Project Special Provisions
Structures & Culverts

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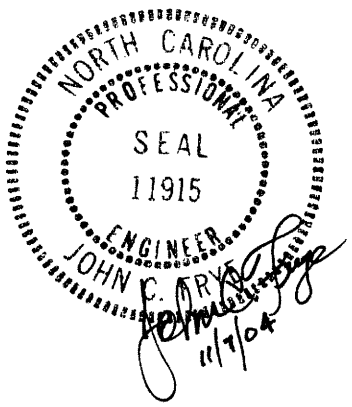

Revised 12-10-04

PROJECT SPECIAL PROVISIONS
STRUCTURES AND CULVERTS

PROJECT R-2237B **CALDWELL COUNTY**

MSE RETAINING WALLS (SPECIAL)

1.0 DESCRIPTION

Design, prepare plans, and construct MSE retaining walls to the lines, grades and locations shown in the plans and in accordance with this specification and the details shown in the plans. Work includes all excavation, leveling pad, concrete face panel, concrete coping, retaining wall backfill, the fabric above the #57 stone, and all other materials, labor, tools, equipment and incidentals necessary to complete the work.

Select a company experienced in the design, manufacturing, and supervision of permanent mechanically stabilized earth (MSE) retaining wall components that has successfully completed at least 3 projects in the last 3 years involving construction of permanent MSE retaining walls totaling at least 20,000 square feet (2000 square meters) of wall face area.

A Professional Engineer registered in the State of North Carolina employed by the MSE Wall Company and having experience in the construction of at least 3 completed MSE wall projects over the past 3 years, must supervise the work.

Submit the experience qualifications and details for the referenced design and construction projects of similar size and scope completed during the last three years, including a brief project description with the owner's name and current phone number.

The Engineer will approve or reject the Contractor's MSE wall company qualifications within 15 calendar days after receipt of a complete submission. Work or design must not be started nor materials ordered until written approval of the qualifications is given.

Document and submit any substitution of personnel to the Engineer for approval.

Value engineering proposals for other wall systems are not considered.

Design the retaining walls to meet the criteria of the current AASHTO Standard Specifications for Highway Bridges and the requirements specified in the plans.

Submit eight sets of complete working drawings/shop plans, erection plans and design calculations, sealed by a North Carolina Registered Professional Engineer, for review and approval prior to beginning wall work. Allow 40 days for review and approval from the date they are received by the Engineer until they are returned to the Contractor.

Provide the option chosen to meet the requirements of the plans, this Special Provision and the Standard Specifications.

2.0 GENERAL

The Resident Engineer schedules a Preconstruction Conference with representatives from the Contractor, the retaining wall system Supplier, and the Geotechnical Engineering Unit to discuss construction details and inspection of the retaining wall.

Provide all necessary material from the Supplier chosen.

Obtain from the Supplier technical instruction and guidance in preconstruction activities, including the Preconstruction Conference, and on-site technical assistance during construction. Follow any instructions from the Supplier closely unless otherwise directed.

3.0 MATERIALS

A. Concrete Panels

Provide the concrete mix designed by the Supplier and approved by the State Materials Engineer prior to use. Furnish a copy of the Supplier's approval to the Engineer and to the Materials and Tests Unit in Raleigh. Design the mix to meet the strength requirements included in this Special Provision under the heading "Casting of Precast Concrete Face Panels".

B. Concrete Leveling Pad

Provide Class A concrete conforming to the applicable requirements in Sections 420 and 1000 of the Standard Specifications for the leveling pad.

C. Concrete Coping

Use Class A Concrete for coping and apply the requirements in Sections 420, 1000, and 1077 of the Standard Specifications. The requirements in Sections 425 and 1070 of the Standard Specifications apply to the reinforcing steel in coping. If preferred, precast coping is permitted unless otherwise stated in the plans.

D. Reinforcing Steel, Reinforcing Mesh, Mats, or Strips, Tie Strips and Fasteners

Use reinforcing Steel conforming to the applicable requirements in Sections 425 and 1070 of the Standard Specifications.

Shop-fabricate tie strips of hot rolled steel conforming to the minimum requirements of ASTM A570-85, Grade 50 (Grade 345) or equivalent. Shop fabricate the reinforcing mesh or mats of cold drawn steel wire conforming to the minimum requirements of AASHTO M32 (M32M) and weld into the finished mesh fabric in accordance with AASHTO M55 (M55M). Hot roll reinforcing strips from bars to the required shape and dimensions with their physical and mechanical properties conforming to AASHTO M223 (M223M), Grade 65 (Grade 450). Cut to lengths and tolerances shown on the plans and punch holes for bolts in the locations shown on plan details. The minimum bending radius of tie strips is 1 inch (25 mm). Inspect all reinforcing and tie strips carefully to ensure they are true to size and free from defects that may impair their strength or durability. Galvanize in accordance with the minimum requirements of AASHTO M111.

Use 1/2" (12.70 mm) diameter bolts, nuts and washers conforming to AASHTO M164 (M164M). Provide Bolt and thread lengths in accordance with Supplier's recommendations. Hot-dip galvanize bolts and nuts in accordance with the requirements of AASHTO M232 (M232M).

E. Miscellaneous Panel Components and Attachment Devices

Provide miscellaneous concrete face panel components, including dowels, polyvinylchloride pipe, stirrups, etc., in accordance with the Supplier's recommendations.

Fabricate clevis connector and connector bar from cold drawn steel wire conforming to the requirements of AASHTO M32 (M32M) and welded in accordance with AASHTO M55 (M55M). Galvanize loops in accordance with AASHTO M111.

Cold form mat anchors or buttonheads, where applicable, symmetrically about the axis of the wire to develop the minimum guaranteed ultimate tensile strength of the wire. Do not use a cold forming process that causes indentations in the wire. Provide mat anchors and buttonheads that do not contain wide open splits or splits not parallel with the axis of the wire.

Galvanize mat anchors and buttonheads after fabrication in accordance with the requirements of AASHTO M111. Repair damage to the galvanized coating prior to or during installation in the acceptable manner providing a coating comparable to that provided by AASHTO M111.

F. Joints and Joint Materials

Provide the type and grade bearing pads approved by the chosen Supplier.

Where shown on the plans, provide a polyester filter fabric cover, approved by the Supplier, for horizontal and vertical joints between panels. Use adhesive approved by the manufacturer to attach the fabric material to the rear of the facing panels.

G. Alignment Pins

Use 5/8" (16 mm) diameter, mild steel and smooth bars galvanized in accordance with AASHTO M111 for pins to align the face panels during construction.

H. #57 Washed Crushed Stone Backfill (Retaining Wall)

Use backfill material conforming to the applicable requirements of Section 1005 of the Standard Specifications and meeting the following criteria:

- Free of organic or otherwise deleterious substances.
- Contains a maximum organic content of 0.1%.
- Soundness (AASHTO T104): Have a maximum weighted average loss of 15% when subjected to five cycles of the soundness test.
- Resistance to Abrasion (AASHTO T96): Have a maximum percentage of wear of 55%.
- Electrochemical:

	Resistivity > 5000 ohm-cm	ASTM D1125
	4.5 < pH < 9.5	ASTM D1293

Before placing any backfill, furnish a Type IV certification in accordance with Article 106-3 of the Standard Specifications. Include a copy of all test results conducted in accordance with the above requirements in the certification. The Engineer determines how often NCDOT samples backfill material to assure compliance with gradation and electrochemical requirements.

1. Sample Preparation

Obtain approximately 2,000 grams of representative material and transfer it into a 1 gallon (3.8 liters) wide mouth plastic jug. Then add an equal weight of deionized or distilled water to the sample, and let this mixture set for approximately 30 minutes. At the end of this period, place a lid on the container and vigorously agitate the mixture for 3 minutes. Repeat this agitation at the 2 hour and 4 hour intervals. Allow the sample to set for approximately 20 hours after the 4 hour agitation so the solids will settle out. At this time remove a sufficient amount of the solution and filter through a coarse paper (Fisher Q8) to obtain the supernate to be analyzed in accordance with the above procedures.

2. Backfill Separation Fabric

Place a layer of fabric on top of the completed wall backfill to prevent migration of fines from common backfill placed above from contaminating the wall backfill.

Use fabric meeting the applicable requirements for Type 2 fabric as described in Section 1056 of the Standard Specifications.

Overlap the fabric a minimum of 18 inches (460 mm).

4.0 CASTING OF PRECAST CONCRETE FACE PANELS

A. General

Cast concrete face panels and apply the requirements of Sections 1000 and 1077 of the Standard Specifications.

B. Acceptance

Supply concrete for precast panels that attains a 28 day compressive strength of 4000 psi (27.6 MPa) unless otherwise shown on plans.

Acceptance of the concrete face panels with respect to compressive strength is determined on the basis of production lots. A production lot is a group of panels that is represented by a single compressive strength sample and consists of either 40 panels or a single day's production, whichever is less. Make compression tests on standard 6" x 12" (152 mm by 305 mm) or 4" x 8" (102 mm by 203 mm) test specimens prepared in accordance with AASHTO T23. Conduct compressive strength testing in accordance with AASHTO T22.

Cast a minimum of four cylinders for each production lot sampled. Cure all specimens in the same manner as the panels. An acceptance test result is the average compressive strength of two cylinders.

