Special Provision No. 999S26

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1.0 SCOPE

This specification covers the requirements for the design, installation and testing of temporary and permanent pre-stressed anchors in soil and rock.

2.0 REFERENCES

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

Ontario Provincial Standard Specifications, General:

OPSS 180 Management and Disposal of Excess Materials

Ontario Provincial Standard Specifications, Construction:

OPSS 904 Concrete
OPSS 906 Structural Steel

Ontario Provincial Standard Specifications, Material:

OPSS 1301 Hydraulic Cementing Materials
OPSS 1302 Water
OPSS 1350 Concrete (Materials and Production)
OPSS 1440 Steel Reinforcement for Concrete

Canadian Standards Association Standards, CSA:

A23.1-00/A23.2-00 Concrete Materials and Methods of Concrete Construction/Method of Test of 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

American Society for Testing and Materials Standards, ASTM:

A53/A53M-02 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
A416/A416M-99 Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
A500-03a Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
A722/A722M-98 Uncoated High-Strength Bar for Prestressing Concrete
D1143-81 Standard Test for Piles Under Static Axial Compressive Load
D1248-84 (1998) Polyethylene Plastics Molding and Extrusion Materials
D1784-83 (1983) Rust Protection for Metal Preservatives in the Humidity Cabinet
3.0 DEFINITIONS

Alignment Load (AL): 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, which 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.

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 so that a minimum grout cover is provided.

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

Design Load (DL): 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.

Free Stressing (unbonded) 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 (lift-off load) in the tendon at any specified time with the use of hydraulic jack, by lifting 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.

Permanent Anchor: means any prestressed anchor intended for permanent use, generally with more than a 24-month service life.

Performance Test: means the incremental cyclic test loading and unloading of an anchor, while recording the total movement of the anchor at each increment, including the residual movement at alignment load.

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

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.

Quality Verification Engineer: means an Engineer with a minimum of five (5) years experience related to the design, installation and stressing of anchors, or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the Contract. The Quality Verification Engineer shall be retained by the Contractor to certify that the work is in general conformance with the contract documents and to issue certificate(s) of conformance.

Temporary Anchor: means a prestressed anchor intended for temporary use, generally with less than a 24-month service life. Temporary anchors installed in corrosive environments may require corrosion protection.

Test Anchor: means an anchor installed and then loaded to verify the design parameters prior to the installation of the production anchors.

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.

4.0 SUBMISSION AND DESIGN REQUIREMENTS

4.01 Submissions

4.01.01 General

At least two weeks prior to the commencement of the work, three copies of the working drawings shall be submitted to the Contract Administrator for information purposes only. These working drawings shall bear the seal and signature of the design and checking Engineers who have a minimum of five years experience on projects of a similar nature and scope to the required work.
4.01.02 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 test anchors. This information shall include but not be limited to the following:

1. 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

2. 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

3. Materials
   i. Physical properties of monobar/multistrand anchors.
   ii. Bond length 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/mechanical properties.

4. 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/auger diameter and lengths, casing diameter and lengths, slurry materials or other materials to facilitate the construction of the anchor hole. The method of verifying the lengths of anchor holes shall also be identified.
   ii. Details of the assembling of the anchor in the 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 grouting 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 grouting placement. Grout mixing procedure and the method of installation including grout pressures.

vi Free stressing zone grouting placement. Grout mixing procedure and the method of installation including grout pressures.

vii Waterproofing of drilled holes 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.

5. 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 applied loads and movement.

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

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


4.01.03 Bentonite Slurry

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

1. The type, source, physical and chemical properties of the bentonite or polymer.
2. The source of water.
4. The water solids ratio, 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.
5. Details of procedure to be used for monitoring the quality of the slurry.
6. A test report describing the properties of the slurry (density, viscosity).
7. Method of disposal of the slurry.

4.01.04 Couplers

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

4.01.05.01 Mill Certificates

One copy of the mill certificates, indicating that the steel meets the requirements of the Contract Documents shall be submitted to the Contract Administrator, at time of delivery 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 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 testing laboratory and appropriate wording stating that the material conforms to the specified material requirements. The stamp shall include the appropriate material specification number, the date and the signature of an authorized officer of the testing laboratory.

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 detailed in OPSS 1440.

4.02 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 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.

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

Except as specified herein the anchors shall be designed in accordance with the design recommendation of the Post Tensioning Institute Recommendations for Prestressed Rock and Soil Anchors.

4.03 Certificate of Conformance

The Contractor shall submit, to the Contract Administrator, a Certificate of Conformance sealed and signed by the Quality Verification Engineer upon completion of the anchor installation and stressing.

