

#### 4.12 S15 – CROWSNEST LAKE ROCKFALL BARRIER

##### Background

The background information on this site has been documented in a number of previous reports to AIT and is summarized as follows:

- A rockfall hazard was identified in the late 1990's around a gully outlet in a rock cut slope along Highway 3 on the southeast shore of Crowsnest Lake, AB. The site is located west of Coleman, AB and approximately 4 km east of the Alberta/British Columbia border.
- A geotechnical assessment of this site was performed for AIT by another consultant in 1999. This assessment led to the construction of a 2 layer, concrete lock-block wall along the southeast shoulder of the highway and downslope of the outlet of the gully in the rock cut slope in the fall of 2000. The purpose of the wall was to prevent rockfall debris from rolling onto the highway. The adjacent rock slopes were also scaled at that time.
- An increased volume and frequency of rockfalls at this site was noted by the maintenance contractor personnel during the summer of 2003. The observed maximum size of rocks reaching the concrete lock-block wall at the toe of the slope were up to small boulder size, and on several occasions boulders rolled across the accumulated debris behind the wall and were deposited on the southeast shoulder of the road and in the eastbound lane. AMEC inspected the site and recommended that the existing concrete lock-block wall be replaced with a rockfall barrier net in order to better manage the current rockfall risk at this site.
- During the week of April 26, 2004, a boulder measuring approximately 2.2 m x 1.3 m x 0.9 m fell and was deposited on the centerline of the highway.
- The concrete lock-block wall was replaced with a rockfall barrier net in November 2005.
- A boulder measuring approximately 2 m x 1.8 m x 1.1 m struck the rockfall barrier net on April 4, 2006 and was successfully retained. The boulder struck and destroyed one of the barrier's support columns and there was also some damage to the barrier ring net and the line of concrete jersey barriers between the barrier net and the edge of the highway. AMEC responded to a call-out request by AIT to inspect the damage to the barrier after this rockfall event. Please refer to AMEC's call-out report<sup>1</sup> for details on the damage and required repairs. The repairs were completed by the maintenance contractor during the week of July 17, 2006.

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<sup>1</sup> "Report on April 15, 2006 Call-Out Request, Crowsnest Lake Rockfall Barrier Net, Highway 3:02, West of Coleman, AB", submitted to AIT on April 28, 2006.

### **Site Assessment**

The site assessment was performed on June 20, 2007. The weather at the time of the site assessment was clear and cool with blustery winds.

The assessment involved a conversation with maintenance contractor personnel (Volker Stevin) at their Coleman shop prior to travelling to site, and then a walk-around of the rockfall barrier net as well as a traverse across the slope face above the rock cut to visually inspect the conditions in the source zone of the rockfalls.

### **Observations**

The following points summarize the information from the site assessment. Please also refer to Appendix S15 for a site plan and annotated photos of the site.

- The maintenance contractor personnel reported that:
  - There seemed to be a relatively larger volume and frequency of rockfalls to date in 2007 than in previous years.
  - At one time early in 2007, three of the four barrier support posts were discovered to be lying flat on the ground as if each had been struck by a rockfall and the pins through the base of each post had been sheared off (as designed) by the impact. They noted that it was necessary to get replacement pins fabricated to re-install the barrier posts in an upright position, however there was no report or evidence of rockfall damage to the barrier posts that would be expected in this situation.
  - The accumulated debris behind the rockfall barrier had been cleaned out several times over the past year and most recently in early June 2007.
  - The east anchor ropes for the barrier had been left disconnected for ease of future access behind the barrier for the loader used to clean out the accumulated debris.
- At the time of the inspection, there was an area of ponded water behind the barrier (see Photos S15-1 and S15-2). This water appeared to be from ditch flow coming from the segment of ditch to the east of the barrier as well as groundwater discharge in the barrier area. This water was being drained by the culvert below the road however the level of the water behind the barrier appeared to be remaining constant.
- The built-up access trail used by the loader to clean out the debris from behind the barrier was still in place at the time of the inspection (see Photo S15-1). The access trail covered the east anchor pile, therefore it was not possible to check the lateral displacement of the upper portion of this pile that was noted during the 2006 inspection.

- The east anchor ropes for the barrier net that were disconnected so that that loader could access the area behind the barrier had not been reconnected and re-tensioned after the cleaning was complete. Photo S15-3 shows the disconnected anchor ropes.
- The other anchor ropes for the remainder of the barrier were relatively slack and did not appear to be sufficiently tensioned. See Photo S15-1 for an illustration.
- The third barrier support post from the left (when viewed facing downslope, i.e. the one that was replaced after the April 2006 rockfall) appears to have been struck and slightly damaged by a rock and is tilted too far towards the highway. Photo S15-4 shows this post.
- As shown in Photo S15-5, there was a broken seam rope and at least one missing barrier net ring near the third barrier support post.
- The gully headwall on the slope above the highway has continued to erode in recent years. Please refer to Photos S15-6 and S15-7 for comparative views of the gully condition from 2003 and 2007. This erosion will continue over time.
- The draped netting on the cut slope face above the rockfall barrier remains in place but as noted in the previous assessments has suffered significant damage from rockfall since it was installed during construction of the rockfall barrier in late 2005.

