

MEMORANDUM



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Project Soils Engineer
Central Region Geotechnical Section

27 August 2012

From: Pavements and Foundations Section
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Re: WO: 2012 – 11037

Assessment and remedial measure recommendations for slope instabilities at east side of the north approach at QEW/Ridgemount Rd Underpass, Welland, Ontario

MERO Pavements and Foundations Section was requested by Central Region (CR) Geotechnical Section and Maintenance to assess the above-noted site and to provide recommendations for the slope instabilities.

Area Map

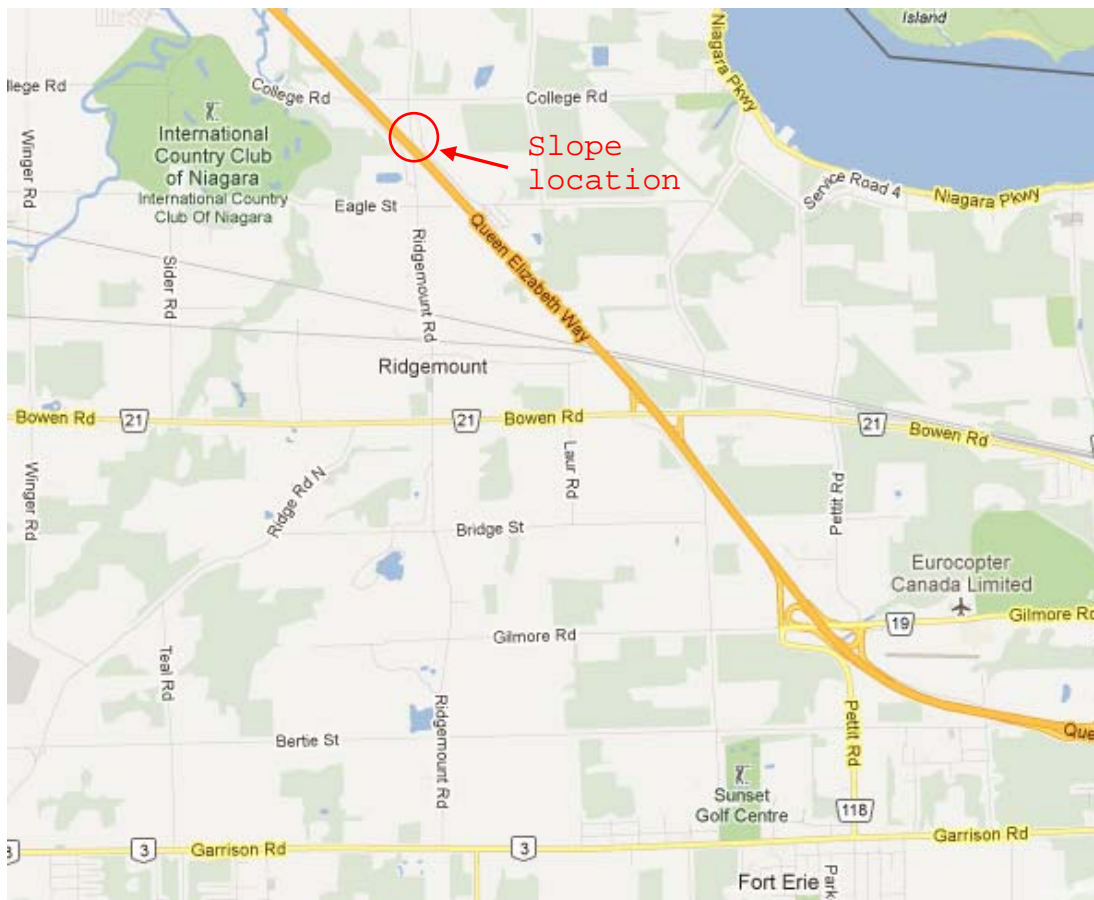


Figure 1: Location of the slope instability area

INTRODUCTION

The Foundations office received an email from Central Region Geotechnical Section dated July 24, 2012, regarding a embankment instability that occurred on Ridgemount Road at the Ridgemount Road/Queen Elizabeth Way (QEW) underpass, east side of the north approach. Crescent-shaped cracks have appeared along the paved shoulder of NBL. A full depth replacement of the asphalt surface and approximately 300 mm of Granular A base of Ridgemount Road had been carried out in 2011. As per Central Region Geotech Section's request, the Foundations office conducted a field review on August 8, 2012, to assess the slope condition at this location.

DESCRIPTION OF THE SITE AND GEOLOGY

The site of the QEW/Ridgemount Rd underpass structure, approaches and embankments is located approximately 9 km north of Fort Erie, Ontario, in Bertie Township, City of Welland. The area map (Map 1) on the first page provides an overview of the site location.