The Certificate of Conformance shall state that the anchors have been supplied, installed and stressed in general conformance with the working drawings.
5.0 MATERIALS

5.01 Anchors

5.01.01 Permanent Anchors

5.01.01.01 General

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

Unless otherwise approved the permanent anchor shall be Dywidag Threadbar Anchors, BBR Cona Multi-Strand Anchors or VSL Multi-Strand Anchors.

5.01.01.02 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 that might lead to premature failure of the prestressing steel.

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

The trumpet shall be fabricated from pipe conforming to ASTM A53 or tubing conforming to ASTM A500. 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 unbonded 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.

5.01.01.03 Prestressing Steel

Prestressing steel shall be according to ASTM A416 and ASTM A722.

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

Prestressing steel shall be according to OPSS 1440.

5.01.01.04 Couplers

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

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

5.01.01.06  Water

Water shall be according to OPSS 1302.

5.01.01.07  Sheath

Plastic sheathing shall be made from high density polyethylene according to ASTM D 1248, Type III, or from polyvinyl chloride in conformance with ASTM D 1784, Class 13464-B or equivalent. The plastic sheathing shall have a minimum compressive strength of 102 MPa and a minimum tensile strength of 48 MPa. 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.

Plastic tubing made from polyethylene or polypropylene shall have an average minimum wall thickness of 1.5 mm. Polyvinyl chloride (PVC) tubing shall have an average minimum wall thickness of 1.0 mm and 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 equivalent to the plastic sheathing.

5.01.01.08  Tendon Bond Length Encapsulation

The prestressing steel 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.

5.01.01.09  Centralizers and Spacers

Centralizers and spacers shall be steel, plastic or a material that is non-detrimental to the prestressing steel. Wood spacers shall not be used.

Spacers shall be used in multiple element tendons to separate the strands or bars individually or into small groups.

5.01.01.10  Grout or Concrete for Bond Zone

The cube strength of the grout and the compressive strength of the concrete 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.

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.
5.01.01.11  Corrosion Inhibiting Compound

The corrosion-inhibiting compound placed in either the free 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 nonreactive with the prestressing steel, the sheathing material and the anchor grout.

5.01.01.12  Corrosion Protection

The anchor shall be provided with Class I, Encapsulated Tendon, double corrosion 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 having the 7d and 28d compressive strengths specified.

5.01.01.13  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.

5.01.01.14  Heat Shrinkable Sleeves

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

5.01.02  Temporary Anchors

The material for temporary anchors shall be the same as specified for the permanent anchor except the double protection system is not required unless specified.

5.02  Test Anchors

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

5.03  Bentonite Slurry or Lean Mix in Free Stressing Zone

The purpose of the backfill in the free stressing zone is to prevent settlement and preventing transfer of the anchor load to the free stressing zone. The backfill shall completely fill the annular space between the tendon and the anchor hole and shall render a stable hole without any hole collapse or cave-in.

Bentonite slurry or lean mix concrete can be used. Bentonite shall meet the requirements of API 13A. For soil anchors, a lean mix concrete (0.4 MPA) can be used to backfill the free stressing zone.

The Contractor shall submit the proposed bentonite slurry or lean mix concrete, reviewed and approved by the Quality Verification Engineer, to the Contract Administrator a minimum of 10 working days prior to placement.
6.0  EQUIPMENT

6.01  General

All equipment for the installation of the anchor, anchor stressing, anchor testing and monitoring the 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 or corrosion protection, or the soldier piles.

6.02  Anchor Testing Equipment

The equipment shall be capable of stressing the tendon to the maximum specified Test Load within the rated capacity.

The equipment shall permit the tendon to be stressed in increments so that the load in the tendon can be raised or lowered in accordance with the test specifications, and allow the anchor to be lift-off tested to confirm the lock-off load.

Dial gauges shall have at least a 75 mm travel and 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 at every load increment to be read to the nearest 0.02 mm. 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.

6.03  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.

6.04  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.

7.0  CONSTRUCTION

7.01  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 design parameters and the design of the anchors.

The anchor system shall be according to this specification and the stamped shop drawings.

7.02 Structural Steel

Structural steel components shall be fabricated according to OPSS 906.

7.03 Prestressing Steel Bond Capacity

If not available from the prestressing steel manufacturer a prestressing strand bond capacity test shall be conducted on the strand in accordance with Appendix A of Recommendations for Prestressed Rock and Soil Anchors as published by the Post Tensioning Institute. The test information shall be submitted to the Contract Administrator prior to commencement of work.

