942.1 GENERAL

Ground anchors are systems used to transfer tensile loads to soil or rock. These systems comprise prestressing steel tendons, steel anchorages, spacers, centralizers and grout. Permanent anchors also require corrosion protection.

Ground anchor design and construction require test anchors and production anchors. Test anchors are to provide design information and to verify ground anchor capacity prior to production anchor installation and testing. Usually one (1) or two (2) anchors are subjected to pre-production tests depending on the scope and complexity of the project. Test anchors are subjected to rigorous testing characterized by a number of cyclic loadings for extended duration of up to 24 hours.

Production anchors testing are to be carried out on each anchor. Production anchors testing are for anchor performance verification and are of relatively short duration.

Post grouting is a process of regrouting an anchor after the primary grout has set. Post grouting is used as a method of increasing the capacity of an anchor.

942.2 REFERENCES

Canadian Highway Bridge Design Code
Foundation Investigation and Design Reports – project-specific
Post Tensioning Institute (PTI) – Recommendations for Prestressed Rock and Soil Anchors.

942.3 TENDER ITEMS

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

942.4 SPECIFICATIONS

The requirements for the above tender items are contained in OPSS 942.
942.5 **SPECIAL PROVISIONS**

The designer should refer to Chapter 'E' of this manual to review the applicable special provisions.

942.6 **STANDARD DRAWINGS**

There are no standard drawings associated with these tender items.

942.7 **DESIGN**

942.7.1 **General**

The ground anchor system must resist imposed tensile loads and limit displacements of the structure to within Service Limit States (SLS) during the service life of the installation and to prevent failure at Ultimate Limit State (ULS).

Guidelines for design, installation, stressing, inspection and testing of ground anchors are available in a number of publications including the Post Tensioning Institute (PTI) – Recommendations for Prestressed Rock and Soil Anchors.

Recommendations for ground anchors shall be included in the Foundation Investigation and Design Report. This is administered by the Pavements and Foundations Section, Materials Engineering and Research Office.

942.7.2 **Geotechnical Resistance (pull-out Capacity)**

Both immediate and time-dependent failure mechanisms for ground anchor components shall be considered. Provided that the strength and durability of ground anchor components is adequate, design can be based on the bond stress at the interface between the anchor grout and the soil or rock. Recommendations for the bond stress shall be provided in the Foundation Investigation and Design Report.

942.7.3 **Spacing, Bond Length and Free-Stressing Length**

Spacing requirements prevent interference between bond zones that could reduce the pullout resistance of the ground anchor.

Bond length requirements should be sufficient for the ground anchor to provide acceptable stress-strain performance over its service life. A minimum length of 3 m is typically required to account for installation uncertainties.
Free stressing length should be sufficient to transfer load resistance beyond the assumed failure wedge of the foundation material. The approximate angle of the failure wedge can be calculated by well-established methods considering the geometry of the anchored structure and the internal strength of the foundation material.

942.7.4 Post Grouting

To increase the capacity of the anchor, post-grouting can be used. Post-grouting includes the regrouting of the anchor after the primary grout has set to enlarge the bond stress area under grouting pressure. Post-grouting can either be specified or can be used in response to not achieving design capacities during construction.

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

942.7.5 Anchor Tests

Pre-Production Test Anchors are installed and tested prior to production tests. For test anchors, the anchors are subjected to rigorous test procedures characterized by a number of cyclic loadings and also maintaining the maximum test load up to 24 hours.

Proof tests on production anchors are for anchor performance verification. Proof tests shall be carried out on all ground anchors. Proof tests are of relatively short duration (10 to 30 minutes for temporary and permanent anchors respectively).

942.8 COMPUTATION

942.8.1 Sources of Information

The main sources of information for anchors are:

a) Foundation Investigation and Design Reports, administered by the Pavements and Foundations Section, Materials Engineering and Research Office.
b) Bridge Office/Structural Sections
c) Canadian Highway Bridge Design Code
d) Post Tensioning Institute (PTI)

942.8.2 Method of Calculation

942.8.2.1 Pre-Production Test Anchors

The unit of measurement for pre-production test anchors is the actual length in metres (m) of the anchor from anchor plate to tip.
942.8.2.2 Production Anchors

The unit of measurement for test anchors is the actual length, in metres (m), of the anchor from anchor plate to tip.

942.8.2.3 Post Grouting of Bond Length

The unit measurement for post grouting is kilograms of grout used. Tender quantity may be established in consultation with the Pavements and Foundations Section, MERO.

942.9 DOCUMENTATION

942.9.1 Drawings

For all designs, a plan illustrating the anchor layout, spacing, inclination and orientation shall be provided in a foundation layout drawing in the contract drawings. Chainage and offset shall be indicated on the drawing as required. The foundation layout drawing shall also include sections, components and details that depict the anchor type, minimum total anchor lengths, design loads, diameters, and materials. The dimensions of anchor holes shall be indicated, including length, diameter and tolerances. A unique identification number shall be provided to describe each anchor. Some of the above information may be provided in an adjacent table on the contract drawings, if practical.

Any requirements for waterproofing of anchor holes shall be detailed on the foundation layout drawing, when required according to the Foundation Investigation and Design report.

The maximum factored loads at Serviceability Limit State (SLS) and Ultimate Limit State (ULS) shall be provided on the drawing.

942.9.2 Quantity Sheets

For each of the Pre-Production Test Anchors, Production Anchor and Post-Grouting of Bond Length tender items, enter the tender item name in the heading of one column of the Quantity Sheet – Quantities – Structure. In one line, enter the total quantity for the entire contract. For contracts with a large number of anchors or when anchors are located in various locations, each location may be identified by chainage and offset on one line and the applicable quantity (total length, m) entered in the applicable column.
942.9.3 **Non-standard Special Provisions**

If applicable, specify the number of pre-production test anchors in a special provision. List project-specific requirements for pre-production test anchors, as applicable.

Requirements for placing grout, including strength, shall be included in a special provision. If applicable, requirements for post-grouting of the bond length shall be included. Include requirements for cement bentonite slurry in the free-stress length, as applicable. Bond stress, bond lengths and free stressing lengths shall be included in a special provision, if applicable, according to the Foundation Investigation and Design Report.

Requirements for testing of production anchors shall be indicated in a special provision.

Special provisions may be recommended to address site specific concerns identified in the Foundation Investigation and Design Report. For example, alerting the Contractor of cobbles or boulders in the native soil or alerting the Contractor of susceptibility of soils to cave-in may be required.

When appropriate, some of the information listed under Contract Drawings subsection may be provided in a special provision.

Specify the name, location and contact information for a testing laboratory to perform testing on behalf of the owner, when required.