Results of Petrographic Examinations and Laboratory Testing of Concrete Cores

The St. Petersburg Pier
St. Petersburg, Florida

August 1, 2013
Lab Nos. 4077-4085
Terracon Project Number: H4135006

Prepared for:
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RESULT OF PETROGRAPHIC EXAMINATIONS AND LABORATORY TESTING OF CONCRETE CORES

INTRODUCTION & BACKGROUND

Nine, 3-3/4" diameter concrete cores from the referenced project were obtained by Terracon, Tampa, Florida personnel and were received at the Terracon Cincinnati, Ohio materials laboratory on July 3, 2013. Sample identification and assigned laboratory numbers are indicated below:

<table>
<thead>
<tr>
<th>Core ID</th>
<th>Terracon Lab No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>4077</td>
</tr>
<tr>
<td>2A</td>
<td>4078</td>
</tr>
<tr>
<td>3A</td>
<td>4079</td>
</tr>
<tr>
<td>4A</td>
<td>4080</td>
</tr>
<tr>
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<td>4083</td>
</tr>
<tr>
<td>4B</td>
<td>4084</td>
</tr>
<tr>
<td>5B</td>
<td>4085</td>
</tr>
</tbody>
</table>

The ‘A’ designated cores were examined petrographically, and chemical analyses for chloride, sulfate and alkali (Na and K) contents were performed. Density and moisture contents were also performed on these cores.

The ‘B’ designated cores had gross visual observation only. Density, moisture contents, and compressive strengths were obtained on these cores.

Core Nos. 1 through 5 presumably refer to the caisson numbers from which the cores were obtained. Caissons 2, 3, 4 and 5 were reportedly constructed in 1970. Caisson 1 (elevator shaft) was reportedly constructed in 1986.

The purpose of the examinations and testing was to evaluate the overall condition of the cores; determine the potential for alkali-silica reactivity to occur, and determine the nature, extent and rate of any observed deterioration if possible.
Petrographic Methodology

The referenced ‘A’ cores were examined petrographically. The cores were initially measured, visually examined in detail, and then sawn lengthwise. Sawn portions of the cores were again visually examined and ground using a series of progressively finer grits to a reflective surface acceptable for stereomicroscopic viewing.

Both the visual and stereomicroscopic examinations were performed in accordance with ASTM Method C-856. Air contents and concrete proportions were determined on the cores in accordance with ASTM Method C-457, Procedure B (Modified Point Count Procedure). Results are presented in Table 1 below. Photographs of the cores as received, after sawing, and after chemical stain testing are presented in Appendix 1.

<table>
<thead>
<tr>
<th>Terracon Lab No.</th>
<th>Core ID</th>
<th>Total Aggregate</th>
<th>Cement Paste</th>
<th>Air Content (% by Volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4077</td>
<td>1A</td>
<td>56.9</td>
<td>42.7</td>
<td>0.4</td>
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<td>4078</td>
<td>2A</td>
<td>49.1</td>
<td>49.4</td>
<td>1.5</td>
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<td>4079</td>
<td>3A</td>
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<td>25.6</td>
<td>7.5</td>
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<tr>
<td>4080</td>
<td>4A</td>
<td>44.9</td>
<td>54.0</td>
<td>1.1</td>
</tr>
<tr>
<td>4081</td>
<td>5A</td>
<td>65.3</td>
<td>28.9</td>
<td>5.8</td>
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</tbody>
</table>
CORE NO. 1A (LAB NO. 4077)

Gross Characteristics

The core was a 3-3/4” diameter core which was received in 3 pieces totaling approximately 27” in length. The exterior surface of the core was irregular and appeared to have the remnant (5%) of an asphaltic layer adhering to it. The 1-1/2” to 2-1/4” upper segment was separated from the underlying concrete by an open fracture normal to the core axis. This fracture contained discontinuous white filmy to glassy deposits of calcium carbonate.

The next segment was approximately 11” in length and was separated from the innermost segment by an apparent mechanical fracture normal to the core axis. This middle segment exhibited some localized aggregate segregation.

The lowest segment of the sample contained a layer of steel reinforcement at a depth of 17”. The steel was ¾” in diameter, and visually appeared to be corroded to a thickness of at least 1/8”.

Coarse Aggregate

The coarse aggregate consisted of a somewhat unevenly distributed, loosely to moderately packed, 1/2” maximum size crushed limestone. The aggregate was sub-angular to sub-rounded, apparently unweathered, and appeared to be of good quality. No preferred particle orientation was observed.

Fine Aggregate

The fine aggregate consisted almost entirely of angular to sub-angular, well-graded, moderately to tightly packed quartz, with very subordinate limestone sand. The quartz consisted of discrete, non-composite, unstrained grains. No chert was apparent.

Matrix

The matrix was gray (when wetted) (Munsell color 2.5Y 5/1) and slightly to moderately absorbent. Cementitious materials were well hydrated, with virtually no unhydrated cement. No fly ash or slag cement was present. No carbonation of the matrix was apparent based on the results of the phenolphthalein stain test. No macro or microfracturing of the matrix was present. The aggregate-matrix bonds were good; the concrete broke almost entirely through the coarse aggregate when struck with a hammer.
Air

The concrete was non-air entrained. Total air content was only 0.4%. Air voids were randomly distributed. Voids were generally spherical to occasionally irregular. Voids were empty of alkali-silica gels although some did contain calcium hydroxide (portlandite). No coalescing voids, honeycombing, or significant underside voids were present.

