May 13, 2013

City of Nanaimo  
455 Wallace Street  
Nanaimo, BC  V9R 5J6

Bill Sims, AScT  
Manager, Water Resources

Dear Mr. Sims:

Lower Dam – Rebar Detection

In March and April 2013, Lewkowich Engineering Associates (LEA) carried out a number of site investigation tasks as a subconsultant to Klohn Crippen Berger (KCB). One of these tasks was coring of four holes near the left bank (north end) of the original Lower Dam concrete wall (Photo 1). This coring and concrete sampling was carried out on March 21, 2013 to investigate three topics:

- Concrete Strength;
- Check for Asbestos; and
- Search for Rebar.

The lab results on asbestos (not detected) and concrete strength are reported in a separate document.

Photo 1: Cored Holes in Lower Chase Dam, March 21, 2013
Drilling conditions were difficult due to the presence of aggregate up to approximately 75 mm diameter in the concrete. The two 75 mm (3”) diameter holes met the same horizontal rebar at a depth of approximately 450 mm (18”) from the upstream face of the 1200 mm (4 ft) thick wall, see Photos 2 and 3. The two 100 mm holes (3 and 4) could not be advanced as deep.

Photos 2 and 3: Horizontal Rebar encountered at 18” depth, Holes 1 & 2

The impression of the rebar on the broken end of the concrete core allowed a direct measurement of the rebar size (see photos 4 and 5). This indicated the rebar to be 21 mm (5/8”) square twist rebar.

Photos 4 and 5: Measurement of Rebar Size
These cored holes, and the rebar, are approximately 12” below the top of the original concrete wall and approximately 20” above the water level (see photo 6). Due to structural and environmental considerations, it was decided to continue the search for rebar using Ground Penetrating Radar (GPR), before resorting to additional random coring. However, attempts using Lewkowich’s GPR equipment in early April were not successful, even in detecting a continuation of the same rebar found in holes 1 and 2. It was thought that the coarse stone/concrete matrix and possibly water penetration were factors in limiting the GPR effectiveness.

A further attempt on April 23, 2013 using more powerful GPR equipment operated by First Call was much more successful. Photos 6 and 7 show the GPR “hits” resulting from this survey, marked with red paint on the upstream face of the Lower Dam. Note the 1980 wall addition sitting on top of the original 4 ft thick concrete wall.

Photos 6 and 7: GPR “hits” marked on upstream face of Lower Dam, April 23, 2013

- Red horizontal dashes mark the continuation of the rebar found in cored holes 1 and 2.
- No evidence of another horizontal rebar was found between the top of the original wall and the water surface.
- The red “dots” mark protruding wires, probably form ties.
- No evidence of vertical bars was found except right down at water surface. These “hits” were at a regular spacing of approximately 30” and were unrelated to possible interference from the form ties etc.
- Despite a thorough GPR “search” of the wall face above the water, no evidence of the continuation of any of these (presumed) vertical bars could be found.
Implications of Rebar - Seismic

The presence of rebar in the Lower Dam wall was considered in the final stages of KCB’s seismic analysis of dam failure and rehabilitation options. It was confirmed that 5/8” bars at 30” centers, as indicated by the field investigations, is much too light to significantly resist the flexural forces, wall movement and cracking in a seismic event (either 1:500 year or 1:10,000 year). Therefore, the seismic analysis conclusions for the wall and dam, and for jet grouting rehabilitation, with or without this amount of rebar, are essentially the same.

Implications of Rebar - Demolition

Similarly, given the concrete strength and condition, this relatively light and widely spaced rebar is not expected to significantly effect wall demolition methods or coats. The tender documents will clarify the expected amount of rebar in the wall.

Implications of Rebar – Dam Failure in Overtopping Flood

Lastly, the question of wall “robustness” in the flood over-topping scenarios (without earthquake) has been considered. Given that the 1980 upper wall addition is assumed to be reinforced, the assumed failure mechanism in the case of flood overtopping is the erosive loss of the downstream slope as the flood overtops the “resistant” upper wall. When wall support from the downstream fill is lost, the lower wall will fail due to the lateral pore pressure from the full reservoir (above crest height) acting on the upstream face.

A structural check on this scenario, by KCB, has found that the elevation of downstream slope support removal at which the wall fails will be only approximately 3m lower with rebar than without. Light reinforcement in this lower wall may slightly delay wall failure, but will not prevent it. The wall failure and full breach development, when it occurs, will still occur within a few minutes, as assumed in Associated Engineering 2012.

Note that Associated Engineering 2012 assumed that, for the over-topping flood dam failure scenarios, the Lower Dam will fail and drain much quicker than the Middle Dam. Therefore the highest downstream peak flood flow rate is related to the Lower Dam failure only and does not depend on a timing coincidence. A slight delay in failure of the Lower Dam due to rebar will not reduce the peak flood rate or the damages and impacts of these scenarios.

Conclusions

- The GPR survey encountered evidence of vertical rebar near the centre of the 4 ft thick wall, at 30” spacing, for a short distance just above water level. The extent of rebar below water level is unknown.
- One horizontal 5/8” square twist rebar was encountered approximately 12” from the top of the original concrete wall, apparently extending along most of the wall length. If the 30” spacing was also used for the horizontal bars, the next bar would be below the water level shown in photos 4 and 5.
The presence of this small amount of rebar does not significantly affect the performance of the wall in a seismic event compared to an unreinforced wall.

The presence of this small amount of rebar does not significantly affect the method or cost of demolition.

The presence of this rebar may somewhat delay the failure of the Lower Dam due to overtopping of the Middle Dam in a flood event (no earthquake), but will not prevent it. This slight change in time-to-failure will not affect the previously-estimated downstream damages and impacts.

Yours truly,
KLOHN CRIPPEN BERGER LTD.

Chris Grapel, P.Eng.
Manager – Civil Projects

Robin J. FitzGerald, P.Eng
Principal, Water Resources

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