7.04 Anchor Fabrication

Anchors shall be either shop or field fabricated in accordance with the approved drawings and schedules using personnel trained and qualified for this work.

The entire 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.

Joints in the protection system shall be made watertight.

7.05 Storage and Handling

Upon delivery, the fabricated anchors and the prestressing steel for fabrication of the tendons on site 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 nor the corrosion protection.

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

Lifting of any pregroated tendons shall not cause excessive bending, which may debond the prestressing steel from the surrounding grout.

7.06 Corrosion Protection Details

7.06.01 Anchorage Protection

The corrosion protection of the tendon in the vicinity of the anchorage shall be carefully designed and built for a proper protection.

All stressing anchorages permanently exposed to the atmosphere or that have 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 unbonded 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.

Corrosion inhibiting compound filled trumpets 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.

Trumps filled with grout shall have either a temporary seal between the trumpet and the unbonded length corrosion protection or the trumpet shall fit tightly over the unbonded length corrosion protection for a minimum of 0.3 m.

7.06.02 Free Stressing Length Protection

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.

7.06.03 Free Stressing Length/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.

7.06.04 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.
7.07  Construction of Anchor Holes

7.07.01  General

The holes shall be constructed to the diameter, orientation and length specified and detailed on the stamped working drawings. A drilling method that will establish a stable hole within the tolerances specified shall be used.

The sides and end of the completed hole 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 holes entry angle from its specified inclination shall be no greater than ± 3 degrees.

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

Holes open for longer than eight hours shall be re-cleaned prior to insertion of the tendon and grouting.

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

1. Identification number.
2. Hole diameter.
3. Hole length.
4. Drilling procedure.
5. Soil, rock and ground water conditions encountered.
6. Time required to drill the hole.
7. Problems encountered.

The construction of the holes shall be inspected by the Quality Verification Engineer.

7.07.02  Waterproofing Holes

Waterproofing of holes shall be done where specified in accordance with the stamped drawings, procedures and equipment.

If during the water tightness test the leakage from a hole over a ten minute period exceeds 9.5 L the 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.

7.08  Anchor Installation

The anchors shall be installed as specified in the Contract Documents and detailed on the stamped 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.
The devices used to centre the tendon and sleeves in the hole throughout the bond length of the tendon 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 be responsible for determining the number of centring devices required, however, one unit shall be placed within 1 m of the bottom of the hole and another at the bond length - free stressing length interface. The centring devices shall not interfere with the required grouting.

The Quality Verification Engineer shall inspect anchor installation.

7.09 Grouting of Permanent Anchors

7.09.01 Quality of Grout Mixture

Any grout mixture showing evidence of dampness, lumps, harden pieces, or contamination shall not be incorporated in the work.

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.

7.09.02 Bleeding Requirements

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 Quality Verification Engineer and the Contract Administrator, a trial batch shall be mixed and the grout tested for bleeding, to ensure that the grout meets the requirements specified in the Contract Documents. The trial batch of grout shall not be used in the actual grouting operation unless approved by the Contract Administrator.

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.
7.09.03  Strength Requirements

7.09.03.01  Grout

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°C 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°C and 25°C.

7.09.03.02  Concrete

Concrete specimens shall be prepared and tested in conformance with OPSS 904.

7.09.03.03  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 as specified herein.

7.10  Primary Grouting of Anchors

The grout shall be installed as specified in the Contract Documents and as detailed on the stamped 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:

1. Identification number.
2. Type of grout.
3. Grout pressure.
4. Volume of grout used.
5. Location of the top of the bond length grout.

The Quality Verification Engineer shall inspect primary grouting of anchors.
7.11 Post Grouting of Bond Length

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

The information required for recording primary grouting shall also 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.

The Quality Verification Engineer shall inspect post grouting.

7.12 Placing of Bentonite Slurry or Lean Mix Concrete in the Free-Stressing Length

The method of placing the cement bentonite slurry or lean mix concrete shall be as specified in the Contract Documents and as detailed on the stamped working drawings.

The cement bentonite slurry for the free stressing length or lean mix concrete 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.

The Quality Verification Engineer shall inspect placement of the cement bentonite slurry or lean mix concrete in the free stressing length.

7.13 Installation of Anchorage

The anchor bearing plate and the anchor head or nut shall be installed perpendicular to the tendon, within ±3 degrees and centred 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.

Anchorages permanently exposed to the atmosphere shall be covered with a corrosion inhibiting compound filled or grout filled cover.

