August 28, 2009

CG25309.B

Alberta Transportation
2nd Floor, 803 Manning Road NE
Calgary, AB T2E 7M8

Attn: Mr. Ross Dickson

Re: Southern Region Geohazard Assessment Program
Highway 742:02 Rockfall Areas, Between ~Km 4.8 and 6.1
June 2009 Inspection Report

This letter documents the 2009 annual site inspection of the rockfall areas along the above-noted segment of Highway 742:02, southbound of Canmore, AB.

AMEC Earth & Environmental (AMEC), a division of AMEC Americas Limited, performed this inspection in partial fulfillment of the scope of work for the supply of geotechnical services for Alberta Transportation's (AT's) Southern Region (AT contract CE061/08).

The site inspection was performed on June 11, 2009 by Mr. Andrew Bidwell, P.Eng. and Mr. Bryan Bale, EIT of AMEC in the company of Mr. Ross Dickson and Mr. Neil Kjelland, P.Eng. of AT along with Mr. George Field, Public Safety Specialist for Kananaskis Country with the Parks Division of Alberta Tourism, Parks and Recreation.

BACKGROUND

During the 2007/2008 geohazards review of the Highway 742 corridor a number of rockfall areas were noted between approximately Km 5.2 and Km 6.1[1] of the highway through the "East End Of Rundle" area. Please refer to the April 2009 report[2] on the geohazards review for a description of the rockfall hazard conditions along this segment of the highway.

Figure 1, attached, illustrates the location of the Km 5.2 to Km 6.1 segment of the highway.

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[1] Km values are referenced from Km = 0 at the junction between Highway 742 and Three Sisters Parkway in Canmore, AB.

[2] AMEC report "Geohazards Review, Highway 742 and Highway 940 Corridors, Southwestern Alberta", submitted to AT on April 8, 2009, AT Consulting Services Agreement CE044/04, AMEC project number CG25262.

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In summary, the 2007/2008 assessment of these rockfall areas was that there is a hazard of rockfall debris from the cut slopes bouncing/rolling onto the highway, This is due to the steep cut and natural rock slopes that generate rockfalls and the undersized or absent catchment ditch along the upslope side of the road. The associated risk to motorists is relatively high, as discussed in the April 2009 report.

A hazard of rockfalls originating from the natural slopes above the highway was also noted. Such rockfalls were assessed to be of relatively lower probability but higher consequence than rockfalls from the cut slopes, and to be a lower risk.

The 2007/2008 assessment recommended:

- Scaling of specific rock blocks from the cut slope around Km 5.6,
- Posting a reduced speed limit in order to increase the time available for motorists to see and safely avoid rocks on the road,
- Establishing a maximum vehicle length permitted on this segment of the highway so that the vehicles on the narrow road will have sufficient manoeuvrability to avoid rockfall debris on the road or turn around if necessary,
- The installation of draped netting at selected locations along the cut slopes and natural slopes above the road to direct rock falls into the upslope road ditch or confine the debris along the toe of the cut slope in areas without a ditch.

Aside from the two locations around Km 5.6 noted above, scaling of the slopes was not recommended as it would likely require a lot of effort with likely relatively little long-term or sustained reduction in the Risk Level.

JUNE 2009 FIELD REVIEW OF ROCKFALL AREAS

Purpose

The purpose of the June 2009 field review of the rockfall areas was to:

- Check for any significant changes in the rockfall conditions along the highway since the 2007/2008 corridor geohazards review.
- To learn of the location(s) of other significant past rockfall events along the highway from Mr. George Field (Parks Division) who has worked in the area for many years and accompanied the AT and AMEC personnel on the June 11, 2009 field review.

- Provide a basis to update or revise the recommended Risk Levels for the rockfall areas, if appropriate.

June 2009 Observations

- No significant changes since the 2007/2008 corridor review were noted in the rockfall conditions along the Km 5.2 to Km 6.1 segment of the highway.

