CONSTRUCTION SPECIFICATION FOR
PRESTRESSED SOIL AND ROCK ANCHORS

TABLE OF CONTENTS

942.01 SCOPE
942.02 REFERENCES
942.03 DEFINITIONS
942.04 SUBMISSION AND DESIGN REQUIREMENTS
942.05 MATERIALS
942.06 EQUIPMENT
942.07 CONSTRUCTION
942.08 QUALITY ASSURANCE
942.09 MEASUREMENT FOR PAYMENT
942.10 BASIS OF PAYMENT

APPENDICES

942-A Commentary

942.01 SCOPE

This specification covers the requirements for the design, installation, and testing of prestressed anchors in soil and rock.

942.01.01 Significance and Use of Appendices

Appendices are not a mandatory part of this specification unless invoked by the Owner.

Appendix 942-A is a commentary appendix to provide designers with information on the use of this specification in a Contract.
REFERENCES

This specification refers to the following specifications, standards, or publications:

**Ontario Provincial Standard Specifications, General**

OPSS 180 Management and Disposal of Excess Materials

**Ontario Provincial Standard Specifications, Construction**

OPSS 903 Deep Foundations
OPSS 906 Structural Steel

**Ontario Provincial Standard Specifications, Material**

OPSS 1301 Cementing Materials
OPSS 1302 Water
OPSS 1350 Concrete - Materials and Production

**Canadian Standards Association**

A23.1-00/A23.2-00 Concrete Materials and Methods of Concrete Construction/Methods of Test for Concrete
A283-00 Qualification Code for Concrete Testing Laboratories
G40.20-98/G40.21-98 General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steels

**ASTM International**

A 53-96 Pipe, Steel, Black and Hot Dipped Zinc-Coated Welded and Seamless
A 416/A 416M-99 Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
A 500-93 Cold Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
A 722/A 722M-98 Uncoated High-Strength Bar for Prestressing Concrete
D 1248-84 (1998) Polyethylene Plastics Molding and Extrusion Materials
D 1784-03 Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
D 3350-02a Polyethylene Plastics Pipe and Fittings Materials
D 4101-03a Polypropylene Injection and Extrusion Materials

**International Organization for Standardization/International Electrotechnical Committee**

ISO/IEC DIS 17025:1999 General Requirements for the Competence of the Testing and Calibration Laboratories

**American Petroleum Institute**


**Others**

Post Tensioning Institute Publications NM
Recommendations for Prestressed Rock and Soil Anchors
For the purpose of this specification, the following definitions apply:

**Alignment Load** means a nominal minimum load applied to an anchor during testing to keep the testing equipment positioned correctly.

**Anchor** means a system used to transfer tensile loads to soil or rock that includes the prestressing steel, anchorage, corrosion protection, sheathings, spacers centralizers, and grout.

**Anchor Head** means the device by which the prestressing force is permanently transmitted from the prestressing steel to the bearing plate.

**Anchorage** means the combined system of anchor head, bearing plate, trumpet, and anchorage corrosion protection that is used to transmit the prestressing force from the prestressing steel to the surface of the ground or the supported structure.

**Apparent Free Length** means the length of tendon or bar that is apparently not bonded to the surrounding ground or grout, as calculated from the elastic movement measured during the load test.

**Bond Length** means the length of the tendon that is bonded to the primary grout and capable of transmitting the applied tensile load to the surrounding soil or rock.

**Centralizer** means a device to support and position the tendon and sleeves in the drill hole throughout the bond length of the tendon so that a minimum grout cover is achieved.

**Coupler** means the method by which the prestressing force can be transmitted from one partial length of prestressing tendon to another.

**Design Load** means the anticipated final maximum effective load in the anchor after allowance for time-dependent losses or gains. The design load includes appropriate load factors to ensure that the overall structure has adequate capacity for its intended use.

**Engineer** means a Professional Engineer licensed by the Professional Engineers of Ontario to practice in the province of Ontario.

**Free Stressing Length** means the designed length of the tendon that is not bonded to the surrounding ground or grout during stressing.

**Lift-Off** means checking the load in the tendon at any specified time with the use of a hydraulic jack at the moment of lifting of the anchor head off the bearing plate.

**Lock-Off Load** means the prestressing force in an anchor immediately after transferring the load from the jack to the stressing anchorage.

**Log Time Cycle** means one rotation of a log cycle of a semilogarithmic plot for the purpose of recording the measurement of movement and time.

**Permanent Anchor** means a prestressed anchor intended for permanent use.

**Performance Test** means cyclic and incremental loading and unloading of an anchor, while recording the total movement of the pulling head in each cycle at each increment, including the residual movement at alignment load.

**Post-Grouting** means regrouting an anchor after the primary grout has set.

**Pre-Production Test Anchor** means an anchor installed and then loaded to verify the design parameters, prior to the installation of the production anchors.
**Prestressing Steel** means strands, a group of strands combined to form a tendon, or a high strength steel bar.

**Primary Grout** means Portland cement based grout that is injected into the anchor hole prior to or after the installation of the anchor tendon to provide for the force transfer to the surrounding ground along the bond length of the tendon.

**Proof Test** means incremental loading of an anchor and recording the total movement of the anchor at each increment.

**Proposal** means a Contractor's submission of changes for which engineering design is required that affects either the original design, delivery, or erection.

**Residual Movement** means the non-recoverable movement of the pulling head measured at alignment load.

**Temporary Anchor** means a prestressed anchor intended for temporary use.

**Test Load (TL)** means the maximum load to which the anchor is subjected during testing.

**Total Movement** means the total movement of the pulling head measured at maximum load in each cycle.

942.04 SUBMISSION AND DESIGN REQUIREMENTS

942.04.01 Submissions

942.04.01.01 General

At least three weeks prior to the commencement of the work, five copies of the Working Drawings shall be submitted to the Contract Administrator.

These Working Drawings shall bear the seal and signature of the design and checking Engineers who each have a minimum of five years experience on projects of a similar nature and scope to the required work.

