

City of Peterborough

CSE STRUCTURAL FORENSIC &
REHABILITATION SERVICES

**SOUTH SUPPORTING WALL:
REVIEW NO.1 (JUNE 23, 2017)
BASE LINE REVIEW**

MEMORIAL CENTRE, PETERBOROUGH (ON)

**PREPARED FOR
THE CITY OF PETERBOROUGH
BY
CARVAJAL STRUCTURAL ENGINEERS INC.**

CSE PROJECT-1897a.17


Professional Engineers
Alberta-British Columbia-New Brunswick
Ontario - Nova Scotia - Saskatchewan

JULY, 2017

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File: 1897.17 – South Supporting Wall Review – June 23, 2017
Peterborough Memorial Centre - 151 Lansdowne St., Peterborough (ON) K9J 1Y4

As requested, Carvajal Structural Engineers Inc. (CSE) has completed the initial structural review of the existing South Supporting Wall (Wall) beneath the Ice Rink Slab at the above captioned site. The initial investigation was performed on June 23, 2017.

The following report provides a factual summary of our understanding of the work and our findings.

1.0 UNDERSTANDING OF WORK

It is our understanding that due to the condition of the South Supporting Wall, continued monitoring of the condition of the wall has been requested by the City of Peterborough (City) until repairs can be performed.

The purpose of our review is to provide a Structural Professional Opinion on the existing condition of the Wall at present time and to monitor for any further deterioration of the Wall in the future. Subsequent reviews will be scheduled on a monthly basis to document any changes to the existing wall structure. Our scope of work for the Initial Assessment is defined as follows:

1. Visit the site to perform a visual survey of the Wall to identify areas of concern (i.e. cracks, water staining, efflorescence).
2. Install tell-tale crack monitors at significant cracks and record initial reading.
3. Perform a delamination survey (sounding) on the concrete surface, on both the north and south face of the Wall, and record the limits of delaminated concrete.
4. Prepare a factual report that summarizes the conditions found.

2.0 DESIGN REVIEW LIMITATIONS

Please be advised that any information contained in this report is derived from our field measurements, our own field observations and the available structural drawings. Any third party use of this information is restricted since our report incorporates a measure of experience with similar structures. This report is solely provided to the City of Peterborough (City). CSE

takes no responsibilities or liabilities for any third party use of this information without prior consultation with CSE.

Please note that CSE reserves the right to update our observations, analysis and recommendations should additional relevant information become available.

3.0 DESCRIPTION OF STRUCTURE REVIEWED

The South Supporting Wall is an eight (8) inch thick reinforced concrete wall that supports both the original slab and the new concrete slab (topping).

On the south side of the Wall is a tunnel where the brine pipes run in the east-west direction. The PVC refrigeration pipes run perpendicular from the brine pipes, through the Wall and into the ice rink slab.

At the north side of the Wall there is backfill material against the wall for approximately half the height of the wall. The underside of the ice rink slab on the north side of the Wall is not visible since it is covered with a steel deck and cork insulation.

4.0 VISUAL OBSERVATIONS REVIEW & TESTING

The following findings summarize our observations and test results. Our initial inspection of the South Wall was performed on June 23, 2017.

4.1 Visual Survey – Crack Monitoring

A complete visual survey of the South Wall was performed (as visually accessible) to document any significant concerns.

Our review revealed that two (2) wide cracks and one (1) medium crack were present along the length of the wall. At each of these locations, tell-tale crack monitors were installed. The initial readings of the tell-tales were recorded and photographs were taken to document the current conditions as of June 23, 2017.

As well, evidence of severe water leakage and efflorescence was typically noted along the length of the wall.

Refer to the Photo Log in Appendix A for photographs of the conditions observed and the initial readings of the tell-tales markers, as well as SK1-01 in Appendix C for locations of the cracks and tell-tale markers.

4.2 Delamination / Hollow Sounding Survey

A delamination survey was performed over the complete surface of the wall, as accessible, to identify delaminated areas of concrete. Both sides of the wall were surveyed.

