Billed/Sent Mahler

AGGREGATE LABORATORY WORKSHEET
UNCONFINED COMPRESSION

TESTED FOR: PGH Parks Conservancy PROJECT: 0812-499-1

DATE COMPLETED: 10-9-09 PSI REPORT NO.: LAB ID NO.: CS-90228

Please find below the results of One (1) concrete core specimens submitted to/obtained by PSI for Unconfined Compressive Strength testing. Tests were performed in general accordance with test method PTM 606/ASTM C-42.

Core No./ Depth (ft)	Before/ After Capping Length (in)	Core Dia. (in.)	Average Core Dia. (in)	Area (in^2)	L/D (Capped)	Corr. Factor	Total Load (lbf)	Comp. Strength (psi)	Break Type
1	5.55 5.76	2.84 2.85	2.85	6.38	2.02	1.0	38,500	6030	Shear

REMARKS: DR J compl?

February 17, 2010

Project C090957

Mr. Philip J. Gruszka
Director of Parks Management and Maintenance Policies
Pittsburgh Parks Conservancy
2000 Technology Drive, Suite 300
Pittsburgh, PA 15219

Results from the
Cursory Structural Assessment of the
Mellon Square Park Renovation Project
Pittsburgh, PA

Dear Mr. Gruszka:

This letter and attachments contain our report on the results from the cursory structural assessment for the Mellon Square Park Renovation Project. This report includes a summary of our field observations, photographs documenting the existing conditions and recommendations with associated costs for restoring the structural integrity of the park.

Project Description

Mellon Square Park (Park) was originally constructed in 1955 and is located above a six (6) level below grade parking garage. The Park construction consists of architectural granite panels, terrazzo paving, fountain and planter features, which are supported by reinforced concrete slabs, walls and columns. The Park is a candidate for historical landmark status and, therefore, care must be exercised during the renovations to maintain the original design features.

Results from Cursory Structural Assessment

GAI Consultants, Inc., (GAI) was retained by the Pittsburgh Parks Conservancy (Conservancy) to perform a cursory structural assessment of the park and underside of the supporting slab. The purpose of this assessment was to evaluate the structural integrity of the park and supporting slab, note any aesthetic damage to the architectural finishes, and to make recommendations for repairs.

A cursory structural assessment of the existing park and slab conditions was performed between the dates of October 28th and November 13th, 2009 by a team of two (2) engineers from GAI. The scope of this assessment included the following items:

1. Visually examining the conditions of the park components and the underside of the structural slab.

2. Photographically documenting the typical conditions present at the Park and the structural slab.

3. Developing repair alternatives with estimated costs.

During the cursory visual walk-through inspection of the Park and structural slab, several observations were made. It should be mentioned that some of the observations were made after granite panels were removed by Cost Construction under a separate contract with the Conservancy. The following is a summary of our observations.

1. The top surface granite panels, bench slabs and coping are generally in good condition. However, there is some cosmetic damage. Approximately 50 panels were observed to have significant chipping (see Photograph 1), seven (7) panels that are completely cracked (see Photograph 2) and one (1) panel missing. There are approximately 23 chipped, one (1) cracked and two (2) missing (see Photograph 3) bench slabs. The coping stones showed the most chipping along the planter edges. This deterioration may be due to people riding their skateboards and/or roller skates along the edges. There are approximately 350 coping stones with significant damage to the outside edges, three (3) stones that are completely cracked and one (1) stone that is missing.

2. 14 stone panels and the coping stones sitting on top of them were removed at 12 locations. Two (2) adjacent panels were removed at two (2) of the 14 locations. The stone facade was removed in order to visually inspect a representative sample area of the structural cast-in-place concrete planter walls. Approximately 1,050 linear feet (LF) of crack (see Photograph 4), 425 square feet (SF) of spall and 625 SF of delamination was observed on the planter and street side walls.

3. The granite steps at both ends of the Park on the Smithfield Street side were found to be in poor condition. The stone steps were not actually damaged, however, showed a significant amount of efflorescence (see Photograph 5). The large midway landing on the 6th Street side of the Park has a one (1) to two (2) inch deep depression that pond the rain water (see Photograph 6). Four (4) of the step stones were removed at four (4) locations in order to inspect the underlying conditions. In all of the locations, the mortar bed was completely deteriorated. As shown in Photograph 7, the mortar now resembles only a fine aggregate.

4. The top surface terrazzo pavement and fountain terrazzo is in generally fair condition. There is an estimated 200-300 LF of significant cracking (see Photograph 8) and approximately 150 SF of spalled/patched terrazzo pavement (see Photograph 9). The patches are normal brushed finished concrete and do not match the terrazzo pavement. The cracking in the fountain wall terrazzo exhibits excessive efflorescence (see Photograph 10).

5. The underside slab on the first level of the parking garage and the mechanical rooms was visually inspected and found to have approximately 375 LF of crack, 75 SF of spalling (see Photograph 11) and 50 SF of delamination.

6. Four (4) concrete cores were obtained, two (2) each in the slab and the planter walls. Table 1 contains a summary of the core locations. One (1) core from the slab and one

(1) core from a planter wall were subjected to compression tests and the other two cores were petrographically examined. The results from the two (2) compressive strength tests were 6060 psi and 5910 psi (see Attachment 1 and 2). The petrographic examinations revealed no significant deterioration in the concrete (see Attachment 3).

Conclusions and Repair Recommendations

Based on the observations described in the previous section, the following conclusions can be made:

1. The planter and outside walls have some minimal deterioration but in general are in good condition. However, we recommend that spalls, delaminations and cracks in the concrete surface be repaired.

2. Some of the broken stones and stones that are slightly out of plum appear to have been pushed inward at the pavement level due to excessive expansion from the terrazzo pavement and topping slab. We recommend that the expansion joint details for the terrazzo pavement be modified.

3. The water retention at the stairs may have been caused by significant deterioration of the mortar beds beneath stone step pavers. It is recommended the drainage plan at the stairs be improved and all of the step pavers be removed and reset.

4. The underside of the slab is generally in good condition. However, there is some spalls, delaminations, and exposed reinforcement. We recommend that all cracks, spalls and delaminations be repaired.

5. The stone façade is generally in good condition. We recommend that the crack granite panels be repaired by sealing the cracks with epoxy injection Panels that are chipped should be replaced entirely.

6. The terrazzo pavement shows some wear and tear. We recommend that the deteriorated pavement be replaced.

7. We recommend to add drains at the stair landings to improve the drainage and minimize ponding at the stair landings.

Construction Cost Estimates

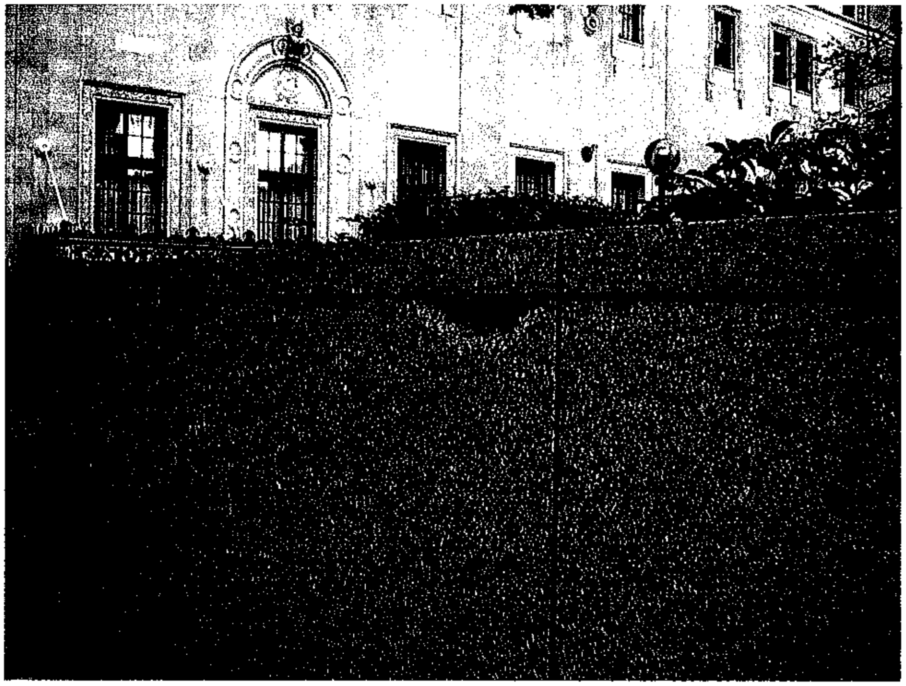
The engineer's estimates of the probable construction costs for the structural rehabilitations for Phase 1 and All Other Phases are shown in Tables 2 and 3, respectively. As shown, the estimated construction costs are $ and $ respectively. The quantities of repair areas were computed based upon the observations of the limited areas uncovered during this investigation, and the assumption that the conditions of the unexposed areas are similar to those observed. Contingencies are included with these estimates to account for the uncertainties associated with the repair quantities. The engineer's estimates do not include an estimate for water proofing, rehabilitation of the fountains, landscaping, architectural modifications, or the structural modification resulting from any future architectural modifications. The unit prices used for the estimates are based upon our experience with similar projects and contractor quotes. Finally, it should be mentioned that GAI is not a construction cost estimator nor a construction contractor and, therefore, our rendering of an opinion of the probable construction cost should not be considered equivalent to the nature and extent of services a construction cost estimator or construction contractor would provide.

