Project B-3157 **Davidson County**

Project Special Provisions
Structures & Culverts

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PROJECT SPECIAL PROVISIONS
STRUCTURES AND CULVERTS

PROJECT B-3157 **DAVIDSON COUNTY**

MAINTENANCE AND PROTECTION OF TRAFFIC BENEATH PROPOSED STRUCTURE AT STATION 29+25.37 -L- (LEFT LANE & RIGHT LANE) (SPECIAL)

Maintain traffic on SR 1242 as shown in Traffic Control Plans and as directed by the Engineer.

Provide a minimum temporary vertical clearance of 15'-6" at all times during construction.

Submit plans and calculations for review and approval for protecting traffic and bracing girders, as described herein, at the above station before beginning work at this location. Have the drawings and design calculations prepared, signed, and sealed by a North Carolina Registered Professional Engineer. The approval of the Engineer will not relieve the Contractor of the responsibility for the safety of the method or equipment.

Protect traffic from any operation that affords the opportunity for construction materials, equipment, tools, etc. to be dropped into the path of traffic beneath the structure. Based on Contractor means and methods determine and clearly define all dead and live loads for this system, which, at a minimum, shall be installed between beams or girders over any travelway or shoulder area where traffic is maintained. Install the protective system before beginning any construction operations over traffic. In addition, for these same areas, keep the overhang falsework in place until after the rails have been poured.

Brace girders to resist wind forces, weight of forms and other temporary loads, especially those eccentric to the vertical axis of the member during all stages of erection and construction. Before casting of intermediate diaphragms, decks, or connecting steel diaphragms do not allow the horizontal movement of girders to exceed ½ inch (13mm).

Payment at the contract unit prices for the various pay items will be full compensation for the above work.

FALSEWORK AND FORMS OVER OR ADJACENT TO TRAFFIC (10-12-01)

This Special Provision applies in addition to Article 420-3 of the Standard Specifications.

This Special Provision covers falsework or forms including metal stay-in-place forms and precast concrete deck panels erected over vehicular, pedestrian or railroad traffic, or vessel traffic on navigable waterways. It also covers falsework and forms for those parts of a substructure unit constructed within 20 ft. (6 m) of the edge of a travelway or railroad track and more than 25 ft. (7.6 m) above the ground line at the time of substructure construction.

1.0 SUBMITTALS

Submit detailed drawings as required by the Standard Specifications or other Special Provisions and one set of design calculations for falsework and forms for review and acceptance before beginning construction of the falsework or forms. Have the drawings and design calculations prepared, signed and sealed by a North Carolina Registered Professional Engineer. These submittal requirements apply to all falsework and form systems covered by this Special Provision.

2.0 DESIGN

Design falsework and forms for the combined effects of dead load and live load and with appropriate safety factors in accordance with these Special Provisions and the respective design codes of the materials used. Include the weight of concrete, reinforcing steel, forms and falsework in the dead load. Live load includes the actual weight of any equipment the falsework supports, applied as concentrated loads at the points of contact, and a uniform load of not less than 20 lbs/ft^2 (1.0 kPa) applied over the supported area. In addition, apply a line load of 75 lbs/ft (1.1 kN/m) along the outside edge of deck overhangs.

3.0 INSPECTION

Before the form or falsework system is loaded, inspect the erected falsework and forms and submit a written statement certifying that the erected falsework system complies with the accepted detailed drawings prepared by the Registered Professional Engineer. Submit a separate certification for each span, unit, or bridge component. Any condition that does not comply with the accepted drawings, or any other condition deemed unsatisfactory by the Engineer, is cause for rejection until corrections are made.

4.0 BASIS OF PAYMENT

Payment at the contract unit prices for the various pay items will be full compensation for the above work required for falsework or forms.

ADHESIVELY ANCHORED ANCHOR BOLTS OR DOWELS (10-12-01)

1.0 DESCRIPTION

The work covered by this Special Provision consists of furnishing all necessary labor, equipment, and materials and performing all operations necessary for installing anchor bolts/dowels in concrete using an adhesive bonding system in accordance with the details shown on the plans and with the requirements of this specification unless otherwise directed.