- The Parks Division personnel identified the location on the highway where a 2006 rockfall event deposited several boulder-sized rocks on the road surface around Km 4.9. Please refer to Figure 1 for an illustration of the location. This rockfall originated at the uppermost slopes above the highway, from which extremely large rocks fell and then bounced/rolled downslope to the highway. By the time the debris reached the highway, the rockfall material had broken down into boulder-sized rocks (greater than 200 mm dimension, and in this case understood to consist of rocks in the order of “washing machine” sized or even greater). Photo 1, attached, was provided by the Parks Division and shows the dust cloud created by the 2006 rockfall as it was occurring.

ASSESSMENT AND RISK LEVELS

Three types of rockfall risk should be considered along this segment of the highway:

1. <u>High frequency, relatively low magnitude rockfalls originating from the highway cut slopes or the natural slopes a short distance above the highway.</u>

Please refer to the April 2009 report for the assessment of this risk, which has not changed after the June 2009 observations.

Recommended Risk Level:

- Probability Factor of 12 to reflect the active rockfall conditions, with a qualitative description of somewhere between up to two falls per year (corresponding to a Probability Factor of 11) and “several” falls occurring each year (corresponding to a Probability Factor of 13).

- Consequence Level of 4 because the narrow roadway, shoulder and ditch conditions resemble those brought about by a rock fall sufficiently large to cause partial closure of the road, fill ditches and cover the shoulders of the road. The consequences of these chronic conditions are mitigated by frequent grading of the roadway. This value also accounts for the possibility of vehicles being struck by falling rocks and vehicles striking rocks that have been deposited on the road with loss of vehicle control resulting.

Therefore, the current recommended Risk Level for rockfall along this segment of the highway is 48.

2. Low frequency, high magnitude rockfalls around Km 5.6 where large blocks of rock may break off and slide down a joint plane and onto the road.

Please refer to the April 2009 report for the assessment of this risk, which has not changed after the June 2009 observations.

Recommended Risk Level:

- Probability Factor of 4 to reflect the current inactivity of this type of rockfall but with a fall occurrence considered to be “improbable” or a “remote” probability.

- Consequence Factor of 6 because if one of the large blocks of rock were to slide onto the road, it could severely damage a vehicle and injure the occupants or require complete closure of the road for at least a period of hours before the debris could be cleared by a loader.

This generates a Risk Level of 24 for this hazard, which is less than the Risk Level for the more frequent, but lower consequence, cut slope rockfalls along this segment of the highway.

3. Low frequency, high magnitude rockfalls originating from the uppermost slopes above the highway, similar to the 2006 event that deposited boulders onto the road around Km 4.9.

The 2006 rockfall event illustrates the rockfall risk to the highway from the uppermost slopes above the road. Naturally occurring rockfalls are likely occurring frequently from these slopes, due to ongoing weathering and freeze/thaw effects on the rock face. Smaller rocks that fall from these slopes come to rest on the talus slopes above the road, however large rockfalls have enough mass and develop enough kinetic energy to bounce and roll all the way down to the road and beyond. The 2006 event had the potential to damage or destroy vehicles and at least seriously injure the occupants.

The source area for rockfalls from the uppermost slopes is widespread, as illustrated on Figure 1, therefore the exact locations or extent of potential impacts along the highway cannot be specified. Therefore, for the purposes of assessing the risk to the highway, the segment of the highway between approximately Km 4.5 and Km 6.1 should be considered at risk from large rockfalls originating from the upper slopes above the highway.

It is also understood from the Parks Division that members of the public have speculated that the use of explosive charges in the avalanche control work for these slopes will lead to an increased number and magnitude of rockfalls from the upper slopes above the highway over time. AMEC considers the likelihood of this to be low, considering the relatively small sizes of the explosive charges detonated within the snowpack on the slopes and the likely minor vibrations induced into the underlying rock slopes.

Recommended Risk Level:

- Probability Factor of 7, which corresponds to a rockfall impacting the road having occurred in the historic past (i.e. the 2006 event) but less frequently than routine occurrences or even being probable each year. This is an increase from the Probability Factor of 2 recommended in the April 2009 corridor review report, at which time the 2006 event was not known and such rockfall reaching the highway was assessed as being very improbable to improbable.

