15 August 2018 Reference No. 18105909-001-L-Rev0

Keith Nyhof, Landscape Architect
BENCH Site Design Inc.
4-1562 Water Street
Kelowna, BC V1Y1J7

GEOTECHNICAL ENGINEERING INPUT FOR MSE RETAINING WALL DESIGN – GIANT'S HEAD MOUNTAIN TRAIL, SUMMERLAND, BC

Dear Mr. Nyhof:

1.0 INTRODUCTION

As requested by BENCH Site Design Inc. (BENCH), Golder Associates Ltd. (Golder) has prepared this letter to provide geotechnical engineering recommendations in support of the design of a proposed 2.0 to 4.35-metre tall Mechanically Stabilized Earth (MSE) wall at the Giant's Head Mountain Trail in Summerland, BC. We understand that BENCH will be preparing the retaining wall design drawings based on our input.

The scope of work included a site visit to examine the current site conditions and surficial geology of the site, and a geotechnical wall stability analysis to provide design and construction recommendations for the proposed MSE wall. These geotechnical engineering services were carried out in accordance with the scope of work outlined in Golder Proposal No. P18105909-001-P-Rev0.

This document should be read in conjunction with the attached *"Important Information and Limitations of this Report"*. The reader's attention is specially drawn to this information, as it is essential for the proper use and interpretation of this document.

2.0 SITE VISIT

A site visit was carried out on 27 July 2018 by a member of Golder's geotechnical staff. The purpose of the visit was to examine the current conditions of the site, identify surficial soil and bedrock, and measure existing slopes and embankments for use in the subsequent wall stability analysis.

The following observations were made during the site visit:

- The site is located at the entrance to Giants Head Park Road from Milne Road in Summerland, BC. Giants Head Park Road is currently closed to the public. The roadway is paved and approximately 3.0 metres wide.

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- There is a 4.0 to 5.0-metre high embankment between Giants Head Park Road and the carpark on Milne Road. The slope of the embankment is approximately 15° and steepens to between 30° and 40° toward the carpark. The slope is moderately to heavily vegetated with bushes and some pine trees. A 1.0-metre wide walking trail cuts across the slope from roughly east to west.
- The surficial soil across the embankment was identified as fill material comprising gravelly sand with some fines. A number of boulders were observed across the slope (maximum diameter of approximately 1.2 metres) which have likely originated from the rock outcrops above Giants Head Park Road.
- The slope above Giants Head Road is approximately 20 metres in height and comprise two sections: a lower and upper section. The slope of the lower section ranges from 20° to 30° and is moderately vegetated with grasses and some large trees and bushes. The surficial soils comprise natural gravelly silts and sands with cobbles and boulders. The upper section of the slope comprises bedrock outcrops and ranges from approximately 45° to near-vertical at the top of the slope. The bedrock is volcanic in origin.

3.0 BACKGROUND INFORMATION

3.1 Golder Library

A background study was carried out using Golder's internal geotechnical library. A hydrogeological investigation was carried out by Golder in August 1980, which included drilling one borehole at the bottom of Giants Head Park Road.

According to the borehole log, the subsurface profile comprises approximately 4.0 metres of native, loose to compact sandy silt with gravel, cobbles and boulders, overlying moderately-hard volcanic rock to a maximum investigation depth of 91.5 metres below ground surface (mbgs).

Due to the site's proximity to the base of the slope, Golder anticipates that a layer of loose colluvial material may also be present overlying the native sandy silt.

3.2 Information Provided by BENCH

The following information was provided to Golder by BENCH to assist the wall stability analysis:

- Preliminary Construction Drawings (90%) for Giant's Head Trail Design Phase 1 & 2 dated 20 July 2018
- Cost Estimate for Giant's Head Trail Design Phase 1 & 2 dated 20 July 2018
- Supplementary Specifications for Giant's Head Trail Design Phase 1 & 2 dated 20 July 2018
- Construction Drawings (100%) for Giant's Head Trail Design Phase 1 & 2 Gabion Wall Coordination (Drawing No. L-2.0 and L-5.4) dated 26 July 2018
- CAD files including survey data of the existing slopes
- Photos of the existing site conditions dated 27 July 2018

Following Golders request for expected live load values, in an email from Keith Nyhof received on 27 July 2018, it was advised that the existing road allows for a maximum live load of 1-tonne truck. This load has been considered in the wall stability analysis.

