## TABLE OF CONTENTS



| | |
|---|---|
| STATE OF MISSOURI<br>GRANT LUCKENBILL<br>NUMBER PE-2012018100<br>PROFESSIONAL ENGINEER<br>7-24-25<br><br>Digitally signed by Grant Luckenbill<br>Date: 2025.07.24 21:16:36-05'00' | **MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION**<br>105 W. CAPITOL AVE.<br>JEFFERSON CITY, MO 65101<br>Phone (888) 275-6636 |
| | **OLSSON**<br>7301 West 133rd Street<br>Overland Park, KS 66213<br>Certificate of Authority # 001592<br>Consultant Phone #913-381-1170 |
| | If a seal is present on this sheet, JSP's has been electronically sealed and dated. |
| | JOB NO. JKU0010<br>Jackson County, MO<br>Date Prepared: 7/24/2025 |
| | |
| Only the following items of the Job Special Provisions (Bridge) are authenticated by this seal: A-B | |

| | |
|---|---|
| STATE OF MISSOURI<br>ROBERT R. SHERWOOD<br>NUMBER PE-2025018558<br>7/24/2025<br>PROFESSIONAL ENGINEER<br><br>Robert R. Sherwood<br>Digitally signed by Robert R. Sherwood<br>DN: C=US, E=rsherwood@olsson.com, O=Olsson, OU=Geotechnical, CN=Robert R. Sherwood<br>Location: Olathe, Kansas<br>Reason: I have reviewed this document<br>Contact Info: 620.306.1530<br>Date: 2025.07.24 16:07:45-05'00' | **MISSOURI HIGHWAYS AND TRANSPORTATION COMMISSION**<br>105 W. CAPITOL AVE.<br>JEFFERSON CITY, MO 65101<br>Phone (888) 275-6636 |
| | **OLSSON**<br>7301 West 133rd Street<br>Overland Park, KS 66213<br>Certificate of Authority # 001592<br>Consultant Phone #913-381-1170 |
| | If a seal is present on this sheet, JSP's has been electronically sealed and dated. |
| | JOB NO. JKU0010<br>Jackson County, MO<br>Date Prepared: 7/24/2025 |
| | |
| Only the following items of the Job Special Provisions (Bridge) are authenticated by this seal: C-E | |

A. CONSTRUCTION REQUIREMENTS

**1.0 Description.** This provision contains general construction requirements for this project.

**2.0 Construction Requirements.** The plans and the asbestos and lead inspection report(s) for the existing structure(s) and the geotechnical report for the new structure(s) are included in the contract in the bridge electronic deliverables zip file for informational purposes only.

**2.1** In order to assure the least traffic interference, the work shall be scheduled so that a lane closure is for the absolute minimum amount of time required to complete the work. A lane shall not be closed until material is available for continuous construction and the contractor is prepared to diligently pursue the work until the closed lane is opened to traffic.

**2.2** Bridge work by contractor forces, including erection, rehabilitation or demolition, shall not be allowed over traffic unless a bridge platform protection system is installed below the work area except for work performed above a deck that is intact. The protection system shall be capable of catching all falling objects such as tools, overhang brackets or materials. Lifting of objects that are heavier than the capacity of the bridge protection system shall not be permitted.

**2.3** Provisions shall be made to prevent any debris and material from falling onto the roadway. If determined necessary by the engineer, any debris and material that falls below the bridge outside the previously specified limits shall be removed as approved by the engineer at the contractor's expense. Traffic under the bridge shall be maintained in accordance with the contract documents.

**2.4** Any damage sustained to the remaining structure as a result of the contractor's operations shall be repaired or the material replaced as approved by the engineer at the contractor's expense.

**2.5** Provisions shall be made to prevent damage to any existing utilities. Any damage sustained to the utilities as a result of the contractor's operations shall be the responsibility of the contractor. All costs of repair and disruption of service shall be as determined by the utility owners and as approved by the engineer.

**2.6 Environmental Contact.** Environmental Section may be contacted at the below address or phone number. The Missouri Department of Health may be contacted at (573) 751-6102.

MoDOT - Design Division - Environmental Section
P.O. Box 270
105 W. Capitol Ave., Jefferson City, MO 65102
Telephone: (573) 526-4778

**2.7 Approved Smelter and Hazardous Waste Treatment, Storage and Disposal Facility.** The following is the approved smelter and hazardous waste treatment, storage and disposal facility:

Doe Run Company - Resource Recycling Division - Buick Facility
Highway KK
Boss, MO 65440
Telephone: (573) 626-4813

**3.0 Method of Measurement.** No measurement will be made.

**4.0 Basis of Payment.** Payment for the above described work will be considered completely covered by the contract unit price for other items included in the contract.

B. DRAINAGE SYSTEM

**1.0 Description.**

**1.1** This work shall consist of furnishing, fabricating and installing the drainage items necessary to complete the entire drainage system as shown on the contract plans.

**1.2** Detailed shop drawings of the drainage system shall be prepared and submitted to the engineer. Shop drawings shall be in accordance with Sec 1080. Catalog data may be furnished for components that are standard manufactured items in lieu of detailed drawings, provided that governing dimensions are given.

**2.0 Materials.**

**2.2** Reinforced fiberglass pipe, collection basins and fittings shall be a Reinforced Thermosetting Resin Pipe (RTRP) system in accordance with the requirements of ASTM D 2996. The RTRP system shall have a minimum short time rupture strength hoop tensile stress of 30,000 psi. The RTRP system shall be pigmented resin throughout the wall. The color of the RTRP system shall be concrete gray or as specified on the bridge plans. The RTRP system shall not be coated with paint, gel-coat or any other exterior coating.

**2.3** The contractor shall furnish a manufacturer's certification to the engineer for each lot furnished, certifying that the materials supplied are in accordance with all requirements specified. The certification shall include results of all required tests. Acceptance of the material will be based on the manufacturer's certification and upon results of such tests as may be performed by the engineer. The certification shall show the quantity and lot number that is represented.

**3.0 Construction Requirements.**

**3.1** All connections shown on the plans to facilitate future removal for maintenance cleanout or flushing shall be made with a threaded gasket coupler system, bolted gasket flange system or a female to male threaded PVC plug. Adhesive bonded joints will be permitted for runs of pipe between such connections.

**3.2** Runs of pipe shall be supported at a spacing of not greater than the lesser of those as recommended by the manufacturer of the pipe or as shown on the bridge plans. Supports that have point contact or narrow supporting areas shall be avoided. Standard sling, clamp, clevis hangers and shoe supports designed for use with steel pipe may be used. Minimum hanger thickness shall be 3/16 inch with the minimum strap width for the pipe sizes shown in the table below. Straps shall have 120 degree minimum contact with the pipe. Pipe supported on a surface with less than 120 degrees of contact shall have a split fiberglass pipe protective sleeve bonded in place with adhesive. All new steel, hangers and miscellaneous hardware for drainage system shall be ASTM A 709 Grade 36 steel except as noted on the bridge plans. All new steel, hangers and miscellaneous hardware for drainage system shall be galvanized in accordance with ASTM A 153 except as noted on the bridge plans.

| Pipe Size inches (mm) | Minimum Strap Width inches (mm) |
|---|---|
| 3 (76.2) | 1.25 (32) |
| 4 (101.6) | 1.25 (32) |
| 6 (152.4) | 1.50 (38) |
| 8 (203.2) | 1.75 (45) |
| 10 (254.0) | 1.75 (45) |
| 12 (304.8) | 2.00 (51) |
| 14 (355.6) | 2.00 (51) |

**3.3** The RTRP system shall be handled and installed in accordance with guidelines and procedures as recommended by the manufacturer.

**3.4** When the drainage system continues between superstructure units and/or between the superstructure and substructure units, the drainage system shall have allowance for the expected differential expansion and contraction movements as recommended by the manufacturer. Runs of pipe shall not exceed 200 feet in length.

