
Project Number: MB44022

Date: 16 October 2023

To: Regional District of Nanaimo
6300 Hammond Bay Road
Nanaimo, BC, V9T 6N2
c/o Scot Merriam, P.Eng., SRM Projects

Attention: James Haddou, P.Eng., Manager, Capital Project Delivery, jhaddou@rdn.bc.ca

Project: GNPCC – Grit and Primary Sedimentation Tanks Refit
RE: Evaluation of Concrete in Grit and Sed Tanks 1 to 3, Revision 01

This Revision supersedes Revision 00 issued on 5 October 2023

Dear James,

As requested by the Regional District of Nanaimo and SRM Projects, Metro Testing and Engineering Ltd. (Metro) performed a limited concrete condition evaluation of the concrete of GNPCC's Nos. 1 to 3 Grit and Sedimentation Tanks at 4600 Hammond Bay Road in Nanaimo. We understood that the purpose of our work was to assist the Regional District of Nanaimo in estimating the remaining service life of the facility, and the likely effort for maintenance and repair.

Metro's general scope of work was limited to evaluating the current condition of the concrete walls and floor of the tanks by means of visual observations, sounding for delamination, and extracting a small number of cores for compressive strength and neutralisation (carbonation) tests in the laboratory. The following report presents our methodology and findings.

Note that Revision 01 of this report presents a corrected Figure 2, but otherwise remains substantially unaltered.

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1 Summary

The Regional District of Nanaimo asked Metro Testing and Engineering Ltd. (Metro) to perform a limited concrete condition evaluation on Grit and Sedimentation Tanks Nos. 1, 2 and 3 at the Greater Nanaimo Pollution Control Centre (GNPCC). Metro visited the site for observations, tests and sample extraction, and tested core samples in the laboratory. Our key findings were:

- The concrete appears to be in generally good condition considering its age and environment. In regard to coated locations of the sediment tanks, the surface was rough from previous surface preparation (prior to coating) but appeared sound underneath the coating. Uncoated areas of the wall had a soft, highly deteriorated, and easily removed surface approximately to the depth of the coarse aggregate. The concrete appeared sound beyond approximately 10 to 12 mm from the current surface. However, examination of the surface of the test area recently treated by high-pressure water jetting suggests that the total depth of removal (loss to scaling plus remaining deteriorated material) may be in the order of 25 mm
- Cracks and joints in walls shared with water filled tanks were generally dry with only two very minor leaks
- Surface damage, likely due to H₂S exposure, is moderate and generally to the depth of the coarse aggregate. The surface deterioration of the columns, primarily due to the presence of larger surface voids and bug holes, was deeper than the walls. However, no reinforcing steel was exposed
- Concrete directly exposed to waste water or H₂S is deteriorating, with a depth of neutralisation of very approximately 10 mm to 12 mm
- Previously repaired concrete, when coated with what appears to be an epoxy, has performed quite well, with no obvious further damage
- The black elastomeric top coating in the grit tanks is blistering at numerous locations. At the water filled blisters, this top coating could easily be peeled from the underlying, lightly coloured coating. The underlying coating appears to be well bonded. However, its nature was not determined

2 Introduction

The Regional District of Nanaimo asked Metro Testing and Engineering Ltd. (Metro) to perform a limited concrete condition evaluation on Grit and Sedimentation Tanks Nos. 1, 2 and 3 of the Nanaimo Pollution Control Centre. Metro visited the site on 28 June, 19 July, and 11 August 2023 and observed the condition of the concrete on site, after the respective tanks had been emptied and pressure-washed. Metro also was present on site on 30 August 2023 for other business, and had the opportunity to observe a water-blasted mock-up surface, which had been prepared for the test application of the proposed repair materials. The tanks were generally dry at the time of our inspections with only very minor leakage from adjoining tanks that were full of liquid.

The purpose of this assessment was to provide information that would guide the preparation of documents and specifications for life extension work of these structures scheduled for 2024 and beyond.

This report documents our visual observations and results of testing carried out on site and subsequently in the laboratory.

Figures 1 and 2 following provide an aerial view of the site location.