The lot is acceptable if the test results are equal to or greater than 4000 psi (27.6 MPa).

If a production lot fails to meet the specified compressive strength requirements, the production lot is rejected unless the Supplier, at his own expense, obtains and submits evidence of a type acceptable to the Engineer that the strength and quality of the concrete placed within the panels of the production lot is acceptable. If such evidence consists of tests made on cores taken from the panels within the production lot, obtain and test the cores in accordance with the requirements of AASHTO T24.

C. Miscellaneous

1. Casting

Set all panel components in place in the forms to conform to the details on the plans and accepted shop plans prior to casting. Cast the panels on a flat area with the front face of the form at the bottom and the rear face at the top. Set tie strip guides or clevis connectors on the rear face.

Give special care to the clevis connectors: Place all clevis connectors normal to the panel and attach them to the alignment templates using the bars provided with the forms. Tolerance for the vertical and horizontal alignment of the clevis connectors is ±1/8" (3 mm). Clean the holes inside the loops so that they are free of all concrete and debris.

Place the concrete in each unit without interruption and consolidate using an approved vibrator, supplemented by hand tamping to force the concrete into corners of the forms and prevent the formation of stone pockets or cleavage planes. Use clear form oil of the same manufacture throughout the casting operation.

2. Concrete Finish

Provide an ordinary surface finish as defined by Subarticle 420-18(B) of the Standard Specifications for the front face (exposed face of wall) unless otherwise shown on the plans. Screed the rear face of the panel to a uniform surface finish to eliminate open pockets of aggregate and surface distortions in excess of 1/4 inch (6 mm).

3. Tolerances

Manufacture all units within the following tolerances:

- All dimensions within 3/16 inch (5 mm), except the lateral position of the tie strips to within 1 inch (25 mm).
- Surface defects on formed surfaces are not to exceed 1/8 inch in 5 feet (3mm in 1.5 m).

4. Marking

Clearly scribe the date of manufacture, the production lot number, and the piece-mark on the rear face of each panel.

5. Handling, Storage and Shipping

Handle, store and ship all units in such manner as to eliminate the danger of discoloration, chipping, cracks, fractures and excessive bending stresses. Support panels in storage on firm blocking located immediately adjacent to tie strips to avoid bending the tie strips. Store panels in a horizontal position and stack no more than six high. Do not ship panels prior to 5 days after production.

5.0 CONSTRUCTION METHODS

A. Site Preparation

Perform surface excavation operations and random fill construction in the vicinity of the structure in accordance with the applicable portions of this Special Provision, and in reasonably close conformity to the lines, grades, dimensions, and cross-sections shown on the plans.

B. Retaining Wall Excavation

Excavate all material necessary for the construction of the retaining walls in accordance with the plans and this provision. Excavation includes the construction and subsequent removal of all necessary bracing, shoring, sheeting and cribbing and all pumping, bailing, and draining. Perform random backfilling in accordance with the details in the plans and dispose of or stockpile surplus or unsuitable excavated material as directed by the Engineer.

Perform all necessary clearing and grubbing at the site in accordance with Section 200 of the Standard Specifications.

Notify the Engineer a sufficient time before beginning the excavation so that measurements may be taken of the undisturbed ground.

Shore or brace the excavation in accordance with local and state safety standards. Perform excavation and related work in such sequence that no portion of the retaining wall will be endangered by subsequent operations.

When the retaining wall is adjacent to a traveled way, obtain approval before beginning the excavation. Submit drawings and design calculations in accordance with the provisions of Subarticle 410-5(D) of the Standard Specifications.

Notify the Engineer after excavating each location of the wall. Do not place the concrete leveling pad until the depth of the excavation and the character of the foundation material have been approved.

Remove all sheeting and bracing as the random backfilling progresses.

Obtain approval for all random backfill material. Large or frozen lumps, wood or other undesirable material is not allowed in the backfill. Compact all backfill in accordance with Subarticle 235-4(C) of the Standard Specifications.

C. Wall Erection

1. Foundation Preparation

Prior to wall construction, grade the foundation for the structure level for a width equal to or exceeding the length of soil reinforcing or as shown on the plans. Compact the foundation to a minimum of 95% of the maximum dry density as determined by AASHTO T99.

2. Leveling Pad Construction

Construct an unreinforced concrete leveling pad of Class A concrete having the dimensions and at the locations and elevations shown on the plans. Cure the leveling pad a minimum of 24 hours before placement of wall panels.

3. Placing Concrete Face Panels

Place precast concrete panels vertically with equipment that does not damage the panels. For erection, handle panels by means of eyes set into the upper edge of the panels. Use other placement methods when approved by the Supplier and Engineer. Place panels in successive horizontal lifts in accordance with the details and at the locations shown on the plans. Externally brace the first lift of panels. Proceed with backfill placement as hereinafter specified. As panel and backfill lifts progress, maintain the panels in vertical position by means of temporary wooden wedges placed in the joint at the junction of the two adjacent panels on the external side of the wall. The maximum tolerance for vertical (plumbness) and horizontal alignment is 3/4 inch (19 mm) when measured along a 10 foot (3 m) straightedge. The maximum allowable offset in any panel joint is 3/4 inch (19 mm). The overall vertical tolerance of the wall (plumbness from top to bottom) is 1/2 inch (13 mm) per 10 feet (3 m) of wall height. As wall erection progresses, install horizontal and vertical joint filler in accordance with the Supplier's instructions.

4. Placing Retaining Wall Backfill and Soil Reinforcing

Place backfill within the structure closely following the erection of each lift of panels. Place the backfill material in layers for the full width shown on the plans. Place layers not more than 7½ inches (190 mm) in depth loose thickness and compact. Compact #57 stone backfill with at least four passes of an 8 – 10 ton (7.3 - 9.1 metric ton) vibratory roller in the vibratory mode, or as directed by the Engineer. At each tie strip level, reinforcing mesh level, or reinforcing mat level of the wall, level and compact the backfill material before placing and attaching tie strip, mat or mesh. Place the reinforcing strips, mat or mesh normal to the face of the wall or as shown on the plans. Compact backfill layers in a direction parallel to the wall and without disturbance or distortion of reinforcing strips, mats, mesh, or wall panels. Use only a hand-operated mechanical compactor within 3 feet (1 m) of the face of the wall as a precaution against pushing panels outward and distorting the vertical face of the wall. Exercise extreme care to prevent bending panel tie strips, mats, or mesh during compaction. Compact as required with a minimum of three passes of the compactor.

At the end of each day's operation, slope the areas adjacent to the stone backfill such that in the event of rain, surface runoff will be diverted away from the backfill area. Contamination of the stone backfill by soil fines from runoff is grounds for rejection of the backfill.

5. Placing Concrete Coping

When cast-in-place coping is used, place a 1/2 inch deep vertical contraction joint in all exposed faces at a spacing equal to two panel widths and in accordance with Article 825-10(B) of the Standard Specifications. Place the contraction joints in the coping so that it aligns with the vertical joints between the panels.

6.0 BASIS OF PAYMENT

Payment will be made under:

MSE Retaining Walls, Sta. _____ .....Lump Sum

FALSEWORK AND FORMWORK (10-12-01)

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 420-17 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)	Translyvania	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, metallize or otherwise protect these devices as directed by the Engineer. 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. 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 (8-13-04)

1.0 GENERAL

Submit working drawings in accordance with Article 105-2 of the Standard Specifications and the requirements of this Special Provision. The list of submittals contained herein does not represent a list of required submittals for this project. Submittals are only necessary for those items as required by the Standard Specifications, other Special Provisions, or contract plans. Make submittals that are not specifically noted in this Special Provision directly to the Resident Engineer.

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

2.0 WORKING DRAWINGS SUBMITTAL CONTACTS

All submittals noted herein are reviewed by the Structure Design Unit and/or the Geotechnical Engineering Unit.

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@dot.state.nc.us

Secondary Structures Contacts:

James Gaither (919) 250 – 4042
Man-Pan Hui (919) 250 – 4044

Eastern Regional Geotechnical Contact (Divisions 1-7):

K. J. Kim
(919) 662 – 4710
(919) 662 – 3095 facsimile
kkim@dot.state.nc.us

Western Regional Geotechnical Contact (Divisions 8-14):

John Pilipchuk
(704) 455 – 8902
(704) 455 – 8912 facsimile
jpilipchuk@dot.state.nc.us

3.0 SUBMITTAL COPIES

The quantities provided in this Special Provision act as a guide in the submittal process.

Unless otherwise required by the contract, submit two sets of supporting calculations to the Structure Design Unit.