- Consequence Factor of 6 because if boulder-sized rockfall from natural slopes above the highway were to reach the road, this could damage or destroy vehicles and severely injure or even kill the occupants. Such an event would likely also require a complete closure of the road while the rockfall debris is cleared.

This generates a Risk Level of 42 for this hazard.

This is an increase from the Risk Level of 12 for this hazard that was recommended in the April 2009 corridor review report.

RECOMMENDATIONS

1. <u>High frequency, relatively low magnitude rockfalls originating from the highway cut slopes or the natural slopes a short distance above the highway.</u>

As recommended in the April 2009 report on the corridor geohazard review, the risk from these rockfalls could be reduced by:

- The installation of draped netting at selected locations along the cut slopes and natural slopes above the road to direct rock falls into the upslope road ditch or confine the debris along the toe of the cut slope in areas without a ditch.

- Posting a reduced speed limit in order to increase the time available for motorists to see and safely avoid rocks on the road.

- Establishing a maximum vehicle length permitted on this segment of the highway so that the vehicles on the narrow road will have sufficient manoeuvrability to avoid rockfall debris on the road or turn around if necessary.

Scaling of the slopes was not recommended as it would likely require a lot of effort with likely relatively little long-term or sustained reduction in the Risk Level.

Please refer to the April 2009 report for further information, along with a discussion of the pros and cons of other mitigative options.

2. Low frequency, high magnitude rockfalls around Km 5.6 where large blocks of rock may break off and slide down a joint plane and onto the road.

As recommended in the April 2009 report on the corridor geohazard review, the risk from these rockfalls could be reduced by scaling specific rock blocks from the cut slope around Km 5.6.

Please refer to the April 2009 report for further information.

3. Low frequency, high magnitude rockfalls originating from the uppermost slopes above the highway, similar to the 2006 event that deposited boulders onto the road around Km 4.9.

Short of relocating the highway or building a long and likely prohibitively expensive rockfall shed to protect the road, the risk from these rockfalls is difficult to reduce due to:

- The difficulty in accessing the rockfall source areas on the steep rock slopes several hundred vertical metres above the road.

- The large size of the rockfall source area, which places a relatively long segment of the highway at risk. It is not a matter of identifying a few potential source locations and targeting them for stabilization or proactive removal of potential rockfall material and/or protecting specific locations along the highway.

AT could consider temporarily and proactively closing this segment of the highway during times when the rockfall risk from the upper slopes is considered too high. However, this would require a very accurate and reliable characterization of the rockfall conditions in those areas in order to be practical and not excessively conservative. It is unlikely that such an effort would be practical or possible within a reasonable time frame given the large size of the rockfall source area being considered and the low frequency of events such as the 2006 rockfall that deposited rocks onto the highway. It would take many years of assessment and monitoring to develop a sufficient body of data from which to draw conclusions.

The potential for increasing rockfalls over time due to the use of explosive charges in avalanche control on these slopes could also be assessed by establishing a means of vibration monitoring in the rockfall source areas. Monitoring could then be performed during avalanche control work to see what level of vibrations are induced in the rock mass and then assessing if the vibrations are significant enough to initiate and propagate cracking in the rock face that could lead to rockfall. The above-noted repeated slope surveys to try to estimate the frequency/magnitude of rockfalls from the upper slopes might also provide insight to whether or not the rockfalls from this area are increasing over time, however it would take years to gather sufficient data to make even preliminary conclusions.

CLOSURE

This report has been prepared for the exclusive use of Alberta Transportation for the specific project described herein. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it are the responsibility of such third parties. AMEC Earth & Environmental, a division of AMEC Americas Limited, cannot accept responsibility for such damages, if any, suffered by any third party as a result of decisions made or actions based on this report. This report has been prepared in accordance with accepted geotechnical engineering practices. No other warranty, expressed or implied, is made.

We trust that this meets your needs at this time. Please contact the undersigned if you have any questions or require any further information.

Respectfully Submitted,

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a division of AMEC Americas Limited

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APEGGA Permit to Practice No. P-04546

Reviewed by:

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Attachments: Figure 1
Photo 1
AT Rockfall Risk Matrix