This report has been prepared to aid in the structural rehabilitation of Mellon Square Park in Pittsburgh, Pennsylvania. The scope of this assessment and report is limited to the specific project, location and time frame described in this report. No third party may rely upon the opinions, conclusions, and certificates or report unless GAI has agreed to such reliance in writing. If additional data concerning this study are obtained, GAI should be informed so that we may examine the data and, if necessary, modify or revise the conclusions presented in this report.

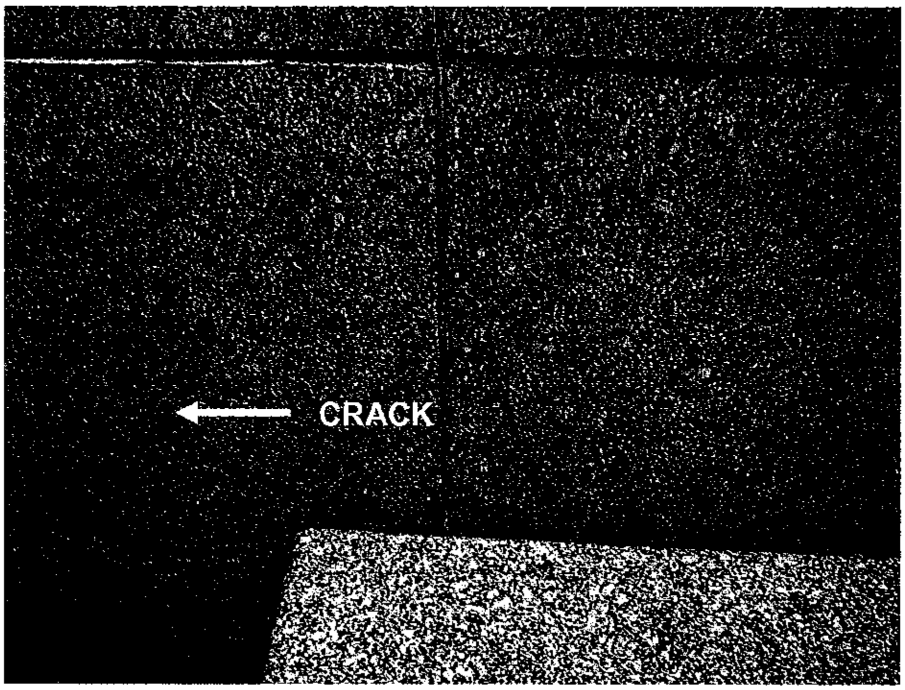
We appreciate having the opportunity to work with you on this project.

Sincerely,
GAI Consultants, Inc.

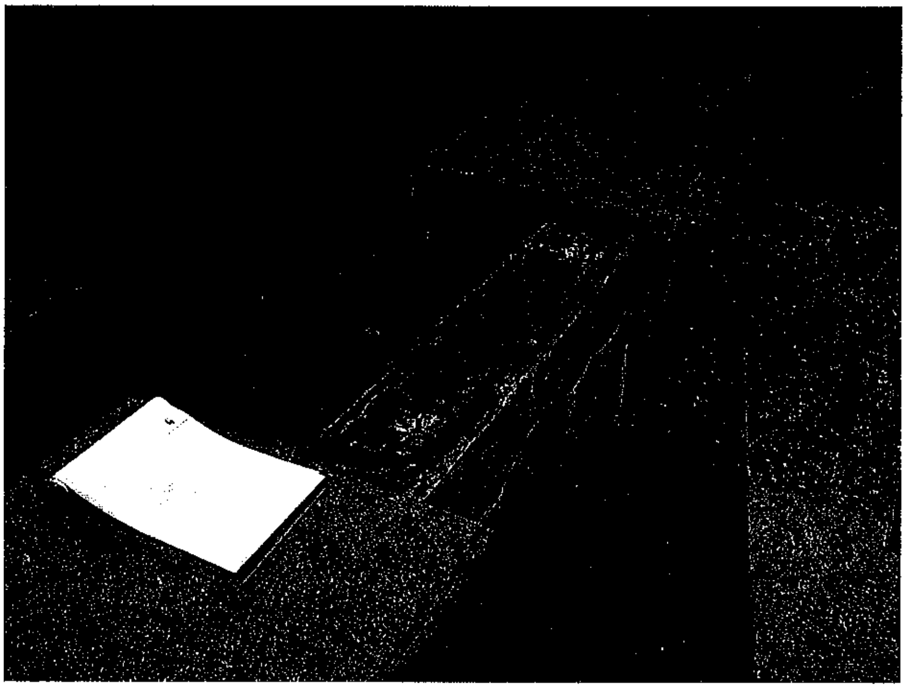
Joseph R. Salvatore, P.E.
Structural Engineering Manager



Photograph 1: Significant Chipping of Panel.