Submit a description of the proposed adhesive bonding system to the Engineer for review, comments and acceptance. Include in the description the bolt type and its deformations, equipment, manufacturer's recommended hole diameter, embedment depth, material specifications, and any other material, equipment or procedure not covered by the plans or these specifications. List the properties of the adhesive, including density, minimum and maximum temperature application, setting time, shelf life, pot life, shear strength and compressive strength. If bars/dowels containing a corrosion protective coating are required, provide an adhesive that does not contain any chemical elements that are detrimental to the coating and include a statement to this effect in the submittal.

2.0 MATERIALS

Use an adhesive bonding system that has been tested for a tensile strength of 125% of the specified anchor bolt/dowel yield load. Provide certification that, for the particular bolt grade, diameter and embedment depth required, the anchor system will not fail by adhesive failure and that the anchor bolt/dowel will not move. The minimum concrete compressive strength is 3000 psi (20.7 MPa) for certification and anchorage selection.

Package components of the adhesive so that one whole container of each component mixes to form one batch of adhesive. Use containers designed so that all of the contents may be removed easily and sealed tightly to prevent leakage. Furnish adhesive material requiring hand mixing in two separate containers designated as Component A and Component B. Provide a self contained cartridge or capsule consisting of two components which are automatically mixed as they are dispensed, as in the case of a cartridge, or drilled into, as in the case of a capsule.

Clearly label each container with the manufacturer's name, date of manufacture, batch number, batch expiration date, direction for use, and warnings and precautions concerning the contents as required by State or Federal Laws and Regulations.

3.0 PROCEDURE

A. Drilling of Holes into Concrete

When directed, use a jig or fixture to ensure the holes are positioned and aligned correctly during the drilling process. Upon approval, adjusting hole locations to avoid reinforcing steel is permitted.

Drill the holes with a pneumatic drill unless another drilling method is approved. Follow the manufacturer's recommendations regarding the diameter of the drilled hole.

Immediately after completion of drilling, blow all dust and debris out of the holes with oil-free compressed air using a wand extending to the bottom of the hole. Remove all dust from the sides of the holes by brushing the holes with a stiff-bristled brush of a sufficient size and then blow the hole free of dust. Repeat this procedure until the hole is completely clean. Check each hole with a depth gauge to ensure proper embedment depth.

Repair spalled or otherwise damaged concrete using approved methods.

B. Inspection of Holes

Inspect each hole immediately prior to placing the adhesive and the anchor bolts/dowels. Ensure all holes are dry and free of dust, dirt, oil, and grease. Rework any hole that does not meet the requirements of this Special Provision.

C. Mixing of Adhesive

Mix the adhesive in strict conformance with the manufacturer's instructions.

D. Embedment of Anchor Bolt/Dowel

Clean each anchor bolt/dowel so that it is free of all rust, grease, oil, and other contaminants.

Unless otherwise shown on the plans, the minimum anchor bolt/dowel embedment depth is such that the adhesive develops at least 125% of the anchor bolt/dowel yield load as determined by the manufacturer.

Insert the anchor bolt/dowel the specified depth into the hole and slightly agitate it to ensure wetting and complete encapsulation. After insertion of the anchor bolt/dowel, strike off any excessive adhesive flush with the concrete face. Should the adhesive fail to fill the hole, add additional adhesive to the hole to allow a flush strike-off.

Do not disturb the anchor bolts/dowels while adhesive is hardening.

4.0 FIELD TESTING

When specified on the plans, test the installed anchor bolts/dowels for adequate adhesive as specified below. Inform the Engineer when the tests will be performed at least 2 days prior to testing. Conduct the tests in the presence of the Engineer.

Use a calibrated hydraulic centerhole jack system for testing. Place the jack on a plate washer that has a hole at least 1/8 inch (3 mm) larger than the hole drilled into the concrete. Position the plate washer on center to allow an unobstructed pull. Position the anchor bolts/dowels and the jack on the same axis. Have an approved testing agency calibrate the jack within 6 months prior to testing. Supply the Engineer with a certificate of calibration.