**4.0 Method of Measurement.** No measurement will be made.

**5.0 Basis of Payment.** Payment for the above described work, including all material, equipment, labor and any other incidental work necessary to complete this item will be considered completely covered by the contract lump sum price for Drainage System (On Structure).

C. SOIL NAIL RETAINING WALL SYSTEM

**1.0 Description.**

**1.1 General.** This work shall consist of constructing a permanent soil nail retaining wall at the location shown on the plans. The contractor shall furnish all labor, working drawings, materials, and equipment required to construct the wall in accordance with the plans and this Provision. Plans for the existing structures, boring logs, and lab data are available for informational purposes only.

**1.2 Contractor's Experience Requirements.** 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 5 years involving construction of permanent soil nail retaining walls totaling at least 10,000 square feet of wall face area and at least 500 permanent soil nails. Also list any projects where the contractor has successfully completed construction of a mixed face wall using soil nails. A brief description of each project with the Owner's name and current phone number shall be included.

**1.2.1** A Registered Professional Engineer 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 5 years shall supervise the work. The Contractor shall not use manufacturer's representatives to satisfy the supervising Engineer requirements of this section. The Registered Professional Engineer shall be licensed in the State of Missouri.

**1.2.2** The on-site supervisor and drill rig operators shall have experience installing permanent soil nails on at least 3 projects over the past 5 years.

**1.2.3** Within 15 calendar days of the award of work, the Contractor shall submit the experience qualifications and details for the referenced construction projects, including a brief project description with the owner's name and current phone number. Upon receipt of the experience qualifications, the engineer will have 20 calendar days to approve of reject the proposed soil nailing Contractor.

**1.2.4** Work shall not be started nor materials ordered until the engineer's written approval of the Contractor's qualifications is given.

1.2.5 For informational purposes only, the following is a list of companies, contact names and telephone numbers of specialty contractors that potentially meet the qualifications of Section 1.2 and 1.2.1.

Drill Tech Drilling and Shoring
Patrick Carr
Phone: (913) 669-7711

Keller
Greg Terri
Phone: (314) 802-2920

Subsurface Constructors
Lyle Simonton
Phone: (866) 421-2460

Berkel & Company
Adam Hurley
Phone: (913) 422-5125

Hayes Drilling
Luke Schuler
Phone: (913) 768-9500

**1.3** The work shall be performed in conjunction with the requirements presented in the JSP Soil Nail Wall Shotcrete Facing and JSP Soil Nail Wall Concrete Facing.

**2.0 Materials.** Materials shall be in accordance with the Standard Specifications or as described in these Provisions.

**2.1 Soil Nail Bar.**

**2.1.1** Soil nail bar shall meet or exceed the requirements of AASHTOM M31/ASTM A615 for Grade 60 steel bars. Soil nail bars shall be new, straight, undamaged, and epoxy coated. The length of the threaded portion of the bar at the wall anchorage shall be as needed to allow proper attachment of the bearing plate and nut. Threading may be continuous spiral deformed ribbing provided by the bar deformations (continuous thread bars) or may be cut into a reinforcing bar. If threads are cut into a reinforcing bar, provide the next-larger bar number designation from what is shown on the plans.

**2.1.2** Bar couplers shall develop 100 percent of the full ultimate tensile strength of the bar as certified by the manufacturer.

**2.1.3** Epoxy coating shall meet the requirements of ASTM A775 except as otherwise specified herein. Epoxy coating shall have a minimum thickness of 12 mils up to a maximum thickness of 17 mils. Bending tests are waived. The coating at the wall anchorage end of epoxy-coated bars may be omitted over the length provided for threading the nut against the bearing plate. Handling of epoxy-coated bars shall be in accordance with Sec 710. Organic coatings, other than epoxy, shall not be used.

**2.1.2 Nail Centralizers.** Manufactured from Schedule 20 or 40 PVC pipe or other material not detrimental to the soil nail (wood shall not be used), securely attached to the nail bar, sized to position the nail bar within 1 inch 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. Install centralizers at intervales not to exceed 8 feet and within a distance of 18 inches from each end of the drill hole.

**2.2 Nail Grout.**

**2.2.1** Neat cement or sand/cement mixture with a minimum 3-day compressive strength of 1,500 psi and a minimum 28-day compressive strength of 3,000 psi meeting the requirements of AASHTO T106/ASTM C109.

**2.2.2** Fine aggregate shall meet the requirements of AASHTO M85/ASTM C33.

**2.2.3** Portland cement shall meet the requirements of AASHTO M85/ASTM C150, Type I, II, III, V, or Type I/II, from one manufacturer.

**2.2.4** Admixtures shall meet the requirements of AASHTO M194/ASTM C494. Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout subject to review and acceptance by the engineer. Accelerators and expansive admixtures are not permitted. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer's recommendations.

**2.2.5** Film Protection shall meet the requirements of AASHTO M171.

**2.3 Bearing Plates, Nuts, and Welded Stud Connectors.**

**2.3.1 Bearing Plates.** ASTM A709 Grade 36 or ASTM A572 Grade 50.

**2.3.2 Nuts.** AASHTO M291/ASTM A563, Grade B, hexagonal, fitted with beveled washer or spherical seat to provide uniform bearing.

**2.3.3 Welded Stud Connectors.** Welded studs shall be in accordance with Sec 1037.

**2.3.4** All nail head elements including bearing plate, beveled plate, nuts, washers, and welded studs shall be galvanized. Zinc galvanized coating shall have a minimum of 3.4 mil thickness applied in accordance with ASTM A123 for bars and structural shapes, and ASTM A153 for nuts, plates, and other hardware.

**2.4 Initial Shotcrete Facing.** Furnish materials in accordance with the JSP Soil Nail Wall Shotcrete Facing.

**2.5 Final Concrete Facing.** Furnish materials in accordance with JSP Soil Nail Wall Concrete Facing.

**2.6 Drainage System**. Includes geocomposite drain strips, filter fabric and underdrain, as shown on the plans, and as specified.

**2.6.1 Geocomposite Strip Drain.** Manufactured with a drainage core (e.g., geonet) and a drainage geotextile attached to or encapsulating the core. Drainage core to be manufactured from long chain synthetic polymers composed of at least 85 percent by mass of polypropylenes, polyester, polyamine, polyvinyl chloride, polyolefin, or polystyrene and having a minimum compressive strength of 40 psi when tested in accordance with ASTM D 1621 Procedure A. The drainage core with the geotextile fully encapsulating the core shall have a minimum flow rate of 0.1 gallons per second per foot of strip width under a gradient of 1.0 tested in accordance with ASTM D 4716..

**2.6.2 Pipe**. ASTM 1785 Schedule 40 PVC Solid Wall; cell classification 12454-B or C, wall thickness SDR 35, with solvent weld or elastomeric joints.

**2.6.3 Fittings.** ASTM D3034, cell classification 12454-B or C, wall thickness SDR 35, with solvent weld or elastomeric joints.

**2.6.4** Provide filter fabric for the geocomposite drain conforming to the provisions for fabric for subsurface drainage geotextile in Sec 1011.

**2.6.5** Provide drainage geotextile and geocomposite drain strips in rolls wrapped with a protective covering and stored in a manner which protects the fabric from mud, dirt, dust, debris, and shotcrete rebound. Do not remove protective wrapping until immediately before installing the geotextile or drain strip. Avoid extended exposure to ultraviolet light. Each roll of geotextile or drain strip in the shipment shall be labeled to identify the production run.

**2.7 Materials Handling and Storage.** Store steel reinforcement on supports to keep the steel from contacting the ground. Damage to the nail steel as a result of abrasion, cuts, nicks, welds, and weld splatter shall be cause for rejection. Protect nail steel from dirt, rust, and other deleterious substances prior to installation. Place protective wrap over anchorage end of nail bar to which bearing plate and nut will be attached to protect during handling, installation, grouting and shotcreting.

