# SECTION 7 - GEOTECHNICAL CONSIDERATIONS

## 7.1 GENERAL

Geotechnical investigations are required for highway, geotechnical and bridge projects. Specific requirements and guidelines for geotechnical investigations are being prepared at the time of this writing and will be presented in the Department's "Guidelines for Consulting Geotechnical Engineers" manual, due in March 2002.

This Section presents basic principles and requirements with which to guide the geotechnical consultant in the preparation of proposals and completion of their investigations. Irrespective of the requirements listed in this document, it is important that the Consultant clearly outlines in their proposal what assumptions were made in estimating the effort and resources necessary to complete the scope of work.

A project may consist of new road construction, grade widening, bridge and culvert design, and specific geotechnical projects such as landslide repair. Within any of these types of projects there may be numerous major areas of investigations, including roadway; borrow; bridge and culvert; soft ground or muskeg; landslide; erosion; and rock. General requirements for these types of investigations are outlined in the following sections. Requirements for culvert corrosion surveys are provided in this section. It should be noted that there are specific qualifications for personnel responsible for gathering field data and testing related to corrosion surveys. Requirements for topsoil survey related to topsoil conservation within the highway right-of-way, and for pre and post borrow assessments are provided in Section 4.

This section provides minimum requirements for testhole spacing. Sound engineering and application of 'common sense' principles should govern the project requirements for testhole spacing and locating. Minimum drilling requirements through problematic areas should be supplemented as required to provide a reasoned basis on which to proceed with the design, using a balance of risk acceptance and avoidance in harmony with project costs and objectives. For the purposes of this Section, 'testhole' and 'borehole' are interchangeable terms. Minimum requirements for field investigations, laboratory tests and reports are summarized in each subsection.

The Consultant's Geotechnical Engineer assigned to the project shall make at least one site visit, preferably prior to start up of the field investigation. This trip will help the engineer to familiarize himself with the site conditions and aid in the positioning of testholes. Several site visits may be required for complex sites such as major landslide or bridge projects.

TABLE A provides a summary of field, laboratory and reporting requirements for each type of project listed below.

**TABLE A – INVESTIGATION AND REPORT CONTENT REQUIREMENTS**

| Type of Investigation | | Office review | Minimum Field Investigation | | | Minimum Laboratory Testing | Reporting Requirements |
|---|---|---|---|---|---|---|---|
| | | | Location | Depth | Instrumentation | | |
| Roadway (Section 7.2) | New construction | 1, 2, 6 | 7, 8 | 21, 22, 23, 25 | 28,30 | 31, 33, 34 | 37-43 |
| | Grade widening | 1, 2, 3, 4, 5, 6 | 7, 9 | 21, 22, 23 | 28, 30 | 32, 33, 34 | |
| Borrow (Section 7.3) | | 1, 2, 6 | 7, 10 | 21, 23 | 29 | 32, 33 | |
| Bridges (Section 7.4) | Abutments | 1, 2, 3, 4, 5, 6 | 7, 11 | 23, 24, 25 | 28, 30 | 32, 33, 34, 35 | |
| | Piers | | 7, 12 | 22, 24, 25 | 28, 30 | 32, 33, 34, 35 | |
| | Culvert | | 7, 13 | 23, 24, 25 | 28, 30 | 32, 33, 34, 35 | |
| | MSE/retaining walls | | 7, 14 | 23, 24, 25 | 28, 30 | 32, 33, 34, 35 | |
| | Wingwalls | | 7, 15 | 23, 24 | 28, 30 | 32, 33, 34, 35 | |
| | Approach fills | | 7, 16 | 22, 24 | 28, 30 | 31, 34 | |
| Culvert – Corrosion Survey (Section 7.4) | | 3 | 17 | 26 | 26 | 36 | |
| Soft ground/ muskeg (Section 7.5) | | 1, 2, 3, 6 | 7, 18 | 23, 27 | 28, 30 | 31, 33, 34 | |
| Landslides (Section 7.6) | | 1, 2, 3, 4, 5, 6 | 7, 19 | 19, 23 | 28, 30 | 32, 33, 34 | |
| Erosion (Section 7.7) | | 1, 2, 3, 5, 6 | 7, 19 | 19, 23 | | 31, 33, 34 | |
| Rock (Section 7.8) | | 1, 2, 3, 6 | 7, 20 | 21 | 28 | 31, 33 | |

