Project Special Provisions
Structure

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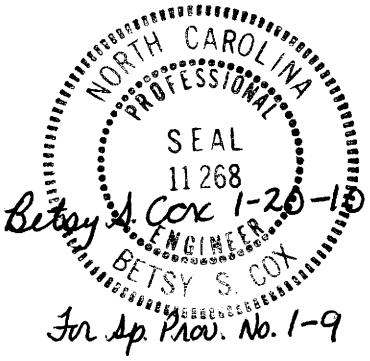

PROJECT SPECIAL PROVISIONS
STRUCTURE

PROJECT R-2100B **ASHE COUNTY**

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 (9-16-08)

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.

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

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.

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.

PILES (8-4-09)

Refer to Section 450 of the *Standard Specifications*.

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)		
Air or Grout Temperature Whichever is Higher	Maximum Elapsed Time	
	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.

PRESTRESSED CONCRETE MEMBERS **(4-02-07)**

The 2006 Standard Specifications shall be revised as follows:

In Section 1078-1 "General" of the Standard Specifications, add the following after the second paragraph:

(A) Producer Qualification

Producers of precast, prestressed concrete members are required to establish proof of their competency and responsibility in accordance with the Precast/Prestressed Concrete Institute's (PCI) Plant Certification Program in order to perform work for the project. Certification of the manufacturing plant under the PCI program and submission of proof of certification to the State Materials Engineer is required prior to beginning fabrication. Maintain certification at all times while work is being performed for the Department. Submit proof of certification following each PCI audit to the State Materials Engineer for continued qualification. These same requirements apply to producers subcontracting work from the producer directly employed by the Contractor.

Employ producers PCI certified in Product Group B, Bridge Products, and in one of the appropriate categories as listed below:

- B2 Prestressed Miscellaneous Bridge Products: Includes solid piles, sheet piles and bent caps.

- B3 Prestressed Straight-Strand Bridge Members: Includes all box beams, cored slabs, straight-strand girders and bulb-tees, bridge deck panels, hollow piles, prestressed culverts and straight strand segmental components.

- B4 Prestressed Deflected-Strand Bridge Members: Includes deflected strand girders and bulb-tees, haunched girders, deflected strand segmental superstructure components and other post-tensioned elements.

Categories for other elements will be as required by the project special provision or plans.

ADHESIVELY ANCHORED ANCHOR BOLTS OR DOWELS (6-11-07)

1.0 GENERAL

Installation and Testing of Adhesively anchored anchor bolts and dowels shall be in accordance with Section 420-13, 420-21 and 1081-1 of the Standard Specifications except as modified in this provision.

2.0 INSTALLATION

Installation of the adhesive anchors shall be in accordance with manufacturer's recommendations and shall occur when the concrete is above 40 degrees Fahrenheit and has reached its 28 day strength.

The anchors shall be installed before the adhesive's initial set ('gel time').

3.0 FIELD TESTING

Replace the third paragraph of Section 420-13 (C) with the following:

"In the presence of the Engineer, field test the anchor bolt or dowel in accordance with the test level shown on the plans and the following:.

Level One Field testing: Test a minimum of 1 anchor but not less than 10% of all anchors to 50% of the yield load shown on the plans. If less than 60 anchors are to be installed, install and test the required number of anchors prior to installing the remaining anchors. If more than 60 anchors are to be installed, test the first 6 anchors prior to installing the remaining anchors, then test 10% of the number in excess of 60 anchors.

Level Two Field testing: Test a minimum of 2 anchors but not less than 10% of the all anchors to 80% of the yield load shown on the plans. If less than 60 anchors are to be installed, install and test the required number of anchors prior to installing the remaining anchors. If more than 60 anchors are to be installed, test the first 6 anchors prior to installing the remaining anchors, then test 10% of the number in excess of 60 anchors.

Testing should begin only after the Manufacturer's recommended cure time has been reached. For testing, apply and hold the test load for three minutes. If the jack experiences any drop in gage reading, the test must be restarted. For the

anchor to be deemed satisfactory, the test load must be held for three minutes with no movement or drop in gage reading."

4.0 REMOVAL AND REPLACEMENT OF FAILED TEST SPECIMENS:

Remove all anchors and dowels that fail the field test without damage to the surrounding concrete. Redrill holes to remove adhesive bonding material residue and clean the hole in accordance with specifications. For reinstalling replacement anchors or dowels, follow the same procedures as new installations. Do not reuse failed anchors or dowels unless approved by the Engineer.

