September 20, 2011

CREDIT RIVER VALLEY ROCK EXCAVATION CUT FOR CONSTRUCTION OF ACCESS ROAD

ROCK SLOPE HAZARD ASSESSMENT
Contract 2011-2003

Submitted to:
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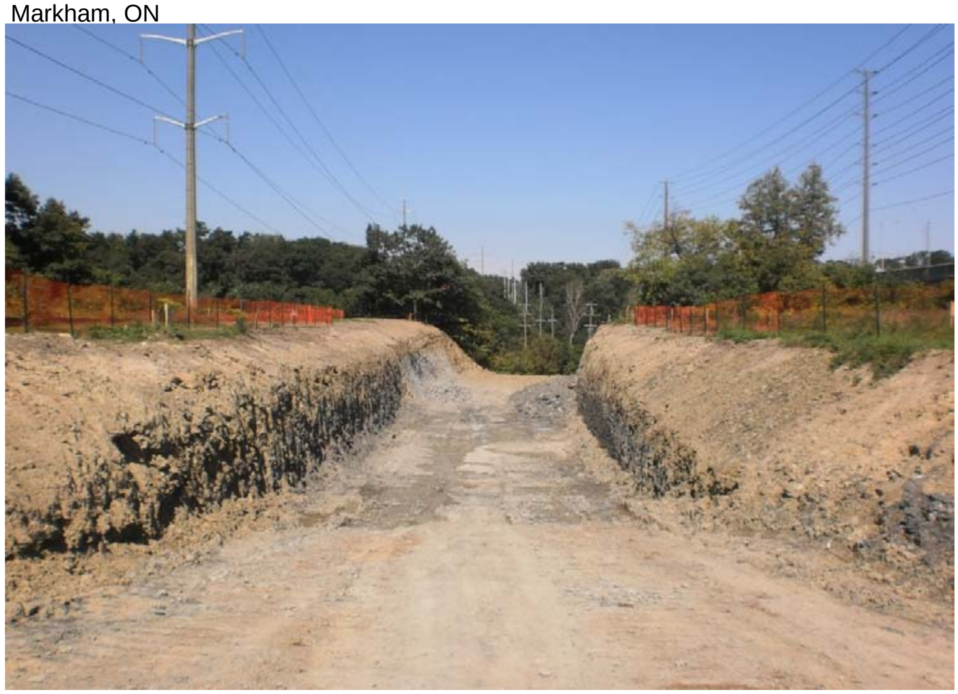

REPORT

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PART A – ROCK SLOPE HAZARD GEOTECHNICAL INVESTIGATION REPORT

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by URS Canada Inc. (URS) to carry out a geotechnical investigation of the rock excavation for the Credit River Valley construction access road at the QEW overpass at Mississauga Road as part of the Contract Administration services for the project. The scope of work was generally carried out in accordance with MTO's Terms of Reference, Section 6.4 Specialty Work Plan for Foundation Engineering Rock Slope Hazard, Credit River Valley Rock Excavation Cut, QEW from Hurontario to Mississauga Road, Contract 2011-2003. In summary, the purpose of the investigation was to examine and evaluate the rock cuts along the access road and provide recommendations for any rock slope protection and stabilization including shotcrete, drainage and rock dowels.

This report presents the findings of the initial site visit and provides remedial options to address any identified stability concerns. This report also includes a review of the Contractors submittal for rock slope protection measures and provides comments on any identified concerns with the proposed work.

2.0 SITE DESCRIPTION

The temporary access road extends along the north side of the QEW from about 100 m east of Mississauga Road to the northwest side of the Credit River and the QEW bridge structure. The site area lies within the physiographic region known as the Lake Iroquois Plain (Chapman and Putman, 1984)[1], which was inundated in Late Pleistocene times by Glacial Lake Iroquois. The surficial sediments (soils) in the study area have been mapped by the Ontario Geologic Survey as cohesive soils (some till) and alluvial deposits of clayey silts, silts and sands within the floodplain, overlying shale bedrock of the Georgian Bay Formation. The site itself is located on the west side of the Credit River in a relatively flat area with the existing ground surface varying from about elevation 94 m to 98 m on the west, sloping steeply down to the river to the east. The Credit River valley is some 18 m to 20 m below the flat area to the west. The temporary access road grades down in a west to east direction towards the river.