The terrain in the area directly adjacent to QEW in the vicinity of the project site is flat with shrub-type vegetation and a ground surface elevation of approximately 175 m. At the location of the QEW underpass, QEW is a four-lane freeway with a posted speed limit of 100 km/h and Ridgemount Road is a two-lane road with a posted speed limit of 50 km/h.

This site is located within the physiographic region know as the 'Haldimand Clay Plan', that consist of lacustrine clay over a thin layer of glacial till underlain by dolomite limestone bedrock.

OBSERVATIONS

Following is a summary of the observations made during the site review. Refer also to the attached figures for illustrations.

- At the east side of the north approach, there are two sections of tension cracks at the crest of the slope. The crack at the north section is approximately 2.4 m long and it's width various from 25 mm to 50 mm. The crack at the south section is about 12 m in length and 25 mm to 75 mm in width. The depths of the cracks are about 20 cm (Figure 2 and 3)
- The underpass embankment slope is 2.4H:1V and the embankment height is approximately 6 m
- Distress of the guide rail (in the form of tilting) was also evident in area where tension crack appears to be the widest (Figure 4)
- The slope is well vegetated with shrubs and small trees (Figure 5)
- Granular fill material was present on the slope faces, near the highest parts of the embankment.
- There is no visible water body in or around the premises of the slope, however well established Prairie Cordgrass at the toe of the slope indicates possible water ponding during wet season.
- There is a tension crack along the toe of the slope running parallel to the road. However, the level ground beyond the toe of the slope does not bulge (Figure 6 and 7)
- Some non-continues crack patterns were also noted on the face of the slope, approximately 3 m down from the slope crest



Figure 2: Tension crack at the edge of pavement



Figure 3: Width of the tension crack



Figure 4: Distress of the guide rail



Figure 5: Vegetation on the slope



Figure 6: Tension crack along the slope toe



Figure 7: Width of the tension crack at the slope toe

ASSESSMENT

Based on review of the background information and field reconnaissance, it is expected that the cause of the on-going distress at this slope is of a surficial nature and related to its fill material, geometry and state of compaction of the fill and granular road base especially at the shoulder where there is less confinement of the fill. These conditions have resulted in surficial slope instabilities and settlements that occur within the embankment itself.

RECOMMENDATIONS

According to the assessment above, the following remediation alternatives have been considered.

1. Granular Buttressing

One viable remediation option to mitigate the on-going surficial instability at this location is to build a granular buttress at a profile of 2.5V:1H, from the crest of the embankment to the toe of the slope. It is recommended that Granular B Type I or Granular A (both with not more than 5 percent passing the number 200 sieve) be used as the new fill material and the fill should be placed and compacted in accordance with the requirements of OPSS 501. To improve the long-term performance of this remediation, the selected granular material should be keyed into the existing embankment by a series of benches to remove the previously distresses/weakened material within about the frost depth on the current side slopes. Excavation should take place 1 m beyond the existing tension cracks towards the road centre line and lateral wise, it should extend 1 m from the north and south ends of the cracks. Benching of the new granular fill into the existing earth slopes should be carried out in accordance with OPSD 208.010. The dimension of the benches should be 1.0 m high and a minimum 2.5 m wide. Benching should start from a minimum of 1m beyond the tensions crack at the road level and extend to the base of the embankment. The surface of the benches should be sloped with a minimum of 3% fall to promote drainage away from the existing embankment fill. Installation of a 1 m wide by minimum 0.6 m ditch filled with rip rap should also be considered. The ditch needs to be sloped for positive drainage away from the distressed area and preferably to a positive drain such as a ditch or creek. A schematic of this remediation option is shown in appendix B (Drawing G1)

2. Granular Buttress and Granular Slope Flattening

Similar to option #1, flatten the slope with granular fill in the manner described above at a profile of 3H:1V, with benching into the existing embankment fill. This approach can further strengthen the slope. However, it will have higher cost than option #1.

3. Excavation of Upper Embankment and Reconstruction with Geogrid Reinforcement

Excavation of the top portion of the existing embankment, followed by reconstruction of this portion of the slope with Geogrid reinforcement, could be considered as another option.

Excavation should take place 1 m beyond the existing tension cracks towards the road centre line and lateral wise it should extend 2 m from the north and south ends of the cracks. The Geogrid reinforcement would have to be installed extending from the face of the side slopes to at least 3 m into the embankment and should be placed at maximum 500 mm vertical spacing. Please note that these recommendations are of a preliminary nature and a detailed design in conjunction with the geogrid supplier would have to be carried out if this method was going to be implemented.