Furnish one complete copy of the submittal, including all attachments, to the Resident Engineer. If requested, provide additional copies of any submittal. At the same time, submit the following number of copies directly to the Structure Design Unit and/or the Geotechnical Engineering Unit:

Working Drawing 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
Box Culvert Falsework [2]	5	0	Plan Note & SN Sheet
Cofferdams [4]	6	1	Articles 410-5 and 420-8
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 (superstructure)	8	0	Article 420-3
Falsework & Forms [2] (substructure)	8	0	Article 420-3
Mechanically Stabilized Earth Retaining Walls [4]	7	1	"MSE Retaining Walls"
Metal Bridge Railing	8	0	Plan Note
Metal Stay-in-Place Forms	8	0	Article 420-3
Metalwork for Elastomeric Bearings [5,6]	7	0	Article 1072-10
Miscellaneous Metalwork [5,6]	7	0	Article 1072-10
Overhead Sign Assemblies	13	0	Article 903-3(C)
Pile Points	7	1	Article 450-8(D) & "Steel Pile Points"
Placement of Equipment on Structures (cranes, etc.)	7	0	Article 420-20

Precast Concrete Box Culverts	2, then 1 reproducible	0	"(Optional) Precast Reinforced Concrete Box Culvert at Station ___"
Precast Retaining Wall Panels	10	0	Article 1077-2
Pot bearings [5]	8	0	"Pot Bearings"
Prestressed Concrete Deck Panels	6 and 1 reproducible	0	Article 420-3
Proprietary retaining walls [4]	9	1	Applicable Project Special Provision
Prestressed Concrete Girder (strand elongation and detensioning sequences)	6	0	Articles 1078-8 and 1078-11
Prestressed Concrete Cored Slab (detensioning sequences) [3]	6	0	Article 1078-11
Revised Bridge Deck Plans (adaptation to metal stay-in-place forms)	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"
Soil Nail Retaining Walls [4]	4	1	Applicable Project Special Provision
Sound Barrier Wall Steel Fabrication Plans [6]	7	0	Article 1072-10 & "Sound Barrier Wall"
Sound Barrier Wall Casting Plans	10	0	Article 1077-2 & "Sound Barrier Wall"
Structural Steel [5]	2, then 7	0	Article 1072-10
TFE Expansion Bearings [5]	8	0	Article 1072-10
Temporary Detour Structures [4]	10	1	Article 400-3 & "Construction, Maintenance and Removal of Temporary Structure at Station ____"
Temporary Shoring [4]	6	1	Article 410-4 & "Temporary Shoring for Maintenance of Traffic"

Temporary Fabric or Wire Walls [8]	0	2	Applicable Project Special Provision
Permanent Anchored Tieback Retaining Walls [4]	4	1	Applicable Project Special Provision
Evazote Joint Seals [7]	9	0	Applicable Project Special Provision
Optional Disc Bearings [5]	8	0	"Optional Disc Bearings"
Removal of Existing Structure over Railroad	5	0	Railroad Special Provisions
Drilled Pier Construction Sequence Plans [8]	0	2	"Drilled Piers"
Pile Hammers [8]	0	2	Article 450-6

FOOTNOTES

1. References are provided to help locate the part of the contract where the working drawing submittals are required. References in quotes refer to the Project Special Provision by that name. Articles refer to the Standard Specifications.
2. Submittals for these items are necessary only when plan notes require them.
3. Submittals for these items may not be required. A list of pre-approved sequences is available from the producer or the Materials and Tests Unit.
4. These submittals are reviewed by the Structure Design Unit and the Geotechnical Engineering Unit. If NCDOT Shoring Standards are used, working drawings need not be submitted, but the Shoring Selection Form should be forwarded to the Geotechnical Engineering Unit.
5. The fabricator may submit these items directly to the Structure Design Unit.
6. The two sets of preliminary submittals required by Article 1072-10 of the Standard Specifications are not required for these items.
7. Submittals for Fabrication Drawings are not required. Submission of Catalogue Cuts of Proposed Material is required. See Section 5.A of the Project Special Provision.
8. Submittals for these items are reviewed by the Geotechnical Engineering Unit only and correspondence regarding these items should be directed to and will come from the Geotechnical Engineering Unit.

SOIL NAIL RETAINING WALLS

1.0 GENERAL

The work under this section consists of design, plan preparation and construction of soil nail retaining walls to the lines and grades shown in the plans and in accordance with these specifications.

Soil nailing consists of excavating in lifts, drilling holes into the ground, placing and grouting the nail tendons in the holes, placing geocomposite drain strips and installing weep holes, applying temporary shotcrete facing, installing the nail head anchorage assembly and constructing the permanent cast-in-place concrete facing.

The term "Soil Nail" as used in this special provision is intended as a generic term and refers to a reinforcing bar grouted into a drilled hole installed in any type of ground including soil, weathered rock and hard rock.

The Contractor must be experienced in the construction of permanent soil nail retaining walls and have successfully constructed at least 3 projects in the last 3 years involving construction of permanent soil nail retaining walls totaling at least 10,000 square feet (1000 square meters) of wall face area and at least 500 permanent soil nails.

A professional engineer registered in the state of North Carolina employed by the soil nailing Contractor and having experience in the construction of at least 3 completed permanent soil nail retaining wall projects over the past 3 years, must supervise the work. The manufacturers' representatives cannot be used to satisfy the supervising Engineer requirements of this section.

Submit the experience qualifications and details for the referenced design and construction projects, including a brief project description with the owner's name and current phone number. The Engineer will have 15 calendar days to approve or reject the proposed soil nailing Contractor and Designer.

The Contractor is advised to review all available subsurface information and conduct additional investigations, as needed, to determine subsurface conditions such as high groundwater, unstable soil, hard rock, etc. that would adversely affect the cost of construction.

Submit 5 copies of plans and calculations to the Engineer for review and approval and allow 40 calendar days from the date they are received until the Engineer returns them.

A pre-construction meeting is required prior to the start of the work and will be attended by representatives of the Contractor, Resident Engineer and the Geotechnical Engineering Unit. Soil nailing requires organized coordination of each of these parties. Conduct the pre-construction meeting to clarify the construction requirements, provide appropriate scheduling of the construction activities and identify contractual relationships and

responsibilities. Review of all submittals should be complete prior to scheduling the pre-construction meeting.

Value engineering proposals for other wall types will not be considered.

2.0 DESIGN CRITERIA AND PLAN REQUIREMENTS

Design and construct soil nail retaining walls in accordance with the Service Load Design (SLD) procedures contained in the FHWA "Manual for Design and Construction Monitoring of Soil Nail Walls", Report No. FHWA-SA-96-069 and the Soil Nailing Field Inspectors Manual, Publication No. FHWA-SA-93-068. The required partial safety factors, allowable strength factors and minimum global stability soil factors of safety must be in accordance with the FHWA manual, unless specified otherwise. Estimated soil/rock design shear strength parameters, slope and external surcharge loads, type of wall facing and facing architectural requirements, soil nail corrosion protection requirements, known utility locations, easements and right-of-ways will be as shown on the "Layout Drawings" or specified herein. Structural design of any individual wall elements not covered in the FHWA manual will be by the service load design methods in conformance with Article 3.22 and other appropriate articles of the latest Edition of the AASHTO Standard Specifications for Highway Bridges including current interim specifications.

Use the soil parameters shown on the plans for design of the wall. Design all components of the wall for 100-year design life.

Include calculations and details for the cast-in-place concrete facing in the soil nail retaining wall design. The cast-in-place concrete facing must be a minimum 8 inches (200 mm) in thickness. Cast the concrete face to produce an Ashlar Stone pattern on the final face. A minimum 6 inch (150 mm) thick by 1 foot (300 mm) wide unreinforced concrete leveling pad is required for the cast-in-place facing.

Temporary shotcrete facing is required and must be a minimum of 4 inches (100 mm) in thickness and reinforced with welded wire and #4 (#13) bars running horizontally above and below the nails and behind the bearing plates.

Geocomposite drainage mats at minimum 10 foot (3 m) centers are required.

A minimum nail inclination of 12 degrees is required. The nail holes must be a minimum of 6 inches (150 mm) and a maximum of 10 inches (250 mm) in diameter with a minimum center to center spacing of 3 feet (1 meter). A minimum clearance from end of soil nail to bottom of nail hole of 6 inches (150 mm) is required. Corrosion protection consisting of epoxy coated bars is required.

Embed the wall to the top of the leveling pad a minimum of 2 feet (600 mm) below the proposed finished bottom of wall grade.

Do not extend nails beyond the Right of Way or easement line.

The submitted plans should include but will not be limited to the following:

- Elevation views showing all nail locations, proposed ground line elevations and stations, proposed leveling pad elevations and construction joint locations.
- Plan views.
- Section views showing shotcrete and concrete reinforcement, vertical nail locations, nail inclinations, drainage details, etc.
- Details of nail head anchorage assemblies, nail holes, drainage mats, etc.
- Verification test nail locations and required design adhesion values.
- Construction sequence.

A professional engineer registered in the state of North Carolina must seal all plans and calculations.

3.0 QUALITY ASSURANCE

The Contractor's superintendent must have a minimum of three years experience and the drill operators and on-site supervisors must have a minimum of one year experience installing permanent soil nails or ground anchors. Prior to starting the work, submit a list identifying the superintendent, drill rig operators and on-site supervisors assigned to the project. The list must contain a summary of each individual's experience and must be sufficiently complete for the Engineer to evaluate the individual qualifications. Consultants or manufacturer's representatives cannot be used to satisfy the requirements of this section.

All nozzlemen are required to have at least one year of continuous experience in similar shotcrete application work and must demonstrate ability to satisfactorily place the material in accordance with the recommendations of ACI 506.3R Guide to Certification of Shotcrete Nozzlemen. Evidence that the proposed nozzelman have been certified to the requirements of ACI 506.3R within the last five years is required.