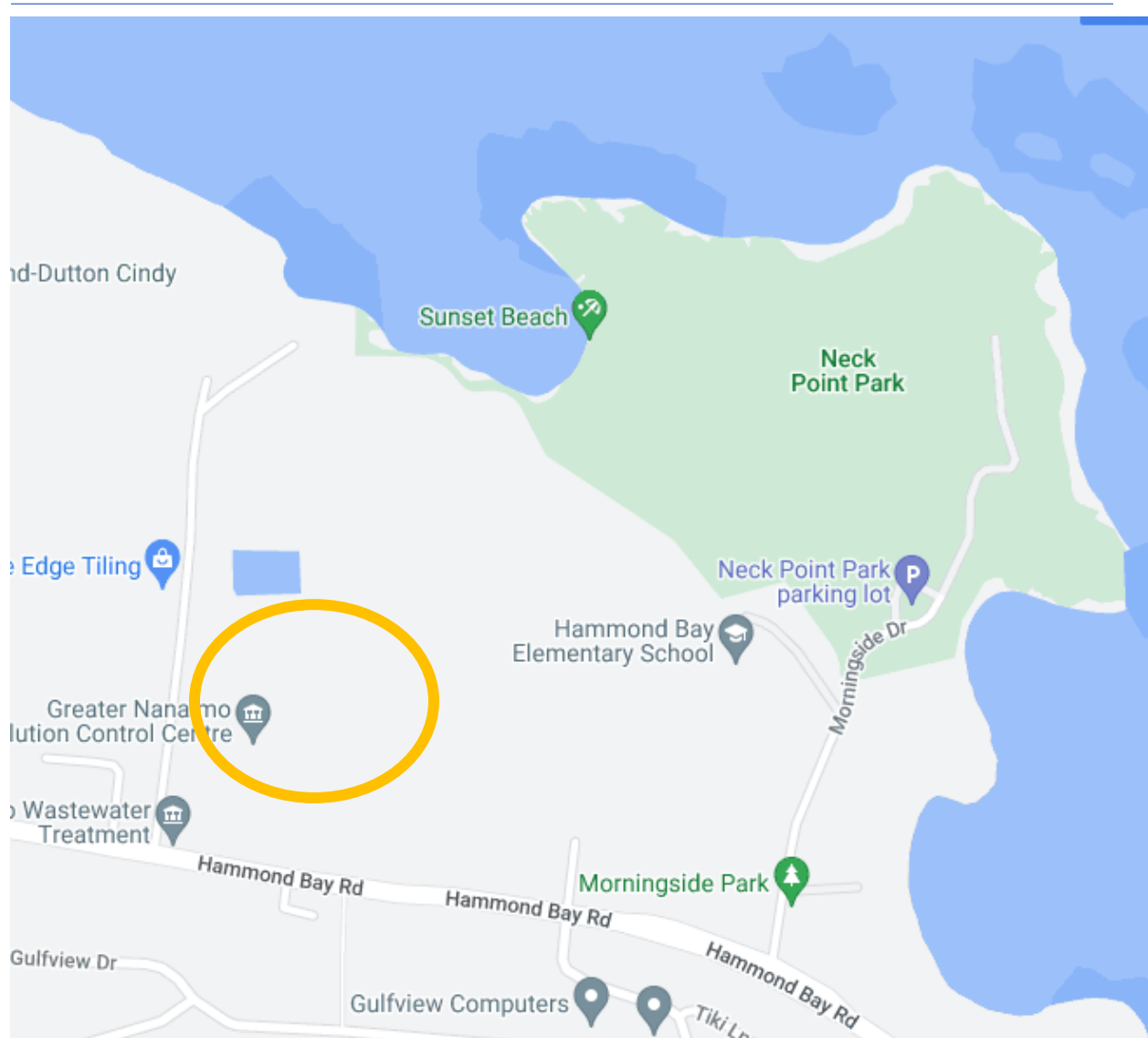


Figure 1 – Location of the Plant (Source: Google Maps)



Figure 2 – Image of the area with the tanks (Source: Google Maps) Sedimentation Tanks 1, 2 and 3 outlined in Yellow, Green, and Blue, respectively. Grit Tanks immediately to the South (bottom) of the Sediment Tanks.

3 Background Information

The original Waste Water Pollution Control Centre was completed in 1973. The early plant included Sedimentation Tanks 1, 2, and 3 and Grit Tanks 1 and 2. Sedimentation Tank 3 was originally used as a chlorine contact tank, and later converted to a sediment tank. Grit Tank 3 was constructed in 1989. There have been several major upgrades since that time that are beyond the scope of this investigation. This investigation was initiated in order to assess the general quality of the concrete and provide specific information that may be required for these 6 structures in advance of planned life extension work to be carried out.

4 Scope of Work

Metro's general scope of work was to:

- Visually assess the condition of the tank walls and floors
- Hammer sound representative surface areas of the walls and carry out a chain drag of the floor of the sediment tanks
- Determine the depth of neutralization by drilling chipping and coring
- Extract a limited number of cores for visual evaluation, determination of the depth of neutralization, scratch hardness, and compressive and direct tensile strength testing
- Visually evaluate the depth to which the concrete may have noticeably softened or otherwise deteriorated

5 Guidelines

The following guidelines and standards were used and applied, in part or as needed, by Metro:

- EGBC's Professional Practice Guidelines: *Expert Witness*
- EGBC's Professional Practice Guidelines: *Intellectual Property*
- EGBC's Quality Management Guidelines
- CSA A23.2-14C: *Obtaining and testing drilled cores for compressive strength testing*
- CSA A23.2-9C: *Compressive strength of cylindrical concrete specimens*

6 Evaluation Methodology

6.1 Visual Observations

Visual evaluations are usually performed from distance and close-up, with unaided eyes, or simple magnifying glasses. The purpose of the field observations was to estimate the extent of visible damage to the tank, such as the growth of exterior cracks or honeycombing. For this project, Metro performed visual observations of the inside walls, columns, and floor slab.

6.2 Ground Penetrating Radar (GPR)

Metro used a Ground Penetrating Radar (GPR) device in order to determine the presence of horizontal reinforcing bars in the structure covered with concrete. Use of the GPR allowed Metro to extract cores without the risk of hitting rebar.

GPR is a time-dependent geophysical technique that can provide a 3-D pseudo image of the subsurface. When, during the scan on a concrete surface, the instrument's antenna crosses a linear object (pipe, cable, rebar) at a right angle, the resulting image looks like an inverted "U"; commonly referred to as a hyperbola (Figures 3 and 4). This image geometry is a result of the emitted beam being cone shaped, and thus the radar antenna can see the target not only when on top of it, but also from offset scanning positions. The summit of the hyperbola is reached when the antenna is immediately above the target. A mark or laser beam situated at midpoint between transmitter and receiver on the antenna housing allows the instrument operator to match the display image to the projected target position. Metal objects produce strong, clear reflections. By contrast, the reflection from a low-density object, like a PVC pipe, will have a similar shape, but a lower amplitude, and thus lower-contrast image. It may also be phase-shifted by 180° (manifested by black-grey-black patterns rather than white-black-white).

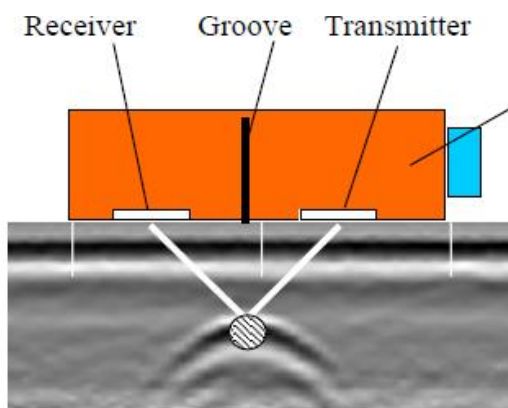


Figure 3 - GPR detection fundamentals.

