PROJECT SPECIAL PROVISIONS

ROADWAY

CLEARING AND GRUBBING – METHOD II:

(9-17-02) SP2 R01

Perform clearing on this project to the limits established by Method "II" shown on Standard No. 200.02 of the *Roadway Standard Drawings*.

#57 STONE: 7-1-95

The Contractor shall place #57 Stone between barrier in accordance with the details in the plans and the following provision.

The #57 Stone shall meet the requirements of Section 1005 of the Standard Specifications.

The stone shall be placed and compacted as directed by the Engineer.
The quantity of #57 Stone to be paid for will be the actual number of tons of stone which has been incorporated into the completed and accepted work. The stone will be measured by being weighed in trucks on certified platform scales or other certified weighing devices.

The quantity of #57 Stone, measured as provided for above, will be paid for at the contract unit price per ton for "#57 Stone". The above prices and payment will be full compensation for furnishing, hauling, placing, and all incidentals necessary to complete the work.

SPI

PIPE TESTING:

4-17-07 SP3R33

Revise the *2006 Standard Specifications* as follows:

Page 3-3, Article 300-6, add the following as a new paragraph before **(A)**:

The Department reserves the right to perform forensic testing on any installed pipe.

PIPE ALTERNATES:

(7-18-06) (Rev 4-17-07) SP3 R36

Description

The Contractor may substitute Aluminized Corrugated Steel Pipe, Type IR or HDPE Pipe, Type S or Type D up to 48 inches in diameter in lieu of concrete pipe in accordance with the following requirements.

Material

Item	Section
HDPE Pipe, Type S or D	1032-10
Aluminized Corrugated Steel Pipe, Type IR	1032-3(A)(7)

Aluminized Corrugated Steel Pipe will not be permitted in counties listed in Article 310-2 of the *2006 Standard Specifications*.

Construction Methods

Aluminized Corrugated Steel Pipe Culverts and HDPE Pipe Culverts shall be installed in accordance with the requirements of Section 300 of the *2006 Standard Specifications* for Method A, except that the minimum cover shall be at least 12 inches. Aluminized Corrugated Steel Pipe Culvert and HDPE Pipe Culvert will not be permitted for use under travelways, including curb and gutter.

Measurement and Payment

____ "*Aluminized Corrugated Steel Pipe Culvert* to be paid for will be the actual number of linear feet installed and accepted. Measurement will be in accordance with Section 310-6 of the *2006 Standard Specifications*.

_____ "*HDPE Pipe Culvert* to be paid for will be the actual number of linear feet installed and accepted. Measurement will be in accordance with Section 310-6 of the *2006 Standard Specifications*.

Payment will be made under:

Pay Item	Pay Unit
___" Aluminized Corrugated Steel Pipe Culverts, ___" Thick	Linear Foot
___" HDPE Pipe Culverts	Linear Foot

ASPHALT PAVEMENTS - SUPERPAVE:

(7-18-06) (Rev 9-19-06) SP6 R01

Revise the *2006 Standard Specifications* as follows:

Page 6-2, Article 600-9 Measurement and Payment

Delete the second paragraph.

Page 6-12, 609-5(C)2(c) add after (AASHTO T 209):

or ASTM D 2041

Page 6-13, last line on page & Page 6-14, Subarticle 609-5(C)(2)(e), delete and substitute the following:

(e) Retained Tensile Strength (TSR) - (AASHTO T 283 Modified), add subarticle (1) Option 1 before the first paragraph.

(1) Option 1

Add subarticle (2) Option 2 and the following sentence as the first sentence of the second paragraph:

(2) Option 2

Mix sampled from truck at plant with one set of specimens prepared by the Contractor and then tested jointly by QA and QC at a mutually agreed upon lab site within the first 7 calendar days after beginning production of each new mix design.

Page 6-28, 610-3(A) Mix Design-General, third sentence of the fourth paragraph:

Substitute 20% for 15%

First, second and third sentences of the fifth paragraph:

Substitute 20% for 15%

Page 6-44, 610-8, third full paragraph, replace the first sentence with the following:

Use the 30 foot minimum length mobile grade reference system or the non-contacting laser or sonar type ski *with at least four referencing stations mounted on the paver at a minimum length of 24 feet* to control the longitudinal profile when placing the initial lanes and all adjacent lanes of all layers, including resurfacing and asphalt in-lays, unless otherwise specified or approved.

Page 6-54, Article 620-4, add the following pay item:

Pay Item	**Pay Unit**
Asphalt Binder for Plant Mix, Grade PG 70-28	Ton

Page 6-69, Table 660-1 **Material Application Rates and Temperatures**, add the following:

Type of Coat	**Grade of Asphalt**	**Asphalt Rate gal/yd^2**	**Application Temperature ^{0}F**	**Aggregate Size**	**Aggregate Rate lb./sq. yd. Total**
Sand Seal	CRS-2 or CRS-2P	0.22-0.30	150-175	Blotting Sand	12-15

Page 6-75, 660-9(B), add the following as sub-item (5)

(5) Sand Seal

Place the fully required amount of asphalt material in one application and immediately cover with the seal coat aggregate. Uniformly spread the fully required amount of aggregate in one application and correct all non-uniform areas prior to rolling.

Immediately after the aggregate has been uniformly spread, perform rolling.

When directed, broom excess aggregate material from the surface of the seal coat.

When the sand seal is to be constructed for temporary sealing purposes only and will not be used by traffic, other grades of asphalt material meeting the requirements of Articles 1020-6 and 1020-7 may be used in lieu of the grade of asphalt required by Table 660-1 when approved.