942.04.01.02 Working Drawings

Information to be shown on the Working Drawings shall describe and illustrate the complete details of the anchor system, anchor testing equipment, and reaction system for the production, and when specified in the Contract Documents, pre-production test anchors. This information shall include but not be limited to the following:

a) Plans, Elevations, and Sections

   i. Anchor spacing.
   ii. Orientation.
   iii. Minimum total anchor length.
   iv. Free stressing length.
   v. Design load.
   vi. A unique identification number for each anchor.
   vii. Anchor components and details.
b) Installation

   i. Construction methods.
   ii. Work restrictions.
   iii. Schedule.
   iv. Sequence and coordination of work.
   v. Monitoring.
   vi. Type and number of tests
   vii. Evaluation of test results.

c) Materials

   i. Physical properties of monobar and multistrand anchors.
   ii. Primary grout materials and mix proportions.
   iii. Post grouting materials and mix proportions.
   iv. Free stressing length materials and mix proportions.
   v. Corrosion protection material physical and mechanical properties.

d) Anchor Hole Construction

   i. Method of constructing the anchor holes and maintaining the stability of the holes during the anchor installation. The drilling equipment and materials including drill bit or auger diameter and lengths, casing diameter and lengths, and slurry material used to facilitate the construction of the anchor hole. The method of verifying the hole length shall also be identified.
   ii. Details for assembling the anchor in the anchor hole.
   iii. Method of placing and centring the anchor tendons including the method used to maintain them in the centre of the hole over the design bond length.
   iv. Bond zone primary grout placement. Grout mixing procedure and the method of installation including grout pressures. The method to determine the surface of the hardened bond length grout shall be identified.
   v. Bond zone post grout placement. Grout mixing procedure and the method of installation including grout pressures.
   vi. Free stressing zone grout placement. Grout mixing procedure and the method of installation including grout pressures.
   vii. Waterproofing of holes drilled in rock for permanent anchors. Details of water tightness tests including setup, water pressure, method of applying pressure, details of consolidation, grouting, redrilling and retesting.

e) Stressing Information

   i. Anchor stressing schedule that includes the working loads and test loads.
   ii. Anchor stressing equipment, and the method for testing the stressing of test anchors and production anchors. Details of the reaction system used to support the applied loads.
   iii. Equipment, including the calibration records of the gauges and jacks and procedure to monitor the applied loads and movements during anchor testing. Details of the reference system and equipment to monitor the movement.

f) All design assumptions, loads, parameters, and bond stresses used for production and test anchors.

g) Testing records when testing has been done to determine bond stress.

h) A soil report shall be prepared for each site to determine the feasibility of anchor use, location of bond length, and design parameters. The aggressivity of the environment shall be determined and included in the report. Where the soil report indicates a corrosive environment exists at the site the soil report shall be submitted with the Working Drawings.

i) Details of destressing and removal of temporary anchors.
942.04.01.03 Slurry

At least two weeks prior to commencement of the work, the following information for the slurry shall be submitted to the Contract Administrator:

a) The type, source, physical, and chemical properties of the bentonite or polymer.

b) The source of water.

c) Method of mixing slurry.

d) The water solids ratio and the mass and volumes of the constituent parts, including any chemical admixtures or physical treatment employed to produce a slurry with the required physical properties.

e) Details of procedure to be used for monitoring the quality of the slurry.

f) A test report showing the properties of the slurry and certifying that the slurry meets the requirements of API 13A.

g) Method of disposal of the slurry.

942.04.01.04 Couplers

At least two weeks prior to commencement of the work, a copy of the manufacturer's catalogue giving the complete data on the coupler material and installation procedures and a copy of the as test reports from the manufacturer certifying strength and fatigue requirements shall be submitted to the Contract Administrator.

942.04.01.05 Submission of Proposals

At least two weeks prior to commencement of the work, five copies of each proposal shall be submitted to the Contract Administrator.

Proposals shall bear the seal and signature of the design and checking Engineers.

942.04.01.06 Prestressing Steel

942.04.01.06.01 Mill Certificates

One copy of the mill test certificates indicating that the steel meets the requirements of the Contract Documents shall be submitted to the Contract Administrator at the time the prestressing steel is delivered to the job site.

Identification on the anchor tendon shall allow tracing of the prestressing steel to its heat or reel number.

Where mill test certificates originate from a mill outside Canada or the United States of America the Contractor shall have the information on the mill certificate verified by testing by a Canadian testing laboratory. The laboratory shall be accredited by the Standards Council of Canada as complying with the requirements of ISO/IEC DIS 17025 for the specific tests or type of tests required by the material standard specified on the mill test certificate. The mill test certificates shall be stamped with the name of the Canadian testing laboratory and appropriate wording stating that the material is according to the Contract Documents. The stamp shall include the appropriate material specification number, testing date, and the signature of an authorized officer of the testing laboratory.
942.04.01.06.02 Samples

The Contract Administrator shall be notified when prestressing steel is available for sampling.

Samples selected by the Contract Administrator shall be properly labelled by the Contractor for submission, at least one week in advance of stressing.

One copy of the stress-strain curves representative of the lots to be used shall be submitted to the Contract Administrator together with the mill certificates specified herein.

942.04.01.07 Return of Submissions

Two copies of each submission to be returned shall be marked as one of the following:

a) Stamped with a wording that allows for permission to construct.

In this case, work can commence on receipt of the drawing by the Contractor. A copy of these drawings shall be available at the site prior to and during construction.

b) Stamped with a wording that allows for permission to construct as noted.

In this case, work can start on receipt of the drawings by the Contractor. The drawings shall be updated as noted and shall bear the seal and signature of an Engineer stating the drawings have been revised according to the noted comments. A copy of the stamped updated drawings shall be available at the site prior to and during construction.

c) Showing only required changes.

In this case, the drawings shall be updated as required and the submission process repeated.

942.04.02 Design

Except for Owner designed anchors, the Contractor shall be responsible for the determination of the applied loads, design assumptions, installation procedures, and the detailed design of the anchor.