4. Upper Slope Reinforcement with Granular Buttress and Geogrid

In order to minimise the impact to the slope from construction, option #2 and #3 could be combined to reinforce the upper part of the embankment (from embankment crest to the mid-slope, which is approximately 3 m vertically down from the embankment crest). Benching of the new granular fill into the existing earth slopes should be carried out in accordance with OPSD 208.010. In this regard, it is suggested that the dimension of the benches be 1 m high by 3 m wide, this could accommodate the geogrid be installed 3 m into the embankment with 1 m vertical spacing. Each layer of geogrid should be wrapped over the face of the slope and tied into the next level to further stabilize and enhance the surficial stability of the slope face. It should be noted that these recommendations are of a preliminary nature and a detailed design in conjunction with the geogrid supplier would have to be carried out if this method was going to be implemented.

5. Rock Protection

Covering the side slope of the embankment with minimum 0.6m thickness of rock protection from the crest of the embankment to the mid-slope, followed by the application of new topsoil along with dense re-seeding of the slope with thick vegetation, could also be implemented to improve surficial stability.

For this option, the vegetation and existing top soil should be stripped from the embankment side slope (from crest of the embankment to the mid-slope) prior to placement of the rock protection. The rock protection should be placed in accordance with OPSS 511.

SURFICIAL DRAINAGE

(Common to all alternatives except for option #5)

- See Figure 8 for illustration.
- Construct a ditch at the north end of the identified instability slope area and sump area as described. The depth of the ditch shall be 500 mm deep from the existing exposed grade and a minimum of 1 m wide.
- Fill the entire ditch (to form an armoured drainage channel) and the rest of the instability area with Rip-Rap R-10 grading aggregates. No additional excavation is required outside the ditch for the armoured drainage channel. The minimum thickness of the Rip-Rap R-10 regarding aggregate fill shall be 300 mm. The armoured drainage channel should outlet into a 0.5 m deep 2 m x 2 m area sump at the toe of the slope, centred on the armoured drainage channel. The sump shall be filled with Rip-Rap R-10 grading aggregates. All Rip-Rap R-10 grading aggregates shall be placed using rock protection construction method from the bottom up (i.e. machine place and random manner and without geotextile separator). Refer to the following Ontario Provincial Standard Specifications for construction method and material selections:
 - OPSS 511: Construction Specification for Rip Rap, Rock Protection and Gravel Sheeting
 - OPSS 1004: Material Specification for Aggregates – Miscellaneous
- Construct an approximately 100 mm high asphalt curb and with opening to direct surface runoff to the armoured drainage channels along the slope. The preferred location for the asphalt curb is immediately in front of the three cable guide rail (3-CGR).