Page 10-41, Table 1012-1, add the following:

Mix Type	Course Aggregate Angularity [(b)] ASTM D5821	Fine Aggregate Angularity % Minimum AASHTO T304 Method A	Sand Equivalent % Minimum AASHTO T176	Flat & Elongated 5:1 Ratio % Maximum ASTM D4791 Section 8.4
S 9.5 D	100/100	45	50	10

Page 10-45, Replace Table 1012-2 with the following:

TABLE 1012-2
NEW SOURCE RAP GRADATION and BINDER TOLERANCES
(Apply Tolerances to Mix Design Data)

Mix Type	**0-20% RAP**			**21-25% RAP**			**26%+ RAP**		
Sieve (mm)	**Base**	**Inter.**	**Surf.**	**Base**	**Inter.**	**Surf.**	**Base**	**Inter.**	**Surf.**
P_b, %		± 0.7%			± 0.4%			± 0.3%	
1 1/2" (37.5)	±10	-	-	±7	-	-	±5	-	-
3/4" (19.0)	±10	±10	-	±7	±7	-	±5	±5	-
1/2" (12.5)	-	±10	±6	-	±7	±3	-	±5	±2
3/8" (9.5)	-	-	±8	-	-	±5	-	-	±4
No. 4 (4.75)	±10	-	±10	±7	-	±7	±5	-	±5
No. 8 (2.36)	±8	±8	±8	±5	±5	±5	±4	±4	±4
No.16 (1.18)	±8	±8	±8	±5	±5	±5	±4	±4	±4
No. 30 (0.600)	±8	±8	±8	±5	±5	±5	±4	±4	±4
No. 50 (0.300)	-	-	±8	-	-	±5	-	-	±4
No. 200 (0.075)	±4	±4	±4	±2	±2	±2	±1.5	±1.5	±1.5

ASPHALT BINDER CONTENT OF ASPHALT PLANT MIXES:

(11-21-00) SP6 R15

The approximate asphalt binder content of the asphalt concrete plant mixtures used on this project will be as follows:

Asphalt Concrete Base Course	Type B 25.0__	4.3%
Asphalt Concrete Intermediate Course	Type I 19.0__	4.7%
Asphalt Concrete Surface Course	Type S 4.75A	7.0%
Asphalt Concrete Surface Course	Type SF 9.5A	6.5%
Asphalt Concrete Surface Course	Type S 9.5__	6.0%
Asphalt Concrete Surface Course	Type S 12.5__	5.5%

The actual asphalt binder content will be established during construction by the Engineer within the limits established in the *Standard Specifications.*

PRICE ADJUSTMENT - ASPHALT BINDER FOR PLANT MIX:

(11-21-00) SP6 R25

Price adjustments for asphalt binder for plant mix will be made in accordance with Section 620 of the *Standard Specifications.*

The base price index for asphalt binder for plant mix is **$318.93** per ton.

This base price index represents an average of F.O.B. selling prices of asphalt binder at supplier's terminals on **October 1, 2007**.

GUARDRAIL ANCHOR UNITS, TYPE 350:

(4-20-04) SP8 R65

Description

Furnish and install guardrail anchor units in accordance with the details in the plans, the applicable requirements of Section 862 of the *Standard Specifications*, and at locations shown in the plans.

Materials

The Contractor may at his option, furnish any one of the guardrail anchor units.

Guardrail anchor unit (ET-2000) as manufactured by:

Trinity Industries, Inc.
2525 N. Stemmons Freeway
Dallas, Texas 75207
Telephone: 800-644-7976

The guardrail anchor unit (SKT 350) as manufactured by:

Road Systems, Inc.
3616 Old Howard County Airport
Big Spring, Texas 79720
Telephone: 915-263-2435

Prior to installation the Contractor shall submit to the Engineer:

(A) FHWA acceptance letter for each guardrail anchor unit certifying it meets the requirements of NCHRP Report 350, Test Level 3, in accordance with Section 106-2 of the Standard Specifications.

(B) Certified working drawings and assembling instructions from the manufacturer for each guardrail anchor unit in accordance with Section 105-2 of the Specifications.

No modifications shall be made to the guardrail anchor unit without the express written permission from the manufacturer. Perform installation in accordance with the details in the plans, and details and assembling instructions furnished by the manufacturer.

Construction Methods

Guardrail end delineation is required on all approach and trailing end sections for both temporary and permanent installations. Guardrail end delineation consists of yellow reflective sheeting applied to the entire end section of the guardrail in accordance with Section 1088-3 of the *Standard Specifications* and is incidental to the cost of the guardrail anchor unit.

Measurement and Payment

Measurement and payment will be made in accordance with Articles 862-6 of the *Standard Specifications*.

Payment will be made under:

Pay Item	**Pay Unit**
Guardrail Anchor Units, Type 350	Each

IMPACT ATTENUATOR UNITS, TYPE 350:
(4-20-04) (Rev 7-18-06) SP8 R75

Description

Furnish and install impact attenuator units and any components necessary to connect the impact attenuator units in accordance with the manufacturer's requirement, the details in the plans and at locations shown in the plans.

