May 7, 2010

Mr. Rick Goldt, CET
Supervisor, Water Control Structures
Upper Thames River Conservation Authority
1424 Clark Road
London, Ontario
N5V 5B9

Dear Mr. Goldt,

Re: Springbank Dam, London, Ontario
South Bank Steel Sheet Pile Inspection 2010

Further to our correspondence of December 17, 2009, we are pleased to present below results of our inspection on 2020 02 11 and 2010 03 of the steel sheet pile wall located on the south bank upstream of the Springbank Dam.

As built Steel Sheet Pile Details

We confirmed externally visible as built details from drawings dated July 21, 1969 for the Springbank Dam Rehabilitation during our inspection. Figure 1 and 2 attached show the elevation of the steel sheet pile wall and the typical cross section through the wall. An anomaly was noticed when reproducing Figure 2 and as built section through the wall. The anchor blocks on the as built drawing are not drawn to the elevation noted. Figure 2 shows the anchor block much deeper in accordance with the as built elevations. The length of the steel sheet pile wall measured from face of the dam east is some 31.27 metres. The concrete parapet on top of the steel sheet pile wall is 31.38 metres long and overhangs the east end of the steel sheet piling. There are nine tie rods along the length of the wall at a spacing of 3.15 metres or every third steel sheet pile inpan. The tie rods are 1.45 metres below the under side of the concrete parapet. The steel sheet pile is a Z shape profile. The distance between out pan flanges is 1.05 metres, which equates to 0.525 m between interlocks. The thickness of the flange and the web of a typical pile were measured above the high water mark, where there is no significant corrosion. The thickness was measured using an ultrasonic measuring device. The measured flange thickness was 12.4 mm and the web thickness was 10.0 mm. Conversions of the imperial measurements, on the as built drawings, indicate a flange thickness of 12.7 mm and a web thickness is 9.9 mm. We are confident that the steel sheet pile profile is a Hoesch 155 profile from these measurements. No legible mill markings were found to further confirm the steel sheet pile profile.

Steel Sheet Pile Wall Condition

The wall is heavily corroded below the high water mark which was measured to be 1.04 metres below the underside of the concrete parapet. Generally, the rust scale from the corrosion remains attached to the steel sheet pile inpan flanges, partially on the webs of the piles and within the joint of the interlocks on the out pans. The surface of the steel has significant pitting. Inspection under the rust scale revealed the same surface condition. Only light surface corrosion exists above the high water mark. The typical condition of the wall may be seen in the attached photos log.

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As mentioned above, ultrasonic thickness measurements were taken above the high water for a background steel thickness check and at several locations below the high water marks to determine the corroded thickness of the steel sheet piling. The loss of steel thickness was calculated based on difference between the theoretical thicknesses of the flange and web of the pile and the readings taken. Results are presented in Table 1, below. Fluctuation in the readings was observed due to the pitted nature of the steel surface. Typical prepared surfaces prior to measuring the thickness may be seen in Photos 11 through 10.

Table 1

Measurement	Thickness	Theoretical Metal Loss	Measurement Location
T1	12.4 mm	nil	Outpan flange, above high water, west of tie rod # 8
T2	10.0 mm	nil	Web, above high water, west of tie rod # 8
T3	9.7 mm	3.0 mm	Outpan flange, 1 m below high water west of tie rod # 7
T4	5.7 mm	4.2 mm	Web, below 1 m high water, west of tie rod # 7
T5	7.1 mm	2.2 mm	Web, 1 m below high water to west of tie rod # 7
T7	7.2 mm	5.7 mm	Outpan flange, 2.9 m below high water east of tie rod # 4
T8	7.1 mm	2.8 mm	Web, 2.9 m below high water east of tie rod # 4

The average loss of steel sheet pile thickness loss based on the measurements taken is 3.6 mm. A modified section modulus based on uniform loss of steel is estimated to around 1700 to 1800 cm^3/m. This is approximately 10 to 15 % less than the original section modulus of 2000 cm^3/m for a Hoesch 155 profile. The actual corroded section modulus may vary since steel surface is pitted and irregular and is not uniform as assumed to determine the modified section modulus.

