

7.6.2 Slope Stability Evaluation

A slope stability evaluation was carried out using commercially available limit equilibrium based software called SLOPE/W (GEO-SLOPE, 2007). The analysis included the effect of dynamic loading due to traffic by considering an equivalent static load equivalent to 0.8 m of additional fill, as per Section 6.9.5 of the CHBDC. The analyses also considered seismic loading using one-half of the ZAR.

Slope stability analysis results for two embankment fill materials (Select Subgrade Material and Earth Borrow) under traffic loads are presented in Figures 9 and 10 in Appendix D. A 2H:1V slope is required for embankments constructed of Select Subgrade Material (SSM) while a 2.5H:1V slope is required for embankments constructed of Earth Borrow. Figures 11 and 12 provide the results under simultaneous seismic and traffic loads.

The slope stability evaluation results indicate that the failure planes generally tend to be relatively shallow (veneer type of failure). The beneficial effects of any vegetation on the slope and the apparent cohesion of granular material were disregarded in carrying out the slope stability evaluation. The actual factor of safety against shallow failure planes is anticipated to be greater than that presented herein.

7.6.3 Evaluation of Potential Ground Settlement due to Approach Embankment

Settlement of the underlying soil due to the proposed approach embankment was evaluated. The following assumptions were made in evaluating the settlement of the site soil under the proposed approach embankments:

- Typical soil profile given Table 6.1 was considered representative;
- The load from the bridge abutments will be transferred to deeper and more competent strata by the piles (other than that by the centre pier) and hence does not contribute to the settlement of the site soil;
- Only immediate (elastic) settlement was considered due to the presence of non-cohesive soils;
- A Poisson's ratio of 0.35 was used for all soil types;
- The existing grade is at approximate elevation of 330.0 m;
- Groundwater is at elevation of 326.0 m (approximately 4.0 m below the existing ground surface);
- The maximum embankment height is approximately 8.2 m (in the immediate vicinity of the bridge abutment);
- Embankment extends approximately 250 m east and west from the abutments;
- The top width of the embankment is 30.0 m;
- The distance between the abutments is approximately 67 m; and
- The pier footing is approximately 4.0 m wide by 30.0 m long.

Evaluation of soil settlement due to the effects discussed above was performed using a computer program called Settle3D (Rocscience, 2009). It is a three-dimensional computer program for the analysis of the immediate vertical settlement and consolidation of soil under surface loads such as embankments. Settlement evaluation was carried out for embankments

constructed using Select Subgrade Material (SSM) with 2H:1V slopes and using Earth Borrow with 2.5H:1V slopes.

The analysis result indicates that for the conditions presented herein, the maximum total vertical settlement of the existing materials is approximately 50 and 45 mm, respectively, under SSM and Earth Borrow embankments. The maximum settlement will take place approximately 20 m back from each abutment. This settlement will take place rapidly and is expected to be completed during construction of the embankment. Plots of settlement contours from typical Settle3D analysis are given in Figures 13 and 14 in Appendix D.

The settlement beneath the abutment centerline which will be caused by the 8.2 m high SSM embankment was evaluated to be 38 mm; a profile of settlement versus depth below original grade (elevation 330.0 m) for this location is provided on Figure 15 in Appendix D. Due to the anticipated settlements, the following was considered.

- Assuming that the piles are driven prior to construction of the embankment, the drag loads of each integral abutment pile would be in the order of 500 kN unfactored and 625 kN at ULS. The dead loads associated with the superstructure and substructure are understood to be 1280 kN per pile at ULS. For HP310x110 piles, the combined drag loads and dead loads per pile are not expected to exceed the structural capacity of the piles. Therefore, embankment staging to minimize drag loads is not required.
- Upon completion of the pile installations and construction of the portion of approach embankment below the elevation corresponding to the underside of the abutment walls, it is anticipated that settlements of less than 12 mm would be induced by the construction of the remaining embankment height. Therefore there will be no special staging requirements.

It is noted that there will also be a minor amount of self-weight settlement of the embankment fill. This self-weight settlement was estimated using charts provided by Poulos and Davis (1974) for embankments having similar geometries to the SSM and Earth Borrow embankments presented herein. The estimated self-weight settlement was approximately 20 mm and 30 mm, respectively, for the SSM and Earth Borrow embankment fills. This settlement is also expected to be completed by the end of construction.

No settlement monitoring will be required for this project.

7.7 FROST PROTECTION

The design frost penetration depth for foundations at the site is 1.4 m based on OPSD 3090.101. Spread footings should be provided with 1.4 m of earth cover or equivalent insulation for frost protection.

The minimum soil cover to the underside of the levelling pad for RSS is the greater of 800 mm and 40% of the actual frost penetration depth. In this case, 800 mm is the greater of the two values and therefore, the minimum frost penetration depth for RSS.

Where construction is undertaken during winter, footing subgrades must be protected from freezing. Due diligence is required to ensure that granular fill materials do not include frozen material, snow or ice.