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TO: C.T. Male Associates
Attn: Mr. Christopher M. Shaver, P.E.
50 Century Hill Drive
Latham, NY 12110

DATE: June 8, 2018

PROJECT: 0518-4160

PROJECT: CITY OF KINGSTON NY PIKE PLAN PROJECT

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE

INTRODUCTION:

Two concrete cores, labeled 1 and 2, were received on May 8, 2018, from Mr. Christopher M. Shaver of C.T. Male Associates, located in Latham, New York. Mr. Shaver reported that the samples were removed from the referenced project and requested petrographic (microscopical) examination in accordance with American Society for Testing and Materials (ASTM) Designation ASTM C 856-17, "Standard Practice for Petrographic Examination of Hardened Concrete," and measured air content in accordance with ASTM C457/C457M-16, "Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete."

AIR-VOID PARAMETERS:

	Measured Parameters		Recommended Parameters
Sample Identification	Core 1	Core 2	
Air Void Content, %	2.9	2.3	7 ± 1½ percent
Void Frequency (voids per inch)	2	2	1½ to 2 times percentage air
Specific Surface, $in.^2/in.^3$	308	348	Greater than 600
Spacing Factor, in.	0.023	.021	0.008 or less

The following air-void parameters are recommended for freeze-thaw resistant concrete: (1) air content of 6 ± 1½ percent for concrete having a 3/4 in. maximum size aggregate and subjected to severe exposure, (2) void frequency (air voids per inch of linear measurement) at least 1½ to 2 times the percentage of air-void volume, (3) specific surface (surface area of the air voids) greater than 600 $in.^2/in.^3$, and (4) spacing factor (average maximum distance from any point in the cement paste to the edge of the nearest void) of 0.008 in. or less (American Concrete Institute (ACI) Committee Reports ACI 201.2R, "Guide to Durable Concrete," and ACI 212.3R, "Chemical Admixtures for Concrete"). The concrete is not air entrained (the incorporation of air in the form of microscopic bubbles), based on measured air-void parameters and the scarcity of spherical voids having diameters less than 1 millimeter (the dimension of entrained air voids, by definition). An appropriate volume, size and distribution of microscopic air bubbles intentionally incorporated in concrete (entrained air voids) help protect concrete from freezing damage by providing areas for freezing and migrating water and relieving the resultant development of disruptive hydraulic and osmotic pressures. That is, ice occupies about 9% more space than the equivalent amount of water. Upon freezing, pressures that develop in the pores of the concrete as liquid water is forced away from frozen zones are accommodated by air voids.

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE

ADDITIONAL TEST RESULTS:

1. Water-cement ratio is estimated at 0.35 to 0.40, based on physical and mineralogical properties of the cement paste. Water-cement ratio of concrete in a freezing environment is recommended not to exceed 0.50, or 0.45 if exposed to deicer salts or other aggressive exposure (ACI 201.2R, "Guide to Durable Concrete").

2. Carbonated cement paste (a normal occurrence) extends from the exterior surfaces to depths of 1/2 in. The depth of carbonated cement paste, an indication of relative permeability, results from the penetration of environmental atmospheric carbon dioxide which converts calcium-containing hydration products to carbonate compounds. Well consolidated and cured concrete of relatively low water-cement ratio will carbonate to a depth of 1/4 in. after 10 years of exposure, and the depth of carbonation will increase to approximately 1/2 in. after 50 years. The rate of carbonation is a function of time, mix composition and proportions, curing regime and environmental conditions.

3. Paste-aggregate bond is tight. The mechanical (strength) and physical (such as porosity, permeability, and absorption) and chemical resistance properties of concrete are to a significant degree affected by the nature of the adhesive bond between aggregate particles and the hardened cement paste. A tight adhesive bond between cement paste and aggregate increases abrasion resistance and resistance to moisture penetration, and results in enhanced shrinkage restraint by the aggregate particles.

4. No evidence of deleterious aggregate reactions (alkali-silica reaction, ASR), harmful secondary deposits or other indication of processes of chemical interaction and related deterioration are detected.

5. Additional details of petrographic observations are presented in the attached data sheets.

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TEST PROCEDURES:

Petrographic examination was performed in accordance with ASTM C 856-17, "Standard Practice for Petrographic Examination of Hardened Concrete." A slice was cut between the top and bottom surface of each core, polished, and examined utilizing a stereomicroscope at magnifications up to 250X, as were freshly fractured surfaces. A thin section (a flat slice of concrete mechanically reduced until translucent and mounted between glasses as a microscope slide) was prepared from each sample in the following manner: An approximately 2-in. by 3-in. rectangular cross section was cut from the top surface to a depth of 2 in., polished, affixed to a large format (2-in. by 3-in.) microscope slide, reduced to thicknesses of approximately 25 micrometers, and examined utilizing a polarized-light microscope at magnifications up to 1000X to review cement paste mineralogy and micromorphology.