5.0 USAGE

The use of adhesive anchors for overhead installments is not permitted without written permission from the Engineer.

6.0 BASIS OF PAYMENT

No separate measurement or payment will be made for furnishing, installing, and testing anchor bolts/dowels. Payment at the contract unit prices for the various pay items will be full compensation for all materials, equipment, tools, labor, and incidentals necessary to complete the work.

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 – General** 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.

PLACING LOAD ON STRUCTURE MEMBERS (8-4-09)

The 2006 Standard Specifications shall be revised as follows:

Replace the fifth paragraph of Section **420-20 – Placing Load on Structure Members** with the following:

Do not place vehicles or construction equipment on a bridge deck until the deck concrete develops the minimum specified 28 day compressive strength and attains an age of at least 14 curing days. The screed may be rolled across a previously cast bridge deck if the entire pour has not achieved initial set. If any portion of the deck concrete has achieved initial set, the screed can not be rolled across the bridge deck until the concrete develops a compressive strength of at least 1,500 psi. Construction equipment is allowed on bridge approach slabs after the slab concrete develops a compressive strength of at least 3,000 psi and attains an age of at least 7 curing days. A curing day is defined in Subarticle 420-15(A).

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COBBLE FACED RETAINING WALL (SPECIAL)

1.0 GENERAL

A. Description

The work in this Special Provision governs the construction of the Cobble Faced Retaining Wall in accordance with the details and dimensions shown on the plans and this special provision. The term Cobble Faced Retaining Wall is used generically in this special provision to refer to any proprietary system able to satisfy this special provision and the contract plans.

The Cobble Faced Retaining Wall is composed of pre-assembled units made of double twisted wire mesh, a welded mesh panel, and two pre-formed steel brackets. The main unit is fabricated from soft tensile, heavily galvanized and PVC coated steel wire. The facing section of the unit is reinforced with additional PVC coated steel rods inserted through the twists during the manufacturing process. The steel wire mesh used in fabrication is according to ASTM A975-97. The facing retains cobbles and permits drainage. Attached behind the woven wire mesh is a welded wire mesh panel and hardware cloth. Two steel brackets, having a diameter of 0.309 in. (9.5mm), are used to pre-form to shape to the required retaining wall slope angle (6 degrees). Filter fabric is used as a separator between the cobbles and backfill.

B. Work Experience

Assign a field supervisor with experience on at least three (3) projects of similar scope to this project, completed over the past five (5) years. The on-site foreman must have completed three (3) projects within the last five (5) years involving installations of similar scope and size. The Department may suspend the construction work if the Contractor substitutes unqualified personnel and the Contractor shall be liable for additional costs resulting from the suspension.

Prior to the preconstruction meeting, submit the name of the Cobble Faced Retaining Wall Contractor and documentation to the Engineer.

C. Preconstruction Meeting

Conduct a Cobble Faced Retaining Wall preconstruction meeting with the field supervisor, the on-site foreman, the Resident Engineer and/or his or her representatives, the Area Roadway Engineer and the Geotechnical Operations Engineer to discuss construction and inspection of the Cobble Faced Retaining Wall.

2.0 MATERIALS

All materials are to be as specified or better, and as approved by the Engineer. Submit requests for substitutions to the Engineer 14 days before intended installation. The

materials used for the construction of the Cobble Faced Retaining Wall must satisfy the following requirements:

A. Wire

Use wire for the manufacture of the mesh and the lacing wire, that has a maximum tensile strength of 75,000 psi (515 MPa) as per ASTM A641/A641-03. Perform all tests on the wire before manufacturing the mesh. Use wire that complies with ASTM A975-97, style 3 coating, galvanized and PVC coated.

B. Woven Wire Mesh Type 8x10

Use mesh and wire for the manufacture of the units with characteristics that meet the requirements of ASTM A975-97 Table 1., Mesh type 8x10 and PVC coated. The nominal mesh opening, D = 3.25 in. (83 mm.) The minimum mesh properties for strength and flexibility should be in accordance with the following:

1) A minimum Mesh Tensile Strength of 2,900 lb/ft (42.3 kN/m) when tested in accordance with ASTM A975-97 section 13.1.1 is required

2) A minimum Punch Test resistance of 5,300 lb (23.6 kN) when tested in compliance with ASTM A975-97 section 13.1.4 is required.

