) (km/hr)	COUNTY	25 YR (mph) (km/hr)
Alamance	70 (112.7)	Franklin	70 (112.7)	Pamlico	100 (160.9)
Alexander	70 (112.7)	Gaston	70 (112.7)	Pasquotank	100 (160.9)
Alleghany	70 (112.7)	Gates	90 (144.8)	Pender	100 (160.9)
Anson	70 (112.7)	Graham	80 (128.7)	Perquimans	100 (160.9)
Ashe	70 (112.7)	Granville	70 (112.7)	Person	70 (112.7)
Avery	70 (112.7)	Greene	80 (128.7)	Pitt	90 (144.8)
Beaufort	100 (160.9)	Guilford	70 (112.7)	Polk	80 (128.7)
Bertie	90 (144.8)	Halifax	80 (128.7)	Randolph	70 (112.7)
Bladen	90 (144.8)	Harnett	70 (112.7)	Richmond	70 (112.7)
Brunswick	100 (160.9)	Haywood	80 (128.7)	Robeson	80 (128.7)
Buncombe	80 (128.7)	Henderson	80 (128.7)	Rockingham	70 (112.7)
Burke	70 (112.7)	Hertford	90 (144.8)	Rowan	70 (112.7)
Cabarrus	70 (112.7)	Hoke	70 (112.7)	Rutherford	70 (112.7)
Caldwell	70 (112.7)	Hyde	110 (177.0)	Sampson	90 (144.8)
Camden	100 (160.9)	Iredell	70 (112.7)	Scotland	70 (112.7)
Carteret	110 (177.0)	Jackson	80 (128.7)	Stanley	70 (112.7)
Caswell	70 (112.7)	Johnston	80 (128.7)	Stokes	70 (112.7)
Catawba	70 (112.7)	Jones	100 (160.9)	Surry	70 (112.7)
Cherokee	80 (128.7)	Lee	70 (112.7)	Swain	80 (128.7)
Chatham	70 (112.7)	Lenoir	90 (144.8)	Transylvania	80 (128.7)
Chowan	90 (144.8)	Lincoln	70 (112.7)	Tyrell	100 (160.9)
Clay	80 (128.7)	Macon	80 (128.7)	Union	70 (112.7)
Cleveland	70 (112.7)	Madison	80 (128.7)	Vance	70 (112.7)
Columbus	90 (144.8)	Martin	90 (144.8)	Wake	70 (112.7)
Craven	100 (160.9)	McDowell	70 (112.7)	Warren	70 (112.7)
Cumberland	80 (128.7)	Mecklenburg	70 (112.7)	Washington	100 (160.9)
Currituck	100 (160.9)	Mitchell	70 (112.7)	Watauga	70 (112.7)
Dare	110 (177.0)	Montgomery	70(112.7)	Wayne	80 (128.7)
Davidson	70 (112.7)	Moore	70 (112.7)	Wilkes	70 (112.7)
Davie	70 (112.7)	Nash	80 (128.7)	Wilson	80 (128.7)
Duplin	90 (144.8)	New Hanover	100 (160.9)	Yadkin	70 (112.7)
Durham	70 (112.7)	Northampton	80 (128.7)	Yancey	70 (112.7)
Edgecombe	80 (128.7)	Onslow	100 (160.9)		
Forsyth	70 (112.7)	Orange	70 (112.7)		

Note on the working drawings any anchorages, connectors, inserts, steel sleeves or other such devices used as part of the falsework or formwork that remains in the permanent structure. If the plan notes indicate that the structure contains the necessary corrosion protection required for a Corrosive Site, epoxy coat, galvanize or metalize these devices. Electroplating will not be allowed. Any coating required by the Engineer will be considered incidental to the various pay items requiring temporary works.

B. Review and Approval

The Engineer is responsible for the review and approval of temporary works' drawings.

Submit the working drawings sufficiently in advance of proposed use to allow for their review, revision (if needed), and approval without delay to the work.

Do not start construction of any temporary work for which working drawings are required until the drawings have been approved. Such approval does not relieve the Contractor of the responsibility for the accuracy and adequacy of the working drawings.

The time period for review of the working drawings does not begin until complete drawings and design calculations, when required, are received by the Engineer.

On the drawings, show all information necessary to allow the design of any component to be checked independently as determined by the Engineer.

If requested by the Engineer, submit with the working drawings manufacturer's catalog data listing the weight of all construction equipment that will be supported on the temporary work. Show anticipated total settlements and/or deflections of falsework and forms on the working drawings. Include falsework footing settlements, joint take-up, and deflection of beams or girders. Falsework hangers that support concentrated loads and are installed at the edge of thin top flange concrete girders (such as bulb tee girders) shall be spaced so as not to exceed 75% of the manufacturer's stated safe working load. Use of dual leg hangers (such as Meadow Burke HF-42 and HF-43) are not allowed. Design the falsework and forms supporting deck slabs and overhangs on girder bridges so that there will be no differential settlement between the girders and the deck forms during placement of deck concrete.

4.0 CONSTRUCTION REQUIREMENTS

All requirements of Section 420 of the Standard Specifications apply.

Construct temporary works in conformance with the approved working drawings. Ensure that the quality of materials and workmanship employed is consistent with that assumed in the design of the temporary works. Do not weld falsework members to any portion of the permanent structure unless approved. Show any welding to the permanent structure on the approved construction drawings.

Provide tell-tales attached to the forms and extending to the ground, or other means, for accurate measurement of falsework settlement. Make sure that the anticipated compressive settlement and/or deflection of falsework does not exceed 1 inch (25 mm). For cast-in-place concrete structures, make sure that the calculated deflection of falsework flexural members does not exceed 1/240 of their span regardless of whether or not the deflection is compensated by camber strips.

A. Maintenance and Inspection

Inspect and maintain the temporary work in an acceptable condition throughout the period of its use. Certify that the manufactured devices have been maintained in a condition to allow them to safely carry their rated loads. Clearly mark each piece so that its capacity can be readily determined at the job site.

Perform an in-depth inspection of an applicable portion(s) of the temporary works, in the presence of the Engineer, not more than 24 hours prior to the beginning of each concrete placement. Inspect other temporary works at least once a month to ensure that they are functioning properly. Have a North Carolina Registered Professional Engineer inspect the cofferdams, shoring, sheathing, support of excavation structures, and support systems for load tests prior to loading.

B. Foundations

Determine the safe bearing capacity of the foundation material on which the supports for temporary works rest. If required by the Engineer, conduct load tests to verify proposed bearing capacity values that are marginal or in other high-risk situations.

The use of the foundation support values shown on the contract plans of the permanent structure is permitted if the foundations are on the same level and on the same soil as those of the permanent structure.

Allow for adequate site drainage or soil protection to prevent soil saturation and washout of the soil supporting the temporary works supports.

If piles are used, the estimation of capacities and later confirmation during construction using standard procedures based on the driving characteristics of the pile is permitted. If preferred, use load tests to confirm the estimated capacities; or, if required by the Engineer conduct load tests to verify bearing capacity values that are marginal or in other high risk situations.

The Engineer reviews and approves the proposed pile and soil bearing capacities.

5.0 REMOVAL

Unless otherwise permitted, remove and keep all temporary works upon completion of the work. Do not disturb or otherwise damage the finished work.

Remove temporary works in conformance with the contract documents. Remove them in such a manner as to permit the structure to uniformly and gradually take the stresses due to its own weight.

6.0 METHOD OF MEASUREMENT

Unless otherwise specified, temporary works will not be directly measured.

7.0 BASIS OF PAYMENT

Payment at the contract unit prices for the various pay items requiring temporary works will be full compensation for the above falsework and formwork.

SUBMITTAL OF WORKING DRAWINGS (1-27-10)

1.0 GENERAL

Submit working drawings in accordance with Article 105-2 of the *Standard Specifications* and this provision. For this provision, "submittals" refers to only those listed in this provision. The list of submittals contained herein does not represent a list of required submittals for the project. Submittals are only necessary for those items as required by the contract. Make submittals that are not specifically noted in this provision directly to the Resident Engineer. Either the Structure Design Unit or the Geotechnical Engineering Unit or both units will jointly review submittals.

If a submittal contains variations from plan details or specifications or significantly affects project cost, field construction or operations, discuss the submittal with and submit all copies to the Resident Engineer. State the reason for the proposed variation in the submittal. To minimize review time, make sure all submittals are complete when initially submitted. Provide a contact name and information with each submittal. Direct any questions regarding submittal requirements to the Resident Engineer, Structure Design Unit contacts or the Geotechnical Engineering Unit contacts noted below.

In order to facilitate in-plant inspection by NCDOT and approval of working drawings, provide the name, address and telephone number of the facility where fabrication will actually be done if different than shown on the title block of the submitted working drawings. This includes, but is not limited to, precast concrete items, prestressed concrete items and fabricated steel or aluminum items.

2.0 ADDRESSES AND CONTACTS

For submittals to the Structure Design Unit, use the following addresses:

Via US mail:
Mr. G. R. Perfetti, P. E.
State Bridge Design Engineer
North Carolina Department
of Transportation
Structure Design Unit
1581 Mail Service Center
Raleigh, NC 27699-1581
Attention: Mr. P. D. Lambert, P. E.

Via other delivery service:
Mr. G. R. Perfetti, P. E.
State Bridge Design Engineer
North Carolina Department
of Transportation
Structure Design Unit
1000 Birch Ridge Drive
Raleigh, NC 27610
Attention: Mr. P. D. Lambert, P. E.

Submittals may also be made via email.

Send submittals to:

plambert@ncdot.gov (Paul Lambert)

Send an additional e-copy of the submittal to the following address:

jgaither@ncdot.gov (James Gaither)

For submittals to the Geotechnical Engineering Unit, use the following addresses:

For projects in Divisions 1-7, use the following Eastern Regional Office address:

Via US mail:
Mr. K. J. Kim, Ph. D., P. E.
Eastern Regional Geotechnical
Manager
North Carolina Department
of Transportation
Geotechnical Engineering Unit
Eastern Regional Office
1570 Mail Service Center
Raleigh, NC 27699-1570

Via other delivery service:
Mr. K. J. Kim, Ph. D., P. E.
Eastern Regional Geotechnical
Manager
North Carolina Department
of Transportation
Geotechnical Engineering Unit
Eastern Regional Office
3301 Jones Sausage Road, Suite 100
Garner, NC 27529

For projects in Divisions 8-14, use the following Western Regional Office address:

Via US mail:
Mr. John Pilipchuk, L. G., P. E.
Western Regional Geotechnical
Manager
North Carolina Department
of Transportation
Geotechnical Engineering Unit
Western Regional Office
5253 Z Max Boulevard
Harrisburg, NC 28075

Via other delivery service:
Mr. John Pilipchuk, L. G., P. E.
Western Region Geotechnical
Manager
North Carolina Department
of Transportation
Geotechnical Engineering Unit
Western Regional Office
5253 Z Max Boulevard
Harrisburg, NC 28075

The status of the review of structure-related submittals sent to the Structure Design Unit can be viewed from the Unit's web site, via the "Contractor Submittal" link.

Direct any questions concerning submittal review status, review comments or drawing markups to the following contacts:

Primary Structures Contact:
Paul Lambert
(919) 250 – 4041
(919) 250 – 4082 facsimile
plambert@ncdot.gov

Secondary Structures Contacts:
James Gaither (919) 250 – 4042
David Stark (919) 250 – 4044

Eastern Regional Geotechnical Contact (Divisions 1-7):
K. J. Kim
(919) 662 – 4710
(919) 662 – 3095 facsimile
kkim@ncdot.gov

Western Regional Geotechnical Contact (Divisions 8-14):
John Pilipchuk
(704) 455 – 8902
(704) 455 – 8912 facsimile
jpilipchuk@ncdot.gov

3.0 SUBMITTAL COPIES

Furnish one complete copy of each submittal, including all attachments, to the Resident Engineer. At the same time, submit the number of hard copies shown below of the same complete submittal directly to the Structure Design Unit and/or the Geotechnical Engineering Unit.

The first table below covers "Structure Submittals". The Resident Engineer will receive review comments and drawing markups for these submittals from the Structure Design Unit. The second table in this section covers "Geotechnical Submittals". The Resident Engineer will receive review comments and drawing markups for these submittals from the Geotechnical Engineering Unit.

Unless otherwise required, submit one set of supporting calculations to either the Structure Design Unit or the Geotechnical Engineering Unit unless both units require submittal copies in which case submit a set of supporting calculations to each unit. Provide additional copies of any submittal as directed by the Engineer.

STRUCTURE SUBMITTALS

Submittal	Copies Required by Structure Design Unit	Copies Required by Geotechnical Engineering Unit	Contract Reference Requiring Submittal [1]
Arch Culvert Falsework	5	0	Plan Note, SN Sheet & "Falsework and Formwork"
Box Culvert Falsework [7]	5	0	Plan Note, SN Sheet & "Falsework and Formwork"
Cofferdams	6	2	Article 410-4
Evazote Joint Seals [6]	9	0	"Evazote Joint Seals"
Expansion Joint Seals (hold down plate type with base angle)	9	0	"Expansion Joint Seals"
Expansion Joint Seals (modular)	2, then 9	0	"Modular Expansion Joint Seals"
Expansion Joint Seals (strip seals)	9	0	"Strip Seals"
Falsework & Forms [2] (substructure)	8	0	Article 420-3 & "Falsework and Formwork"
Falsework & Forms (superstructure)	8	0	Article 420-3 & "Falsework and Formwork"
Girder Erection over Railroad	5	0	Railroad Provisions
Maintenance and Protection of Traffic Beneath Proposed Structure	8	0	"Maintenance and Protection of Traffic Beneath Proposed Structure at Station ___"
Metal Bridge Railing	8	0	Plan Note
Metal Stay-in-Place Forms	8	0	Article 420-3
Metalwork for Elastomeric Bearings [4,5]	7	0	Article 1072-10

Miscellaneous Metalwork [4,5]	7	0	Article 1072-10
Optional Disc Bearings [4]	8	0	"Optional Disc Bearings"
Overhead Signs	13	0	Article 903-3(C) & Applicable Provisions
Pile Splicers	7	2	Subarticle 450-7(C) & "Piles"
Pile Points	7	2	Subarticle 450-7(D) & "Piles"
Placement of Equipment on Structures (cranes, etc.)	7	0	Article 420-20
Pot Bearings [4]	8	0	"Pot Bearings"
Precast Concrete Box Culverts	2, then 1 reproducible	0	"Optional Precast Reinforced Concrete Box Culvert at Station ___"
Precast Retaining Wall Panels	10	1	Article 1077-2
Prestressed Concrete Cored Slab (detensioning sequences) [3]	6	0	Article 1078-11
Prestressed Concrete Deck Panels	6 and 1 reproducible	0	Article 420-3
Prestressed Concrete Girder (strand elongation and detensioning sequences)	6	0	Articles 1078-8 and 1078-11
Removal of Existing Structure over Railroad	5	0	Railroad Provisions
Revised Bridge Deck Plans (adaptation to prestressed deck panels)	2, then 1 reproducible	0	Article 420-3
Revised Bridge Deck Plans (adaptation to modular expansion joint seals)	2, then 1 reproducible	0	"Modular Expansion Joint Seals"
Sound Barrier Wall Casting Plans	10	0	Article 1077-2 & "Sound Barrier Wall"
Sound Barrier Wall Steel Fabrication Plans [5]	7	0	Article 1072-10 & "Sound Barrier Wall"
Structural Steel [4]	2, then 7	0	Article 1072-10

Temporary Detour Structures	10	2	Article 400-3 & "Construction, Maintenance and Removal of Temporary Structure at Station ____"
TFE Expansion Bearings [4]	8	0	Article 1072-10

FOOTNOTES

1. References are provided to help locate the part of the contract where the submittals are required. References in quotes refer to the provision by that name. Articles and subarticles refer to the *Standard Specifications*.
2. Submittals for these items are necessary only when required by a note on plans.
3. Submittals for these items may not be required. A list of pre-approved sequences is available from the producer or the Materials & Tests Unit.
4. The fabricator may submit these items directly to the Structure Design Unit.
5. The two sets of preliminary submittals required by Article 1072-10 of the *Standard Specifications* are not required for these items.
6. Submittals for Fabrication Drawings are not required. Submittals for Catalogue Cuts of Proposed Material are required. See Section 5.A of the referenced provision.
7. Submittals are necessary only when the top slab thickness is 18" or greater.

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GEOTECHNICAL SUBMITTALS

Submittal [1]	Copies Required by Geotechnical Engineering Unit	Copies Required by Structure Design Unit	Contract Reference Requiring Submittal [2]
Crosshole Sonic Logging (CSL) Reports	1	0	"Crosshole Sonic Logging"
Drilled Pier Construction Sequence Plans	1	0	"Drilled Piers"
Pile Driving Analyzer (PDA) Reports	2	0	"Pile Driving Analyzer"
Pile Driving Equipment Data [3]	1	0	Article 450-5 & "Piles"
Retaining Walls	8	2	Applicable Provisions
Contractor Designed Shoring	7	2	"Temporary Shoring", "Anchored Temporary Shoring" & "Temporary Soil Nail Walls"

FOOTNOTES

1. With the exception of "Pile Driving Equipment Data", electronic copies of geotechnical submittals are required. See referenced provision.

2. References are provided to help locate the part of the contract where the submittals are required. References in quotes refer to the provision by that name. Articles refer to the *Standard Specifications*.

3. Download Pile Driving Equipment Data Form from following link:
http://www.ncdot.org/doh/preconstruct/highway/geotech/formdet/
Submit one hard copy of the completed form to the Resident Engineer. Submit a second copy of the completed form electronically, by facsimile or via US Mail or other delivery service to the Geotechnical Engineering Unit. Electronic submission is preferred. See second page of form for submittal instructions.

CRANE SAFETY (8-15-05)

Comply with the manufacturer specifications and limitations applicable to the operation of any and all cranes and derricks. Prime contractors, sub-contractors, and fully operated rental companies shall comply with the current Occupational Safety and Health Administration regulations (OSHA).

Submit all items listed below to the Engineer prior to beginning crane operations involving critical lifts. A critical lift is defined as any lift that exceeds 75 percent of the manufacturer's crane chart capacity for the radius at which the load will be lifted or requires the use of more than one crane. Changes in personnel or equipment must be reported to the Engineer and all applicable items listed below must be updated and submitted prior to continuing with crane operations.

CRANE SAFETY SUBMITTAL LIST

A. **Competent Person:** Provide the name and qualifications of the "Competent Person" responsible for crane safety and lifting operations. The named competent person will have the responsibility and authority to stop any work activity due to safety concerns.

B. **Riggers:** Provide the qualifications and experience of the persons responsible for rigging operations. Qualifications and experience should include, but not be limited to, weight calculations, center of gravity determinations, selection and inspection of sling and rigging equipment, and safe rigging practices.

C. **Crane Inspections:** Inspection records for all cranes shall be current and readily accessible for review upon request.