Legend:

Office Review

1. Surface geology, bedrock geology maps and reports
2. Airphoto review
3. Consultant and Department geotechnical, bridge and design reports and file records
4. Construction records
5. Maintenance records, local peoples perspective
6. Site visit by Project Engineer

Field Investigation

7. Testhole or testpit
8. Drill at 200 m maximum spacing, (for topsoil survey assessment requirements refer to Section 4). Offset testholes as appropriate to provide coverage across the full width of the proposed construction. As a suggested guideline alternate drilling of centerline holes with testholes advanced along the right and left ditch lines.
9. Drill at 300 m maximum spacing if it can be determined that previous soils information is available and relevant, otherwise use 200 m maximum spacing. For topsoil survey assessment requirements refer to Section 4. Offset testholes as appropriate to provide coverage across the full width of the proposed construction. Drill along shoulder of the road to assess the existing road structure, along the existing embankment slope to determine the presence of waste materials for benching requirements, and along existing ditch which will form the foundation for the new fill.
10. Minimum of two testholes per borrow, for pre and post borrow disturbance assessment requirements refer to Section 4.
11. Minimum of one testhole per abutment. Siting of abutment and pier testholes should be done in conjunction with bridge planning objectives and existing site constraints.
12. Minimum of one testhole per land based pier. Drilling at all river based piers is preferred, however the use of Geometric Penetrating Radar (GPR) tied into land based testholes, or approved technique to determine soil conditions at river based pier locations may be acceptable. Limitations of the technique used should be discussed in the report. Siting of abutment and pier testholes should be done in conjunction with bridge planning objectives and existing site constraints.
13. Minimum of one testhole per 25 m culvert length at new culvert sites. Use judgement at culvert replacement sites.
14. Minimum of two testholes along each wall base, otherwise at 50 m spacing along Mechanically Stabilized Earth (MSE) structure.
15. Wingwall drilling is left to the discretion of the Consultant. Consultant will be required to document reasons for not doing investigation.
16. Typically drill one testhole per approach fill, about 50 m from abutment seat.
17. See Section 7.4.

18. Where feasible use auger truck to probe, alternatively use muskeg probe or vane testing. Some testhole sampling of muskeg and underlying mineral soils is required. Probe muskeg at 20 m spacing along alignment, alternate left and right offset probes at 20 m spacing.
19. The actual number of testholes required is typically site specific. The number, location and depth of testholes to be determined by Consultant after site visit. For proposal purposes the Consultant should use engineering judgement and provide documentation of reasoning. Instrumentation requirements are also to be determined by the Consultant on a site-specific basis.
20. Probe to rock surface at 50 m intervals, core rock at 100 m intervals
21. Drill a minimum 2 m below ditch level or below bottom of borrow
22. Drill to a depth equal to the fill height, or minimum of 2 m below existing natural grade in fill sections, whichever is greater. The depth of drilling should be consistent with the data requirements for stability analysis, etc.
23. Samples are to be taken of each major soil type encountered, and where moisture conditions show abrupt change. Block samples of muskeg may be required. Undisturbed (pushed thin wall tube) samples and/or cores to be retrieved for advanced laboratory testing as appropriate.
24. Drill a minimum 3 m below pile foundation depth or a minimum 3 m below footing depth. Core a minimum 3 m into competent bedrock where encountered.
25. Standard Penetration Test (SPT), Cone Penetration Test (CPT), Dynamic Cone Penetration Test (DCPT), vane testing, pressuremeter, dilatometer and/or muskeg probe as appropriate
26. Corrosion survey. For requirements see Section 7.4
27. Probe to firm ground at least 1 m below bottom of organic layer where organic terrain is encountered. Where buried valleys infilled with loose or soft compressible materials are encountered probe to at least three times the embankment height or 10 m, whichever is greater.
28. The Consultant may elect to install slotted standpipe piezometers and slope indicators at deep cut locations.
29. Slotted standpipe piezometers should be installed in at least one testhole per borrow, and may be appropriate for installation at culvert and Mechanically Stabilized Earth excavations and along approach cuts into bridge or culvert sites.
30. Recommendations for instrumentation during construction should be included in the report. Such instrumentation may include standpipe and pneumatic piezometers, horizontal and vertical slope indicators, settlement monitoring devices, pile dynamic analyzer (PDA), etc.