3) A minimum Connection to Selvedges of 1,200 lb/ft (17.5 kN/m) when tested in accordance with ASTM A975-97 is required.

C. Polyvinyl Chloride Coating (P.V.C.)

The technical characteristics and the resistance of the PVC to aging should meet the relevant standards. The main values for the PVC material are as follows:

1) The initial property of the PVC coating shall be in compliance with ASTM A975-97 section 8.2.

2) Before UV and abrasion degradation, the PVC polymer coating shall have a projected minimum durability of 60 years when tested in accordance with UL 746B *Polymeric Material – Long Term Property Evaluation* for heat aging test.

D. Fabrication at Manufacturing Facility

1) Units

Manufacture and ship units with all components mechanically connected at the production facility. The units are supplied pre-assembled in a collapsed form, folded and bundled from the production facility. Each bundle is labeled with a tag reporting the size of the units contained.

2) Lacing Wire

Use lacing wire meeting all of the physical characteristics outlined in Section 2A, 2B, and 2C and having a minimum diameter of 0.127 in. (3.20 mm).

3) Ring Fasteners

Stainless steel ring fastener may be used instead of, or to compliment, the lacing wire. Use ring fasteners meeting the requirements of ASTM A975-97 section 6.3. Use ring fasteners with a minimum open dimension of 1.75 in (44 mm), a maximum closed diameter of 0.75 in (19 mm), and a nominal overlap of 1 in. (25 mm) after closure. Do not exceed a spacing of 6 in. (150 mm) for between each ring fastener. The rings can be installed using pneumatic or manual tools.

4) Pre-formed Steel Brackets

Pre-formed steel brackets manufactured for supporting the exposed face of the unit at the required finished slope angle and also to prevent any bulging of the face.

E. Hardware Cloth

Use a zinc coated hardware cloth with a mesh opening of 0.25 by 0.25 inches (6.4 by 6.4 mm).

F. Select Material Class II

Use Select Material Class II in accordance with Section 1016 of the 2006 *Standard Specifications for Roads and Structures*.

F. Filter Fabric

Use Engineering Fabric Type 1 in accordance with Section 1056 of the 2006 *Standard Specifications for Roads and Structures*.

G. Cobbles

Use cobbles meeting the requirements of Class A Riprap in Section 1043 of the 2006 *Standard Specifications for Roads and Structures* .

3.0 CONSTRUCTION REQUIREMENTS

Use reasonable care in handling, assembling and installing the units to prevent damage including damage to the PVC coating. Units damaged will be repaired in a manner satisfactory to the Engineer or replaced at no cost to the Department.

A. Assembly

The units are assembled individually by taking each folded unit out of the bundle and placing on a hard flat surface. Open the units, unfold, and press out of their original shape. When the units are unfolded for assembly, they will have one or two shipping folds. They can be removed by placing the fold over a board and walking along the sides.

The procedure for using lacing wire consists of cutting off a piece of wire approximately 1.5 times the length of the edge to be tied. Join longer edges by several lengths of wire. Secure lacing wires around the selvedge wire or heavier edge wire, where present, by looping and twisting the lacing wire around itself. Proceed tying with alternate double and single loops. Use double at intervals not greater than 6 in. (150 mm). Pull the units tightly together during the tying operation. Pliers may be used to create tight joints. Secure the other end of the tie wire by again looping and twisting the wire around itself. Use reasonable care to avoid damaging the wire coating.

When steel ring fasteners are used, the use of either a mechanical or a pneumatic fastening tool is required. Use a ring spacing in accordance with ASTM A975-97 Table 2, Panel to Panel connection, Pull-Apart Resistance. In any case, do not exceed a ring fastener spacing of 6 in. (150 mm). Install rings at the top and the bottom connections of the side and along all edges. Use lacing wire or fasteners, as described in Section 2.0, for all connections.

B. Installation

After the foundation has been prepared, place the pre-assembled units in position empty, and tie or fasten to adjacent units along all edges in order to form a continuously connected monolithic structural unit. Place and secure the woven wire mesh and hardware cloth inside the facing element of the unit, a minimum of 6 in. (150 mm) overlap is required on top and bottom. Use a minimum return of 6.5 feet (2 m) in length for the uppermost course at the top of the structure.