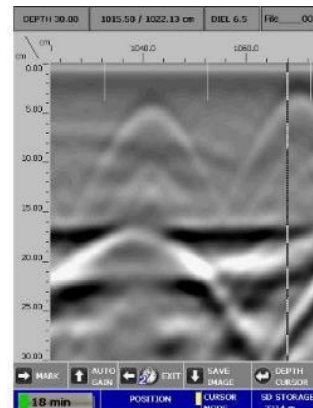


Figure 4 - Example of GPR data display.

6.3 Coring

Coring was conducted using a drill rig equipped with water-lubricated 50 mm and 70 mm ID, diamond tipped core barrels, as required. We followed applicable guidance by CSA A23.2-14C for the extraction and care of the core samples for compressive and tensile strength testing.

6.4 Core Observations and Scratch Testing

In addition to the specific tests above, Metro conducted general observations on the extracted core samples. These results aid in increasing the accuracy and certainty of Metro's findings and subsequent recommendations. These observations include estimating air entrainment, depth of neutralisation measurements, concrete density measurements, and Moh's Hardness scratch tests.

6.5 Compressive Strength Test

We conducted compressive strength tests on cores in the dry condition per CSA A23.2-14C. The calculation of the strength followed CSA A23.2-14C, including correction for L/D-ratios, where necessary.

6.6 Direct Tensile Strength Test

Of the 6 cores extracted, 2 were cut in half to produce 4 test specimens and used for direct tensile strength testing following a procedure derived from CSA A23.2 - 6B.

7 Test Results

7.1 Visual Observations

7.1.1 General conditions

Metro visited the site several times for observations and sample extraction. The table below summarises the site visits:

	Tank		
	Grit and Sed. 1	Grit and Sed. 2	Grit and Sed. 3
Date	28 June 2023	July 19 2023	11 August 2023
Time	08:40 – 16:20	9:00 - 13:00, 17:00 -20:00	08:10 – 14:20
Ambient	Sunny, dry, estimated air temperature 20 – 25°C	Sunny, dry, estimated air temperature 25 - 29°C	Sunny, dry, estimated air temperature 20 – 25°C
Concrete surface	Mostly dry, 20-25°C	Dry	Mostly dry, 20-22°C
Metro Staff	Roland Heere	Neil McAskill	Roland Heere, Greg Wilson
Scope of evaluation on site	Visual evaluation, limited rebar cover survey, hammer sounding and chain drag for delamination. Chipping shallow holes for depth of neutralisation tests. Core and patch holes.	Sed Tank: Visual evaluation, hammer sounding of walls, chain drag of floor. Core and patch holes. Grit tank: Hammer sounded several locations on walls and floor. Measured depth of neutralization on walls and floor at several locations.	Visual evaluation, limited rebar cover survey, hammer sounding and chain drag for delamination. Chipping shallow holes for depth of neutralisation tests. Core and patch holes.

Samples taken	4, 50 mm diameter cores from Sed. tank walls for depth of neutralization testing.	4 small diameter cores from Sed tank 2 for determination of depth of neutralization	3, 75 mm diameter cores each, from Sed. and Grit tanks for compression, scratch hardness and depth of neutralization
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7.1.2 Condition of the No. 1 Sedimentation Tank

In general, the concrete surfaces appeared to be firm. The South wall, and portions of the East and West walls (near the South wall), as well as the centre wall segments, had the appearance of epoxy-coated exposed aggregate concrete. The remaining surfaces were largely exposed concrete of a smoother texture. However, a small portion of the exposed concrete surfaces showed significant erosion, to a depth of several millimetres. Of note was that the East wall was completely dry, even though the adjacent tank was filled with sewer water. None of the joints and cracks of the E, S and W walls were wet or leaking. One minor leak was found towards the effluent discharge channel (N wall). Of further note was that no significant concrete deterioration was visible at the scum line (approximately 2.9 m above main floor level at approximately mid-length of E wall).

Hammer sounding of the walls (from bottom to approximately 2.2 m above floor level) did not identify any concrete delamination. A stiff polymer coating adhered almost fully and appeared to be strong and durable. Only minor delamination of that coating was detected at the edge between walls and floors. It appears that the delaminated material may have been spilled unintentionally during the previous repair.

Hard strikes with the narrow end of a masonry hammer revealed that the outer two to three millimetres of the exposed concrete were softer than concrete at greater depths. Treatment of these shallow exploration holes with phenolphthalein indicated that exposed concrete was typically neutralised to a depth of approximately 10 to 15 mm. Depth of neutralisation in coated concrete appeared to be near zero. A rebar cover survey at several locations indicated that the concrete cover over rebar was typically >40 mm, with the exception of approximately 30 mm for columns.

Metro extracted 4 short core samples, with nominal 50 mm diameters, from the East and West walls. These holes were patched with SikagROUT 212.

7.1.3 Condition of the No. 1 Grit Tank

In general, the concrete surfaces appeared to be firm. The South wall, and portions of the East and West walls, had a black, tough, polymeric coating. The coating adhered well where free of

blisters, and was extremely resistant to hammer strikes. However, liquid-filled blisters were present, especially in the East wall. Their diameters ranged from several to 150 mm.

The remaining surfaces were largely exposed concrete of a smoother, slightly sandy texture. No leaks were observed. No significant concrete deterioration was visible at the scum line.

Hammer sounding of the walls did not identify any large concrete delamination. One delamination within a previous repair patch was present in the West wall near its North corner. The delamination had a diameter of approximately 300 mm.

Hard strikes with the narrow end of a masonry hammer revealed that the outer two to three millimetres of the exposed concrete were softer than concrete at greater depths. Treatment of these shallow exploration holes with phenolphthalein indicated that exposed concrete was typically neutralised to a depth of approximately 10 to 15 mm. A rebar cover survey in several locations indicated that the concrete cover over rebar was typically 50-60 mm, with the exception of ≥ 35 mm in the West wall.

During hammer sounding, it was our subjective impression that the concrete in Grit Tank 2 was harder than the concrete in Sedimentation Tank 2.