In the presence of the Engineer, field test 10% of the first 50 anchor bolts/dowels prior to installing any additional anchors. For testing, apply and hold briefly 90% of the anchor bolt/dowel yield load shown on the plans. No visible signs of movement of the anchor bolts/dowels is permitted under this load. Upon receiving satisfactory results from these tests, install the remaining anchors. Test a minimum of 2% of the remaining anchors as previously described.

Record data for each anchor bolt/dowel tested on the report form entitled "Installation Test Report of Adhesively Anchored Anchor Bolts or Dowels". Obtain this form from the North Carolina Department of Transportation Materials and Tests Engineer. Submit a copy of the completed report forms to the Engineer.

Final acceptance of the adhesively anchored system is based on the conformance of the pull test to the requirements of this specification. Failure to meet the criteria of this specification is grounds for rejection.

5.0 BASIS OF PAYMENT

No separate measurement or payment will be made for furnishing, installing, and testing anchor bolts/dowels.

Payment at the contract unit prices for the various pay items will be full compensation for all materials, equipment, tools, labor, and incidentals necessary to complete the above work.

EVAZOTE JOINT SEALS (02/04/03)

1.0 SEALS

Use preformed seals compatible with concrete and resistant to abrasion, oxidation, oils, gasoline, salt and other materials that are spilled on or applied to the surface. Use a low-density closed cell, cross-linked ethylene vinyl acetate polyethylene copolymer nitrogen blown material for the seal.

Use seals manufactured with grooves 1/8" (3 mm) ± wide by 1/8" (3 mm) ± deep and spaced between 1/4 (6 mm) and 1/2 inch (13 mm) apart along the bond surface running the length of the joint. Use seals sized so that the depth of the seal meets the manufacturer's recommendation, but is not less than 70% of the uncompressed width. Provide a seal designed so that, when compressed, the center portion of the top does not extend upward above the original height of the seal by more than 1/4 inch (6 mm). Splice the seal using the heat welding method by placing the joint material ends against a teflon heating iron of 350°F (177°C) for 7 - 10 seconds, then pressing the ends together tightly. Do not test the welding until the material has completely cooled. Use material that resists weathering and ultraviolet rays. Provide a seal that has a working range of 30% tension and 60% compression and is watertight along its entire length including the ends.

Provide seals that meet the requirements given below.

TEST	TEST METHOD	REQUIREMENT
Elongation at break	ASTM D3575	210 ± 15%
Tensile strength, psi (kPa)	ASTM D3575	110 ± 15 (755 ± 100)
Compression Recovery (% of original width)	AASHTO T42 50% compr. for 22 hr. @ 73°F (23°C) 1/2 hr. recovery	87 ± 3
Weather/Deterioration	AASHTO T42 Accelerated Weathering	No deterioration for 10 years min.
Compression/Deflection	@ 50% deflection of original width @ 50% deflection of original width	10 psi (69 kPa) min. 60 psi (414 kPa) max.
Tear Strength, psi (kPa)	ASTM D624	16 ± 3 (110 ± 20)
Density	ASTM D545	2.8 to 3.4
Water Absorption (% vol/vol)	ASTM D3575 Total immersion for 3 months	3

Have the top of the evazote seal clearly shop marked. Inspect the evazote seals upon receipt to ensure that the marks are clearly visible upon installation.

2.0 ADHESIVES

Use a two component, 100% solid, modified epoxy adhesive with the seal that meets the requirements of ASTM C881, Type 1, Grade 3, Class B & C and has the following physical properties:

Tensile strength ..... 3500 psi (24.1 MPa) min.
Compressive strength ..... 7000 psi (48.3 MPa) min.
Shore D Hardness ..... 75 psi (0.5 MPa) min.
Water Absorption ..... 0.25% by weight

Use an adhesive that is workable to 40°F (4°C). When installing in temperatures below 40°F (4°C) or for application on moist, difficult to dry concrete surfaces, use an adhesive specified by the manufacturer of the joint material.