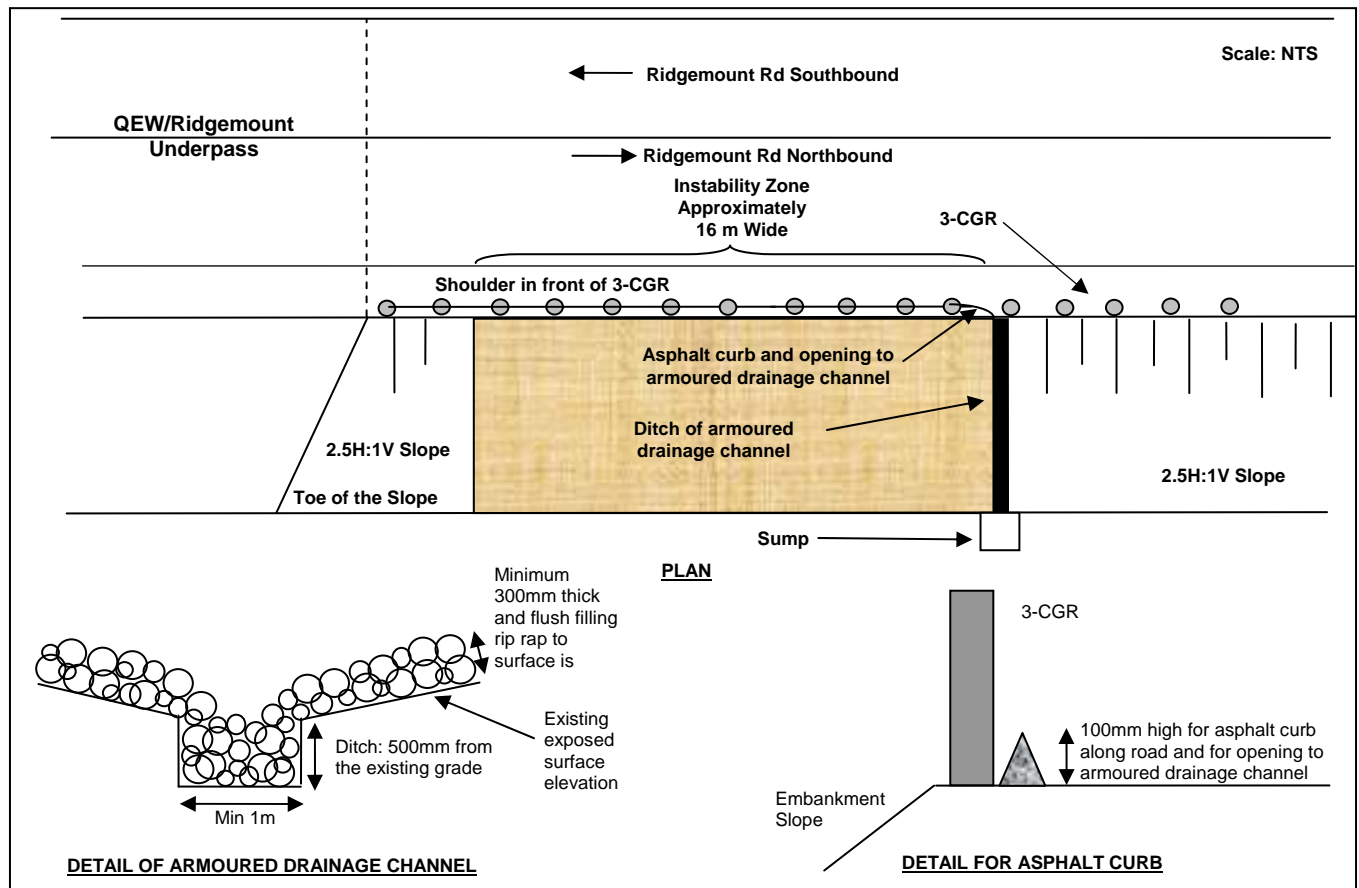


Figure 8: Surficial drainage illustration

SLOPE VEGETATION

(Common to all alternatives except for option #5)

Surface vegetation is also recommended to apply topsoil and vegetative cover to the slope if vegetated finish is required. Otherwise raw granular or rock face could be left and is preferred due to less complexity in construction. If vegetated slope is required, the slope surface should be covered with 250 mm topsoil and hydroseeded with appropriate vegetations. If this remediation work was carried out late in the year, seeding or planting shall be conducted in the next spring. Recommendations for restoration of the pavement structure are not within scope of this memo report and should be provided by CR Geotechnical Section.

Recommendations for vegetating slopes should come from the appropriate maintenance office. Recommendations for re-establishing the road surface and pavement should come from the CR Geotechnical Section.

EVALUATION OF ALTERNATIVES

Remediation #	Remediation Alternatives	Advantages	Disadvantages	Level of Risk
1	Granular Buttressing	Low cost Low complexity Good performance Less impact to the existing road structure	Require road side drainage	Low
2	Granular Buttress and Granular Slope Flattening	Good performance Low complexity	Higher cost Require road side drainage	Low
3	Excavation of Upper Embankment and Reconstruction with Geogrid Reinforcement	Good performance Less impact to the existing embankment structure	Certain impact to the existing road structure Complexity of construction Higher cost Require road side drainage	Low
4	Upper Slope Reinforcement with Granular Buttress and Geogrid	Good performance Less impact to the existing embankment structure	Certain impact to the existing road structure Complexity of construction Higher cost Require road side drainage	Low
5	Slope Cover with Rock Protection	Good drainage Good performance Low complexity	Possible low material availability Higher cost	Low

PREFERRED REMEDIATION OPTION

After analyses and comparison of the options, Option #1 **Granular Buttressing** is recommended. The embankment should be constructed at 2.5H:1V with a granular buttress keyed into the exiting embankment side slopes with benching. It provides the best combination of construction simplicity, access to materials, cost and performance. (See remediation plan #1 for details). A schematic of this remediation option is shown in appendix B (Drawing G1). If another remediation option is selected for implementation, a schematic drawing for the option will be provided upon request.

Hong Ye, EIT
for

D. Dundas, P. Eng.
Senior Foundation Engineer

Appendix A

FOUNDATIONS RELATED GENERAL SPECIAL PROVISION

Special No.	Date
206S03	26 Apr 2012

FOUNDATIONS RELATED REFERENCED STANDARD SPECIFICATIONS

OPSS No.	Date
0501	02 Jun 2011
0511	01 Apr 1991
0802	29 Sep 2011
1004	27 Jun 2006

FOUNDATIONS RELATED REFERENCED STANDARD DRAWING

OPSD No.	Date
208.01	16 Dec 2010

Appendix B

Slope remediation Granular Buttressing (Drawing 1)

