

Supersedes 6/8/00

**BEDFORD
13527**

January 27, 2011

SPECIAL PROVISION

SECTION 225 -- ROCK BOLTS

Item 225.2 - Prestressed Rock Bolts

Description

1.1 This work shall consist of furnishing, drilling, installing, and testing prestressed, grouted rock bolts and accessories at the locations and in the patterns shown on the plans or as ordered. On this project, it may be necessary to install rock bolts at any location on the rock face. A detail for the rock bolt is attached as Figure 1.

Materials

2.1 Rock Bolt Bars.

2.1.1 Rock bolt bars shall be straight shaft, deformed, solid, continuous threadbar, new, and undamaged. Rock anchor steel shall be protected from dirt, rust and deleterious substances.

2.1.2 Rock bolt bars shall be ASTM A722 Grade 150 steel, galvanized. The diameter of the rock bolt bars shall be determined by the Engineer. All exposed parts of the rock anchor, shall be galvanized in accordance with ASTM A123/ASTM A153.

2.2 Anchorage Assembly, Couplers, Trumpets, Covers and Centralizers.

2.2.1 The anchorage, couplers and bearing plate shall be capable of developing a minimum of 100 percent of the guaranteed minimum ultimate tensile strength of the steel rock bolt bar and shall be galvanized in accordance with ASTM A123/ASTM A153.

2.2.2 Surface Bearing Plates. Surface bearing plates shall be fabricated from A36 steel and shall have a minimum size of 7" x 7.5" x 1.75".

2.2.3 Beveled Washers, Flat Washers and Wedges. Beveled washers, hardened flat washers, and wedges for the anchorage shall be designed to preclude premature failure of the pre-stressing steel due to notch or pinching effects.

2.2.4 Heavy 2H Hex Nuts. Heavy 2H hex nuts shall be constructed for threaded engagement with the outer end of the rock bolt bar. The nut should be heavy duty type with round head, conforming to ASTM A-325. Anchor nuts shall develop an ultimate strength not less than 100 percent of the guaranteed ultimate strength (GUTS) of the bar and conform to ASTM A 436.

2.2.5 Centralizer. Centralizers are required and shall be fabricated from Schedule 40 PVC, or other material not detrimental to the steel rock bolt bar (wood shall not be used) and shall be capable of being securely attached to the bar. The centralizers shall be sized to meet the tolerance requirements for the grout cover defined in section 3.2.

2.2.6 Coupler Protection. The coupler and any exposed bar section next to it shall be covered with a corrosion proof compound or wax impregnated cloth tape. The coupler area shall be covered by a smooth plastic tube complying with the requirements set forth in section 2.5, overlapping the adjacent sheathed bar by at least 1 inch. The two joints shall be sealed each by a coated heat shrink sleeve of at least 6 inches length, or approved equal. The corrosion proof compound shall completely fill the space inside the cover tube.

2.3 Cement Grout.

2.3.1 Rock bolt grout shall be a non-shrink neat cement with a maximum water to cement ratio of 0.45 by weight.

2.3.2 Water for mixing grout shall be potable and free from substances which might be deleterious or corrosive to concrete or steel.

2.3.3 Grout strength accelerators shall not be used. Admixtures which control bleed and retard set may be used. Admixtures shall be mixed and placed in accordance with the manufacturer's recommendations.

2.3.4 The cement grout mix shall provide a minimum compressive strength of 3000 psi at the time of stressing.

2.3.5 Appropriate measures shall be taken to preclude freezing of the grout prior to its reaching design strength.

2.3.6 Cement shall conform to AASHTO M 85/ASTM C 150, Type I, II, or III Portland cement.

2.4 Sheathing. Sheathing used over the rock bolt bar in the unbonded (free stressing) zone shall be made of material with the following properties: resistant to chemical attack from aggressive environments, grout or corrosion inhibiting compounds; resistant to aging by ultra-violet light; non-detrimental to the rock bolt bar and capable of withstanding abrasion, impact and bending during handling and installation. The minimum wall thickness for the sheathing shall be 0.060 inch for polyethylene or polypropylene, 0.040 inch for PVC tubing and 0.20 inch for steel tubing or pipe. The sheathing shall permit the unobstructed elongation of the unbonded length during stressing.