3.0 INVESTIGATION PROCEDURES

3.1 Site Visit/Inspection

The investigation consisted of a review of the Contract Drawings and the Contractor's submittal for rock slope protection measures followed by a site visit to examine the rock cut conditions. The initial site visit was carried out by Mr. Mark Telesnicki, P.Eng. (Golder) on September 9, 2011. Also present during the site visit were Mr. Stan Glass and Mr. Masud Alam, of URS. During the site visit the existing rock cuts were inspected visually and photographs were taken of areas of interest or concern. The rock excavation work was nearly complete at the time of the inspection but it is understood, from discussions on site, that the road may need to be widened slightly in some areas and needs to be deepened by approximately 2 m along much of the length. The geometry of the roadway and rockcuts was assessed and observations were made regarding the major rock structure (bedding and joints), overall stability of the cuts and groundwater seepage. The stability of the rock faces was assessed initially in the field.

[1] Chapman, L. J. and P utman, D. F., 1984. " The Physiography of Southern Ontario", Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P. 2715, Scale 1:600,000.

3.2 Site Observations

At the time of the site visit, rock excavation for the access road had been carried out for a length of approximately 150 m from approximately Chainage 10+325 to 10+475, and consisted of two near vertical rock cuts up to 6 m in height (referred to as the north and the south cuts) with overburden slopes above the bedrock surface (refer to Plate 1). We understand, based on the Contract Drawings, that the access road will branch into an upper road and a lower road with the upper road continuing along the river bank to the south and the lower road continuing easterly down the slope and then southerly to the bridge pier.

The rock cuts were designed to be excavated at a slope of 12 vertical to 1 horizontal (12V:1H) slope, however, the current rock face angles were noted to be somewhat variable, but appeared to be close to the 12V:1H slope in most areas. The overburden above the crest of the rock cuts on either side of the access road varied in thickness but was generally approximately 1 to 2 m thick and had been sloped back from the edge of the rock faces at angles varying from about 1 vertical to 1 horizontal (1V:1H) to 2H:1V (visually estimated but not measured).

4.0 DESCRIPTION OF SUBSURFACE CONDITIONS

The temporary access road has been excavated through up to approximately 2 m of silty clay with sand overburden and into sedimentary rock consisting of shale of the Georgian Bay Formation. The shale was noted to be dark grey, moderately weathered (typically in the upper 1.5 m depth from the bedrock surface and up to 3 m deep at the river valley – refer to Plate 2) to fresh, fine grained, thinly bedded and fissile with harder interbedded layers of siltstone and/or limestone (refer to Plate 3). The bedding is generally near horizontal and one significant near vertical joint set striking northwest – southeast (indicated on Plate 2) and one inclined joint set dipping between 30 and 50 degrees to the east (toward the river valley) were noted. The joints are typically planar and smooth to slightly rough.

Groundwater seepage was noted along the south rock cut face at a number of locations (refer to Plate 3). The seepage appears to originate along a bedding plane joint located about 1.5 m to 2 m below the bedrock surface. The rock face was noted to be damp below the bedding plane at the time of the inspection; however, no running water was noted. No significant seepage was noted along the north rock cut face at the time of the inspection.

5.0 CLOSURE

The site visit/inspection was carried out by Mr. Mark Telesnicki, P.Eng., a rock mechanics specialist and Principal of Golder Associates who also prepared this report. The report was reviewed by Mr. Jorge Costa, P.Eng. , a Principal of Golder Associates and the Designated MTO Foundation Contact in accordance with the Terms of Reference.

PART B – ROCK SLOPE HAZARD FOUNDATION DESIGN REPORT

6.0 ROCKFALL HAZARD ASSESSMENT

The bedding within the shale bedrock together with the joint sets have resulted in a blocky rock mass which is susceptible to ongoing weathering and subsequent ravelling type failures. No deep seated failure mechanisms (i.e. planar sliding, wedge failures or toppling failures) were noted on either of the rock cut faces along the access road.

Ongoing physical weathering processes (rain, ice, sun, freeze/thaw, and wind) will continue to degrade the rock faces over time. In general, weathering processes often exploit existing weaknesses in the rock mass such as fractures or joints, resulting in the break down of the rock mass which can eventually result in rock falls. The exposed rock faces in the shale are particularly susceptible to ice jacking due to freeze thaw in the winter months and wetting and drying cycles over the remainder of the year. Ravelling in the shale generally results in small pieces of rock (up to about 0.1 m in size) falling from the face; however, the harder limestone/siltstone layers often result in small unstable blocks or slabs (up to approximately 0.2 m across and 0.1 m thick) on the face which eventually fall when the supporting shale below ravels and spalls.