The anchors shall be designed to safely withstand the applied loads specified in the Pre-Production Test Anchor clause and fulfill the acceptance criteria specified in the Production Anchor clause and perform satisfactorily at the design load through the required service life.

The design assumptions shall accurately represent the subsurface conditions prevalent at the site.

When the bond stress is specified in the Contract Documents, it shall be used for design unless a different bond stress is approved in writing by the Contract Administrator.

When the bond stress is not specified in the Contract Documents or when a higher stress than that specified in the Contract Documents is used in the design, the bond stress assumed by the Contractor shall be confirmed by full scale testing of anchors.

Temporary anchors in a corrosive environment shall be designed as permanent anchors.

Except as specified herein, the anchors shall be designed according to the design recommendation of the Post Tensioning Institute Recommendations for Prestressed Rock and Soil Anchors publication.
942.05 MATERIALS

942.05.01 Permanent Anchors

942.05.01.01 General

Tendons shall be manufactured from steel bars or strand either in single or multiple element tendons.

The permanent anchors shall be Dywidag Threadbar Anchors, BBR Cona Multi-Strand Anchors, VSL Multi-Strand Anchors, or other approved equivalent anchors.

942.05.01.02 Anchorages

The components of the anchorage shall be capable of developing at least 100% of the guaranteed minimum ultimate capacity of the tendon or bar.

The anchor head shall be wedges for prestressing strands and anchor nuts for prestressing bars. The wedges shall be designed to uniformly engage the strand with no notch or pinching effects.

The bearing plate shall be fabricated from steel according to CSA G40.20/G40.21.

The trumpet shall be fabricated from steel pipe according to ASTM A 53 or tubing according to ASTM A 500. The trumpet shall have a minimum wall thickness of 3 mm for diameters up to 100 mm and 5 mm for larger diameters. The joint between the trumpet and the bearing plate and the joint between the trumpet and sheath shall be watertight. The trumpet shall overlap the free stressing length corrosion protection by at least 100 mm. The trumpet shall be long enough to accommodate movements of the structure and the tendon during stressing and testing.

The anchorage covers shall completely encapsulate the anchor head with a watertight seal between the cover and the bearing plate.

942.05.01.03 Prestressing Steel

Prestressing steel shall be according to ASTM A 416 and ASTM A 722.

Bars shall be high-tensile strength bars grade 1030 MPa, 1100 MPa, or 1230 MPa.

Strand shall be seven-wire, uncoated, stress relieved and low relaxation strand grade 1720 MPa, 1760 MPa or 1860 MPa.

The strand and bar shall meet the bond capacity test specified in subsection Prestressing Steel Bond Capacity.

942.05.01.04 Couplers

Couplers for bars shall be as specified by the supplier of the anchor and shall develop at least 100% of the guaranteed minimum ultimate strength of the tendon. Strand tendons shall not be coupled.

942.05.01.05 Cement

Cement shall be according to OPSS 1301 and shall be certified free of false set.

942.05.01.06 Water

Water shall be according to OPSS 1302.
942.05.01.07 Sheathing

Plastic sheathing shall be made from high density polyethylene according to ASTM D 1248, Type III, or from polyvinyl chloride (PVC) in conformance with ASTM D 1784, Class 13464-B or equal. The plastic sheathing shall be such that a bond of 5 MPa is developed when grout with a compressive strength of 30 MPa is used.

Hot melt extruded plastic tubing made from polyethylene according to ASTM D 3350 and ASTM D 1248 shall have an average minimum wall thickness of 1.5 mm. Hot melt extruded plastic tubing from polypropylene according to ASTM D 4101 shall have an average minimum wall thickness of 1.5 mm. Steel tubing or pipe shall have an average minimum wall thickness of 5.0 mm.

The materials for the sheathing accessories such as end caps, grouting caps, grout tubes and sealing caps shall have properties equal to the plastic sheathing.

942.05.01.08 Heat Shrinkable Sleeves

Heat shrinkable sleeves shall be fabricated from a radiation cross-linked polyolefin tube internally coated with an adhesive sealant.

942.05.01.09 Grout Tubes

Grout tubes shall have an adequate inside diameter to enable the grout to be pumped to the bottom of the drill hole. They shall be able to withstand 1 MPa pressure.

Post-grout tubes shall be strong enough to withstand the post-grouting pressure.

942.05.01.10 Bond Breaker

The bond breaker shall be fabricated from plastic tube or pipe made from medium to high density polyethylene according to ASTM D 1248 or from polyvinyl chloride according to ASTM D 1784, Class 13464-B or equivalent, with a minimum wall thickness of 1 mm.

942.05.01.11 Centralizers and Spacers

Centralizers and spacers shall be steel or plastic.

942.05.01.12 Grout

The grout cube for high early strength grout shall be at least 20 MPa at 7 Days and 30 MPa at 28 Days. The type of cement used shall be suitable for the required use of the grout. Accelerators shall not be used. The grout shall bleed less than 2 percent when allowed to stand for 1 hour.

942.05.01.13 Corrosion Inhibiting Compound

The corrosion inhibiting compound placed in either the free stressing length or the anchorage area shall be an organic compound, grease, or wax with appropriate polar moisture displacing, corrosion inhibiting additives, and self-healing properties. The compound shall permanently stay viscous and be chemically stable and non-reactive with the prestressing steel, the sheathing material, and the anchor grout.

942.05.02 Temporary Anchors

The material for temporary anchors shall be the same as specified for the permanent anchors except the double protection system is not required.
942.05.03 Pre-Production Test Anchors

The material for the pre-production test anchors shall be the same as specified for the production anchor being evaluated.

942.05.04 Bentonite Cement Slurry

Bentonite and polymers shall meet the requirements of API 13A.

The bentonite cement slurry shall consist of a stable mixture of cement and a colloidal suspension of pulverized solids or polymers thoroughly mixed with water. The density, viscosity, sand content, and pH of the slurry while being used during excavation shall be according to API RP13B-1.

942.05.05 Concrete

Concrete shall be according to OPSS 1350 with a nominal 28-Day compressive strength of 30 MPa.