**3.0 Soil Nail Wall Design Requirements.**

**3.1 General.**

**3.1.1** Construct the wall according to the plans, the specifications, and as approved by the engineer.

**3.1.2** As an alternate to the soil nail wall as shown on the plans, the contractor has the option to use the layout shown in the plans and redesign the wall with adjustments to the nail type, length, spacing, diameter, temporary and permanent facing design, and other potential cost reduction design items. Alternate design proposals shall be submitted at least 2 weeks prior to the bid date for evaluation and approval of the redesign concept. Sufficient preliminary design and preliminary plans shall be included in the proposal to allow the engineer to approve the proposal for bidding purposes. The engineer will review the proposal and approve or reject the proposal within 5 days of the bid submittal date.

**3.1.3** Any contractor proposed redesign of the soil nail walls shall use design procedures outlined in FHWA Report No. FHWA-NHI-14-007, titled Geotechnical Engineering Circular No. 7, "Soil Nail Walls Reference Manual." Slope and external surcharge loads, seismic design coefficient, type of wall facing, corrosion protection requirements, easements, and right-of-way will be as shown on the plans and/or required by the specifications. Evaluation of global stability for the soil nail wall staged lift construction conditions shall be the responsibility of the Contractor's soil nail wall designer.

**4.0 Submittals.**

**4.1 Design Calculations.** For any contractor proposal to redesign of the soil nail wall system that has been approved prior to bidding as outlined in Section 3.1.2, at least 21 days before the planned start of the wall excavation and verification test nail installation, submit all applicable sets of final design calculations and final plans to the engineer for review and approval. Include all details, dimensions, ground profiles and cross-sections necessary to construct the soil nail wall. Also include the global stability calculations for the temporary conditions anticipated during construction and the permanent conditions. The Engineer shall approve or reject the Contractor's submittal of design calculations and working drawings within 14 days after submission. Successful verification testing results will be required prior to proceeding with production soil nail installation. Designs and plans shall be sealed by a professional engineer licensed in the state of Missouri.

**4.2 Working Drawings.** Utility locations, right of way and other applicable information is available on the plans. At least 21 days before starting soil nail work, submit working drawings to the engineer. Working drawings shall include, but not be limited to the following items:

**(A)** A plan view of the wall identifying:
(1) A reference baseline and elevation datum.
(2) The offset from the construction centerline or baseline to the face of the wall at the base at all changes in horizontal alignment.
(3) Beginning and end of wall stations.
(4) Right of way, permanent or temporary construction easement limits, location of all known active or abandoned existing utilities, adjacent structures, or other potential interferences. Any drainage structure or drainage pipe centerline behind, passing through, or passing under the wall.
(5) Limit of the longest soil nails behind top of wall.
(6) Plan locations of wall drainage network.

**(B)** An elevation view of the wall identifying:
(1) The elevation at the top of the wall, at all horizontal and vertical break points, and at least every 25 feet along the wall.
(2) Elevations at the wall base.
(3) Beginning and end of wall stations.
(4) The distance along the face of the wall to all steps in the wall base.
(5) Wall elevation view showing nail locations and elevations; vertical and horizontal nail spacing; location of geocomposite drain strips; final concrete facing reinforcing details and expansion/contraction joints along the wall length.
(6) Existing and finish grade profiles both behind and in front of the wall.
(7) Locations and elevations of wall drainage network, including location of weep holes.

**(C)** General notes for constructing the wall including construction sequencing or other special construction requirements.

**(D)** Soil nail wall typical sections including stage excavation lift elevations, nail spacing and inclination, nail bar sizes and corrosion protection details.
**(E)** A typical detail of production and test nails defining the nail length, minimum drill hole diameter, inclination, and test nail bonded and unbonded test lengths.
**(F)** Details, dimensions, and schedules for all nails, reinforcing steel, wire mesh, bearing plates with headed studs, etc. and/or attachment devices for shotcrete and cast-in-place concrete.
**(G)** Dimensions and schedules for all reinforcing steel including reinforcing bar bending details.
**(H)** Details for terminating wall and adjacent slope construction.

**4.2.1** The working drawings and any calculations associated with a contractor proposed wall redesign shall be signed and sealed by a registered Professional Engineer in the state of Missouri. The engineer will approve or reject the contractor's submittals within 14 days after the receipt of the complete submission. The contractor will not begin construction or incorporate materials into the work until the submittal requirements are satisfied and found acceptable to the engineer.

**4.3 Soil Nail Wall Construction Plan.** The contractor is responsible for providing the necessary survey and alignment control during the excavation for each lift, locating drillholes and verifying limits of wall installation. At least 21 days before starting soil nail work, submit a Soil Nail Wall Construction Plan to the Engineer that includes the following:

**(A)** The start date and proposed detailed wall construction sequence.
**(B)** Proposed methods and equipment for excavating soil to the staged excavation lifts indicated on the approved working drawings, including the proposed grade elevations for each excavation lift shown on the wall elevation view.
**(C)** Measures to ensure wall and slope stability during various stages of wall construction and excavation, information on space requirements for installation equipment, temporary shoring plans (if applicable), information on provisions for working in the proximity of underground facilities or utilities (if applicable).
**(D)** Drilling and grouting methods and equipment, including any variation of these along the wall alignment.
**(E)** Nail grout mix design, including compressive strength test results (per AASHTO T106/ASTM C109) supplied by a qualified independent testing lab verifying the specified minimum 3-day and 28-day grout compressive strengths. Previous test results for the same grout mix completed within one year of the start of grouting may be submitted for verification of the required compressive strengths.
**(F)** Nail grout placement procedures and equipment.
**(G)** Shotcrete facing mix design, materials, application methods, and support testing methods.
**(H)** Soil nail testing program design, test methods, equipment setup, and reporting procedures.
**(I)** Identification number and certified calibration records for each test jack and pressure gauge and load cell to be used. Jack and pressure gauge shall be calibrated as a unit. Calibration records shall include the date tested, the device identification number, and the calibration test results and shall be certified for an accuracy of at least 2 percent of the applied certification loads by a qualified independent testing laboratory within 180 days prior to submittal.
**(J)** Manufacturer Certificate of Compliance for the soil nail ultimate strength, nail bar steel, portland cement, centralizers, bearing plates, headed studs, nuts, washers, and corrosion protection.

**4.3.1** The engineer shall approve or reject the contractor's Construction Plan within 14 days after the submission. Approval of the Construction Plan does not relieve the contractor of his responsibility for the successful completion of the work.

**4.4** The working drawings shall be revised when plan dimensions are revised due to field conditions or for other reasons. Within 10 days after completion of the work, as-built drawings shall be submitted to the Engineer. Revised design calculations shall be signed and sealed by the Contractor's engineer registered in the State of Missouri for all Contractor proposed and implemented design changes made during the construction of the wall.

**5.0 Construction Requirements.**

**5.2 Site Drainage Control.** Provide positive control and discharge of all surface water that will affect construction of the soil nail retaining wall. Maintain all pipes or conduits used to control surface water during construction.

**5.3 Excavation**. Coordinate the work and the excavation so the soil nail wall is safely constructed. Perform the wall construction and excavation sequence in accordance with the approved working drawings and work plan.

**5.3.1** Excavate to the final wall face using procedures that: 1) prevent overexcavation; 2) prevent ground loss, swelling, air slaking, or loosening; 3) prevent loss of support for completed portions of the wall; 4) prevent loss of support of soil in front of and around bridge end bent piling, and 5) prevent loss of soil moisture at the face. Costs associated with additional thickness of shotcrete or concrete or other remedial measures required due to irregularities in the cut face, excavation overbreak, or inadvertent over excavation, shall be borne by the Contractor.