Materials

NON-GATING IMPACT ATTENUATOR UNITS:

The impact attenuator unit (QUADGUARD) as manufactured by:

Energy Absorption Systems, Inc.
One East Wacker Drive
Chicago, Illinois 60601-2076
Telephone: 312-467-6750

The impact attenuator unit (TRACC) as manufactured by:

Trinity Industries, Inc.
2525 N. Stemmons Freeway
Dallas, Texas 75207
Telephone: 800-644-7976

GATING IMPACT ATTENUATOR UNITS:

The impact attenuator unit (BRAKEMASTER) as manufactured by:

Energy Absorption Systems, Inc.
One East Wacker Drive
Chicago, Illinois 60601-2076
Telephone: 312-467-6750

The impact attenuator unit (CAT) as manufactured by:

Trinity Industries, Inc.
2525 N. Stemmons Freeway
Dallas, Texas 75207
Telephone: 800-644-7976

Prior to installation the Contractor shall submit to the Engineer:

(A) FHWA acceptance letter for each impact attenuator unit certifying it meets the requirements of NCHRP Report 350, Test Level 3, in accordance with Article 106-2 of the *Standard Specifications*.

(B) Certified working drawings and assembling instructions from the manufacturer for each impact attenuator unit in accordance with Article 105-2 of the *Standard Specifications*.

No modifications shall be made to the impact attenuator unit without the express written permission from the manufacturer. Perform installation in accordance with the details in the plans, and details and assembling instructions furnished by the manufacturer.

Construction Methods

If the median width is 40 feet or less, the Contractor shall supply one of the NON-GATING Impact Attenuator Units listed in the Materials Section herein.

If the median width is greater than 40 feet, the Contractor may use any of the GATING or NON-GATING Impact Attenuator Units listed in the Materials Section herein.

Measurement and Payment

Impact Attenuator Unit, Type 350 will be measured and paid for at the contract unit price per each. Such prices and payment will be full compensation for all work covered by this provision including but not limited to furnishing, installing and all incidentals necessary to complete the work.

Payment will be made under:

Pay Item	**Pay Unit**
Impact Attenuator Unit, Type 350	Each

STEEL U-CHANNEL POSTS:
(7-18-06) SP9 R02

Amend the *2006 Standard Specifications* as follows:

Page 9-15 Subarticle 903-3(D) first paragraph, last sentence, delete the last sentence and add the following:

Use posts of sufficient length to permit the appropriate sign mounting height. Spliced posts are not permitted on new construction.

AGGREGATE PRODUCTION:
(11-20-01) SP10 R05

Provide aggregate from a producer who uses the current Aggregate Quality Control/Quality Assurance Program that is in effect at the time of shipment.

No price adjustment is allowed to contractors or producers who use the program. Participation in the program does not relieve the producer of the responsibility of complying with all requirements of the *Standard Specifications*. Copies of this procedure are available upon request from the Materials and Test Unit.

CONCRETE BRICK AND BLOCK PRODUCTION:
(11-20-01) SP10 R10

Provide concrete brick and block from a producer who uses the current Solid Concrete Masonry Brick/Unit Quality Control/Quality Assurance Program that is in effect on the date that material is received on the project.

No price adjustment is allowed to contractors or producers who use the program. Participation in the program does not relieve the producer of the responsibility of complying with all requirements of the *Standard Specifications*. Copies of this procedure are available upon request from the Materials and Test Unit.

PORTLAND CEMENT CONCRETE (Alkali-Silica Reaction):
2-20-07 SP10 R16

Revise the *2006 Standard Specifications* as follows:

Article 1024-1(A), replace the 2nd paragraph with the following:

Certain combinations of cement and aggregate exhibit an adverse alkali-silica reaction. The alkalinity of any cement, expressed as sodium-oxide equivalent, shall not exceed 1.0 percent. For mix designs that contain non-reactive aggregates and cement with an alkali content less than 0.6%, straight cement or a combination of cement and fly ash, cement and ground granulated blast furnace slag or cement and microsilica may be used. The pozzolan quantity shall not exceed the amount shown in Table 1024-1. For mixes that contain cement with an alkali content between 0.6% and 1.0%, and for mixes that contain a reactive aggregate documented by the Department, regardless of the alkali content of the cement, use a pozzolan in the amount shown in Table 1024-1.

Obtain the list of reactive aggregates documented by the Department at:http://www.ncdot.org/doh/operations/materials/pdf/quarryasrprob.pdf

Table 1024-1
Pozzolans for Use in Portland Cement Concrete

Pozzolan	*Rate*
Class F Fly Ash	20% by weight of required cement content, with 1.2 lbs Class F fly ash per lb of cement replaced
Ground Granulated Blast Furnace Slag	35%-50% by weight of required cement content with 1 lb slag per lb of cement replaced
Microsilica	4%-8% by weight of required cement content, with 1 lb microsilica per lb of cement replaced

GLASS BEADS:
(7-18-06) SP10 R35

Revise the *Standard Specifications* as follows:

Page 10-223, 1087-4(C) Gradation & Roundness

Replace the second sentence of the first paragraph with the following:

All Drop-On and Intermixed Glass Beads shall be tested in accordance with ASTM D1155.

Delete the last paragraph.

PORTABLE CONCRETE BARRIER
(2-20-07) SP10 R50

The *2006 Standard Specifications* is revised as follows:

Page 10-245, Article 1090-1(A) General, add the following after the first sentence:

The requirement for approved galvanized connectors will be waived if the barrier remains the property of the Contractor.

ENGINEERING FABRICS TABLE 1056-1:
(7-18-06) SP10 R40

Revise the *Standard Specifications* as follows:

Page 10-100, Table 1056-1, replace the values for Trapezoidal Tear Strength with the following:

Physical Property	ASTM Test Method	Type 1	Type 2	Type 3		Type 4
Typical Applications		Shoulder Drain	Under Riprap	Class A Temporary Silt Fence	Class B Temporary Silt Fence	Soil Stabilization
Trapezoidal Tear Strength	D4533	*45* lb	*75* lb	--	--	*75* lb

CHANGEABLE MESSAGE SIGNS
(11-21-06) SP11 R 11

Revise the *2006 Standard Specifications* as follows:

Page 11-9, Article 1120-3, Replace the 3rd sentence with the following:

Sign operator will adjust flash rate so that no more than two messages will be displayed and be legible to a driver when approaching the sign at the posted speed.