D. **Certifications:** **By July 1, 2006**, crane operators performing critical lifts shall be certified by NC CCO (National Commission for the Certification of Crane Operators), or satisfactorily complete the Carolinas AGC's Professional Crane Operator's Proficiency Program. Other approved nationally accredited programs will be considered upon request. All crane operators shall also have a current CDL medical card. Submit a list of anticipated critical lifts and corresponding crane operator(s). Include current certification for the type of crane operated (small hydraulic, large hydraulic, small lattice, large lattice) and medical evaluations for each operator.

GROUT FOR STRUCTURES (7-12-07)

1.0 DESCRIPTION

This special provision addresses grout for use in structures, including continuous flight auger (CFA) piles, micropiles, soil nail and anchored retaining walls and backfilling crosshole sonic logging (CSL) tubes or grout pockets, shear keys, dowel holes and recesses for cored slabs and box beams. This provision does not apply to grout placed in post-tensioning ducts for bridge beams, girders, or decks. Provide grout composed of portland cement, water and at the Contractor's option, fine aggregate and/or pozzolan. If necessary,

use set controlling admixtures. Proportion, mix and place grout in accordance with the plans, the applicable section of the *Standard Specifications* or special provision for the application and this provision.

2.0 MATERIALS

Refer to Division 10 of the *Standard Specifications*:

Item	Article
Portland Cement	1024-1
Water	1024-4
Fine Aggregate	1014-1
Fly Ash	1024-5
Ground Granulated Blast Furnace Slag	1024-6
Admixtures	1024-3

At the Contractor's option, use an approved packaged grout in lieu of the materials above with the exception of the water. Contact the Materials and Tests (M&T) Unit for a list of approved packaged grouts. Consult the manufacturer to determine if the packaged grout selected is suitable for the application and meets the compressive strength and shrinkage requirements.

3.0 REQUIREMENTS

Unless required elsewhere in the Contract, provide non-metallic grout with minimum compressive strengths as follows:

Property	Requirement
Compressive Strength @ 3 days	2500 psi (17.2 MPa)
Compressive Strength @ 28 days	4500 psi (31.0 MPa)

For applications other than micropiles, soil nails and ground anchors, use non-shrink grout with shrinkage of less than 0.15%.

When using approved packaged grout, a grout mix design submittal is not required. Submit grout mix designs in terms of saturated surface dry weights on M&T Form 312U in accordance with the applicable section of the *Standard Specifications* or special provision for the structure. Use an approved testing laboratory to determine the grout mix proportions. Adjust proportions to compensate for surface moisture contained in the aggregates at the time of mixing. Changes in the saturated surface dry mix proportions will not be permitted unless a revised grout mix design submittal is accepted.

For each grout mix design, provide laboratory test results for compressive strength, density, flow and if applicable, aggregate gradation and shrinkage. Submit compressive strength for at least 3 cube and 2 cylinder specimens at the age of 3, 7, 14 and 28 days for a total of at least 20 specimens tested. Perform laboratory tests in accordance with the following:

Property	Test Method
Compressive Strength	AASHTO T106 and T22
Density	AASHTO T133
Flow for Sand Cement Grout	ASTM C939 (as modified below)
Flow for Neat Cement Grout (no fine aggregate)	Marsh Funnel and Cup API RP 13B-1, Section 2.2
Aggregate Gradation for Sand Cement Grout	AASHTO T27
Shrinkage for Non-shrink Grout	ASTM C1090

When testing grout for flow in accordance with ASTM C939, modify the flow cone outlet diameter from ½ to ¾ inch (13 to 19 mm).

When grout mix designs are submitted, the Engineer will review the mix designs and notify the Contractor as to their acceptability. Do not use grout mix designs until written acceptance has been received. Acceptance of grout mix designs or use of approved packaged grouts does not relieve the Contractor of responsibility to furnish a product that meets the Contract requirements.

Upon written request from the Contractor, a grout mix design accepted and used satisfactorily on a Department project may be accepted for use on other projects.

4.0 SAMPLING AND PLACEMENT

The Engineer will determine the locations to sample grout and the number and type of samples collected for field and laboratory testing. Use API RP 13B-1 for field testing grout flow and density of neat cement grout. The compressive strength of the grout will be considered the average compressive strength test results of 3 cube or 2 cylinder specimens at 28 days.

Do not place grout if the grout temperature is less than 50°F (10°C) or more than 90°F (32°C) or if the air temperature measured at the location of the grouting operation in the shade away from artificial heat is below 40°F (4°C).

Provide grout at a rate that permits proper handling, placing and finishing in accordance with the manufacturer's recommendations unless directed otherwise by the Engineer. Use grout free of any lumps and undispersed cement. Agitate grout continuously before placement.

Control grout delivery so the interval between placing batches in the same component does not exceed 20 minutes. Place grout before the time between adding the mixing water and placing the grout exceeds that in the table below.

ELAPSED TIME FOR PLACING GROUT (with continuous agitation)		
	Maximum Elapsed Time	
Air or Grout Temperature Whichever is Higher	No Set Retarding Admixture Used	Set Retarding Admixture Used
90°F (32°C) or above	30 min.	1 hr. 15 min.
80°F (27°C) through 89°F (31°C)	45 min.	1 hr. 30 min.
79°F (26°C) or below	60 min.	1 hr. 45 min.

5.0 MISCELLANEOUS

Comply with Articles 1000-9 through 1000-12 of the *Standard Specifications* to the extent applicable for grout in lieu of concrete.

CURING CONCRETE **(6-12-09)**

The 2006 Standard Specifications shall be revised as follows:

Replace the first paragraph of Section **420 -15(A) – Curing Concrete – Gene ral** with the following:

Unless otherwise specified in the contract, use any of the following methods except for membrane curing compounds on bridge deck and approach slab, or on concrete which is to receive epoxy protective coating in accordance with 420-18. Advise the Engineer in advance of the proposed method. Have all material, equipment, and labor necessary to promptly apply the curing on the site before placing any concrete. Cure all patches in accordance with this article. Improperly cured concrete is considered defective.

Replace the third paragraph of Section **420-15(C) – Curing Concrete – Membrane Curing Compound Method** with the following:

Seal the surface with a single uniform coating of the specified type of curing compound applied at the rate of coverage recommended by the manufacturer or as directed, but not less than 1 gallon per 150 square feet of surface area.

BED MATERIAL **(SPECIAL)**

Bed Material shall be placed in the culvert as shown on the plans and in accordance with applicable parts of Section 876 of the Standard Specifications.

Payment for the above work will be included in the pay item for:

Bed Material.....Tons

ARCHITECTURAL CONCRETE SURFACE TREATMENT (SPECIAL)

1.0 GENERAL

The purpose of this special provision is to identify wall locations and their corresponding surface finish required. The Contactor is to consult the Natural Stone Veneer and Cast-In-Place Simulated Stone Form Liner Finish Special Provisions for additional information and pay items.

Wall No.	Begin Station	End Station	Wall Type	Approximate Wall Area	Approximate Wall Length	Surface Finish **	Rail/Fence/Barrier
1	357+30.00 -L- RT	358+70.00 -L- RT	SMSE	1607	140	Custom Formliner	
2	10+55.00 -Y1- RT	12+05.00 -Y1- RT	SNW	2174	150	Custom Formliner	Black Chainlink along top of wall
3	402+85.00 -L- LT	405+00.00 -L- LT	MSE	1752	215	Custom Formliner	
4	407+95.00 -L- RT	413+50.00 -L- RT	MSE	11771	555	Custom Formliner	
5	414+10.00 -L- RT	415+45.00 -L- RT	MSE	2083	135	Custom Formliner	
6	10+40 -Y2- RT	12+50.00 -Y2- RT	MSE	2077	210	Custom Formliner	
7	418+85.00 -L- RT	421+85.00 -L- RT	MSE	3803	300	Custom Formliner	
8	422+15.00 -L- RT	422+70.00 -L- RT	MSE	584	55	Custom Formliner	Black Chainlink along top of wall
9	423+45.00 -L- LT	426+00.00 -L- LT	SNW	2501	255	Custom Formliner	No fence
10	423+80.00 -L- RT	425+15.00 -L- RT	MSE	1707	135	Custom Formliner	Black Chainlink along top of wall
11	10+40.00 -DR1- RT	11+65.00 -DR2- RT	MSE	1622	125	Custom Formliner	Black Chainlink along top of wall
12	428+25.00 -L- RT	428+95.00 -L- RT	CIP GRAVITY	332	70	Custom Formliner	Black Chainlink along top of wall
13	429+65.00 -L- RT	435+90.00 -L- RT	SMSE	11,768	625	Custom Formliner	Black Chainlink along top of wall
14	436+60.00 -L- LT	438+35.00 -L- LT	CIP GRAVITY	971	175	Custom Formliner	Black Chainlink along top of wall
15	437+70.00 -L- RT	442+25.00 -L- RT	SMSE	6850	455	Custom Formliner	Black Chainlink along top of wall
16	11+15.00 -DR2- RT	11+45.00 -DR2- RT	CIP GRAVITY	168	30	Custom Formliner	No fence
17	443+25.00 -L- LT	445+95.00 -L- LT	SNW	4253	270	Custom Formliner	Black Chainlink along top of wall
18	449+85.00 -L- RT	451+40.00 -L- RT	MSE	1315	155	Custom Formliner	Black Chainlink along top of wall
19	458+00.00 -L1- LT	465+10.00 -L1- LT	SNW	6174	710	Custom Formliner	Black Chainlink along top of wall
20	459+50.00 -L1- RT	465+90.00 -L1- RT	CIP SMSE	7528	640	Custom Formliner	Moment Slab with TL-2 Rated Barrrier
21	468+50.00 -L1- RT	470+10.00 -L-/-L1- RT	CIP GRAVITY	693	160	Natural Stone Veneer	Black Aluminum betterment
22	472+40.00 -L- LT	473+80.00 -L- LT	MSE	1024	140	Custom Formliner	Black chain link (Canyons)
23	476+50.00 -L- RT	479+30.00 -L- RT	SNW	2728	280	Custom Formliner	Probably aluminum betterment; otherwise ch lnk
24	479+30.00 -L- LT	482+10.00 -L- LT	MSE	2814	280	Custom Formliner	Black Chainlink along top of wall
25	483+50.00 -L- LT	486+40.00 -L- LT	SMSE	2639	290	Custom Formliner	Partial parapet wall w/Black Chainlink along top of wall
26	485+60.00 -L- LT	486+40.00 -L- LT	CIP GRAVITY	405	80	Natural Stone Veneer	No fence
27	487+60.00 -L- LT	488+20.00 -L- LT	CIP GRAVITY	163	60	Natural Stone Veneer	No fence

Wall No.	Begin Station	End Station	Wall Type	Approximate Wall Area	Approximate Wall Length	Surface Finish **	Rail/Fence/Barrier
28	488+20.00 -L- LT	488+70.00 -L- LT	MSE	925	94	Custom Formliner	Moment Slab with TL-2 Rated Solid Barrrier
29	503+00.00 -L- LT	506+00.00 -L- LT	MSE	2563	300	Custom Formliner	Black Aluminum betterment
30	10+75.00 -DR3- LT	11+50.00 -DR3- LT	CIP GRAVITY	243	75	Custom Formliner	Guardrail instead of fence
31	519+40.00 -L- RT	521+30.00 -L- RT	CIP GRAVITY	1759	290	Custom Formliner	HOA putting in their own fence
32	534+60.00 -L- RT	539+00.00 -L- RT	SNW	8394	440	Custom Formliner	Black Chainlink along top of wall
33	539+30.00 -L- LT	543+50.00 -L- LT	MSE	4644	420	Custom Formliner	Black Aluminum betterment
34	541+00.00 -L- RT	544+00.00 -L- RT	SNW	4008	300	Custom Formliner	Black Chainlink along top of wall
35	545+40.00 -L- LT	547+20.00 -L- LT	MSE	1718	180	Custom Formliner	(across from y15) Black Aluminum betterment
36	547+30.00 -L- RT	552+50.00 -L- RT	SNW	9398	520	Custom Formliner	48" Black Chainlink along top of wall
37	13+00 -Y17- LT	15+50.00 -Y17- LT	MSE	3330	250	Custom Formliner	Moment Slab with TL-4 Rated Barrrier
38	553+90.00 -L- LT	556+80.00-L- LT	MSE	3193	290	Custom Formliner	Moment Slab with TL-4 Rated Barrrier
39	560+80.00 -L- LT	562+30.00 -L- LT	SMSE	1391	150	Custom Formliner	Black Aluminum betterment
40	10+75.00 -Y10 REV- RT	11+75.00 -Y10 REV- RT	CIP GRAVITY	316	100	Natural Stone Veneer	Black chain link or nothing?

CAST-IN-PLACE SIMULATED STONE FORM LINER FINISH (SPECIAL)

1.0 GENERAL

The work covered by this special provision consists of constructing textured surfaces on formed reinforced concrete surfaces as indicated on the Plans and in this Special Provision. The Contractor shall furnish all materials, labor, equipment, and incidentals necessary for the construction of architectural concrete surface treatment using simulated stone masonry form liners (molds) and a compatible concrete coloring system.

The architectural concrete surface treatment should match the appearance (stone size and shape, stone color, and stone texture, pattern, and relief) of natural stone and rock as in a custom form that has been constructed to simulate the rock headwall at Appalachian State University, George M. Holmes Convocation Center or as directed by the Engineer. Grout pattern joints (mortar joints) and bed thickness should re-create the appearance and color of cast-in-place and/or precast concrete surfaces as indicated in the Plans, this Special Provision, or as directed by the Engineer.

2.0 SUBMITTALS

Shop Drawings - The Contractor shall submit for review and acceptance, plan and elevation views and details showing overall simulated stone pattern, joint locations, form tie locations, and end, edge or other special conditions. The drawings should include typical cross sections of applicable surfaces, joints, corners, stone relief, stone size, pitch/working line, mortar joint and bed depths. If necessary, the Contractor shall revise the shop drawings until the proposed form liner patterns and arrangement have been accepted by the Engineer. Shop drawings should be of sufficient scale to show the detail of all stone and joints patterns. The size of the sheets used for the shop drawings shall be 22" x 34" (560mm x 864mm).

The form liner shall be patterned such that long continuous horizontal or vertical lines do not occur on the finished exposed surface. The line pattern shall be random in nature and shall conceal construction joint lines. Special attention should be given to details for wrapping form liners around corners.

Shop drawings shall be reviewed and accepted prior to fabrication of form liners.

Sample Panels – After the shop drawings have been reviewed and accepted by the Engineer, the Contractor shall construct 36" x 60" (610mm x 610mm) transportable sample panel(s) at the project site. The materials used in construction of the sample panel(s) shall comply with section 420 of the Standard Specifications. The sample panel(s) shall be constructed using approved form liners. Sample panels will be required for each different form liner pattern that is to be used on the project. Any sample panel that is not accepted by the Engineer is to be removed from the project site and a new sample panel produced at no additional expense to the Department.

Architectural surface treatments and patterns of the finished work shall achieve the same final effect as demonstrated on the accepted sample panel(s). Upon acceptance by the Engineer, the sample panel(s) shall be used as the quality standard for the project. After the acceptance of the

completed structure, the Contractor shall dispose of the sample panels as directed by the Engineer.

3.0 MATERIALS

Form Liner

Form liners are to be a high-quality reusable product manufactured of high-strength urethane that attaches easily to the forming system and shall not compress more than ¼ inch when the wall is poured at 10 vertical feet per hour.

The form liners are to be patterned after the above referenced wall, or as directed by the Engineer. The custom form liner is to be constructed according to this Special Provision and as supplied by:

Hunt Valley Distributors, LLC
3705 Crondall Lane
Owings Mills, MD 21117
410.356.9677

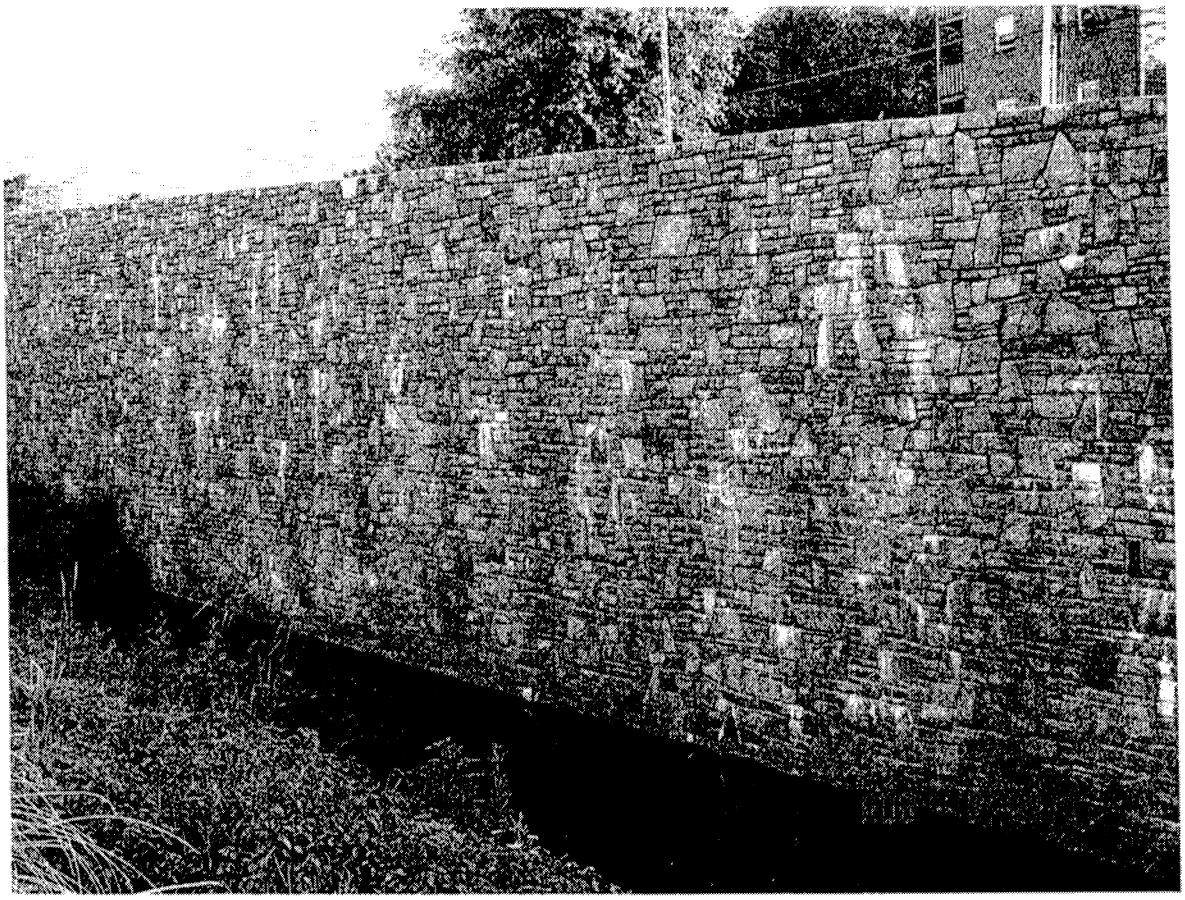
The Contractor has the option of supplying stone-textured surface treatment as specified above or an approved equal by one of the alternative manufactures listed below. One form liner pattern will be used on this project.