**5.3.2** Excavate existing slope from top down in a series of benches in accordance with the approved working drawings. Limit height of exposed unsupported final excavation face to the vertical nails spacing plus the required reinforcing lap or the short-term stand-up height of the ground, whichever is less.

**5.3.3** Remove any cobbles, boulders, rubble or debris that will protrude more than 2 inches into the required shotcrete thickness.

**5.3.4** Suspend soil nail wall construction and temporarily stabilize the face by immediately placing an earth berm against the face if the excavation face becomes unstable at any time. If such condition develops, do not proceed with soil nail construction until remedial measures are proposed by the contractor and accepted by the engineer.

**5.3.5** Excavation to the next lift shall not proceed until nail installation, reinforced shotcrete placement, attachment of bearing plates and nuts and nail testing has been completed and accepted in the current lift. Nail grout and shotcrete shall have cured for at least 72 hours or attained at least their specified 3-day compressive strength before excavating the next underlying lift. Excavating the next lift in less than 72 hours will only be allowed if the contractor submits compressive strength test results from a qualified independent testing lab, verifying that the nail grout and shotcrete mixes being used will provide the specified 3-day compressive strengths in lesser time.

**5.4 Shotcrete**. Furnish and apply shotcrete to the excavation face in accordance with the plans and the JSP Soil Nail Wall Shotcrete Facing. Apply shotcrete to excavation face within 24 hours of the installation of the nails unless otherwise approved by the engineer. The application of

shotcrete may be delayed if it can be demonstrated that the delay will not adversely affect the excavation face stability.

**5.5 Nail Installation**. Provide nail length and drillhole diameter necessary to develop the load capacity to satisfy the acceptance criteria for the design load required. Drill holes for the soil nails at the locations, elevations, orientations, and lengths shown on the approved working drawings. Select drilling equipment and methods suitable for the ground conditions and in accordance with the accepted installation methods submitted by the contractor. The use of drilling muds or other fluids to remove cuttings will not be allowed. The use of self-drilling nail bars (also known as hollow, self-grouting or pressure-grouted nail bars) will not be allowed.

**5.5.1** Stabilize drill holes with temporary casing if unstable, caving, or sloughing material is anticipated or encountered.

**5.5.2** Immediately suspend or modify drilling operations if ground subsidence is observed, if the soil nail wall is adversely affected, or if adjacent structures are damaged from the drilling operation. Immediately stabilize the adverse conditions at no additional cost.

**5.5.3** Provide nail bars as shown in the working drawings. Provide centralizers sized to position the bar within 1 in. of the center of the drillhole. Position centralizers as shown on the working drawings. Securely attach centralizers to the bar so they will not shift during handling or insertion into the drill hole yet will still allow grout tremie pipe insertion to the bottom of drill hole and allow grout to flow freely up the hole.

**5.5.4** Inspect each nail bar before installation and repair or replace damaged bars or corrosion protection. Check uncased drill holes for cleanliness prior to insertion of the soil nail bar. Insert nail bars with centralizers into the drill hole to the required length without difficulty and in a way that prevents damage to the drill hole, bar, or corrosion protection. Do not drive or force partially inserted soil nails into the hole. Remove nails which cannot be fully inserted to the design depth and clean the drill hole to allow unobstructed installation.

**5.6 Nail Installation Tolerances.** Nail location and orientation tolerances from approved soil nail wall design are:

(a) Nail head location: 6 inches any direction.
(b) Nail inclination: + or – 2 degrees
(c) Location tolerances are applicable to only one nail and not accumulative over large wall areas.
(d) Center nail bars within 1 inch of the center of the drill hole.

**5.6.1** Soil nails which do not satisfy the specified tolerances, due to the contractor's installation methods, will be replaced at no additional cost. Backfill abandoned nail drill holes with tremied grout. Nails which encounter unanticipated obstructions during drilling shall be relocated, as approved by the engineer.

**5.7 Grouting.** Grout the drill hole after installation of the soil nail bar and within 2 hours of completion of drilling. Inject the grout at the lowest point of each drillhole through a grout tube, casing, hollow-stem auger, or drill rods. Keep the outlet end of the conduit delivering grout below the surface of the grout as the conduit is withdrawn to prevent the creation of voids. Completely fill the drillhole in one continuous operation. Cold joints in the grout column are not allowed except at the top of the test bond length of proof tested production nails.

**5.7.1** Test nail grout according to AASHTO T106/ASTM C109 at a frequency of one test per mix design and minimum of one test for every 10 cubic yards of grout placed and at least one test per crew shift. Provide grout cube test results to the engineer within 24 hours of testing.

**5.7.2** Grout equipment shall produce a uniformly mixed grout free of lumps and undispersed cement and be capable of continuously agitating the mix. Use a positive displacement grout pump equipped with a pressure gauge which can measure at least twice but no more than three times the intended grout pressure. Place the grout within 60 minutes after mixing or within the time recommended by the admixture manufacturer, if admixtures are used.

**5.7.3** Remove the grout and nail if grouting is suspended for more than 30 minutes and replace with fresh grout and undamaged nail bar at no additional cost.

**5.8 Nail Head Assembly.** Attach nail head assemblies, consisting of bearing plates, nuts and stud connectors as shown in the plans and accepted submittals. If uniform contact is not possible with the underlying shotcrete, install nail head assemblies on a mortar pad to provide even bearing against shotcrete.

**5.8.1** Fully encase the nail head assemblies in the cast-in-place concrete facing or closure pour.

**5.9 Concrete Wall Facing.** Construct final concrete facing in accordance with the plans and the JSP Soil Nail Wall Concrete Facing.

**6.0 Nail Testing.**

**6.1 General.** Perform verification and proof testing of designated test soils. Perform verification tests on sacrificial test nails at locations shown on the plans. Perform successful proof testing on no less than 5 percent of the production soil nails in each row or a minimum of 1 per row, whichever is greater. Additional tests may be required by the engineer depending on the subsurface conditions encountered and the results of the initial soil nail tests.

**6.1.1** Testing of any nail shall not be performed until the nail grout and shotcrete facing have cured for at least 72 hours or attained at least their specified 3-day compressive strength.

**6.1.2** Provide testing equipment which includes 2 dial gauges with rigid supports; hydraulic jack and pressure gauge; electronic load cell; and a jacking block or reaction frame. Provide pressure gauges graduated in 100 psi increments or less. Use dial gauges capable of measuring to 0.001” and accommodating the maximum anticipated movement. Submit identification number and calibration records for each load cell, jack and pressure gauge with the soil nail wall installation and testing plan. Calibrate the jack and pressure gauge as a unit.

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

**6.2 Verification Tests.** Conduct verification tests on sacrificial soil nails prior to installation of production soil nails to confirm the appropriateness of the contractor’s drilling and installation methods and verify the required nail pullout resistance.

**6.2.1** Construct verification test nails with the same construction methods to be used on production nails.

**6.2.2** Verification test soil nails shall have both a bonded and unbonded length. The nail bar shall not be grouted along the unbonded length. Fully grouted nails shall not be used for load testing. The unbonded length shall be at least 3 feet within the drill hole. The bonded length in verification tests shall be as indicated on the plans. For any approved contractor redesign of the soil nail wall, the bonded length in verification tests shall be determined in accordance with Chapter 9 of FHWA Report No. FHWA-NHI-14-007, titled Geotechnical Engineering Circular No. 7, "Soil Nail Walls Reference Manual."

**6.2.3** The maximum load during the verification test is defined as the Verification Test Load (VTL). The VTL shall be as indicated on the plans. For any approved contractor redesign of the soil nail wall, the VTL shall be determined in accordance with Chapter 9 of FHWA Report No. FHWA-NHI-14-007, titled Geotechnical Engineering Circular No. 7, "Soil Nail Walls Reference Manual."