Measured parameters of the air-void systems were determined on polished cross sections in accordance with ASTM C457/C457M-16, "Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete." This method utilizes an electromechanical microscope stage and an electronic, computerized counting apparatus to move a polished cross section at equal increments, establishing a grid on the sample. At each interval, the stage stops (2000 total stops), and the material under the cross hairs is identified and recorded on a counter by the operator. The number of air voids that pass under the cross hairs as the stage moves is also recorded, providing statistically accurate measurement of the parameters of the air-void system. A stereomicroscope was used at a magnification of 125X on a traverse length of 100 in.

REMARKS:

The samples will be retained for a period of ninety days from the date of this report. Unless other disposition is requested by that time, the samples will be discarded.

Should you have any questions concerning this report, or if we may be of further assistance, please feel free to contact us at (763) 533-2461.

Dean E. Kofoed
Licensed Professional Geologist
President/Principal Petrographer
Concrete Microscopy, Inc.

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM C 856-17

CLIENT:	C.T. Male Associates Construction Materials Testing Latham, New York	**DATE:**	June 8, 2018
		CMI PROJECT NO.	0518-4160
PROJECT:	CITY OF KINGSTON NY PIKE PLAN PROJECT	**PERFORMED BY:**	Dean E Kofoed
		DATA SHEET:	1 of 2

SAMPLE IDENTIFICATION: Core 1.

GENERAL SAMPLE OBSERVATIONS:

Sample Dimensions: 4 in. diameter, 10-1/8 in. long.

Surface Condition:
Top - Relatively smooth troweled surface.

Bottom - Formed surface.

Reinforcement: None observed.

Cracks and Distinctive Features: None observed.

AIR CONTENT AND DISTRIBUTION: Measured at 2.9%. Not air entrained, based on the scarcity of spherical voids having diameters less than 1 millimeter.

ESTIMATED WATER-CEMENT RATIO: 0.35 to 0.40

MICROCRACKING: None observed.

PASTE-AGGREGATE BOND: Tight. Fractures induced in the laboratory utilizing a small hammer pass through a large majority of aggregate particles.

CEMENT PASTE MATRIX:

Color:	Medium gray.
Hardness:	Hard.
Luster:	Vitreous.
Depth of Carbonation, from Exterior Surface:	1/4 to 3/8 in. from troweled surface. 1/8 to 5/16 in. from formed surface.
Unhydrated Portland Cement Particles, %, by Volume of Paste:	6% to 8%.
Calcium Hydroxide, %, by Volume of Paste:	12% to 14%.
Residual Fly Ash, %, by Volume of Paste:	None observed.
GGBFS, Ground Granulated Blast-Furnace Slag:	None observed.

AGGREGATE:

Coarse: Crushed dolomite.

Fine: Sand mainly comprised of quartz and dolomite.

Gradation and Size: Well graded to a nominal maximum size of 1/2 in.

Shape and Distribution: Angular to subangular, tabular to slightly elongate coarse aggregate. Angular to subrounded, tabular to subspherical fine aggregate. Uniform aggregate distribution.

SECONDARY DEPOSITS: None observed.

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM C 856-17

CLIENT:	C.T. Male Associates Construction Materials Testing Latham, New York	**DATE:**	June 8, 2018
		CMI PROJECT NO.	0518-4160
PROJECT:	CITY OF KINGSTON NY PIKE PLAN PROJECT	**PERFORMED BY:**	Dean E Kofoed
		DATA SHEET:	2 of 2

SAMPLE IDENTIFICATION: Core 2.

GENERAL SAMPLE OBSERVATIONS:

Sample Dimensions: 4 in. diameter, 10 in. long.

Surface Condition:
Top - Relatively smooth troweled surface.

Bottom - Formed surface.

Reinforcement: None observed.

Cracks and Distinctive Features: A single hairline crack extends from the formed surface to a depth of 5/8 in.

AIR CONTENT AND DISTRIBUTION: Measured at 2.3%. Not air entrained, based on the scarcity of spherical voids having diameters less than 1 millimeter.

ESTIMATED WATER-CEMENT RATIO: 0.35 to 0.40

MICROCRACKING: None observed.

PASTE-AGGREGATE BOND: Tight. Fractures induced in the laboratory utilizing a small hammer pass through a large majority of aggregate particles.

CEMENT PASTE MATRIX:

Color:	Medium gray.
Hardness:	Hard.
Luster:	Vitreous.
Depth of Carbonation, from Exterior Surface:	3/8 to 1/2 in. from troweled surface. 3/8 to 1/2 in. from formed surface.
Unhydrated Portland Cement Particles, %, by Volume of Paste:	6% to 8%.
Calcium Hydroxide, %, by Volume of Paste:	14% to 16%.
Residual Fly Ash, %, by Volume of Paste:	None observed.
GGBFS, Ground Granulated Blast-Furnace Slag:	None observed.

AGGREGATE:

Coarse: Crushed dolomite.

Fine: Sand mainly comprised of quartz and dolomite.

Gradation and Size: Well graded to a nominal maximum size of 1/2 in.

Shape and Distribution: Angular to subangular, tabular to slightly elongate coarse aggregate. Angular to subrounded, tabular to subspherical fine aggregate. Uniform aggregate distribution.

SECONDARY DEPOSITS: None observed.