Custom Rock International
1156 Homer Street
St. Paul, Minnesota 55116
800.637.2447

Fitzgerald Prime Form and Construction Supply Company
1341 East Pomona Street
Santa Ana, California 92705
714.547.6710
Fax 714.547.7958

Greenstreak Plastics
3400 Tree Court Industrial Boulevard
St. Louis, Missouri 63112
314.225.9400 / 800.325.9504
Fax 800.551.5145

Symons Corporation
200 East Touhy Avenue
Des Plaines, Illinois 60018
847.296.3200
Fax 847.635.9287



Example 1: Stone Wall at Appalachian State University, Boone, North Carolina

Color Stain

The final coloration is to be approved by the State Historic Preservation Office, where applicable, the Town of Blowing Rock, and/or the Engineer.

Color stains shall be a special penetrating stain mix as provided by the manufacturer and shall be in multiple colors of gray, brown, white, and black to achieve a full, natural color variation in the finished surface. The stain shall create a surface finish that is breathable (allowing water vapor transmission), and that resists deterioration from water, acid, alkali, fungi, sunlight, or weathering. Stain mix shall meet the requirements for mildew resistance of Federal Test Method Standard 144, Method 6271, and requirements for weathering resistance of 1,000 hours accelerated exposure measures by Weatherometer in accordance with ASTM G 26. Color samples must be submitted for approval. Concrete stains shall be supplied by one of the following or as approved by the Engineer.

Sherwin Williams
H & C Shield Plus
101 Prospect Ave., NW
Cleveland, OH 44115

Canyon Tone Stain
United Coatings
E 1901 Cataldo
Green Acres, Washington 90016

Cementrate Acrylic Stain
Fosroc, Inc.
55 Skyline Drive
Plainview, New York 11803

Hydroshield Stain
Robson-Downes Associates, Inc.
Oxford, Maryland 21654

Form Release Agent

Form release agent shall be a nonstaining petroleum distillate free from water, asphaltic, and other insoluble residue, or an equivalent product. Form release agents shall be compatible with the color system applied and any special surface finish.

Form Ties

Form ties shall be set back a minimum of 2" (51 mm) from the finished concrete surface. The ties shall be designed so that all material in the device to a depth of at least 2" (51mm) back of the concrete face (bottom of simulated mortar groove) can be disengaged and removed without spalling or damaging the concrete. The Contractor shall submit the type of form ties to the Engineer for approval.

A pre-installation conference with manufacturer representative and the Engineer to assure understanding of simulated stone masonry form liner use, color application, requirements for construction of sample panel(s), and to coordinate the work. The Contractor shall be required to disclose their source of simulated stone masonry manufacturer and final coloration contractor at the Preconstruction Conference.

3.0 CONSTRUCTION

Simulated Stone Form Liner System and Surface Finish

The Contractor shall demonstrate his workmanship by first constructing a sample panel of the simulated stone masonry form liner pattern and coloration. The sample panel shall be constructed on site a minimum of six weeks prior to the construction of the walls. The sample panel shall measure 3' height by 5' length by 8" thick and shall be unreinforced, vertically cast, and of concrete construction to determine the surface texture resulting from the use of form liners. Sample panels shall be cast, finished, and stained until approved by the Engineer. The approved sample panel shall remain on site as the basis for comparison for work constructed on the project. The architectural surface treatment and pattern of the finished work shall achieve the same final effect as demonstrated on the approved sample panel. Upon completion of all work, the panel shall be removed from the site.

The simulated stone form liners are to be capable of withstanding anticipated concrete pour pressures without leakage or without causing physical or visual defects. The simulated stone form liners are to be removable without causing concrete surface deterioration or weakness in the substrate. Form release agents, form stripping methods, patching materials, as well as related construction are to be in accordance with the manufacturer's recommendations or as directed by the Engineer.

Linear butt joints shall be carefully blended into the approved pattern and finished off the final concrete surface. No visible vertical or horizontal seams or conspicuous form marks created by butt joining will be permitted.

The Contractor shall submit the type of form ties to be used in this construction to the Engineer for approval prior to use. Form tie holes shall be finished in accordance with standard concreting practices and shall be acceptable to the Engineer. All patching material shall exactly match the color and appearance of the poured concrete surface.

Concrete surfaces shall be clean, free of laitance, dirt, dust, grease, efflorescence, paint, or other foreign material, following manufacturer's specifications for surface preparation prior to application of color stain. The surface area shall also be free of blemishes, discolorations, surface voids, and unnatural form marks. The Contractor is advised that sandblasting will not be allowed for cleaning concrete surfaces. Pressure washing for removal of laitance shall be used.

The contractor shall provide a Color Application Artist who is trained in the special techniques to achieve realistic surface appearances, if requested by the Engineer. To avoid contaminating or damaging the wall surfaces, color stain application shall be scheduled when all concrete work is completed, the concrete has cured a minimum of 28 days, the surface has been determined to be acceptable for coloring, and after adjacent earthwork is complete. The Contractor is to coordinate coloring applications without interference from other work. The Contractor is required to apply coloring to an appropriate test area of 50 square feet and as designated by the Engineer, which will serve as a quality standard for the remaining surface to be colored. Upon approval of the test area by the Engineer, the remaining surfaces may be colored. Stains shall be

applied when ambient air temperatures are in accordance with manufacturer's specifications or as directed by the Engineer. The number of coats of stain applied shall be in accordance with manufacturer's specifications or as directed by the Engineer. Treated surfaces located adjacent to exposed soil or pavement shall be temporarily covered to prevent dirt or soil splatter from rain.

Following the completion of all work, repairs of any damage made by other construction operations shall be made to the form lined and colored surfaces as directed by the Engineer.

4.0 MEASUREMENT AND PAYMENT

This work will not be measured for payment, but shall be included in the per square foot or linear foot bid price for the pertinent walls and barrier rails, respectively, as shown on plans. Payment will include the furnishing and use of all form liners, coloring stains, the construction, finishing, and removal of all sample panels, and all equipment, materials, labor, and incidentals necessary to complete the work in conformance with the Contract Documents.

SOIL NAIL RETAINING WALLS (SPECIAL)

1.0 GENERAL

A soil nail is defined as a steel bar grouted in a drilled hole inclined at an angle below horizontal. A soil nail retaining wall consists of soil nails spaced at a regular pattern and connected to a cast-in-place reinforced concrete face with nail heads embedded in the concrete. Shotcrete is used for temporary support of the excavation during construction. Design and construct soil nail retaining walls based on actual elevations and dimensions in accordance with the contract and accepted submittals. For this provision, "soil nail wall" refers to a soil nail retaining wall and "Soil Nail Wall Contractor" refers to the contractor installing soil nails and applying shotcrete. Also, "concrete facing" refers to a cast-in-place reinforced concrete face.

2.0 SUBMITTALS

Three submittals are required. These submittals include (1) Soil Nail Wall Contractor personnel and experience, (2) soil nail wall design and (3) soil nail wall construction plan. Provide 11 hard copies of working drawings and 3 hard copies of design calculations for the soil nail wall design submittal and 4 hard copies of the remaining submittals. Also, submit an electronic copy (PDF on CD or DVD) of each submittal. Allow 10 calendar days for the review of the Soil Nail Wall Contractor personnel and experience submittal. After the personnel and experience submittal is accepted, submit the remaining submittals at least 30 calendar days before starting soil nail wall construction. Do not begin soil nail wall construction including preconstruction test panels or sacrificial soil nails for verification tests until the construction plan is accepted.

A. Soil Nail Wall Contractor Personnel and Experience Submittal

Use a Soil Nail Wall Contractor prequalified by the NCDOT Contractual Services Unit for anchored retaining walls work (work code 3020). Submit documentation that the Soil Nail Wall Contractor has successfully completed at least 5 soil nail wall projects and 500 soil nails within the last 3 years with wall heights similar to those for this project and an exposed face area for all 5 walls of at least 10,000 ft^2 (930 m^2). Documentation should include the General Contractor and Owner's name and current contact information with descriptions of each past project.

Provide verification of employment with the Soil Nail Wall Contractor for the Superintendent, Project Manager and Nozzlemen assigned to this project. Submit documentation that the Superintendent and Project Manager each have a minimum of 5 years experience in soil nail wall construction with past projects of scope and complexity similar to that anticipated for this project. Documentation should include resumes, references, certifications, project lists, experience descriptions and details, etc. Submit documentation that each Nozzleman is certified as an ACI Shotcrete Nozzelman by the American Concrete Institute (ACI) in accordance with ACI Certification Publication CP-60. Nozzlemen should be certified in either dry or wet mix vertical based on how the shotcrete will be applied for this project. Perform work

with the personnel submitted and accepted. If personnel changes are required during construction, suspend soil nail wall construction until replacement personnel are submitted and accepted.

B. Soil Nail Wall Design Submittal

A Design Engineer is required to design soil nail walls. Use a Design Engineer approved as a Geotechnical Engineer (key person) for a consultant prequalified by the NCDOT Contractual Services Unit for the anchored retaining wall design discipline. The Design Engineer may also act as the Project Manager provided the Design Engineer meets the Project Manager requirements above.

The Retaining Wall Plans show a plan view, typical sections, details, notes and an elevation or profile view (wall envelope) for each soil nail wall. Before beginning soil nail wall design, survey existing ground elevations shown on the plans and other elevations in the vicinity of soil nail walls as needed. Based on these elevations, finished grades and actual soil nail wall dimensions and details, submit revised wall envelopes for review and acceptance. Use the accepted revised wall envelopes for design.

Design soil nail walls in accordance with the plans and the allowable stress design method in the *FHWA Geotechnical Engineering Circular No. 7 "Soil Nail Walls"* (Publication No. FHWA-IF-03-017) unless otherwise required. When a note on plans requires a live load (traffic) surcharge, use a surcharge load of 250 psf (12 kPa). For steel beam guardrail with 8' (2.4 m) posts above soil nail walls, design walls for an additional horizontal load of 300 lbs/linear ft (4.38 kN/linear m) of wall. For concrete barrier rails with moment slabs above soil nail walls, design walls for an additional horizontal load of 500 lbs/linear ft (7.30 kN/linear m) of wall. Apply additional loads to the back of soil nail walls at a depth of 2 ft (0.6m) below grade elevation.

Do not extend soil nails beyond right-of-way or easement lines. If existing or future obstructions such as foundations, guardrail, fence or handrail posts, pavements, pipes, inlets or utilities will interfere with soil nails, maintain a minimum clearance of 6" (150 mm) between the obstruction and the nails. Use soil nails meeting the following requirements unless otherwise approved.

- Minimum vertical and horizontal spacing of 3 ft (1 m)
- Minimum inclination of 12 degrees below horizontal
- Clearance between the end of the bar and the hole of 6" (150 mm)
- Diameter ranging from 6 to 10 inches (150 to 250 mm)

Four inch (100 mm) diameter soil nails may be approved for drill holes in rock at the discretion of the Engineer.

Geocomposite drain strips are required between the shotcrete and excavation face. Space drain strips to miss nail heads and on 10 ft (3 m) centers, maximum. Connect drain strips to leveling pads. Extend continuous drains along base of concrete facing in front of leveling pads. Provide drains meeting the requirements of an aggregate shoulder drain in accordance with Roadway Standard Drawing No. 816.02.

For temporary facing, use a minimum shotcrete thickness of 4" (100 mm) and reinforce shotcrete with #4 (#13) whaler bars around each nail head. Two reinforcing bars (one on each side of the nail head) in both the vertical and horizontal directions for a total of 4 whaler bars per soil nail are required.

For permanent facing, use a minimum cast-in-place reinforced concrete thickness of 8" (200 mm). Extend concrete facing a minimum of 6" (150 mm) above where finished grade intersects the back of soil nail walls unless required otherwise on the plans. When barriers are required above soil nail walls, use concrete barrier rails with moment slabs as shown on the plans.

Use 6 inch (150 mm) thick aggregate leveling pads beneath concrete facing. Unless required otherwise on the plans, embed top of leveling pads a minimum of 1 ft (0.3 m) below where finished grade intersects the front face of soil nail walls.

Submit working drawings and design calculations including unit grout/ground bond strengths for review and acceptance in accordance with Article 105-2 of the *Standard Specifications*. Submit working drawings showing plan views, wall profiles with soil nail locations including known test nail locations, typical sections and soil nail, drainage, shotcrete, leveling pad, concrete facing and reinforcing details. If necessary, include details on working drawings for concrete barrier rails with moment slabs and obstructions extending through walls or interfering with soil nails, concrete barrier rails and moment slabs. 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 soil nail lengths. When using a software program for design, provide a hand calculation verifying the analysis of the section with the longest soil nails. Have soil nail walls designed, detailed and sealed by the Design Engineer.

C. Soil Nail Wall Construction Plan Submittal

Submit detailed project specific information including the following.

1. Excavation methods and equipment.

2. List and sizes of proposed drilling rigs and tools, tremies and grouting equipment.

3. Sequence and step-by-step description of soil nail wall construction including details of excavations, drilling and grouting methods, soil nail and wall drainage system installation and facing construction.

4. Shotcrete equipment and placement details including mix process, test panels, thickness measuring gauges and application methods.

5. Soil nail testing details, procedures and plan sealed by a Professional Engineer registered in North Carolina with calibration certificates dated within 90 calendar days of the submittal date.

6. Examples of construction and test nail records to be provided in accordance with Sections 6.0 and 7.0, Item F, respectively.

7. Grout mix design including laboratory test results in accordance with the *Grout for Structures* provision and acceptable ranges for grout flow and density.

8. Shotcrete mix design in accordance with the *Shotcrete* provision.

9. Other information shown on the plans or requested by the Engineer.

If alternate installation and testing procedures are proposed or necessary, a revised construction plan submittal may be required. If the work deviates from the accepted submittal without prior approval, the Engineer may suspend soil nail wall construction until a revised plan is submitted and accepted.

3.0 MATERIALS

Provide Type 3 Manufacturer's Certifications in accordance with Article 106-3 of the *Standard Specifications* for soil nail and wall drainage materials. Store steel materials on blocking a minimum of 12" (300 mm) above the ground and protect it at all times from damage; and when placing in the work make sure it is free from dirt, dust, loose mill scale, loose rust, paint, oil or other foreign materials. Load, transport, unload and store soil nail wall materials such that they are kept clean and free of damage. Do not crack, fracture or otherwise damage grout inside sheathing of shop grouted encapsulated soil nails. Damaged or deformed materials will be rejected.

A. Soil Nails

A soil nail consists of a grouted steel bar with corrosion protection and a nail head assembly. Use epoxy coated or encapsulated deformed steel bars meeting the requirements of AASHTO M275 or M31, Grade 60 or 75 (420 or 520). Splice bars in accordance with Article 1070-10 of the *Standard Specifications*.

For epoxy coated bars, provide epoxy coated reinforcing steel meeting the requirements of Article 1070-8 of the *Standard Specifications*.

For encapsulated bars, use unperforated corrugated high-density polyethylene (HDPE) sheathing a minimum of 0.04" (1 mm) thick meeting the requirements of AASHTO M252. Provide at least 0.4" (10 mm) of grout cover between the bar and sheathing and at least 0.8" (20 mm) of grout cover between the sheathing and drill hole wall.

Fabricate centralizers from schedule 40 polyvinyl chloride (PVC) plastic pipe or tube, steel or other material not detrimental to steel bars (no wood). Size centralizers to position the bar within 1 inch (25 mm) of the drill hole center and allow a tremie to be inserted to the bottom of the hole. Use centralizers that do not interfere with grout placement or flow around bars. For encapsulated bars, centralizers are required both inside and outside of encapsulation.

Use grout in accordance with the contract.

Nail head assemblies consist of steel bearing plates, washers, nuts and shear studs. Provide steel bearing plates meeting the requirements of ASTM A36 and washers and hex nuts in accordance with the bar manufacturer's recommendations. Provide welded stud shear connectors in accordance with Article 1072-8 of the *Standard Specifications*.

B. Wall Drainage Systems

Wall drainage systems consist of drain strips, drains and outlet components. Furnish certifications with minimum average roll values (MARV) as defined by ASTM D4439 for core compressive strength and flow rate properties of drain strips. For testing drain strips, a lot is defined as a single day's production. Identify, store and handle drain strips in accordance with ASTM D4873. Drain strips with defects, flaws, deterioration or damage will be rejected. Do not leave drain strips uncovered for more than 7 days.

Use at least 12 inch (300 mm) wide prefabricated geocomposite drain strips consisting of a non-woven polypropylene geotextile bonded to one side of an HDPE or polystyrene drainage core, e.g., sheet drain. Provide drain strips with cores meeting the following requirements.

Core Property	ASTM Test Method	Requirement (MARV[1])
Thickness	D5199	¼ - ½ inch (6 – 13 mm)
Compressive Strength	D1621	40 psi (276 kPa)
Flow Rate (with a gradient of 1.0)	D4716	5 gpm (1 l/s)[2]

[1] MARV does not apply to thickness
[2] per ft (m) of width tested

Use drain and outlet materials meeting the requirements of subsurface drainage materials in accordance with Section 1044 of the *Standard Specifications*.

C. Shotcrete

Use shotcrete in accordance with the contract.

D. Reinforcing Steel

Use deformed steel bar and welded wire reinforcement meeting the requirements of reinforcing steel in accordance with Section 1070 of the *Standard Specifications*.

E. Leveling Pads

Use Class VI Select Material in accordance with Section 1016 of the *Standard Specifications* for aggregate leveling pads.

F. Concrete Facing and Coping

Provide concrete facing and coping meeting the requirements of Section 1000 of the *Standard Specifications*. Use Class A Concrete in accordance with Article 1000-4 of

the *Standard Specifications* and curing agents for concrete in accordance with Section 1026 of the *Standard Specifications*.

Create a Simulated Stone Finish on the exposed wall face in accordance with the Architectural Concrete Surface Treatment and Cast-In-Place Simulated Stone Form Liner Surface Finish Special Provisions. The coping is to be smooth finished.

G. Masonry

Use masonry for brick veneers in accordance with Section 1040 of the *Standard Specifications*.

H. Joint Materials

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

4.0 PRECONSTRUCTION MEETING

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

5.0 CONSTRUCTION METHODS

Control drainage during construction in the vicinity of soil nail walls. Direct run off away from soil nail walls and areas above and behind walls.

Perform necessary clearing and grubbing in accordance with Section 200 of the *Standard Specifications*. Notify the Engineer before blasting in the vicinity of soil nail walls. Perform blasting in accordance with the contract. Install foundations located behind soil nail walls and within a horizontal distance equal to the longest soil nail length before beginning soil nail wall construction.

Do not excavate behind soil nail walls. If overexcavation occurs, repair walls at no additional cost to the Department with a method proposed by the Contractor and accepted by the Engineer. A revised soil nail wall construction plan may be required.

Perform any welding in accordance with the contract. At the Contractor's option, welding may be performed in the field in lieu of employing an American Institute of Steel Construction (AISC) certified fabricator in accordance with Subarticle 1072-1(A) of the *Standard Specifications*. For field welding, use welders certified as a bridge welder in accordance with the NCDOT Field Welder Certification Program.

Use equipment and methods reviewed and accepted in the construction plan or approved by the Engineer. Inform the Engineer of any deviations from the accepted plan.