PAVEMENT MARKING LINES:
(11-21-06) (Rev. 9-18-07) SP 12 R01

Revise the *2006 Standard Specifications* as follows:

Page 12-2, 1205-3(D) Time Limitations for Replacement, add the following at the beginning of the chart:

Facility Type	Marking Type	Replacement Deadline
Full-control-of-access multi-lane roadway (4 or more total lanes) and ramps, including Interstates	All markings including symbols	By the end of each workday's operation if the lane is opened to traffic

Page 12-14, Subarticle 1205-10, Measurement and Payment, delete the first sentence of the first paragraph and replace with the following:

Pavement Marking Lines will be measured and paid for as the actual number of linear feet of pavement marking lines per application that has been satisfactorily placed and accepted by the Engineer.

SOIL NAIL RETAINING WALLS (SPECIAL)

1.0 GENERAL

The work under this section shall consist 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 shall consist 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 shall 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, shall supervise the work. The Contractor shall not use manufacturers' representatives to satisfy the supervising Engineer requirements of this section.

The Contractor shall also 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.

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

A pre-construction meeting shall be held prior to the start of the work and shall be attended by representatives of the Contractor, Resident Engineer and the Geotechnical Engineering Unit. Soil nailing requires organized coordination of each of these parties. The pre-construction meeting shall be conducted to clarify the construction requirements, to provide

appropriate scheduling of the construction activities and to identify contractual relationships and responsibilities. Review of all submittals shall be completed 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 construction of the soil nail walls shall be 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 shall 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 shall be by the service load or load factor 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.

Calculations and details for the cast-in-place concrete facing shall be included in the soil nail wall package. The cast-in-place concrete facing shall be a minimum 8 inches (200 mm) in thickness. 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 shall 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 shall be employed. The nail holes shall 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). Minimum clearance from end of soil nail to bottom of nail hole shall be 6 inches (150 mm). Corrosion protection shall include epoxy coated bars.

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

Nails shall not extend beyond the Right of Way or easement line.

The plans shall include but shall 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 shall seal all plans and calculations.

3.0 QUALITY ASSURANCE

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

All nozzlemen shall have at least one year of continuous experience in similar shotcrete application work and shall demonstrate ability to satisfactorily place the material in accordance with the recommendations of ACI 506.3R Guide to Certification of Shotcrete Nozzlemen. The proposed nozzlemen shall present evidence that they have been certified to the requirements of ACI 506.3R within the last five years.

Work shall not 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 shall 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

The Contractor shall 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, the Contractor shall 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 shall include the date tested, device identification number and the calibration test results and shall 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, proposed access arrangements and capacities.

5.0 MATERIALS

All materials shall 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 shall 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 shall 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 shall be new, straight, undamaged and epoxy coated.
Epoxy Coating	AASHTO M284. Minimum 12 mils (0.3 mm) electrostatically applied. Bend test requirements shall be waived.
Bearing Plates	AASHTO M183 steel plates bearing plates shall 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 shall 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

All steel reinforcement items and nail steel shall be carefully handled and shall be stored 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 shall be cause for rejection. Grounding of welding leads to the nail steel will not be allowed. Nail steel shall be protected 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 shall 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. Epoxy coating shall be repaired using an epoxy field repair kit approved by the epoxy manufacturer.

Encapsulated nails shall be handled in a manner that does not crack or otherwise damage the grout inside the sheath.

Drainage geotextile and geocomposite drains shall be provided in rolls wrapped with a protective covering and stored in a manner which protects the fabric from mud, dust, dirt, debris and shotcrete rebound. Protective wrapping shall not be removed until the geotextile or drain strip is installed. Extended exposure to ultra-violet light shall be avoided. Each roll of geotextile or drain strip in the shipment shall be labeled to identify that production run.

Cement shall be adequately stored to prevent moisture degradation and partial hydration. Cement that is caked or lumpy shall not be used.

7.0 DEWATERING AND DAMAGE CONTROL

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

The Contractor shall 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. The Contractor shall 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 shall be repaired by the Contractor to the Engineer's satisfaction at no additional cost to the Department.

The Contractor shall be responsible for the condition of any pipe or conduit which may be used for temporary construction dewatering and all such pipes or conduits shall be maintained clean and free of sediment during construction. Upon substantial completion of the work, construction dewatering conduits shall be removed from the site. Alternatively, construction dewatering conduits shall 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 cost shall be considered incidental to the work and shall be at no additional cost to the Department.

8.0 EXCAVATION

A. Mass Grading

Overexcavating the original ground beyond the final wall face shall not be allowed. Should overexcavation beyond the final wall face occur as a result of the Contractor's operations, such overexcavation shall be restored by the Contractor using a method approved by the Engineer and at no additional cost to the Department.

B. Wall Face Excavation

Excavation shall proceed from the top down in a staged horizontal lift sequence as shown in the plans. The excavated surface ("neat line") shall be within 1 inch (25 mm) of its plan location. The ground level in front of the wall face shall not be excavated more than 3 feet (1 m) below the level of the row of nails to be installed in that lift. A lift shall not be excavated 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, shotcrete and nail grout on the preceding lift shall have been cured for a minimum one day and three days, respectively. After a lift is excavated, the cut surface shall be cleaned of all loose materials, mud, rebound and other foreign

material that could prevent or reduce shotcrete bond. The excavated vertical wall face should not be exposed for more than 24 hours for any reason.