Construction Requirements

3.1 Contractor Qualifications. The work defined in this section is specialty construction requiring a Contractor who is highly knowledgeable and experienced in the installation of rock

bolts. The Contractor performing the work in this section shall submit proof of five projects within five years on which the Contractor has successfully installed rock bolts of similar types and capacities required for this project. A brief description of each project with the owner's name and current phone number shall be included.

3.2 Design Load, Tolerance and Construction Criteria.

3.2.1 Design Load. The design load for the rock bolts for this project shall be determined by the Engineer unless otherwise directed.

3.2.2 The minimum hole diameter shall be selected such that a minimum of 1.25 inches of grout cover is provided around the rock bolt bar within the anchor zone.

3.2.3 The bonded length and associated hole diameter shall be large enough to provide a capacity of at least 1.33 times the design load or as directed by the Engineer.

3.2.4 The unbonded length shall be as directed by the Engineer.

3.2.5 Centralizers shall have a maximum spacing of 7 feet and the lowest centralizer shall be located 3 feet or less from the end of the rock bolt bar.

3.2.6 The deviation of the drilled hole entry angle from the specified inclination and direction shall be no more than 3 degrees.

3.3 Drilling. Rotary percussion equipment shall be used to drill the holes. The drill hole diameter shall conform to the requirements of this special provision. As a minimum, the drill hole shall extend 12 inches below the design depth of the rock bolt bar. In down bolting situations, the drill holes shall extend 16 inches beyond the length of the rock bolt bar. Care shall be taken to insure an accurate and straight hole. Drilled holes shall be cleaned of all drill cuttings, sludge and debris before the rock bolt bar is inserted into the hole.

3.4 Installation.

3.4.1 As a minimum, the bottom of the rock bolt bar shall be positioned 12 inches above the bottom of the drilled hole. In down bolting situations, the bottom of the rock bolt bar shall be positioned 16 inches above the bottom of the drilled hole.

3.4.2 The threaded outer end of the rock bolt bar shall extend the minimum length beyond the anchorage that will be capable of accepting the proof test and lift off equipment. The anchorage nut shall be tightened using an approved post tensioning hydraulic jack, which permits tightening of the nut during tensioning.

3.4.3 All equipment used for placing shall be such that it will not damage the rock bolt or its accessories.

3.4.4 Chipping out the rock or building a pad may be required to provide a level surface for the bearing plate. Pads must be constructed of materials that will withstand the applied lock off

load without loss of strength over the life of the rock bolt. The design, method of construction and materials used for the pad must be submitted to the Engineer for approval.

3.4.5 The contractor shall keep and provide a borehole log for each borehole drilled for rock anchors. The log shall include, but not limited to the following: hole location, hole diameter, hole length, angle from horizontal, date/time of drilling, drilling equipment used, encountered subsurface conditions (groundwater, joints, voids, soil/weak rock, etc.), and name of driller. The borehole logs shall be submitted to the NHDOT on a daily basis.

3.4.6 All damage to the galvanized surfaces, and threaded portions of all fittings and fasteners and cut ends of bolts after assembly, shall be repaired by thoroughly wire brushing the damaged area and painting it with two to four coats or to a thickness equivalent to the surrounding galvanizing, of an approved organic zinc-rich repair paint containing 92 percent (min) zinc by weight.

3.5 Grouting.

3.5.1 Grouting of the annular space around the rock bolt shall be accomplished by pressure grouting with a grout pump, providing a minimum of 90 psi capacity. Mixers and pumps shall have adequate capacity and hoses shall be sized to allow continuous grouting of an individual bolt within one hour or less.

3.5.2 All grout pipes, tubes and fittings shall be clean and free from dirt particles, grease, hardened grout, or other contamination before grouting is commenced for any bolt. All surplus water and diluted grout shall be flushed or blown from all lines before commencing injections. The grout line shall be attached to the grout injection tube with suitable fittings such that leakage is entirely prevented.

3.5.3 The grout shall be injected at a pressure, which is sufficient to overcome hydrostatic head. The pressure, which is used shall be approved by the Engineer. Dewatering or pre-grouting may be required for proper grouting of the rock bolt in groundwater or poor rock conditions.

3.5.4 Bolts in upward inclination shall use a sealing grout to seal the opening around the bolt prior to grouting through a short tube, which extends through the sealing grout. Such bolts shall be considered grouted when there is a full return of grout through a vent hole within the sealing grout.