7.14 Testing

7.14.01 General

Testing shall be carried out according to the stamped 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 the specified 28 d strength.

Anchor tests shall be conducted at a time mutually acceptable to the Contractor and Contract Administrator.
The anchor tests shall be constantly monitored by the Quality Verification Engineer and the test results recorded and submitted to the Contract Administrator.

7.14.02 Reaction System

The reaction system shall be designed by the Contractor and shall be installed as detailed on the stamped working drawings.

7.14.03 Reference System and Testing Equipment

The layout of the reference systems and testing equipment required for testing shall be as detailed on the stamped 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 reaction system. Reference beams shall be sufficiently rigid to support instrumentation such that variations in readings do not occur.

All gauges, scales and reference points attached to the test anchor shall be mounted so as to prevent movement relative to the test anchor during the test.

Dial gauges shall bear on the pulling head of the jack and their stems shall be coaxial 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.

7.14.04 Reference System Enclosures

The Contractor shall construct suitable enclosures to provide complete protection for personnel, equipment and instruments from variations in the weather conditions and disturbances during the test program.

These provisions shall include the following specific requirements:

a) The test enclosures shall be weatherproof and provide adequate lighting and 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.

7.14.05 Test Anchors

7.14.05.01 Installation of Test Anchors

Test anchors are required for temporary and permanent anchors. For contractor-designed anchors, at least one test anchor shall be installed and tested in each significantly different ground condition. For owner-designed anchors, the number of test anchors shall be as specified in the contract documents.

Test anchors shall be constructed using the materials, methods and procedures specified herein and as detailed on the stamped working drawings.
The test anchors shall not be incorporated in permanent or temporary works unless approved by the Contract Administrator.

**7.14.05.02 Test Procedures and Measurements**

The Anchor Test shall be carried out generally in accordance with the prevailing requirements of ASTM D1143-81 superseded where applicable by the procedure specified in this document.

With measurements recorded at intervals as directed by the Contract Administrator, the Anchor Test shall be conducted by incrementally loading and unloading according to the following schedule, or until the anchor fails.

\[
\text{AL, 0.25DL, 0.50DL, 0.75DL, 1.00DL, 0.75DL, 0.50DL, 0.25DL, 0.50DL, 0.75DL, 1.00DL, 1.25DL, 1.50DL, 1.25DL, 1.00DL, 0.75DL, 0.50DL, 0.25DL, 0.50DL, 0.75DL, 1.00DL, 1.25DL, 1.50DL, 1.75DL, 2.00DL*, 1.75DL, 1.50DL, 1.25DL, 1.00DL, 0.75DL, 0.50DL, 0.25DL, 0.00DL**}
\]

Where AL = Alignment Load  
DL = Design Load of Anchor

* At 2.00T, the load shall be maintained for 24 hours.
** At this point, an additional loading cycle, directly to a load up to the ultimate load as specified shall be conducted.

Each load shall be maintained for a minimum of 15 minutes or until the rate of displacement is not greater than 0.25 mm per hour.

Vertical and horizontal movement of the reaction system and tendon elongation shall be recorded with respect to an independent fixed reference point. A record of the test enclosure temperature is also required.

During the load hold periods, the anchor load shall not be allowed to deviate from the Test Pressure by more than 0.35 MPa.

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

The load shall always 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.

**7.14.05.03 Removal of Test Anchors**

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

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

7.14.06.01 General

Every anchor shall be tested as specified in the Contract Documents according to the test and lift off subsections below.

7.14.06.02 Test Procedures and Measurements

During all tests, a record of load, time and movement shall be maintained at each loading interval. The Contractor shall provide to the Contract Administrator complete test records for all tests including plots of tendon movement versus tendon load, tendon load versus time, and tendon movement versus time.

7.14.06.03 Acceptance Tests

7.14.06.03.01 General

The anchorages shall meet the following proof test and lift-off test prior to acceptance.

7.14.06.03.02 Proof Test – Permanent Anchors

The following proof test shall be applied to the anchorages:

a) After preloading the anchor to 1.5T for 30 minutes, the proof test shall be conducted by incrementally loading and unloading the anchor according to the following schedule, or until the anchorage fails, as determined by the Contract Administrator. The acceptance criteria apply to only the peak loading.

Loads shall be applied as follows:

0.25DL, 1.00DL, 1.50DL*, 1.00DL, 0.25DL

Where:

DL = Specified Working Load of Anchorage

* At 1.50DL, the load shall be maintained for a minimum of 30 minutes. Measurement shall be recorded according to the following time increment schedule.