A. Excavation

Construct soil nail walls from the top down by removing material in front of walls and providing an excavation face to receive shotcrete meeting the following tolerances.

- Within 2" (50 mm) of the location shown on the plans
- Within 2% of vertical
- No negative batter (excavation face leaning forward)

Excavate in accordance with the accepted submittals and in staged horizontal lifts with heights not to exceed the vertical soil nail spacing. Do not excavate more than 3 ft (1 m) below where soil nails will be installed. Remove any cobbles, boulders, rubble or debris that will protrude more than 2" (50 mm) into the required shotcrete thickness. Rocky ground such as colluvium, boulder fills and weathered rock may be difficult to excavate without leaving voids.

Apply shotcrete to the excavation face within 24 hours of excavating the lift unless approved otherwise by the Engineer. The application of shotcrete may be delayed if it can be demonstrated that the delay will not adversely affect the excavation face stability. If the excavation face will be exposed for more than 24 hours, use polyethylene sheets anchored at the top and bottom of the lift to protect the face from changes in moisture content.

If the excavation face becomes unstable at any time, suspend soil nail wall construction and temporarily stabilize the face by immediately placing an earth berm against the unstable face. Soil nail wall construction may not proceed until remedial measures are proposed by the Contractor and accepted by the Engineer. A revised soil nail wall construction plan submittal may be required.

Do not excavate the next lift until the soil nail installations, shotcrete application, nail head assemblies and soil nail testing for the preceding lift are complete and the soil nails for the preceding lift are accepted by the Engineer. Also, do not excavate the next lift until the grout and shotcrete for the preceding lift have cured at least 3 days and 1 day, respectively.

B. Soil Nail Installation

Install soil nails in the same way as acceptable verification test nails. Drill and grout soil nails the same day and do not leave drill holes open overnight.

Control drilling and grouting to prevent excessive ground movements, damaging structures and pavements and fracturing rock and soil formations. If ground heave or subsidence occurs, suspend soil nail wall construction and take action to minimize movement. If structures or pavements are damaged, suspend wall construction and repair structures and pavements at no additional cost to the Department with a method proposed by the Contractor and accepted by the Engineer. The Engineer may require a revised soil nail wall construction plan when corrective action is necessary.

1. Drilling

   Use drilling rigs capable of drilling through whatever materials are encountered to the dimensions and orientations required for the soil nail wall design. Drill straight and clean holes at locations shown in the accepted submittals. Drill hole locations and inclinations are required to be within 6" (150 mm) and 2 degrees, respectively, of that shown in the accepted submittals unless approved otherwise by the Engineer.

   Stabilize drill holes with temporary casings if unstable, caving or sloughing material is anticipated or encountered. Do not use drilling fluids to stabilize drill holes or remove cuttings.

2. Soil Nail Bars

   Use centralizers to center steel bars in drill holes. Securely attach centralizers at maximum 8 ft (2.4 m) intervals along bars. Attach uppermost and lowermost centralizers 18" (450 mm) from the top and bottom of drill holes.

   Before placing soil nail bars, allow the Engineer to check location, orientation and cleanliness of drill holes. Provide steel bars as shown in the accepted submittals and insert bars without difficulty or forcing insertion. Do not vibrate or drive soil nail bars. If a bar can not be completely inserted easily, remove the bar and clean or redrill the hole.

3. Grouting

   Remove oil, rust inhibitors, residual drilling fluids and similar foreign materials from holding tanks/hoppers, stirring devices, pumps, lines, tremie pipes and all other equipment in contact with grout before use.

   Place grout with a tremie in accordance with the contract and accepted submittals. Inject grout at the lowest point of drill holes through a tremie pipe, e.g., grout tube, casing, hollow-stem auger or drill rod, in one continuous operation. Fill drill holes progressively from the bottom to top and withdraw tremie at a slow even rate as the hole is filled to prevent voids in the grout. Extend tremie pipe into grout a minimum of 5 ft (1.5 m) at all times except when grout is initially placed in a drill hole.

   Provide grout free of segregation, intrusions, contamination, structural damage or inadequate consolidation (honeycombing). Cold joints in grout are not allowed except for soil nails that are tested. Extract temporary casings as grout is placed. Monitor and record grout volumes during placement.

4. Nail Heads

   After shotcreting, attach nail head assemblies as shown in the accepted submittals. Before shotcrete reaches initial set, seat plates and tighten nuts so plates contact

shotcrete uniformly. If uniform contact is not possible, install nail head assemblies on a mortar pad to provide even bearing against shotcrete.

C. Wall Drainage Systems

Install wall drainage systems as shown in the accepted submittals. Before shotcreting, place and secure geocomposite drain strips with the geotextile side against the excavation face. For highly irregular excavation faces, the Engineer may allow placing drain strips after shotcreting with weep holes through the shotcrete. Ensure that drain strips continuously contact the excavation face and allow for full flow the entire height of the wall. Discontinuous drain strips are not allowed. If splices are needed, overlap drain strips a minimum of 12" (300 mm) such that flow is not impeded. Connect drain strips to leveling pads by embedding strip ends at least 4" (100 mm) into the no. 57 stone.

Construct drains in accordance with Section 816 of the *Standard Specifications*. Provide drains with positive drainage toward outlets.

D. Shotcreting

Perform shotcreting in accordance with the contract and accepted submittals. Use nozzlemen who were accepted in the Soil Nail Wall Contractor personnel and experience submittal and made satisfactory preconstruction test panels.

Clean the excavation face and ungrouted zones of drill holes near the face of loose materials, mud, rebound and other foreign material. Moisten surfaces to receive shotcrete. Secure reinforcement to prevent movement and vibration while shotcreting.

Direct shotcrete at right angles to the excavation face except when placing shotcrete around reinforcing bars. Rotate nozzle steadily in a small circular pattern. Apply shotcrete from the bottom up. Make shotcrete surface uniform and free of sloughing or sagging.

Completely fill ungrouted zones of drill holes near the excavation face and any other voids with shotcrete. Consider subsurface conditions and resulting potential for voids when estimating shotcrete quantities. No additional payment will be made for unanticipated shotcrete quantities.

Taper construction joints to a thin edge over a minimum distance equal to the shotcrete thickness. Wet the joint surface before applying shotcrete on adjacent sections.

Repair surface defects as soon as possible after placement. Remove any shotcrete which lacks uniformity, exhibits segregation, honeycombing or lamination or contains any voids or sand pockets and replace with fresh shotcrete to the satisfaction of the Engineer.

E. Leveling Pads and Concrete Facing

Construct leveling pads and drains at elevations and with dimensions shown in the accepted submittals. Construct drains in accordance with Section 816 of the *Standard Specifications*. Compact no. 57 stone for aggregate leveling pads with a vibratory compactor to the satisfaction of the Engineer.

Construct cast-in-place reinforced concrete facing in accordance with the accepted submittals and Section 420 of the *Standard Specifications*. Do not remove forms until concrete achieves a minimum compressive strength of 2400 psi (16.5 MPa). Unless required otherwise on the plans, provide a Class 2 Surface Finish for concrete facing in accordance with Article 420-17 of the *Standard Specifications*.

Construct concrete facing joints at a maximum spacing of 30 ft (9 m) unless required otherwise on the plans. 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 reinforcement 2" (50 mm) from either side of expansion joints.

Seal joints above and behind soil nail walls between concrete facing and ditches with joint sealer.

F. Coping

Construct concrete coping as detailed in the MSE or Soil Nail Wall Plans and 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 coping in accordance with Article 420-17 of the *Standard Specifications*.

Construct coping joints at a maximum spacing of 10 ft (3 m). 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.

Use a cast-in-place reinforced concrete coping at top of walls for soldier pile wall with dimensions shown on the plans. Extend coping or concrete facing a minimum of 6" (150 mm) above where finished grade intersects the back of soldier pile walls unless required otherwise on the plans. Wrap the coping around the top of the wall and extend coping down the back of panels a minimum of 6" (150 mm).

6.0 CONSTRUCTION RECORDS

Provide 2 original hard copies of soil nail wall construction records including the following within 24 hours of completing each lift.

1. Names of Soil Nail Wall Contractor, Superintendent, Nozzleman, Drill Rig Operator, Project Manager and Design Engineer
2. Wall description, county, NCDOT contract, TIP and WBS element number
3. Wall station and number and lift location, dimensions, elevations and description
4. Soil nail locations, diameters, lengths and inclinations, bar types, sizes and grades, corrosion protection and temporary casing information
5. Date and time drilling begins and ends, soil nail bars are placed, grout and shotcrete are mixed and/or arrives on-site and grout placement and shotcrete application begins and ends
6. Grout volume, temperature, flow and density records
7. Ground and surface water conditions and elevations, if applicable
8. Weather conditions including air temperature at time of grout placement and shotcrete application
9. All other pertinent details related to soil nail wall construction

After completing each soil nail wall or stage of a soil nail wall, submit electronic copies (PDF on CD or DVD) of all corresponding construction records.

7.0 TESTING

Verification and proof tests are required as shown on the plans. For this provision, "verification tests" are performed on test nails not incorporated into the wall, i.e., sacrificial soil nails and "proof tests" are performed on test nails incorporated into the wall, i.e., production soil nails assuming test nails are acceptable in accordance with this provision. "Verification test nails" refer to soil nails on which verification tests are performed and "proof test nails" refer to soil nails on which proof tests are performed.

In general, 1 verification test for each soil type with a minimum of 2 tests per soil nail wall and proof tests on 5 percent of production soil nails with a minimum of 1 test per nail row are required. More or less soil nail testing may be required depending on the subsurface conditions encountered. The Engineer will decide the actual number and locations of verification and proof tests. The approximate locations of known verification test nails are shown on the plans.

Do not test soil nails until grout and shotcrete achieve the required 3 day compressive strength. Do not begin construction of any production soil nails until verification tests are satisfactorily completed.

A. Testing Equipment

Use testing equipment that includes the following.

- 2 dial gauges with rigid supports
- hydraulic jack and pressure gauge
- jacking block or reaction frame
- electrical resistance load cell (verification tests only)

Use dial gauges capable of measuring to 0.001" (0.025 mm) and accommodating the maximum anticipated movement. Provide pressure gauges graduated in 100 psi (690 kPa) increments or less. Submit identification number and calibration records for each load cell, jack and pressure gauge with the soil nail wall construction plan. Calibrate the jack and pressure gauge as a unit.

Align testing equipment to ensure uniform loading. Use a jacking block or reaction frame that does not damage the shotcrete or contact the shotcrete face within 3 ft (1 m) of test nails. Align dial gauges within 5 degrees of the test nail axis. Place dial gauges opposite each other on either side of the test nail. Set up testing equipment and measuring devices such that resetting or repositioning the components before completing testing is not required.

B. Test Nails

Test nails have both unbonded and bond lengths. Grout only the bond lengths before testing. Minimum required unbonded and bond lengths are 3 ft (1 m) and 10 ft (3 m), respectively.

Soil nail bars for production soil nails may be overstressed under higher test nail loads. Use larger or higher grade steel bars to allow for higher loads instead of shortening bond lengths to less than the minimum. Any costs associated with higher capacity bars will be considered incidental to the soil nail testing pay items.

C. Verification Tests

Install sacrificial soil nails in accordance with the accepted submittals and this provision. Use the same equipment, methods and drill hole diameter for sacrificial soil nails as will be used for production soil nails.

Use the following equation to determine maximum bond lengths, L_{BVT} (ft or m), for verification test nails.

$$L_{BVT} \leq \frac{C_{RT} \times A_t \times f_y}{Q_{ALL} \times 3},$$

where,

C_{RT} = reduction coefficient, 0.9 for Grade 60 and 75 (420 and 520) bars or 0.8 for Grade 150 (1035) bars,

A_t = bar area (in^2 or m^2),

f_y = bar yield stress (ksi or kPa) and

Q_{ALL} = allowable unit grout/ground bond strength (kips/ft or kN/m).

Use the following equation to determine design test loads, DTL_{VT} (kips or kN), for verification test nails.

$$DTL_{VT} = L_{BVT} \times Q_{ALL}$$

Calculate DTL_{VT} based on as-built bond lengths. Perform verification tests by incrementally loading test nails to failure or a maximum test load of 300 percent of DTL_{VT} according to the following schedule.

Load	Hold Time
AL*	1 minute
0.25 DTL_{VT}	10 minutes
0.50 DTL_{VT}	10 minutes
0.75 DTL_{VT}	10 minutes
1.00 DTL_{VT}	10 minutes
1.25 DTL_{VT}	10 minutes
1.50 DTL_{VT}	60 minutes (creep test)
1.75 DTL_{VT}	10 minutes
2.00 DTL_{VT}	10 minutes
2.50 DTL_{VT}	10 minutes
3.00 DTL_{VT}	10 minutes
AL*	1 minute

*Alignment load (AL) is the minimum load required to align testing equipment and should not exceed 0.05 DTL_{VT}.

Reset dial gauges to zero after applying alignment load. Record test nail movement at each load increment and permanent set after load is reduced to alignment load.

Monitor test nails for creep at the 1.50 DTL_{VT} load increment. Measure and record test nail movement during the creep portion of the test at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. Repump jack as needed to maintain the intended load during hold times.

D. Proof Tests

Use the following equation to determine maximum bond lengths, L_{BPT} (ft or m), for proof test nails.

$$L_{BPT} \leq \frac{C_{RT} \times A_t \times f_y}{Q_{ALL} \times 1.5},$$

where variables are as defined in Item C above.

Use the following equation to determine design test loads, DTL_{PT} (kips or kN), for proof test nails.

$$DTL_{PT} = L_{BPT} \times Q_{ALL}$$

Calculate DTL_{PT} based on as-built bond lengths. Perform proof tests by incrementally loading test nails to failure or a maximum test load of 150 percent of DTL_{PT} according to the following schedule.

Load	Hold Time
AL*	Until movement stabilizes
0.25 DTL_{PT}	Until movement stabilizes
0.50 DTL_{PT}	Until movement stabilizes
0.75 DTL_{PT}	Until movement stabilizes
1.00 DTL_{PT}	Until movement stabilizes
1.25 DTL_{PT}	Until movement stabilizes
1.50 DTL_{PT}	10 or 60 minutes (creep test)
AL*	1 minute

*Alignment load (AL) is the minimum load required to align testing equipment and should not exceed 0.05 DTL_{PT}.

Reset dial gauges to zero after applying alignment load. Record test nail movement at each load increment and monitor test nails for creep at the 1.50 DTL_{PT} load increment. Measure and record test nail movement at 1, 2, 3, 5, 6 and 10 minutes. When the test nail movement between 1 minute and 10 minutes exceeds 0.04" (1 mm), maintain the maximum test load for an additional 50 minutes and record movements at 20, 30, 50 and 60 minutes. Repump jack as needed to maintain the intended load during hold times.

E. Test Nail Acceptance

Test nail acceptance is based on the following criteria.

1. For verification tests, total creep movement is less than 0.08" (2 mm) between the 6 and 60 minute readings and creep rate is linear or decreasing throughout the creep test load hold time.

2. For proof tests, total creep movement is less than 0.04" (1 mm) between the 1 and 10 minute readings or less than 0.08" (2 mm) between the 6 and 60 minute readings and creep rate is linear or decreasing throughout the creep test load hold time.

3. Total test nail movement at maximum test load exceeds 80 percent of the theoretical elastic elongation of the test nail unbonded length.

4. Pullout failure does not occur at or before the 2.0 DTL_{VT} or 1.5 DTL_{PT} load increment. Pullout failure is defined as the inability to increase the load while test nail movement continues. Record the pullout failure load as part of the test data.

Maintain stability of test nail unbonded lengths for subsequent grouting. If the test nail unbonded length of a proof test nail can not be satisfactorily grouted after testing, do not incorporate the test nail into the wall and replace the nail with another production soil nail at no additional cost to the Department.

F. Test Nail Results

Submit 2 original hard copies of test nail records including movement versus load plots for each load increment within 24 hours of completing each test. The Engineer will review the test records and associated construction records to determine if the test nail is acceptable.

If the Engineer determines a verification test nail is unacceptable, revise the soil nail wall design and/or installation methods. Submit a revised soil nail wall design and/or construction plan for review and acceptance and provide an acceptable verification test nail with the revised design and/or installation methods at no additional cost to the Department.

If the Engineer determines a proof test nail is unacceptable, either perform additional proof tests on adjacent production soil nails or revise the soil nail wall design for the production soil nails represented by the unacceptable proof test nail as determined by the Engineer. Submit a revised soil nail wall design and/or construction plan for review and acceptance and provide an acceptable proof test nail with the revised design and/or installation methods at no additional cost to the Department. If required, remove representative production soil nails and/or provide new production soil nails with the revised design and/or installation methods at no additional cost to the Department.

After completing soil nail testing for each wall or wall stage, submit electronic copies (PDF on CD or DVD) of all corresponding test records.

8.0 MEASUREMENT AND PAYMENT

Soil Nail Retaining Walls will be measured and paid for in square feet (meters). Soil nail 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 concrete facing or coping. The bottom of wall elevation is as shown on the plans and no payment will be made for portions of soil nail walls below bottom of wall elevations.

The contract unit price for *Soil Nail Retaining Walls* will be full compensation for providing design, submittals, labor, tools, equipment and soil nail wall materials,

excavating, installing soil nails and wall drainage systems, grouting, shotcreting including test panels, welding and providing reinforcement, leveling pads, concrete facing, coping and any incidentals necessary to design and construct soil nail walls in accordance with this provision. If necessary, the contract unit price for *Soil Nail Retaining Walls* will also be full compensation for providing brick veneers in accordance with the contract.

The contract unit price for *Soil Nail Retaining Walls* does not include the cost for fences, handrails, ditches, guardrail and barriers associated with soil nail walls as payment for these items will be made elsewhere in the contract.

Soil Nail Verification Tests and *Soil Nail Proof Tests* will be measured and paid for in units of each, depending on the type of test. Soil nail tests will be measured as the number of initial verification or proof tests required by the Engineer or as shown on the plans. No payment will be made for subsequent tests performed on the same test nails or replacement nails. The contract unit prices for *Soil Nail Verification Tests* and *Soil Nail Proof Tests* will be full compensation for soil nail testing in accordance with Section 7.0 of this provision.

Payment will be made under:

Pay Item	**Pay Unit**
Soil Nail Retaining Walls	Square Foot (Meter)
Soil Nail Verification Tests	Each
Soil Nail Proof Tests	Each

MSE RETAINING WALLS **(SPECIAL)**

1.0 GENERAL

A. Description

A mechanically stabilized earth (MSE) retaining wall consists of steel or geogrid reinforcements in the reinforced zone connected to 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 Systems

Use an MSE wall system approved by the Department in accordance with any NCDOT restrictions for the chosen system, the plans and the NCDOT MSE wall policy. Value engineering proposals for other MSE wall systems will not be considered. Do not use MSE wall systems with SRW units or conditional approval for critical walls or MSE walls connected to critical walls. Critical walls are defined in the NCDOT MSE wall policy. Obtain the list of approved MSE wall systems and NCDOT MSE wall policy from:
www.ncdot.org/doh/preconstruct/highway/geotech/msewalls

C. Aggregate

"Aggregate" refers to fine or coarse aggregate. Coarse aggregate is required in the reinforced zone for critical walls and when noted on the plans. Otherwise, aggregate is required in the reinforced zone for MSE walls.