3.5.5 The anchor bond length shall be grouted by injecting grout at the lowest point in the anchor.

3.6 Proof Tests, Acceptance Criteria and Lock Off Procedures.

3.6.1 Each production rock bolt shall be proof tested in accordance with the requirements of this specification. Testing of the rock bolts shall not be performed until the rock bolt grout has attained at least 100 percent of the minimum required compressive strength. Rock bolts

which do not meet the proof test criteria contained herein shall be rejected and a replacement rock bolt shall be installed.

3.6.2 The testing equipment shall include at a minimum one dial gauge, a dial gauge support, and a jack with pressure gauge. The equipment shall be capable of stressing the rock bolt to the maximum specified test load within the rated capacity. The pump shall be capable of applying each load increment in less than 60 seconds. The equipment shall permit the rock bolt to be stressed in increments so that the load can be raised or lowered in accordance with the test specifications, and allow the bolt to be lift-off tested to confirm the lock-off load. Stressing equipment shall have been calibrated by an independent test laboratory within an accuracy of $\pm 2\%$ within 60 days prior to use. Rock anchor testing will not be allowed until approval of the calibration report by the Engineer. The calibration certificate and graph shall be available on site at all times. The calibration shall be traceable to the National Institute of Standards and Technology (NIST). The production gauge shall have graduations not larger than 100 psi. One certified dial gauge, traceable to the National Institute of Standards and Technology (NIST), shall be used which permit the measurement of total movement at every load increment to be read to the nearest 0.001 inch. The dial gauge shall have sufficient travel to record the total rock bolt movement at the maximum test load without the need to reset at an interim point.

3.6.3 Testing Equipment Setup Prior to setting the dial gauge, the alignment load shall be accurately placed on the rock bolt. The alignment load shall be determined by the Engineer as percent of the design load. The dial gauge shall bear on the pulling head of the jack and the stems shall be in alignment with the rock bolt direction. The dial gauge shall be supported on an independent fixed frame, such as a tripod, which will not move as a result of stressing or other construction activities during the test.

3.6.4 Testing Schedule. Proof tests shall be performed by incrementally loading the rock bolt to 133 percent of the design load (DL). The rock bolt movement at each load shall be measured and recorded by the Engineer. At load increments other than the maximum test load, the load shall be held long enough to obtain a stable reading. Incremental loading for proof tests shall be in accordance with the following schedule:

AL
 0.25DL
 0.50DL
 0.75DL
 1.00DL
 1.20 DL
 1.33DL
 AL

Lock-off

Lift- off Reading

All load increments shall be maintained within 5 percent of the intended load. Depending on performance, either 10 minute or 60 minute creep tests shall be performed at the maximum test

load (1.33 DL). The creep period shall start as soon as the maximum test load is applied and rock bolt movement shall be measured and recorded at 1, 2, 3, 4, 5, 6, and 10 minutes. Where the rock bolt movement between 1 and 10 minutes exceeds 0.040 inch, the maximum test load shall be maintained an additional 50 minutes and movements shall be recorded at 20, 30, 40, 50, and 60 minutes. Total creep movement must not exceed 0.080 inch between the 6 and 60 minute readings.

3.6.5 Proof Test Acceptance Criteria. Proof tests shall be considered acceptable when all of the following criteria is met.

1. A total creep movement of less than 0.04 inch is observed between the 1 and 10 minute readings or a total creep movement of less than 0.08 inch is observed between the 6 and 60 minute readings.
2. The creep rate is constant 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 rock bolt unbonded length.
4. A pullout failure does not occur at the maximum test load. Pullout failure is defined as the load at which attempts to increase the test load simply result in continued pullout movement of the rock bolt. The pullout failure load shall be recorded as part of the test data.

3.6.6 Lock Off Procedures. After completion and acceptance of the proof test, the rock bolt shall be locked off at the design load or at a load as directed by the Engineer. After transferring the load to the anchorage and prior to removing the jack, a lift-off test shall be conducted to confirm the magnitude of the load in the rock bolt. This load shall be determined by reapplying the load to the rock bolt to lift off the anchor nut without turning the anchor nut. The lift-off load shall be within 5 percent of the design lock off load. If this criteria is not met, the rock bolt load shall be adjusted accordingly and the initial lift-off reading repeated.