Place units in position according to the required wall angle. Place and securely attach pre-form steel brackets to the reinforcing steel wire in the anchor panel and at the top of the welded panel. (Make a small cut to the filter fabric, if necessary) Use reasonable care when placing the backfill and cobbles to ensure that the PVC coating is not damaged.

C. Filter Fabric Installation

Install filter fabric as a separator between the cobbles at the face of the wall and the fill, as shown on plans

D. Placing Fill

Place fill in accordance with Section 235 of the 2006 *Standard Specifications for Roads and Structures*.

After a layer of fill has been placed, perform sufficient hand shoveling to achieve a level top surface before compaction is performed.

E. Compaction

Compact fill in accordance with Section 235 of the 2006 *Standard Specifications for Roads and Structures*.

The number of compaction layers will be as such to achieve the required vertical spacing between the units, according to the project specifications.

F. Placing Cobbles

After the installation of the filter fabric and compacted fill, place the cobbles behind the facing a minimum distance of 24 in. (0.6 m). Hand place cobbles at the wall face to provide a uniform, dry stacked appearance. Perform soil compaction within 3 ft (1 m) of the face carefully with a walk behind compactor to prevent any wall distortion or bulging of the face unit.

G. Top of each Unit

Once the compacted layers have achieved the top of the unit, fold the top end and securely staple to the soil.

Connect all adjacent units (above, underneath and sideways) along the face at contact edges. Bury the top return portion of the last unit on top 12 in. (300 mm) beneath the soil surface.

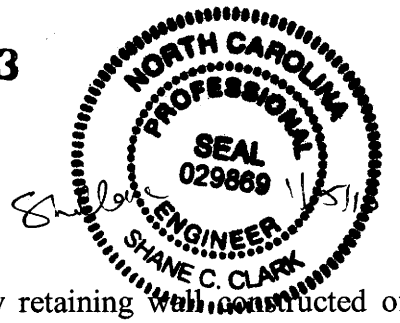
4.0 MEASUREMENT AND PAYMENT

Cobble Faced Retaining Wall will be measured and paid for as the actual number of square feet of exposed face area incorporated into the completed and accepted retaining wall. The wall height is measured as the difference between the top and bottom of the wall. The bottom of wall is defined as the point where the finished grade intersects the front of the wall. The top of the wall is defined as the top elevation of the completed Cobble Faced Retaining Wall

The contract price and payment will be full compensation for furnishing all labor, materials (including excavation and backfill) required to provide the Cobble Faced Retaining Wall including but not limited to those items as shown on the plans and contained in this special provision.

Payment will be made under:

Cobble Faced Retaining Wall .....Square Foot (Square Meter)



PRECAST GRAVITY RETAINING WALLS (SPECIAL)

1.0 GENERAL

A precast gravity retaining wall is a gravity retaining wall constructed of unreinforced precast concrete units and a geogrid/engineering fabric reinforced leveling pad. Design and construct precast gravity retaining walls based on actual elevations and dimensions in accordance with the contract and accepted submittals. For this provision, "precast gravity wall" refers to a precast gravity retaining wall and "precast units" refer to unreinforced precast concrete units.

2.0 PRECAST GRAVITY WALL DESIGN SUBMITTAL

Submit 11 hard copies of working drawings and 3 hard copies of design calculations and an electronic copy (PDF on CD or DVD) of each for the precast gravity wall design submittal. Provide the submittal at least 30 calendar days before conducting the precast gravity wall preconstruction meeting. Do not begin precast gravity 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 precast gravity wall. When noted on plans and before beginning precast gravity wall design, survey existing ground elevations shown on the plans and submit a revised wall envelope for review and acceptance. Use the accepted revised wall envelope for design.

Design precast gravity walls in accordance with the plans and Section 5.9 of the *AASHTO Standard Specifications for Highway Bridges* unless otherwise required. Design precast gravity walls to meet minimum clearances shown on the plans. Do not locate precast units or footings beyond right-of-way or easement lines.

Use 12 inch (300 mm) thick geogrid/engineering fabric reinforced Class VI footings beneath precast units that extend a minimum of 6" (150 mm) in front of the bottom row of precast units and has a total length of not less than 10 feet when measured from the front of the extension to the back edge of the geogrid/engineering fabric. Unless required otherwise on the plans, embed bottom of footings a minimum of 2 ft (0.6 m) below where finished grade intersects the front face of precast gravity walls.