**6.2.4** Conduct verification tests by incrementally loading the verification test nails to pullout or the VTL in accordance with the table below. Record soil nail movements at each load increment and at each time step. Set dial gauges to zero after applying the alignment load. Following application of the VTL, reduce load to the alignment load and record the permanent set. Each load increment shall be held for at least 10 minutes. Maintain load during the creep test to within 2 percent of the intended load by use of a load cell. Maintain all other load increments within 5 percent of the intended load. Repump jack as needed to maintain load during hold times.

| Load | Hold Time (minutes)[2] |
|---|---|
| AL[1] | 1 |
| 0.13 VTL | 10 (record soil nail movement at 1, 2, 5, 10) |
| 0.25 VTL | 10 (record soil nail movement at 1, 2, 5, 10) |
| 0.38 VTL | 10 (record soil nail movement at 1, 2, 5, 10) |
| 0.50 VTL | 10 (record soil nail movement at 1, 2, 5, 10) |
| 0.63 VTL | 10 (record soil nail movement at 1, 2, 5, 10) |
| 0.75 VTL (Creep Test) | 60 (record at 1, 2, 5, 10, 20, 30, 50, 60) |
| 0.88 VTL | 10 |
| 1.00 VTL | 10 |
| AL | 1[3] |

(1) Alignment load shall be 0.025 VTL.
(2) Measure soil nail movement after each load increment has been achieved and at each time step indicated above.
(3) Record permanent soil nail movement.

**6.3 Proof Tests.**

**6.3.2** Proof test soil nails shall have a bonded length and a temporary unbonded length. Fully grouted nails shall not be used for load testing. The temporary unbonded length shall be at least 3 feet within the drill hole. The bonded length in proof tests shall be as indicated on the plans. For any approved contractor redesign of the soil nail wall, the bonded length in proof tests shall be determined in accordance with Chapter 9 of FHWA Report No. FHWA-NHI-14-007, titled Geotechnical Engineering Circular No. 7, "Soil Nail Walls Reference Manual."

**6.3.3** The maximum load during the proof test is defined as the Proof Test Load (PTL). The PTL shall be as indicated on the plans. For any approved contractor redesign of the soil nail wall, the

PTL shall be determined in accordance with Chapter 9 of FHWA Report No. FHWA-NHI-14-007, titled Geotechnical Engineering Circular No. 7, “Soil Nail Walls Reference Manual.”

**6.3.4** Conduct proof tests by incrementally loading the proof test nails in accordance with the table below. Hold each load increment until movement stabilizes and record soil nail movements at each load increment and time interval. Set dial gauges to zero after applying the alignment load. Maintain load during the creep test to within 2 percent of the intended load by use of a load cell. Maintain all other load increments within 5 percent of the intended load. Repump jack as needed to maintain load during hold times.

| Load | Hold Time (minutes)[3] |
|---|---|
| AL[1] | 1 |
| 0.17 PTL | until movement stabilizes[4] |
| 0.33 PTL | until movement stabilizes |
| 0.50 PTL | until movement stabilizes |
| 0.67 PTL | until movement stabilizes |
| 0.83 PTL | until movement stabilizes |
| 1.0 PTL (Creep Test)[2] | 10 (record soil movement at 1, 2, 5, 6, 10) |
| AL | 1 |

(1) AL = alignment load shall be AL ≤ 0.025 PTL.
(2) If the nail movement measured between 1 and 10 minutes exceeds 0.04 in., PTL shall be maintained for 50 more minutes and movements shall be recorded at 20, 30, 50, and 60 minutes. Record permanent soil movement.
(3) Measure times after the target load has been attained in each increment.
(4) If the soils reinforced with nails are relatively susceptible to deformation or creep, it is recommended to hold each load increment for 10 minutes and to record the soil nail movement at 1, 2, 5, and 10 minutes.

**6.4 Test Nail Acceptance Criteria.**

**6.4.1.** A verification test nail will be considered acceptable when the following criteria are met:
(1) The total creep movement is less than 0.08 in. between the 6- and 60-minute readings, and the creep rate is linear or decreasing throughout the creep test load hold period.
(2) The total movement (ΔVTL) measured at VTL exceeds 80 percent of the theoretical elastic elongation of the unbonded length of the test nail, as defined in Chapter 9 of FHWA Report No. FHWA-NHI-14-007, titled Geotechnical Engineering Circular No. 7, “Soil Nail Walls Reference Manual.”
(3) Pullout does not occur before achieving 1.0 × VTL.

**6.4.2.** A proof test nail will be considered acceptable when the following criteria are met:
(1) The creep movement between the 1- and the 10-minute readings is less than 0.04 in.
(2) In cases when the creep movement between the 1- and the 10-minute readings is greater than 0.04 in., the creep movement between the 6- and the 60-minute readings is less than 0.08 in., and the creep rate is linear or decreasing throughout the creep test load hold period.
(3) The total movement (ΔPTL) measured at PTL exceeds 80 percent of the theoretical elastic elongation of the unbonded length of the test nail, as defined in Chapter 9 of FHWA Report No. FHWA-NHI-14-007, titled Geotechnical Engineering Circular No. 7, “Soil Nail Walls Reference Manual.”
(4) Pullout does not occur before achieving 1.0 × PTL.

(5) The temporary unbonded test length in proof tests is successfully maintained for subsequent satisfactory grouting. If the unbonded test length of production proof test nails cannot be satisfactorily grouted after testing, the proof test nail shall become sacrificial, and shall be replaced with an additional production nail installed at no additional cost to the Owner.

**6.5 Test Nail Rejection.**

**6.5.1.** The engineer will evaluate the results of each verification test and provide recommendations for acceptance or modification of the design if necessary. Installation methods that do not satisfy the nail testing requirements shall be rejected. The contractor shall propose alternative methods and install replacement verification test nails.

**6.5.2.** The contractor shall evaluate the results of each proof test and provide recommendations to the engineer for review. The engineer may require the contractor to replace some or all of the installed production nails between a failed proof test nail and the adjacent passing proof test nail. Alternatively, the engineer may require the installation and testing of additional proof test nails to verify that the adjacent previously installed production nails have sufficient load carrying capacity.

**7.0 Displacement Monitoring**

**7.1** Install survey markers to monitor horizontal and vertical displacements along the soil nail wall. Install survey markers along the top of the soil nail wall in the initial shotcrete facing and final shotcrete or facing while shotcreting the initial soil nail wall lift and along the top of the finished wall immediately after placement and initial concrete/shotcrete set. Space markers a maximum of 25 feet apart.

**7.2** Total horizontal and vertical displacement of the soil nail wall shall be limited to the following relationship:

$$\delta_i = \frac{H}{500} \qquad \text{or} \qquad \delta_i = \frac{H}{333} \quad \text{for fine grained soils}$$

Where:

δi = Deflection (vertical or horizontal) (feet)
H = Height of the wall (feet)

**7.3** Survey the markers one time per day during soil nail wall construction to record lateral and vertical movements. Monitoring shall continue once every week following completion of the final shotcrete finish wall construction for a period of two months. An electronic copy of the survey data in Microsoft Excel format shall be submitted to the Engineer for review on the day following the readings.

**7.4** Should the wall experience displacement exceeding the specified limits, the contractor shall notify the engineer and take immediate corrective measures to control additional displacement.

**7.5** Bridge abutment, piers, roadway pavement, and bridge approach pavement within 50 feet of the wall shall be monitored for vertical and horizontal movement in a manner approved by the Engineer within an accuracy of 0.01 in. Monitoring of adjacent structures will be done by a licensed surveyor and approved by the Engineer. A monitoring plan, including the locations of measurement points and the frequency of recording measurements shall be submitted to the

Engineer for approval as part of the Soil Nail Wall Installation Plan. Monitoring shall begin with a base-line measurement recorded no more than 10 calendar days prior to the start of any excavation or any shoring, or similar ancillary features. In addition to monitoring for movement, the condition of the adjacent structure, including cracks and crack widths, before and after construction of the soil nail wall, shall be documented by visual inspection, photographs, and/or video.