Work cannot be started nor materials ordered until the Contractor's personnel qualifications have been approved by the Engineer. The Engineer may suspend the work if the Contractor substitutes non-approved personnel for approved personnel. The Contractor will be fully liable for costs resulting from the suspension of work and no adjustments in the contract time resulting from the work suspension will be allowed.

4.0 CONSTRUCTION SUBMITTALS

Provide the following submittals for the Engineer's review and approval. Changes or deviations from the approved submittals must be re-submitted for approval by the Engineer. The Contractor will not be allowed to begin wall construction until all submittal requirements are satisfied and found acceptable to the Engineer. No adjustments in

contract time will be allowed due to incomplete submittals. Items listed below that have been included on the contractor prepared plans need not be resubmitted.

At least 30 days prior to initiating the work, submit to the Engineer:

1. Proposed schedule and detailed construction sequences.

2. Methods of excavation to the staged lifts indicated in the plans and excavation equipment types.

3. Drilling methods and equipment.

4. Nail grout mix design including:

   - Brand and type of Portland cement.

   - Source, gradation and quality of all aggregates.

   - Proportions of mix by weight.

   - Compressive strength test results (per AASHTO T106) verifying the required minimum seven day grout compressive strengths or previous test results completed within one year of the start of the work may be submitted for verification of the required compressive strength.

5. Nail grout placement procedures and equipment.

6. Soil nail testing methods and equipment including:

   - Details of the jacking frame and appurtenant bracing.

   - Details showing methods of isolating test nails during shotcrete application (i.e., methods to prevent bonding of the soil nail bar and the shotcrete).

   - Details showing methods of grouting the unbounded length of test nails after completion of testing.

   - Equipment list.

7. Identification number and certified calibration records for each load cell, test jack pressure gauge and jack master pressure gauge to be used. Calibration records must include the date tested, device identification number and the calibration test results and be certified for an accuracy of at least two percent of the applied certification loads by a qualified independent testing laboratory within 30 days prior to submittal.

8. Certified mill test results for nail bars together with properly marked samples from each heat specifying the ultimate strength, yield strength, elongation and composition.

9. Certifications of compliance for bearing plates and nuts.

10. A detailed construction dewatering plan addressing all elements necessary to divert, control and dispose of surface water.

11. Certified concrete and shotcrete mix designs including:

    - Brand and type of Portland cement used.
    - Source, gradation and quality of aggregates as specified herein.
    - Proportions of mix by weight.
    - Proposed admixture, manufacturer, dosage, technical literature if allowed.
    - Compressive strength test results verifying the 3-day and 28-day compressive strengths.

12. Certified mill tests for all reinforcing steel together with properly marked samples from each heat specifying the minimum ultimate strength, yield strength, elongation and composition.

13. Complete engineering data for the drainage geotextile and geocomposite drain strip including a 1 ft (300 mm) square sample, manufacturers' certificate of compliance and installation instructions.

14. Certifications of Compliance for weep hole drainage pipes and curing compounds (if used).

15. Specification and data for review on equipment proposed for the project including shotcreting and compressed air equipment, form work for Ashlar stone face, proposed access arrangements and capacities.

5.0 MATERIALS

All materials must conform to the requirements of the applicable sections of the Standard Specifications for Roads and Bridges of the North Carolina Department of Transportation and the following provisions:

Centralizers	PVC pipe or tube, steel or other material not detrimental to the nail steel (wood must not be used); securely attached to the nail bar; sized to position the nail bar within 1 inch (25 mm) of the center of the drill hole; sized to allow tremie pipe insertion to the bottom of the drill hole; and sized to allow grout to freely flow up the drill hole.
Nail Grout	Neat grout is to be used with a minimum seven day compressive strength of 3000 psi (21 MPa) per AASHTO T106 and a minimum cement of nine sacks per cubic yard.
Cement	Portland Cement conforming to AASHTO M85 Type I, II or III.
Fine Aggregate	Clean, natural sand, AASHTO M6. Artificial or manufactured sand will not be accepted.
Coarse Aggregate	AASHTO M-80, Class B for quality.
Water	Potable, clean and free from substances deleterious to concrete and steel or elements that would cause staining.
Chemical Admixtures	ASTM C1141 and the following:
Accelerator	Fluid type, applied at nozzle, meeting requirements of ASTM D98, C494 Types C or E and C266.
Water-reducer and Superplastisizer	AASHTO M-194, Type A, D, F or G.
Air-Entraining Agent	AASHTO M-194.
Plasticizers	AASHTO M-194, Type A, D, F or G.
Mineral Admixtures:	
Fly Ash	AASHTO M-295, Type F or C.
	Silica Fume ASTM C1240, 90 percent minimum silicon dioxide solids content, not to exceed 12 percent by weight of cement.
Reinforcing Bars	AASHTO M-31, Grade 60 or 75 (420 or 520), deformed. See Section 1070 of the Standard Specifications .
Welded Wire	AASHTO M55/ASTM A185 or A497.
Curing Compounds	AASHTO M-148, Type ID of Type 2.
Prepackaged Concrete	ASTM C928.

Excavation Protection	AASHTO M-171 or Polyethylene film.
Solid Bar Nails	AASHTO M31, Grade 60 or 75 (420 or 520) (or Grade 150, 1035 for testing only), threaded steel bars without splices or welds. All bars must be new, straight, undamaged and epoxy coated.
Epoxy Coating	AASHTO M284. Minimum 12 mils (0.3 mm) electrostatically applied. Bend test requirements will be waived.
Bearing Plates	AASHTO M183 steel plates bearing plates must be furnished by the nail bar manufacturer.
Nuts	AASHTO M291, Grade B, hexagonal fitted with beveled washer or spherical seat to provide uniform bearing. Nuts must be furnished by the nail bar manufacture.
Washer	AASHTO M291 steel.
Joint Filler & Sealant	Section 1028 of the Standard Specifications.
Geocomposite Drain	Miradrain 6200 or Equal.
Weep Hole	ASTM 1785 Schedule 40 PVC, solid and perforated wall.
Drainage Pipe	Cell classification 12454-B or 12354-C, wall thickness SDR 35, with solvent weld or elastomeric gasket joints.
Fittings	ASTM D3034, cell classification 12454-B or 12454-C, wall thickness SDR 35, with solvent weld or elastomeric gasket joints.

6.0 HANDLING AND STORAGE

Carefully handle and store all steel reinforcement items and nail steel on supports to prevent contact with the ground. Damage to the nail steel as a result of abrasion, cuts or nicks, welds and weld spatter will be cause for rejection. Grounding of welding leads to the nail steel will not be allowed. Protect nail steel from dirt, rust and other deleterious substances at all times. Corrosion or pitting of the nails will be cause for rejection. Any epoxy coated nails that are damaged or defective in a manner that adversely affects the strength or serviceability of the unit must be repaired to the satisfaction of the Engineer or rejected and removed from the site by the Contractor at no additional cost to the Department. Repair epoxy coating using an epoxy field repair kit approved by the epoxy manufacturer.

Handle encapsulated nails in a manner that does not crack or otherwise damage the grout inside the sheath.

Provide drainage geotextile and geocomposite drains in rolls wrapped with a protective covering and store in a manner that protects the fabric from mud, dust, dirt, debris and shotcrete rebound. Do not remove protective wrapping until the geotextile or drain strip is installed. Avoid extended exposure to ultra-violet light. Label each roll of geotextile or drain strip in the shipment to identify that production run.

Adequately store cement to prevent moisture degradation and partial hydration. Do not use cement that is caked or lumpy.

7.0 DEWATERING AND DAMAGE CONTROL

Localized areas of perched water may be encountered at the interface of geologic units. Contact the Engineer if groundwater problems persist at the excavation face.

Provide all labor, equipment and materials required to maintain the work area in a sufficiently dry condition such that adverse water related effects do not occur during the construction period. Provide positive control and discharge of all surface water and perched ground water, if encountered, to the extent necessary to prevent adverse conditions as determined by the Engineer.

Damage caused by failure of the construction dewatering and drainage control plan to existing structures, soils or structures included in the work will be repaired by the Contractor to the Engineer's satisfaction at no additional cost to the Department.

The Contractor will be responsible for the condition of any pipe or conduit which may be used for temporary construction dewatering and all such pipes or conduits must be maintained clean and free of sediment during construction. Upon substantial completion of the work, remove construction dewatering conduits from the site. Alternatively, construction dewatering conduits can be fully grouted (abandoned) or left in a manner that protects the structure and all adjacent facilities from migration of fines through the conduit and potential ground loss.

All dewatering and drainage control costs will be considered incidental to the cost of the soil nail retaining wall.

8.0 EXCAVATION

A. Mass Grading

Overexcavating the original ground beyond the final wall face will not be allowed. In the event that overexcavation beyond the final wall face occurs as a result of the Contractor's operations, restore such overexcavation using a method approved by the Engineer and at no additional cost to the Department.