2.0 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.

A Design Engineer is required to design MSE walls. Use a Design Engineer approved as a Geotechnical Engineer (key person) for a consultant prequalified by the NCDOT Contractual Services Unit for the MSE retaining wall design discipline.

The Retaining Wall Plans show a plan view, typical sections, details, notes and an elevation or profile view (wall envelope) for each MSE wall. Before beginning MSE wall design, survey existing ground elevations shown on the plans and other elevations in the vicinity of MSE walls as needed. Based on these elevations, finished grades and actual MSE wall dimensions and details, submit revised wall envelopes for review and acceptance. Use the accepted revised wall envelopes for design.

Design MSE walls in accordance with any NCDOT restrictions for the chosen MSE wall system, the plans and the *AASHTO LRFD Bridge Design Specifications* unless otherwise required. Also, design MSE walls with a uniform reinforcement length throughout the wall height and a minimum reinforcement length of 0.7H or 6' (1.8 m), whichever is greater, unless shown otherwise on the plans with H as defined below. Extend the reinforced zone a minimum of 6" (150 mm) beyond the end of reinforcement as shown on the plans. Use the simplified method for determining maximum reinforcement loads and design factors for reinforcement approved by the Department for the chosen MSE wall system or default values in accordance with the AASHTO LRFD specifications. Design steel components including reinforcement and connection materials for nonaggressive backfill with corrosion losses in accordance with the AASHTO LRFD specifications.

When a note on plans requires a live load (traffic) surcharge, use a surcharge load of 250 psf (12 kPa) in accordance with Figure C11.5.5-3 of the AASHTO LRFD specifications. For steel beam guardrail with 8' (2.4 m) posts above MSE walls, design upper two rows of reinforcement for an additional horizontal load of 300 lbs/linear ft (4.38 kN/linear m) of wall in accordance with the AASHTO LRFD specifications. If existing or future obstructions such as foundations, guardrail, fence or handrail 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) for H ≤ 10' 2 ft (0.6 m) for H > 10'
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)
Front slope is as shown on the plans and H is the maximum design height plus embedment per wall as shown on the plans		

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

For MSE walls with panels, place a minimum of 2 bearing pads in each horizontal panel joint such that the final horizontal joint opening is 3/4 inch (19 mm). Additional bearing pads may be required for panels wider than 5 ft (1.5 m) as determined by the Engineer. Cover joints on the back of panels with filter fabric a minimum of 12" (250 mm) wide.

For MSE walls with SRW units, place coarse aggregate between and behind blocks for a horizontal distance of at least 18" (450 mm) and fill any block core spaces with coarse aggregate.

Separation fabric is required between aggregate and overlying fill or pavement section with the exception of when concrete pavement is placed directly on aggregate. Separation fabric may also be required between coarse aggregate 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 as 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 for MSE walls with SRW units and when noted on the plans. 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 as shown on the plans.

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 required resistances, typical sections with reinforcement and connection details, aggregate 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, geogrid splices, reinforcement connected to end bent caps and obstructions extending through walls or interfering with reinforcement, concrete barrier rails and moment slabs. 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 designing MSE walls with computer software other than MSEW, verify the design with MSEW version 3.0 or later, manufactured by ADAMA Engineering, Inc. At least one MSEW analysis is required per 100 ft (30 m) of wall length with a minimum of one MSEW analysis for the wall section with the longest reinforcement length. Submit electronic executable MSEW input and output files with the design calculations. Have MSE walls designed, detailed and sealed by the Design Engineer.

3.0 MATERIALS

A. Certifications, Storage and Handling

Provide certifications in accordance with Article 106-3 of the *Standard Specifications*. Furnish Type 3 Manufacturer's Certifications for MSE wall materials with the exception of precast elements and the following. For reinforcement, provide Type 1 Certified Mill Test Reports for tensile strength. For SRW units, provide Type 1 Certified Mill Test Reports or 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 2 Typical Certified Mill Test Reports or Type 5 Typical Certified Test Reports for durability.

Store steel materials on blocking a minimum of 12" (300 mm) above the ground and protect it at all times from damage; and when placing in the work make sure it is free from dirt, dust, loose mill scale, loose rust, paint, oil or other foreign materials. 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. Mark, store and transport panels in accordance with Section 1077 of the *Standard Specifications*.

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 required concrete cover. 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, at least 4 cylinders are required per 2000 ft^2 (186 m^2) of panel face area or a single day's production, whichever is less.

Provide panels with a Simulated Stone Finish in accordance with the Architectural Concrete Surface Treatment and Cast-In-Place Simulated Stone Form Liner Surface Finish Special Provisions, 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 straight 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 Section 1040 of the *Standard Specifications* and ASTM C1372 with the exception of absorption, compressive strength and unit height 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 at least 6 blocks are required per lot.

Provide blocks with a maximum absorption of 5% and a unit height within 1/16 inch (2 mm) of the dimension shown in the accepted submittals.

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 grids (mesh, mats and ladders) meeting the requirements of Article 1070-3 of the *Standard Specifications* and metallic strips 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 that have been 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. Machine direction (MD) and cross-machine direction (CD) are as defined by ASTM D4439. 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. Aggregate

Provide aggregate meeting the requirements of Sections 1005 and 1014 of the *Standard Specifications*.

1. Fine Aggregate

Use fine aggregate meeting the requirements of standard size nos. 1S, 2S, 2MS or 4S in accordance with Table 1005-2 of the *Standard Specifications*. When using steel reinforcement with fine aggregate, provide aggregate meeting the electrochemical requirements of Article 7.3.6.3 of the *AASHTO LRFD Bridge Construction Specifications* tested in accordance with the following methods:

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

2. Coarse Aggregate

Use coarse aggregate meeting the requirements of standard size nos. 5, 57, 57M, 6M, 67 or 78M in accordance with Table 1005-1 of the *Standard Specifications*.

E. 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* and curing agents for concrete in accordance with Section 1026 of the *Standard Specifications*. For testing precast coping for

compressive strength, at least 4 cylinders are required per 40 yd^3 (31 m^3) of concrete or a single day's production, whichever is less.

F. Wall Drainage Systems

Wall drainage systems consist of drains and outlet components. Use drain and outlet materials meeting the requirements of subsurface drainage materials in accordance with Section 1044 of the *Standard Specifications*.

G. Bearing Pads

Use bearing pads approved by the Department for the chosen MSE wall system that meet the material requirements in Section 3.6.1.a of the *FHWA Manual "Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume I"* (Publication No. FHWA-NHI-10-024). Obtain the list of approved bearing pads for each MSE wall system from the website shown elsewhere in this provision.

H. Geotextile Fabrics

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

I. Miscellaneous Components

Miscellaneous components may include attachment devices, connectors (e.g., pins, bars, plates, etc.), dowels, fasteners (e.g., bolts, nuts, etc.) and any other MSE 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.

J. Joint Sealer

Use joint sealer 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 if necessary, assistance with installation.

5.0 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 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, aggregate and backfill. Contain and maintain aggregate 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. 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 required otherwise on the plans, install foundations located in the reinforced zone before placing aggregate or the first reinforcement layer. Notify the Engineer when foundation excavation is complete. Do not place leveling pad concrete, aggregate 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 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).

Set panels with a vertical joint width of 1/2 to 1 inch (13 to 25 mm). Place bearing pads in horizontal panel joints and cover panel joints with filter fabrics as shown in the accepted submittals. Attach filter fabrics to back of panels with adhesives, tapes or other approved methods.

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 steel reinforcement. Geogrids may be spliced once per reinforcement length in accordance with the accepted submittals. Contact the Engineer when unanticipated existing or future obstructions such as foundations, guardrail, fence or handrail 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 aggregate in the reinforced zone in 8 to 10 inch (200 to 250 mm) thick lifts. Compact fine aggregate 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 aggregate 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 aggregate. Do not use sheepsfoot, grid rollers or other types of compaction equipment with feet. Compact aggregate in a direction parallel to the wall face. Do not displace or damage reinforcement when placing and compacting aggregate. End dumping directly on geogrids is not permitted. Do not operate heavy equipment on reinforcement until it is covered with at least 8" (200 mm) of aggregate. 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 and leveling concrete in accordance with Section 420 of the *Standard Specifications*. When single faced precast concrete barriers are placed in front of MSE walls, stop coping just above barriers such that coping does not interfere with placing barriers up against wall faces. 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 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.

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 or top of panels or blocks for MSE walls without coping. The bottom of wall elevation is as shown on the plans and no payment will be made for portions of MSE walls below bottom of wall elevations.

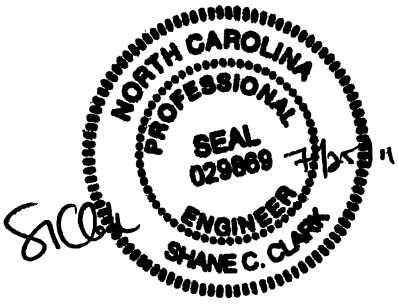
The contract unit price for *MSE Retaining Walls* will be full compensation for providing design, submittals, labor, tools, equipment and MSE wall materials, excavating, backfilling, hauling and removing excavated materials and providing site assistance, leveling pads, facing elements, reinforcement,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

The contract unit price for *MSE Retaining Walls* does not include the cost for fences, handrails, ditches, guardrail and barriers associated with MSE walls as payment for these items will be made elsewhere in the contract.

Payment will be made under:

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



MSE RETAINING WALLS WITH A CIP FACE **(SPECIAL)**

1.0 GENERAL

A. Description

A mechanically stabilized earth (MSE) retaining wall consists of steel or geogrid reinforcements in the reinforced zone connected to vertical facing elements. For this provision, the facing elements are temporary and the tensile reinforcements are steel and connected to a cast-in-place reinforced concrete face. 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 with a cast-in-place face and "MSE Wall Vendor" refers to the vendor supplying the chosen MSE wall system. Also, "concrete facing" refers to a cast-in-place reinforced concrete face.

B. MSE Wall Systems

Use an MSE wall system supplied by one of the following MSE Wall Vendors. Value engineering proposals for MSE wall systems supplied by other vendors will not be considered.

The Reinforced Earth Company
8614 Westwood Center Drive, Suite 1100
Vienna, VA 22182
(703) 749-4325
www.reinforcedearth.com

T&B Structural Systems, LLC
6800 Manhattan Boulevard, Suite 304
Fort Worth, TX 76120
(888) 280-9858
www.tbssus.com

Tricon Precast, Ltd.
15055 Henry Road
Houston, TX 77060
(281) 931-9832
www.triconprecast.com

Hilfiker Retaining Walls
1902 Hilfiker Lane
Eureka, CA 95503
(800) 762-8962
www.hilfiker.com

C. Aggregate

"Aggregate" refers to coarse aggregate and is required in the reinforced zone for MSE walls.

2.0 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.

A Design Engineer is required to design MSE walls. Use a Design Engineer approved as a Geotechnical Engineer (key person) for a consultant prequalified by the NCDOT Contractual Services Unit for the MSE retaining wall design discipline.

The Retaining Wall Plans show a plan view, typical sections, details, notes and an elevation or profile view (wall envelope) for each MSE wall. Before beginning MSE wall design, survey existing ground elevations shown on the plans and other elevations in the vicinity of MSE walls as needed. Based on these elevations, finished grades and actual MSE wall dimensions and details, submit revised wall envelopes for review and acceptance. Use the accepted revised wall envelopes for design.

Design MSE walls in accordance the plans and the *AASHTO LRFD Bridge Design Specifications* unless otherwise required. Also, design MSE walls with a uniform reinforcement length throughout the wall height and a minimum reinforcement length of 0.7H or 6' (1.8 m), whichever is greater, unless shown otherwise on the plans with H as defined below. Extend the reinforced zone a minimum of 6" (150 mm) beyond the end of reinforcement as shown on the plans. Use the simplified method for determining maximum reinforcement loads. Design reinforcement and connection materials for nonaggressive backfill with corrosion losses in accordance with the AASHTO LRFD specifications.

When a note on plans requires a live load (traffic) surcharge, use a surcharge load of 250 psf (12 kPa) in accordance with Figure C11.5.5-3 of the AASHTO LRFD specifications. For steel beam guardrail with 8' (2.4 m) posts above MSE walls, design upper two rows of reinforcement for an additional horizontal load of 300 lbs/linear ft (4.38 kN/linear m) of wall in accordance with the AASHTO LRFD specifications. If existing or future obstructions such as foundations, guardrail, fence or handrail 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 aggregate leveling pads beneath temporary and concrete facing. 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) for H ≤ 10' 2 ft (0.6 m) for H > 10'
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)
Front slope is as shown on the plans and H is the maximum design height plus embedment per wall as shown on the plans		

Use select material in the reinforced zone for MSE walls and extend the reinforced zone 6" (150 mm) beyond the end of reinforcement. Use welded wire facing for temporary facing elements and retention fabric to retain aggregate. Extend fabric at least 4 ft (1.2 m) back behind facing into aggregate.

Separation fabric is required between aggregate and overlying fill or pavement section with the exception of when concrete pavement is placed directly on aggregate. Separation fabric may also be required between aggregate and backfill or natural ground as determined by the Engineer.

Extend a continuous drain along the base of the concrete facing in front of the leveling pad. Provide drains meeting the requirements of an aggregate shoulder drain in accordance with Roadway Standard Drawing No. 816.02.

Design concrete facing in accordance with the plans and the Load Factor Design method of Section 5 of the *AASHTO LRFD Bridge Design Specifications* unless otherwise required. Provide reinforcement of sufficient density to satisfy Article 5.7.3.4 of the AASHTO LRFD specifications. Use a minimum concrete facing thickness of 8" (200 mm). Extend concrete facing a minimum of 6" (150 mm) above where finished grade intersects the back of MSE walls unless required otherwise on the plans. When barriers are required above MSE walls, use concrete barrier rails with moment slabs as shown on the plans.

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 required resistances, typical sections with reinforcement and connection details, aggregate type, retention and separation fabric locations and details of leveling pads, welded wire and concrete facing, bin walls, etc. If necessary, include details on working drawings for concrete barrier rails with moment slabs, reinforcement connected to end bent caps and obstructions extending through walls or interfering with reinforcement, concrete barrier rails and moment slabs. 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 designing MSE walls with computer software other than MSEW, verify the design with MSEW version 3.0 or later, manufactured by ADAMA Engineering, Inc. At least one MSEW analysis is required per 100 ft (30 m) of wall length with a minimum of one MSEW analysis for the wall section with the longest reinforcement length. Submit

electronic executable MSEW input and output files with the design calculations. Have MSE walls designed, detailed and sealed by the Design Engineer.

3.0 MATERIALS

A. Certifications, Storage and Handling

Provide certifications in accordance with Article 106-3 of the *Standard Specifications*. For steel reinforcement, furnish Type 2 Typical Certified Mill Test Reports for tensile strength. For all other MSE wall materials, provide Type 3 Manufacturer's Certifications. Store steel materials on blocking a minimum of 12" (300 mm) above the ground and protect it at all times from damage; and when placing in the work make sure it is free from dirt, dust, loose mill scale, loose rust, paint, oil or other foreign materials. Load, transport, unload and store MSE wall materials such that they are kept clean and free of damage.

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

B. Temporary Facing Elements

Use welded wire reinforcement facing meeting the requirements of Article 1070-3 of the *Standard Specifications*. Use support struts and wires for welded wire facing meeting the requirements of AASHTO M32.

C. Steel (Inextensible) Reinforcement

Use welded wire reinforcement grids (mesh and mats) meeting the requirements of Article 1070-3 of the *Standard Specifications* and metallic strips 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*.

D. Geotextile Fabrics

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

E. Aggregate

Provide aggregate meeting the requirements of Sections 1005 and 1014 of the *Standard Specifications*. Use coarse aggregate meeting the requirements of standard size nos. 5, 57, 57M, 6M, 67 or 78M in accordance with Table 1005-1 of the *Standard Specifications*.

F. Wall Drainage Systems

Wall drainage systems consist of drains and outlet components. Use drain and outlet materials meeting the requirements of subsurface drainage materials in accordance with Section 1044 of the *Standard Specifications*.

G. Miscellaneous Components

Miscellaneous components may include attachment devices, connectors (e.g., pins, bars, plates, etc.), fasteners (e.g., bolts, nuts, etc.) and any other MSE wall components not included above. Galvanize steel components in accordance with Section 1076 of the *Standard Specifications*. Provide miscellaneous components in accordance with the MSE Wall Vendor's requirements for the chosen MSE wall system.

H. Concrete Facing

Provide concrete facing 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 in accordance with Article 1000-4 of the *Standard Specifications* and curing agents for concrete in accordance with Section 1026 of the *Standard Specifications*. Create a Simulated Stone Finish in accordance with the Architectural Concrete Surface Treatment and Cast-In-Place Simulated Stone Form Liner Surface Finish Special Provisions.

I. Joint Sealer

Use joint sealer 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 if necessary, assistance with installation.

5.0 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 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 welded wire facing and

reinforcement layer are 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, aggregate and backfill. Contain and maintain aggregate 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. 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 required otherwise on the plans, install foundations located in the reinforced zone before placing aggregate or the first reinforcement layer. Notify the Engineer when foundation excavation is complete. Do not place welded wire facing, aggregate or reinforcement until obtaining approval of the excavation depth and foundation material.

Construct leveling pads at elevations and with dimensions shown in the accepted submittals. Compact aggregate leveling pads with a vibratory compactor to the satisfaction of the Engineer. Construct cast-in-place reinforced concrete facing in accordance with the accepted submittals and Section 420 of the *Standard Specifications*. Do not remove forms until concrete achieves a minimum compressive strength of 2400 psi (16.5 MPa). Unless required otherwise on the plans, provide a Class 2 Surface Finish for concrete facing in accordance with Article 420-17 of the *Standard Specifications*.

Erect and support welded wire facing with no negative batter (wall face leaning forward) such that the final position is as shown in the accepted submittals. Stagger vertical joints of welded wire facing to create a running bond when possible unless shown otherwise on the plans or accepted submittals. 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 retention fabrics as shown in the accepted submittals and cover fabrics with at least 3" (75 mm) of aggregate. 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, fence or handrail 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 aggregate in the reinforced zone in 8 to 10 inch (200 to 250 mm) thick lifts. 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 aggregate 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 aggregate. Do not use sheepsfoot, grid rollers or other types of compaction equipment with feet. Compact aggregate in a direction parallel to the wall face. Do not displace or damage reinforcement when placing and compacting aggregate. Do not operate heavy equipment on reinforcement until it is covered with at least 8" (200 mm) of aggregate. 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*.

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.

Construct concrete facing joints at a maximum spacing of 30 ft (9 m) unless required otherwise on the plans. 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 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 concrete facing and ditches with joint sealer.

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 concrete facing. The bottom of wall elevation is as shown on the plans and no payment will be made for portions of MSE walls below bottom of wall elevations.