3.0 SAWING THE JOINTS

When the plans call for sawing the joints, initially form the joints to the width shown on the plans.

Allow the concrete slab to cure for at least 2 days prior to sawing the concrete joint to its final specified width and depth.

When sawing the joint to receive the evazote seal, always use a rigid guide to control the saw in the desired direction. To control the saw and to produce a straight line as indicated on the plans, anchor and positively connect a template or a track to the bridge deck. Do not saw the joint by visual means such as a chalk line. Fill the holes used for holding the template or track to the deck with an approved, flowable non-shrink, non-metallic grout.

Saw cut to the desired width and depth in one or two passes of the saw by placing and spacing two metal blades on the saw shaft to the desired width for compression seals.

The desired depth is the depth of the seal plus 1/4 inch (6 mm) above the top of the seal plus approximately 1 inch (25 mm) below the bottom of the seal. An irregular bottom of sawed joint is permitted as indicated on the plans. Grind exposed corners on saw cut edges to a 1/4" (6 mm) chamfer.

Remove any staining or deposited material resulting from sawing with a wet blade to the satisfaction of the Engineer.

Use extreme care to saw the joint straight to the desired width and to prevent any chipping or damage to sawed edges of the joint.

4.0 PREPARATIONS FOR SAWED JOINTS

When the plans call for sawing the joint, the Engineer thoroughly inspects the sawed joint opening for spalls, popouts, cracks, etc. Make all necessary repairs prior to blast cleaning and installing the seal.

Immediately before sealing, clean the joints by sandblasting with clean dry sand. Sandblast to provide a firm, clean joint surface free of curing compound, loose material and any foreign matter. Sandblast without causing pitting or uneven surfaces.

After blasting, either brush the surface with clean brushes made of hair, bristle or fiber, blow the surface with compressed air, or vacuum the surface until all traces of blast products and abrasives are removed from the surface, pockets, and corners.

If nozzle blasting, use compressed air that does not contain detrimental amounts of water or oil.

Examine the blast cleaned surface and remove any traces of oil, grease or smudge deposited in the cleaning operations.

Bond the seal to the blast cleaned surface on the same day the surface is blast cleaned.

5.0 PREPARATIONS FOR ARMORED JOINTS

When the plans call for armored joints, form the joint and blockout openings in accordance with the plans. If preferred, wrap the temporary form with polyethylene sheets to allow for easier removal. Do not use form release agents.

A. Submittals

Submitting detailed working drawings is not required; however, submitting catalog cuts of the proposed material is required. In addition, direct the joint supplier to provide an angle segment placing plan.

B. Surface Preparation

Prepare the surface within the 48 hours prior to placing the elastomeric concrete. Do not place the elastomeric concrete until the surface preparation is completed and approved.

1. Angle Assembly

Clean and free metallized steel of all foreign contaminants and blast the non-metallized steel surfaces to SSPC SP-10. Blast-cleaning anchor studs is not required.

2. Concrete

Prior to placing the elastomeric concrete, thoroughly clean and dry all concrete surfaces. Sandblast the concrete surface in the blockout and clear the surface of all loose debris.

C. Elastomeric Concrete Placement

Make sure that a manufacturer's representative is present when placing elastomeric concrete. Do not place elastomeric concrete if the ambient air temperature is below 45°F (7°C).

Prepare and apply a primer, as per manufacturer's recommendations, to all vertical concrete faces, all steel components to be in contact with elastomeric concrete, and to areas specified by the manufacturer. Align the angles with the joint opening.

Prepare, batch, and place the elastomeric concrete in accordance with the manufacturer's instructions. Place the elastomeric concrete in the areas specified on the plans while the primer is still tacky and within 2 hours after applying the primer. Pay careful attention to properly consolidate the concrete around the steel and anchors. Trowel the elastomeric concrete to a smooth finish.