Laboratory Test Program

31. The frequency of testing shall be a minimum of one 'suite' of tests per borehole. A 'suite' of tests consists of a moisture content test, and as appropriate, an Atterberg limit test and/or a grain size analysis, and estimates of optimum moisture content and maximum dry density for each tested sample.
32. The frequency of testing shall be a minimum of two 'suites' of tests per borehole. A 'suite' of tests consists of a moisture content test, and as appropriate, an Atterberg limit test and/or a grain size analysis and estimates of optimum moisture content and maximum dry density for each tested sample.

33. Moisture content profile shall be completed for each testhole, meaning that all samples will be tested for moisture content.
34. Advanced testing as determined by the Consultant. This may include direct shear tests, triaxial tests, unconfined compressive tests, permeability tests, consolidation tests, point load tests, slaking tests, pinhole dispersion tests or other tests as deemed appropriate and justified by the Consultant.
35. Soluble sulphate testing for determination of cement type for locations where concrete will come into contact with soil.
36. Corrosion survey: soil resistivity and pH testing, sulphide, sulphate and chloride testing.

Report Content

The project report shall be a complete and comprehensive document. The report format is left to the discretion of the Consultant. The report shall provide the following information and any additional information as indicated in the project terms of reference.

37. Executive summary
38. Office information review
    - Surface geology, terrain and drainage description
    - Bedrock geology if appropriate
    - Airphoto review comments
    - Existing geotechnical reports and file review
    - Discussions with locals, maintenance personnel, etc.
39. Field investigation
    - Field observations: terrain description, ground cover, drainage pattern, scarps, cracks, distressed ground, seeps, heaves, pavement distress, weather at time of inspection, etc
    - Description of drilling program, including testhole locations and depths summary
    - Adverse conditions encountered during drilling, caving or sloughing, loss of drill fluid circulation, refusal conditions, etc.
    - Discussion of groundwater conditions encountered during drilling, immediately after drilling, and after stabilization
    - Generalized soil condition descriptions, with exceptions noted as appropriate
    - Description of field tests and results, SPT, CPT, etc.
    - Details of instrumentation and monitoring program
    - Field corrosion test results, as applicable
40. Laboratory testing
    - Table of results indicating sample data, soil description, Unified Soils Classification System (USCS) description as modified by Prairie Farm Rehabilitation Association (PFRA), and all test results
    - Description of advanced test results, indicating limitations of test and test conditions, type of sample
    - Chemical test results, soluble sulphates, etc.
41. Engineering Assessment
    - Discussion of type of analysis undertaken

- Discussion of material parameters used
- Presentation of analysis findings and limitations if any
- Discussion of risk, including uncertainty, associated with findings
- Discussion of various hazard mitigative options, pros and cons, cost - benefit

42. Recommendations
    - Requirements for mitigation of geotechnical risk at the site including but not limited to:
        - Requirements for contract special provisions
        - Staged construction, rate of fill placement
        - Surcharge or overbuild
        - Cut and fill slope angles
        - Stabilization measures for natural slopes, embankment or cut slopes and cost estimates for it.
        - Site dewatering, soil moisture conditioning
        - Swelling soil and frost heave mitigation
        - Soft ground construction
        - Fill and foundation settlement estimates
        - Volume modification factors for various fill materials to be encountered
        - Erosion control requirements
        - Foundation options and design parameters, bearing and skin friction values, negative or downdrag consideration, cement type related to soluble sulphate concentrations
        - Consolidation design, wick drains, drainage designs
        - Lateral earth pressure
        - Other construction related issues – requirements for monitoring & instrumentation, PDA or test pile requirements
        - Other geotechnical related recommendations as appropriate
43. Appendix
    - List of references
    - Testhole logs, including electronic copy
    - Muskeg probe logs
    - Instrumentation records and readings
    - Stratigraphic cross-section and plan drawings
    - Photographs, site sketches
    - Advanced test result sheets