Tie Rod and Wale Bolt Condition

A thick rust scale exists on the exposed tie rods ends, nuts and beveled plate washers and on the wale bolts and plate washers. A typical tie rod, nut and beveled plate washer assembly was cleaned off and the tie rod diameter and the width across flats of the tie rod nut were measured to obtain a sense of steel loss on these elements. Photos 11 through 18 show these elements. The nominal diameter of the tie rod as shown on the plan is 50.8 mm (2"). The existing diameter was measured on the threaded tie rod portion beyond the nut using calibrated calipers. The diameter measured 42 mm ($1^{21}/_{32}$"). The threads were very rounded with little distinction between the crest and root of the threads, as may be seen in Photo 14. The measured distance across the flats on the tie rod nut was 69 mm ($2^{23}/_{32}$"). Typically the distance across the flats of a nut for a 50.8 mm rod is 80 mm. These two measurements indicate a steel surface loss 4 mm and 5.5 mm, respectively. Similarly a measurement was taken across the flats of the head of the wale bolt. Typically for a 22 mm ($^{7}/_{8}$") diameter bolt the distance across the flats on the bolt head is 33.3 mm ($1^{5}/_{16}$"). A distance of 29.4 mm ($1^{5}/_{32}$") was measured indicating a surface loss of 2 mm.

All bolts are secure at this time but further corrosion may lead to connection failure. Connection may be lost as threads corrode inside the tie rod nut. Also reduction in size of the wale bolt head may eventually result in bolt pulling through the wall or becoming slack. Determination of any loss in tie rod and bolt diameters requires excavation for inspection. This will also permit the double channel wale to be inspected. The wale serves as a beam element to distribute the individual tie rod loads to the steel sheet pile wall. The distribution occurs through the wale bolts that attach the wale to the steel sheet pile wall.

Steel Sheet Pile Wall Inclination

Vertical inclination of the steel sheet piling was measured to the west of several tie rods, to determine if the corrosion has increased the increased deflection of the steel sheet piles. The distance off vertical was measured in millimeters over the length of a 1,220 mm long spirit level. The verticality measurements are presented in Table 2, below. No excessive deflection in the vertical alignment was observed. A visual check along the length of the wall showed no irregular horizontal alignment. See Photos 19 through 21.

Table 2

Measurement	Inclination (mm/mm)	Inclination (degrees)	Comments
I1	13/1220	0.61	1.2 m below tie rod # 2, toe out
I2	5/1220	0.24	2.4 m below tie rod # 2, toe out
I3	18/1220	0.85	1.2 m below tie rod # 3, toe out
I4	15/1220	0.70	2.4 m below tie rod # 3, toe out
I5	20/1220	0.94	2.2 m below tie rod # 4, toe out
I7	12/1220	0.56	1.4 m below tie rod # 5, toe out
I8	20/1220	0.94	0.8 m below tie rod # 6, toe out
I9	14/1220	0.66	0.0 m below tie rod # 7, toe out

Structural Assessment

A quick check of the wall using a free earth analysis with a low water of 6.5 metres below the top of wall and soil properties of a typical granular backfill and existing dense sand below river bend was done. European yield strengths of 265 MPa and 235 MPa steel were considered. The check indicated some reserve capacity existed in the original design. The selection of the sheet pile for the rehabilitation in 1968 may have considered the need for a robust pile section to drive to refusal. Further analysis was completed using the modified section modulus. Preliminary indications suggest that there is presently adequate safety factor in the strength of the piles. The field measurements of the wall inclination were found marginally greater than those obtained through analysis using the modified section modulus. The actual steel strength and soil properties and design surcharge are necessary to complete a more accurate analysis.

At the present time the steel sheet pile wall does not appear in any imminent danger of failure. Localized failure of bolts and connections may occur if remedial action is not taken.