7.0 REMEDIAL OPTIONS

Several options can be considered for addressing the rockfall hazards associated with ravelling type failures along the rock cuts. In developing the remedial options below, a 10 to 15 year design life was considered based on our understanding of the time period over which the construction access road will potentially be required for future work on the bridge. The remedial options are summarized in Table 1 following the text of this report and include the following:

1) Do Nothing

This option serves as the base case and would involve leaving the rock cuts as they are. There is considerable risk associated with this option, as rockfalls will continue to occur on a regular basis and will become more and more frequent as the faces weather. There may be a need to remove rockfall debris which will accumulate over time at the base of the cuts in the proposed drainage ditches. Unless an exclusion zone, several metres wide, is maintained along the toe of each rock face there would be a very high rockfall hazard which could result in damage to excavation equipment and/or personnel injury. We understand that the Ministry of Labour carried out an inspection of the site recently and identified the risk of rockfalls as an issue that needed to be addressed by a geotechnical engineer. This option would result in a significant safety hazard and it is considered unlikely that this option would be acceptable to the Ministry of Labour.

2) Rock Scaling

The entire length of the rock cuts could be scaled using machine scaling methods in order to remove all loose and unstable rock. This would significantly reduce the risk of rockfalls in the short term however, scaling is a temporary remedial measure which would need to be repeated every 1 to 3 years as the rock mass continues to weather and degrade. Rock scaling would not address the issue of ongoing weathering and degradation of the rock faces over time. There would be some residual risk after scaling and the risk of rockfalls would gradually increase between scaling events.

3) Draped Double Twist Mesh

Double-twist wire mesh draped from the crest of the rock cuts would allow falling rocks to be directed to the base of the rock faces. The mesh should be secured along the crest of the cuts using rock dowels and steel cables and should extend down the rock faces to within approximately 1 m of the toe of the cuts. This option would not address the ongoing weathering of the rock faces which will result in increased rockfall frequency over time. Rockfall debris at the toe of the slope would require periodic removal to accommodate future rockfalls. In may also be necessary to remove loose rock hung-up behind the mesh on the rock face periodically.

4) Reinforced Shotcrete, Drainholes and Rock Bolts

The fourth option for mitigating the risk of rockfalls would involve covering the rock face with wire mesh and shotcrete or steel fibre reinforced shotcrete. The shotcrete (and wire mesh if used) should be secured with pattern rock bolts. Drainage should also be included in the design to alleviate any potential water pressure build-up behind the shotcrete. This option would mitigate the ongoing weathering of the face and would slow the erosion over time. With good workmanship this option should require little to no maintenance over the 10 to 15 year design life.

8.0 ESTIMATED CONSTRUCTION COSTS

Budgetary estimates for the remedial options described in Section 7.0 are as follows:

Rock Scaling

Item	Quantity	Unit	Unit Rate	Total
Machine Scaling	80	hr	$420	$33,600*

Note: Initial year of scaling is included in the rock excavation unit cost; however, scaling needs to be repeated every 1 to 3 years depending on the intended use.

Draped Mesh

Item	Quantity	Unit	Unit Rate	Total
Draped Mesh	1772	m2	$95	$85,500

Note: Requires regular removal of rockfall debris estimated to be $3,000 to $5,000 per year.

Reinforced Shotcrete with Drainage

Item	Quantity	Unit	Unit Rate	Total
Reinforced Shotcrete (including drainage and rock bolts)	1772	m2	$450	$797,400

The above costs are budgetary only and are intended for comparative purposes to evaluate remedial options. Actual construction costs may vary significantly depending on the contract requirements/restrictions etc.

9.0 RECOMMENDED ALTERNATIVE

In order to evaluate the various options the following evaluation matrix has been prepared.

Option	Capital Cost Rating	Life Cycle Cost Rating	Effectiveness in Reducing Rockfall Risk	Overall Rating	Comments
Do Nothing	4	3	1	8	Option should be eliminated due to unacceptable rockfall risk
Regular Rock Scaling	3	1	2	6	Requires regular scaling
Draped Mesh	2	2	3	7	
Shotcrete and Bolts	1	4	4	9	

Note: Options are rated on a relative basis with 4 being the highest or most advantageous of the four options

The recommended remedial alternative based on the criteria above, which includes initial capital cost, ongoing maintenance costs (life cycle cost) and effectiveness in reducing rockfall risk, is the shotcrete option (with pattern rock bolts and drainage provisions). This option will provide MTO with the lowest rockfall risk and the lowest annual maintenance costs for a 10 to 15 year design life.