## 7.2 ROADWAY

The selection of the most desirable gradeline and alignment for highway grading projects are normally conducted through shallow testhole drilling methods inside and immediately outside of the proposed roadway prism. The reporting requirements for grade widening investigations are considered to be the same as for new construction. However there may be room for a relaxation in the frequency of testhole and laboratory testing requirements for grade widening projects, depending on the availability and quality of existing soil information.

Requirement for the depth and distribution of testholes/test pits should be determined based on findings of the office review and site visit by the Project Engineer. It is expected that additional testholes, beyond those stated in Table A will be undertaken if adverse soil conditions are expected or encountered during the course of the field drilling. Consideration should be given to augment the roadway investigation at deep cuts and high fills with offset testholes in order to provide sufficient stratigraphic data for a stability analysis to be undertaken. The possible presence of 'snake pits', narrow pits excavated to dispose of wet or otherwise deleterious soils along the toe of existing embankments should be evaluated through the file review, airphoto assessment, field inspection and drilling program.

Soil samples shall be taken of each change in soil type within a testhole. The size of samples shall be sufficient to meet the laboratory testing requirements.

Requirements for topsoil survey are provided in Section 4.

## 7.3 BORROW

The selection of suitable borrow material can have a significant impact on the success of a project during construction and in the long-term. Consultants are directed to avoid the use of frost susceptible materials as a road building material unless it can be demonstrated that no economically viable alternative exists and the design is optimized to limit the influence of silt. Most borrow investigations are completed using auger drilling techniques or test pits. Typically borrow reports form a subsection of a grading geotechnical report, however occasionally project requirements may dictate that a stand-alone report be prepared.

Requirement for the depth and distribution of testholes/test pits should be determined based on findings of the office review and site visit. It is expected that additional testholes, beyond those stated in Table A will be undertaken if adverse soil conditions are expected or encountered during the course of the field drilling. Long term monitoring of groundwater conditions is a requirement of borrow investigations. The consultant should be prepared to revisit the site several weeks or months after drilling to monitor groundwater levels.

Soil samples shall be taken of each change in soil type within a testhole. The size of samples shall be sufficient to meet laboratory testing requirements.

## 7.4 BRIDGE AND MAJOR CULVERTS

Foundation investigations for bridge and culvert structures require a high level of care and experience. It is recommended that senior personnel with relevant experience be assigned to these projects. A field visit by the Project Engineer is a prerequisite that must be completed prior to field drilling. Site conditions may be adverse at the proposed site, but favorable a short distance away. Although a bridge site may be feasible, the approach cuts into a particular valley may traverse unstable terrain, requiring costly mitigative work. The Project Engineer must have sufficient experience to identify such conditions and to bring field issues forward to the design team at an early stage.

Similar equipment and methods of sampling used for grading design are commonly used for investigating bridge approach fills and foundations. The use of rotary drilling or wireline coring may be required to retrieve intact rock samples. Insitu vane shear, pressuremeter, cone penetration, and dilatometer tests are also undertaken where results from these tests would allow better interpretation of ground conditions for design.

### 7.4.1 CORROSION SURVEY

Corrosion surveys may be required as stand-alone projects or as a component of a larger study. The following steps provide a recommended procedure for determination of the corrosive potential of the soil and water at a culvert site. Procedures for determination of time to first penetration for water-side and soil-side corrosion, and design of cathodic protection systems are not included in this section.

Procedures for field determination of pH and resistivity.

a) Take the pH and resistivity values of the soil on the road sideslope on both sides of the road, and in the upstream and downstream banks.
b) Take the pH and resistivity values of the water at the upstream and downstream ends.
c) Check for the presence of sulphide, sulphates, and chlorides.