**8.0 Construction Records.** Provide original hard copy of soil nail wall construction records within 24 hours of completing each lift. Include the following in the construction records:

(A) Names of Soil Nail Wall Contractor, Superintendent, Nozzleman, Drill Rig Operator and Project Manager and Design Engineer.
(B) Wall number, MoDOT contract number.
(C) Soil nail locations, diameters, lengths and inclinations, bar types, sizes and grades, corrosion protection and temporary casing information.
(D) Date and time drilling begins and ends, soil nail bar is placed, grout and shotcrete application.
(E) Grout volume, temperature, flow, and density records.
(F) Ground and surface water conditions and elevations, if applicable.
(G) Weather conditions including air temperature at time of grout and shotcrete placement.
(H) All other pertinent details related to soil nail wall construction.

**9.0 Method of Measurement.**

**9.1** Measurement for the soil nail wall system will be made to the nearest square foot. The quantity to be paid will be measured from the wall outline as shown on the plans. No adjustment in the measured quantity of shotcrete or other wall related quantities will be permitted for additional wall area required to meet the minimum wall elevations, additional shotcrete needed to fill voids created by irregularities in the cut face, excavation overbreak, inadvertent excavation beyond the plan final wall face excavation line, or failure to construct the facing to the specified line and grade and tolerances.

**9.2** Final measurement will not be made except for authorized changes during construction or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity. No measurement will be made for temporary shoring necessary to construct the wall. No separate payment will be made for providing working drawings, slope excavation, shotcrete, reinforcing steel, soil nail bars and attachment hardware, wall drainage network, tree removal, displacement monitoring, and nail verification and proof testing.

**9.3** All excavation required for the construction of the soil nail wall will be included in roadway items.

**9.4** The accepted quantity of soil nail wall, complete in place, will be considered completely covered at the contract unit price for Soil Nail Wall System. An approved Contractor redesign, constructed, and accepted soil nail wall system will be considered completely covered at the unit bid price per square foot of wall.

**10.0 Basis of Payment.** Payment for all labor, equipment, materials, tests, and incidentals necessary to construct the soil nail wall, including the wall drainage will be considered completely covered by the contract unit price per square foot for Soil Nail Wall System.

D. SOIL NAIL WALL SHOTCRETE FACING

**1.0 General**

**1.1 Description.** This work consists of constructing one or more courses of shotcrete on an exposed vertical surface for the soil nail retaining wall to be constructed.

**1.2 Description of Work.** Shotcrete facing and wall drainage work consists of furnishing all materials and labor required for placing and securing geocomposite drainage material, subsurface drainage, weepholes, wire mesh reinforcement, and shotcrete for the permanent shotcrete facing and nail head bearing plates and nuts for the soil nail wall shown on the plans. The work shall also include any preparatory trimming and cleaning of soil/rock surfaces and shotcrete cold joints to receive new shotcrete.

**1.3 Shotcrete.** Shotcrete shall comply with the requirements of ACI 506.2, "Specifications for Materials, Proportioning and Application of Shotcrete" except as otherwise specified. Shotcrete may be produced by either a wet-mix or dry-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. The dry-mix process consists of shotcrete without mixing water which is conveyed through the hose pneumatically with the mixing water introduced at the nozzle.

**1.4 Reference to Other Work** The work will be performed in conjunction with the requirements presented in the JSP Soil Nail Retaining Wall System.

**2.0 Materials**

**2.1 General Material Specifications.** Use standard specifications for the following:

(a) Air-entraining admixture (wet mix only), Sec 1054.3
(b) Chemical admixtures (wet mix only), Sec 1054
(c) Curing material, Sec 1055
(d) Hydraulic cement, Sec 1019
(e) Pozzolans, Sec 1019
(f) Reinforcing steel, Sec 706 & 710

**2.2 Shotcrete Aggregate.**

**2.2.1** For fine aggregate, furnish rounded particles conforming to AASHTO M 6 Class B including the reactive aggregate supplementary requirement, except as amended or supplemented by the following:

(a) Material passing #200 sieve, AASHTO T 11: 3.0 % max
(b) Sand equivalent value, AASHTO T 176: 75 min. referee method

**2.2.2** Aggregate for shotcrete shall meet the strength and durability requirements of AASHTO M80/M6 and meet the following gradation requirements:

| Sieve Size | Percent Passing (AASHTO T 27) |
|---|---|
| 1/2" | 100 |
| 3/8" | 90-100 |
| #4 | 70-85 |
| #8 | 50-70 |
| #16 | 34-55 |
| #30 | 20-35 |

| | |
|---|---|
| #50 | 8-20 |
| #100 | 2-10 |

**3.0 Construction .**

**3.1 General.** Conform to the following:

(a) ACI 506R Guide to Shotcrete.
(b) ADI 506.2 Specifications for Proportioning Application of Shotcrete.
(c) AASHTO C 311 Method for Sampling and Testing Fly Ash or Natural Pozzolans for Use as Mineral Admixture in Concrete.
(d) ASTM C 1077 Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation.

**3.1.1** Place geocomposite drain strips along the exposed cut face including PVC connections pipes, and wall footing drains as shown on the plans.

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

**3.2 Wall Drainage Network**

**3.2.1** Install geocomposite drain strips centered between the columns of nails as shown on the plans. The drain strips shall be at least 12 inches wide and placed with the geotextile side against the cut face. Secure all elements of the wall drainage network in wall sections requiring soil nails as shown on the plans, specified herein, or as required by the engineer to suit the site condition.

(a) Secure geocomposite drain strips securely to the excavation face and prevent shotcrete from contaminating the ground side of the geotextile.
(b) Drain strips shall be continuous.
(c) Where necessary, make splices with a 12 inch minimum overlap such that the flow of water is not impeded.
(d) Should the fabric on the geocomposite drain be torn or punctured, replace the damaged section completely or repair by placing a piece of fabric that is large enough to cover the damaged area and provide a minimum 6-inch overlap.

**3.2.2** Install solid PVC connection pipes through weep holes to direct water from the geocomposite drain strips through the CIP concrete facing to a footing drain [Note: the footing drain is constructed after construction of the concrete facing].

(a) Connect the connection pipes to the drain strips using either prefabricated drain grates as shown on the plans or using the alternative method described below.
(b) Install the drain grate per the manufacturer's recommendations. Seal the joint between the drain grate and the drain strip, and the discharge end of the connector pipe to prevent shotcrete intrusion. Extend connection pipes that end at the footing drain to the edge of the drain. Do not puncture the drainage fabric around the footing drain.
(c) As an alternative method for connection of the connector pipe to the drain strip, cut a hole slightly larger than the diameter of the pipe into the strip plastic core but not through the geotextile. Wrap both ends of the connection pipe in such a manner that prevents migration of fines through the pipe. Tape or seal the inlet end of the pipe where it penetrates the drain strip and the discharge end of the connector pipe in a manner that prevents penetration of shotcrete into the drain strip or pipe. To assure passage of groundwater from the drain strip into the connector pipe, slot the inlet end

of the connector pipe at every 45 degrees around the perimeter of the pipe to a depth of 0.25 inch.

**3.2.3** Provide weepholes through the shotcrete and CIP wall as shown on the plans. Use PVC pipe to form the weephole. Cover the end of the pipe contacting the soil or rock with a drainage geotextile. Prevent shotcrete intrusion into the discharge end of the pipe.

**3.2.4** Install footing drains at the bottom of wall as shown on the plans.

**3.2.5**. If precast final facing is used, provide blockouts in shotcrete and precast facing with a minimum height of 6 inches and width to accommodate the drain strips. Extend drain strips through the blockout to ensure flow of water from the strip drains to the footing drain.