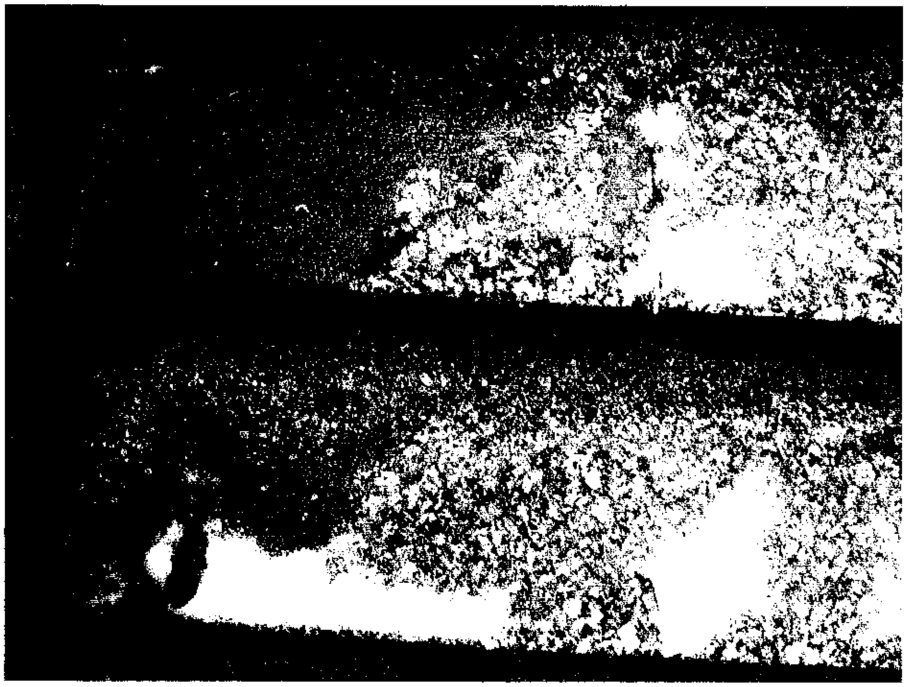


Photograph 2: Cracked Panel

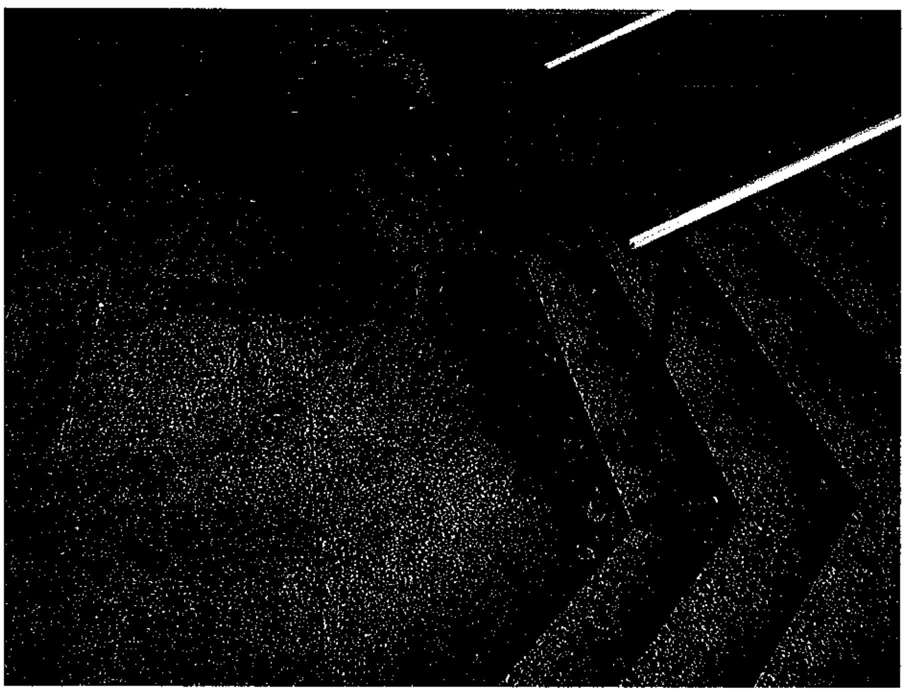


Photograph 3: Missing Bench

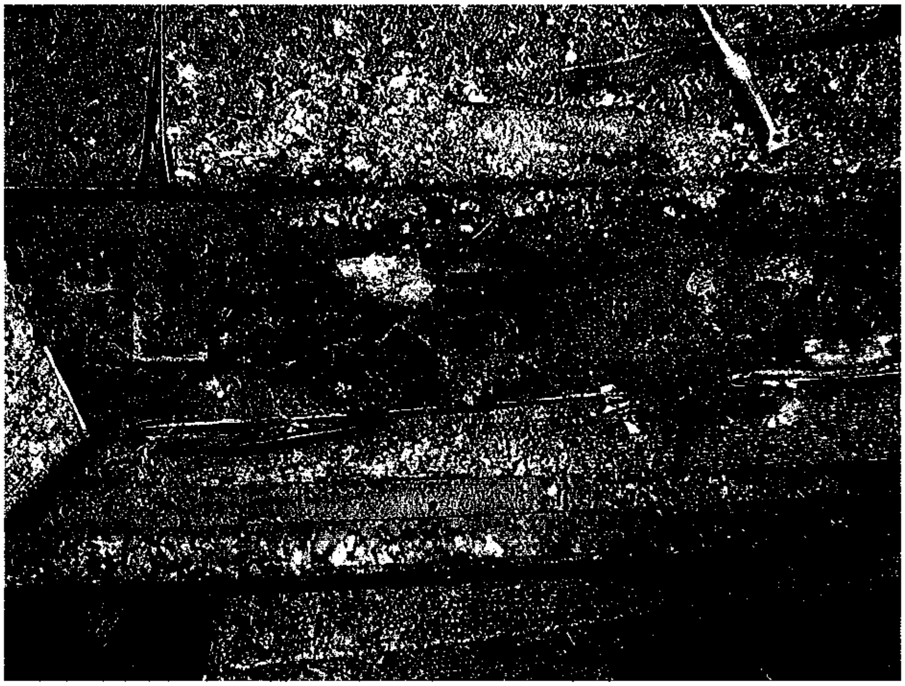
Photograph 4: Crack in Planter Wall



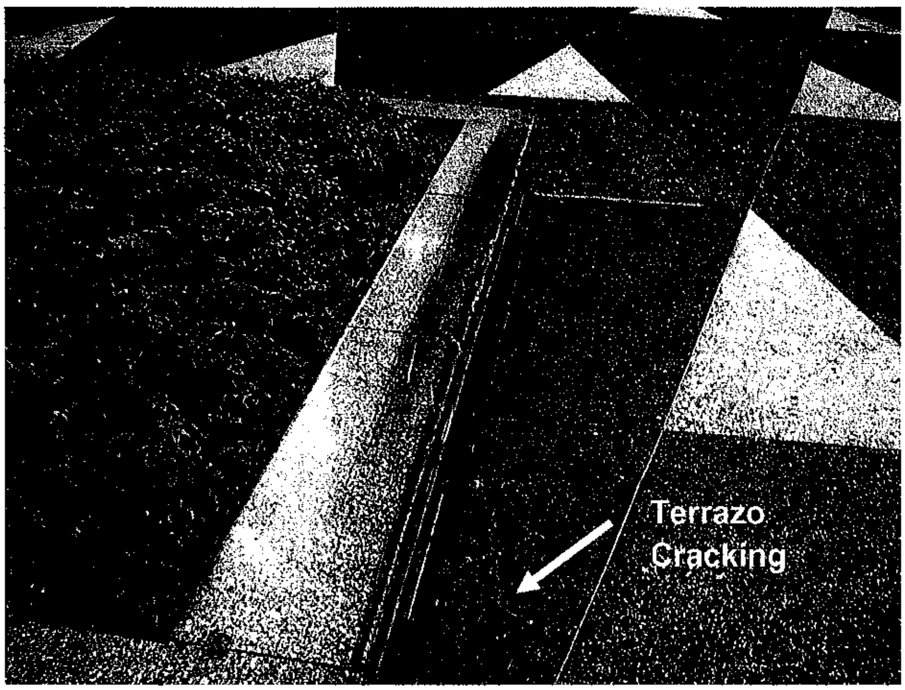
Photograph 5: Efflorescence on Stair Treads



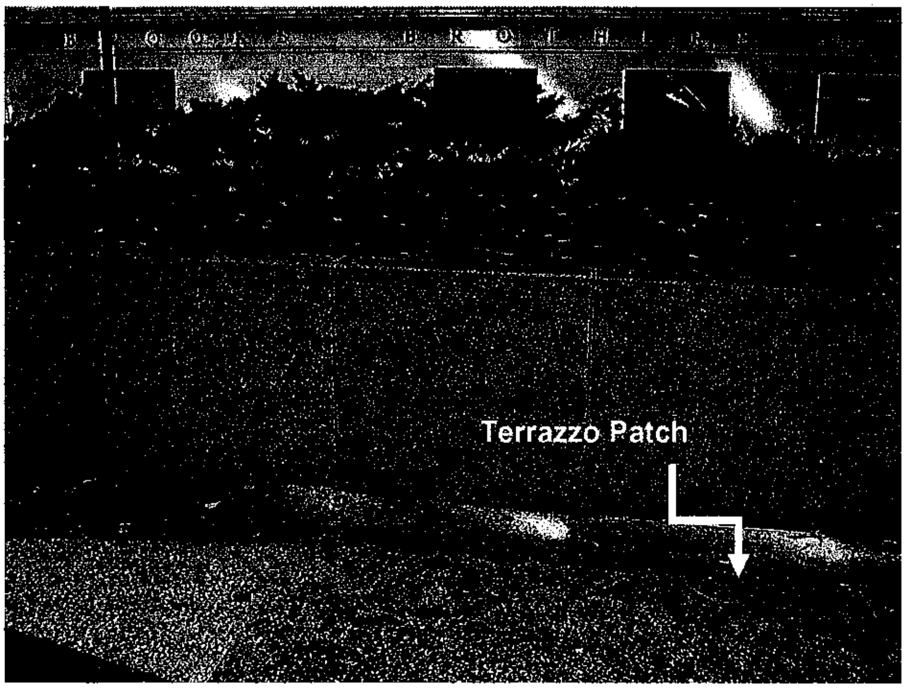
Photograph 6: Ponding of Water on Midway Landing, Sixth Street Stairs