7.1.4 Condition of the No. 2 Sedimentation Tank

The walls of the Sedimentation Tank 2 were generally sound. Two distinct areas were noted. One area comprised a coated surface with a rough profile (approximate ICRI Concrete Surface Profile #9) and sound alkaline concrete immediately under the surface coating. This rough surface profile was likely caused by surface preparation prior to coating application. The second area comprised approximately $\frac{1}{2}$ of the tank's inner surface still having the original formed texture. This surface was very soft and could be easily scratched to a depth of approximately 5 mm. Beyond 5 mm depth, the concrete became substantially harder. In areas without the coating, including the columns, the depth of neutralization was generally 10 to 12 mm.

The columns were not coated. Their surfaces were visibly eroded, although no exposed reinforcing steel was noted. The approximate depth of neutralization of the column concrete was approximately 10 to 12 mm below the inner margin of the rough surface.

Hammer sounding accessible areas of the walls between approximately 600 mm and 2.5 m above the floor revealed no areas of delamination. No visual clues for possible presence of delamination were observed above the level of hammer sounding.

Chain dragging of the floor on both sides of the tank revealed no areas of delamination.

At the time of inspection, Sed Tanks 1 and 3 were operational and were filled with water. Remarkably, only very slight leakage was noted at isolated locations in this tank.

Four short, 50 mm diameter cores were extracted to supplement the depth of neutralization testing at shallow drill holes in the walls. The cores revealed similar depths of neutralization of 10 to 12 mm in uncoated areas, and <3 mm in coated areas.

7.1.5 Condition of the No. 2 Grit Tank

The upper portion (approximately 2 m) of the south and west Grit tank 2 walls were coated with 2 different coatings down to the upper boundary of the sloping floor on the south side. The soft black outer coating was easily peeled off, revealing a harder yellow coating underneath. Large, liquid-filled blisters separating the two layers were noted in all areas coated. The bottom of the north wall adjoining the sedimentation tank was not coated.

Depth of neutralization on the floor and three of the walls of the No. 2 Grit tank was similar to the Sedimentation Tank, with 10 to 12 mm of neutralization in uncoated areas, and <3 mm in the coated areas. Hammer sounding of localized uncoated areas of the floor and walls did not reveal any areas of delamination.

7.1.6 Condition of the No. 3 Sedimentation Tank

In general, the concrete surfaces appeared to be firm. The South wall, and portions of the East and West walls (near the South wall), as well as the centre wall segments, had the appearance of polymer-coated exposed aggregate concrete. The uncoated surfaces had a smoother texture. However, a small portion of the uncoated concrete surfaces showed significant erosion, to a depth of several millimetres.

The West wall was almost completely dry, even though the adjacent tank was filled with sewer water. One obvious leak observed was from a pipe penetration, and is not related to cracked concrete or deficient joints. None of the joints and cracks were wet or actively leaking, although some dampness was observed around a joint in the floor in the South-East portion of the tank (Photograph 24). A vertical pour joint in the West wall showed efflorescence (see Photo 19), indicating that moisture had percolated at some time. No significant concrete deterioration was visible at the scum line (approximately 2.9 m above main floor level, as measured at the East wall at about mid-tank). Several pour joints, narrow cracks, and missing caulking material in control joints were observed. An irregular crack in the East wall has passed through aggregate, indicating that it is a stress crack through concrete with a generally competent and strong cement matrix (Photograph 25).

Hammer sounding of the walls (from bottom to approximately 2.2 m above floor level, as measured at the East wall at about mid-tank) did not identify any concrete delamination. Coatings appeared to be durable and tough on the surface, but had widespread blistering. The South wall had the most severe blistering. Chain drag testing the floor also did not identify any delaminations.

Limited rebar cover survey in several locations indicated that the concrete cover over rebar was typically >40 mm.

Metro extracted 3 cores with approximately 70 mm diameters from the East and West walls, and patched the holes with a silica fume micro fibre modified shotcrete mix. The top approximately 10 mm of each core had neutralised concrete. Concrete at greater depths was highly alkaline.

A high-pressure water jetted test patch observed by Metro on 30 August 2023 showed that after removing approximately 10 – 12 mm weakened concrete, the next layer of relatively firm concrete still showed whitish deposits around large aggregate to an additional depth of approximately 10 to 12 mm. Thus, the total affected depth is approximately 20 to 25 mm. We did not have the opportunity to determine the nature of these deposits. However, they may be related to sulphate attack. Photographs 22 and 23 illustrate the test patch surface profile.

7.1.7 Condition of the No. 3 Grit Tank

In general, the concrete surfaces appeared to be firm. The walls had a black, tough, polymeric coating at approximately 2.2 m above bottom floor level and higher, as measured at the East wall at about mid-tank. The coating was tough and extremely resistant to hammer strikes. However, liquid-filled blisters were present. Their diameters ranged from several to 100 mm. The tough black coating had peeled off in an approximately 3 m² large area of the South wall, exposing a yellowish sub-coat. The concrete immediately underneath that sub-coat was highly alkaline.

The coating in the NE corner appeared to have partially flaked off. It could not be removed with reasonable effort, and obscured the concrete. The condition of the concrete, and of any joint which may be present, is uncertain at that location.

Hammer sounding of the wall areas without the tough polymeric coating did not identify any concrete delamination. Chain drag testing the floor also did not identify any delamination.

Metro extracted 3 cores with approximately 70 mm diameters from the East and West walls, and patched the holes with a silica fume micro fibre modified shotcrete mix. The top approximately 5 to 8 mm of each core had neutralised concrete. Concrete at greater depths was highly alkaline.

7.2 Locating Reinforcing Steel

Metro used a GPR scanner to locate reinforcing steel before extracting cores and drilling. This ensured that we did not unintentionally damage rebar during coring.

7.3 Coring

Coring was conducted using a drill rig equipped with water-lubricated diamond tipped core barrels. Metro followed applicable guidance by CSA A23.2-14C for the extraction and care of the core samples. Cores were extracted in a horizontal orientation. We patched all holes with a silica fume micro fibre modified shotcrete mixture batched to an earth-damp consistency and rammed into place.