Sufficient testing to accurately establish the corrosive nature of the soil and water in which the culvert is to located, must be carried out, the location and numbers of the readings (or samples) is to be at the discretion of the Consultant.

d) If the existing structure is a metal culvert, take static potential readings between the soil and culvert at 3, 6, 9, and 12 o'clock positions at the upstream and downstream ends. Readings shall be taken using a copper - copper sulphate half cell or approved equivalent.

The Consultant may be required to undertake all the above tasks (a to d), or partial tasks. The site-specific requirements will be as directed by the Project Sponsor with input from the Consultant.

#### 7.4.1.1 Reporting Requirements

- Provide a summary of all pH, resistivity, sulphide, sulphate, and chloride values obtained, together with the average values used for calculation purposes.
- Provide brief details of the testing methods used to obtain the values, and the significance of the results.

#### 7.4.1.2 Qualifications

A Corrosion Technologist with at least 3 years related experience is the minimum qualifications required for personnel responsible for gathering field data, testing, adjusting and servicing cathodic protection systems etc.

A Professional Engineer who has specialized in corrosion engineering is the minimum qualification required for personnel responsible for preparing reports, interpreting data, providing recommendations, and designing cathodic protection systems etc.

## 7.5 SOFT GROUND/MUSKEG

Muskeg investigations are usually undertaken as part of a grading project. Test pits using backhoes, track mounted auger drilling and probing using muskeg probes or other acceptable methods of investigating the depth and characteristics of soft soils and muskegs provide supplementary means of acquiring relevant subsurface information to assist in site evaluation and assessment.

On occasion the Consultant may consider block sampling peat deposits and subsequent laboratory strength or consolidation testing. Owing to the difficulty and cost of this procedure, the Consultant should be prepared to justify the expenditure. Insitu vane shear testing can also be used for strength estimation.

The Consultant should identify any specific construction techniques required to build on muskeg or soft ground. In addition the risk factors associated with construction and long term maintenance of the roadway over muskeg terrain should be identified. An engineering and cost/benefit analysis should justify recommendations for inclusion or removal of the muskeg or soft ground. Muskeg probe logs should be maintained and included in the report Appendix.

## 7.6 LANDSLIDE

Landslide investigations are typically a stand-alone project, however these types of investigations may also be undertaken as part of a grading design. The scope of the investigation can range from a site visit to more elaborate, costly drilling and monitoring programs. The project scope for landslide projects can be complex and time-critical. Consultants who work on these types of projects must be experienced geotechnical or geological engineers. It is recommended that senior personnel with relevant experience be assigned to oversee these projects.

A detailed airphoto interpretation shall be included in all landslide projects, in addition to a thorough review of past site information and nearby sites located in similar geologic settings. A field visit by the Project Engineer is a prerequisite that must be completed prior to field drilling. Site observations should be well documented through photographs and plan view sketches annotated with field observations. The site may be actively failing such that several visits may be required for the Project Engineer to fully comprehend and appreciate the failure mode and scale of the project. A multi-staged investigation may be required, spanning several weeks or months, depending on the level of activity at the site and the consequences of failure of the slide. The landslide geotechnical assessment is to be completed in two phases, a preliminary assessment, and a detailed design phase.

At least two feasible mitigative options shall be presented in the form of a preliminary landslide assessment. The preliminary assessment should include documentation of the investigation completed to date, the various soil parameters used, and appropriate reference sources, relevant slope stability analysis results, and current instrumentation monitoring results. The preliminary reports should identify the risk factors at the landslide site, and the associated probability of occurrence and consequence of occurrence. Relative terms such as low, medium or high may be used provided that these subjective terms are well defined. Lack of site information is considered to be a risk factor and this should be identified in the preliminary report. Large true-scale (same scale on both axes) stratigraphic cross-sections shall be included with the preliminary assessment.

The Department will undertake a review of the preliminary options and direct the Consultant to continue to detailed design of one approved option. Additional investigative, monitoring and analysis requirements may be added after the Department reviews the preliminary assessment. Any changes to the original scope of work will be negotiated.