The Contractor shall take all necessary measures to ensure that installed nails are not damaged during excavation. Nails damaged or disturbed during excavation shall be repaired or replaced by the Contractor to the satisfaction of the Engineer at no cost to the Department. Hardened nail grout protruding from the final wall excavation more than 2 inches (50 mm) shall be removed 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, nor the surrounding exposed ground.

Excavation to the final wall face ("neat line") and application of the shotcrete shall be completed 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 shall 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 shall 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 shall 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, the Contractor shall 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 shall be constructed to prevent sloughing or failure of the temporary slopes. The Contractor shall 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

The Contractor shall 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. Any overexcavations shall be backfilled with shotcrete. Any shotcrete used to fill voids created by the removal of cobbles and boulders or other obstructions shall 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 should 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 shall be brought to the immediate attention of the Engineer.

Unstable areas shall be temporarily stabilized by means of buttressing the exposed face with an earth berm or other methods acceptable to the Engineer. Work shall be suspended in unstable areas until remedial measures submitted by the Contractor and approved by the Engineer have successfully arrested 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 shall 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). Wood preservative shall be 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

Temporary work benches may be required to install the nails along the upper portions of the wall. Any temporary benches shall be located behind the traffic barriers placed along the existing lanes of 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 soil nail retaining wall. Equipment and nails may hang over the existing lanes; however, lane closures should be used 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 shall include the removal and subsequent handling of all materials encountered in drilling the holes to the required lengths.

B. Equipment

Drilling equipment shall be designated to drill straight and clean holes. The size and capability of drilling equipment shall be suitable for installation of 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. Sufficient casing/auger lengths shall be available 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

Each nail hole shall be drilled at the locations and to the lengths and minimum diameters indicated in the plans unless otherwise approved by the Engineer. Cuttings shall be removed from the holes using compressed air or by mechanical auger flights. Compressed air shall 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 shall not be allowed. At final penetration depth, the nail hole shall be thoroughly cleaned and made ready for examination by the Engineer before nail bar installation or placement of grout. No portion of the nail hole shall be left open for more than 60 minutes prior to grouting unless otherwise approved by the Engineer.

D. Nail Hole Support

The Contractor shall 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 shall be allowed until the Contractor selects a method which prevents ground movement. Holes shall 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 additional installation material and other costs due to casing holes shall be at no additional expense to the Department.

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

E. Optional Nail Installation Methods

Optional nail installation methods shall require approval by the Engineer in accordance with submittals. At the Contractor's option, the initial reinforced shotcrete layer may be installed prior to drilling nail holes provided that this construction sequence has been documented in a submittal and approved by the Engineer. The Contractor's documentation shall include 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 shall be allowed without prior written approval by the Engineer of the proposed drilling, installation and grouting methods. Only installation methods which have been successfully verification-tested will be approved for production nail installation. Methods which fail to meet the verification and proof test acceptance criteria shall be rejected. Methods which differ from those

used during installation of verification nails shall require additional verification testing prior to approval; Installation and testing shall be completed by the Contractor at no additional cost to the Department.

Nails shall be installed at the locations and to the lengths as shown in the plans or designated by the Engineer. Nails may be added, eliminated or relocated as determined by the Engineer to accommodate actual field conditions.

Bar sizes and grades shall be provided for each nail hole as indicated in the plans. The bar shall be fitted with centralizers as shown in the plans and inserted 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 during installation. Where the bar cannot be completely inserted, the Contractor shall remove the bar and clean or redrill the hole to permit unobstructed installation. Partially installed bars shall not be driven or forced into the drill hole but shall be rejected. When open-hole drilling methods are being used, the Contractor shall have hole cleaning tools on-site suitable for cleaning drill holes along their full length just prior to bar insertion and/or grouting.

G. Grouting

The drill hole shall be grouted 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 shall be rejected and replaced by the Contractor at no additional cost to the Department. No portion of the nail hole shall be left open for more than 60 minutes prior to grouting unless otherwise approved by the Engineer. The grout shall be injected at the lowest point of each drill hole through a grouting conduit and the hole filled 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. The grout shall be pumped through a grout tremie pipe, casing, hollow-stem auger or drill rods. The conduit delivering the grout shall be maintained at least 5 feet (1.5 m) below the surface of the grout as the conduit is withdrawn. The grouting conduit shall be withdrawn 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 shall be available in delivery trucks or grout mixing/pumping plants when the first grout is placed in each nail hole. The quantity of grout and the grouting pressures shall be recorded by the Engineer.

If the grouting of any nail is suspended for more than 30 minutes before grouting is completed or if the quality of the grout placement results in a nail that does not satisfy any of the requirements specified herein, then the steel and grout shall be removed from the hole, disposed of and replaced with fresh grout and undamaged steel at no additional cost to the Department.

1. Grout Testing

   Nail grout shall have a minimum compressive strength of 3000 psi (21 Mpa) in seven days. Nail grout shall be tested 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

   The grout equipment shall produce a uniformly mixed grout free of lumpy and undispersed cement. A positive displacement grout pump shall be provided. The pump shall be equipped 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 cannot be used. The grouting equipment shall be sized to enable the entire nail to be grouted in one continuous operation. The mixer shall be capable of continuously agitating the grout during usage.

H. Attachment of Bearing Plate and Nut

The bearing plate and nut shall be attached as shown in the plans. The plate shall be seated 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, the plate shall be seated on a mortar pad to provide uniform support. Once the mortar pad has attained strength (minimum one day), the nut shall be hand wrench tightened.

