Technical Circular T-04/17
Date March 22, 2017

To: **All Engineering Directors**
All Regional Directors
All HQ Directors: Operations, Planning and Major Projects
All District Managers Transportation

Subject: **Geotechnical Design Criteria**

Purpose:

To provide guidance on the criteria to be used in geotechnical evaluation and design of all Ministry works.

Background:

A formal approach to document the Ministry Geotechnical Design Criteria is needed to provide for consistent application of the criteria across Ministry projects.

The roles of designers involved with the design, design coordination and field reviews shall be done in accordance with BC MoTI Technical Circular T-06/09 "Engineer of Record and Field Review Guidelines".

http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/technical-circulars/2009/t06-09.pdf

The use of "consented to by the Ministry" shall mean consented to by the Ministry engineer who has the authority, responsibility and technical expertise to provide consent.

Climate Change:

Given the potential for climate change to impact geotechnical design in BC MOTI Technical Circular T-06/15 "Climate Change and Extreme Weather Event Preparedness and Resilience in Engineering Infrastructure Design shall apply to all assignments".

http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/technical-circulars/2015/t06-15.pdf

Design Criteria:

Construction procedures and methodology should be consistent with the current version of the Standard Specifications for Highway Construction.

http://www2.gov.bc.ca/gov/content/transportation/transportation-infrastructure/engineering-standards-guidelines/standard-specifications-for-highway-construction

1.0 Soil Slope and Embankment Design

Soil slope and embankment global stability shall be designed to meet the values in Table 6.2b (Resistance Factors, Consequence Factors and Factors of Safety for Global Stability of Embankments) in the MoTI Supplement to CHBDC S6-14 (MoTI SUPPLEMENT). The Ministry will work with designers to define factors of safety appropriate to unusual geotechnical conditions (ex. drawdown).

http://www2.gov.bc.ca/gov/content/transportation/transportation-infrastructure/engineering-standards-guidelines/structural/standards-procedures/volume-1

The designer will provide an economic cut/fill slope design including any support measures that may be necessary to achieve stability for the design life of the project.

Strengthened earthworks will mean material other than intact bedrock, either placed or in situ, which has been improved by tensile reinforcement acting through interface friction, bearing or other means (such as reinforced soil or soil nailing) or by external support such as gabions, where the slope face is less than 70 degrees to the horizontal. Reinforced soil slopes shall be designed in accordance with FHWA-NHI-10-024 and FHWA-NHI-025 "Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Volume 1 & Volume 2" November 2009. Where the slope face is greater than 70 degrees, the design will be in accordance with criteria specified for retaining walls, see Section 5.0.

2.0 Rock Slope Design

The rock cut design shall include stability analyses, an economical cut slope, ditch design for rockfall containment and provide recommendations for any stabilization measures necessary to optimize the stability and rockfall control for the design life of the project.

For strong rock masses where potential failure mechanisms are structurally controlled, kinematic stability analysis shall be performed. Limit Equilibrium Stability analysis shall be performed on dominant kinematcially possible failure mechanisms to determine support requirements to achieve the minimum Factors of Safety in Table 6.2b in the MoTI SUPPLEMENT.

For weak rock masses where rock mass strength governs stability and it is not structurally controlled, Limit Equilibrium Stability analysis shall be performed to ensure new rock cuts achieve the Factors of Safety in Table 6.2b in the MoTI SUPPLEMENT.

For rock masses which may border on weak or strong, the designer shall perform both analyses.

Ditches below rock cuts should be designed in consideration of the geometric criteria proposed for the project and achieve a minimum 85% retention rate for potential rockfall. For high traffic volumes areas or sites with potential higher frequency rockfall activity, higher retention rates should be considered if cost effective to do so.

The ditch design needs to consider rockfall volume, particle sizes and the potential for rockfall hazards originating from above new cut slopes. Mitigation measures for rockfall hazards originating from slopes above the design rock cut shall be considered and incorporated into the design as consented to by the Ministry.

Rock cut designs shall include a practical ditch design based on geometric criteria proposed for the project. Recommendations for the rock cut at the detailed design stage shall be based on a site specific investigation and will take priority over the requirements outlined in Technical Bulletin GM2001 Rock Slope Design.

The following references should be consulted when developing ditch design:

- BC Supplement to TAC Geometric Design Guide, Figure 440.H

  http://www2.gov.bc.ca/gov/content/transportation/transportation-infrastructure/engineering-standards-guidelines/highway-design-survey/tac-bc

- MoTI Technical Bulletin GM02001 Rock Slope Design

  http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/technical-bulletins/geotechnical-materials-and-pavement/tb_gm02001_rock_slope_design.pdf

- Oregon Department of Transportation (ODOT) - Rockfall Catchment Area Design Guide - Final Report SPR-3(032), Metric Edition, 2001

  http://www.oregon.gov/ODOT/TD/TP_RES/ResearchReports/RokfallCatchAreaDesMetric.pdf

- Ritchie (1963) Ritchie, A.M., 1963. The evaluation of rock fall and its control. Highway Record. Vol 17.