## 7.7 EROSION

Erosion and sediment control issues are considered geotechnical issues for all projects. The Department is developing two manuals to assist in the assessment and design of erosion control measures. One manual will address issues related to long-term or permanent erosion control. Primarily consultants will use this manual. The second manual will address issues related to short-term or construction related erosion and sediment control. This will be a field manual intended for use by contractors and consultant field personnel. It will provide guidance for contractors in the development of ECO Plans and erosion control installation techniques. Both manuals are scheduled for publication in August 2002.

The consultant should determine what types of erosion and sediment control measures are suited to each particular site. The most effective means of sediment control is erosion prevention, hence the design should be directed to prevention techniques, where these techniques can be shown to offer practical and economically competitive solutions. Innovative solutions are encouraged.

Typically there may be several alternative designs appropriate for a given erosion condition. The permanent erosion control requirements shall be designed using an engineering approach based on acceptable principles of open channel flow hydraulics and soil mechanics. At least two feasible options should be prepared identifying pros and cons of each option, relative costs and associated risk factors for each option. The designs shall be supported by documentation of any design assumptions, soil and hydraulic parameters used in the analysis, method of analysis, and philosophy for selection of a given erosion control method. Erosion plans and sediment control related to wetlands and sensitive water bodies may require special design treatment stipulated by other agencies. Referrals to the appropriate agencies (e.g. Alberta Environmental Protection) shall be done at an early stage of the design.

All designs for permanent erosion control measures shall be submitted to the Project Sponsor and the Director of Geotechnical Services, TSB for review at least 3 weeks in advance of final design. The submission shall include drawings, quantities, estimated costs and design data.

## 7.8 ROCK

For projects where bedrock or boulders are encountered, e.g., shale, sandstone, large gravel or rock boulders of size 0.5 cubic metres and greater, or a combination of these materials are encountered, a “rock investigation” shall be undertaken as part of the geotechnical investigation. This rock investigation is to be conducted through rock core drilling and/or test pitting. The percent recovery and Rock Quality Designation (RQD) of cored materials is to be reported. Strength tests are to be conducted to determine classification of rock in terms of the rock classification outlined in the “Canadian Foundation Engineering Manual”. Seismic or GPR techniques may be useful in determine the bedrock horizon and in estimating the shear velocity of the rock. Shear velocity can be correlated to rippability, as noted in various equipment supplier handbooks. At this time the Department recognizes the compressive strength and point load index tests to determine classification of rock materials for pay item purposes.

For grading project a rock investigation report is required as a separate document. This report shall contain a detailed description of the investigation, test results, photographs of cores, and test pits, logs of stratigraphy, and quantity and classification of rock materials. Rock materials can be classified for payment purposes as common excavation, rock, and common excavation plus 'extra over' rock depending on the assessment from field and laboratory investigation.

## 7.9 BACKFILLING OF TEST HOLES AND RESTORATION OF TEST PITS

Test pits are considered to be large excavations. Test pits that are not properly restored may cause premature road distress. Deep excavations along the highway sideslope or ditch may destabilize the embankment. For these reasons where test pits are to be advanced in an existing roadbed or along the embankment sideslope or along the ditch at the base of the highway embankment slope; a test pit plan containing the method of excavation and backfilling test pits is required for approval by the Project Sponsor.

Test holes are to be properly backfilled in accordance with the established practices of backfilling testholes. In areas with environmental sensitivity, holes may have to be backfilled with cement grout, or other approved materials, to avoid cross contamination of aquifer zones and migration of surface waters or run-off to lower aquifers. This is especially significant at bridge sites. Each site should be treated separately and the Consultant shall provide proposed methods for backfilling the testholes for approval by the Project Sponsor.

If testholes are left open for a period of time, for the purposes of monitoring groundwater or sloughing conditions, provisions shall be made to temporarily cover and restrict access to the testhole and for permanent backfilling after the monitoring period is complete. The pavement or gravel surface is to be restored to its original condition after backfilling. Testholes that are not properly backfilled can cause injury to humans and livestock that can be a cause for litigation against the Consultant.