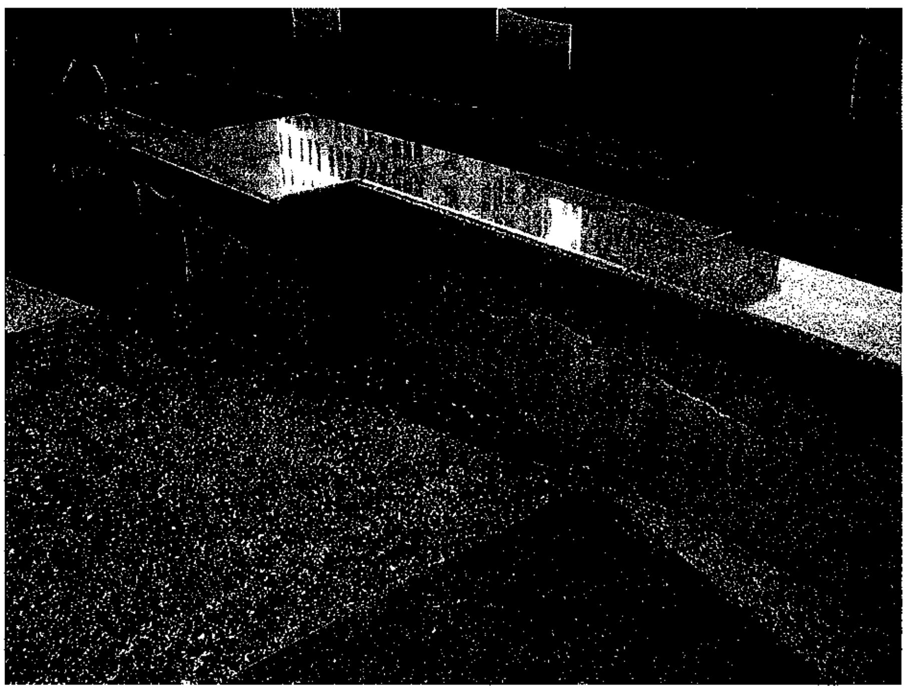
Photograph 7: Deteriorated Mortar Bed



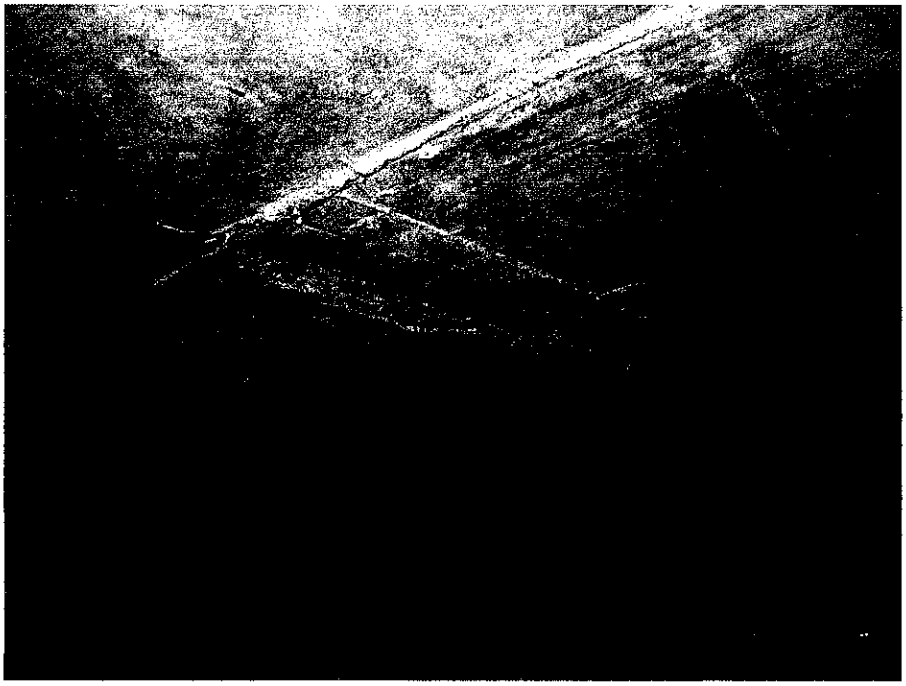
Photograph 8: Typical Terrazzo Cracking. Note Skateboard Damage on Coping



Photograph 9: Typical Terrazzo Patch



Photograph 10: Efflorescence through Cracks in Fountain Walls



Photograph 11: Spalling on Underside of Structural Slab

Table 1

SUMMARY OF CORE SAMPLE TESTING

Core Sample	Core Location	Required Testing Performed
1	Vertical through terrazzo pavement, topping slab and underlying structural slab near Smithfield/Oliver Stairs	Petrographic Analysis and Chloride Content
2	Vertical through terrazzo pavement, topping slab and underlying structural slab near Smithfield/Oliver Stairs	Unconfined Compression
3	Horizontal inside perimeter planter wall on Oliver side Near smithfield/Oliver Stairs	Petrographic Analysis and Chloride Content
4	Inside perimeter planter wall on 6th street side near Smithfield/6th street stairs	Unconfined Compression

Table 2
Engineers Estimate of Probable Construction Cost
for Phase 1

Item No.	Description	Estimated Quantity	Unit	Unit Price	Extended Price
1	General Requirements	1	LS		
2	Stone Removal and Replacement	1325	EA		
3	Step Removal and Replacement	800	EA		
4	Step Repair	1	EA		
5	Terrazzo Spall Repair	20	SF		
6	Terrazzo Crack Repair	100	LF		
7	Concrete Crack	250	LF		
8	Concrete Spall/Delamination Repair	250	SF		
9	Addition of Drain at Stair Landing	1	EA		
10	Caulking of Terrazzo and Planter Walls	500	LF		
11	Waterproofing	300	SF		
			Subtotal		
			Contingency		
			Total Cost		

Table 3
Engineers Estimate of Probable Construction Cost
for All Other Phases

Item No.	Description	Estimated Quantity	Unit	Unit Price	Extended Price
1	General Requirements	1	LS		
2	Stone Removal and Replacement	4000	EA		
3	Step Removal and Replacement	0	EA		
4	Step Repair	0	EA		
5	Terrazzo Spall Repair	80	SF		
6	Terrazzo Crack Repair	100	LF		
7	Concrete Crack	1020	LF		
8	Concrete Spall/Delamination Repair	1020	SF		
9	Caulking of Terrazzo and Planter Walls	1200	LF		
10	Waterproofing	1100	SF		
			Subtotal		
			Contingency		
			Total Cost		

psi *Information To Build On*
Engineering • Consulting • Testing

UNCONFINED COMPRESSION

Client:	Pittsburgh Parks Conservancy 2000 Technology Drive Suite 300 Pittsburgh, Pa 15219	Project:	Mellon Square Park
Attention:	Mr. Matt Koczko	Project No.:	0812499-1
Date:	November 10, 2009	Lab ID No.:	CD-90228

Please fine below the result(s) of one (1) concrete core specimens submitted to PSI for Unconfined Compressive Strength testing. Testing was performed in general accordance with test method ASTM C-42.

Specimen ID	Length (in.)		Core Diameter (in)		Area (in^2)	L/D capped	Corr. Factor	Total Load (lbf)	Compressive Strength (psi)	Fracture Type
	Before Cap	After Cap	Indv.	Average						
1	5.55	5.76	2.84 2.85	2.85	6.36	2.02	1.000	38500	6060	Shear

Ambient Temperature: 74° F

Rate of Loading: 6000lbs/min

Remarks: N/A

Respectfully submitted,
Professional Service Industries, Inc.

Daniel J. Stanisky
Laboratory/Project Manager

DJS:sp

[illegible]

AGGREGATE LABORATORY WORKSHEET
UNCONFINED COMPRESSION

TESTED FOR: PGH Parks Conservancy PROJECT: 0812-499-1

PSI REPORT NO.:
DATE COMPLETED: 10-9-09 LAB ID NO.: CS-90228

Please find below the results of One (1) concrete core specimens submitted to/obtained by PSI for Unconfined Compressive Strength testing. Tests were performed in general accordance with test method PTM 606/ASTM C-42.

Core No./ Depth (ft)	Before/ After Capping Length (in)	Core Dia. (in)	Average Core Dia. (in)	Area (in^2)	L/D (Capped)	Corr. Factor	Total Load (lbf)	Comp. Strength (psi)	Break Type
1	5.55 5.76	2.84 2.85	2.85	6.38	2.02	1.0	38,500	6,030	Shear

REMARKS: DR 2 compl

Information To Build On
Engineering • Consulting • Testing

UNCONFINED COMPRESSION

Client: Pittsburgh Parks Conservancy
2000 Technology Drive
Suite 300
Pittsburgh, Pa 15219
Attention: Mr. Matt Koczko
Date: November 24, 2009

Project: Mellon Square Park

Project No.: 0812499-2
Lab ID No.: CS-90239

Please fine below the result(s) of one (1) concrete core specimens submitted to PSI for Unconfined Compressive Strength testing. Testing was performed in general accordance with test method ASTM C-42.

Specimen ID	Length (in.)		Core Diameter (in)		Area (in^2)	L/D capped	Corr. Factor	Total Load (lbf)	Compressive Strength (psi)	Fracture Type
	Before Cap	After Cap	Indv.	Average						
1	3.75	4.01	2.87 2.87	2.87	6.47	1.40	0.948	40300	5910	Shear

Ambient Temperature: 74° F

Rate of Loading: 6000lbs/min

Remarks: N/A

Respectfully submitted,
Professional Service Industries, Inc.

Daniel J. Stanisky
Laboratory/Project Manager

DJS:sp

Mark E. Patton Ltd
Materials Consultant
105 Pfeffer Road, Suite 1
Phone: 724 325 1915 Export, PA 15632 Facsimile: 724 325 1917

January 5, 2010
MP0912479

PETROGRAPHIC EXAMINATIONS AND WATER-SOLUBLE CHLORIDE STUDIES OF TWO CONCRETE CORES

FOR

PITTSBURGH PARKS CONSERVANCY
(Mellon Square Park Plaza)

* * * * * * *

INTRODUCTION

Reported herein are the results of petrographic examinations and water-soluble chloride profiles of two concrete cores submitted by Mr. Matt Koczko of GAI Consultants, Inc. at the request of Mr. Philip J. Gruszka, Director of Parks Management and Maintenance Policies at the Pittsburgh Parks Conservancy. Specific information about the cores or their locations are not provided, other than the cores are reported to be from the Mellon Square Plaza in Pittsburgh, Pennsylvania.

Accordingly, the cores were prepared and examined using methods outlined in ASTM C856, "Petrographic Examination of Hardened Concrete." Samples were taken from each core, prepared and submitted for water-soluble chloride testing using methods of ASTM C1218, "Water-Soluble Chloride in Mortar and Concrete."

STUDIES

Samples – Received for the study are two $2^{7}/8$ inch diameter cores. The cores are not identified with any markings but for convenience are designated Cores 1 and 2 for the report. Core 1 is shown in Figure 1 and has a length of 7 inches. A transverse crack completely separates the core at a depth of $3^{1}/4$ inches. The top surface of the core has a heavy textured finish; the bottom end is a fractured surface. At a depth of $2^{3}/4$ inches there is a $^{1}/2$- inch diameter deformed reinforcement oriented horizontally. Immediately below the $^{1}/2$ inch diameter bar, there is a $^{5}/8$ inch diameter deformed reinforcement oriented horizontally and perpendicular to the $^{1}/2$ inch diameter bar.

Core 2 is shown in Figure 2 and has a total length of $6^{1}/2$ inches. There are three distinct sections in Core 2; a nominal $^{7}/8$- inch thick pale green terrazzo topping and wearing surface bonded to a two inch thick concrete underbed that rests on, but is not bonded to a concrete substrate slab. The top surface of the terrazzo is a rough, exposed aggregate surface; the bottom end of the concrete slab section is a fractured surface.