The slump shall be 150 to 180 mm.

942.06 EQUIPMENT

942.06.01 General

All equipment for the installation of the anchor, anchor stressing, anchor testing, and monitoring of the anchor test shall be suitable for the intended purposes and capable of working on the site under the prevailing access and clearance conditions.

The equipment used shall not cause damage to the anchor tendon, corrosion protection, or retained structural members.

The equipment used shall be in according to those listed in the required submissions.

942.06.02 Grouting Equipment

Mixers and pumps shall be of an adequate capacity and hoses shall be sized to allow continuous grouting of an individual anchor within one hour. A colloidal mixer with a gauge to measure the water shall be used.

942.06.03 Temporary Anchor Concrete Placement Equipment

Continuous flight augers shall be used for the placement of concrete for temporary anchors up to a maximum ratio of hole diameter to length of 1:35. Open hole concrete placement shall be limited to a minimum hole diameter of 600 mm and a maximum ratio of hole diameter to length of 1:15.

942.06.04 Anchor Testing Equipment

The rated capacity of the equipment shall not be exceeded when stressing the tendon to the maximum specified test load. The pump shall be capable of applying each load increment in less than 60 seconds.

The equipment shall permit the tendon to be stressed in increments so that the load in the tendon can be increased or decreased according to the test specifications and to allow the anchor to be lift-off tested to confirm the lock-off load.
Dial gauges shall have at least a 75 mm travel. Longer gauge stems or sufficient gauge blocks shall be provided to allow for greater travel where required. Gauges shall have precision of at least 0.02 mm.

Dial gauges shall permit the measurement of total tendon movement to the nearest 0.02 mm at every load increment. The gauge shall have sufficient travel to record the total anchor movement at test load without the need to reset at an interim point.

Jacks used for stressing tendons shall have a minimum ram extension of 150 mm.

Stressing equipment shall be calibrated within an accuracy of ± 2% immediately prior to use.

Current calibration curves, bearing the seal and signature of an Engineer shall be provided for all gauges and jacks.

942.07 CONSTRUCTION

942.07.01 General

The Contractor shall be responsible for the material, fabrication, installation, testing, and monitoring of production and test anchors.

In addition, for non-Owner designed anchors, the Contractor shall be responsible for the preparation of a soils report, the determination of design parameters, and the design of the anchors.

The anchor system shall be according to this specification and the approved Working Drawings.

Concrete placement as stated in OPSS 903 may be used for temporary anchors inclined a minimum of 30 degrees below the horizontal and having a minimum hole diameter of 450 mm.

942.07.02 Qualification of Supervisory Staff

On site work shall be done under the direction of a supervisor with a minimum of five years experience in carrying out this type of work. Such experience shall have been obtained within the preceding ten years on projects of similar nature, complexity, and scope as the required work.

942.07.03 Qualification of Installing Personnel

All work shall be performed under the direction of a specialist with at least five years of proven satisfactory experience in the installation of the type of anchor system used. Such experience shall have been obtained within the preceding ten years on projects of similar nature, complexity, and scope.

942.07.04 Qualification of Testing Personnel

All tests shall be performed under the direction of a recognized specialist having a minimum of five years experience with the testing equipment being used. Such experience shall have been obtained within the preceding ten years on projects of similar nature, complexity, and scope.

942.07.05 Structural Steel

Structural steel components shall be fabricated according to OPSS 906.

942.07.06 Prestressing Steel Bond Capacity

If not available from the prestressing steel manufacturer, a prestressing strand bond capacity test shall be conducted on the strand according to Appendix A of the Recommendations for Prestressed Rock and Soil Anchors publication. The test information shall be submitted to the Contract Administrator prior to commencement of work.
942.07.07 Anchor Fabrication

Anchors shall be either shop or field fabricated according to the approved Working Drawings and schedules by personnel trained and qualified for this work.

Prestressing steel shall be cut with an abrasive saw or when approved by the prestressing steel supplier, an oxyacetylene torch may be used.

All of the bond length shall be free of dirt, manufacturers’ lubricants, corrosion-inhibiting coatings, or other deleterious substances that may significantly affect the grout-to-tendon bond or the service life of the anchor.

When encapsulated anchors are pregrouted, it shall be done on an inclined, rigid frame or bed by injecting the grout from the low end of the tendon.

Joints in the protection system shall be made watertight by use of an epoxy bonding agent.

942.07.08 Storage and Handling

Upon delivery, the fabricated anchors and the prestressing steel for fabrication of the tendons and all hardware shall be stored and handled in a manner that avoids mechanical damage, corrosion, and contamination with dirt or deleterious substances.

Handling of the tendons shall not cause mechanical damage or contamination to the prestressing steel, the corrosion protection, or the epoxy coating.

Rope or nylon slings shall be used.

Cement and additives for grout shall be stored under cover and protected against moisture.

Lifting of any pregrouted tendons shall not cause excessive bending that may debond the prestressing steel from the surrounding grout.

942.07.09 Corrosion Protection Details

942.07.09.01 General

The anchor shall be provided with Class I, encapsulated tendon, double corrosion protection as specified in the Recommendation for Prestressed Rock and Soil Anchors publication.

942.07.09.02 Anchorage Protection

The corrosion protection of the tendon in the vicinity of the anchorage shall ensure proper protection.

All stressing anchorages permanently exposed to the atmosphere or that has a concrete cover less than 50 mm shall be covered with a corrosion inhibiting compound-filled or grout-filled cover.

On strand tendons, the trumpet shall be long enough to enable the tendon to make a transition from the diameter of the tendon along the free stressing length to the diameter of the tendon at the wedge plate without damaging the encapsulation.

The trumpet shall be completely filled with a corrosion inhibiting compound or grout. Compounds may be placed any time during construction. Grout shall be placed after the anchor has been tested and stressed to the lock-off load.

Corrosion inhibiting compound-filled trumpets shall have a permanent seal between the trumpet and the free stressing length corrosion protection.
Trumpets filled with grout shall have either a temporary seal between the trumpet and the free stressing length corrosion protection or the trumpet shall fit tightly over the free stressing length corrosion protection for a minimum of 0.3 m.