The contract unit price for *MSE Retaining Walls* will be full compensation for providing design, submittals, labor, tools, equipment and MSE wall materials, excavating, backfilling, hauling and removing excavated materials and providing site assistance, welded wire facing, fabrics, reinforcement, aggregate, miscellaneous components, wall drainage systems, leveling pads, concrete facing and any incidentals necessary to design and construct MSE walls in accordance with this provision. If necessary, the contract unit price for *MSE Retaining Walls* will also be full compensation for reinforcement connected to and aggregate 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 for *MSE Retaining Walls*.

The contract unit price for *MSE Retaining Walls* does not include the cost for fences, handrails, ditches, guardrail and barriers associated with MSE walls as payment for these items will be made elsewhere in the contract.

Payment will be made under:

Pay Item	**Pay Unit**
Mechanically Stabilized Earth Retaining Wall with Cast-In-Place Face	Square Foot (Meter)

SHORED MECHANICALLY STABILIZED EARTH RETAINING WALLS (SPECIAL)

1.0 GENERAL

A. Description

A Shored Mechanically Stabilized Earth (SMSE) retaining wall is defined as a soil retaining system with steel or geogrid tensile reinforcements in the reinforced zone and vertical precast concrete panels or a Cast-In-Place (CIP) face, combined with a soil nail wall system consisting of soil nails spaced at a regular pattern and connected to a reinforced shotcrete face supporting the excavation When a composite MSE and Soil Nail Wall system is proposed on a project, the MSE component of the system should consider the long-term retaining benefits provide by the Soil Nail Wall and the potential reduction in excavation and reinforced backfill. Contributions of the Soil Nail wall include a reduction in lateral loads on the MSE mass and significant contributions to global stability.

Design and construct SMSE retaining walls based on actual elevations and dimensions in accordance with the contract and accepted submittals. For this provision, "SMSE Wall" refers to the entire wall system, "MSE wall" refers to the mechanically stabilized earth wall part of the SMSE wall, "Soil Nail Wall" refers to the soil nail wall part of the SMSE wall.

Use a MSE Wall Installer prequalified by the NCDOT Contractual Services Unit for constructing the MSE wall (work code 3015). Use a Soil Nail Wall Contractor prequalified by the NCDOT Contractual Services Unit for designing and constructing the Soil Nail Wall (work code 3020).

B. MSE Wall System

Use a 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/

Only fully approved MSE wall systems are allowed.

2.0 SMSE WALL DESIGN SUBMITTALS

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 SMSE wall design submittal. Provide the submittal at least 30 calendar days before conducting the SMSE wall preconstruction meeting. Do not begin SMSE 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 SMSE wall. Before beginning SMSE 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.

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.

(A) MSE Wall Design

Design MSE walls in accordance with any restrictions for the chosen MSE wall system, the plans and FHWA Publication *FHWA-CFL/TD-06-001* and other requirements stated below.

Design MSE walls with a minimum reinforcement length of 5 feet (1.5 meters) or 0.4 times the wall height, whichever is greater; except for the top two layers of reinforcement, which must have a minimum length of 5 feet (1.5 meters) and 0.6 times the wall height. Where the reinforcement length is less than 0.5 times the wall height, use a factor of safety against reinforcement pullout of 2.0. Use a maximum vertical reinforcement spacing of 2.5 feet (0.75 meters). Extend the reinforcement to the soil nail wall, where applicable, otherwise extend the select material 6" (150 mm) beyond the end of the reinforcement.

For geogrid reinforcement, use the reinforcement coefficients and geogrid reduction factors submitted to the Department for the approval of the chosen MSE wall system. For metallic reinforcement, for zinc use a corrosion loss rate of 0.6 mils/year (15 um/year) for the first two years and 0.16 mils/year (4 um/year) thereafter. For carbon steel, use a corrosion loss rate of 0.5 mils/year (12 um/year).

Use 6 inch (150 mm) thick cast-in-place unreinforced concrete leveling pads beneath panels that are continuous at steps and extend a minimum of 6" (150 mm) in front of and behind bottom row of panels. Unless required otherwise on the plans, embed top of leveling pads in accordance with *FHWA-CFL/TD-06-001* For slopes steeper than 3:2 (H:V), use an embedment of H/3. 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. 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. At the Contractor's option,

connect cast-in-place concrete coping to panels with dowels or extend coping down the back of the MSE walls. Also, connect cast-in-place leveling concrete for precast concrete coping to panels with dowels. When barriers are required above SMSE 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 SMSE walls designed, detailed and sealed by a Professional Engineer registered in North Carolina.

(B) Soil Nail Wall Design

Design soil nail walls for a 100-year design service life and a traffic surcharge equal to 240 psf (11.5 kPa). This surcharge is not applicable for construction traffic. If a construction surcharge will be present within a horizontal distance equal to the height of the wall, design the soil nail wall for the required construction surcharge.

At the judgement of the Engineer, the soil nail wall can be omitted where rock is encountered and is strong enough to support the excavation.

Batter the soil nail wall to 1:14 (H:V). For pavements above soil nail walls, maintain a minimum clearance of 36" (900 mm) between the smse wall face and edge of pavement. For slopes above soil nail walls, maintain a minimum clearance of 12" (300 mm) between the wall face and toe of slope.

Do not extend soil nails beyond right-of-way or easement lines. If existing or future obstructions such as foundations, guardrail posts, pavements, pipes, inlets or utilities will interfere with soil nails, maintain a minimum clearance of 6" (150 mm) between the obstruction and the nails. Use soil nails meeting the following minimum requirements.

(1) Vertical and horizontal spacing of 3 ft (1 m)

(2) Inclination of 10 degrees below horizontal

(3) Diameter of 4" (100 mm)

Geocomposite drain strips are required at minimum 10 ft (3 m) centers between the shotcrete and excavation face. Use a minimum shotcrete thickness of 4" (100 mm) and reinforce shotcrete with #4 (#13) whaler bars around each nail head. Two reinforcing bars (one on each side of the nail head) in both the vertical and horizontal directions for a total of 4 whaler bars per soil nail are required. Do not embed shotcrete facing below bottom of excavation or the grade in front of soil nail walls.

Submit soil nail wall designs including unit grout/ground bond strengths for review and acceptance in accordance with Article 105-2 of the *Standard Specifications*. Submit working drawings showing plan views, wall profiles with soil nail locations and typical sections with soil nail, drainage, shotcrete and reinforcing details. If necessary, include details on working drawings for obstructions interfering with soil nails or extending through walls. Also, submit a sequence and step-by-step description of soil nail wall construction including details of excavations, drilling and grouting methods, soil nail installation and testing and shotcreting. Submit design calculations for each soil nail wall section with different surcharge loads, wall geometry or material parameters. A minimum of one analysis is required for each wall section with different soil nail lengths. Submit 3 hard copies of design calculations and 10 hard copies of drawings and an electronic copy (PDF on CD or DVD) of both the calculations and drawings. Have soil nail 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 7 Contractor's Certifications for soil nail materials and geocomposite drain strips. Provide Type 2 typical Certified Mill Test Reports for geogrid tensile strength. Provide Type 3 Manufacturer's Certifications for all other materials.

Load, transport, unload and store SMSE wall materials such that they are kept clean and free of damage. Damaged panels with excessive discoloration, chips or cracks as determined by the Engineer will be rejected. Store steel materials on blocking a minimum of 12" (300 mm) above the ground and protect it at all times from damage; and when placing in the work make sure it is free from dirt, dust, loose mill scale, loose rust, paint, oil or other foreign materials. Damaged or bent materials will be rejected.

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 ft^2 (186 m^2) 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. Cast-In-Place (CIP) Face

Design concrete facing in accordance with the plans and the Load Factor Design method of Section 8 of the *AASHTO Standard Specifications for Highway Bridges* unless otherwise required. Provide reinforcement of sufficient density to satisfy Section 8.16.8.4 of the AASHTO specifications. Use a minimum concrete facing thickness of 8" (200 mm). Extend concrete facing a minimum of 6" (150 mm) above where finished grade intersects the back of MSE walls unless required otherwise on the plans. When barriers are required above MSE walls, use concrete barrier rails with moment slabs in accordance with the plans and design concrete facing for impact loads applied to top of walls as shown on the plans.

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

a. Temporary Facing Elements

Use welded wire reinforcement facing meeting the requirements of AASHTO M55 or M221. Use support struts and wires for welded wire facing meeting the requirements of AASHTO M32.

b. Miscellaneous Components

Miscellaneous components may include attachment devices, connectors (e.g., pins, bars, plates, etc.), fasteners (e.g., bolts, nuts, etc.) and any other wall components not included above. Galvanize steel components in accordance with Section 1076 of the *Standard Specifications*. Provide miscellaneous components in accordance with the MSE Wall Vendor's recommendations for the chosen MSE wall system.

c. Geotextile Fabrics

Use retention fabrics meeting the requirements of Class 3 and the UV resistance, AOS and permittivity for separation geotextile in accordance with

AASHTO M288. Use separation fabrics meeting the requirements of Type 2 Engineering Fabric in accordance with Section 1056 of the *Standard Specifications*.

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*.

D. Select Material

Provide select material meeting the requirements of standard size nos. 57, 67 or 78M in accordance with Sections 1005 and 1014 of the *Standard Specifications*. 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 yd^3 (31 m^3) 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*.

K. Soil Nails

A soil nail is defined as a steel bar grouted in a drilled hole inclined at an angle below horizontal. A soil nail consists of a grouted steel bar with corrosion protection and a nail head assembly. Use epoxy coated or encapsulated deformed steel bars meeting the requirements of AASHTO M275 or M31, Grade 60 or 75 (420 or 520). Splice bars in accordance with Article 1070-10 of the *Standard Specifications*.

For epoxy coated bars, provide epoxy coated reinforcing steel meeting the requirements of Article 1070-8 of the *Standard Specifications*.

For encapsulated bars, use unperforated corrugated high-density polyethylene (HDPE) sheathing a minimum of 0.04" (1 mm) thick meeting the requirements of AASHTO M252. Provide at least 0.4" (10 mm) of grout cover between the bar and sheathing and at least 0.8" (20 mm) of grout cover between the sheathing and drill hole wall.

Fabricate bar centralizers from schedule 40 polyvinyl chloride (PVC) plastic pipe or tube, steel or other material not detrimental to steel bars (no wood). Size centralizers to position the bar within 1 inch (25 mm) of the drill hole center and allow a tremie to be inserted to the bottom of the hole. Use centralizers that do not interfere with grout placement or flow around bars. For encapsulated bars, centralizers are required both inside and outside of encapsulation.

Use grout in accordance with the contract.

Nail head assemblies consist of steel bearing plates, washers and nuts. Provide bearing plates meeting the requirements of ASTM A36 and washers and hex nuts in accordance with the bar manufacturer's recommendations.

L. Composite Drain Strips

Provide minimum average roll values (MARV) as defined by ASTM D4439 for core properties of drain strips. For testing drain strips, a lot is defined as a single day's production. Identify, store and handle drain strips in accordance with ASTM D4873. Drain strips with defects, flaws, deterioration or damage will be rejected. Do not leave drain strips uncovered for more than 7 days.

Use at least 12 inch (300 mm) wide prefabricated geocomposite drain strips consisting of a non-woven polypropylene geotextile bonded to one side of an HDPE or polystyrene drainage core, e.g., sheet drain. Provide drain strips with cores meeting the following requirements.

Core Property	Test Method	Requirement (MARV)
Thickness	ASTM D5199	¼ - ½ inch (6 – 13 mm)
Compressive Strength	*ASTM D1621*	40 psi (276 kPa) min
Flow Rate (with a gradient of 1.0)	*ASTM D4716*	5 gpm (1 l/s) min*

* per ft (m) of width tested

M. Shotcrete

Use shotcrete in accordance with the contract.

N. Concrete Reinforcing Steel

Use deformed steel bar reinforcement and welded wire fabric meeting the requirements of reinforcing steel in accordance with Section 1070 of the *Standard Specifications*.

4.0 Corrosion Monitoring

Corrosion monitoring is required for SMSE 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 SMSE Wall Preconstruction Meeting

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

6.0 SMSE WALL VENDOR SITE ASSISTANCE

Provide a representative employed by the MSE wall vendor to assist and guide the SMSE Wall Installer on-site for at least 8 hours when the first panels 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 SMSE walls. Direct run off away from SMSE walls, select material and backfill. Contain and maintain select material and backfill and protect material from erosion.

Construct to the tolerances found in Table 4 of FHWA-CFL/TD-06-001.

Perform necessary clearing and grubbing in accordance with Section 200 of the *Standard Specifications*. Excavate as necessary for SMSE walls in accordance with the accepted submittals.

(A) MSE Wall Installation

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.

Erect and support panels with no negative batter (wall face leaning forward) such that the final position is as shown in the accepted submittals. Set panels with a joint width of 1/2 to 1 inch (13 to 25 mm).

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 select material in the reinforced zone in 8 to 10 inch (200 to 250 mm) thick lifts. . 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*.

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. 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 SMSE walls between coping and ditches with joint sealer as shown on the plans.

When using an anchored NCDOT portable concrete barrier (PCB), anchor the barrier in accordance with Roadway Standard Drawing 1170.01 and Section 1170 of the *Standard Specifications*.

(B) Soil Nail Excavation

Notify the Engineer before blasting in the vicinity of soil nail walls. Perform blasting in accordance with the contract. Install foundations located behind soil nail walls and within a horizontal distance equal to the longest soil nail length before beginning soil nail wall construction.

Do not excavate behind soil nail walls. If overexcavation occurs, repair walls at no additional cost to the Department with a method proposed by the Contractor and accepted by the Engineer.

Construct soil nail walls from the top down by excavating material in front of walls in accordance with the accepted submittals and in staged horizontal lifts with heights not to exceed the vertical soil nail spacing. Do not excavate more than 3 ft (1 m) below where soil nails will be installed. Remove any cobbles, boulders, rubble or debris that will protrude more than 2" (50 mm) into the required shotcrete thickness. Rocky ground such as colluvium, boulder fills and weathered rock may be difficult to excavate without leaving voids.

Install geocomposite drain strips as shown in the accepted submittals. Before shotcreting, place and secure drain strips with the geotextile side against the excavation face. Ensure that drain strips continuously contact the excavation face and allow for full flow the entire height of the wall. Discontinuous drain strips are not allowed. If splices are needed, overlap drain strips a minimum of 12" (300 mm) such that flow is not impeded.

Apply shotcrete to the excavation face within 24 hours of excavating the lift unless approved otherwise by the Engineer. The application of shotcrete may be delayed if it can be demonstrated that the delay will not adversely affect the excavation face stability. If the excavation face will be exposed for more than 24 hours, use polyethylene sheets anchored at the top and bottom of the lift to protect the face from changes in moisture content.

If the excavation face becomes unstable at any time, suspend soil nail wall construction and temporarily stabilize the face by immediately placing an earth berm against the unstable face. Soil nail wall construction may not proceed until remedial measures are proposed by the Contractor and accepted by the Engineer.

Do not excavate the next lift until the soil nail installations, shotcrete application, nail head assemblies and soil nail testing for the preceding lift are complete and the soil nails for the preceding lift are accepted by the Engineer. Also, do not excavate the next lift until the grout and shotcrete for the preceding lift have cured at least 3 days and 1 day, respectively.

Cut off excess drain strips and expose strip ends below shotcrete facing when excavation and shotcreting is complete.

(C) Soil Nail Installation

Drill and grout soil nails the same day and do not leave drill holes open overnight. Control drilling and grouting to prevent excessive ground movements, damaging structures and pavements and fracturing rock and soil formations. If ground heave or subsidence occurs, suspend soil nail wall construction and take action to minimize movement. If structures or pavements are damaged, suspend wall construction and repair structures and pavements at no additional cost to the Department with a method proposed by the Contractor and accepted by the Engineer.

(1) Drilling

Use drilling rigs capable of drilling through whatever materials are encountered to the dimensions and orientations required for the soil nail wall design. Drill straight and clean holes at locations shown in the accepted submittals. Stabilize drill holes with temporary casings if unstable, caving or sloughing material is anticipated or encountered. Do not use drilling fluids to stabilize drill holes or remove cuttings.

(2) Soil Nail Bars

Use centralizers to center steel bars in drill holes. Securely attach centralizers at maximum 8 ft (2.4 m) intervals along bars. Attach uppermost and lowermost centralizers 18" (450 mm) from the top and bottom of drill holes.

Before placing soil nail bars, allow the Engineer to check location, orientation and cleanliness of drill holes. Provide steel bars as shown in the accepted submittals and insert bars without difficulty or forcing insertion. Do not vibrate or drive soil nail bars. If a bar can not be completely inserted easily, remove the bar and clean or redrill the hole.

(3) Grouting

Remove oil, rust inhibitors, residual drilling fluids and similar foreign materials from holding tanks/hoppers, stirring devices, pumps, lines, tremie pipes and all other equipment in contact with grout before use.

Place grout with a tremie in accordance with the contract and accepted submittals. Inject grout at the lowest point of drill holes through a tremie pipe, e.g., grout tube, casing, hollow-stem auger or drill rod, in one continuous operation. Fill drill holes progressively from the bottom to top and withdraw tremie at a slow even rate as the hole is filled to prevent voids in the grout. Extend tremie pipe into grout a minimum of 5 ft (1.5 m) at all times except when grout is initially placed in a drill hole.

Provide grout free of segregation, intrusions, contamination, structural damage or inadequate consolidation (honeycombing). Cold joints in grout are not allowed except for soil nails that are tested. Extract temporary casings as grout is placed. Monitor and record grout volumes during placement.

(4) Nail Heads

After shotcreting, attach nail head assemblies as shown in the accepted submittals. Before shotcrete reaches initial set, seat plates and tighten nuts so plates contact shotcrete uniformly. If uniform contact is not possible, install nail head assemblies on a mortar pad to provide even bearing against shotcrete.

(D) Shotcreting

Perform shotcreting in accordance with the contract and accepted submittals. Use nozzlemen who made satisfactory preconstruction test panels.

Clean the excavation face and ungrouted zones of drill holes near the face of loose materials, mud, rebound and other foreign material. Moisten surfaces to receive shotcrete. Secure reinforcement to prevent movement and vibration while shotcreting.

Direct shotcrete at right angles to the excavation face except when placing shotcrete around reinforcing bars. Rotate nozzle steadily in a small circular pattern. Apply shotcrete from the bottom up. Make shotcrete surface uniform and free of sloughing or sagging.

Completely fill ungrouted zones of drill holes near the excavation face and any other voids with shotcrete. Consider subsurface conditions and resulting potential for voids when estimating shotcrete quantities. No additional payment will be made for unanticipated shotcrete quantities.

Taper construction joints to a thin edge over a minimum distance equal to the shotcrete thickness. Wet the joint surface before applying shotcrete on adjacent sections.

Repair surface defects as soon as possible after placement. Remove any shotcrete which lacks uniformity, exhibits segregation, honeycombing or lamination or contains any voids or sand pockets and replace with fresh shotcrete to the satisfaction of the Engineer.

(E) Soil Nail Testing

For this provision, "proof tests" are performed on test nails incorporated into the wall, i.e., production soil nails assuming test nails are acceptable in accordance with this provision. "Proof test nails" refer to soil nails on which proof tests are performed.

In general, proof tests on 5 percent of production soil nails with a minimum of 1 test per nail row is required. More or less soil nail testing may be required depending on the subsurface conditions encountered. The Engineer will decide the actual number and locations of proof tests.