To obtain a vertical cross section from each core for the petrographic examinations, a longitudinal saw cut using a water-cooled saw with a diamond-tipped blade is made close to the center of each core. One saw cut cross sectional surface from each core is then prepared by lapping with progressively finer abrasives to obtain a smooth, light reflective cross sectional surface from each core for the studies. The prepared surfaces from each core are shown in Figures 3 and 4.

For the chloride testing, nominal $^{1}/2$–inch thick, horizontal slices of concrete are saw cut at selected depths from the sections of concrete not used for the prepared cross sections. In Core 1, chloride testing is done on samples taken at depths of 0 to $^{1}/2$ inch, $^{1}/2$ to 1 inch, and $2^{1}/4$ to $2^{3}/4$ inches; the deepest sample represents the concrete immediately above the reinforcing steel. In Core 2, chloride tests are done at depths of 1 to 1 $^{1}/2$ inches in the underbed, which represents the concrete just above the wire reinforcement in the underbed, and at depths of 0 to $^{1}/2$ inch and $^{1}/2$ to 1 inch in the substrate slab. The samples are submitted to Spectrochemical Laboratories of the West Penn Testing Group for the water-soluble chloride testing. The concrete slices are prepared by the laboratory by alternately crushing and sieving to obtain crushed samples of concrete for the water-soluble chloride content determinations as described in ASTM C1218.

Petrographic Examinations

Core 1 – Coarse aggregate of the core are crushed, vesicular blast furnace slag particles that are light, medium and dark gray, sometimes with a bluish tint, and light to medium brown and beige. Fine aggregate is natural sand that contains mainly quartz with minor to trace amounts of feldspar, mafic minerals, sandstone, siltstone, quartzite, and chert with fine undersized particles of the coarse aggregate. The aggregates are well graded and uniformly dispersed.

Paste in the body of the core varies from light medium and medium beige brown to medium and dark gray, sometimes with a blue tint. To depths of $^{3}/4$ inch, paste is mainly light medium and medium beige brown grading to light medium and medium gray with depth. There are discrete areas at depth in Core 1 where paste is beige brown. Overall paste is hard and firm.

At the finished surface region of the core, there is a distinct boundary at a depth that varies from $^{1}/8$ to $^{3}/16$ inch. As shown in Figure 5, paste above the boundary is not air entrained with non spherical voids prominent; below the boundary paste is well air entrained. Non spherical voids at the boundary are lined and filled with secondary deposits that are identified as ettringite. The boundary represents a bond line between a thin layer of mortar placed on the original surface of the core. Pastes in both the body of the core and the thin topping are similar with respect to color and hardness. Both the topping and the concrete in the body of the core have similar fine aggregates.

Fresh fractured surfaces induced in paste in the laboratory have textures that vary from sometimes finely granular to mainly semi-conchoidal. Mineral admixtures such as fly ash are not present. The hydration of the paste is advanced; relict and residual portland cement particles are present. The calcium hydroxide component of the cement hydration products occurs as moderate size discrete units. The brown color of the paste near the surface and in discrete areas of paste at depth is due to oxidation of a reaction product formed from components of the blast furnace slag interacting with certain hydration products of the portland cement. These reactions usually result in a blue-gray paste that when exposed to the atmosphere oxidizes and changes to a brown or earth tone.

Compositional and textural features of the paste are indicative of a portland cement content estimated to be moderately high (e.g. 6 bags per cubic yard) and a water-cement ratio that is variable on a microscale and estimated to vary from moderately low to moderate (e.g. 0.43 to 0.48). The air content of the core is estimated to be high, from 7 to 8 percent. Air in the core occurs mainly as microscopic and fine spherical voids with lesser amounts of small spherical voids, all characteristic of entrained air. There are a few coarse non spherical and spherical voids present that are characteristic of entrapped air. Small areas are present throughout the core where fine entrained air voids are so numerous that paste has the texture of froth. Secondary deposits of ettringite line and fill voids throughout the core.

The top surface of the core has a heavy textured finish that is intact. There are a few fine, tight, shallow, vertical surface cracks that extend to depths of less than $^{1}/_{16}$ inch. The top surface is carbonated to depths that vary from less than $^{1}/_{32}$ inch to $^{1}/_{16}$ inch. A horizontal crack occurs at a depth of $3^{1}/_{4}$ inches in the core, completely bisecting the core.

A deformed $^{1}/_{2}$-inch diameter reinforcement is present at a depth of $2^{3}/_{4}$ inches with a $^{5}/_{8}$-inch diameter reinforcement present at a depth of $3^{1}/_{4}$ inches and oriented perpendicular to the $^{1}/_{2}$ inch diameter bar. Both reinforcements are oriented horizontally in the core and both are clean and free of corrosion.

Core 2 – Terrazzo- Coarse aggregate is $^{1}/_{2}$ inch and smaller crushed foliated dark rock. Many of the coarse aggregate particles are elongated. No separate fine aggregate is present, but the grading of the coarse aggregate includes undersized particles that would represent the coarser fractions of a fine aggregate. The coarse aggregate particles are not in point contact with one another.

Paste is uniformly pale green with small rounded inclusions of dark green pigment distributed throughout. Paste is hard and firm. Fine, tight, randomly-oriented interconnected cracks throughout the terrazzo form a polygonal pattern with individual polygons $^{1}/_{16}$ to $^{1}/_{8}$ inch across. No mineral admixtures are present. Hydration of the cement is advanced. A white portland cement is used in the terrazzo. Fresh fractured surfaces induced in the paste have textures that are semi-conchoidal.

Compositional and textural features of the paste are indicative of a white portland cement content estimated to be high (e.g. 1 bag of portland for every 200 pounds of aggregate) and a water cement ratio estimated to be low (e.g. 0.42). The air content of the terrazzo is estimated to be 2 percent. Air occurs mainly as discrete, widely-spaced, small spherical voids

The top surface of the terrazzo is a rough surface that is carbonated to depths of $^{1}/_{16}$ inch with the coarse aggregate prominently exposed. The $^{7}/_{8}$ inch thick terrazzo layer is well bonded to the underbed.

Underbed – The underbed is 2 inches thick and well bonded to the terrazzo layer. The concrete is made with no coarse aggregate, only a coarse sand fine aggregate that is mainly quartz with minor to trace amounts of feldspar, mafic minerals, tramp slag, coal and lignite in the finer fractions, and in the coarser fractions, rounded particles of varieties of sandstone, siltstone, limestone, quartzite and chert.

Paste varies from light beige to medium beige gray and also varies from moderately hard and firm to hard and firm. Mineral admixtures are not present. Hydration of the cement is advanced; relict and residual portland cement particles are abundant. Fresh fractured surfaces induced in the laboratory have textures that vary from finely granular to sub conchoidal.

Compositional and textural features are indicative of a lean concrete made using a portland cement content estimated to be low (e.g. 5 bags per cubic yard) and a water-cement ratio that is estimated to vary on a microscale from mainly moderately low to moderately high (e.g. 0.45 to 0.54).

The air content of the underbed is estimated to be 8 to 10 percent. Air in the underbed occurs mainly as numerous non-spherical voids are present throughout the depth that are characteristic of entrapped air due to difficulty with consolidating a lean underbed mix typically used for bonded terrazzo.

The interface with the terrazzo is essentially not carbonated. Secondary deposits identified as acicular crystals of ettringite are abundant throughout the underbed, lining and filling the non spherical voids. Ettringite occurs as single well formed single crystals and tufts lining and filling voids.

A thin $^{3}/_{32}$ inch diameter wire is present at a depth of $1^{3}/_{4}$ inch in the underbed. The wire is clean and free of corrosion.

<u>Substrate Concrete</u> – Coarse aggregate of the substrate concrete in Core 2 is nominal $^{3}/_{4}$ inch maximum size crushed gravel that contains varieties of sandstone, limestone, quartzite, and light beige and dark gray-brown chert. Fine aggregate is natural sand that contains mainly quartz with minor to trace amounts of feldspar, mafic minerals, varieties of sandstone, siltstone, chert coal and lignite. One light beige porous chert particle just below the surface is cracked with the cracks extending out into the flanking paste as shown in Figure 7. Paste immediately flanking the cracked aggregate appears "wet" but no alkali silica gel is found. No other cracked chert particles are present in the core.

Paste is uniformly light beige gray, moderately hard and firm. Mineral admixtures such as fly ash are not present. Fresh fractured surfaces induced in the paste in the laboratory have textures that are finely granular. Hydration of the paste is advanced; relict and residual portland cement particles are present. The calcium hydroxide component of the cement hydration products occurs mainly as coarse and sometimes patchy units.

Compositional and textural features of the paste are indicative of a portland cement content estimated to be moderately high (e.g. 6 bags per cubic yard) and a water-cement ratio estimated to vary on a microscale in the moderate range (e.g. 0.48 to 0.52). The air content of the concrete is estimated to be from 6 to 7 percent. Air in the core occurs mainly as fine and small spherical voids characteristic of entrained air voids and as a few coarse spherical and non spherical voids characteristic of entrapped air. Secondary deposits identified as ettringite line and fill many of the air voids in the core.