B. Wall Face Excavation

Excavate from the top down in a staged horizontal lift sequence as shown in the approved submittals. The excavated surface ("neat line") must be within 1 inch (25 mm) of the location shown on the approved submittals. Do not excavate the ground level in front of the wall face more than 3 feet (1 m) below the level of the row of nails to be installed in that lift. Do not excavate a lift until nail installation, reinforced shotcrete placement and nail testing for the preceding lift are complete and acceptable to the Engineer. Prior to advancing the excavation, allow shotcrete and nail grout on the preceding lift to cure for a minimum one day and three days, respectively. After a lift is excavated, clean the cut surface of all loose materials, mud, rebound and other foreign material that could prevent or reduce shotcrete bond. The excavated vertical wall face cannot be exposed for more than 24 hours for any reason.

Take all necessary measures to ensure that installed nails are not damaged during excavation. Repair or replace to the satisfaction of the Engineer and at no cost to the Department nails that are damaged or disturbed during excavation. Remove hardened nail grout protruding from the final wall excavation more than 2 inches (50 mm) in a manner that prevents fracturing the grout at the nail head. Sledge hammer removal of the grout is not allowed. The use of hand held rock chippers is acceptable provided their use does not damage or disturb the remaining grout at the nail head, the nail bar or the surrounding exposed ground.

Complete the excavation to the final wall face ("neat line") and application of the shotcrete in the same work shift unless otherwise approved by the Engineer. Extensions of the excavation face exposure period must be approved by the engineer. The Contractor must demonstrate for each material type at his own expense that the unsupported final excavation face will be stable over the proposed extension of the exposure period. Extensions to the face exposure period will be periodically reviewed and may be revoked by the Engineer at his discretion. Risk of damage to existing structures or structures included in this work will be borne by the Contractor where approval for extended face exposure period is granted by the Engineer. Where extension of the face exposure period is allowed, provide and install polyethylene sheets (properly anchored to the top and bottom of the excavation) to reduce degradation of the cut face caused by changes in soil moisture, unless otherwise approved by the Engineer.

C. Wall Discontinuities

Where the Contractor's excavation and installation methods result in a discontinuous wall along any continuous nail row, the ends of the wall at the points of discontinuity must be constructed to prevent sloughing or failure of the temporary slopes. Submit a plan for wall discontinuity construction sequencing and shoring to the Engineer for review and approval at least 30 days prior to starting work on the affected wall sections.

D. Protrusions and Voids

Remove all cobbles, boulders, rubble or debris which are encountered at the soil face during excavation and which protrude from the soil face more than 2 inches (50 mm) into the design shotcrete thickness shown on the plans. Backfill any overexcavations with shotcrete. Any shotcrete used to fill voids created by the removal of cobbles and boulders or other obstructions will be considered incidental to the shotcrete wall facing and no additional payment will be made. Generally, rocky ground such as colluvium, hard rock, fill with boulders and weathered rock will be difficult to excavate on a neat line without leaving pockets and voids. The Contractor is recommended to evaluate the subsurface conditions in order to anticipate the total volume of shotcrete needed.

E. Excavation Face Instability

Raveling or local instability of the final wall face excavation due to the presence of groundwater, problematic soil conditions, equipment vibrations or other causes must be brought to the immediate attention of the Engineer.

Temporarily stabilize unstable areas by means of buttressing the exposed face with an earth berm or other methods acceptable to the Engineer. Suspend work in unstable areas until remedial measures submitted by the Contractor and approved by the Engineer have successfully stopped facial instability.

Timber backing or lagging behind soil nail walls that is to remain in place and is greater than 1 inch (25 mm) total thickness must be pressure treated with wood preservative for soil and fresh water use in accordance with AWPB LP-22 to a minimum retention 4 pounds per cubic foot (0.06 kilonewtons per cubic meter). Use one of the following wood preservatives: Creosote, Creosote-Coal tar solution, Penta Chlorophenol, Copper Naphthenate, ammonia copper arsenate, ammoniacal, copper zinc arsenate, acid copper chromate or chromated copper arsenate.

F. Access

If temporary work benches are required to install the nails, locate these benches behind any traffic barriers placed for protection of existing traffic. Payment for temporary work benches including the placement and removal of fill and any temporary shoring required will be considered incidental to the cost of the temporary soil nail wall. Equipment and nails may hang over the existing lanes; however, implement lane closures in accordance with the Traffic Control Plans such that equipment and nails do not hang over or into traffic.

9.0 INSTALLATION

A. Classification of Materials

No classification of drilled materials will be made except for identification purposes. Nail installation will include the removal and subsequent handling of all materials encountered in drilling the holes to the required lengths.

B. Equipment

Use drilling equipment that can drill straight and clean holes and has the size and capability to install nails as specified herein. This will include drill rigs with the capability of nail installation and grout placement through the drill casing or hollow-stem auger where drill hole stability cannot be maintained in open holes. Provide sufficient casing/auger lengths on site to maintain uninterrupted installation of soil nails. Where hard drilling conditions such as rock, cobbles, boulders or obstructions are encountered, a down-hole, pneumatic hammer drill bit may be required to advance the nail holes.

C. Drilling

Drill each nail hole at the locations and to the lengths and minimum diameters indicated in the approved submittals unless otherwise approved by the Engineer. Remove cuttings from the holes using compressed air or by mechanical auger flights. Compressed air may not be used where raveling or erodible conditions cause significant disturbance or voids to develop or where facial instability is induced. Water, drilling muds or other fluids used to assist in cutting removal will not be allowed. At final penetration depth, thoroughly clean and make ready the nail hole for examination by the Engineer before nail bar installation or placement of grout. No portion of the nail hole may be left open for more than 60 minutes prior to grouting unless otherwise approved by the Engineer.

D. Nail Hole Support

Provide positive support of the hole during drilling as required to prevent excessive groundwater infiltration or sloughing and caving of the hole prior to nail insertion and/or grouting. Where caving and sloughing occurs, no further drilling will be allowed until the Contractor selects a method which prevents ground movement. Holes must be continuously supported by casing or alternate methods approved by the Engineer. Drilling fluids such as bentonite or water will not be allowed as a means of hole support. All installation material and other costs due to casing holes will be at no additional expense to the Department.

Provide casing made of steel construction and of ample strength to withstand handling and installation stresses, grout pressure, surrounding earth and groundwater pressures. Remove casings as the grout is placed. The casing extraction may be facilitated by the use of a vibratory extractor, if required. During removal, continually align the casing with the hole.

E. Optional Nail Installation Methods

Optional nail installation methods will require the approval of the Engineer. At the Contractor's option, a thin shotcrete layer may be installed prior to drilling nail holes provided that this construction sequence has been documented and approved by the Engineer. Include in the Contractor's documentation calculations demonstrating the bearing plates are adequate to service the design loads and transfer the stress to the wall

by neglecting the bearing area beneath the plate encompassed by the drill hole or block out.

F. Production Nails

No drilling or bar placement for production nails will be allowed without prior written approval by the Engineer of the proposed drilling, installation and grouting methods. Only installation methods that have been successfully verification tested will be approved for production nail installation. Methods which fail to meet the verification and proof test acceptance criteria will be rejected. Methods that differ from those used during installation of verification nails will require additional verification nails prior to approval at no additional cost to the Department.

Provide bar sizes and grades for each nail hole as indicated in the approved submittals. Fit the bar with centralizers as shown in the plans and insert into the drill hole to the required depth without difficulty and in such a manner as to prevent damage to the drill hole and corrosion protection. Where the bar cannot be completely inserted, remove the bar and clean or redrill the hole to permit unobstructed installation. Partially installed bars may not be driven or forced into the drill hole and will be rejected. When using open-hole drilling methods are being used, hole cleaning tools suitable for cleaning drill holes along their full length just prior to bar insertion and/or grouting are required.

G. Grouting

Grout the drill hole after installation of the nail bar. Grouting prior to insertion of the nail bar may be allowed provided neat grout without sand is used and the nail bar is immediately inserted through the grout to the specified design length without difficulty. Nails inserted in the grout that has taken set will be rejected and must be replaced at no additional cost to the Department. No portion of the nail hole may be left open for more than 60 minutes prior to grouting unless otherwise approved by the Engineer. Inject grout at the lowest point of each drill hole through a grouting conduit and fill the hole in one continuous operation. Gravity flow of grout into the nail hole from the excavation face will not be allowed. Cold joints in the grout placement will not be allowed, except for proof test nails. Pump the grout through a grout tremie pipe, casing, hollow-stem auger or drill rods. Maintain the conduit delivering the grout at least 5 feet (1.5 m) below the surface of the grout as the conduit is withdrawn. Withdraw the grouting conduit at a slow and even rate as the nail hole is filled in a manner that prevents the creation of voids. A sufficient quantity of grout to fill the entire nail hole must be available in delivery trucks or grout mixing/pumping plants when the first grout is placed in each nail hole. Record the quantity of grout and the grouting pressures.

If the grouting of any nail is suspended for more than 30 minutes before grouting is complete or if the quality of the grout placement results in a nail that does not satisfy any of the requirements specified herein, then remove and dispose of the steel and grout and install fresh grout and undamaged steel at no additional cost to the Department.

1. Grout Testing

   Provide nail grout that has a minimum compressive strength of 3000 psi (21 Mpa) in seven days. Test the nail grout in accordance with AASHTO T106 at a frequency no less than every 50 cubic yards (38 cubic meters) of grout placed or once per week, which ever comes first.