Do not test soil nails until grout and shotcrete achieve the required 3 day compressive strength.

(1) Testing Equipment

Use testing equipment that includes the following.

(a) 2 dial gauges with rigid supports

(b) Hydraulic jack and pressure gauge

(c) Jacking block or reaction frame

Use dial gauges capable of measuring to 0.001" (0.025 mm) and accommodating the maximum anticipated movement. Provide pressure gauges graduated in 100 psi (690 kPa) increments or less.

Align testing equipment to ensure uniform loading. Use a jacking block or reaction frame that does not damage the shotcrete or contact the shotcrete face within 3 ft (1 m) of test nails. Align dial gauges within 5 degrees of the test nail axis. Place dial gauges opposite each other on either side of the test nail. Set up testing equipment and measuring devices such that resetting or repositioning the components before completing testing is not required.

(2) Proof Tests

Proof test nails have both unbonded and bond lengths. Grout only the bond lengths before testing. Minimum required unbonded and bond lengths are 3 ft (1 m) and 10 ft (3 m), respectively.

Soil nail bars for production soil nails may be overstressed under higher test nail loads. Use larger or higher grade steel bars to allow for higher loads instead of shortening bond lengths to less than the minimum.

Use the following equation to determine maximum bond lengths, L_B (ft or m).

$$L_B \leq \frac{C_{RT} \times A_t \times f_y}{Q_{ALL} \times 1.5},$$

where,

C_{RT} = reduction coefficient, 0.9 for Grade 60 and 75 (420 and 520) bars or 0.8 for Grade 150 (1035) bars,
A_t = bar area (in^2 or m^2),
f_y = bar yield stress (ksi or kPa) and
Q_{ALL} = allowable unit grout/ground bond strength (kips/ft or kN/m).

Use the following equation to determine design test loads, DTL (kips or kN).

$$DTL = L_B \times Q_{ALL}$$

Calculate DTL based on as-built bond lengths. Perform proof tests by incrementally loading test nails to failure or a maximum test load of 150 percent of DTL according to the following schedule.

Load	Hold Time
AL*	Until movement stabilizes

0.25 DTL	Until movement stabilizes
0.50 DTL	Until movement stabilizes
0.75 DTL	Until movement stabilizes
1.00 DTL	Until movement stabilizes
1.25 DTL	Until movement stabilizes
1.50 DTL	10 or 60 minutes (creep test)
AL*	1 minute

*Alignment load (AL) is the minimum load required to align testing equipment and should not exceed 0.05 DTL.

Reset dial gauges to zero after applying alignment load. Record test nail movement at each load increment and monitor test nails for creep at the 1.50 DTL load increment. Measure and record test nail movement at 1, 2, 3, 5, 6 and 10 minutes. When the test nail movement between 1 minute and 10 minutes exceeds 0.04" (1 mm), maintain the maximum test load for an additional 50 minutes and record movements at 20, 30, 50 and 60 minutes. Repump jack as needed to maintain the intended load during hold times.

(3) Test Nail Acceptance

Test nail acceptance is based on the following criteria.

(a) Total creep movement is less than 0.04" (1 mm) between the 1 and 10 minute readings or less than 0.08" (2 mm) between the 6 and 60 minute readings and creep rate is linear or decreasing throughout the creep test load hold time.

(b) Total test nail movement at maximum test load exceeds 80 percent of the theoretical elastic elongation of the test nail unbonded length.

(c) Pullout failure does not occur at or before the 1.5 DTL load increment. Pullout failure is defined as the inability to increase the load while test nail movement continues. Record the pullout failure load as part of the test data.

Maintain stability of test nail unbonded lengths for subsequent grouting. If the test nail unbonded length of a proof test nail can not be satisfactorily grouted after testing, do not incorporate the test nail into the wall and replace the nail with another production soil nail at no additional cost to the Department.

(4) Test Nail Results

Submit 2 original hard copies of test nail records including movement versus load plots for each load increment within 24 hours of completing each test. The Engineer will review the test records to determine if the test nail is acceptable.

If the Engineer determines a test nail is unacceptable, either perform additional proof tests on adjacent production soil nails or revise the soil nail wall design for the production soil nails represented by the unacceptable proof test nail as determined by the Engineer. Submit a revised soil nail wall design for review and acceptance and provide an acceptable proof test nail with the revised design and/or installation methods at no additional cost to the Department. If required, remove representative production soil nails and/or provide new production soil nails with the revised design and/or installation methods at no additional cost to the Department.

After completing soil nail testing for each wall, submit electronic copies (PDF on CD or DVD) of all corresponding test records.

8.0 MEASUREMENT AND PAYMENT

Shored Mechanically Stabilized Earth (SMSE) Retaining Walls will be measured and paid for in square feet (meters). SMSE walls will be measured as the exposed face area of the MSE wall 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 SMSE wall. No payment will be made for portions of SMSE walls below bottom of wall elevations or the Soil Nail Wall part of the SMSE wall.

The contract unit price bid for *SMSE Retaining Walls* will be full compensation for design, submittals, furnishing labor, tools, equipment and wall materials, excavating, backfilling, hauling and removing excavated materials and providing site assistance, leveling pads, simulated stone form lined facing elements, reinforcement, select material, wall drainage systems, fabrics, coping, miscellaneous components, excavating, installing soil nails and geocomposite drain strips, grouting, testing nails, shotcreting including test panels and providing reinforcement and any incidentals necessary to design and construct SMSE walls in accordance with this provision.

Shored Mechanically Stabilized Earth (SMSE) Retaining Walls with CIP Face will be measured and paid for in square feet (meters). SMSE walls with CIP Face will be measured as the exposed face area of the MSE wall 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 SMSE wall. No payment will be made for portions of SMSE walls below bottom of wall elevations or the Soil Nail Wall part of the SMSE wall.

The contract unit price bid for *SMSE Retaining Walls* will be full compensation for design, submittals, furnishing labor, tools, equipment and wall materials, excavating, backfilling, hauling and removing excavated materials and providing site assistance, leveling pads, simulated stone form lined CIP face, reinforcement, select material, wall drainage systems, fabrics, coping, miscellaneous components, excavating, installing soil nails and

geocomposite drain strips, grouting, testing nails, shotcreting including test panels and providing reinforcement and any incidentals necessary to design and construct SMSE walls in accordance with this provision.

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*.

Moment Slab with TL-2 or TL-4 Barrier Rail will be measured and paid for in accordance with Article 460-4 of the *Standard Specifications*. The contract unit price bid for *Moment Slab with TL-2 or TL-4 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**
SMSE Retaining Wall	Square Foot (Meter)
SMSE Retaining Wall with CIP Face	Square Foot (Meter)

SHOTCRETE (4-15-08)

1.0 DESCRIPTION

This special provision addresses shotcrete produced by either the dry or wet mix process used for temporary support of excavations and other applications as shown on the plans or directed by the Engineer. Provide shotcrete composed of portland cement, water, aggregate and at the Contractor's option, pozzolan. Type IP blended cement may be used in lieu of portland cement and fly ash and Type IS blended cement may be used in lieu of portland cement and ground granulated blast furnace slag. If necessary, use admixtures for shotcrete produced by the wet mix process. Proportion, mix and place shotcrete in accordance with the plans, the applicable section of the *Standard Specifications* or special provision for the application and this provision.

2.0 MATERIALS

Refer to Division 10 of the *Standard Specifications*:

Item	Article
Cement	1024-1
Water	1024-4
Fine Aggregate, 2S or 2MS	1014-1
Coarse Aggregate	1014-2
Fly Ash	1024-5
Ground Granulated Blast Furnace Slag	1024-6
Silica Fume	1024-7
Admixtures	1024-3

3.0 REQUIREMENTS

Unless required elsewhere in the contract, provide shotcrete with minimum compressive strengths as follows:

Property	Requirement
Compressive Strength @ 3 days	2000 psi (13.8 MPa)
Compressive Strength @ 28 days	4000 psi (27.6 MPa)

Submit shotcrete mix designs in terms of saturated surface dry weights on M&T Form 312U in accordance with the applicable section of the *Standard Specifications* or special provision for the application. If the Contractor desires to mix shotcrete by volume, contact the NCDOT Materials and Tests (M&T) Unit before submitting mix designs. Adjust mix proportions to compensate for surface moisture contained in the aggregates at the time of mixing. Use an approved testing laboratory to determine the shotcrete mix proportions. Changes in mix proportions will not be permitted unless a revised mix design submittal is accepted.

When shotcrete mix designs are submitted, the Engineer will review the mix designs and notify the Contractor as to their acceptability contingent upon compressive strength test results for cores from preconstruction test panels. Do not use mix designs for preconstruction test panels until written acceptance has been received. Acceptance of shotcrete mix designs does not relieve the Contractor of responsibility to furnish a product that meets the contract requirements.

4.0 PRECONSTRUCTION TEST PANELS

Before beginning construction, furnish at least 1 preconstruction test panel for each shotcrete mix design and nozzleman using the same equipment that will be used for construction. Use 3 ft by 3 ft (1 m by 1 m) forms at least 4" (100 mm) thick for test panels.

Determine air content for shotcrete produced by the wet mix process in accordance with AASHTO T152 or T196. Batch, deliver, mix and place shotcrete in accordance with Section 5.0 and the applicable section of the *Standard Specifications* or special provision for the application. Make preconstruction test panels in the presence of the Engineer with forms in a vertical position and from the same shooting position anticipated for construction. Do not disturb test panels within the first 24 hours and cure panels in accordance with AASHTO T23 without immersing panels.

Drill 3" (75 mm) dia. cores in accordance with AASHTO T24. Extract 6 cores from each preconstruction test panel and provide them to the Engineer. The compressive strength of the shotcrete will be considered the average compressive strength test results of 3 cylinder specimens from the same preconstruction test panel at 28 days.

5.0 SAMPLING AND PLACEMENT

Use equipment capable of handling and delivering shotcrete at a steady uninterrupted flow. Use air supply systems that deliver clean, dry air free of contamination and capable of maintaining sufficient nozzle velocity at all times. Apply shotcrete with the same equipment and methods as used for the preconstruction test panels. Install approved thickness measuring gauges on 5 ft (1.5 m) centers in each direction to establish shotcrete thickness.

Do not apply shotcrete during heavy rains or runoff or high winds such that the nozzle stream separates during placement. Do not place shotcrete if surface to receive shotcrete is frozen or the air temperature measured at the location of the shotcreting operation in the shade away from artificial heat is below 40°F (4°C). Do not apply shotcrete if the shotcrete temperature is less than 50°F (10°C) or greater than 90°F (32°C). Protect shotcrete from freezing and rain until the shotcrete reaches initial set as determined by the Engineer.

Produce shotcrete of required strength, consistency, quality and uniformity with minimum rebound. Thoroughly mix materials in sufficient quantity to place continuously. Do not use rebound or previously expanded material in the mix. Apply shotcrete before the time between adding the mixing water and placement exceeds 60 minutes.

The Engineer will decide when and where to sample shotcrete and the number of samples to collect for field testing. One production test panel is required per 33 yd^3 (25 m^3) of shotcrete applied with a minimum of 1 test panel per day. Apply shotcrete to production test panels at the same time shotcrete is applied for the application during construction. Make, cure and core production test panels in the same way as required for preconstruction test panels in accordance with Section 4.0. The compressive strength of the shotcrete will be considered the average compressive strength test results of 3 cylinder specimens from the same production test panel at 28 days.

6.0 MISCELLANEOUS

Comply with Articles 1000-9 through 1000-12 of the *Standard Specifications* to the extent applicable for shotcrete in lieu of concrete.

FOAMED CONCRETE (SPECIAL)

1.0 DESCRIPTION

This work consists of furnishing and placing foamed concrete of the appropriate type at the locations indicated on the plans and where directed by the Engineer. The Contractor shall furnish all labor, materials and equipment required for completing the work. The work shall be done in accordance with this provision and in conformity with the lines, grades, thickness and typical sections shown on the plans or established by the Engineer in writing.

The Contractor shall schedule a pre-construction meeting with the representatives of the Contractor, the subcontractors of this work, the Resident Engineer, and the Western Region Geotechnical Operations Engineer. The pre-construction meeting shall be conducted at least ten (10) working days prior to the start of any foamed concrete work to clarify the construction requirements, to provide appropriate scheduling of the construction activities and to identify contractual relationships and responsibilities. All costs associated with attending the pre-construction meeting shall be considered incidental to the work

The subcontractor of the foamed concrete work shall provide proven records of the following credentials to be approved for this project:

1. He shall be able to supply the required material for the project, and
2. He shall have done at least three (3) foamed concrete construction projects of similar size and nature to this project.

2.0 SUBMITTALS

Two (2) submittals are required. These submittals include (1) Foamed Concrete supplier experience and (2) detailed construction schedule and foamed concrete mix design.

Submit documentation that the Foamed Concrete supplier has successfully completed at least three (3) foamed concrete construction projects of similar size and nature to this project. Documentation should include the General Contractor and Owner's name and current contact information with descriptions of each past project.

Allow ten (10) working days for the review of the Foamed Concrete supplier experience submittal. After the personnel and experience submittal is accepted, submit the detailed construction schedule and the foamed concrete mix design at least five (5) working days before pre-construction meeting.

Do not begin foamed concrete construction until after the Foamed Concrete supplier experience submittal has been accepted and the pre-construction meeting has been held.

3.0 MATERIALS

A. Materials shall meet the requirements of the following:

Materials	Standard Specification Section
Portland cement (Type I, II, or III)	Section 1000
Fine Aggregate	Section 1014-1
Fly Ash	Section 1024-5
Boiler Slag	Section 1024-6
Water	Section 1024-4
Admixtures	Section 1024-3
Foaming agent	(See Below)

The foaming agent shall conform to the requirements of ASTM C-869 unless specified otherwise by this specification.

B. The foamed concrete shall conform to the following:

Cast Wet Density
68 lb/ft^3 +/- 3 lb/ft^3

Minimum Compressive Strength
300 psi at 7 days and
500 psi at 28 days

The foamed concrete shall be mixed in accordance with the recommendations of the supplier of the foaming agent. The Contractor shall be responsible for designing the mix so that the foamed concrete meets the corresponding criteria listed above.

C. Demonstrate mix density at the end of the hose prior to beginning placement for each pour. Adjust the mix density, as required, prior to beginning each pour. Re-verify the density at the point of placement at the beginning of the pour and thereafter at 30 minute intervals during the entire concrete placement. The Contractor shall adjust his operations as necessary to maintain the wet cast density within the specified range.

The Engineer will take samples of the foamed concrete to make specimens for the compressive strength tests at the point of placement. The Contractor shall assist the Engineer as needed to take the samples. The Engineer will sample as follows:

1. Six representative samples (3 in x 6 in cylinders) will be taken at the point of placement for each day's pour or each 100 cubic yards of material placed, whichever is more frequent. Samples will be marked for clear identification, and all pertinent field information will be recorded on the corresponding field report, including the station and elevation of the placement. Slump and air content will not be measured.

2. Samples will be obtained by overfilling the cylinders by pouring the concrete down the inside of the cylinders, allowing air to escape during filling. DO NOT ROD THE SAMPLES. The sides and bottom of the cylinder molds will be tapped to close any accidentally entrained air voids. Strike off the top of the cylinder (not more than three times) and cover.
3. Samples will be stored in accordance with ASTM C-495. Excessive handling may damage these test cylinders.
4. After 24 hours the samples will be transported to the appropriate NCDOT location for storage and testing. Three cylinders each will be compressive strength tested at both 7 days and 28 days. Compressive strength testing will be done in accordance with ASTM C-495 except cylinders will not be oven dried.

4.0 CONSTRUCTION METHODS

Mixing and placing operations shall be under the supervision of the Engineer. A representative of the supplier of the foaming agent shall be on site during the initial placement and at such times as requested by the Engineer to advise the Contractor on his operations. The foamed concrete shall be placed in lifts not less than nine (9) inches and not to exceed twenty (20) inches unless otherwise approved by the Engineer or noted on the plans. Subsequent lifts shall be placed only after a minimum 12 hour waiting period has been observed.

The foamed concrete shall be placed on supporting surfaces which have been cleaned of loose debris, dust, or other foreign material to the satisfaction of the Engineer. Dewater excavations prior to foamed concrete placement. Surfaces against which the foamed concrete is to be placed shall be free of ice, snow, or standing water and shall be at a temperature of 35°F or higher. Placement of concrete in cold weather must conform to Standard Specifications Section 420-7.

5.0 ACCEPTANCE CRITERIA

Foamed Concrete will be accepted based on the result of density tests at the time of placement and 7 day and 28 day compressive strength test results. All foamed concrete incorporated into the final work must meet the density requirements at the time of placement. The average compressive strength of three cylinders tested will be used to determine acceptance for the 7 day and 28 day compressive strength requirements. Additionally, no individual compressive strength test from each set of three cylinders may be more than 20 percent below the required compressive strength.

Failure to meet the cast wet density or the strength criteria may require removal and replacement of that entire lift, and all overlying lifts, at the Contractor's expense as determined by the Engineer.

6.0 MEASUREMENT AND PAYMENT

The quantity of *Foamed Concrete* to be measured for payment will be the actual quantity of *Foamed Concrete* in cubic yards incorporated into the completed project. Measurement will be

made in place based on the actual dimensions of foamed concrete completed and accepted. The quantity of foamed concrete measured as provided above will be paid for at the contract unit price per cubic yard for *Foamed Concrete*. No payment will be made for foamed concrete which does not meet the acceptance criteria. The unit bid price for this item shall include the cost of furnishing all equipment, labor, and materials necessary to complete the required work. All costs for form work, temporary supports for pipes, boxes, and welded wire fabric, cold weather insulating, density testing, dewatering excavations prior to foamed concrete placement, and incidentals, shall be included in the bid price for foamed concrete.

Payment will be made under:

Pay Item	**Pay Unit**
Foamed Concrete	Cubic Yard

CAST-IN-PLACE GRAVITY RETAINING WALLS (SPECIAL)

1.0 GENERAL

A cast-in-place (CIP) gravity retaining wall consists of CIP unreinforced concrete and is typically constructed in accordance with the CIP gravity retaining wall drawing included in the plans. Construct CIP gravity retaining walls based on actual elevations and dimensions in accordance with the contract and accepted construction submittal. For this provision, "CIP gravity wall" refers to a CIP gravity retaining wall.

2.0 MATERIALS

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Portland Cement Concrete, Class A	1000
Select Material, Class V	1016
Curing Agents for Concrete	1026
Joint Materials	1028
Reinforcing Steel	1070
Masonry	1040
Subdrain Fine Aggregate	1044-1

Use Class V Select Material (standard size no. 78M stone) and subdrain fine aggregate for subsurface drainage at weep holes.

3.0 CONSTRUCTION SUBMITTAL

The plans typically show a plan view, typical sections, details, notes and an elevation or profile view (wall envelope) for each CIP gravity wall. Before beginning CIP gravity wall construction, survey existing ground elevations at the wall face and other elevations in the vicinity of CIP gravity walls as needed. Based on these elevations, finished grades and actual CIP gravity wall dimensions and details, submit wall envelopes for review and acceptance. Use the accepted wall envelopes for construction.