Water-Soluble Chloride Content Determinations – Water-soluble chloride tests are done at depths of 0 to $^{1}/2$, $^{1}/2$ to 1, and $2^{1}/4$ to $2^{3}/4$ inches in Core 1, with the depth at $2^{1}/4$ to $2^{3}/4$ inches representative of the concrete immediately above the embedded reinforcement. In Core 2, water-soluble chloride tests are done at depths of 1 to $1^{1}/2$ inches in the underbed section, and at depths of 0 to $^{1}/2$ and $^{1}/2$ to 1 inch in the substrate concrete section. The chloride test in the underbed section is done in the concrete immediately above the level of the wire mesh in the underbed.

Respective water-soluble chloride contents in Core 1 at depths of 0 to $^{1}/2$, $^{1}/2$ to 1 and $2^{1}/4$ to $2^{3}/4$ inches are 0.006, 0.002 and 0.007 percent by weight of concrete. These values are converted to weight by portland cement using the estimated portland cement content of 6 bags or 564 pounds per cubic yard and assuming a concrete unit weight of 3,960 pounds per cubic yard. Respective water-soluble chloride contents by weight of portland cement in Core 1 at depths of 0 to $^{1}/2$, $^{1}/2$ to 1 and $2^{1}/4$ to $2^{3}/4$ inches are calculated to be 0.042, 0.014 and 0.049 percent.

Water-soluble chloride contents in Core 1 are all well below the limit of 0.15 percent by weight of portland cement established by the American Concrete Institute as the threshold for the nucleation of corrosion of embedded steel in non-carbonated concrete.

The water-soluble chloride content in the underbed of Core 2 at a depth of 1 to $1^{1}/2$ inches is 0.024 percent by weight of concrete. Using the estimated portland cement content of 5 bags or 470 pounds per cubic yard and an assumed unit weight of 3,800 pounds per cubic yard, the water-soluble chloride content is calculated to be 0.19 percent by weight of portland cement.

Respective water-soluble chloride contents of the substrate concrete of Core 2 at depths of 0 to $^{1}/2$ and $^{1}/2$ to 1 inch are 0.006 and 0.014 percent by weight of concrete. Using the estimated portland cement content of 6 bags per cubic yard and an assumed concrete unit weight of 3,960 pounds per cubic yard, respective water-soluble chloride contents at depths of 0 to $^{1}/2$ and $^{1}/2$ to 1 inch are calculated to be 0.042 and 0.098 percent by weight of portland cement. The water-soluble chloride content in the underbed at the level of the wire reinforcement exceeds the limit for corrosion established by the ACI. In the substrate concrete, the water-soluble chloride levels are below the established threshold for corrosion of embedded reinforcement in non-carbonated concrete.

SUMMARY AND DISCUSSION

Core 1 – The concrete is air entrained and made using a crushed blast furnace coarse aggregate, a natural sand fine aggregate, a portland cement content estimated to be 6 bags per cubic yard and a water cement ratio estimated to vary on a microscale from 0.43 to 0.48. The variation in water cement ratio in the body of the core is due to incomplete intermixing of batch or tempering water or both.

A thin $^{1}/8$ to $^{3}/16$ inch thick layer of non-air entrained concrete is intimately bonded to the top of the concrete. The thin layer of concrete is most likely an additional layer of concrete spread over the slab after the initial placement had stiffened and is a result of problems encountered during finishing. The lack of entrained air voids with numerous non-spherical distorted voids is an indication of prolonged manipulation of the surface layer. The thin layer is well bonded, intact and carbonated to depths of $^{1}/_{16}$ inch.

The air content of the concrete is estimated to be from 7 to 8 percent. There are a few small areas of paste present where fine spherical entrained air voids are so numerous that paste has the texture of froth. Secondary deposits of ettringite line and fill many of the voids present at the surface region and throughout the core. A horizontally oriented $^{1}/_{2}$ inch diameter deformed reinforcement is present at a depth of $2^{3}/_{4}$ inches with a perpendicular $^{5}/_{8}$ inch diameter deformed bar immediately below. Both reinforcements are clean and free of corrosion.

Water-soluble chloride contents are from 0.014 to 0.049 percent by weight of portland cement to the depths of $2^{3}/_{4}$ inches, the location of the embedded reinforcement. The water-soluble chloride contents are below the limit of 0.15 percent by weight of portland cement established by the American Concrete Institute as the threshold for nucleation of corrosion of embedded steel in non-carbonated concrete.

In summary the concrete in Core 1 is in good condition, well air entrained and there are no indications of distress at the surface or freeze thaw damage in the thin layer of concrete at the surface or in the body of the core.

<u>Core 2</u> – There are three distinct concretes present in Core 2. The uppermost section of concrete in the core is a terrazzo that is made using a crushed siliceous stone coarse aggregate and white portland cement in proportions estimated to be 1 bag of portland cement for every 200 pounds of coarse aggregate with a water cement ratio estimated to be 0.42.

The air content of the terrazzo is estimated to be 2 percent. The top surface of the terrazzo is carbonated to depths of $^{1}/_{16}$ inch. Approximately twenty percent of the coarse aggregate particles are elongated and the particles are not in point contact.

There are small spherical inclusions of medium dark green pigment present throughout the terrazzo. Throughout the terrazzo are fine, tight, randomly oriented interconnected cracks that form polygons nominally $^{1}/8$ inch in size. The fine, tight cracks are due to drying shrinkage. The terrazzo is well bonded to the underbed and is intact.

The underbed in Core 2 is a non air entrained lean concrete that is made with a coarse mainly siliceous sand aggregate, a portland cement content estimated to be 5 bags per cubic yard and a water-cement ratio that is variable on a microscale and estimated to vary from 0.45 to 0.54. The variation in water-cement ratio is due to incomplete intermixing of batch or tempering water or both.

Air in the underbed occurs as numerous non-spherical voids characteristic of entrapped air due to difficulty consolidating a lean mortar. The air content of the underbed is estimated to be 8 to 10 percent. Secondary deposits of ettringite line and fill the voids throughout the underbed. Nominal $^{3}/32$ inch diameter wire mesh is present at a depth of $1^{3}/4$ inches and is clean and free of corrosion. The top surface of the underbed is essentially not carbonated. The underbed is placed on the substrate concrete and is unbonded.

A water-soluble chloride content determination is done at a depth of 1 to $1^{1}/2$ inches in the underbed. The water-soluble chloride content is measured to be 0.024 percent by weight of concrete, and calculated to be 0.19 percent by weight of portland cement, which exceeds the threshold limit of 0.15 percent by weight of portland cement.

In summary, the underbed in Core 2 is in good condition and is characteristic of underbeds used in terrazzo. There are no indications of distress such as freeze-thaw damage in the underbed.

The substrate concrete of Core 2 is made using crushed siliceous and calcareous gravel coarse aggregate; fine aggregate that is natural siliceous sand; a portland cement content estimated to be 6 bags per cubic yard, and a water-cement ratio that is variable on a microscale and estimated to vary from 0.48 to 0.52. The air content of the substrate concrete is estimated to be from 6 to 7 percent.

There is a porous chert coarse aggregate particle present just below the top surface of the substrate concrete. The chert particle is cracked and the cracks extend into the flanking paste. Paste immediately flanking the coarse aggregate where cracks extend into the paste have a wet appearance on the prepared surface, but no alkali-silica gel is found. The chert aggregate particle contains chalcedony, which is known to be potentially alkali-silica reactive. No other cracked particles or indications of deleterious reactions are present.

The top surface of the substrate concrete is carbonated to depths of $^1/_{32}$ inch. Secondary deposits identified as ettringite line and fill many of the air voids throughout the substrate concrete.

Chloride content determinations are done to a depth of 1 inch in the substrate concrete show that water-soluble chloride contents do not exceed 0.014 percent by weight of concrete, which is calculated to be 0.098 percent by portland cement. Water-soluble chloride contents in the substrate concrete do not exceed the threshold limit of 0.15 percent by weight of portland cement.

In summary, other than the single cracked particle that is judged to be involved in an alkali-silica reaction, there are no other indications of distress in the substrate concrete. The substrate concrete is well air entrained.

Submitted,

Mark E. Patton

Mark E. Patton, PhD., P.E.