10.0 REVIEW OF CONTRACTOR'S ROCK PROTECTION MEASURES

A review of the Contractor's proposed measures for addressing the rockfall hazard was carried out as part of this assignment. The Contractor's shop drawings prepared by RWH Engineering Inc. and T.H. O'Rourke, dated May 2011 were provided by URS. In summary, the Contractor's design is comprised of a 100 mm thick layer (75 mm min.) of shotcrete applied over a welded wire mesh fixed to the rock face with 25 mm diameter by 2 m long rock bolts on a 1.8 m x 1.8 m pattern. Drainage behind the shotcrete will be provided by 300 mm wide vertical strips of drainage composite. The results of our review are summarized as follows:

- The shotcrete thickness is in accordance with SP299S08 and is considered adequate,
- Given the rough and irregular nature of the rockface it will be difficult to contour the mesh closely to the face and as a result additional shotcrete thickness will be required in many areas in order to adequately cover the mesh,
- The rock bolts (diameter, length and spacing) are considered adequate. It is important that they are installed at 15 degrees downward as shown on the drawings in order to cross the bedding planes in the rock,
- Some longer rock bolts (up to 3 m long) may be required in areas of the south rock cut where the zone of weathered rock extends down about 3 m from the crest to within 2 m of the base of the rock cut (Plate 4). These bolts should be spaced at 1.8 m centre to centre,

- There is a concern that groundwater seepage directed along the 300 mm wide drainage strips may freeze during the winter months and may cause the shotcrete covering the strips to crack and spall from the face. For this reason the drainage strips are not recommended, unless the Contractor can adequately address this issue in his design submissions. Drainholes on a regular pattern in accordance with SP299S08 (i.e. 3.0 m long, 25 mm minimum diameter drain holes at 3.0 m centres, inclined approximately 10 degrees above the horizontal and lined with slotted PVC pipe, conforming to ASTM D1784) are recommended. Drainholes (or drainage strips if accepted) should be laid out to intersect the bedding plane on the south rock face which is the source of the groundwater seepage,
- The groundwater drainage from the drainage composite strips (if used) must be allowed to exit at the base of the cut (i.e. the base of the drainage strips should not be covered with shotcrete),
- There is no indication on the drawings as to how the welded wire mesh will be fixed to the rock face above the uppermost rock bolts which are located 1.2 m below the crest of the rock face. This aspect of the design should be further detailed by the Contractor, and
- The toe of the overburden slope should be set back a minimum of 1 m from the edge of the rock face, resulting in a 1 m wide exposed rock bench along the crest. The shotcrete should then be extended up over the crest of the cut to cover the bench. This will mitigate the risk of sloughing of the overburden over the rock face and will mitigate to some extent further weathering of the top of rock behind the vertical shotcrete face.
- The overburden slopes should be protected against erosion. The Contractors submission does include an erosion control blanket which should cover the entire overburden slope from crest to toe as shown on the drawings.

11.0 CLOSURE

This report was prepared by Mr. Mark Telesnicki, P.Eng., a Principal of Golder Associates. Mr. Jorge Costa, P.Eng., Golder's Designated MTO Foundations Contact for this project conducted an independent quality control review of the report for compliance with the Terms of Reference.