Bearing plates that are damaged or defective as determined by the Engineer shall be replaced at no 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 shall 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 shall 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 shall be submitted to the Engineer for approval.

10.0 SHOTCRETING

This work shall consist of furnishing all materials, equipment, tools and labor required for placing and securing geocomposite drainage material, weep holes and reinforced shotcrete

for the soil nail wall. The work shall include preparatory trimming and cleaning of soil/rock surfaces and shotcrete cold joints for the soil nail wall shown in the plans.

Shotcrete shall comply with the requirements of ACI 506R, "Specification for Shotcrete", except as otherwise specified. Shotcrete shall consist 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 shall 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. For additional descriptive information, the Contractor's attention is directed to ACI 506R.

A. Mix Design

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

1. Aggregate

Aggregate for shotcrete shall meet the strength and durability requirement of AASHTO M-80 and M-43 and shall meet 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

Shotcrete shall be proportioned and delivered with the following minimum contents per cubic yard: Cement content shall be 658 pounds per cubic yard (390 kilograms

per cubic meter). Aggregate cement ratio shall not be more than 4.5 by weight. Water/cement ratio shall not be greater than 0.45. For wet-mix shotcrete the air content at delivery to the pump shall be in the range of 7 to 10 percent when tested in accordance with ASTM C231.

3. Strength Requirements

   Shotcrete shall be proportioned to produce a 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 must 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. Mixing equipment shall be capable of thoroughly mixing the materials in sufficient quantity to maintain placing continuity. Ready mix shotcrete shall comply with AASHTO M-157. Shotcrete shall be batched, delivered and placed within 90 minutes of mixing.

B. Field Quality Control

Both preconstruction and production shotcrete test panels will be required. Test panels shall not be disturbed within the first 24 hours. Test panels shall be field cured under conditions similar to those anticipated for the work.

Field control tests shall be performed by qualified personnel in the presence of the Engineer. The Contractor shall 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 in accordance with ACI 506R will perform compressive strength testing. The frequency specified for test panels is approximate. A greater or lesser number of panels may be made as required by the Engineer.

Preconstruction and production test panels shall 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 shall 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 specimen 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 shall be borne by the Contractor.

1. Preconstruction Test Panels

   The Contractor shall 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 shall 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 shall be in accordance with ACI 506.2 and the following:

   1. One preconstruction test panel shall be of the maximum shotcrete thickness shown in the plans and shall include the maximum anticipated reinforcing congestion. Cores extracted from the test panel shall demonstrate adequate cover of the reinforcement and shall be equal to core grade two or better in accordance with ACI 506.2.

   2. One preconstruction test panel shall be at least 4 inches (100 mm) thick and constructed without reinforcement for compressive strength testing.

   3. The sides of the test panels shall be sloped at 45 degrees.

2. Production Test Panels

   The Contractor shall 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. The production test panels shall be constructed simultaneously with the shotcrete facing installation at times designated by the Engineer.

3. Core Testing

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

   Core holes in the wall shall be filled solid 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 shall be immediately suspended and the work carefully inspected by the Engineer. The Contractor shall 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. The shotcreted surface shall be broomed and roughened if needed to ensure proper bond of subsequent layers.

C. Shotcrete Alignment Control

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

D. Surface Preparation

Prior to shotcrete the "birds beak" ungrouted zone above the nail grout at the face, the Contractor shall remove all loose materials from the surface of the grout and prepare the joint in accordance with all requirements for joint construction specified herein.

The Contractor shall remove all loose materials and loose dried shotcrete from previous placement operations from all receiving surfaces by methods acceptable to the Engineer. The removal shall be accomplished 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 shall be removed to a sufficient depth to provide a base that is suitable to receive the shotcrete. Material that loosens as the shotcrete is applied shall be removed. No shotcrete shall be placed on frozen surfaces.

E. Delivery and Application

A clean, dry, oil-free supply of compressed air sufficient for maintaining adequate nozzle velocity for all parts of the work shall be maintained at all times. The equipment shall be capable of delivering the premixed material accurately, uniformly and continuously through the delivery hose. Thickness, methods of support, air pressure and rate of placement of shotcrete shall be controlled to prevent sagging or sloughing of freshly-applied shotcrete.

The shotcrete shall be applied from the lower part of the area upwards to prevent accumulation of rebound on uncovered surfaces. Where shotcrete is used to complete

the ungrouted zone of the nail drill hole near the face, the nozzle shall be positioned into the mouth of the drill hole to completely fill the void. Rebound shall not be worked back into the construction nor shall the rebound be salvaged. Rebound which does not fall clear of the working area shall be removed. The nozzle shall be held at a distance and at an angle approximately perpendicular to the working face so that rebound will be minimal and compaction will be maximized. The nozzle should be rotated steadily in a small circular pattern.

F. Defective Shotcrete

Surface defects shall be repaired as soon as possible after initial placement of the shotcrete. All shotcrete which lacks uniformity, which exhibits segregation, honeycombing or lamination or which contains any voids or sand pockets shall be removed and replaced with fresh shotcrete by the Contractor to the satisfaction of the Engineer.

G. Construction Joints

Construction joints shall be uniformly tapered toward the excavation face over a minimum distance equal to the thickness of the shotcrete layer. The surface of the nail grout at the face of the wall shall be cleaned and prepared to receive shotcrete in a manner equal to all other construction joints.

H. Finish

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

I. Climate

Shotcrete shall not be placed in cold weather unless adequately protected 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. Cold weather protection shall be maintained until the strength of the in-place shotcrete is greater then 750 psi (5.2 MPa). Cold weather protection shall include heating under tents, blankets or other means acceptable to the Engineer. Materials shall be heated in order that the temperature of the shotcrete, when deposited, shall be not less than 50°F (10°C) or more than 90°F (32°C).