In general, a large area of hollow sounding concrete was identified along the complete length of the wall. The majority of the delaminations were found along the top portion of the wall, on both the interior and exterior faces. Typically the top 12" of the wall was found to be severely

delaminated. In many locations the area of delaminated concrete extended down towards the base of the wall.

See SK1-01 and SK1-02 in Appendix C for the locations of the delaminated areas and areas of structural concern.

5.0 FINAL COMMENTS

Based on our initial investigation, it is our professional opinion that the wall is in poor condition and has structurally deteriorated. Wide cracks were observed along the length of the wall and large areas of delaminated concrete were identified.

Regularly scheduled monthly monitoring of the wall shall be performed to identify if the condition of the Wall worsens.

Tell-tale crack markers have been installed at the location of each crack identified to determine if the width of the cracks increase. In the subsequent reviews, the readings of the tell-tale markers shall be recorded and photographed and compared to the previous readings.

The existing limits of delaminated concrete have been outlined and recorded. In the following monthly reviews a secondary hammer tap survey shall be performed around the perimeter of the noted delaminated areas to determine if the limits of the delaminated concrete are increasing.

We trust the above is to your satisfaction, should you have any further questions, please do not hesitate to contact the undersigned.

Yours truly,
Claire Miller, E.I.T
Structural Designer
Structural Rehabilitation Engineer
CSE Structural Forensic & Rehabilitation Services
Carvajal Structural Engineers Inc.



George Carvajal, P. Eng.
Senior Structural Engineer & Principal
Structural Rehabilitation Specialist

CSE Structural Forensic & Rehabilitation Services
Carvajal Structural Engineers Inc.
BCIN 31226

File: 1897.17
CC: M. Fairey (TS), N. Kloke (TS), M. MacGillivray (City), CSE Files

APPENDIX A

STRUCTURAL REHABILITATION TERMINOLOGY

APPENDIX A DEFINITIONS

Absorption	The process of a liquid being soaked up by the concrete surface, due to surface tension and capillary action.
Aggregate	Aggregate(s) are the stones which are mixed with the cement paste to make concrete. Aggregate are classified as fine or coarse depending on their size.
Air Entrainment	Air entrained concrete contains small air bubbles within the cement paste which acts to relieve the pressure of freezing water. Air entrained concrete has better resistance to freeze-thaw damage than non-air entrained concrete.
Alkali-Aggregate Reaction	This is a type of concrete deterioration occurs when minerals within some types of aggregate chemically react. The reaction that take place produces a product which has a larger volume which eventually damages the concrete.
Beam	A horizontal member which usually is located at the top of walls or columns (underside of slabs). A beam forms part of the framing system of a typical Concrete Structure.
C.I.	Condition Index: This is numerical value between 1 to 100 given to a specific Component or Structure.
Calcium Chloride	A white salt which reduces the melting point of water. In cold weather climates calcium chloride is used extensively to melt the ice that accumulates on concrete structures. Calcium chloride contamination breaks down the protective characteristic of concrete which contributes to the corrosion of the reinforcing steel.
Carbonation	Carbonation is a process by which carbon dioxide from the air penetrates the concrete and reacts with the cement paste. Carbonation breaks down the protective characteristic of concrete which contributes to the corrosion of the reinforcing steel.
Cement Paste	Concrete is made of different sized aggregate and a bonding glue. The bonding glue is called the cement paste or "paste".
Chain Drag	Areas of delamination can be located using this procedure. By dragging a chain (50 mm Link Chain) across the surface of the concrete (or lightly hitting the surface with a hammer) there is an obvious and distinct sound that is created at delaminated concrete areas (see Fig. A1).
Chemical Testing	Although there are many test that can be performed on concrete to obtain information on it's condition, there are typically only two (2) chemical tests which are performed on a Concrete Structure. These tests are the Chloride Ion Test and Carbonation Test.