3.7 Submittals. Submit a rockbolt installation plan, for approval, that includes the Contractor's qualifications, details the rock anchor type, couplings, face plate and nut, drilling operation, the proposed rope access methods if applicable and safety plan, the assembly of the bolt with its accessories, the method of bolt installation including grout mixes, testing procedures, and the method for providing a level surface for the bearing plate ten days prior to commencement of work in accordance with 105.02. Submit manufacture's certificates of compliance for the following: rockbolt threadbar, complete rockbolt head assembly including nuts, wedges, washers, plates, covers and trumpet, smooth sheathing, centralizers, corrosion inhibitor compound, and grout design with admixtures.

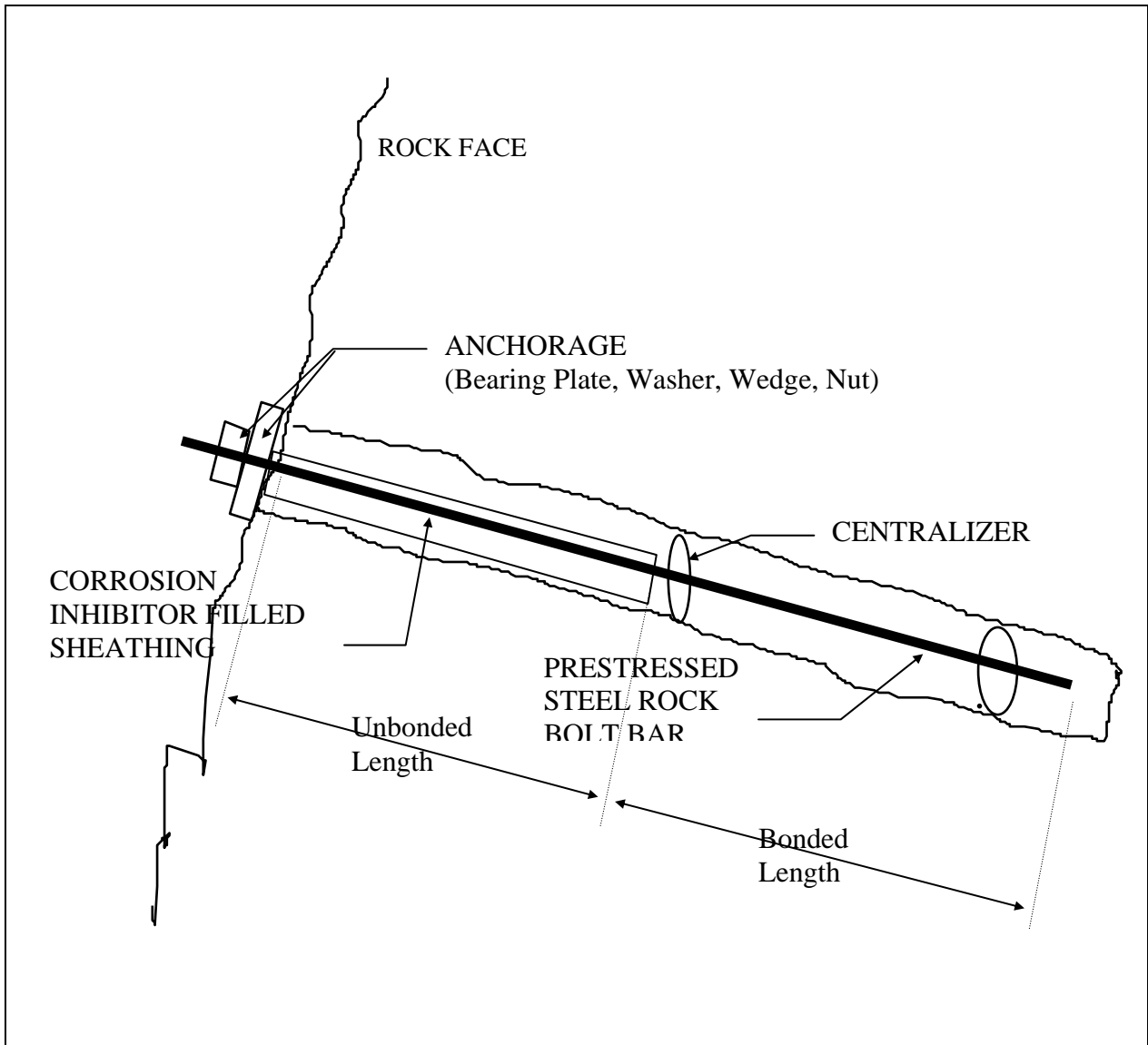


FIGURE 1

PRESTRESSED CORROSION PROTECTED GROUTED ROCK BOLT