Shotcrete application shall also be suspended during high winds and heavy rains when in the opinion of the Engineer the quality of the application is not acceptable. Newly placed shotcrete exposed to rain that washes out cement or otherwise makes the shotcrete unacceptable to the Engineer shall be removed and replaced. The Contractor shall provided polyethylene sheeting or equivalent when adverse exposure to weathering is anticipated. Polyethylene film shall be adequately secured to the top and bottom of the excavation.

11.0 CIP CONCRETE FACING

Construction of the concrete facing shall conform to the requirements of Section 420 of the Standard Specifications, unless otherwise specified herein. The exposed face of the concrete facing shall be formed with 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. Formwork and falsework system shall be approved by the Engineer before the beginning of any formwork.

The vertical face of the wall shall 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 will be allowed.

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

Internal vibrations shall be used and no external vibrations shall be 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.

Patching as needed shall be accomplished with epoxy mortars or specially mixed grouts for patching. Concrete from subsequent placements shall not be used for patching. Patch may be recessed slightly and smearing fill material on the surrounding finished surface should not be allowed. Light sand blasting shall be used to improve the appearance of the finished surface of the wall as directed by the Engineer.

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

The cast-in-place concrete facing shall have the same appearance on the surface as the existing retaining wall at the south end of the proposed retaining wall. The Contractor will also be responsible for restoring the surface and appearance of the existing retaining wall. The cost of the restoration of the existing wall as well as the aesthetic treatment of the proposed wall will be considered incidental to the cost of the soil nail retaining wall. The final appearance of both the existing and proposed retaining walls is subject to approval by the Resident Engineer.

12.0 WALL DRAINAGE NETWORK

The drainage network consists of installing prefabricated geocomposite drainage strips and weep hole drain pipes as shown in the plans or as directed by the Engineer. All elements of the drainage network shall be installed prior to shotcreting.

A. Geocomposite Drainage Strips

Geocomposite drain strips shall be installed as shown in the plans. Drain strips at construction joints shall be placed such that the joint is aligned as close as practical along the middle of the longitudinal axis of the drain strip.

The geocomposite drain strip shall be at least 12 inches (300 mm) wide and shall be secured to the cut face with the geotextile side against the ground before shotcreting. Securing pins shall be at least 8 inches (200 mm) long with a 1.5 inch (38 mm) diameter head and shall be installed on a minimum grid pattern of 24 inches (600 mm) on center. Drain strips shall be made continuous. Splices shall be made with a 12 inch (300 mm) minimum overlap such that the flow is not impeded.

When the drain strips cannot be secured tight against the excavation face, polyethylene film shall be placed 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

Weep hole drainage pipes shall be installed at locations shown in the plans or as directed by the Engineer. The distance between each weep hole shall be no more than 10 feet (3 m). The pipes shall be lengths of solid PVC pipe installed to direct water from the geocomposite drain strips to the outside of the C.I.P. concrete facing. The pipes shall be connected to the drain strips by installing prefabricated drain grates in accordance with the drain strip manufacturer's recommendations. The joint between the drain grate and the drain strip and the drainage pipe shall be sealed to prevent shotcrete intrusion. Damage of the geocomposite drainage board which, in the opinion of the Engineer, may cause interruption in flow shall require installation of additional weep holes, at the Contractor's expense.

C. Half V-Ditch

A 4 inch (100 mm) thick concrete half V-ditch is required along the entire length of the soil nail retaining wall as shown on the typical section in the plans. The cast-in-place concrete face shall extend a minimum of 12 inches (300 mm) above the top of wall elevation to form the vertical portion of the ditch. The 4 inch (100 mm) thick concrete paving shall extend up the slope 2 feet (600 mm) back from the wall to form the other side of the ditch. Payment for the half V-ditch will be considered incidental to the cost of the soil nail retaining wall.

13.0 NAIL TESTING

Both verification and proof testing of the nails shall be required. The Contractor shall 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 shall 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, the casing shall be placed 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

Testing equipment shall include two dial or vernier gauges, a dial gauge support, jack and pressure gauge, master pressure gauge and a reaction frame.

A minimum of two dial or vernier gauges capable of measuring to 0.001 inch (.025 mm) shall be available at the site to measure the nail movement. The dial gauges shall have a minimum stroke of 3 inches (75 mm). The dial gauges shall be aligned within five degrees from the axis of the nail and shall be supported independent of the jacking set-up and the wall. A hydraulic jack and pump shall be used to apply the test load.

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

The jack shall be independently supported and centered over the nail so that the nail does not carry the weight of the jack. A calibrated master pressure gauge shall also be kept at the site. The master gauge shall be calibrated with the test jack and pressure gauge as a unit. The loads on the nails during the verification tests shall be monitored with both pressure gauge and electric load cell. The load cell shall be used to maintain constant load hold throughout the creep test. The Contractor shall provide recent calibration curves in accordance with submittals. The stressing equipment shall be placed over the nail in such a manner that the jack, bearing plates, load cell and stressing anchorage are in alignment. The jack shall be positioned at the beginning of the test such that unloading and repositioning of the jack during the test will not be required.

The reaction frame shall be 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 shall be designed to prevent fracture of the shotcrete. No part of the reaction

frame shall bear within 6 inches (150 mm) of the edge of the test nail blockout unless otherwise approved by the Engineer.

B. Verification Testing

Verification testing shall be performed 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 shall be performed within the limits of the work area. A minimum of two verification tests are required at locations approved by the Engineer. Additional verification tests are required where ground conditions differ from those shown in the plans.

