

April 21, 2017

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Devon van der Meulen
Manager of Utilities
District of Summerland
Box 159
Summerland, BC V0H 1Z0

Re: THIRSK SPILLWAY - ANCHOR LIFT-OFF TESTING

Dear Mr. van der Meulen:

Associated Engineering was retained by the District of Summerland to review the results of the anchor lift off tests, conducted on November 30 and December 1, 2016 by Dywidag Systems International (DSI).

1 BACKGROUND

The Thirsk Arch Dam and spillway was originally constructed by the District of Summerland in 1940/41. In 2006 the Thirsk Arch Dam was raised and the spillway replaced to provide additional storage capacity. Today, the Thirsk Dam consists of three separate structures: a concrete gravity spillway (14 m high by 125 m long), a concrete arch dam (26 m high), and an earth-filled saddle dam.

The gravity spillway is divided into 18 blocks, with each block designed to be stable under normal hydrostatic loading, assuming the drains are effective. Each block is also anchored at the heel (upstream foundation level) to provide stability under ice, flood and earthquake loading. See attached Drawing #2143-1-307. The anchors were designed to be post-tensioned (stressed) to "clamp" the spillway to the rock foundation. If the anchors lose their post-tensioning, the dam will have reduced safety against overturning and sliding.

The anchors are post-tensioned, double corrosion protected, 63 mm diameter, Grade 550/730 MPa Dywidag Threadbar. The anchors vary in length from 13 to 20 m and were installed and tested between November 2006 and March 2007. The anchors have alternating 6 m and 10 m free-stressing lengths, plus a minimum 5 m bond length, with a design working load of 1030 kN. The anchors were installed, grouted and performance tested to 1460 kN and were then locked off at approximately 1380 kN.

The lock-off load exceeds the design load to allow for losses, which include seating losses, creep in the steel, creep in the grout, and creep in the rock.

Typically losses occur due to creep in the anchor steel, anchor grout, concrete and grout under the anchor base plate or other undetermined causes.

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2 LIFT-OFF TESTS

The dam operation manual specified that 25% of the spillway anchors be re-tested after seven years in service. The District of Summerland retained Dywidag-Systems International (DSI) to conduct the lift-off tests specified in the dam maintenance manual. The reservoir was drawn down in November 2016 to provide access to the anchor heads. The District of Summerland retained a contractor to remove the grout from the anchor pockets after the reservoir was dewatered. The lift-off tests on the selected anchors were carried out on November 30, 2016 and December 1, 2017. The lift-off tests utilized a calibrated jack, hydraulic pump, and pressure gauge supplied by DSI.

We have attached the anchor testing results from DSI, which include a jack calibration and anchor test report for the lift-off tests.

3 DISCUSSION

The lift-off tests indicate that all of the tested anchors are post-tensioned to a greater force than the specified design load, 1030 kN. However, the results vary from 1036 kN to 1421 kN, which indicates a significant variability in the anchor losses.

A few of the anchors have lost approximately 25% to 30% of their original post-tensioning. This significantly exceeds the losses that we expected. Typically most of the losses would occur in the first year or so. If that is the case, and no significant losses are continuing to occur, the anchor tension is now acceptable. However, if the losses are continuing to occur, some of the anchors may drop below the specified working load in the future. Because we only have two data points (testing in 2006/2007 and 2016), we cannot confirm that the creep has stabilized. Typically losses occur shortly after construction and we anticipate that ongoing losses are very small; however, to be prudent, we recommend that the spillway re-stressable anchors be re-tested in one or two years time to confirm that the anchor tension losses have stabilized. At that time, we also recommend testing additional anchors in Blocks #13 to #15 (tallest blocks with the greatest demands), to ensure they are performing as intended.

However, it may be possible to extend the time to the next anchor testing, by re-evaluating the spillway block stability. The original spillway design was based on the Canadian Dam Association (CDA) – “Dam Safety Guidelines”, issued in January 1999. This was the standard in force at the time of the design. The Canadian Dam Safety Association updated the Dam Safety Guidelines in 2007. This current version of the Guidelines has re-classified the Probably Maximum Flood load case as an extreme event, with reduced performance factors. This is the controlling load case in the spillway design and the re-classification effectively reduces the demands on the spillway anchors.

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Our preliminary assessment is that the demands on the anchors will be reduced, with the potential to extend the time to anchor re-testing. We recommend that we confirm this preliminary result with a detailed updated stability analysis using the performance factors in the current Dam Safety Guideline. If the reduction in the anchor loads is confirmed, this will provide a rationale for extending the anchor re-testing to four or five years. We estimate that this additional stability analysis would cost about \$6,000 to \$7,000 plus applicable taxes.

Yours truly,

Dale B. Harrison, P.Eng.
Senior Structural Engineer

Shane Cook, M.A.Sc., PMP, P.Eng.
Manager – Bridge Rehabilitation

DH/SC/lp