Chloride Ions	Penetration of chloride ions (from de-icing salts) into a concrete elements breaks down the protective characteristic (passivity) of concrete and steel. This breakdown in passivity contributes to the corrosion of the reinforcing steel.
Column	A vertical member which typically supports a beam and/or a slab. A column forms part of the framing system of a concrete structure.
Component	CSE defines a component as a single element (real or imaginary) in the concrete structure which has a specific function. Components are defined as Slabs, Columns, Walls, Beams, Ledge Beams, etc... Slab components are further subdivided into Slab-On-Grade Slabs, Suspended Slabs, Roof Slabs and Ramp Slabs.
Compressive Strength	Typically concrete core samples are removed and tested in the laboratory for their compressive strength. Due to the long hydration period of concrete, the average strength of the test should be greater than the specified 28 day strength found in the design documents.
Concrete Cracks	Identification of concrete cracks is an important key sign of concrete structure distress. The proper interpretation of concrete cracks requires an expert structural engineer. To overcome this interpretation problem CSE defines two type of cracks namely Structural Cracks and Leaking Cracks. Structural Cracks are cracks which are greater in width than 0.5 mm and Leaking Cracks are cracks which are leaking.
Construction Joint	A joint which is created by placing fresh concrete against older already harden concrete. These joints are susceptible to leakage. Construction Joints are sometimes referred to as Cold Joints.
Corrosion Activity	Reinforcing steel embedded in the concrete can corrode (rust). Reinforcing steel which is actively corroding can be indirectly measured using a half-cell test. The degree of corrosion taking place is referred to as its Corrosion Activity and is measured in negative volts.
Cover Meter	A Cover Meter survey is the determination of how much concrete lies between the top of the reinforcement steel and the surface of the concrete. Concrete cover should typically be more than 25 mm (1") for Concrete Structures. The evaluation of concrete cover is typically performed with an electromagnetic instrument. CSE is only interested in areas which contain less than 15 mm (1/2") of concrete cover.
Crazing	Crazing the name given to small random cracking of the concrete surface. Concrete mixes with high cement content and/or silica fume mixes are susceptible to crazing.
Damaged Concrete	Damaged Concrete (distressed) is defined as areas of concrete which contain delamination, spalls, exposed reinforcing steel and patches (repair areas). Damaged Concrete is identified by a visual observations and performing a hollow sounding survey (chain drag for slabs).
Deflection	For the purpose of this manual, a deflection is a bow or a bending of a concrete element. Any visible bows or bending of concrete elements

indicate a serious problem. You should contact an Engineer to review your concrete structure if you notice any bending.

Delamination

A delamination is a separation of the concrete from the reinforcing steel (horizontal separation). This horizontal separation occurs when the steel corrodes and expands creating high tensile forces which breaks the bond between the steel and concrete.

Although the proper definition of a delamination is as noted above, for the purpose of this report a delamination also includes any exposed steel, any concrete spalls, any hollow sounding areas (on concrete), popouts (which are not caused by corrosion) and any repair patched (Fig. A1).

The two (2) definitions are used interchangeably throughout this manual and some care should be exercised during their interpretation.

Distress

For the purpose of this manual any Problem defined by CSE is considered a distress.

Drainage

Current standards in the design of new concrete structures require the top surface of the slab to be sloped towards the drains. The ability of a slab to move surface water to the nearest drain is referred to as its "drainage".

Durability

A concrete element is considered to be "Durable" when it can effectively resist wear and tear during normal operations. The durability of concrete is related to its material properties and the workmanship quality of its installation.

Dusting

Dusting takes place when the top surface of the concrete softens and rubs off as a powder. Excessive dusting is usually caused by many factors and is indicative of the workmanship during the placement.

Efflorescence

A white deposit which is left on the surface of concrete when water evaporates. The deposits are usually salts from de-icing chemicals or from the paste of the concrete and are usually found on the underside of the concrete elements.

Exp.Life

Expected Life: The Expected Life of a Component (or Structure) is based on the C.I. of the Component (or Structure) and the age of the component (or site). The Expected Life provide the you with an indication on the remaining life (in years) of the component (or site) based on the following assumptions:

- i) The current condition of the concrete structure remains as is, that is no further deterioration takes place.
- ii) The component or site is completely protected from further environmental exposure.
- iii) At the end of the Expected Life it is estimated that it would be more economical to completely replace the component or site than it would be to repair it.