D. Joint Preparation

Prior to installing the seal, the Engineer thoroughly inspects the armored joint opening for proper alignment and full consolidation of elastomeric concrete under the angle assemblies. Make all necessary repairs prior to cleaning the joint opening and installing the seal.

Clean the armored joint opening with a pressure washer rated at 3000 psi (20.7 MPa) minimum at least 24 hours after placing the elastomeric concrete. Dry the cleaned surface prior to installing the seal.

Examine the cleaned surface and remove traces of oil, grease or smudge deposited during the cleaning operations.

Bond the seal to the cleaned surface on the same day the surface is cleaned.

6.0 SEAL INSTALLATION

Install the joint seal according to the manufacturer's procedures and recommendations and as recommended below. Do not install the joint seal if the ambient air temperature is below 45°F (7°C). Have a manufacturer's representative present during the installation of the first seal of the project.

Begin installation at the low end of the joint after applying the mixed epoxy to the sides of both the joint material and both sides of the joint, making certain to completely fill the grooves with epoxy. With gloved hands, compress the material and with the help of a blunt probe, push it down into the joint until it is recessed approximately 1/4 inch (6 mm) below the surface. Do not push the seal at an angle that would stretch the material. Once work on a joint begins, do not stop until it is completed. Clean the excess epoxy off the surface of the joint material *quickly* and *thoroughly*. Do not use solvents to remove excess epoxy. Remove excess epoxy in accordance with the joint manufacturer's recommendations.

Install the seal so that it is watertight. Testing of the joint seal is not required, but it is observed until final inspection.

7.0 BASIS OF PAYMENT

Payment for all evazote joint seals will be at the lump sum contract price bid for "Evazote Joint Seals" which prices and payment will be full compensation for furnishing all material, including elastomeric concrete when required, labor, tools and equipment necessary for installing these units in place and accepted.

EPOXY PROTECTIVE COATING (10-12-01)

1.0 DESCRIPTION

This work consists of preparing the concrete surface and furnishing and applying an epoxy protective coating to the surfaces described in this Special Provision. When epoxy protective coating is required, cure the top surfaces of the bent or end bent caps in accordance with the Standard Specifications, but do not use the Membrane Curing Compound method.

2.0 MATERIALS

Use an epoxy coating that meets the most recently published NCDOT Specification on the date of advertisement. Use the epoxy coating that meets NCDOT-Type 4A Flexible, epoxy coating, moisture insensitive.

Provide a certification for the proposed epoxy showing that it meets NCDOT-Type 4A.

The following companies have epoxies that meet Type 4A Specifications:

- E-Bond Epoxy, Inc.
  Fort Lauderdale, Florida 33307
- Permagile Industries
  Plainview, NY 11803
- Poly-Carb
  Cleveland, OH 44139
- Tamms, Inc.
  Mentor, OH 44060
- Adhesive Engineering
  Cleveland, OH 44122-5554
- Kaufman Products
  Baltimore, MD 21226-1131
- Prime Resins
  Lithonia, GA 30058
- Sika Corporation
  Lyndhurst, N. J. 07071

A copy of the specifications for Epoxy Resin Systems is available from the Materials and Tests Unit.

3.0 SURFACES

With the exception of cored slab bridges, apply the epoxy protective coating to the top surface area, including chamfer area, of bent caps under expansion joints and of end bent caps, excluding areas under elastomeric bearings. For cored slab bridges, do not apply the epoxy protective coating to the bent or end bent caps. Also, apply epoxy protective coating to the ends of prestressed concrete members as noted on the plans.

Use extreme care to keep the area under the elastomeric bearings free of the epoxy protective coating. Do not apply the epoxy protective coating in the notch at the ends of the prestressed concrete girders.

Thoroughly clean all dust, dirt, grease, oil, laitance, and other objectionable material from the concrete surfaces to be coated. Air-blast all surfaces immediately prior to applying the protective coating.

Only use cleaning agents pre-approved by the Engineer.