**3.3 Preconstruction Submissions.**

**3.3.1** Shotcrete material, equipment, preparation, and application. Submit the following to the engineer for acceptance at least 30 days before placing shotcrete:

(a) Description of proposed equipment for mixing and applying shotcrete. Include the manufacturer instructions, recommendations, literature, performance, and test data.
(b) Proposed shotcrete mix design with mix proportions.
(c) Representative samples of shotcrete material, if requested by the engineer.
(d) Results of all shotcrete preconstruction testing.
(e) Proposed method for applying and curing shotcrete.
(f) Other information necessary to verify compliance with ACI 506.2.
(g) Certification that shotcrete conforms to the standards specified herein.
(h) Fiber samples, if used, with supplier or manufacturer recommendations for use.

**3.3.2** Submit the following to the engineer for acceptance at least 30 days before placing shotcrete:

(a) Project references. Include project's name, owner's name, and phone numbers from at least 3 projects of comparable nature completed in the last 2 years.
(b) Nozzle operator's experience and training. For each nozzle operator, include shotcrete application experience on at least two projects of comparable nature.
(c) Shotcrete supervisor experience. Include direct shotcrete application experience on three comparable projects.
(d) Testing laboratory certification. Include documentation that the strength-testing laboratory complies with ASTM C 1077 and has the experience to perform the test specified in this job special provision. The testing laboratory shall be AASHTO accredited for ASTM C 1077 or demonstrate the ability to perform the requisite tests.

**3.4 Equipment**

**3.4.1 Water Supply System.** For dry mix, provide a water storage tank at the job site. Provide a positive displacement pump with a regulating valve that is accurately controlled to provide water in the pressures and volumes recommended by the delivery machine manufacturer.

**3.4.2 Mixing.** Use equipment capable of handling and applying shotcrete containing the specified maximum size aggregate and admixtures. Provide an air hose and blowpipe to clear dust and rebound during shotcrete application.

**3.4.3 Air Supply System.** Use an air supply system capable of supplying the delivery machine and hose with air at the pressures and volumes recommended by the machine manufacturer. Do

not use air supply systems that deliver oil-contaminated air or are incapable of maintaining constant pressure.

**3.4.4 Delivery Machine.** Use a delivery machine capable of supplying material to the delivery hose at a uniform rate. The ejection from the nozzle must adhere to the treated surface with minimum rebound and maximum density when the nozzle is held in the range of 3 to 6 feet from the target surface.

**3.5 Composition (Shotcrete Mix Design).** Design and produce shotcrete mixtures conforming to Table 1 for the type of shotcrete specified. Use the amount of water required to produce shotcrete of suitable strength, consistency, quality, and uniformity with the minimum amount of rebound. Use the same material types and sources as submitted with the mix design in the field trials and production work.

**3.5.1 Fibers.** If fibers are required, add them to the mix in the proportions recommended by the manufacturer.

**3.5.2 Hydration Stabilizing Admixtures.** Hydration stabilizing admixtures may be used to extend the allowable delivery time for shotcrete. Dosage is based on the time needed to delay the initial set of the shotcrete for delivery and discharge on the job. Design shall include discharge time limit in the dosage submittal. Dosage required to stabilize shotcrete shall be determined using job site material and field trial mixtures. The extended-set admixture shall control the hydration of all cement minerals and gypsum. The maximum allowable design discharge is 3.50 hours.

**3.5.3** If a hydration-stabilizing admixture is approved for use in the concrete mix, concrete shall be delivered and placed within the approved design discharge time limit. An approved and compatible hydration activator may be used at the discharge site to insure proper placement and testing.

**3.5.4** Dosage and type of extended-set admixture shall be included with proposed mix design. When requested, the admixture manufacturer shall provide the service of a qualified person to assist in establishing the proper dose of extended-set admixture and make dosage adjustments required to meet changing job site conditions.

Table 1: Composition of Shotcrete.

| Type of Shotcrete Process | Minimum Cement Content (lb/cy) | Maximum W/C(1) Ratio | Air Content Range (%) | Minimum 28-Day Compressive Strength(3) (psi) |
|---|---|---|---|---|
| Wet | 550 | 0.55 | NA | 3,000 |
| Dry | 550 | 0.5 | NA | 3,000 |
| Wet (w/EA)(2) | 550 | 0.45 | 5 min. | 3,000 |
| Dry (w/EA) | 550 | 0.45 | 5 min. | 3,000 |

Notes:
(1) W/C = Water/Cement (by weight).
(2) EA = Entrained Air.
(3) According to AASHTO T 23.

**3.6 Preconstruction Testing.** Conduct preconstruction shotcrete field trials before starting shotcrete production. Allow the engineer the opportunity to witness all phases of the preconstruction testing.

**3.6.1** In the presence of the Engineer, fabricate a minimum of two test panels per proposed nozzle operator using the same nozzle operator, equipment, materials, mixture proportions, and procedures to be used during the production work. Fabricate two panels for the initial facing shotcrete. Install the same reinforcement (reinforcing steel or welded-wire fabric) that will be used during production work in one panel of the initial facing shotcrete to evaluate proper steel encasement. Fabricate the test panels with a minimum shotcrete thickness equal to the respective production
thickness and in accordance with the requirements of ASTM C1140.

**3.6.2** From the test panels without the reinforcement, obtain a minimum of five, 3-inch diameter cores and test for compressive strength in accordance with ASTM C1140. Test two cores at 3 days and two cores at 28 days. Note: An extra core sample is available, if needed, for further testing.

**3.6.3** Sawcut the test panels with the reinforcement into “quarters” to evaluate the quality of the in-place shotcrete and steel encapsulation. Costs for corrective measures and additional investigation to verify shotcrete acceptance are at the contractor’s expense.

**3.7 Production Shotcrete Testing** Fabricate one shotcrete test panel for every 50 cubic yards of final facing shotcrete placed, but not less than once during each shift shotcrete is placed. Panels shall have minimum dimensions of 24 inches x 24 inches x 4 inches thick and shall be gunned in the same position as the completed work. Panels shall be field cured in the same manner as the production work. Obtain four, 3-inch diameter cores from each panel and test for compressive strength in accordance with ASTM C1140 and ASTM C42. Test two core samples at 3 days and two at 28 days. Promptly forward all test data to the Engineer. Testing of the 28-day cores may be waived if the required minimum 28-day strength is obtained at 3 days. If the quality of shotcrete is questionable in the opinion of the Engineer, the Engineer may direct the contractor to saw or core the panel to determine the shotcrete quality and if remedial action is necessary. Costs for corrective measures and additional investigation to verify shotcrete acceptance are at the contractor’s expense.

**3.8 Compressive Strength Testing**. Soak the cylinders in water for 40 hours immediately before testing. Test three cylinders from each test panel four days after field trial and test the remaining three cylinders 28 days after the field trial. Perform tests according to AASHTO T 23. All specified strength requirements shall be satisfied before the shotcrete mix design will be considered for acceptance.

**3.9 Mix Design Acceptance.** The engineer will accept or reject the shotcrete mix design based on the results of the preconstruction field trials and testing. Before approving any changes to a previously accepted mix design, the engineer may require additional preconstruction testing at no additional cost to the agency.

**3.10 Surface Preparation and Application of Shotcrete**.

**3.10.1 Surface Preparation.** Clean loose material, mud, rebound, and other foreign matter from all surfaces to receive shotcrete. Remove curing compound on previously placed shotcrete surfaces by sandblasting. Install approved depth gages to indicate the thickness of the shotcrete layers. Install depth gages on 6-foot centers longitudinally and transversely with no less than two gauges per increment of surface area to receive the shotcrete. Moisten all surfaces. Secure reinforcement to prevent movement and vibration while shotcreting.