Note: A concrete structure with a very low Expected Life does not mean the structure will collapse at the end of the Expected Life, but it does indicate that you should take action to resolve the problem identified and consult a qualified engineer to review your structure.

Formwork	The wood framing used during the construction of the concrete structure to temporarily hold the concrete in place. Formwork usually leaves straight line marks on the concrete surface where the forms butt together. You should not confuse these markings with joints or even cracks.
Hollow Sounding	The determination of how extensive a concrete element is delaminated can be determined by sounding the surface of the concrete and listening for a hollow "echo" sound. This occurs when a delamination is present (a physical separation) which echo's (bounces the sound waves) back and forth through the separation creating a unique sound. Sounding the surface can be performed with a chain or a hammer.
Hollow Sounding W/P	It is important to determine the extent of delamination on the top surface of the slab. When a slab is waterproofed, the top surface of the slab is not directly accessible for a proper evaluation. You must try to correlate the amount of hollow-sounding W/P areas to actual concrete delaminations. This can be accomplished by assuming that all hollow sounding W/P areas are delaminations (very conservative but not always true). This assumption is not applicable for unbonded W/P systems. A Coring Survey can be used to confirm your observations.
Honeycombing	Honeycombing are large voids of air pockets usually located in confined areas (congested forms). The presence of honeycombing indicates a consolidation or congestion problem during the placement of concrete.
Ledge Beam	A beam which contains an expansion joint system.
Loading	For the purpose this report, loading refers to the service loads applied to a Concrete Structure such as vehicles, people, landscaping, waterproofing systems, partitions etc...
Physical Testing	Physical Testing refers to usually destructive testing of the concrete where sample of the concrete materials are obtain for testing. Some physical testing are non-destructive (such as the corrosion activity test) which do not require samples of concrete.
Popouts	Popouts are small localized spalls of concrete. The spalls are not typically created due to corrosion of steel but to chemical reactions within the concrete mix. The Facility Doctors treats popouts as delaminations.
Post or Prestressed Concrete	In Post or Prestressed Concrete, the structural steel are held in tension (stretched condition). This is a very specialized method of design construction which requires an additional The Facility Doctor System Module.
Problem	CSE defines a Problem as a specific concrete damage (distress).

Reinforcing Steel	Sometimes called "rebar" or "steel", reinforcing steel forms part of structural concrete by providing the tension strength in the concrete elements.
Slab	A slab is the deck or horizontal flat surface of the concrete structure (the floor). The slab is supported on beams and columns.
Spacing Factor	The spacing factor is an indication of the maximum distance between air voids in air entrained concrete.
Spalls	A spall is the final step of a delamination. Usually a large chunk of concrete is flaked off exposing the reinforcing steel.
Specific Surface	The specific surface is the surface area of air voids in a unit volume of concrete.
Steel Framed Structure	A steel framed concrete structure uses large steel elements as the support framing for the concrete structure (steel columns & steel beams). The steel framing is usually covered by a concrete envelope to protect it from fire.
Structure	CSE defines a Structure as the concrete structure you are analyzing. The Structure can be a whole Parking Facility or a single concrete element.
V.E.	Valued Engineering: This is a numerical rating between 1 to 100 given to a Problem based on the total area of the component and the quantity of damage (Density).
W/P	Waterproofing (W/P): The application of a concrete sealer, thin-elastomeric membrane or a thick asphaltic system on the top surface of a slab.
Walls	A vertical member which support a beam and/or a slab. A wall usually forms part of the framing and shear resistance of a concrete structure.
Water Ponding	Water ponding usually takes place on the top surface of slabs where the slab is flat and the water cannot flow to the drains.
Wet Spots	Wet spots are found typically on the underside of slabs, beams and walls. Wet spots are usually associated with leaking cracks.