Fill precast unit core spaces with no. 57 stone, if applicable. Assume a unit weight of 100 pcf (15.7 kN/m^3) for stone. Fill between and behind precast units with no. 57 stone for a horizontal distance of at least 18" (450 mm) and make stone continuous in all directions. When adjacent precast units are different sizes, it may be necessary to fill behind units with more than 18" (450 mm) of no. 57 stone to make stone continuous. Place separation fabric between stone and backfill, natural ground or overlying aggregate. When a subdrain pipe is required with a note on plans, use a 4" (100 mm) dia. continuous perforated subdrain pipe in the no. 57 stone behind the bottom row of precast units.

At the Contractor's option, use cap or top precast units at top of walls unless there is a back slope or barrier above precast gravity walls as shown on the plans. For precast gravity walls with back slopes, use top precast units only and extend top of walls a minimum of 4" (100 mm) above where finished grade intersects the back of walls. If necessary, adjust paved ditch width or back slope for varying grade elevations along top of walls and make ditches continuous with cast-in-place concrete ditches when top of wall steps down. When barriers are required above precast gravity walls, do not use cap precast units and use concrete barrier rails with moment slabs in accordance with 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 maximum applied bearing pressures, typical sections, separation fabric locations and details of footings, precast units, etc. If necessary, include details on working drawings for cast-in-place concrete ditches, concrete barrier rails with moment slabs and obstructions extending through walls. Submit design calculations for each wall section with different surcharge loads, geometry or material parameters. When using a software program for design, provide a hand calculation verifying the analysis of the tallest wall section. Have precast gravity walls designed, detailed and sealed by a Professional Engineer registered in North Carolina.

3.0 MATERIALS

A. Leveling Pad

Provide geogrid/engineering fabric reinforced, compacted stone leveling pads. The geogrid/engineering fabric can be composed of polyester or polypropylene and must have minimum long-term design strength of 1745 lb/ft in the reinforcement direction. The geogrid/engineering fabric will be placed in the middle of the compacted Class VI stone. Provide a calculation verifying that he ultimate wide width tensile strength (ASTM D4595) is adequate to provide the required long-term design strength.

B. Precast Concrete Units

Provide precast concrete units meeting the requirements of Sections 1000 and 1077 of the *Standard Specifications*. A minimum compressive strength of 4000 psi (27.6 MPa) at 28 days is required. For testing precast units 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.

With the exception of front faces of precast units, provide a final finish in accordance with Article 1077-11 of the *Standard Specifications*. Unless required otherwise on the plans, provide precast units with a vertical rock like face and a concrete gray color with no tints, dyes, pigments or stains. Before beginning precast unit production, obtain approval of the precast unit type, face and color proposed for the project.

C. No. 57 Stone

Use standard size no. 57 stone meeting the requirements of Class VI Select Material in accordance with Section 1016 of the *Standard Specifications*.

D. Wall Drainage Systems

Wall drainage systems consist of subdrain pipes and outlet components. Use subsurface drainage materials meeting the requirements of Section 815 of the *Standard Specifications*.

E. Separation Fabrics

Use separation fabrics meeting the requirements of Type 1 Engineering Fabric in accordance with Section 1056 of the *Standard Specifications*.

F. 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*.

4.0 PRECAST GRAVITY WALL PRECONSTRUCTION MEETING

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

5.0 CONSTRUCTION METHODS

Control drainage during construction in the vicinity of precast gravity walls. Direct run off away from precast gravity walls, no. 57 stone and backfill. Contain and maintain stone and 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 precast gravity 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 precast gravity walls. For this provision, temporary shoring for wall construction is defined as temporary shoring not shown on the plans or required by the Engineer including shoring for OSHA reasons or the Contractor's convenience.

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

Construct cast-in-place concrete footings at elevations and with dimensions shown in the accepted submittals and in accordance with Section 420 of the *Standard Specifications*. Cure footings a minimum of 24 hours before placing precast units.

Place precast units with no negative batter (wall face leaning forward) such that the final position is as shown in the accepted submittals. Stagger vertical precast unit joints to create a running bond when possible unless shown otherwise in the accepted submittals. Place precast units with a maximum joint width of ½ inch (13 mm). Construct precast gravity walls with a horizontal tolerance of ¾ inch (19 mm) when measured with a 10 ft (3 m) straight edge and a vertical tolerance within 2 degrees of the batter shown in the accepted submittals.