Report Signature Page

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MJT/JMAC/ms

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TABLE 1

Table 1: Comparison of Rockfall Hazard Remedial Options

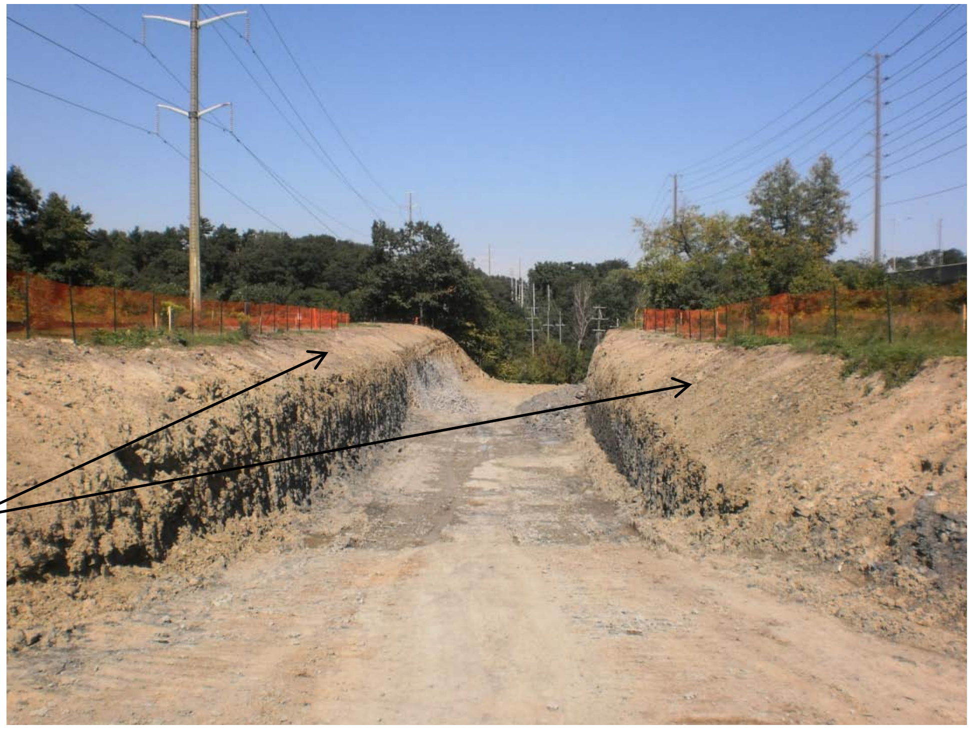
Option	Advantages	Disadvantages	Relative Cost	Risk
Do Nothing	■ No further work on site required	■ Requires an exclusion zone along the toe of both rock cut faces (may require additional rock excavation to increase roadway width) ■ Rockfalls will continue to occur potentially requiring removal of rockfall debris ■ Potential damage of equipment/or injury to personnel	■ No immediate cost	■ Very high risk of rockfalls ■ Rockfall risk increases over time ■ Unlikely to be acceptable to the Ministry of Labour
Rock Scaling	■ Equipment on site currently to carry out the work ■ Can be completed relatively quickly	■ Would not address ongoing weathering ■ Would need to be repeated on a regular basis ■ Potential damage of equipment/or injury to personnel ■ Currently no provision in construction contract for ongoing maintenance	■ No initial capital cost (included in the rock excavation item) ■ Relatively high periodic costs	■ Moderate reduction of rockfall risk in the short term ■ Rockfall risk increases between scaling events
Draped Mesh	■ Provides adequate protection from rockfalls over the design life ■ Allows for groundwater drainage from the slope	■ Does not mitigate ongoing weathering and erosion of the rock face ■ Requires periodic removal of rockfall debris	■ Moderate initial capital cost and low regular maintenance costs	■ Significant reduction in rockfall hazard over design life

Table 1: Comparison of Rockfall Hazard Remedial Options (Continued)

Option	Advantages	Disadvantages	Relative Cost	Risk
Reinforced Shotcrete (with Rock Bolts and Drainage)	■ Provides high degree of protection from rockfalls ■ Mitigates ongoing weathering of rock cuts ■ Very little to no maintenance required	■ Specialist Contractor and equipment required ■ Requires good workmanship ■ Requires drainage to relieve groundwater pressures	■ Highest relative initial capital cost ■ Little to no ongoing maintenance costs	■ Significant reduction in rockfall risk over the design life

PLATES

Sloped
Overburden at
Crest of Cuts



View of Construction Access Road Looking East

View of Construction Access Road Looking West

Credit River Valley Access Road General View of Rockcut	PLATE 1
Golder Associates	11-1117-0055 Sept. 12, 2011

Prepared By: MJT
Reviewed By: JMAC

Typical Rock Cut Face Showing the Upper Weathered Zone at the Top of the Cut

View of the North Face Showing Prominent Joint Sets and Deeper Weathering Near the River Bank

Credit River Valley Access Road Weathered Zones and Rock Structure	PLATE 2
Golder Associates	11-1117-0055
	Sept. 12, 2011

Prepared By: MJT
Reviewed By: JMAC

Harder Layer
Resulting in Unstable
Slabs

Typical Cut Face Showing Ravelling Failures and Slabs in the Harder Interbedded Layers

QEW/Credit River
Bridge

Seepage from
Bedding Plane and
Damp Rock Face
Below

View of South Rock Face Showing Groundwater Seepage

Credit River Valley Access Road Unstable Slabs and Water Seepage	PLATE 3
Golder Associates	11-1117-0055
	Sept. 12, 2011

Prepared By: MJT
Reviewed By: JMAC

View of South Rock Cut Looking West Showing Deep Weathered Zone

Deeper Weathered Zone on South Rock Cut

Credit River Valley Access Road Deep Weathered Zone	PLATE 4
Golder Associates	11-1117-0055
	Sept. 12, 2011

Prepared By: MJT
Reviewed By: JMAC

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