4.0 APPLICATION

Apply epoxy protective coating only when the air temperature is at least 40°F (4°C) and rising, but less than 95°F (35°C) and the surface temperature of the area to be coated is at least 40°F (4°C). Remove any excess or free standing water from the surfaces before applying the coating. Apply one coat of epoxy protective coating at a rate such that it covers between 100 and 200 ft^2/gal (2.5 and 5 m^2/liter).

Note: Under certain combinations of circumstances, the cured epoxy protective coating may develop "oily" condition on the surface due to amine blush. This condition is not detrimental to the applied system.

Apply the coating so that the entire designated surface of the concrete is covered and all pores filled. To provide a uniform appearance, use the exact same material on all visible surfaces.

5.0 BASIS OF PAYMENT

No separate measurement or payment will be made for preparing, furnishing and applying the epoxy protective coating to the concrete surfaces.

Payment at the contract unit prices for the various pay items will be full compensation for the above work including all materials, equipment, tools, labor, and incidentals necessary to complete the work.

OPTIONAL PRECAST REINFORCED CONCRETE BOX CULVERT AT STATION 17+48.00 -Y1- AND 20+81.50 -Y6- (2-14-04)

1.0 GENERAL

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

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

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

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

2.0 PRECAST REINFORCED CONCRETE BOX SECTIONS

A. Types

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

B. Design

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

2. Placement of Reinforcement – Provide a 1 inch (25 mm) concrete cover over the circumferential reinforcement subject to the provisions of Section F. Extend the inside circumferential reinforcement into the male portion of the joint and the outside circumferential reinforcement into the female portion of the joint. Detail the clear distance of the end circumferential wires so it is not less than 1/2 inch

(13 mm) nor more than 2 inches (51 mm) from the ends of the box section. Assemble reinforcement per the requirements of AASHTO M259, Section 7.3. The exposure of the ends of the wires used to position the reinforcement is not a cause for rejection.

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

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

C. Joints

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

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

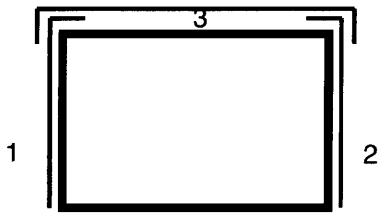

Figure 1

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

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

D. Manufacture

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

1. Mixture – In addition to the requirements of Section 1077 of the Standard Specifications, do not proportion the mix with less than 564 lb/yd3 (335 kg/m3) of portland cement.

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

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

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

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

E. Physical Requirements

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

F. Permissible Variations

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

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

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

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

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

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

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

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

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

G. Marking

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

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

H. Construction

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

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

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

3.0 BASIS OF PAYMENT

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

FALSEWORK AND FORMWORK (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 (2-14-04)

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:

Western Regional Geotechnical
Manager
North Carolina Department
of Transportation
Geotechnical Engineering Unit
Western Regional Office
1589 Mail Service Center
Raleigh, NC 27699-1589

Attention: Mr. M. A. Mulla, P. E.

Via other delivery service:

Western Regional Geotechnical
Manager
North Carolina Department
of Transportation
Geotechnical Engineering Unit
Western Regional Office
1020 Birch Ridge Drive
Raleigh, NC 27610

Attention: Mr. M. A. Mulla, P. E.

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):
Mohammed Mulla
(919) 250-4088
(919) 250-4237 facsimile
mmulla@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.

ELASTOMERIC BEARINGS (10-03-02)

Use elastomeric bearings in accordance with Article 1079-2 of the Standard Specifications except as follows:

TABLE 1079-2
NATURAL RUBBER ELASTOMER REQUIREMENTS

Grade (durometer)	50	60
PHYSICAL PROPERTIES Hardness ASTM D2240	50 +5 -5	60 +5 -5

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 100,000 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 Soils and Foundation Design Section. 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.

9.0 NAIL 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. 16	35-55
No. 30	20-35
No. 50	8-20
No. 100	2-10

No.

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.

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.

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 at Station _____ ..... Lump Sum