7.4 Core Observations and Scratch Testing

7.4.1 Visual Inspections of Cores

Visual inspections were conducted on untrimmed cores A to F. Cores A and B had coatings at the top. Both coatings were partially peeling off. Core B had blistered coating. Cores C to F had no coating and exposed aggregate on top, with cement paste eroded to several mm deep. However, Core C had a thin dark deposit on top.

The aggregates in Core B were not uniformly distributed. The fracture face at the bottom of all cores (due to extraction) propagated through paste, paste-aggregate interface, and individual coarse aggregates particles.

7.4.2 Air Entrainment

Metro observed the core samples A to F under a stereo microscope for potential air entrainment. Cores B to F appeared to be well air entrained. Core A appeared to have poorly distributed air voids and thus seemed to be insufficiently air entrained. All cores also contained some entrapped air voids. In Core B, the largest observed void had approximate dimensions of 5x5x7 mm³.

7.4.3 Depth of Neutralisation

Core samples were sprayed with phenolphthalein indicator solution in the laboratory. For each core, we took three measurements of the depth between surface and onset of purple colour reaction. We spaced these measurements approximately evenly along the circumference of the cores. Table 2 below shows the averages of the readings.

Table 2: Average Depth of Neutralization	
Core ID	Average Depth (mm)
A	8
B	6
C	10
D	7
E	7
F	8

7.4.4 Concrete Density

The as-is density of cores A to F were measured through determining the as-is weights and volumes. The dry masses of the cores were measured first. Then, the saturated surface dry (SSD) masses were measured, as well as the underwater immersed weights. For each specimen, the immersed weight was subtracted from the SSD weight to calculate displacement volume. Density was calculated by dividing the dry mass by the volume. Table 3 below summarises the test results.

Table 3: As-is Density			
Core ID	As-is Weight (g)	Volume (cm ³)	Density (kg/m ³)
A	1317.4	535.9	2458
B	1388.3	570	2436
C	1270.7	508.1	2501
D	1343.3	540.2	2487
E	1396.1	552.4	2527
F	1376.3	550.2	2501
Average:			2485

7.4.5 Scratch Testing

Metro estimated the concrete hardness versus depth, using a Moh's Hardness kit. The table below summarises the results. Due to the aggressive environment acting on the surface of the concrete, it was expected that the concrete near the surface is softer than at greater depth. Scratch testing on the depths of neutralisation area do not differ drastically with the first range of depth. A reference table for assigned material hardness values can be found in the Appendix for illustration. Note that the scratch test results are averages for the depth increments shown in the table below.

Table 4: Moh's Hardness Test			
Core ID	Depth of Sample		
	0-40 mm	40-80 mm	80+ mm
A	2-3	3-3.5	3.5-4
B	2-3	3-3.5	3.5-4
C	2-3	3.5-4	3.5-4
D	2-3	2-3	2-3
E	2-3	2-3	3-3.5
F	2-3	3-3.5	3.5-4

7.5 Compressive Strength Test

We conducted compressive strength tests on four cores, in the dry condition, and as per CSA A23.2-14C. The calculation of the strength followed CSA A23.2-14C and required correction for L/D-ratios. The tables below show core dimensions and test results.

Table 5: Core Length and Diameter		
Core ID	Diameter (mm)	Capped Length (mm)
A	70.8	
B	70.8	128.0
C	70.7	105.7
D	70.8	119.0
E	70.8	
F	70.8	122.3

Table 6: Compression Test				
Core ID	Max. Load (kN)	Area (mm ²)	L/D Ratio	Corrected Compressive Strength (MPa)
A	Tensile test, see Table 7			
B	202.7	3937	1.81	51.0
C	214.7	3925	1.50	52.3
D	186.0	3937	1.68	45.7
E	Tensile test, see Table 7			
F	234.0	3937	1.73	57.5
Average:				51.6

7.6 Direct Tensile Strength Test

We conducted tensile strength tests on four specimens cut from Cores A and E, in the dry condition, as per guidance provided in CSA A23.2-6B. The calculation of the strength followed CSA A23.2-6B.

Table 7: Tensile Test			
Core ID	Max. Load (kN)	Area (mm ²)	Direct Tensile Strength (MPa)
A1	18.47	3926	4.7
A2	14.29	3926	3.6
E1	19.66	3926	5.0
E2	15.10	3926	3.8
Average:			4.3

8 Discussion

Our interpretations of the test results are as follows:

1. From visual clues, observations of cores, and sounding, we are of the opinion that the concrete at depth (approximately 5 to 40 mm below current surface, depending on location) is sound and of good quality.
2. The density of the concrete is approximately 2485 kg/m³. The compressive strength of 4 cores tested averaged 51.6 MPa. These results are indicative of good quality concrete.
3. The scratch tests indicate that the concrete is somewhat soft for its strength, but still within reasonable limits.
4. One core each from Sedimentation Tank 3 and Grit Tank 3 were tested in direct tension. Both cores were cut in half to provide 2 specimens each. The average strength in direct tension was 4.3 MPa. The direct tensile testing carried out indicates that the concrete has good tensile capacity and corresponds well to the compressive strength.
5. The depth of neutralization measured at numerous locations in the 6 structures evaluated was generally 10 to 12 mm in unprotected concrete. Below that depth, the hardness of the concrete appears to increase substantially. However, additional bond testing on the concrete substrate during repair is recommended, in order to identify the optimum depth of material removal to expose a competent substrate surface.
6. The concrete comprising the grit tanks is in similar condition to the sedimentation tanks. However, the upper portion of the grit tanks is coated with a flexible polymeric coating that is poorly bonded to another substrate coating. The first coating, based on limited examination, appears to be well bonded to a smooth substrate. The nature of the coating system was not determined.