942.07.09.03 Free Stressing Length Protection

The tendon shall be fully encased within a corrugated PVC sheathing that is in turn encased within a smooth PVC sheathing over the length of the free stressing zone and protected with grout.

Corrosion protection of the free stressing length shall be provided by a sheath filled with a corrosion inhibiting compound or grout or a heat shrinkable tube internally coated with a mastic compound. The corrosion inhibiting compound shall completely coat the tendon elements, fill the void between them and the sheath, and fill the interstices between the wires of 7-wire strands. Provisions shall be made to retain the compound within the sheath.

The corrosion protective sheath surrounding the free stressing length of the tendon shall be long enough to extend into the trumpet, but shall not come into contact with the stressing anchorage during testing.

For pregrouted encapsulations, a separate bond breaker shall be provided to prevent the tendon from bonding to the grout surrounding the free stressing length.

Fusion bonded epoxy may be used to provide an additional layer of protection to the prestressing steel.

942.07.09.04 Free Stressing Length and Bond Length Transition

The transition between the corrosion protection for the bonded and free stressing lengths shall be designed and fabricated to ensure continuous protection from corrosion.

The corrosion protection surrounding the free stressing length of the tendon shall not contact the bearing plate or anchor head.

942.07.09.05 Coupler Protection

On encapsulated bar tendons, 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 overlapping the adjacent sheathed tendon by at least 25 mm. The two joints shall be sealed each by a coated heat shrink sleeve of at least 150 mm length or approved equal. The corrosion proof compound shall completely fill the space inside the cover tube.

942.07.10 Construction of Anchor Holes

942.07.10.01 General

The anchor holes shall be constructed to the diameter, orientation, and length specified in the Contract Documents and detailed on the approved Working Drawings. A drilling method that will establish a stable anchor hole within the tolerances specified in the Contract Documents shall be used.

The sides and end of the completed anchor holes shall be maintained in a stable condition.

The anchor hole entry shall be located within 300 mm of its plan location. The deviation of the anchor hole entry angle from its inclination as specified the Contract Documents shall be no greater than ± 3 degrees.

Open anchor holes and drilled casings shall be cleaned upon completion of drilling.

Anchor holes open for longer than eight hours shall be recleaneous prior to insertion of the tendon and primary grouting.
The following information shall be recorded for each anchor hole and submitted to the Contract Administrator:

a) Identification number.

b) Anchor hole diameter.

c) Anchor hole length.

d) Drilling procedure.

e) Soil, rock, and ground water conditions encountered.

f) Time required to drill the anchor hole.

g) Problems encountered.

**942.07.10.02 Waterproofing Anchor Holes**

Waterproofing of anchor holes shall be done when specified in the Contract Documents and according to the approved Working Drawings, procedures, and equipment.

If during the water tightness test, the leakage from an anchor hole over a ten-minute period exceeds 9.5 L, the anchor hole shall be consolidation grouted, redrilled, and retested.

Redrilling shall be done when the grout strength is considerably less than the strength of the surrounding rock.

**942.07.11 Anchor Installation**

The anchors shall be installed as specified and detailed on the approved Working Drawings.

Care shall be taken to ensure the sheathing, corrosion protection, and grout tubes are not damaged during installation of the anchors.

Damaged anchors that cannot be repaired to the satisfaction of the Contract Administrator shall be replaced.

Method of repair shall be submitted to the Contract Administrator for approval.

The prestressing steel in the tendon bond length shall be protected with a grout filled corrugated plastic encapsulation. Centralizers shall be used to ensure a grout cover of at least 12 mm over the encapsulation.

The centralizers shall be maintained in position during installation.

The centralizer shall support the tendon in the drill hole and position the tendon so a minimum grout cover of 12 mm is achieved. Centralizers used inside a sheath shall provide a nominal grout cover of 5 mm over the prestressing steel. All centralizers shall be designed to permit grout to flow freely around the tendon and up the drill hole.

The Contractor shall determine the number of centralizers required; however, one unit shall be placed within 1 m of the bottom of the hole and another at the bond length and free stressing length interface. The centralizers shall not interfere with the placement of grout.

Spacers shall be used in multiple element tendons to separate the strands or bars individually or into small groups.
942.07.12 Primary Grouting of Anchors

The grout shall be placed as specified in the Contract Documents and as detailed on the approved Working Drawings.

The grout shall entirely fill the annular space between the anchor and the bore hole wall in the bond length.

Anchors shall be grouted as soon as practical after installation. The stressing tails of prestressing steel strands shall be aligned prior to initial set of the grout.

After grouting, the anchor shall remain undisturbed until the grout has reached the strength specified in the Contract Documents.

The following information shall be recorded for each anchor and submitted to the Contract Administrator:

a) Identification number.

b) Type of grout.

c) Grout pressure.

d) Volume of grout used.

e) Location of the top of the bond length grout.

942.07.13 Post-Grouting of Bond Length

When specified in the Contract Documents, post-grouting of the bond length shall be done according to the submitted procedures and equipment.

The information required to be recorded for primary grouting shall be recorded for post grouting.

Ground movement shall be monitored and if excess movement is observed the grouting shall be terminated and the situation reported to the Contract Administrator.

The Contract Administrator shall be notified prior to the commencement of post-grouting of both permanent and temporary anchors.

942.07.14 Placing of the Cement Bentonite Slurry in the Free-Stressing Length

The method of placing the cement bentonite slurry shall be as specified in the Contract Documents and as detailed on the approved Working Drawings.

The cement bentonite slurry for the free stressing length shall completely fill the annular space between the prestressing steel and the borehole wall and shall prevent any transfer of the anchor load to the free stressing zone.

942.07.15 Installation of Anchorage

The anchor bearing plate and the anchor head or nut shall be installed perpendicular to the tendon within ± 3 degrees and centered on the bearing plate, without bending or kinking of the prestressing steel elements. Wedge holes and wedges shall be free of rust, grout, and dirt. Special care shall be exercised to obtain the continuity of corrosion protection in the vicinity of the anchorage as described in the Corrosion Protection Details subsection. The stressing tail shall be cleaned and protected from damage until final testing and lock-off.

