5.0 FOUNDATIONS

5.1 General

In general, the foundation for a water control structure, whether consisting of insitu or earth fill materials, should have adequate strength to resist sliding, sufficient bearing capacity to prevent excessive settlements, and adequate measures to control seepage and prevent piping. The susceptibility of the foundation to swelling, frost action, and weathering should also be considered.

In addition, slopes flanking the structure should be designed to be stable, particularly where failure of these slopes would result in excessive damage or loss of the structure, or blockage, and where the structure is not easily accessible.

5.2 Site Characterization

A geotechnical characterization of the project site and, specifically, of the structure locations is normally prepared using geological information, air photos and contour mapping, observations made during the field investigation program including monitoring data from instruments, and the results of laboratory testing.

During this process, particular importance should be given to identifying possible adverse conditions such as the existence of potentially weak, continuous beds of slickensided claystone or clay shale materials that are prevalent in Alberta; bentonitic clays, highly plastic clays, and swelling soils/rock; dispersive clays; pervious zones; and liquefiable foundation materials.

The site characterization should provide definitive information concerning the geological setting and stratigraphy of the site, permeability and groundwater conditions, geotechnical characteristics and properties of the soil and rock materials, and the foundation design parameters and seepage control design factors for the water control structure.

5.3 Foundation Considerations

5.3.1 Deformations

Deformations may include:

- Immediate rebound vertically and along any weak seams, due to unloading caused by excavations.
- Time dependent swelling due to unloading caused by excavations.
- Immediate and time dependent settlements including longitudinal movements (spreading), and/or lateral movements due to the structure and backfill loads.

- Time dependent heave or settlement/shrinkage due to a change in the groundwater regime.
- Time dependent and cyclic heave/settlement due to freeze/thaw action.
- Earthquake-induced deformations.

Of particular importance in the design of a structure are the long-term differential movements that may occur between components rather than the total movements.

Possible measures that can be employed to reduce the long-term differential movements include:

- Site selection to minimize the variability of the foundation conditions under the structure.
- Reducing rebound by keeping excavations to a minimum. This should include following the existing contours as much as possible.
- Allowing rebound and swelling to occur prior to constructing the structure or component thereof.
- Sequencing construction to allow settlement to occur in a predetermined manner.
- Preconsolidation measures including preloading.
- Subcutting of soft or compressible materials and replacement with compacted granular materials or concrete.
- Providing a granular drainage blanket to prevent frost penetration.
- Employing mitigative measures to reduce the potential for liquefaction to occur.

5.3.2 Bedrock Shear Strength

The shear strength of bedrock is generally comprised of the cross bedding and the bedding plane components.

In general, once the characteristics and properties of the material are known and the rock has been classified, design values for the shear strength may be derived by using empirical correlations, making comparisons with other case histories with similar bedrock formations, performing stability analysis of existing slopes and failed slopes, and by conducting laboratory tests.

As noted in Section 5.2, special attention should be given to siltstones and claystone and clay shale materials. These materials have been known to have shear strengths that approach residual values. Design values for residual shear strengths may be derived using the methods noted in the previous paragraph.

Laboratory tests to determine the lowest possible shear strengths normally consist of direct shear tests of pre-cut, pre-polished shearing planes. Current practice for estimating the "design" residual shear strength from laboratory results is to include an allowance to account for the influence of any surface asperities, waviness, and roughness along the potential insitu shear plane when compared to the laboratory prepared sample. Depending on the actual conditions of the insitu shear plane, an allowance ranging between 1.5° and 2.5° may be added to the laboratory value to provide an estimate of the potential "design" residual shear strength. Shear strength estimates derived from laboratory tests should be assessed in conjunction with estimates derived from the other previously noted methods in order to determine the most appropriate residual shear strength that should be adopted for the design.

5.3.3 Soil Shear Strength

In general, once the characteristics and properties of the material are known and the soil has been classified, design values for the shear strength may be derived by using empirical correlations, making comparisons with other case histories with similar materials, analysis of existing and failed slopes at the site, and by conducting laboratory tests.

5.3.4 Rock Quality and Weathering Characteristics

For rock foundations, the rock quality including the degree of fracturing, and the potential for rapid deterioration upon exposure, especially with claystones, mudstones, and siltstones, may need to be assessed.

The Rock Mass Rating (RMR) developed by Bieniawski (1976, 1978) may be used to classify the condition of the rock mass. Slaking tests can be used to evaluate the resistance of rock materials to weathering.

In cases where rapid deterioration is a concern, protective measures, such as shotcrete, foundation concrete, or backfill materials, installed within a specific time after exposure of the foundation may be warranted.

5.3.5 Overbreak During Rock Excavation

For foundations involving large quantities of rock, the amount of overbreak that may occur during foundation excavation, especially where blasting is anticipated, should be estimated in order to assess the potential implications on the proposed design and the impacts on quantities and costs. Methods that can be used to evaluate overbreak include reviewing joint spacing and patterns in the rock; mapping rock exposures, reviewing relevant case histories, and, where appropriate, conducting test blast sections.

5.3.6 Groundwater Conditions

The existing groundwater conditions should be determined as part of the geotechnical site characterization. This information is required to assess the existing and post construction phreatic and seepage conditions, identify any site-specific construction dewatering requirements, and determine long-term drainage requirements.

5.3.7 Frost Penetration

The depth of frost penetration for a particular location and installation condition can be estimated using a heat transfer model such as THERM1. Input data consist of freezing index information for the site, and the thermal properties of the various materials.

Typical thermal properties for various soil, rock, construction and insulating materials are available from published literature such as USACE CRREL 82-8, Mellor (1973), ACI (2000), ASHRAE (1993), and manufacturer's product data. The thermal conductivity for some materials can be significantly affected by its porosity and moisture content; consequently, care is required in determining an appropriate thermal conductivity value.