2. Grouting Equipment

   Provide grouting equipment that produces a uniformly mixed grout free of lumpy and undispersed cement. A positive displacement grout pump is required. Use a pump with a pressure gauge which can measure at least twice but no more than three times the intended grout pressure and a stroke counter (for piston-type grout pumps). Grout pumps without the specified pressure gauge and piston-type grout pumps without a stroke counter may not be used. Size the grouting equipment to be able to grout the entire nail in one continuous operation. A mixer that is capable of continuously agitating the grout during usage is required.

H. Attachment of Bearing Plate and Nut

Attach the bearing plate and nut as shown in the approved submittals. Seat the plate by hand wrench tightening the nut such that uniform contact with the shotcrete is achieved while the shotcrete is still plastic and prior to its initial set. Where uniform contact between the plate and the shotcrete cannot be provided, seat the plate on a mortar pad to provide uniform support. Once the mortar pad has attained strength (minimum one day), hand tighten the nut with a wrench.

Replace bearing plates that are damaged or defective as determined by the Engineer at no additional cost to the Department.

I. Test Nail Unbonded Length

Isolation of the nail bar tendon for production proof test nails is required to prevent bonding of the shotcrete to the nail bar. Isolation through the shotcrete facing must be made in a manner which maintains the tolerances of reinforcing steel behind the bearing plate. Blockouts in the shotcrete that result in no reinforcing below the nail head will not be allowed. Details of the method of test nail isolation through the shotcrete facing and the method by which the unbonded length of production proof test nails will be maintained during testing and grouted back after testing must be submitted to the Engineer for approval.

10.0 SHOTCRETING

Furnish all materials, equipment, tools and labor required for placing and securing geocomposite drainage material, weep holes and reinforced shotcrete. If necessary, trim and clean the soil/rock surfaces and shotcrete cold joints prior to shotcreting.

Shotcrete must comply with the requirements of ACI 506R, "Specification for Shotcrete", except as otherwise specified. Shotcrete consists of an application of one or more layers of mortar or concrete conveyed through a hose and pneumatically projected at a high velocity against a prepared surface.

Shotcrete may be produced by either a dry-mix or a wet-mix process. The wet-mix process consists of thoroughly mixing all the ingredients except accelerating admixtures but including the mixing water, introducing the mixture into the delivery equipment and delivering it, by positive displacement, to the nozzle. The wet-mix shotcrete may then be air jetted from the nozzle at high velocity onto the surface. Dry-mix process is shotcrete without mixing water which is conveyed through the hose pneumatically and the mixing water is introduced at the nozzle.

A. Mix Design

No shotcrete admixture may be used without the Engineer's approval. Thoroughly mix at the rate specified by the manufacturer any admixtures used to entrain air, reduce water-cement ratio, retard or accelerate setting time or accelerate the development of strength. Accelerating additives must be compatible with the cement used, be non-corrosive to steel and not promote other detrimental effects such as cracking and excessive shrinkage. The maximum allowable chloride ion content of all ingredients may not exceed 0.10% when tested to AASHTO T260.

1. Aggregate

Provide aggregate for shotcrete that meets the strength and durability requirement of AASHTO M-80 and M-43 and the following gradation requirements:

Sieve Size	% Passing by Weight
1/2 inch (13 mm)	100
3/8 inch (10 mm)	90-100
No. 4	70-85
No. 8	50-70
No. 16	35-55
No. 30	20-35
No. 50	8-20
No. 100	2-10

2. Proportioning

   Proportion and deliver shotcrete with a minimum cement content of 658 pounds per cubic yard (390 kilograms per cubic meter). Aggregate cement ratio may not be more than 4.5 by weight and water/cement ratio may not be more than 0.45. For wet-mix shotcrete the air content at delivery to the pump should be in the range of 7 to 10 percent when tested in accordance with ASTM C231.

3. Strength Requirements

   Produce a shotcrete mix capable of attaining 2000 psi (14 MPa) compressive strength in three days and 4000 psi (28 MPa) in 28 days. The average compressive strength of each set of three cores should be equal to or exceed 85 percent with no individual core less than 75 percent of the specified compressive strength.

4. Mixing and Batching

   Aggregate and cement may be batched by weight or by volume in accordance with the requirements of ASTM C91 and ASTM C685, respectively. Provide mixing equipment that is capable of thoroughly mixing the materials in sufficient quantity to maintain continuity during placement. Ready mix shotcrete must comply with AASHTO M-157. Batch, deliver and place ready mix shotcrete within 90 minutes of mixing.

B. Field Quality Control

Both preconstruction and production shotcrete test panels are required. Do not disturb test panels within the first 24 hours. Field cure the test panels under conditions similar to those anticipated for the work.

Perform field control tests in the presence of the Engineer. Provide equipment, materials and the services of one or more employees as necessary to obtain shotcrete cores for testing including construction of test panel boxes, field curing requirements and coring. The Department will perform compressive strength testing in accordance with ACI 506R. The frequency specified for test panels is approximate. The Engineer may require a greater or lesser number of panels.

Preconstruction and production test panels must be 18 x 18 inches (450 x 450 mm) and a minimum of 4 inches (100 mm) thick.

Test reports that indicate unsatisfactory compressive shotcrete properties will result in suspension of the crew responsible for the unsatisfactory specimens until they have demonstrated that they are capable of producing acceptable work or until additional specimens have been submitted, tested and proven satisfactory. Cost associated with field quality control testing including additional testing and lost production due to tests failing to meet the specifications will be borne by the Contractor.

1. Preconstruction Test Panels

   Furnish at least two preconstruction test panels for each proposed mixture being considered and for each shooting position to be encountered on the job, made by each application crew. Preconstruction test panels must be made by each application crew using the equipment, materials, mixture proportions and procedures proposed for the job prior to the commencement of work.

   Preconstruction test panels for plain shotcrete must be in accordance with ACI 506.2 and the following:

   a. Provide one preconstruction test panel with the maximum shotcrete thickness and the maximum anticipated reinforcing congestion. Cores extracted from the test panel must demonstrate adequate cover of the reinforcement and must be equal to core grade two or better in accordance with ACI 506.2.

   b. Provide one preconstruction test panel at least 4 inches (100 mm) thick without reinforcement for compressive strength testing.

   c. Slope the sides of the test panels at 45 degrees.

2. Production Test Panels

   Furnish at least one production test panel or, in lieu of production test panels, six 3 inch (75 mm) diameter cores from the shotcrete face for every 5000 square feet (460 square meters) or 50 cubic yards (38 cubic meters) of shotcrete placed, whichever is less. Construct the production test panels simultaneously with the shotcrete facing installation at times designated by the Engineer.

3. Core Testing

   Cut at least six core samples from each pre-construction test panel and production test panel at the frequency specified herein. Soak cores in water for at least 40 hours in accordance with AASHTO T24. Cores should be at least 3 inches (75 mm) in diameter and have a minimum length to diameter ratio of one. When the length of a core is less than twice the diameter, apply correction factors given in ASTM C42 to obtain the compressive strength of individual cores. Test three cores at 3-days and three more cores at 28-days for compressive strength testing.

   Fill core holes in the wall with patching mortar or shotcrete after cleaning and thoroughly dampening.

4. Visual Observation

   A clearly defined pattern of continuous horizontal or vertical ridges or depressions at the reinforcing elements after they are covered will be considered an indication of insufficient cover of reinforcement or poor application and probable voids. In this case the application of shotcrete will be immediately suspended and the work

carefully inspected by the Engineer. Implement and complete corrective measures prior to resuming the shotcrete operations.

The shotcrete procedure may be corrected by adjusting the nozzle distance and orientation perpendicular to the surface, adjusting the water content of the shotcrete mix or other means acceptable to the Engineer. If necessary, broom and roughen the shotcreted surface to ensure proper bond of subsequent layers.

C. Shotcrete Alignment Control

Provide alignment wires and/or thickness control pins to establish shotcrete thickness and maintain a plain surface. The maximum distance between the wires on any surface should be equal to the vertical nail spacing. Ensure that the alignment wires are tight, true to line and placed to allow further tightening.

D. Surface Preparation

Prior to shotcreting the "birds beak" (ungrouted zone of the nail drill hole near the face), remove all loose materials from the surface of the grout and prepare the joint in accordance with all requirements for joint construction specified herein.

Remove all loose materials and loose dried shotcrete from all receiving surfaces by methods acceptable to the Engineer. Accomplish the removal in such a manner as not to loosen, crack or shatter the surfaces to receive the shotcrete. Any surface material which, in the opinion of the Engineer, is so loosened or damaged must be removed to a sufficient depth to provide a base that is suitable to receive shotcrete. Remove material that loosens as the shotcrete is applied. Do not place shotcrete on frozen surfaces.

E. Delivery and Application

Maintain a clean, dry, oil-free supply of compressed air sufficient for providing adequate nozzle velocity for all parts of the work at all times. Use equipment that is capable of delivering the premixed material accurately, uniformly and continuously through the delivery hose. Control thicknesses, methods of support, air pressure and rate of placement of shotcrete to prevent sagging or sloughing of freshly-applied shotcrete.