3.3 Proposed MSE Wall

According to the construction drawings provided by BENCH, the proposed MSE wall will be positioned parallel to Milne Road along the top of the existing carpark. The wall is to comprise 457 x 457 x 3048-millimetre SierraScape facing units with a total height of between 2.0 and 4.35 metres. Facing units will include LD2 locking tail struts and will be infilled with 101 to 152 millimetre-diameter cobble rock as per MMCD specifications. The area at the base of the wall will be leveled and finished with specified subgrade and compacted aggregate.

We understand that geotechnical input is required for the following aspects of the design:

- Length, type and frequency of geogrid reinforcement
- Subgrade preparation
- Suitable reinforced fill material
- Construction specifications and quality assurance requirements

Comments and recommendations for these aspects are provided in Section 5.0 of this document.

4.0 GEOTECHNICAL WALL STABILITY ANALYSIS

Golder conducted an internal and global (external) stability analysis for a representative section of the tallest portion of the proposed MSE wall taking into consideration the information collected above. The analysis was conducted in general accordance with the National Concrete Masonry Association (NCMA) methodology for the design of MSE structures using the limit equilibrium approach.

The internal and global stability of the wall was assessed for both static and seismic conditions by calculating the factors of safety for a representative wall section. The factor of safety (FOS) represents the ratio between forces driving slope movement and the forces resisting slope movement where a FOS of 1 indicates these forces are balanced. The proposed wall was designed to a minimum FOS of 1.5 for static conditions and 1.1 for seismic conditions in accordance with the current state of geotechnical practice.

4.1 Internal Stability Analysis

Golder conducted an internal stability analysis using the SRWall software developed by the National Concrete Masonry Association. The internal stability analysis was used to determine the strength, spacing and minimum length of geosynthetic reinforcement layers required to support the self-weight and seismic loads of the reinforced mass and surcharge load applied to it. A maximum vehicle surcharge load equivalent to fire truck was considered for this analysis. The internal stability design considers the long-term tensile strength of the geosynthetic and its resistance to sliding over and pulling out of the soil. The design intent is to confirm that the reinforced mass will act as a monolithic block that has a suitable factor of safety against internal shear failure (Tensar Earth Technologies, 2004).

The internal stability analysis was carried out using dimensions and specifications from the construction drawings provided by BENCH. The results of the internal stability analysis provided a factor of safety (FOS) of 2.5 for sliding, 5.2 for overturning and 4.2 for bearing capacity of the proposed MSE wall. A seismic analysis was also carried out which provided FOS values above the specified design criteria.

4.2 Global Stability Analysis

Golder analyzed the static and seismic behavior of the proposed wall using the Slope/W software (Version 9.0) developed by GeoStudio International Ltd. The Morgenstern-Price method was applied to all models. The global stability analysis was used to examine the stability of the monolithic block under the gravity, seismic and surcharge loads applied to it, as well as the bearing capacity available from the foundation soils (Tensar Earth Technologies, 2004). A maximum vehicle surcharge load equivalent to a fire truck was considered for this analysis.

The global stability analysis was carried out using dimensions and specifications from the construction drawings provided by BENCH. The results of the global stability analysis provided a FOS of above 1.6 for the static analysis and a FOS of above 1.2 for the seismic analysis for the proposed MSE wall.

5.0 COMMENTS AND RECOMMENDATIONS

Based on the results of Golder's site visit, background study and wall stability analysis, the following comments and recommendations have been made for the design and construction of the proposed MSE wall.