## 7.10 INSTRUMENTATION INSTALLATION AND MONITORING

Whenever instrumentation is required to monitor ground and groundwater conditions, an instrumentation installation and monitoring report must be prepared and submitted. A copy of the reduced monitoring data (on diskette) and analysis report must also be submitted to the Project Sponsor. Specific requirements for reporting will be developed for inclusion in the Department's "Guidelines for Consulting Geotechnical Engineers" manual, due in March 2002.

Instrumentation shall be protected from environmental hazards such as wildlife, recreational vehicles, construction traffic, maintenance vehicles, vandalism, etc. All installations should be well marked with adjacent tall lathe or sturdy posts, and labeled with permanent markings to identify the installation number, consultant and drill date. Provisions should be made to provide protective housings for instrument cables. In developed areas where vandalism is a concern, the used of locked metal protectors is recommended, especially in highly visible and well trafficked areas. Excess materials from the field program should be removed from the site and disposed of at approved dumpsites. It is unacceptable to dispose of any excess materials on site.

## 7.11 LABORATORY TESTING

Methods of undertaking laboratory testing and reporting for geotechnical purposes are outlined in ASTM and AASHTO standards with modifications for special non-standard requirements.

For grading projects, the standard laboratory testing 'suite' shall include:

i) Visual description and classification according to Unified Soils Classification System as modified by the PFRA (ASTM D2487-98).
ii) Field moisture content (ATT-15, Part I or IV as appropriate, or ASTM D2216).
iii) Atterberg limits (AASHTO Designation T89 or T90 or ASTM D4318 Method A).
iv) Washed sieve analysis, including the 5000, 1250, 400, 160, and 80 metric sieves (AASHTO Designation T88).

The following information shall also be included in these tests and form part of the summary of test:

i) Estimates of Standard Proctor maximum dry density and optimum moisture content based on the Department's tables. (Refer to the Department's Transportation Laboratory Test Procedures).
ii) Plasticity Index and Liquidity Index.

Field visual description and classification, and laboratory moisture content tests shall be conducted on all soils samples.

Additional testing may be required depending on the project requirements. Test methods for: triaxial; direct shear; consolidation; swell; dispersion; hydraulic conductivity; rock quality, durability and strength; and other advanced geotechnical testing shall follow applicable ASTM test methodologies.

## 7.12 GEOSYNTHETIC AND EROSION CONTROL MATERIALS

The need for geosynthetics and erosion control materials must be supported by an analysis and design. Specifications for geosynthetic materials shall reference material properties that are appropriate for the design use intended. The use of ‘generic’ or ‘all-purpose’ specifications is considered appropriate only when these specifications address the analysis and design requirements of the project. Where judgment is used in selecting materials, reasons must be provided to show the practical, as well as economic, benefits of such material usage.

## 7.13 BOREHOLE DATA REPORTING

Reporting of test hole logs shall be done through a geotechnical borehole database system, such as GCA gINT software (Geotechnical Computer Application), or an acceptable end product equivalent. A Department customized template for gINT is available (free of charge) on the gINT website (http://www.gcagint.com/reports.htm). An electronic copy of all borehole logs shall be submitted to the Project Sponsor.

## 7.14 PRESENTATION OF SOILS AND ROCK INFORMATION ON MOSAICS

Soil descriptions on the mosaics are to consist of the principal soil types. Where rock or rock type materials are encountered, only the field visual descriptions must be shown on the mosaic logs with the corresponding graphic symbol. The results of the identified rock test will normally be made available to bidders. The gINT utility program facilitates conversion of standard testhole logs to a format appropriate for presentation on mosaics. (Reference: Drafting Guidelines (CB 4)).

## 7.15 REPORTING REQUIREMENTS

Where applicable, geotechnical conceptual requirements for planning, design, construction and maintenance shall be submitted for discussion and evaluation at an early stage of the project life cycle. Content requirements for geotechnical reports are outlined in Table A and preceding subsection.

The methods for field work, laboratory work, preparation and submission of reports must be well defined and compatible with the overall design and synchronize with the project schedule. The geotechnical report must accompany the design when submitted for review. The grading or bridge design shall have the soils logs and the proposed erosion and sediment control schemes included. Refer to Section 7.7 for reporting requirements for permanent erosion control measures. Depending on the nature of the project, some of this information may be needed at the concept engineering stage, if acceptance of concepts is required.