0 min, 1 min, 2 min, 3 min, 6 min, 9 min, 12 min, 15 min, 18 min, 30 min.

If the acceptance criteria as specified herein are met, the anchorage shall be prestressed to 1.50DL, then shall be locked-off at the transfer load of 1.10DL.

If the acceptance criteria as specified herein are not met in the 30 minute period the test shall be extended as required, with readings at 30 minute increments, up to 180 minutes.

If the acceptance criteria as specified herein are not met, the provisions of the clause "Unacceptable Results" as specified herein shall apply.
7.14.06.03.03  Proof Test – Temporary Anchors

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

Where:

AL = Alignment Load
DL = Specified Working Load of Anchorage

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.

7.14.06.04  Lock-Off Procedure

After testing has been completed, the load in the tendon shall be such that after seating losses (wedge seating), the specified Lock-Off Load has been applied to the anchor tendon.

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 ultimate load of the tendon or bar (F_{pu}).

The wedges shall be seated at a minimum load of 50% of F_{pu}. If the Lock-Off Load is less than 50%, shims shall be used under the wedge plate and the wedges seated at 50% of F_{pu}. The shims shall then be removed to reduce the load in the tendon to the desired Lock-Off Load. Bar tendons may be locked off at any load less than 70% of F_{pu}.

7.14.06.05  Lift-Off Tests

A minimum of three lift off tests shall be conducted at each site. Lift-off tests shall be conducted at times and locations determined by the Quality Verification Engineer. 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 stamped working drawings, but will generally be as follows:

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 anchor tendon. This load is determined by re-applying load to the tendon to lift off the wedge plate (or anchor nut) without unseating the wedges (or turning the anchor nut). This moment represents zero time for any long term monitoring.

The stressing anchorages shall be suitable for conducting lift-off tests until the locked-in anchor load has been verified.

Acceptance criteria for lift-off tests shall be as specified herein.
If acceptance criteria for lift-off tests are not met, the provisions of the clause "Unacceptable Stressing Results" apply.

7.14.06.06 Acceptance Criteria

An anchorage is acceptable when:

1. The tendon movement for the last log time cycle is less than 1.5 mm where log time cycle is defined as 1/10 final time to final time*.

   *3 for 30 min, 6 for 60 min, 9 for 90 min, 12 for 120 min, 15 for 150 min, 18 for 180 min.

   and

2. The recorded elastic movement of the tendon exceeds 0.80 of the theoretical elongation of the free-stressing length.

The Quality Verification Engineer shall evaluate the anchorage lift-off test results and determine whether the anchor is acceptable.

An anchorage is acceptable when the load measured in the lift-off test is within 10% of the locked-in transfer load.

7.14.06.07 Unacceptable Stressing Results

Anchorages that do not meet the acceptance criteria for proof test shall be treated as follows:

1. Abandon the deficient anchor and install new anchors.

2. Use the deficient anchor at a reduced working load and add another anchor to compensate for the load deficiency. In this case the acceptable working load for the anchorage shall be determined by conducting modified Proof Tests for the reduced loads until acceptance criteria are met. The acceptable working load shall be 50% of the load achieved in the acceptable modified Proof Test. The modified Proof Test will involve maintaining the test load for up to 12 hours for permanent anchors, and up to 6 hours for temporary anchors.

   or

3. Use post-grouting techniques to increase the anchor capacity to meet the acceptable criteria. Post-grout pressures shall not exceed 3600 kPa without approval of the Contract Administrator. The ground surface shall be observed and if pressure induced distress occurs the post-grouting operation should be immediately stopped.

Unless otherwise determined by the Contract Administrator anchorages that do not meet the acceptance criteria for lift-off tests shall be treated as follows:

1. The transfer load shall be adjusted to 1.10T. The lift-off test shall be repeated after a minimum time of 48 hours.

2. If the criteria for the lift-off test are not met after completing this procedure anchorage shall be treated as specified for anchorages that do not meet the proof test acceptance criteria.
7.15 **Management of Excess Materials**

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

7.16 **As Built Drawings**

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

1. For all work incorporated in the completed structure that required the submission of working drawings.
2. 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 as built drawings shall bear the seal and signature of the Quality Verification Engineer.

8.0 **MEASUREMENT FOR PAYMENT**

8.01 Actual Measurement

8.01.01 **Production Anchor**

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

8.01.02 **Test Anchor**

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

8.01.03 **Post-Grouting of Bond Length**

Measurement will be in kg. of grout used.

9.0 **BASIS OF PAYMENT**

9.01 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.