### **Discussion and Assessment**

It is understood that the maintenance contractor has left the east anchor ropes disconnected in order to allow future access behind the barrier for the loader used to clean out the accumulated rockfall debris. **This has significantly reduced the capacity of the rockfall barrier net and in its current state it likely only provides nominal to negligible rockfall protection to the highway.** This is a fundamental item with respect to the proper application of the rockfall barrier and must be corrected as soon as possible. As discussed in the design report for the rockfall barrier and in the April 2006 call-out report to AIT, the east anchor ropes may be temporarily disconnected as required for access during cleaning of the rockfall debris behind the barrier but they must be re-connected and all anchor ropes properly tensioned after the cleaning is completed in order to restore the design capacity of the rockfall barrier. Leaving the east anchor ropes disconnected and the remaining anchor ropes under-tensioned is contrary to the design basis and manufacturer's instructions for the barrier net.

The issue of the apparent lateral displacement of the upper portion of the east anchor pile that was noted during the 2006 inspection remains unresolved. The portion of the loader access trail covering this pile will need to be cleared away to expose the pile and visually check its condition.

The continued erosion in the upper portion of the gully above the rockfall barrier has likely caused an increase in the amount of rockfalls at this site. This erosion is expected to continue

in the future with the gully headwall area continuing to expand upslope and laterally. However, the design capacity of the rockfall barrier is judged to remain sufficient because the maximum size of rocks exposed in the upper portions of the gully are not significantly different than previously and the design rockfall case for the barrier net was for a large rock releasing from the gully headwall. The lateral extent of the rockfall barrier is also judged to be sufficient because any rolling rocks/rockfalls are channelled into the existing gully by the shape of the slope face.

The ponded water around the barrier net is likely not a significant concern because the barrier net components are corrosion protected. However, periodic inspection of the barrier net condition as per the manufacturer's instructions will need to be performed to confirm this.

The damage to the draped netting on the cut slope face above the rockfall barrier is not a significant issue because this netting was only installed as a temporary measure to protect workers from small rockfalls during construction of the barrier net. It is not relied upon to manage the risk of rockfall to the highway, therefore the damage to it is not of significant concern.

### **Recommended Risk Level**

Based on the Risk Level Criteria for rockfalls (Table A2 in Appendix A), the recommended Risk Level for this site is as follows:

- Probability Factor of 15 to reflect the active rockfall conditions at this site, with ongoing and persistent rockfalls during specific times of the year and where the area producing rockfalls is expanding. This is unchanged from the 2006 assessment.
- Consequence Factor of 6 because for the rockfall conditions at this site and with the barrier net at nominal to negligible capacity, there is a potential for rocks to be deposited on the road that are large enough to damage or destroy vehicles and severely injure occupants if struck by traffic (or potentially kill occupants if they strike a moving vehicle).

Therefore, the recommended Risk Level is 90, which is an increase from the value of 15 recommended for the site when the barrier net is properly maintained at its design capacity and the rockfall debris is cleaned out from behind the barrier as required.

### **Further Discussion**

When the barrier net capacity is restored it is expected that the barrier will continue to successfully manage the rockfall risk to the highway at this site. However, as noted in the report on the April 15, 2006 call-out, there remains a risk of a rockfall that exceeds the design case for the barrier that cannot be quantified with the available information for this site. Please refer to Section 6.2 of the report on the April 15, 2006 call-out for a discussion of this issue and AMEC's recommendations for ongoing inspection and documentation of rockfall debris accumulation at the barrier. The recommended inspection work would monitor and review the rockfall risk at this site in a proactive manner rather than simply assuming that the existing

barrier is sufficient unless proven otherwise by the barrier failing to retain a large rockfall in the future.

### **Recommendations**

AMEC recommends the following work for this site:

**The east anchor ropes should be re-connected to the east anchor pile immediately. All of the anchor ropes should be re-tensioned as per the manufacturer's instructions.** These measures are required to restore the design capacity of the barrier.

**Periodic inspections of the barrier net condition as per the manufacturer's installation, service and maintenance instructions should be performed by the maintenance contractor.** These inspections are required to confirm and maintain the barrier capacity. Copies of the manufacturer's instructions were attached to AMEC's report on the April 15, 2006 call-out request.

**The annual geotechnical inspections of this site should be continued in order to ensure that the barrier net is being properly maintained.**

**The recommendations from the April 15, 2006 call-out request report for additional work to estimate the probability of a future rockfall exceeding the barrier capacity and therefore provide a greater assurance that the existing barrier capacity is sufficient to maintain an acceptably low level of rockfall risk to the highway should be implemented.**