ML/ARD evaluations shall be completed in accordance with BC MoTI Technical Circular T-04/13 "Evaluating the Potential for Acid Rock Drainage and Metal Leaching at Quarries, Rock Cut Sites and from Stockpiled Rock or Talus Materials used by the MoTI."

http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/technical-circulars/2013/t04-13.pdf

3.0 Foundation Design

Both shallow and deep foundation design shall be completed using Limit States Design procedures as outlined in the MOTI SUPPLEMENT, and CSA CHBDC S6-14.

http://www2.gov.bc.ca/gov/content/transportation/transportation-infrastructure/engineering-standards-guidelines/structural/standards-procedures/volume-1

http://www2.gov.bc.ca/gov/content/transportation/transportation-infrastructure/engineering-standards-guidelines/structural

4.0 Settlement Analysis

Settlement analysis of pre-existing and new structures/embankments shall be performed in accordance with the MOTI SUPPLEMENT, and CSA CHBDC S6-14. Foundations will be designed such that differential settlements are limited to tolerable amounts as specified by the structural design, geometric design and utility considerations. Settlement analysis must consider and separately tabulate expected static settlement and any seismic induced settlement under the specified earthquake loading conditions. Seismic performance criteria are provided for slopes and embankments in the MoTI SUPPLEMENT.

Embankment settlement will be predicted and appropriate means to minimize impacts, such as preloading, surcharging, use of lightweight fills and special construction requirements, will be evaluated.

The use of lightweight fills shall be in accordance with the MoTI SUPPLEMENT.

5.0 Retaining Wall Design

Slope angles steeper than 70 degrees shall be designed as retaining walls. Retaining wall designs must follow the methods outlined in the MOTI SUPPLEMENT, and CSA CHBDC S6-14. Items not covered shall be designed in accordance with AASHTO "LFRD Bridge Design Specifications", 7th Edition, 2014 (including interim revisions) and FHWA-NHI-10-024 and FHWA-NHI-025 "Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Volume 1 & Volume 2" November 2009.

For the design life of components, wherever there are time dependent calculations, use 100 years. Examples would be for corrosion and creep calculations.

Soil nailed walls shall be designed in accordance with FHWA-NHI-14-007 "Soil Nail Walls Reference Manual" February 2015.

https://www.fhwa.dot.gov/engineering/geotech/pubs/nhi14007.pdf

Retaining wall types shall meet the durability requirements and aesthetic requirements specified for the project and shall be subject to the consent of the Ministry.

Wall heights, proprietary wall systems and geosynthetic materials are restricted to those shown in the BC Ministry of Transportation Recognized Products Book under "R" on the website:

http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/recognized-products-list/recognized_products_list.pdf

6.0 Seismic Design

Performance levels to be used for the seismic design of new and existing structures are defined in the MoTI SUPPLEMENT, and CSA CHBDC S6-14.

The Ministry may provide the acceleration time histories for site specific numerical analyses of site response and soil-structure interaction. If the project does not supply this information, a site specific seismic hazard value can be obtained from the Geological Survey of Canada at the following website:

http://www.earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/index_2015-en.php

Time history input motions used in the design are subject to the consent of the Ministry. Time histories developed shall be provided to the Ministry.

Liquefaction potential of foundation soils shall be evaluated for structures, retaining walls and embankments as per MoTI SUPPLEMENT and CSA CHBDC S6-14.

ATC-49 provides guidance in determining performance limits for pile foundations.

Factor of safety for pseudo static analysis shall be 1.1.

Seismic design for the stability of retaining walls, slopes and embankments will be done in accordance with the MoTI SUPPLEMENT, and CSA CHBDC S6-14. The new or modified retaining walls, slopes and embankments shall be designed based on the performance criteria described in Section 4.4.6.4 of the MoTI SUPPLEMENT.

In Ministry Service Areas 21 and 22 (South Peace and North Peace), the induced earthquake hazard should be considered in the design. The seismic response spectra from fracking and the methodology for the design should be as consented to by the Ministry.

7.0 Pavement Structure Design

Pavement structures shall be designed as outlined in BC MoTI Technical Circular T-01/15 "Pavement Structure Design Guidelines".

http://www2.gov.bc.ca/assets/gov/driving-and-transportation/transportation-infrastructure/engineering-standards-and-guidelines/technical-circulars/2015/t01-15.pdf

New roadway pavement structure designs shall be conducted using either i) AASHTO 1993 Guide for the Design of Pavement Structures or ii) AASHTO (2004) ME Pavement (Mechanistic Empirical Pavement Design Method Guide).

Traffic information needs to be analyzed correctly to ensure ESAL's are calculated close to expectations. Ministry traffic data is typically available online from the Traffic Data Program website: www.th.gov.bc.ca/trafficData/index.html. The Equivalent Single Axle Loads (ESALs) for various truck configurations are determined based on the Transportation Association of Canada (TAC) Vehicle and Weights Dimension Study.

Design Variance:

A variance from these design criteria may be requested from the individual acting in the position of the Chief Engineer of the BC Ministry of Transportation.

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