5.1 Site Preparation

Based on the surficial geology observed during our site visit and a review of nearby subsurface geotechnical investigation data available in Golder's internal library, Golder anticipates that the subgrade consists of a nominal layer of topsoil overlying approximately 4.0 metres of native sandy silt overlying volcanic bedrock. Due to the site's proximity to the base of the slope, a layer of loose colluvial material may also be present overlying the native sandy silt.

The subgrade along the proposed wall alignment must be stripped of all vegetation, surficial organic soils, loose colluvium and/or fill material under the full-time supervision of a member of Golder's geotechnical team. The stripped subgrade shall be proof rolled using a vibratory compactor to confirm that no soft or spongy areas are present.

5.2 Frost Protection

Environment Canada's Climate Normals data for Penticton Airport indicate that the area has a freezing index of 201 degree-days Celsius. Based on the freezing index the MSE wall should be provided with 750mm of soil cover for frost protection.

5.3 Leveling Pad

The leveling pad shall consist of a minimum of a 150mm layer of 19mm minus well-graded crushed base course material (as per MMCD) compacted to 95% of ASTM D1557 modified proctor dry density. Leveling pad shall extend no less than 150 mm laterally on each side of the wall.

5.4 Geo-Composite Reinforcement

Primary reinforcement shall consist of Tensar UX1400 uniaxial geogrid or approved equivalent. Secondary reinforcement shall consist of Tensar BX1100 biaxial geogrid or approved equivalent.

Primary reinforcement shall have a length of 4 m measure from the face of the wall. Secondary reinforcement shall have a length of 1 m measured from the face of the wall.

Primary and secondary reinforcement shall be installed on alternating wall courses with primary reinforcement beginning on top of the first course of MSE wall units.

5.5 Structural Fill

Structural grade fill shall consist of well graded 150 mm minus pit run sand and gravel having less than eight percent fines passing the 0.075 mm sieve size. Structural grade fill shall be placed in horizontal lifts not exceeding 300 mm in loose thickness and should be compacted to 95% of ASTM D1557 modified proctor dry density.

5.6 Toe Drain

A 100 mm perforated PVC drain shall be installed at the toe of the retaining wall. The drain shall be fully encapsulated in washed 19 mm drain rock wrapped in Nilex 4551 geotextile cloth. The toe drain shall be positively sloped towards an appropriate water discharge area to be determined by others and approved by Golder.

5.7 Construction Requirements and Quality Assurance

Surface water management at the crest of the excavation shall be implemented as required in order to direct surface water away from the back of the wall at all times.

Foundation preparation should be carried out as per Section 2.1 and Golder are to observe proof rolls prior to subgrade placement.

Golder are to carry out density tests during placement and compaction of 19mm minus crush layer as required.

Gradation analysis shall be conducted by Golder on structural backfill material prior to placement and upon request of Golder.

During placement and compaction of fill to the top of the MSE units, lift thickness should not exceed 300 mm. Golder is to conduct density tests on each lift of fill unless otherwise determined by a geotechnical engineer of record.

Placement of geogrid is to be carried out as per Section 2.4. Golder are to observe and measure each course of geogrid to confirm conformance to design. Geogrid should be tensioned prior to placement of additional loose lift. Placement of additional course should be staggered horizontally by half a block-size.

Inspection and testing of material carried out by Golder should be repeated until the construction phase is complete.

6.0 CLOSURE

We trust the forgoing is sufficient for your current needs. Once BENCH has completed the issued for-construction wall drawing set as per the design requirements outlined in this technical memorandum, Golder sign the drawings to take responsibility for the geotechnical aspects of the retaining wall design.

Please do not hesitate to contact the undersigned should you have any questions or concerns.

Yours truly,

Golder Associates Ltd.

Carlin Horkoff, PEng
Junior Geotechnical Engineer

Reviewed By:

Glen Rutherford, PEng
Associate, Senior Geotechnical Engineer

CH/GR/syd

Attachments: *Important Information and Limitations of this Report*

https://golderassociates.sharepoint.com/sites/30274g/deliverables/issued to client_reserved for wp/18105909-001-l-rev0/18105909-001-l-rev0-giant's head trail design-15aug_18.docx

Important Information and Limitations of this Report

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.