The tendon stressing tail shall be cut to its final length according to the tendon manufacturer’s recommendations after the anchor is accepted by the Contract Administrator.
Anchorages permanently exposed to the atmosphere shall be covered with a corrosion inhibiting compound filled or grout filled cover.

942.07.16 Testing

942.07.16.01 General

Testing shall be carried out according to the approved Working Drawings and as specified herein.

The maximum anchor load shall not exceed 80% of the guaranteed minimum ultimate strength of the tendon.

Stressing shall not commence until the grout has reached its 28-Day strength.

Anchor tests shall be conducted at a time mutually acceptable to the Contractor and Contract Administrator.

The test shall be constantly monitored and the test results recorded and submitted to the Contract Administrator.

942.07.16.02 Reaction System

The reaction system shall be designed by the Contractor and shall be installed as detailed on the approved Working Drawings.

942.07.16.03 Reference System and Testing Equipment

The layout of the reference systems and testing equipment required for testing shall be as detailed on the approved Working Drawings and as specified herein.

All reference beams shall be independently supported with the support firmly embedded in the ground at a distance of not less than 2.5 m from the anchor. Reference beams and their supports shall be sufficiently rigid to support instrumentation and to prevent movement relative to the test anchor as a result of stressing or other construction activity during testing.

Dial gauges shall bear on the pulling head of the jack and their stems shall be co-axial with the tendon direction.

The jacks shall be secured with chains to provide adequate protection to personnel in the event of breakage of the anchor or stressing system.

942.07.16.04 Reference System Enclosures

Suitable enclosures shall be constructed to provide complete protection for personnel, equipment, and instruments from variations in the weather conditions and disturbances during the test program.

These provisions shall meet the approval of the Contract Administrator and include the following specific requirements:

a) The test enclosures shall be weatherproof and adequately lighted and have consistent and controllable heat in order to eliminate temperature variations.

b) The test enclosure shall be provided with a level dry floor.

c) A field office equipped with tables, chairs, heating, and lighting shall be provided adjacent to the test anchors.
Pre-production tests shall be conducted to determine the bond stress when:

a) A bond stress is not specified in the Contract Documents.

b) A higher bond stress than specified in the Contract Documents is used in the design.

c) To establish the adequacy of other components of the anchor in advance of the production anchors.

For contractor designed anchors, at least one pre-production test anchor shall be installed and tested in each significantly different ground condition.

For owner designed anchors the number of pre-production test anchors shall be as specified in the Contract Documents. The test anchor shall be constructed using the materials, methods, and procedures specified herein and as detailed on the approved Working Drawings.

Pre-production test anchors shall not be incorporated into the permanent or temporary work unless agreed upon by the Contract Administrator and the Contractor.

Pre-production test anchors shall not be incorporated into the permanent or temporary work unless agreed upon by the Contract Administrator and the Contractor.

Pre-Production Test Procedures and Measurements

When the pre-production anchor is to be incorporated into the work, the load in the anchor shall be adjusted to lock-off load in the final cycle.

The pre-production test shall be conducted by cyclically and incrementally loading and unloading the anchor according to the schedule below or until the anchor fails.

AL, 0.25 DL, AL
AL, 0.25 DL, 0.50 DL, AL
AL, 0.25 DL, 0.50 DL, 0.75 DL, AL
AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, AL
AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, 1.25 DL, AL
AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, 1.25 DL, 1.50 DL, AL
AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, 1.25 DL, 1.50 DL, 1.75 DL, AL
AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, 1.25 DL, 1.50 DL, 1.75 DL, 2.00 DL, AL
AL, 0.00 DL

Where

AL = Alignment Load
DL = Design Load

At each load increment, the total movement of the pulling head shall be recorded to the nearest 0.02 mm with respect to the independent fixed reference point. After each maximum increment in a cycle the load shall be decreased to the alignment load and the residual movement of the pulling head shall be recorded to the nearest 0.02 mm.

The load shall be maintained at each increment for a minimum of one minute or long enough to record the movement of the pulling head.

The maximum load in a cycle shall be maintained for a minimum of 10 minutes. Total movement readings shall be recorded at 1, 2, 3, 4, 5, 6, and 10 minutes.
If the difference between the total movements at 1 minute and 10 minutes exceeds 1 mm, the test load shall be maintained for an additional 50 minutes and the total movements shall be recorded at 20, 30, 40, 50, and 60 minutes. Where the difference in movement between the 6-minute and 60-minute log cycle exceeds 1.5 mm the previously acceptable maximum load shall be the accepted test load.

Vertical and horizontal movements of the reaction system and the temperature within the test enclosure shall be recorded.

During the load hold periods, the test pressure shall not be allowed to deviate by more than 0.35 MPa.

When required, repumping back to the test load pressure shall be done to compensate for small movements, hydraulic oil seepage, and changes in temperature of the hydraulic oil.

The load shall be returned to the specified test load prior to taking the movement reading at the specified interval. The test load shall not be exceeded during the period of observation.

942.07.16.05.03 Removal of Pre-Production Test Anchors

The test anchors shall be removed flush with the surrounding ground and the test site restored to its pretest conditions.

The test anchorages shall not be removed until the Contract Administrator has given permission in writing to remove them.

942.07.16.06 Production Anchors

942.07.16.06.01 General

Every anchor shall be tested as specified in the Contract Documents according to the Performance Test or the Proof Test clauses below.

942.07.16.06.02 Performance Test Procedures and Measurements

A performance test shall be conducted on the first two anchors installed and on a minimum of two percent of the number of remaining anchors. The location of the performance test anchors shall be acceptable to the Contract Administrator.

When the anchors are installed in soils having plasticity index greater than 20 or when a soil report indicates that the ground is susceptible to time dependent movements, the performance test procedures shall be extended to investigate creep failures. The extended creep test shall be made on a minimum of two permanent anchors or on the number of anchors as determined by the Contract Administrator.