APPENDIX B

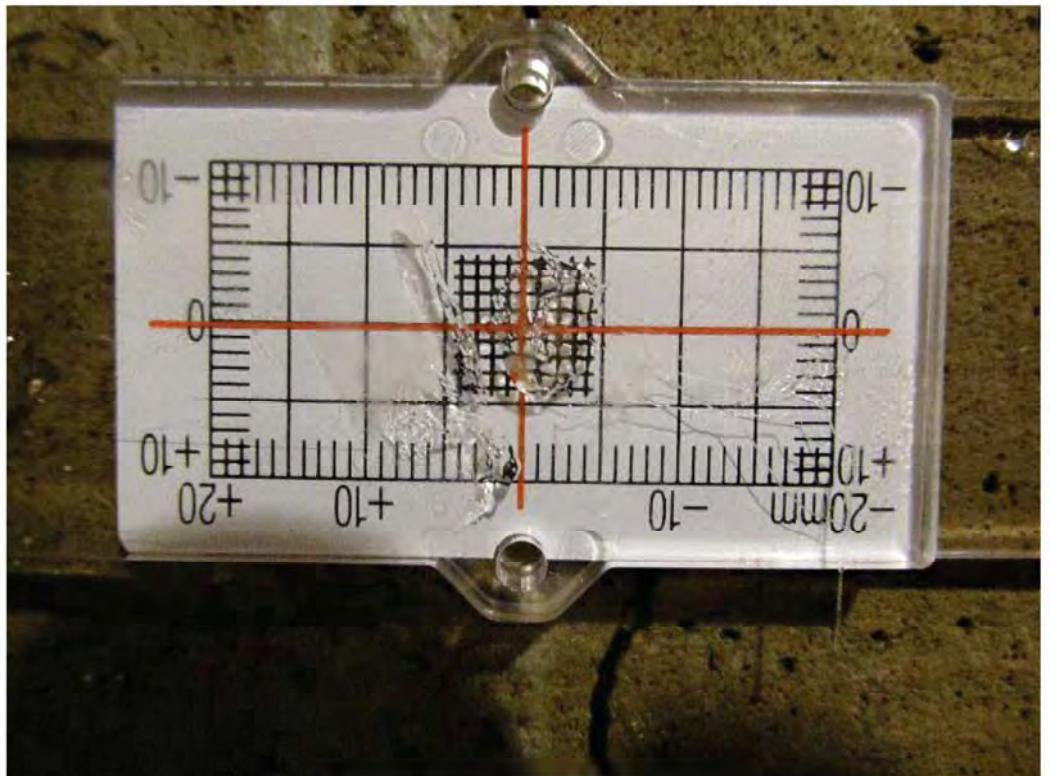
PHOTOGRAPHS

- ▶ Tell-Tale Marker 1
- ▶ Location: Grid Line 10
- ▶ Comments: Crack Width is Wide.