9 Conclusions and Recommendations

Based on the inspection observations and testing carried out the following is concluded:

1. The concrete at depth, and the embedded rebar, appear to be of acceptable quality. If the current exposure conditions do not become more aggressive; and if the tanks are properly maintained, protected, and repaired where necessary, then they can be expected to have many more years, and perhaps several decades, of remaining service life.
2. Repair of deteriorating exposed surfaces is recommended. The repair, in general terms, should comprise of mechanical removal of isolated delaminations (if any are found) and of deteriorating coatings, followed by a high-pressure water blasting, which removes all weakened concrete. Note that high-pressure water blasting, if water pressure, nozzle distance and advance, and water flow are correctly selected, can be an excellent tool to remove weakened concrete while keeping sound concrete largely intact. Adequate exposure of competent concrete may be verified by spraying the pressure-washed surfaces with a phenolphthalein indicator solution, and by tensile bond testing as recommended below. Competent surfaces can then be protected with a suitable coating system
3. In addition to phenolphthalein tests, the tensile bond strength capacity of the substrate concrete should be tested prior to coating application, to demonstrate that an appropriate amount of concrete has been removed in the preparation process. Based on the tensile testing carried out, Metro expects that a tensile bond capacity of ≥ 2.5 MPa on average, and no result below 2.0 MPa, should be expected. We understand that the RDN specifications refer to NACE No. 6/SSPC-SP-13, which specify a minimum tensile strength of 1.7 MPa for severe service. In Metro's opinion, the bulk concrete of the tank walls, if properly prepared, is capable of achieving such strengths.
4. Consider repairing degraded caulking in joints, and injecting cracks which show signs of leakage.

10 Limitations and Closure

This report has been prepared with a customary standard of care and skill, for the exclusive use RDN and for the specific purpose described in Sections 2 and 4 above. Any use of this report by third parties, or their reliance on information reported in our report are at the sole responsibility of such third parties. Metro Testing & Engineering Ltd. will not accept any responsibility for any damages suffered by any third party as a result of decisions, or actions, based on this report.

Unless where we specifically expressed it, we have not independently verified information quoted from drawings, plans, literature, or other reports. This report reflects Metro's best judgment based on the information available. If conditions other than those detected and reported are noted subsequently, please inform Metro immediately so that we can review and revise this report as necessary.

We trust this meets your present requirement. Please do not hesitate to call if you have any questions.

Yours truly,

Metro Testing + Engineering Ltd.

Greg Wilson
Sr. Materials Investigator

Neil McAskill,
Sr. Materials Specialist



Roland Heere, P.Eng.
Sr. Materials Engineer



Appendix A – Moh’s Hardness Reference Scale

A.1 Moh's Hardness Scale Values

Hardness Scale	
Assigned Value	Material
2	Gypsum
2.5	Porcelain**
3	Calcite
3.5	Copper
4	Fluorite
5	Apatite
5.5	Glass
6	Orthoclase
7	Quartz
8	Topaz
9	Corundum

**Note: Material is of similar density and appearance to porcelain but is not part of the official kit.

Appendix B – Photographic Documentation



Photograph 1 illustrates the interior of Sed Tank 2 looking north. Note the demarkation between the coated areas and non coated areas.



Photograph 2 illustrates Sed Tank 2 looking south toward the grit tank. Again, note the coated and uncoated concrete.



Photograph 3 illustrates a clear demarcation between the coated and non coated areas in Sed Tank 2. The coating has clearly preserved the surface and appears to bond well.



Photograph 4 illustrates the coated and uncoated portion of the centre curb of Sed Tank 2. The area on top of the curb does not appear to be coated and is heavily eroded.



Photograph 5 illustrates the existing surface on a typical column in Sed Tank 2. Refer to Photograph 6 where the soft surface has been scratched off.



Photograph 6 illustrates the column in Photograph 5 where the weakened neutralized surface was easily scratched off revealing a hard dense and alkaline surface 10 to 12 mm below the existing surface.



Photograph 7 illustrates a coated area in Sed Tank 2. Note the roughness of the surface and the minimal depth of neutralization in drill hole. Also, no areas were noted where the existing coating is peeling off.



Photograph 8 illustrates the transition of coated area to non coated area on the west side of Sed Tank 2.



Photograph 9 illustrates a drill sample into an uncoated area with typical depth of neutralization of 10 to 12 mm in Sed Tank 2.



Photograph 10 illustrates a wall joint between Sed Tank 2 and 3. Note the lack of leakage even though the adjacent tank is full of liquid.



Photograph 11 illustrates slight seepage in Sed Tank 2, coming from an adjacent, liquid-filled Sed tank.