If a subdrain pipe is required, construct wall drainage systems as shown in the accepted submittals and in accordance with Section 815 of the *Standard Specifications*. Provide subdrain pipes with positive drainage towards outlets. Place no. 57 stone between and behind precast units in 8 to 10 inch (200 to 250 mm) thick lifts. Compact stone with hand operated compaction equipment. Overlap separation fabric a minimum of 18" (450 mm) at seams. Backfill for wall construction behind no. 57 stone in accordance with Article 410-8 of the *Standard Specifications*. Set cap precast units with a ½ to 1-½ inch (13 to 38 mm) overhang.

Construct cast-in-place concrete 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). 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*.

6.0 MEASUREMENT AND PAYMENT

Precast Gravity Retaining Walls will be measured and paid for in square feet (meters). Precast 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 cap/top precast units. The bottom of wall elevation is defined as where the finished grade intersects the front face of the precast gravity wall. No payment will be made for portions of precast gravity walls below bottom of wall elevations.

The contract unit price bid for *Precast Gravity Retaining Walls* will be full compensation for design, submittals, furnishing labor, tools, equipment and precast gravity wall materials, excavating, backfilling, hauling and removing excavated materials and providing leveling pads, precast units, no. 57 stone, wall drainage systems, fabrics and any incidentals necessary to design and construct precast gravity 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 *Precast Gravity Retaining Walls*.

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

Payment will be made under:

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

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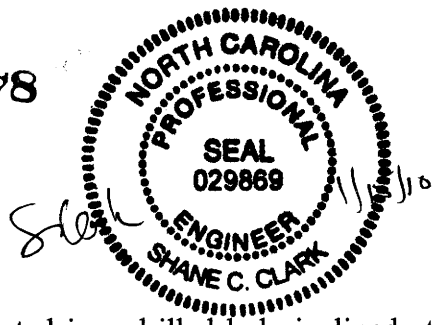

SOIL NAIL RETAINING WALLS (2-16-10)

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.

A Design Engineer is required to design soil nail walls. Submit documentation that the Design Engineer is registered as a Professional Engineer in North Carolina and has at least 5 years experience in designing soil nail walls with heights and in subsurface conditions similar to those for this project. Documentation should include resumes, references, certifications, project lists, experience descriptions and details, etc. The Design Engineer may also act as the Project Manager provided the Design Engineer meets the Project Manager requirements above.

B. Soil Nail Wall Design Submittal

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

Design 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.

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 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 in accordance with 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 interfering with soil nails 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 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 in accordance with Section 7.0.

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 bent 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. 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

Use drain and outlet materials meeting the requirements of Section 816 of the *Standard Specifications*.

C. Shotcrete

Use shotcrete in accordance with the contract.

D. 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*.

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 Concrete Barrier Rails with Moment Slabs

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

G. Joint Materials

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

4.0 SOIL NAIL WALL 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, Project Manager and Design Engineer 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, Concrete Facing and Concrete Barrier Rails with Moment Slabs

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.

If a brick veneer is required as shown on the plans, construct brick masonry in accordance with Section 830 of the *Standard Specifications*. Anchor brick veneers to concrete facing with approved brick to concrete type anchors according to the manufacturer's specifications with a minimum vertical spacing of 16" (400 mm) and a minimum horizontal spacing of 32" (800 mm) with each row staggered 16" (400 mm) from the row of anchors above and below.

Construct concrete barrier rails with moment slabs in accordance with the plans. Construct 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*. Seal joints above and behind soil nail walls between concrete facing and ditches with joint sealer as shown on the plans.

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 SOIL NAIL 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. The bottom of wall elevation is defined as where the finished grade intersects the front face of the soil nail wall. No payment will be made for portions of soil nail walls below bottom of wall elevations.

The contract unit price bid for *Soil Nail Retaining Walls* will be full compensation for design, submittals, furnishing 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 and any incidentals necessary to design and construct soil nail walls in accordance with this provision. If necessary, the contract unit price bid for *Soil Nail Retaining Walls* will also be full compensation for providing brick veneers in accordance with the contract.

The contract unit price bid for *Soil Nail Retaining Walls* does not include the cost for fences, hand rails, ditches, guardrail and barriers. With the exception of concrete barrier rails with moment slabs, see roadway pay items for these items.

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

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 price bid 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

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.