The performance test shall be conducted by cyclically and incrementally loading and unloading the anchor according to the following schedule:

AL, 0.25 DL, AL
AL, 0.25 DL, 0.50 DL, AL
AL, 0.25 DL, 0.50 DL, 0.75 DL, AL
AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, AL
AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, 1.25 DL, AL
AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, 1.25 DL, 1.5 DL, AL
AL and adjust to lock-off load

Where

AL = Alignment Load
DL = Design Load
At each load increment, the total movement of the pulling head shall be recorded to the nearest 0.02 mm with respect to the independent fixed reference point. After each maximum increment in a cycle the load shall be decreased to the alignment load and the residual movement of the pulling head shall be recorded to the nearest 0.02 mm.

The load shall be maintained at each increment for a minimum of one minute or long enough to record the movement of the pulling head.

The maximum load in a cycle shall be maintained for a minimum of 10 minutes. Total movement readings shall be recorded at 1, 2, 3, 4, 5, 6, and 10 minutes.

If the difference between the total movements at 1 minute and 10 minutes exceeds 1 mm, the test load shall be maintained for an additional 50 minutes and the total movements shall be recorded at 20, 30, 40, 50, and 60 minutes. Where the difference in movement between the 6-minute and 60-minute log cycle exceeds 1.5 mm the previously acceptable maximum load shall be the accepted test load.

Vertical and horizontal movements of the reaction system and the temperature within the test enclosure shall be recorded.

During the load hold periods, the test pressure shall not be allowed to deviate by more than 0.35 MPa.

When required, repumping back to the test load pressure shall be done to compensate for small movements, hydraulic oil seepage, and changes in temperature of the hydraulic oil.

The load shall be returned to the specified test load prior to taking the movement reading at the specified interval. The test load shall not be exceeded during the period of observation.

**942.07.16.06.03 Extended Creep Test**

The extended creep test shall be conducted by incrementally loading and unloading the anchor as specified in the Performance Test Procedures and Measurements clause for Production Anchors. At each maximum load in a cycle, the load shall be held constant according to the following time schedule:

<table>
<thead>
<tr>
<th>Load</th>
<th>Observation Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td></td>
</tr>
<tr>
<td>0.25 DL</td>
<td>10</td>
</tr>
<tr>
<td>0.50 DL</td>
<td>30</td>
</tr>
<tr>
<td>0.75 DL</td>
<td>30</td>
</tr>
<tr>
<td>1.00 DL</td>
<td>45</td>
</tr>
<tr>
<td>1.25 DL</td>
<td>60</td>
</tr>
<tr>
<td>1.50 DL</td>
<td>300</td>
</tr>
</tbody>
</table>

The total movements of the pulling head shall be recorded at 1, 2, 3, 4, 5, 6, 10, 15, 20, 25, 30, 45, 60, 75, 90, 100, 120, 150, 180, 210, 240, 270, and 300 minutes as appropriate to the time corresponding to the load.

When conducting the extended creep test, the loading equipment shall maintain and measure the hydraulic pressure within 0.35 MPa.

**942.07.16.06.04 Proof Test**

Proof tests shall be performed on all the production anchors. The test shall be conducted by incrementally loading the anchor according to the following schedule:

AL, 0.25 DL, 0.50 DL, 0.75 DL, 1.00 DL, 1.20 DL, 1.33 DL, AL, and Adjust to Lock-off Load
At the test load of 1.33 DL, the load shall be maintained constant for 10 minutes and the total movement shall be recorded at 1, 2, 3, 4, 5, 6, and 10 minutes. If the difference between the total movements at 1 minute and 10 minutes exceeds 1 mm, the test load shall be maintained for an additional 50 minutes and the movements readings shall be recorded at 20, 30, 40, 50, and 60 minutes. The anchor shall be returned to AL after holding the load at test load for 50 minutes and the residual movement recorded.

The hydraulic pressure during the load hold period shall not deviate by more than 0.35 MPa and the load shall be returned to the test load prior to taking the movement reading. The total movements at each load increment shall be recorded.

942.07.16.06.05 Lock-Off Procedure

The performance test and the proof test results shall be submitted to the Contract Administrator prior to applying the lock-off load. The lock-off load shall not be applied unless otherwise approved by the Contract Administrator. The load in the tendon or bar after seating losses shall be such that the specified lock-off load has been applied to the anchor.

The magnitude of the lock-off load shall be 1.10 DL or as specified by the Contract Administrator and shall not exceed 70% of the guaranteed minimum tensile strength of the tendon or bar.

942.07.16.06 Lift-Off Tests

A minimum of three lift-off tests shall be conducted at each site. The location of the anchor to be tested and the time of test shall be as determined by the Contract Administrator. The lift-off test shall not be performed until 48 hours has elapsed after transferring the lock-off load. The method of testing shall be as detailed on the approved Working Drawings.

The lift-off test shall be performed after transferring the load to the anchor and prior to removing the jack from its location. The lift-off load shall be determined by re-applying the load to the tendon or bar to lift off the wedge plate or anchor nut without unseating the wedges or turning the anchor nut.

942.07.16.07 Acceptance Criteria

An anchor shall be considered acceptable when all three of the following acceptance test criteria specified herein are satisfied:

a) The total creep movement at test load during the last log time cycle is less than 1.5 mm.

b) The apparent free stressing length based on the elastic movement at the test load is not less than 80% of the designed free stressing length.

c) The load measured during the lift-off test is within 10% of the designed lock-off load.

942.07.16.08 Unacceptable Stressing Results

The anchorages that do not meet the acceptance criteria for the performance test or the proof test shall be treated as follows:

a) Abandon the deficient anchor and install a new anchor.

b) Lock-off the anchors at no more than 50% of the accepted test load sustained during test or as determined by the Contract Administrator and install an additional anchor to compensate for the deficiency.

c) Post grout the anchor at a grouting pressure not exceeding 3.6 MPa or as recommended by the Contract Administrator and then conduct a proof test and apply the acceptance criteria to the test results. The post grouting shall be terminated immediately if any distress on the ground surface is observed during grouting.
d) Readjust the transfer load to 1.10 DL for an anchor that does not meet the lift-off criteria and repeat the test after a minimum of 48 hours. If the anchor does not meet the lift-off test criteria after completing this procedure, it shall be considered unacceptable.