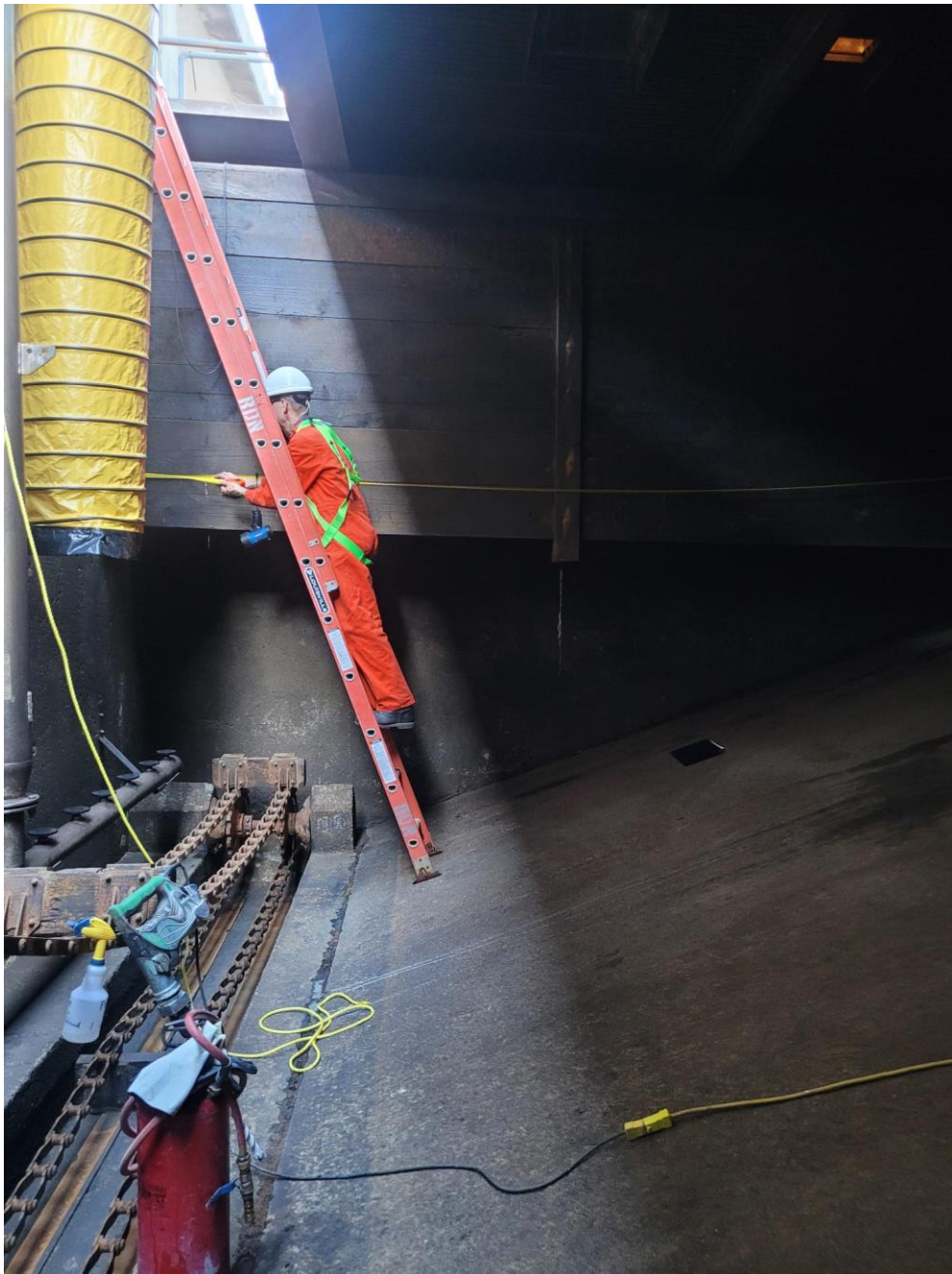
Photograph 12 illustrates the South wall of Grit Tank 2 where it intersects the sloping floor. Note the blistering of the coating on the back wall. The floor of the grit tank is uncoated and has typical depth of neutralization of 10 to 12 mm. Refer to Photograph 13 for details of the wall coating.



Photograph 13 is an area of the south wall of the Grit Tank 2 shown in Photograph 12. The soft rubbery blistered coating was easily removed revealing harder better adhered coating underneath. Only slight neutralization of the concrete was noted under the two coatings.



Photograph 14 illustrates the west wall of Sed Tank 2. Note the extensive blistering of the coating and the uncoated concrete below.



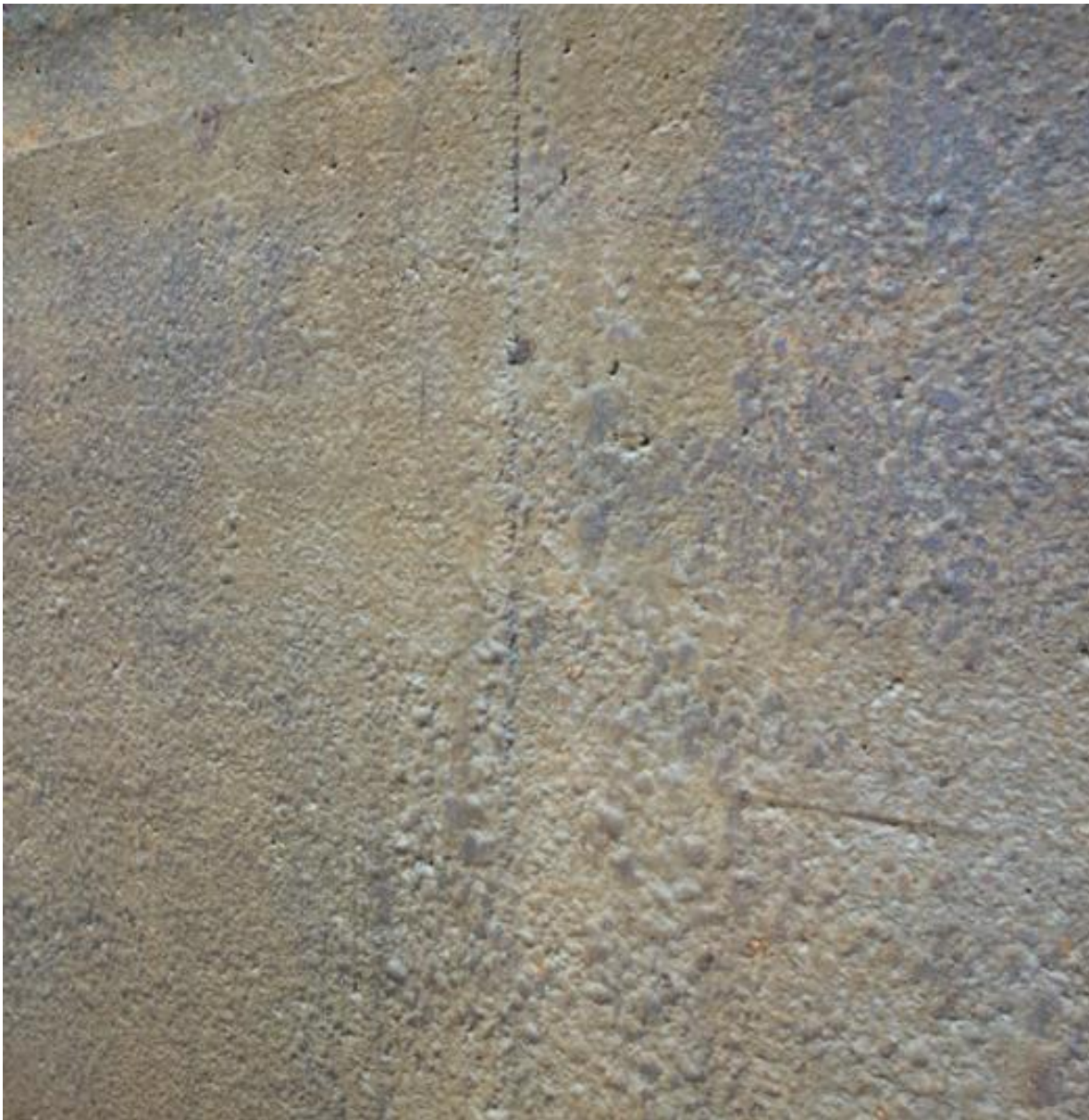
Photograph 15 illustrates the sloping floor and East Wall of Grit Tank 2.