**3.10.2 Weather Limitations.** Place shotcrete when the ambient temperature is 40ºF or higher. Do not perform shotcrete operations during high winds and heavy rains.

**3.10.3 Shotcrete application.**

(a) Apply shotcrete to both soil and rock exposed along the cut slope face.
(b) Do not apply shotcrete to frozen surfaces.
(c) Use acceptable nozzle operators who have fabricated acceptable test panels according to Paragraph 3.6.
(d) Apply shotcrete within 45 minutes of adding cement to the mixture. Apply shotcrete at a temperature between 50ºF and 80ºF.
(e) Direct the shotcrete at right angles to the receiving surface. Apply shotcrete in a circular fashion to build up the required layer thickness. Apply shotcrete in a steady uninterrupted flow. If the flow becomes intermittent, direct the flow away from the work area until it becomes steady.
(f) Make the surface of each shotcrete layer uniform and free of sags, drips, or runs.
(g) Limit the layer thickness of each shotcrete application to 2 inches. Thicker applications may be approved if the contractor can demonstrate that no sloughing or sagging is occurring. If additional thickness is required, broom or scarify the applied surface and allow the layer to harden. Dampen the surface before applying an additional layer.
(h) Remove laitance, loose material, and rebound. Promptly remove rebound from the work area.
(i) Taper construction joints to a thin edge over a distance of at least 1 foot. Wet the joint surface before placing additional shotcrete on the joint. Do not use square construction joint.
(j) Repair surface defects as soon as possible after placement. Remove any shotcrete which lacks uniformity, exhibits segregation, honeycombing or lamination or contains any voids or sand pockets and replace with fresh shotcrete.
(k) Use shooting wires, thickness control pins, or other devises acceptable to the engineer to ensure that the thickness of shotcrete satisfies the minimum requirements shown on the plans. Install thickness control devices normal to the surface such that they protrude the required shotcrete thickness outside the surface.

**3.10.4 Production Summary.** Prepare and submit a summary of shotcrete production application for each day. Furnish the summary to the engineer within 24 hours. Include the following information in the report:

(a) Quantity and location of shotcrete applied including sketches.
(b) Observations of success or problems of equipment operation, application, final product conditions, and any other relevant issues during production and application.
(c) Description of placement equipment.
(d) Batch number(s) if applicable.

**3.11 Quality Control Records.**

**3.11.1** Submit field quality control test reports within two working days of performing the tests. Include the following information in the reports:

(a) Sample identification including mix design and test panel number and orientation.
(b) Date and time of sample preparation including curing conditions and sample dimensions.
(c) Date, time, and type of test.
(d) Complete test results including load and deformation data during testing, sketch of sample before and after testing, and any unusual occurrences observed.
(e) Names and signature of person performing the test.

(f) Location of steel reinforcement, if used, covered by shotcrete.
(g) Name of nozzle operator.

**3.12 Protection and Curing.**

**3.12.1** Protect and cure the surface according to Section 703. If no stained or finished surface is required, apply curing compound to the final exposed shotcrete surface according to Section 703. Protect and maintain shotcrete at a temperature above 40ºC until shotcrete has achieved a minimum strength of 750 psi.

**3.13 Acceptance**.

**3.13.1** Material for concrete will be evaluated by visual inspection of the work, conformance testing and by certification for material manufactured off-site. Compressive strength will be evaluated by conformance testing using Table 1 for specification limits. See Table 2 for minimum sampling and testing requirements and acceptance quality category.

Table 2: Sampling and Testing of Shotcrete

| Property or Characteristic | Category | Test Methods or Specifications | Frequency | Sampling Point |
|---|---|---|---|---|
| Air Content | -- | AASHTO T 152 or AASHTO T 196 | 1 per load(1) | Truck, mixer or agitator (2) |
| Unit Mass | -- | AASHTO T 121 | 1 per load(1) | Truck, mixer or agitator (2) |
| Compressive Strength | II | AASHTO T 23 | 1 set per 33 cy, but not less than 1 set each day (3) | Production test panels (3) |

Notes:
(1) When continuous mixing is used sample every 10 cy.
(2) Sample according to AASHTO T 141.
(3) Prepare production test panels according to Paragraph 3.6. Obtain 3-inch diameter core specimens from each panel according to AASHTO T 24. A single compressive strength test result is the average result from two 3-inch diameter core specimens from the same test panel tested according to AASHTO T 23 at 28 days.

**4.0 Method of Measurement.** No measurement will be made.

**5.0 Basis of Payment.** Payment for the above-described work will be considered completely covered by the contract unit price per square foot of Soil Nail Wall System.

E. SOIL NAIL WALL CONCRETE FACING

**1.0 Description.** This work shall consist of furnishing and installing precast or cast-in-place concrete facing for the soil nail wall in accordance with this Job Special Provision and as shown on the Plans.

**2.0 Material.** All material shall be in accordance with Standard Specifications Division 1000, specifically Sections 501, 1036, 1039, 1052.30, and 1081.

**2.1** Cast in place concrete shall be Class B. Precast concrete shall be in accordance with Sec. 1052.30.

**2.2** The steel reinforcement used in the concrete facing shall be epoxy coated. Reinforcement shall be either Grade 60 deformed bars or an equivalent welded steel wire fabric. Reinforcement for coping or top cap units shall be Grade 60 deformed bars.

**2.3** Joint material for precast panels shall be used in accordance with the panel manufacturer's recommendations.

**2.4** Class B or B-1 air entrained concrete shall be used for the coping used for precast panel facing.

**2.5** All steel and hardware utilized in the connection between the precast concrete panels and the closure pour shall be galvanized.

**3.0 Design Requirements for Precast Facing**.

**3.1** The contractor shall be responsible for the design of the precast concrete panels, concrete coping, and the connections between the precast panels and the closure pour.

**3.2** The contractor shall submit the manufacturer's design plans, details, and computations for the precast facing to the engineer. All submitted information shall be clear and complete, and thoroughly checked before the information is submitted. All submitted information shall be legible and of sufficient contrast to be suitable for archiving in accordance with MoDOT's current practice for archiving. Submitted information determined to be unsuitable for archiving purposes will be returned for corrective action.

**3.3** The contractor will be solely responsible for the content of the design plans, details, and computations that are submitted, and for the performance of the precast concrete wall facing and connections. The contractor shall be solely responsible for ensuring that the information submitted by the manufacturer is in accordance with all contract plans and specifications. Completed design plans shall contain all material, fabrication and construction requirements for erecting the precast concrete wall facing complete in place.

**3.4** All design plans, details and computations submitted for distribution shall be signed, sealed and stamped in accordance with the laws relating to architects and professional Engineers (Chapter 327, RSMo).

**4.0 Construction Requirements.**

**4.1** Precast or cast-in-place coping shall be placed with precast facing in accordance with the design plans. Capstone may not be used. The maximum distance between construction joints shall be 20 feet. The joints in the coping should align with the vertical joints in the precast panels.

**4.2** The concrete wall facing shall be built vertical.

**4.3** The concrete wall facing shall be built in accordance with the dimensions and elevations specified on the plans. The concrete wall facing shall constructed as either cast-in-place concrete or precast panels. Nominal panel dimensions may be modified to meet the geometry required of the wall but must be approved by the Engineer.

**4.4 Construction Tolerances.**

| Dimensional Item | Dimensional Tolerance |
|---|---|
| Face Panel Joint Gaps | ± 3/4 in. |
| Vertical and Horizontal Alignment | ± 1/16 in. per ft. |

**4.5** Vertical alignments shall be measured along a theoretical vertical line established from the top of the wall to the base of the wall.

**5.0 Method of Measurement.** No measurement will be made.

**6.0 Basis of Payment.** Payment for the above-described work will be considered completely covered by the contract unit price per square foot of Soil Nail Wall System.