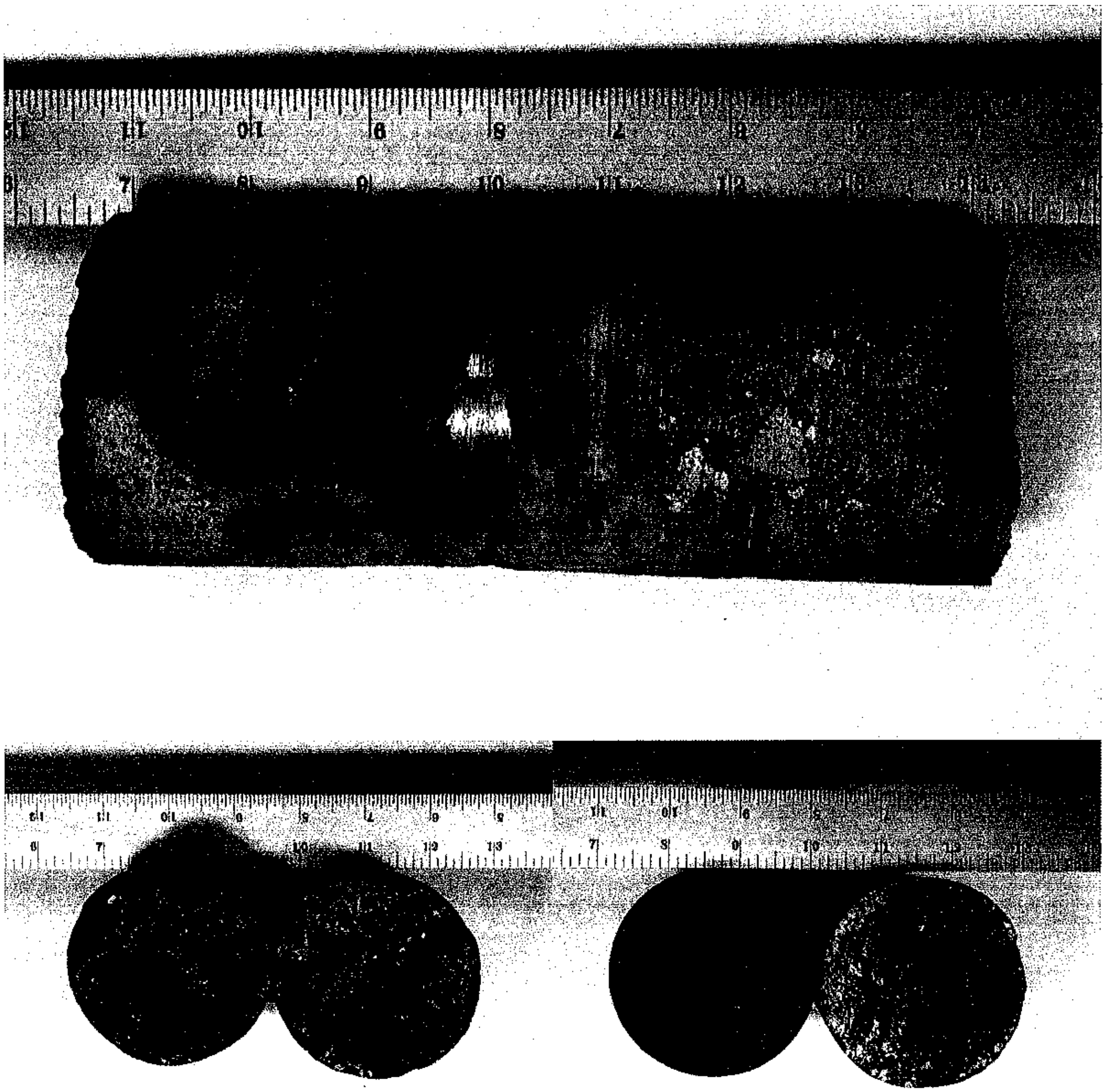


Figure 1 – Views of the side, fractured surfaces and top and bottom of Core 1. The top image shows the side of the core with the core oriented with the top to the left. The fractured surfaces at the depth of the reinforcement shown in the top image are shown in the lower left image. The bottom right image shows the textured top surface on the left of the image and the fractured bottom surface on the right.

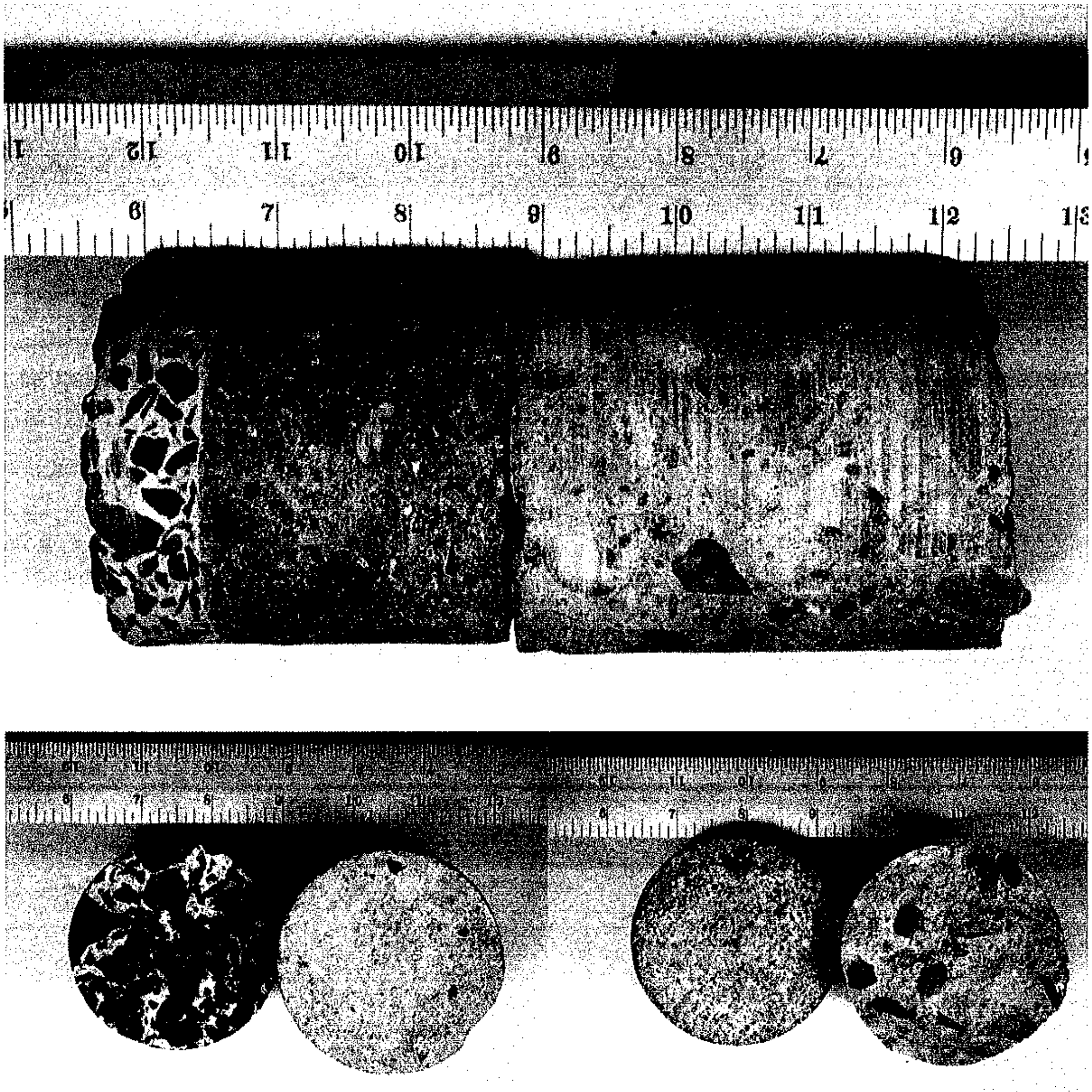


Figure 2 – Views of the side, tops and bottoms of Core 2. The top image shows the side view and three distinct sections of the core; the core is oriented with the top to the left. The bottom left image shows the top surface of the terrazzo (left) and substrate concrete (right). The bottom right image shows the bottom surface of the underbed (left) and fractured bottom surface of the substrate concrete (right).