Apply the shotcrete from the lower part of the area upwards to prevent accumulation of rebound on uncovered surfaces. Where shotcrete is used to complete the "birds beak" (ungrouted zone of the nail drill hole near the face), the nozzle must be positioned into the mouth of the drill hole to completely fill the void. Do not use or salvage rebound shotcrete. Remove rebound which does not fall clear of the working area. Hold the nozzle at a distance and an angle approximately perpendicular to the working face so that rebound will be minimal and compaction will be maximized. Rotate the nozzle steadily in a small circular pattern.

F. Defective Shotcrete

Repair surface defects as soon as possible after initial placement of the shotcrete. Remove all 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.

G. Construction Joints

Uniformly taper construction joints toward the excavation face over a minimum distance equal to the thickness of the shotcrete layer. Clean and prepare the surface of the nail grout at the face of the wall to receive shotcrete in a manner equal to all other construction joints.

H. Finish

Shotcrete finish should be either an undisturbed gun finish as applied from the nozzle or a screened finish. Remove shotcrete extending into the cast-in-place section beyond the tolerances specified.

I. Climate

Do not place shotcrete in cold weather when the ambient temperature is below 40°F (4.5°C) and the shotcrete is likely to be subjected to freezing temperatures before gaining sufficient strength to avoid damage. Maintain cold weather protection until the strength of the in-place shotcrete is greater then 750 psi (5.2 MPa). Cold weather protection may include heating under tents, blankets or other means acceptable to the Engineer. Materials may be heated in order that the temperature of the shotcrete, when deposited, is not less than 50°F (10°C) or more than 90°F (32°C).

Suspend shotcrete application during high winds and heavy rains when in the opinion of the Engineer the quality of the application is not acceptable. Remove and replace shotcrete that is exposed to rain and washes out cement or otherwise makes the shotcrete unacceptable to the Engineer. Provide polyethylene sheeting or equivalent when adverse exposure to weathering is anticipated. Secure polyethylene film to the top and bottom of the excavation.

11.0 CIP CONCRETE FACING

Construction of the concrete facing must conform to the requirements of Section 420 of the Standard Specifications, unless otherwise specified herein. Form the exposed face of the concrete facing with an acceptable forming system. A properly designed form bracing system to resist the lateral concrete pressure is required to keep the finished wall in good alignment. Submit formwork and falsework system to be approved by the Engineer before the beginning of any formwork.

Cast the concrete face to produce an Ashlar Stone pattern on the final face.

The vertical face of the wall must be plumb or have a back-batter no greater than two percent (2%) for the total height of the wall. No forward leaning of the wall in any magnitude is allowed.

Deliver the concrete to the formed area by means of tremie or drop chute to prevent the formation of honeycomb. Concrete must be placed in maximum three foot (1 m) lifts and vibration may not be used to move the concrete horizontally.

Use internal vibrations only. No external vibrations are allowed. Vibrate one lift at a time and extend the vibrator to 6 to 12 inches (150 to 300 mm) into the preceding lift. After a momentary pause, withdraw the vibrator slowly, at a rate of one to two inches (25 to 50 mm) per second. Insert the vibrator at an interval of 12 to 18 inches (300 to 450 mm) and adjust the interval as necessary to insure the affected area of vibrator overlap by a sufficient amount. Maintain a constant time lag from the time of concrete placement to the time of vibration application through the entire wall.

Accomplish patching as needed with epoxy mortars or specially mixed grouts for patching. Do not use concrete from subsequent placements for patching. Patch may be recessed slightly and smearing fill material on the surrounding finished surface is not allowed. Use light sand blasting to improve the appearance of the finished surface of the wall as directed by the Engineer.

After stripping and patching, apply the finished wall surface as soon as possible with one coat of cure and seal compound. The cure and seal compound should be compatible with the form release compound.

12.0 WALL DRAINAGE NETWORK

The drainage network consists of installing prefabricated geocomposite drainage strips and weep hole drain pipes as shown in the approved submittals or as directed by the Engineer. Install all elements of the drainage network prior to shotcreting.

A. Geocomposite Drainage Strips

Install geocomposite drain strips as shown in the approved submittals. Place drain strips at construction joints such that the joint is aligned as close as practical along the middle of the longitudinal axis of the drain strip.

Use geocomposite drain strips at least 12 inches (300 mm) wide and secure to the cut face with the geotextile side against the ground before shotcreting. Use securing pins at least 8 inches (200 mm) long with a 1.5 inch (38 mm) diameter head on a minimum grid pattern of 24 inches (600 mm) on center. Discontinuous drain strips are not allowed. If splices are needed, overlap a minimum of 12 inches (300 mm).

When the drain strips cannot be secured tight against the excavation face, place polyethylene film over the drain edges to prevent excess shotcrete from entering the sides of the drain. Alternatively, the drains may be installed in 16 inch (400 mm) wide strips and the film omitted.

B. Weep Hole Drainage Pipes

Install weep hole drainage pipes at locations shown in the approved submittals or as directed by the Engineer. The distance between each weep hole may not be more than 10 feet (3 m). Install pipes of solid PVC pipe to direct water from the geocomposite drain strips to the outside of the facing. Connect the pipes to the drain strips by installing prefabricated drain grates in accordance with the drain strip manufacturer's recommendations. Seal the joint between the drain grate and the drain strip and the drainage pipe to prevent shotcrete intrusion. Damage of the geocomposite drainage board which, in the opinion of the Engineer, may cause interruption in flow will require installation of additional weep holes, at the Contractor's expense.

13.0 NAIL TESTING

Both verification and proof testing of the nails are required. Supply all material, equipment and labor to perform the tests. The Engineer will collect all required data with the assistance of the Contractor. Testing of nails may not be performed within three days of nail grout placement or shotcrete application, whichever occurs last.

Where temporary casing of the unbonded test length of test nails is provided, place the casing in a manner which precludes causing any reaction between the casing and the grouted zone of the nail and/or the stressing apparatus during nail testing.

A. Testing Equipment

Two dial or vernier gauges, a dial gauge support, jack and pressure gauge, master pressure gauge and a reaction frame are required for testing.

Use a minimum of two dial or vernier gauges capable of measuring to 0.001 inch (.025 mm) to measure the nail movement. The dial gauges should have a minimum stroke of 3 inches (75 mm). Align the dial gauges within five degrees from the axis of the nail and support the dial gauges independently of the jacking set-up and the wall. Apply the test load with a hydraulic jack and a pump.

The jack and pressure gauge must be calibrated by an independent testing laboratory as a unit. Provide a pressure gauge that is graduated in 1000 psi (700 KPa) increments or less and has a range not exceeding twice the anticipated maximum pressure during testing unless otherwise approved by the Engineer. Use the pressure gauge to measure the applied load. The minimum ram travel of the jack may not be less than 4 inches (100 mm). The jack should be capable of applying each load in less than one minute.

Independently support and center the jack over the nail so that the nail does not carry the weight of the jack. Calibrate the master pressure gauge with the test jack and pressure gauge as a unit. Monitor the loads on the nails during the verification tests with both the master pressure gauge and electric load cell. The load cell will be used to maintain constant load hold throughout the creep test. Provide recent calibration curves. Place the stressing equipment over the nail in such a manner that the jack, bearing plates, load cell and stressing anchorage are in alignment. Position the jack at

the beginning of the test such that unloading and repositioning of the jack during the test is not required.

Provide a reaction frame that is sufficiently rigid and of adequate dimension such that excessive deformation of the test apparatus requiring repositioning of any components does not occur. Where the reaction frame bears directly on the shotcrete, the reaction frame must be designed to prevent fracture of the shotcrete. No part of the reaction frame may bear within 6 inches (150 mm) of the edge of the test nail blockout unless otherwise approved by the Engineer.

B. Verification Testing

Perform verification testing horizontally prior to procuring materials for or installation of production nails to verify the Contractor's installation methods, soil conditions, nail capacity and design assumptions. Verification tests must be performed within the limits of the work area. A minimum of two verification tests or one verification test for each set of assumed soil parameters, which ever is greater, are required at locations approved by the Engineer. Additional verification tests are required where ground conditions differ from those anticipated or shown on the approved submittals.

Submit details of the verification testing arrangement including the method of distributing test load pressures to the excavation surface (reaction frame), test nail bar size and grade, grouted hole diameter and reaction plate dimensioning to the Engineer for approval. All verification nail testing must be performed using the same equipment, methods and hole diameter as planned for the production nails. Changes in the drilling or installation method may require additional verification testing as determined by the Engineer at no additional cost to the Department. The nails used for the verification tests are sacrificial and may not be incorporated into the production nail schedule.

Test nails will have both bonded and unbonded lengths. Prior to testing only the bonded length of the test nail may be grouted. The unbonded length of the test nail must be at least 5 feet (1.5 m) unless otherwise approved by the Engineer. The bonded length of the test nail will be based on the bar grade and size such that the allowable bar load is not exceeded, but may not be less than 10 feet (3 m) unless otherwise approved by the Engineer. The allowable bar load during testing may not exceed 80 percent of the ultimate strength of the steel for Grade 150 (1035) bars or 90 percent of the yield strength for Grade 60 and 75 (420 and 520) bars. The minimum bond length of 10 feet (3 m) may require larger or higher grade bars than the production nails in order to achieve 200% of the design load without overstressing the bar. Provide higher capacity bars instead of shortening the bond length too less than the minimum.