942.07.16.09 Submission of Records

The Contract Administrator shall be provided with complete test records for all tests including the plots of movements versus load and the movements versus time plotted on a semilogarithmic sheet.

942.07.17 Quality Control

942.07.17.01 General

In addition to the quality control procedures initiated by the Contractor, the following work shall also be done.

942.07.17.02 Quality of Grout Mixture

942.07.17.02.01 General

The Contractor shall be responsible for testing of bleeding, preparation and initial storage of grout cubes for determination of compressive strength, and delivery of the grout cubes to a testing laboratory designated by the Owner.

The Contractor shall employ staff from a testing company certified according to CSA A283 - Certification for Additional Tests 1B, by an organization accredited by the Standards Council of Canada, to carry out testing for bleeding, making and curing of grout cubes and early strength determination.

Making of grout cubes for compressive strength test and testing of bleeding, shall be done on a level, vibration free surface.

942.07.17.02.02 Testing for Bleeding

The testing for bleeding of the grout shall be according to CSA A23.2-1B.

Prior to the grouting operation, in the presence of the Contract Administrator, a trial batch shall be mixed and the grout tested for bleeding to ensure that the grout meets the requirements of this specification. The trial batch of grout shall not be used in the actual grouting operation.

During the grouting operation, bleeding measurements shall be performed on the grout sampled at the mixer. The measurements shall be performed at least once a day and as requested by the Contract Administrator.

The bleeding test results shall be submitted to the Contract Administrator in writing. The test results that indicate the grout is not meeting the requirements of the Contract Documents shall be reported immediately to the Contract Administrator and the grouting operation halted until the cause of the problem is identified and corrected.

942.07.17.02.03 Making, Curing, and Transportation of Cubes for Compressive Strength Tests

Grout cubes shall be prepared as follows on site from the grout pumped into the anchor body:

a) One set of grout cubes, consisting of three cubes, shall be made each day the grouting operations are carried out.

b) The grout cubes shall be prepared according to CSA A23.2-1B, and stored at a temperature between 15 and 25°C and shall not be moved prior to demolding.
c) The grout cubes shall be demolded and transported to the laboratory designated by the Owner within 24 hours 4 hours.

d) The grout cubes shall be transported in a sealed white opaque plastic bag containing at least 250 mL of water and maintained at a temperature between 15 and 25°C.

942.07.17.02.04 Early Strength Determination

The Contractor shall prepare and test additional grout cubes to determine when the grout has attained a strength of 20 MPa.

The laboratory conducting the test shall be certified as specified herein.

942.07.18 As Built Drawings

As built drawings shall be prepared by the Contractor for the Owner designed installations as follows:

a) For all work incorporated in the completed structure that required the submission of Working Drawings.

b) For all changes from the original Contract requirements.

The as built drawings shall be submitted to the Contract Administrator in a reproducible format prior to final acceptance of work.

The submission of as built drawings shall be accompanied by a letter bearing the seal and signature of an Engineer stating the as built drawings contain all the changes to the work.

The as built drawings shall bear the seal and signature of an Engineer.

942.07.19 Management and Disposal of Excess Materials

Management and disposal of excess material shall be according to OPSS 180.

942.08 QUALITY ASSURANCE

942.08.01 Sampling and Testing of Prestressing Steel

The sampling of prestressing bar will be on a random basis.

The testing of prestressing steel strand and bars shall be according to ASTM A 416/A 416M, and A 722/A 722M.

942.08.02 Anchor Material

Anchor material shall be examined for conformance to this specification and the manufacturer's requirements.

942.08.03 Grout

A compressive strength test will be carried out according to CSA A23.2-1B.

Each day of grouting operations will be represented by a minimum of one 28-Day compressive strength result obtained by averaging the results of three grout cubes prepared as detailed in the Making, Curing, and Transportation of Cubes for Compressive Strength Tests clause.
When the 28-Day compressive strength fails to meet the requirements stated in this specification, the Contractor shall install additional anchors at no additional cost to the Owner.

942.08.04 Material and Stressing Records and Test Results

Material and stressing records and test results will be examined for conformance to the Contract Documents.

942.09 MEASUREMENT FOR PAYMENT

942.09.01 Actual Measurement

942.09.01.01 Pre-production Test Anchors and Production Anchors

Measurement will be made in metres along the actual length of the anchor from the anchor plate to the tip.

942.09.01.02 Post-Grouting of Bond Length

Measurement will be made in kilograms of mixed grout used.

942.10 BASIS OF PAYMENT

942.10.01 Pre-Production Test Anchors - Item
Production Anchor - Item
Post-Grouting of Bond Length - Item

Payment at the Contract price for the above items shall be full compensation for all labour, Equipment, and Material to do the work.
Appendix 942-A, Commentary for OPSS 942, April 2004

Note: This appendix does not form part of the standard specification. It is intended to provide information to the designer on the use of this specification in a Contract.

Designer Action/Considerations

The following shall be specified in the Contract Documents:

- Pre-production test anchors when required. (942.04.01.02)
- Prestressing steel requirements. (942.04.01.06.01)
- The bond stress when required. (942.04.02)
- Diameter, orientation, length, inclination, and tolerances of holes for anchors. (942.07.10.01)
- Waterproofing of anchor holes. (942.07.10.02)
- Placement of primary grout for anchors and grout strength. (942.07.12)
- Post-grouting of bond length when required. (942.07.13)
- Method of placing of the cement bentonite slurry in the free-stressing length. (942.07.14)
- Number of pre-production test anchors for owner designed anchors. (942.07.16.05.01)
- Test load. (942.07.16.05.02)
- Anchor testing requirements. (942.07.16.06.01)

Related Ontario Provincial Standard Drawings

None.