Recommendations

It is recommended that the tie rods and wale bolts inside the wall be exposed and inspected for corrosion to confirm their condition. This would require saw cutting and removal of the pavement surface and excavation of the backfill behind the wall to expose the wale, tie rods and wale bolts. The inside face of the steel sheet pile wall and double channel wale may be inspected for corrosion at the same time. After completion of this additional inspection more definitive recommendations regarding remedial measures may be made.

The inspection costs estimated below are for opening up only two adjacent tie rods and interconnecting wale and wale bolts.

Pavement Removal and Replacement	$3,000.00
Excavate and Backfill with Compaction	1,500.00
Inspection of Wall Elements with Report	1,500.00
Contingency 20%	1,200.00
Total Estimate	$7,200.00

At this time without further inspection replacement of the wale bolts is anticipated along with reinforcing of the tie rod connections on the outside face. Further inspection may reveal the need to replace the waling. Also, localized reinforcement of the piling will be required in due time if corrosion continues.

Repairs should be anticipated in the next five years. Our preliminary estimate for wale and wale bolt replacement with an allowance for possible tie rod repairs is as follows:

Pavement Removal and Replacement	$12,000.00
Excavate and Backfill	5,000.00
Wale and Wale Bolts	16,000.00
Tie Rod Repair Allowance	7,000.00
Contingency 20%	8,000.00
Total Estimate	$48,000.00

Alternatively, as recommended above a test pit could be excavated to confirm the tie rod and wale condition inside the wall.

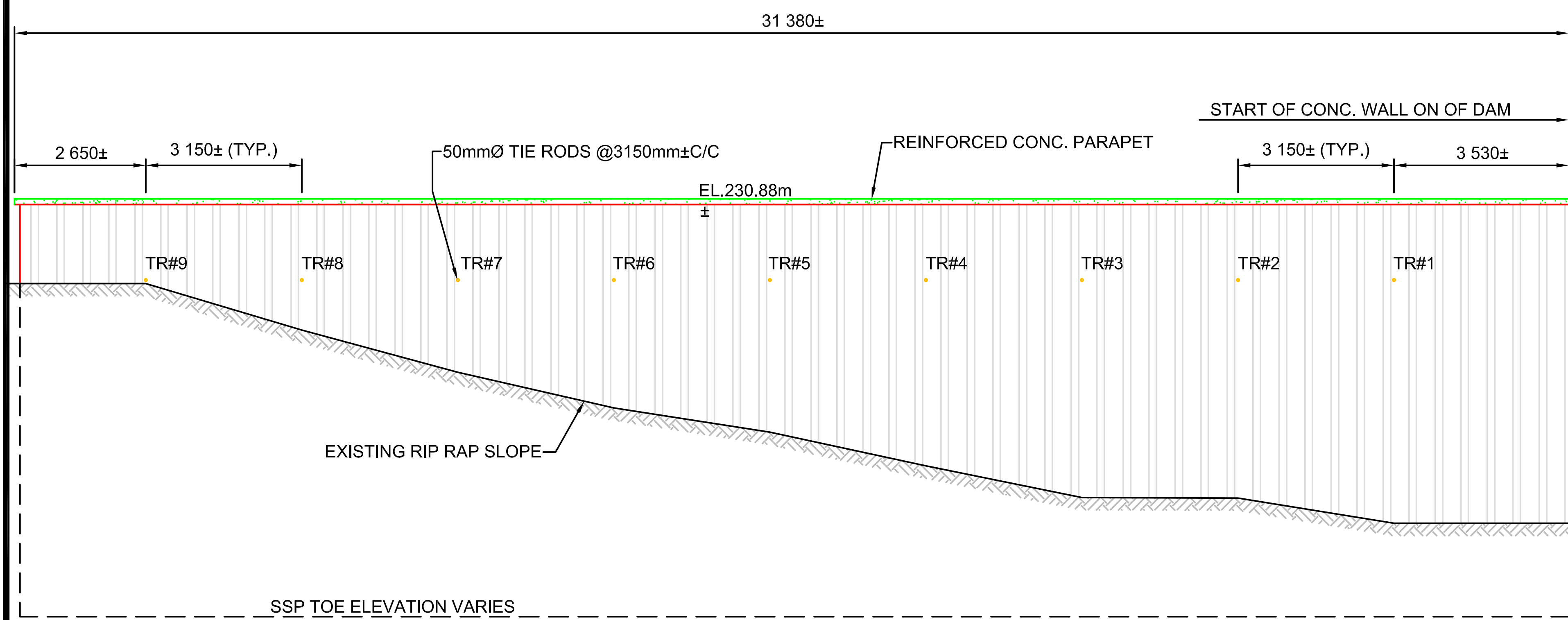
Should you require additional information, please do not hesitate to call.