The verification test bonded length L_{BV} may not exceed the test allowable bar load divided by two times the design adhesion value. Use the following equation for sizing the test nail bond length to avoid overstressing the verification nail bar:

$$L_{BV} \leq \frac{Cf_yA_s}{2A_D}$$

Where: L_{BV} = Maximum Verification Test Nail Bond Length (ft or m)

f_y = Bar Yield Stress (ksi or kPa)

A_s = Bar Area (in^2 or m^2)

A_D = Design Adhesion (kips/ft or kN/m)

C = 0.8 for Grade 150 (1035) Bar and 0.9 for Grade 60 and 75 (420 and 520) Bars

Determine the design load during testing by the following equation:

$$DTL = L_B \times A_D$$

Where: DTL = Design Test Load

L_B = As-Built Bonded Test Length (ft or m)

A_D = Design Adhesion (kips/ft or kN/m)

Load and unload verification test nails to twice the design test load (DTL) in accordance with the following schedule.

LOADING		UNLOADING	
LOAD	HOLD TIME	LOAD	HOLD TIME
AL	1 minute	1.75DTL	Until Stable
0.25DTL	10 minutes	1.50DTL	Until Stable
0.50DTL	10 minutes	1.25DTL	Until Stable
0.75DTL	10 minutes	1.00DTL	Until Stable
1.00DTL	10 minutes	0.75DTL	Until Stable
1.25DTL	10 minutes	0.50DTL	Until Stable
1.50DTL	60 minutes	.25DTL	Until Stable
1.75DTL	10 minutes	AL	Until Stable
2.00DTL	10 minutes		

Hold each load increment for at least ten minutes. Monitor the verification test nail for creep at the 1.50 DTL load increment. Measure and record nail movements during the creep portion of the test at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. Extended creep measurements may be required as determined by the Engineer. Maintain all load increments within five percent of the intended load during the creep test using the load cell. Unload the nail in increments of 25 percent with deflection measurements recorded at each unload increment. Each unload increment may be held only for a sufficient time to allow stabilization of the movement reading.

The alignment load (AL) is the minimum load required to align the testing apparatus and may not exceed five percent of the design test load. "Zero" dial gauges after the alignment load has been applied.

C. Proof Testing

Proof testing is required on at least five percent of the production nails in each shotcrete lift to verify the Contractor's methods and the design nail capacity. The Engineer will determine the specific locations and number of these tests.

Proof test nails will have both bonded and unbonded lengths. Prior to testing only the bonded length of the test nail may be grouted. The unbonded length of the test nail must be at least 5 ft (1.5 m) unless approved otherwise by the Engineer. The bonded length of the test nail will be such that the allowable bar load is not exceeded but may not be less than 10 feet (3 m) unless otherwise approved by the Engineer. The allowable bar load may not exceed 80 percent of the ultimate steel strength for Grade 150 (1035) bars and 90 percent of the yield strength for Grade 60 and 75 (420 and 520) bars.

The proof test bonded length L_{BP} may not exceed the test allowable bar load divided by 1.5 times the design adhesion value. Use the following equation for sizing the test nail bond length to avoid overstressing the production bar:

$$L_{BP} \leq \frac{C f_y A_s}{1.5 A_D}$$

Where: L_{BP} = Maximum Proof Test Nail Bond Length (ft or m)

f_y = Bar Yield Stress (ksi or kPa)

A_s = Bar Stress Area (in^2 or m^2)

A_D = Design Adhesion (kips/ft or kN/m)

C = 0.8 for Grade 150 (1035) Bar and 0.9 for Grade 60 and 75 (420 and 520) Bars

Perform proof tests by incrementally loading the nail to 1.5 times the design test load. Determine the design test load by the equation shown for the verification test nails. Measure and record nail movements at each load in the same manner as for verification test nails. Monitor the load with a pressure gauge with a sensitivity and range meeting the requirements of pressure gauges used for verification test nails. Load proof test nails in accordance with the following schedule.

LOADING

LOAD	HOLD TIME
AL	Until Stable
0.25DTL	Until Stable
0.50DTL	Until Stable
0.75DTL	Until Stable
1.00DTL	Until Stable
1.25DTL	Until Stable
1.50DTL	10 or 60 minutes

The alignment load (AL) should be the minimum load required to align the testing apparatus and may not exceed five percent of the design load (DTL). "Zero" dial gauges after the alignment load has been applied.

Maintain all load increments within five percent of the intended load. Depending on performance, either 10 minute or 60 minute creep tests are required at the maximum test load (1.50 DTL). The creep period will start as soon as the maximum test load is applied. Measure and record nail movements at 1, 2, 3, 5, 6 and 10 minutes. Where nail movement between one minute and 10 minutes exceeds 0.04 inch (1 mm), maintain the maximum test load an additional 50 minutes and record movements at 20, 30, 50 and 60 minutes.

D. Test Nail Acceptance

A test nail will be considered acceptable when:

1. For verification tests, a creep rate less than 0.08 inches (2 mm) per log cycle of time between the six and 60 minute readings is observed during creep testing and the rate is linear or decreasing throughout the creep test load hold period.

2. For proof tests: (a) a total creep less than 0.04 inches (1 mm) is observed between the one and 10 minute readings creep test or a creep rate less than 0.08 inches (2 mm) per log cycle of time is observed during the 60 minute creep test between six and 60 minute readings and; (b) the creep rate is linear or decreasing throughout the creep test load hold period.

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

4. A pullout failure does not occur at the maximum test load. Pullout failure load is defined as the load at which attempts to increase the test load simply result in continued excessive pullout movement of the test nail. Record the pullout failure load as part of the test data.

Proof test nails may be incorporated into the production nail schedule provided that (1) the unbonded test length of the nail hole has not collapsed during testing, (2) the minimum required hole diameter has been maintained and (3) the test nail length is equal to or greater than the scheduled production nail length. Complete test nails meeting these requirements by satisfactorily grouting the unbonded test length. If the unbonded test length of production proof test nails cannot be grouted subsequent to testing due to caving conditions or other reasons, replace the test nail with a similar production nail to the satisfaction of the Engineer at no additional cost to the Department.

E. Test Nail Results

1. Verification Test Nails

The Engineer will evaluate the results of each verification test. Installation methods that do not satisfy the nail testing requirements will be rejected. Where the design adhesion is not attainable by reasonable means, revise the production nail schedule. Incorporate any increases in the quantity, the lengths or the diameters of nails as required by the designer. Reasonable means will be considered to include gravity grouted nails installed as specified herein to the minimum diameter required or to a maximum diameter of 10 inches (250 mm).

2. Proof Test Nails

The Engineer may require that the Contractor replace some or all of the installed production nails between the failed proof test nail and the adjacent passing proof test nail. Abandon nails which fail in proof test and replace them with new proof test nails. Also, the Engineer may require that additional proof testing be conducted to verify that adjacent nails have sufficient load carrying capacity. Modifications may be required which include installing additional test or production nails, installing longer production nails, increasing the drill hole diameter or modifying the installation methods.

14.0 TOLERANCES

A. Soil Nails

Center the bars within 1 inch (25 mm) of the center of the hole. Individual nails must be positioned plus or minus 6 inches (150 mm) from the design locations shown in the approved submitals unless otherwise directed by the Engineer. Location tolerances will be considered applicable to only one nail and not accumulative over large wall areas. The nail inclination should be plus or minus two degrees of that shown in the plans. Use a magnetic angle-indicator tool to align the drill inclination prior to drilling each nail installation hole. Relocate nails which encounter unanticipated obstructions during drilling as directed by the Engineer. Replace soil nails which do not satisfy the specified tolerances due to the Contractor's installation to the Engineer's satisfaction at no additional cost to the Department.

B. Bearing Plates

The location of the bearing plate may not vary from its proposed location within the concrete facing vertical plane by more than ¾" (19 mm).

15.0 RECORDS

Record the following information:

1. Contractor's and drill rig operator's names
2. Design and as-built, nail locations and elevations
3. Deviations from specified tolerances
4. Design and as-built, hole lengths and diameters
5. Design and as-built, bar lengths and sizes
6. Groundwater conditions
7. Caving or sloughing of excavation
8. Casing requirements
9. Drilling difficulties
10. Date and time of start and finish of drilling
11. Date, time and method grout was placed including grout pressure
12. Total daily quantity of grout placed and quantity per hole
13. Design changes

Upon completion of the work, submit a complete record of the construction activities including the information listed above to the Engineer.

16.0 MEASUREMENT AND BASIS OF PAYMENT

No separate measurement for payment purposes will be made for this work. The lump sum payment will be for each soil nail retaining wall and the cast-in-place concrete face with Ashlar stone pattern. Payment will include all costs for concrete, reinforcing steel, excavation, soil nails, labor, design and all other materials and equipment including grouting, drilling holes, testing and all tools and any other miscellaneous items necessary to complete the work.

Payment will be made under:

"Soil Nail Retaining Wall Sta 274+42.76 -L-".....Lump Sum
"Soil Nail Retaining Wall Sta 282+81.32 -L-".....Lump Sum
"Soil Nail Retaining Wall Sta 344+89.06 -L-".....Lump Sum