June 23, 2011

Alberta Transportation
Central Region
#401, 4902–51 Street
Red Deer, Alberta
T4N 6K8

Mr. Dennis Grace, P.Eng.
Project Engineer

Dear Mr. Grace:

Central Region GeoHazard Assessments
Site C24 H564:10 Slide
May 2011 Site Assessment Report

Alberta Transportation has initiated a process of risk management at specific geohazard sites that includes a document control system. This annual site assessment report forms Section B of the document control system for the above site.

The site was inspected on May 13 and 17, 2011 by Mr. Darren Ratcliffe of Klohn Crippen Berger Ltd. Photographs from the inspection are attached.

This report was prepared by Klohn Crippen Berger Ltd. for Alberta Transportation Central Region under Contract No. CE101/2008.

1. PROJECT BACKGROUND

1.1 Site Location

About 20 km southeast of Drumheller and south of the Red Deer River, Highway 564:10 (previously known as Duck Lake Road) descends into a coulee (known as East Coulee) to join with Highway 569. On the east side of the coulee, a large slide developed and resulted in an apparent dip in the highway grade. The slide area is about 300 m wide with a steep scarp relatively close to edge of highway. Instrumentation was installed at the site in July 1985.

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1.2 Site History

June - November 1979

In 1979 it was proposed to widen the existing road in this location by cutting the slope above and filling below, adopting 3H:1V slopes. The installation of horizontal drains at observed spring sources was also recommended. Test holes drilled in the area identified highly variable soil strengths and bentonitic layers in the soil.

It is assumed that the work was done as planned in the summer of 1979. In November 1979, a crack was observed in the road surface that was 30 mm wide and had settled about 70 mm. Cracks on the downhill slope had opened up to 50 mm wide and were over 1 m deep.

July 1985

In July 1985, a site investigation was undertaken at the slide location. Four locations were drilled; hole details are presented in Table 1. The drilling indicated that the subsurface conditions comprised medium to high plasticity sandy clay over high plasticity clayshale and sandstone. Four slope inclinometers and three standpipe piezometers were installed. The instruments indicated that the water level and the shear movement generally corresponded with the clay-clayshale interface.

Table 1 July 1985 Test Hole Summary

Hole ID	Location	Elevation (m) (Local Datum)	Total Depth (m)	Depth to Clayshale (m)	Water Depth (m)	Movement Depth (m)	Movement Elevation (m)
SI #1	5+263, 37 m LT	199.3	18.6	16.7	16.0	16.8	182.5
SI #2	5+331, 47 m LT	200.8	11.0	5.0	5.2	5.8	195.0
SI #3	5+220, 16 m LT	202.4	11.0	7.9	5.6	8.2	194.2
SI #4	5+298, 17 m LT	208.3	12.5	10.5 (more likely 7.0)		8.2	200.1

Liquid limits in the overburden soils ranged from 35% to 80% with an average moisture content of about 15%. SPT blow count values typically ranged from 12 to 23 blows per 300 mm, but were reduced to about 3 to 4 blows per 300 mm in soft wet zones. A direct shear test was performed on an overburden sample from test hole SI #1 at a depth of 9.1 m. The test indicated a friction angle of 33°; however, the material at this depth is about 7 m above the observed shear plane.

The clayshale liquid limits ranged from about 55% to 190%, indicating the presence of highly bentonitic, low strength layers. Natural moisture contents were typically about 25%.

1986 - 1991

Over the period 1986 to 1990, numerous complaints from various landowners were received and resulted in an Alberta Transportation memorandum dated January 1990 describing the section of highway as "winding, traversing rugged terrain and there is evidence of road settlement and landslides on the hillside". It was believed at the time that the road was constructed over some old underground mine shafts; however, a review of an EUB plan indicates that the highway is to the east of the eastern limit of the mining activity. It was recommended in 1990 that this section of road not be paved.

A study of two alternative road alignments was carried out at this time and was summarized in a memorandum dated June 1991. The outcome was that in view of the very high cost of the alternatives, it was recommended that the alignment follow the existing road. It was recommended that any effects of the slide investigated in 1985 be repaired with periodical maintenance as the most economical procedure.

2007–2008

In August 2007, the movement area observed was about 70 m long and the road surface appeared to have dropped by about 1 m. Cracking was observed at the crest of the slope and in numerous locations below the highway. Barricades were erected to close the lane beside the top of the slope. The slide was likely reactivated by ground saturation from the high regional precipitation in 2007. The level of movement had effectively closed half the highway. A summary of the instrumentation status as of August 2007 is provided in Table 2 below.