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 shall be developed by the Contractor and submitted to the Engineer for approval. All nail testing shall be made 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 and shall be provided at no additional cost to the Department. The nails used for the verification tests shall be sacrificial and shall not be incorporated into the production nail schedule.

Test nails shall have both bonded and unbonded lengths. Prior to testing only the bonded length of the test nail shall be grouted. The unbonded length of the test nail shall be at least 5 feet (1.5 m) unless otherwise approved by the Engineer. The bonded length of the test nail shall be based on the bar grade and size such that the allowable bar load is not exceeded, but shall not be less than 10 feet (3 m) unless otherwise approved by the Engineer. The allowable bar load during testing shall not be greater than 80 percent of the ultimate strength of the steel for Grade 150 (1035) bars nor greater than 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. The Contractor shall provide higher capacity bars instead of shortening the bond length too less than the minimum.

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

$$L_{BV} \leq \frac{C f_y A_s}{2 A_D}$$

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

The design load during testing shall be determined 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)

Verification test nails shall be incrementally loaded to twice the design test load (DTL) followed by unloading 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		

Each load increment shall be held for at least ten minutes. The verification test nail shall be monitored for creep at 1.50 DTL load increment. Nail movements during the creep portion of the test shall be measured and recorded at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. Extended creep measurements may be required and shall be monitored as determined by the Engineer. All load increments shall be maintained within five percent of the intended load during the creep test by use of the load cell. The nail shall be unloaded in increments of 25 percent with deflection measurements recorded at each unload increment. Each unload increment shall be held only for a sufficient time to allow stabilization of the movement reading.

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

C. Proof Testing

Proof testing shall be performed 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 locations and number of these tests shall be determined by the Engineer.

Proof test nails shall have both bonded and unbonded lengths. Prior to testing only the bonded length of the test nail shall be grouted. The unbonded length of the test nail shall be at least 5 ft (1.5 m). The bonded length of the test nail will be such that the allowable bar load is not exceeded but shall not be less than 10 feet (3 m) unless otherwise approved by the Engineer. The allowable bar load shall 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} shall not exceed the test allowable bar load divided by 1.5 times the design adhesion value. The following equation shall be used 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

Proof tests shall be performed by incrementally loading the nail to 150 percent of the design test load. The design test load shall be determined as for verification test nails. The nail movement at each load shall be measured and recorded by the Engineer in the same manner as for verification test. The load shall be monitored by a pressure gauge with a sensitivity and range meeting the requirements of pressure gauges used for verification test nails. Incremental loading for proof tests shall be 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 should not exceed five percent of the design load (DTL). Dial gauges should be "zeroed" after the alignment load has been applied.

All load increments shall be maintained within five percent of the intended load. Depending on performance, either 10 minute or 60 minute creep tests shall be

performed at the maximum test load (1.50 DTL). The creep period shall start as soon as the maximum test load is applied and the nail movement shall be measured and recorded at 1, 2, 3, 5, 6 and 10 minutes. Where nail movement between one minute and 10 minutes exceeds 0.04 inch (1 mm), the maximum test load shall be maintained an additional 50 minutes and movements shall be recorded 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. The pullout failure load shall be recorded 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, (3) corrosion protection is provided and (4) the test nail length is equal to or greater than the scheduled production nail length. Test nails meeting these requirements shall be completed by satisfactorily grouting the unbonded test length. Maintaining the unbonded test length for subsequent grouting is the Contractor's responsibility. If the unbonded test length of production proof test nails cannot be grouted subsequent to testing due to caving conditions or other reasons, the Contractor shall 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. The Contractor shall propose alternative methods and install replacement verification test nails. Where the design adhesion is not attainable by reasonable means, the Engineer will

revise the production nail schedule. The Contractor shall incorporate any increases in the quantity, the lengths or the diameters of nails required by the Engineer. Reasonable means shall be considered to include gravity grouted nails installed as specified herein to the minimum diameter shown in the plans 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. Nails which fail in proof test shall be abandoned and replaced 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

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

B. Shotcrete Facing

Shotcrete shall comply with the requirements of ACI 506R, "Specification for Shotcrete", except as otherwise specified. Shotcrete shall consist 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 shall then be air jetted from the nozzle at high velocity onto the surface. Dry-mix process is shotcrete without mixing water that is conveyed through the hose pneumatically and the mixing water is introduced at the nozzle. For additional descriptive information, the Contractor's attention is directed to ACI 506R.

C. Bearing Plates

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

15.0 RECORDS

Accurate records shall be maintained by the Engineer and shall contain the following information for each nail:

1. Contractor's name
2. Drill rig operator's name
3. As-built, surveyed nail location
4. Deviation from specified tolerances
5. Nail diameter
6. As-built, surveyed nail elevation
7. Design nail length
8. Nail diameter
9. Installed nail length
10. Groundwater conditions
11. Caving or sloughing of excavation
12. Casing requirements
13. Drilling difficulties
14. Date and time of start and finish of drilling
15. Length and diameter of drilled hole
16. Date, time and method grout was placed including grout pressure
17. Total daily quantity of grout placed and quantity per hole
18. Design changes

The Contractor shall assist the Engineer as necessary to obtain the as-built nail locations and all other information as required by the Engineer. Upon completion of the work, the Contractor shall submit a complete record of the construction activities to the Engineer.

16.0 MEASUREMENT AND PAYMENT

No separate measurement for payment purposes will be made for this work. The lump sum payment shall be for each soil nail wall and the cast-in-place concrete face. 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 .....Lump Sum