4.0 CONSTRUCTION METHODS

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

Perform all necessary clearing and grubbing in accordance with Section 200 of the *Standard Specifications*. Excavate as necessary for CIP gravity walls in accordance with the plans and accepted construction submittal. Embed bottom of footings a minimum of 2 ft (0.6 m) below bottom of walls unless required otherwise on the plans. If applicable and at the Contractor's option, "temporary shoring for wall construction" may be used in lieu of temporary slopes to construct CIP gravity walls. 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.

Notify the Engineer when foundation excavation is complete. Do not place concrete until obtaining approval of the excavation depth and foundation material.

Construct CIP gravity walls at elevations shown in the accepted construction submittal and in accordance with the plans and Section 420 of the *Standard Specifications*. Extend top of walls 6" (150 mm) above grade elevations unless required otherwise on the plans.

Construct joints at a maximum spacing of 30 ft (9 m) unless required otherwise on the plans. 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.

Construct 3" (75 mm) diameter weep holes on 10 ft (3 m) centers along CIP gravity walls. Provide subsurface drainage at weep holes in accordance with Article 410-9 of the *Standard Specifications*. Exit weep holes just above finished grade and slope holes at 1" per foot (25 mm per 0.3 m) through walls so water drains out of the front of CIP gravity walls. If applicable, extend weep holes through concrete barriers in front of CIP gravity walls at the same slope.

Do not remove forms until concrete achieves a minimum compressive strength of 2400 psi (16.5 MPa). Unless required otherwise on the plans, provide a Class 2 Surface Finish for exposed faces of CIP gravity walls in accordance with Article 420-17 of the *Standard Specifications*.

Create a Simulated Stone Finish in accordance with the Architectural Concrete Surface Treatment and Cast-In-Place Simulated Stone Form Liner Surface Finish Special Provisions on all exposed faces unless a Natural Stone Veneer is required on the plans. If a Natural Stone Veneer is required on plans, consult the Natural Stone Veneer Special Provisions for more information.

Seal joints above and behind CIP gravity walls between walls and ditches with joint sealer.

5.0 MEASUREMENT AND PAYMENT

CIP Gravity Retaining Walls will be measured and paid for in square feet (meters). CIP gravity 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 concrete for CIP gravity walls. The bottom of wall elevation is as shown on the plans and no payment will be made for portions of CIP gravity walls below bottom of wall elevations.

The contract unit price for *CIP Gravity Retaining Walls* will be full compensation for providing submittals, labor, tools, equipment and CIP gravity walls materials, excavating, backfilling, hauling and removing excavated materials and providing concrete, concrete

facing, subsurface drainage at weep holes and any incidentals necessary to construct CIP gravity walls in accordance with the provision.

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 for *CIP Gravity Retaining Walls*.

The contract unit price for *CIP Gravity Retaining Walls* does not include the cost for fences, handrails, ditches, guardrail and barriers associated with CIP gravity walls as payment for these items will be made elsewhere in the contract.

Payment will be made under:

Pay Item	**Pay Unit**
CIP Gravity Retaining Walls	Square Foot (Meter)

NATURAL STONE VENEER (SPECIAL)

1.0 GENERAL

The natural stone veneer (masonry) shall be in accordance with the plans and the Standard Specifications with the following additions and exceptions.

A. Quality Assurance

The masonry veneer is to consist of natural stone that is similar in color and origin to stones in adjacent areas or walls. The stone is to be layed in a random ledgestone pattern with vertical inlays to replicate the patterns in within the historic masonry architecture of the Green Park Inn area, adjacent walls, or as directed by the Engineer.

Prior to construction of masonry work, actual stone samples or sections of stone shall be submitted for approval of color and texture. After approval, a sample veneer panel wall(s) shall be erected using proposed materials, and bond and joint tooling required for final work. Provide special features as directed for caulking and contiguous work. The sample panel(s) shall be built at the site, where directed, of full thickness and approximately 6.0 feet (L) x 4.0 feet (H), indicating the proposed range of color, texture and workmanship to be expected in the completed work. Written acceptance of visual qualities of the panel(s) shall be obtained prior to constructing any other masonry work.

An accepted panel shall be retained during construction as a standard for judging quality of completed masonry work. Approved panel shall not be altered, moved, or destroyed until all masonry work is completed. Sample panel may be used to test proposed cleaning procedures.

B. Protection of Work

Cold weather protection shall be in accordance with the Standard Specifications.

During erection, cover top of walls with heavy waterproof sheeting at end of each days' work. Cover partially completed structures when work is not in progress. Extend cover a minimum of 1.0 feet down both sides and hold cover securely in place.

Do not apply concentrated loads for at least 3 days after building masonry walls.

2.0 MATERIALS

A. Stone Masonry Units, General

Obtain natural stone from one or more quarries as needed to produce a veneering that meets the criteria noted above.

B. Masonry Accessories

For masonry accessories, see the special provision entitled "Masonry Accessories".

C. Mortar

Mortar shall be in accordance with Section 830-3 of the Standard Specifications. The color of the mortar sand shall match as close as possible the mortar of other walls within the Town of Blowing Rock, or adjacent walls, as directed by the Engineer.

3.0 **INSTALLATION**

A. General

Build single-wythe veneer to maximum thickness of the masonry units, using units of nominal thickness shown or specified.

Using conventional stone masonry construction methods, cut stones as needed to produce the ledgestone pattern.

Wet stone having ASTM C-67 absorption rates greater than 25 gal./(min. x 19.4 mm_2).

Frozen Materials and Work:

Do not use frozen materials or materials mixed or coated with ice or frost. For masonry which is specified to be wetted, comply with the BIA recommendations. Do not build on frozen work. Remove and replace masonry work damaged by frost or freezing.

Ledgestone Pattern:

Lay exposed stone masonry except where otherwise shown or specified, in a ledgestone pattern, as defined above or as directed by engineer.

Layout veneer in advance for accurate spacing of surface bond patterns, with varying joint widths to properly locate openings, movement-type joints, returns and offsets. Avoid the use of less-than-half size units at corners and where possible at other locations.

Lay-up stone veneer plumb and true and with courses level, accurately spaced and coordinated with other work.

Stopping and Resuming Work:

Rack back ½ masonry unit length in each course; do not tooth. Clean exposed surfaces of set masonry, wet units lightly (if specified to be wetted), and remove loose masonry units and mortar prior to laying fresh masonry.

B. Batch Control

Measure/batch materials by volume or weight, such that required proportions for mortar can be accurately controlled and maintained. Measurement of sand by shovel will not be permitted.

Mix mortars with maximum amount of water consistent with workability to provide maximum tensile bond strength within the capacity of the mortar.

Mix mortar ingredients for a minimum of 3 minutes and a maximum of 5 minutes in a mechanical batch mixer. Use water clean/free of deleterious materials which would impair the work. Discard mortar which has begun to set, or if more than 2 hours has elapsed since initial mixing or 1½ hr. in hot weather. Retemper mortar during first 1½ hr. period as required to restore workability.

Lay stone units with completely filled bed, head and collar joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not slush head joints.

C. Joints

Maintain consistent joint widths, except for minor variations required to maintain stone alignment. Deeply rake exposed joints between stones. Rake out mortar in preparation for application of caulking or sealants where shown.

Remove stone masonry units disturbed after laying; clean and relay in fresh mortar. Do not pound corners at jambs to fit stretcher units which have been set in position. If adjustments are required, remove units, clean off mortar, and reset in fresh mortar.

D. Anchoring Stone Masonry Veneer Work

Anchor single wythe stone masonry veneer to backing with metal ties as follows:

Anchor veneer to precast panels with metal anchors attached to dovetail slots embedded into the concrete structure. Provide anchors with flexible tie section, unless otherwise indicated.

Space veneer anchors not more than 1.25 ft o.c. vertically and 2.0 ft o.c. horizontally. Provide additional anchors with 1.0 ft of openings and space not more than 3.0 ft around perimeter.

At dovetail anchors in concrete walls space veneer anchors at each 5^{th} stone course vertically and 2.0 ft o.c. horizontally.

E. Control and Expansion Joints

Provide vertical control joints in stone masonry as in common in the industry, shown on plans or as directed by the Engineer. Build-in related masonry accessory items as masonry work progresses.

F. Repair, Pointing and Cleaning

Replace stone masonry units which are loose, chipped broken, stained or otherwise damaged, or if units do not match adjoining units as intended.

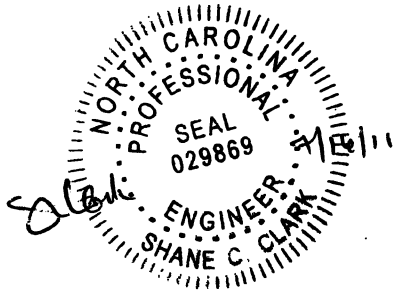
Provide new units to match adjoining units and install in fresh mortar pointed to eliminate evidence of replacement.

During tooling of joints, enlarge any voids or holes, except weepholes, and completely fill with mortar. Point-up all joints at corners, openings and adjacent work to provide neat, uniform appearance, properly prepared fro application of caulking or sealant compounds.

Clean exposed natural stone masonry surfaces by the bucket and brush, hand cleaning method or by high pressure water method.

4.0 BASIS OF PAYMENT

Payment for stone masonry veneer shall be paid per square foot contract price bid for the "Natural Stone Veneer" which price and payment shall be full compensation for all work covered by this special provision including but not limited to furnishing all materials (including native stone, mortar, masonry accessories, anchors, samples, etc.), labor tools, and equipment necessary for installing these units in place and accepted.



MASONRY ACCESSORIES (SPECIAL)

1.0 General

Types of masonry accessories include:

Stone veneer anchors

A. Quality Assurance

Provide masonry accessory units from a single source manufacturer.

Submit manufacturer's product data for each type of masonry accessory, and other manufactured products, including certifications that each type complies with specified requirements.

B. Delivery, Storage, and Handling

Deliver masonry accessories to project in undamaged condition.

Store and handle masonry accessories to prevent their deterioration or damage due to moisture, temperature changes, contaminants, corrosion or other causes.

Store masonry accessories including metal items to prevent deterioration by corrosion and accumulation of dirt.

2.0 MATERIALS

A. Joint Reinforcement, Ties and Anchoring Devices

Comply with requirements indicated below for basic materials and with requirements indicated under each form of joint reinforcement, tie and anchor for size and other characteristics:

Zinc-Coated (Galvanized) Steel Sheet:

Carbon steel with zinc coating complying with ASTM A 525, Coating Designation G90.

Application: Use for dovetail slots and where indicated.

Hot-Dip Galvanized Carbon Steel Sheet:

ASTM A 366, Class 2 or ASTM A 635; hot dip galvanized after fabrication to comply with ASTM A 153; Class B.

Application: Use for anchors.

Masonry Ties:

Stone Veneer:

Dovetail anchor slot:
1.0 inch wide x 1.0 inch deep with 0.75 inch throat, 20 gage, galvanized.

Dovetail with riangular ties anchor:
12 gage X 3/16" diameter X 7", hot dipped galvanized.

Stone Masonry Veneer Anchors: Two-piece assemblies which permit vertical or horizontal differential movement between wall and concrete wall parallel to, but resist tension and compression forces perpendicular to, plane of wall.

For anchorage to concrete work, provide manufacturer's standard anchors with dovetail anchor section formed from 2.7 mm (12 gage) thick sheet metal and corrugated metal tie section sized to extend within 1.0 inch of masonry face.

Dovetail Slots: Furnish dovetail slots, with filler strips, of slot size indicated, fabricated from
0.9 mm (20 gage) sheet metal.

Manufacturers: Subject to compliance with requirements, provide products of one of the following:

AA Wire Products Co.
Dur-O-Wall, Inc.
Heckman Building Products, Inc.
Hohmann & Barnard, Inc.
Masonry Reinforcing Corp. of America
National Wire Products Corp.

3.0 INSTALLATION

A. Anchoring Masonry Work

General

Provide anchor devices of type indicated.

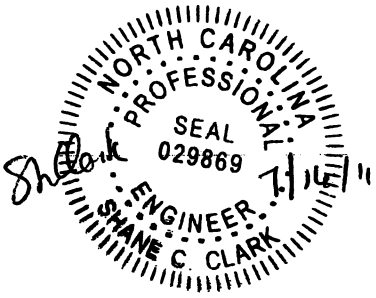
Anchor veneer to cast-in-place wall where masonry abuts or faces concrete wall to comply with the following:

Install stone veneering with a full mortar back. Anchor masonry to concrete wall with adjustable anchors embedded in dovetail slots and embedded into the concrete.

Space anchors as indicated, but not more than 2.0 ft o.c. vertically and 3.0 ft o.c. horizontally.

4.0 PAYMENT

No separate payment will be made for masonry accessories. The entire cost of the masonry accessories shall be considered incidental to the "Natural Stone Veneer" construction.



MOMENT SLAB WITH TL-2 BARRIER RAIL (SPECIAL)

1.0 GENERAL

Provide concrete barrier rails with moment slabs above retaining walls in accordance with the contract and accepted submittals.

2.0 MATERIALS

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Portland Cement Concrete	1000
Reinforcing Steel	1070
Barrier Delineators	1088-2

Use Class AA Concrete for concrete barrier rails and Class A Concrete for moment slabs in accordance with Article 1000-4 of the *Standard Specifications*. Use epoxy coated reinforcing steel for concrete barrier rails in accordance with Article 1070-8 of the *Standard Specifications*.

3.0 DESIGN SUMBITTAL

Design moment slab and barrier rail with the following considerations:

- The top of barrier rail shall be a minimum of 42" above the top of the sidewalk.
- The barrier rail and moment slab shall be designed for a TL-2 barrier as designated in AASHTO LRFD Bridge Design Specifications.
- The front and back faces of the barrier rail shall be plumb.
- The decorative stone relief, as defined in the Architectural Concrete Surface Treatment special provision, shall not be used for strength of the barrier rail. The thickness of the decorative stone relief pattern on the front or the back of the barrier rail shall be in addition to the concrete structural element used to meet the TL-2 barrier design.
- The decorative stone relief may be included to obtain the 42" barrier rail height.
- The barrier rail including the decorative relief shall not encroach on the 5'-0" width of sidewalk.
- The barrier rail is to sit in line and plumb with the wall finish face .
- All reinforcing steel in the barrier and moment slab shall be Grade 60 and shall be epoxy coated.
- Concrete for the barrier rail and moment slab shall be Class AA concrete as defined in the Standard Specifications.

Provide 11 hard copies of working drawings and 3 hard copies of design calculations for the moment slab with TL-2 barrier rail submittal and 4 hard copies of the remaining submittals. Also, submit an electronic copy (PDF on CD or DVD) of each submittal. Provide the submittal at least 30 calendar days before conducting the MSE Retaining Wall

with CIP Face preconstruction meeting. Do not begin wall construction until the design submittal is accepted.

4.0 CONSTRUCTION METHODS

Construct concrete barrier rails with moment slabs in accordance with the plans and accepted submittals. Construct cast-in-place reinforced concrete moment slabs in accordance with Section 420 of the *Standard Specifications* and concrete barrier rails in accordance with Subarticle 460-3(C) of the *Standard Specifications*.

Create a Simulated Stone Finish in accordance with the Architectural Concrete Surface Treatment and Cast-In-Place Simulated Stone Form Liner Surface Finish Special Provisions on all exposed faces.

Do not remove forms until concrete achieves a minimum compressive strength of 2400 psi (16.5 MPa).

5.0 MEASUREMENT AND PAYMENT

Moment Slab with TL-2 Barrier Rail will be measured and paid for in linear feet (meters). Concrete barrier rails with moment slabs will be measured as the length of concrete barrier rail above retaining walls. The contract unit price for *Moment Slab with TL-2 Barrier Rail* will be full compensation for providing concrete barrier rails with moment slabs in accordance with the contract.

Payment will be made under:

Pay Item	Pay Unit
Moment Slab with TL-2 Barrier Rail	Linear Foot (Meter)

MOMENT SLAB WITH TL-4 BARRIER RAIL (SPECIAL)

1.0 GENERAL

Provide concrete barrier rails with moment slabs above retaining walls in accordance with the contract and accepted submittals.

2.0 MATERIALS

Refer to Division 10 of the *Standard Specifications*:

Item	Section
Portland Cement Concrete	1000
Reinforcing Steel	1070
Barrier Delineators	1088-2

Use Class AA Concrete for concrete barrier rails and Class A Concrete for moment slabs in accordance with Article 1000-4 of the *Standard Specifications*. Use epoxy coated reinforcing steel for concrete barrier rails in accordance with Article 1070-8 of the *Standard Specifications*.

3.0 DESIGN SUMBITTAL

Design moment slab and barrier rail with the following considerations:

- The top of barrier rail shall be a minimum of 42" above the top of the sidewalk.
- The barrier rail and moment slab shall be designed for a TL-4 barrier as designated in AASHTO LRFD Bridge Design Specifications.
- The front and back faces of the barrier rail shall be plumb.
- The decorative stone relief, as defined in the Architectural Concrete Surface Treatment special provision, shall not be used for strength of the barrier rail. The thickness of the decorative stone relief pattern on the front or the back of the barrier rail shall be in addition to the concrete structural element used to meet the TL-2 barrier design.
- The decorative stone relief may be included to obtain the 42" barrier rail height.
- The barrier rail including the decorative relief shall not encroach on the 5'-0" width of sidewalk.
- The barrier rail is to sit in line and plumb with the wall finish face .
- All reinforcing steel in the barrier and moment slab shall be Grade 60 and shall be epoxy coated.
- Concrete for the barrier rail and moment slab shall be Class AA concrete as defined in the Standard Specifications.

Provide 11 hard copies of working drawings and 3 hard copies of design calculations for the moment slab with TL-4 barrier rail submittal and 4 hard copies of the remaining submittals. Also, submit an electronic copy (PDF on CD or DVD) of each submittal. Provide the submittal at least 30 calendar days before conducting the MSE Retaining Wall

with CIP Face preconstruction meeting. Do not begin wall construction until the design submittal is accepted.

4.0 CONSTRUCTION METHODS

Construct concrete barrier rails with moment slabs in accordance with the plans and accepted submittals. Construct cast-in-place reinforced concrete moment slabs in accordance with Section 420 of the *Standard Specifications* and concrete barrier rails in accordance with Subarticle 460-3(C) of the *Standard Specifications*.

Create a Simulated Stone Finish in accordance with the Architectural Concrete Surface Treatment and Cast-In-Place Simulated Stone Form Liner Surface Finish Special Provisions on all exposed faces.

Do not remove forms until concrete achieves a minimum compressive strength of 2400 psi (16.5 MPa).

5.0 MEASUREMENT AND PAYMENT

Moment Slab with TL-4 Barrier Rail will be measured and paid for in linear feet (meters). Concrete barrier rails with moment slabs will be measured as the length of concrete barrier rail above retaining walls. The contract unit price for *Moment Slab with TL-4 Barrier Rail* will be full compensation for providing concrete barrier rails with moment slabs in accordance with the contract.

Payment will be made under:

Pay Item	Pay Unit
Moment Slab with TL-4 Barrier Rail	Linear Foot (Meter)