Table 2 August 2007 Instrument Readings

Hole ID	Observation
SI #1	Sheared at 10 m
SP #1	Sheared at 4.3 m
SI #2	Destroyed
SP #2	Sheared at 5.5 m
SI #3	Sheared at 7 m
SP #3	Water level at 3.1 m
SI #4	Sheared at 4 m

In the fall of 2007, the roadway was reinstated and the backslope ditch was protected with gravel-filled geo-cells. To reduce the driving stresses on the failure plane, the slope below the active area was excavated to match the adjacent steep slope section. The intent was to stabilize the slope with soil nails immediately thereafter. However, due to mechanical difficulties with the soil nail launcher in cold weather, the nailing had to be delayed until the spring of 2008 when the ambient air temperature was warm enough for the launcher to achieve satisfactory nail penetration. As part of the fall 2007 construction, 300 m of guardrail was installed.

Due to the road not being stabilized immediately after it was rebuilt, cracks began to form in the road. By the end of November, a crack approximately 50 mm wide had appeared extending about 4 m into the road structure over a 20 m long length. The area had also noticeably settled. Cracking and settlement continued into the spring of 2008.

To repair the zone of cracking and settlement, a portion of the road along the line of the crack was excavated and the back face of the excavation was soil nailed. A GRS (geosynthetic reinforced soil) wall was then constructed to reinstate the highway and restore the grade. Areas on either side of the GRS wall were also soil nailed. A total of about 650 soil nails were installed at the site.

2. SITE OBSERVATIONS

The site has been monitored at least twice per year since the 2007/2008 construction. Cracking and settlement over the original 70 m long section of highway at the crest of the slide has continued and has essentially returned to the condition observed in 2007 as shown in Photos 1 and 2 below. As shown, the guardrail indicates a lateral displacement at the edge of the highway. A barricade has been provided at the north end to direct traffic away from the settled zone.

No distress except for some minor tilting of the GRS wall was observed. Significant cracking was observed in the slope below and to the northeast of the wall location consistent with the large slide or series of slides in the area.

Photo 1 Site Conditions May 13, 2011 (looking northeast)

Photo 2 Site Conditions May 13, 2011 (looking southwest)

3. SITE ASSESSMENT

It is considered that the highway is located at the crest of a major slide system in the coulee. Movements appear to be limited to the 70 m length originally observed in 2007 with the edge of the highway slowly displaced by the larger slide movement below. No signs of movement were observed beyond the settled zone on the highway. However, the current level of movement has effectively closed half the highway.

The slide was likely reactivated by ground saturation from the high regional precipitation levels in previous years. The observations indicate that this is a relatively deep slide in weak bedrock material and the attempts to stabilize the top of the slide have not been successful. It is considered that the creep movements will continue at a slow rate. A rapid failure, in particular due the remedial works installed below the highway, is considered a low probability.

Based on the risk level criteria provided by Alberta Transportation relating to safety, a risk rating of 54 was assigned to this site. This is based on a probability factor of 9 for an instability feature, and a consequence factor of 6 due to the partial closure of the highway.

4. RECOMMENDATIONS

The stabilization of deep slides in weak materials is particularly difficult and has a high project cost. The most cost effective approach would be to move the highway alignment away from the edge of the slope. However, this will require the excavation of the high backslope with local over steepening along the slide area with a face stabilization method, such as an anchored or nailed wall.

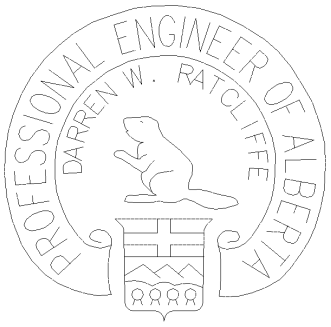
In the interim, it is recommended to move the guardrail to the edge of the movement area, as shown on Figure 1. Approximately 200 m of guardrail will require realignment. It is recommended that new steel posts be installed along the new alignment and the existing guardrail be simply moved from the old posts to the new posts, leaving the old timber posts in place. An additional 30 m of new guardrail is required at the southwest end.

The realignment will reduce the highway width from about 12 m to about 8 m wide. Although this width is considered adequate for the low volume of traffic on the highway, it is recommended that a 10 m wide road be adopted due to the combined hill and curve. To achieve a 10 m wide road, surfacing gravel should be placed and compacted over the existing geo-cell protected ditch. The geo-cell will reinforce the subgrade and provide protection against erosion. A minimum 1 m wide ditch should be maintained on the backslope side of the road. Local trimming of the toe of the slope (no steeper than 1H:1V) should be undertaken to obtain the required width. Any exposed slope should be protected with the "Green Armor" slope seeding system. The base of the ditch should be protected with a layer of road gravel.

Please contact the undersigned if you have any questions regarding this letter.

Yours truly,

KLOHN CRIPPEN BERGER LTD.



Darren W. Ratcliffe, P.Eng.
Project Manager

APEGGA Permit to Practice No. 9196