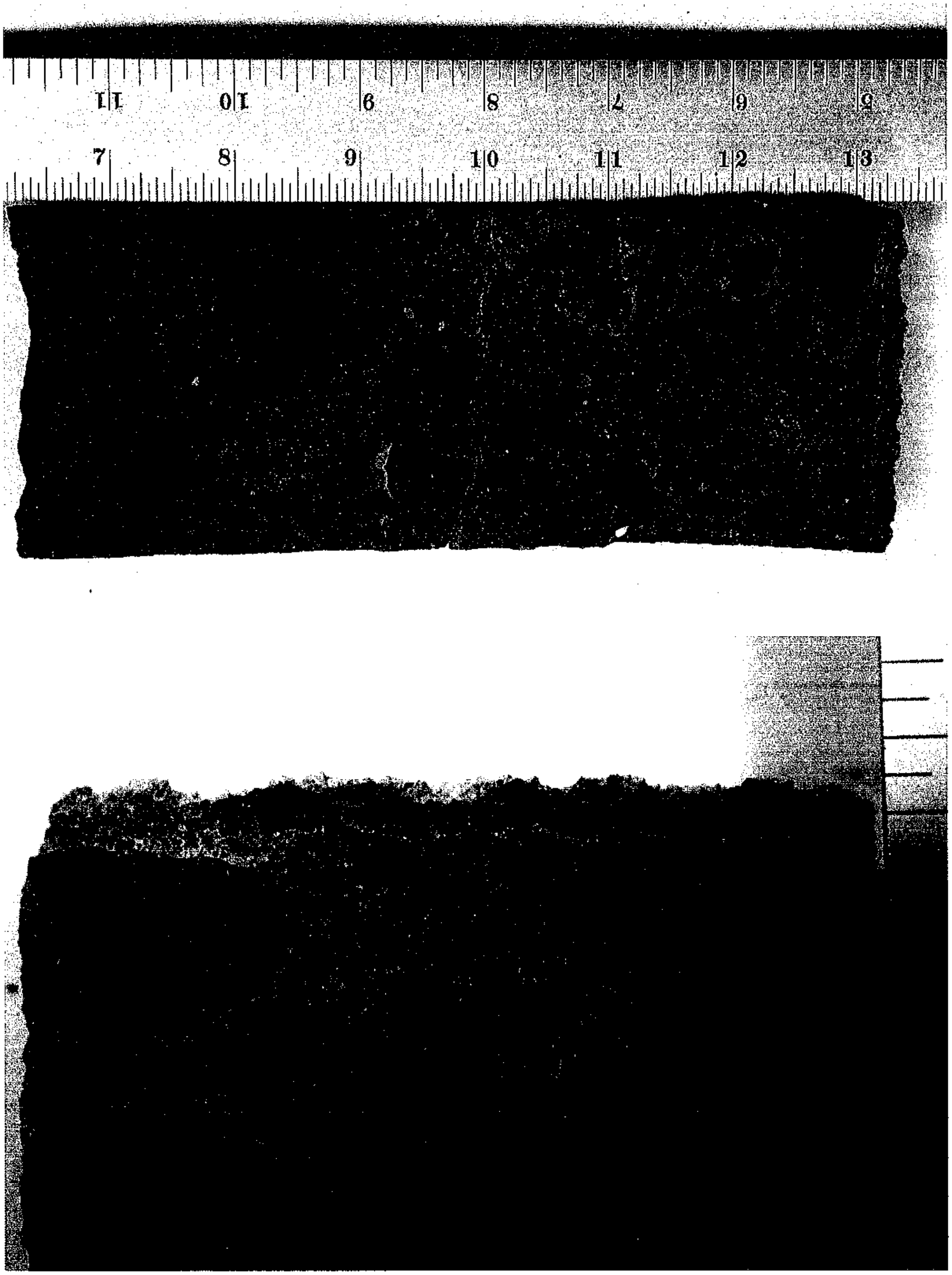


Figure 3 – View of the prepared surface of Core 1 (top) with the core oriented to the right. The bottom image is a close up of the top surface region showing the thin layer of mortar on the top surface of the core.

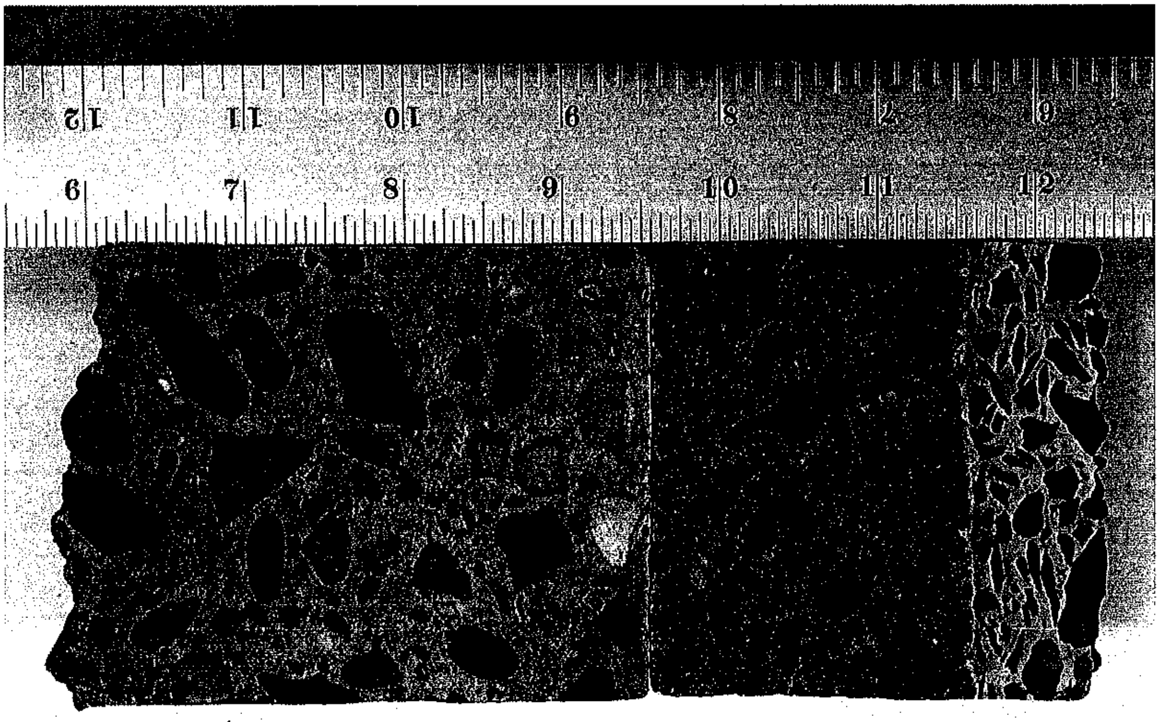


Figure 4 – View of the prepared cross section of Core 2 showing the three sections of the core. The core is oriented with the top to the right.

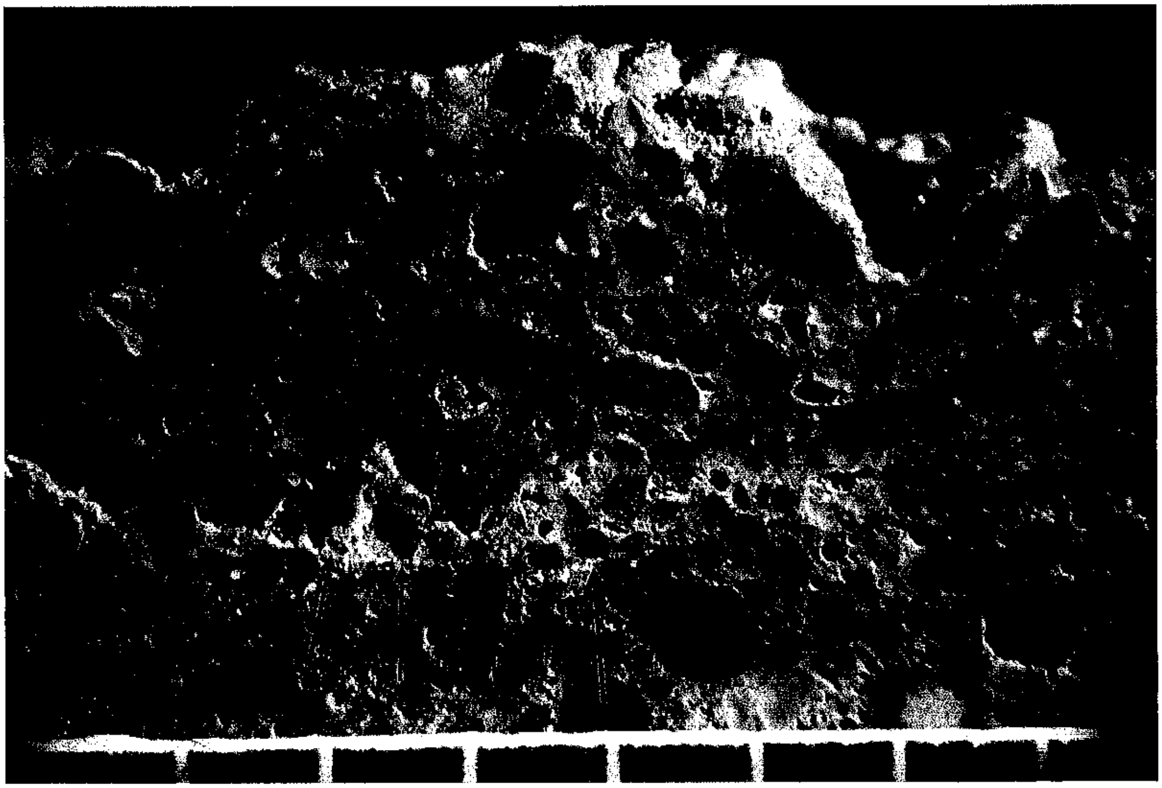


Figure 5 – A close up view of the thin mortar coating on the top surface of Core 1. The thin layer is non-air entrained. The entrained air voids are visible in the substrate concrete as are the fine, white needles of ettringite at the interface. The interface is marked by the black arrows. Increments of the blue scale at the bottom of the image are $^{1}/_{16}$ inch.

Figure 6 – View of the air void system in Core 1. Small areas with numerous voids that give the paste the texture of froth are visible (black arrow) as are the white secondary deposits of ettringite. Increments of the blue scale at the bottom of the image are 1/16 inch.

Figure 7 – Views of the cracked chert aggregate particle just below the top surface of the substrate concrete showing the cracks extending into the flanking paste. Increments of the blue scale at the bottom of the images are $^{1}/16$ inch.