Yours truly,

Philip Lampkin, P.Eng
Senior Engineer

LICENSED PROFESSIONAL ENGINEER
P.F.F. LAMPKIN
2010.05.07
PROVINCE OF ONTARIO

NOTE:
STEEL RAILING IS NOT SHOWN IN THIS ELEVATION VIEW.



LEGEND

TR#3 TIE ROD

FIGURE 1
ELEVATION

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CLIENT UPPER THAMES RIVER CONSERVATION AUTHORITY

0 1 2 4m 1:125

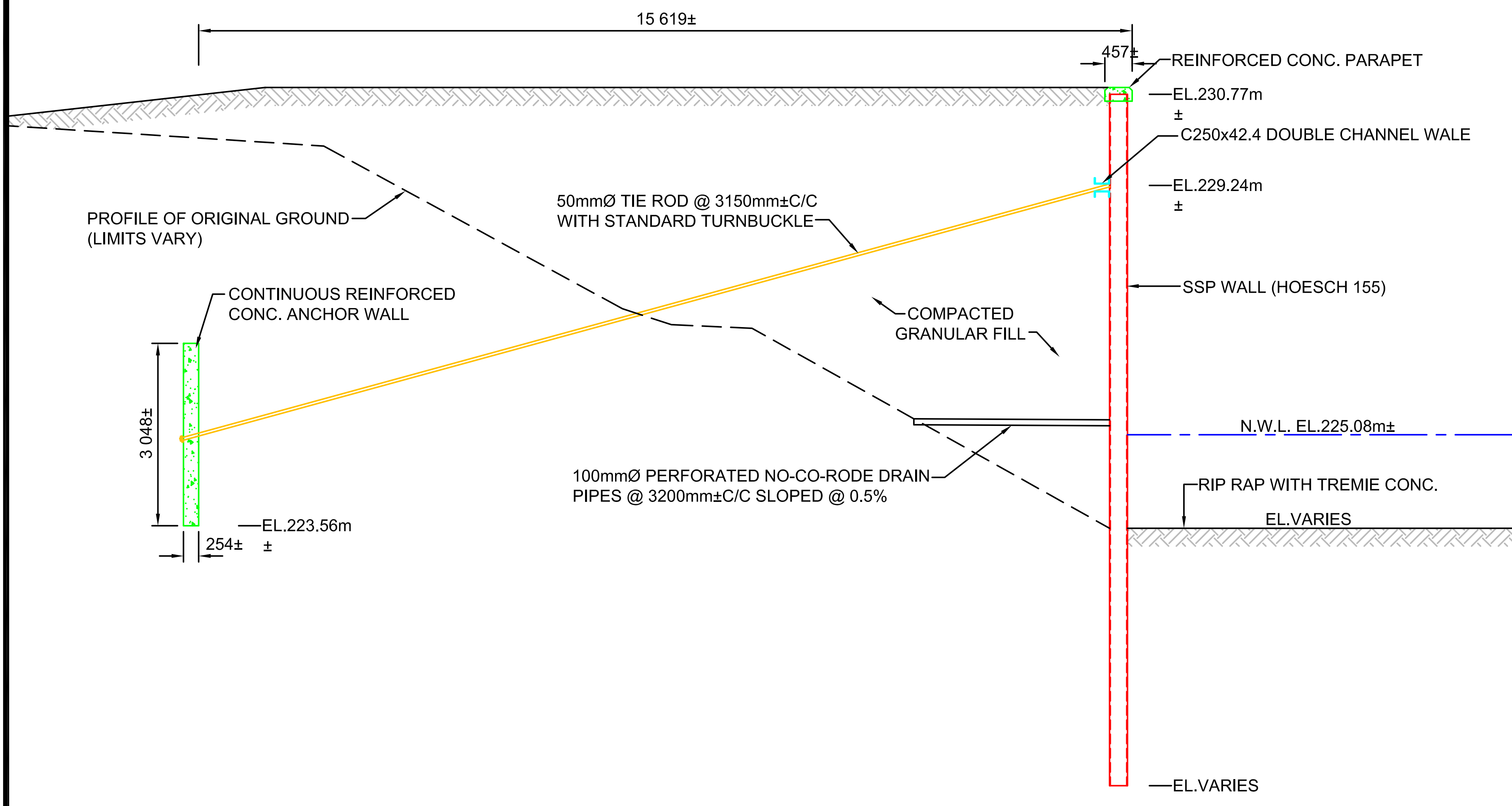

FIGURE 2

TYP. SECTION

CLIENT

UPPER THAMES RIVER CONSERVATION AUTHORITY

0 0.5 1.5 3m

1:100

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Photo #1 – Front Elevation, east end of wall.

Photo #2 –Front Elevation, east end of wall at embankment. High water mark visible.

Photo #3 – Face of wall viewing west toward upstream face of dam.

Photo #4 – Evident corrosion and pitting on face of outpans. Rust scale on inpans and partially on webs and interlocks.

Photo #5 – Face of wall viewing east up the bank line.

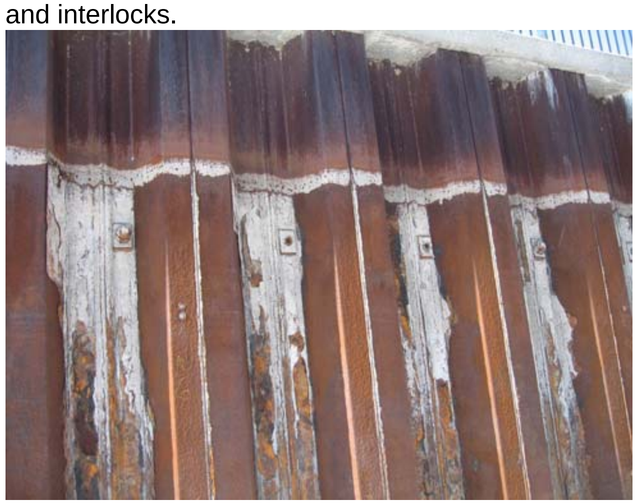

Photo #6 – Tie rod shown every third inpan. Heavy corrosion below high water mark.

Photo #7 – Prepared surface for steel sheet pile thickness measurement at location T1 above high water mark.

Photo #8 – – Close up of prepared surface for thickness measurement at location T1 & T2.

Photo #9 – Prepared surface for thickness measurement at location on T4 & T5 steet sheet pile web.

Photo #10 – Prepared surface for thickness measurement at location on T8 on web with rust scale to the right.

Photo #11 – Typical corroded tie rod , tie rod nut and bevelled washer at tie rod #7.

Photo #12 – Measurement across the flat on tie rod nut #7.

Photo #13 - Measurement across the tie rod on tie rod #7.


Photo #14 – Tie rod nut and assembly clean of rust scale. Tie rod thread root and crest rounded and barely visible.


Photo #15 – Wale bolt assembly.


Photo #16 – Partially cleaned wale bolt assembly.


Photo #17 - Wale bolt assembly cleaned of rust scale.

Photo #18 – Measurement across the flat of the wale bolt.

Photo #19 – Horizontal alignment of top of wall at rail height.

Photo #20 – Horizontal alignment of top of wall at concrete cap height.

Photo #21 – Vertical alignment of face of wall, viewing west to dam

Photo #22 – Vertical alignment of face of wall along face of wall viewing west to dam.