Photograph 16 shows the uncoated north wall of Grit Tank 2. The surface is soft and easily scratched typical to other areas in Sed Tank 2. The underlying surface is sound and hard when hammer sounded.



Photograph 17 Sed Tank 3, open construction joint in walkway on top of tank.



Photograph 18 Sed Tank 3, blistered coating.



Photograph 19 Sed Tank 3, West wall, efflorescence around crack, indicating minor leakage.



Photograph 20 Grit Tank 3, South wall, delaminated top coating, exposing base layer.



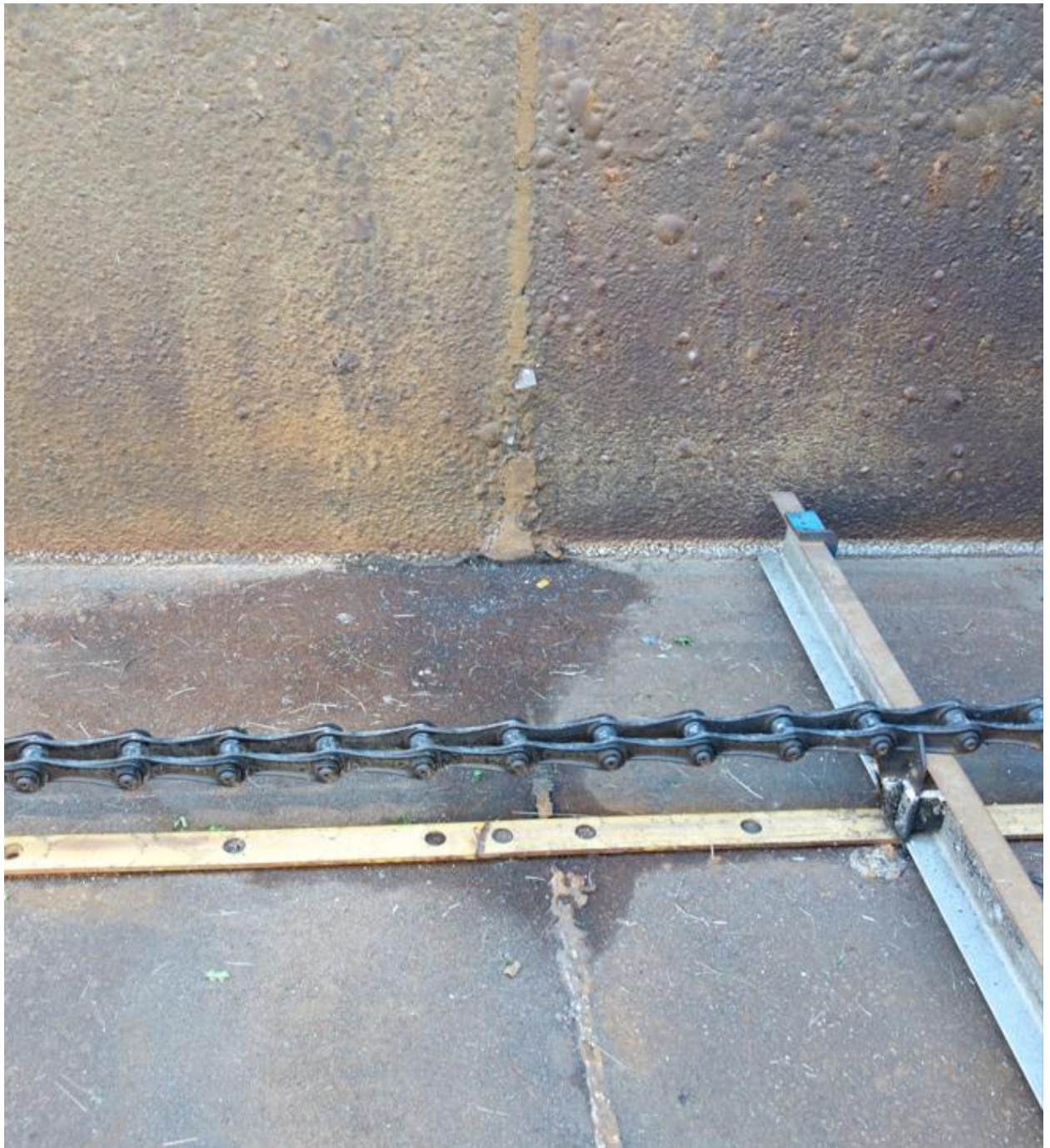
Photograph 21 Grit Tank 3, North-East corner, rough joint, condition could not be evaluated non-destructively.



Photograph 22 illustrates the test area in Sedimentation Tank 3. Refer to Photograph 23 for a close-up view.



Photograph 23 illustrates a close-up view of the surface preparation in the Sedimentation Tank 3.



Photograph 24 Sedimentation Tank 3, dampness around joint in floor.



Photograph 25 Sedimentation Tank 3, East wall, detail of a narrow stress crack through cement paste and aggregate, indicating strong cement matrix.