The Consultant shall provide two copies of the report to the Project Sponsor, unless otherwise directed.

The final project report must include a section or sections on the geotechnical issues identified in the earlier design stages, and how these were treated during construction. As-Constructed drawings must be provided (in microstation .dgn format) and any variations of methods, etc., outlined. Comments, notes and recommendation provided to the Project Manager should be included in the construction completion report.

### 7.15.1 DIFFERING SITE CONDITIONS (DSC) CLAUSES

Subsurface conditions are a result of natural geologic processes modified over time by natural events or the actions of man. Geotechnical investigations are undertaken to provide subsurface information to the designer and contractor. However, unanticipated ground conditions can and do occur. Contractors will be paid based on the terms of their contract. This may involve changes in compensation where unforeseen conditions are encountered. Nothing can completely remove the risk of encountering a differing site condition. However the potential for costly disputes over what constitutes differing site conditions is greatly reduced through a well-defined geotechnical baseline. To this end full disclosure of the geotechnical investigation report will be available to contractors at the tender stage. The Consultant therefore is responsible for ultimately setting the geotechnical baseline through the accuracy and factual representations of their work and to the contract conditions and specifications developed through the recommendations contained in the report.

Geotechnical reports are composed of factual, interpreted and qualified information. It is preferable to include all geotechnical information in the contract documents, however a stand alone geotechnical report can be referenced in the contract documents and made available at a prescribed time and location for inspection by the bidders. Factual information includes testhole logs, field and lab test results and the like. Interpreted information represents the opinions of a qualified geotechnical engineer based on the factual information. This should describe the thought process that led to the design, specifications and special provisions included on the plans and in the contract documents. Qualified information is factual information where the source of the data was not under direct control of the geotechnical design staff. Historical construction records, previous geotechnical reports and the like are examples of qualified information.

There are two principle types of DSC claims. A Type I DSC refers to subsurface or latent physical conditions at the site, including surface conditions, that differ materially from those indicated in the contract. Type I DSC is usually related to the factual information presented in the contract. A Type II DSC refers to unknown physical conditions at the site of an unusual nature differing from those ordinarily encountered and generally recognized as to be inherent in work of the character provided for in the contract. Type II DSC is usually related to the interpreted information presented in the contract. Both types of DSC can be greatly reduced through the establishment of a well defined geotechnical baseline with which to compare the encountered site conditions and the predicted or interpreted site conditions. To this end the Consultant should be neither overly optimistic about site conditions nor overly pessimistic, but should rely on a rational and objective approach to interpretation of the site conditions.

Specific disclaimer clauses can be used as plan notes to define factual and interpreted information, particularly in the case of bridge and culvert projects. This is preferred to the inclusion of blanket or general disclaimer. An example of a specific clause might be: "The testhole logs for TH100 to TH110 are representative of the condition at the location where each boring was made but conditions may vary between testholes." This note indicates that the Consultant has used proper drilling techniques to locate, drill and log the testholes shown on the plans and documents. Soil conditions encountered at the location of the testholes that differ materially from those stated on the logs form the basis of a Type I DSC. Soil conditions between boreholes that differ substantially from those noted at the testhole locations, or that could not have been reasonably interpreted from the drilling logs, or that are unknown in the region would form the basis of a Type II DSC.

## Current References for Section 7:

American Association for State Highway and Transportation Officials (AASHTO) – Provisional Standards and Volume II Test, 1995, AASHTO.

American Society for Testing Materials (ASTM) Specifications, 1996, ASTM.

Canadian Foundation Engineering Manual, 3rd Edition, Canadian Geotechnical Society.

Canadian System of Soil Classification, 1987, Agriculture Canada.

Drafting Guidelines (CB-4), July 1995, Alberta Transportation.

Erosion Control Reference Material, Updated Draft, May 2001, Alberta Transportation.

Guidelines for Consulting Geotechnical Engineers and Technologists Assignments, May 1998, Alberta Transportation.

Transportation Laboratory Test Procedures, 2000, Alberta Transportation.

*This page left blank intentionally.*