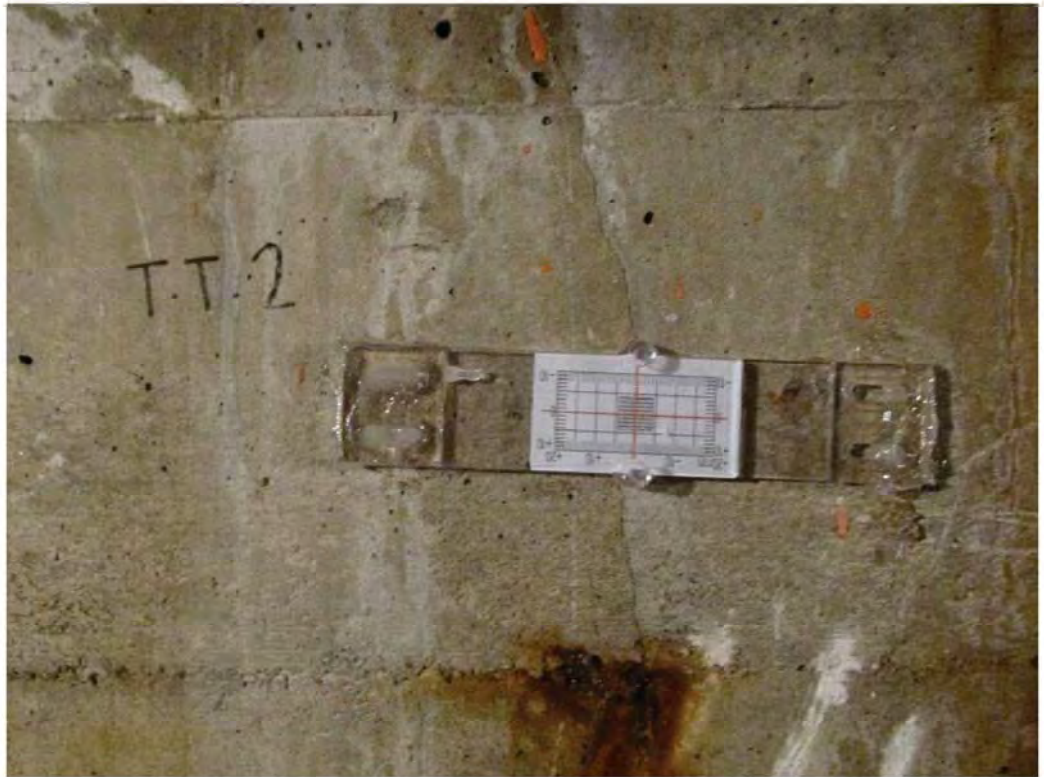
PHOTOGRAPH NO.1

- ▶ Tell-Tale Marker 1
- ▶ Location: Grid Line 10
- ▶ Comments: Initial Crack Width Reading of "0",



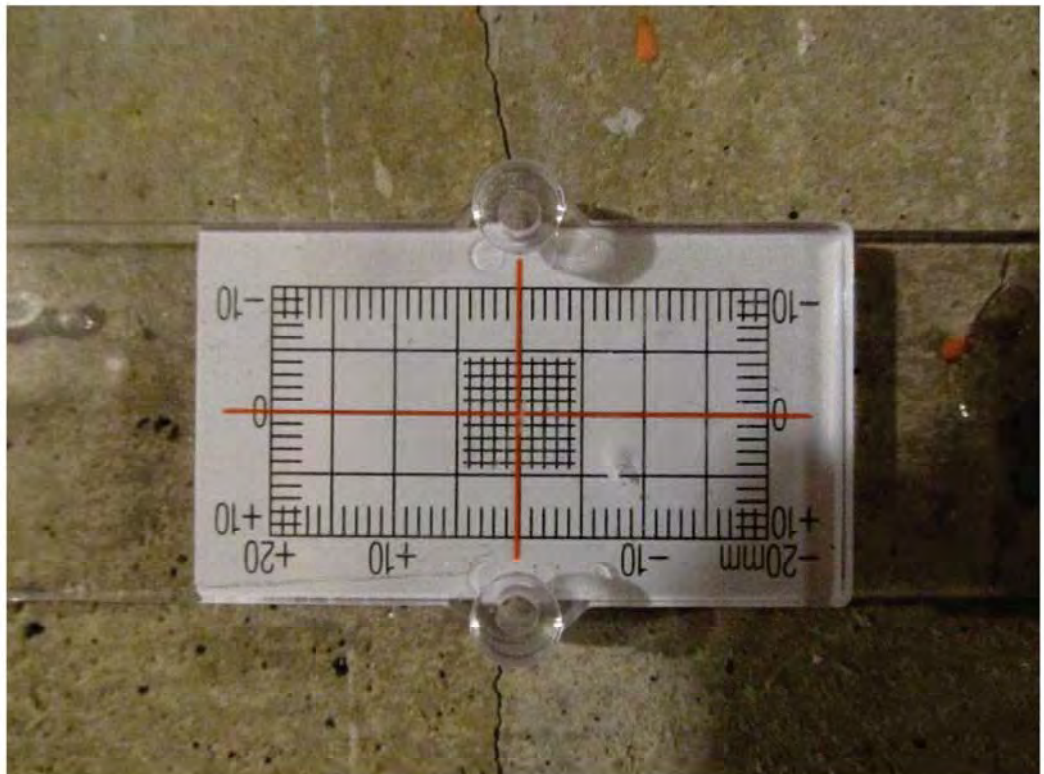
PHOTOGRAPH NO.2

- ▶ Tell-Tale Marker 2
- ▶ Location: Between Grid Line 14 & 15
- ▶ Comments: Crack Width is Medium.



PHOTOGRAPH NO.3

- ▶ Tell-Tale Marker 2
- ▶ Location: Between Grid Line 14 & 15
- ▶ Comments: Initial Crack Width Reading of "0".



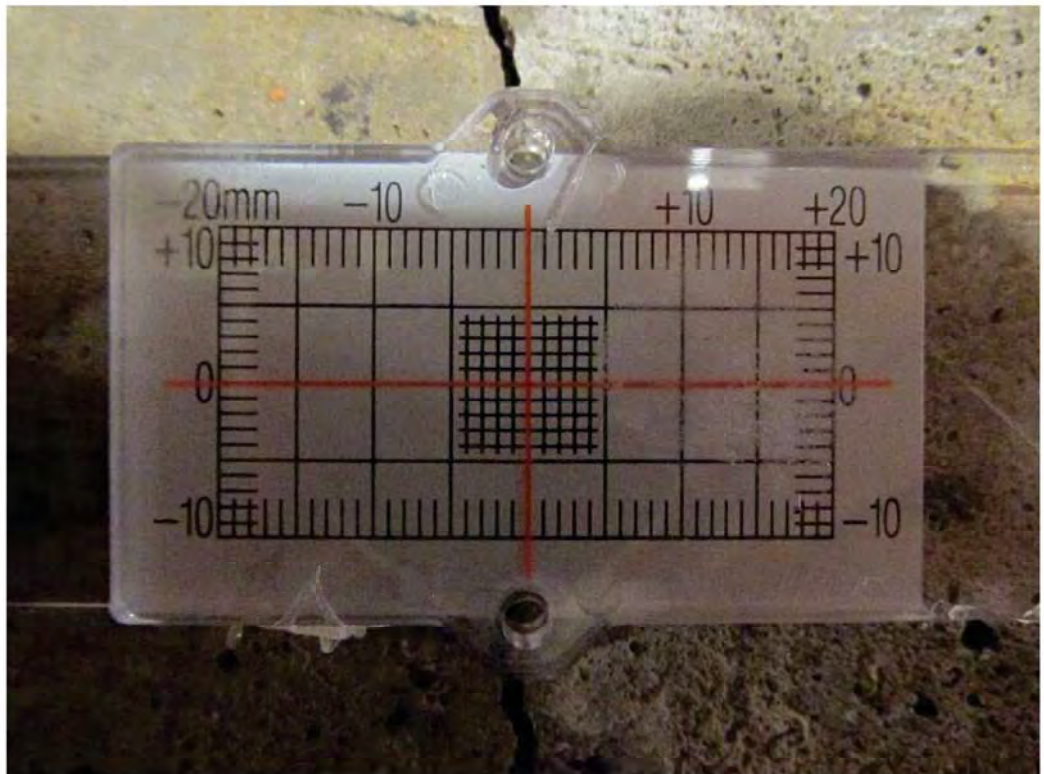
PHOTOGRAPH NO.4

- ▶ Tell-Tale Marker 3
- ▶ Location: Grid Line 19
- ▶ Comments: Crack Width is Wide.



PHOTOGRAPH NO.5

- ▶ Tell-Tale Marker 3
- ▶ Location: Grid Line 19
- ▶ Comments: Initial Crack Width Reading of "0",



PHOTOGRAPH NO.6

- ▶ Inside Face of Wall
(North Face)
- ▶ Location: Grid Line 6
- ▶ Comments: Typical
Condition of Severe
Efflorescence and
Medium Water Staining.



PHOTOGRAPH NO.7

- ▶ Inside Face of Wall
(North Face)
- ▶ Location: Grid Line 19
- ▶ Comments: Vertical
Crack in Wall and Typical
Water Staining &
Efflorescence.



PHOTOGRAPH NO.8

APPENDIX C

CSE BASE LINE DELAMINATION SURVEY (SK1-01 and SK1-02)