CORE NO. 2A (LAB NO. 4078)

Gross Characteristics

The core consisted of 2 pieces separated by a 1-1/2" thick presumed wooden water stop. The exterior segment of the core was 11" long and the bottom segment was 14" long. The top surface was slightly irregular, sandy, slightly friable, and exhibited remnants of an apparent asphalt layer. This segment exhibited significant aggregate segregation, with portions of the core up to 5" in length x 2" in width containing no coarse aggregate. The bottom segment of the core exhibited no significant features. The core contained no steel reinforcement and exhibited no visible fractures.

Coarse Aggregate

The coarse aggregate consisted of an extremely unevenly distributed, loosely to moderately packed, 1/2" maximum crushed limestone. The aggregate was angular to sub-angular, apparently unweathered, and appeared to be of good quality. No preferred particle orientation was observed but large portions of the core were devoid of coarse aggregate.

Fine Aggregate

The fine aggregate consisted almost entirely of angular to sub-angular, well-graded, tightly packed quartz. The quartz occurred as individual, non-composite, unstrained particles. No chert was apparent.
Matrix

The matrix was gray (when wetted) (Munsell color 5Y 6/1), and slightly to moderately absorbent. Cementitious materials were hydrated, with virtually no unhydrated cement. No fly ash or slag cement was present. The matrix was carbonated in the upper 1/4” of the core. The aggregate-matrix bonds were good; the concrete broke entirely through the coarse aggregate when struck with a hammer.

Air

The concrete was non-air entrained. Total air content was 1.5%. Air voids were randomly distributed. Voids were generally spherical to occasionally irregular. Voids were empty of alkali-silica gels or other mineral deposits. No coalescing voids, honeycombing, or significant underside voids were present.

CORE NO. 3A (LAB NO. 4079)

Gross Characteristics

The core consisted of 2 pieces totaling approximately 25-1/2” in length. The exterior surface of the core contained a rust-colored, apparent asphalt layer covering approximately 50% of the surface. The remainder of the surface was irregular, and apparently eroded up to a depth of 1/8” to 3/16”. Localized deposits of soft, white calcium carbonate were present on the surface. The core segments were separated by an apparent mechanical fracture oriented normal to the core axis at 14” depth. The core contained no steel reinforcement.

Coarse Aggregate

The coarse aggregate consisted of a somewhat unevenly distributed, moderately packed, 1” maximum crushed limestone. The aggregate was angular to sub-angular, apparently unweathered, and appeared to be of good quality. No preferred particle orientation or aggregate segregation was observed.
Fine Aggregate

The fine aggregate consisted almost entirely of angular to sub-angular well-graded, moderately to tightly packed quartz. Quartz grains were discrete, non-composite, unstrained grains. No chert was apparent.

Matrix

The matrix was gray (when wetted) (Munsell color 5Y 6/1) and moderately absorbent. Cementitious materials were well hydrated, with virtually no unhydrated cement. No fly ash or slag cement was present. The matrix was carbonated in the upper 3/8" of the core. No macro or microfracturing of the matrix was present. The aggregate-matrix bonds were good; the concrete broke predominantly through the coarse aggregate when struck with a hammer.

Air

The concrete was highly air entrained. Total air content was 7.5%. Air voids were randomly distributed. Voids were generally spherical to occasionally irregular. Voids were empty of alkali-silica gels or other mineral deposits. No coalescing voids, honeycombing, or significant underside voids were present.

CORE NO. 4A (LAB NO. 4080)

Gross Characteristics

The core consisted of 3 segments totaling approximately 28" in length. Much of the exterior 6" was nearly, or totally, devoid of coarse aggregate. The core broke along an angular, apparently mechanical, fracture from 6" to 9" in depth. A second mechanical fracture, oriented normal to the core axis, was present at 14" depth. The top surface of the core exhibited an apparent rusted steel feature, and a partly open void was apparent approximately 1" below the top surface. Portions of the top surface were also soft and friable. The coarse aggregate was fine in size (1/2" maximum), highly irregularly distributed, and very loosely to densely packed. No steel reinforcement was present in this core.
Results of Petrographic Examination
Michael Maltzan Architecture, Inc. ■ St. Petersburg Pier ■
St. Petersburg, FL ■ Terracon Project No. H4135006

Coarse Aggregate

The coarse aggregate consisted of a very unevenly distributed, very loosely to densely packed, 1/2” maximum crushed limestone. The aggregate was angular to sub-angular, apparently unweathered, and appeared to be of good quality. No preferred particle orientation was observed, but large portions of the core were devoid of coarse aggregate.

Fine Aggregate

The fine aggregate consisted almost entirely of angular to sub-angular, well-graded, moderately to tightly packed quartz. The quartz occurred as discrete, non-composite, unstrained grains. No chert was present.

Matrix

The matrix was gray (when wetted) (Munsell color 5Y 6/1) and moderately absorbent. Cementitious materials were well hydrated, with virtually no unhydrated cement. No fly ash or slag cement was present, although apparent slag cement concrete inclusions were present in companion Core 4B. No carbonation of the matrix was apparent based on the result of the phenolphthalein stain test. No macro or microfracturing of the matrix was present, but a partially open void was apparent approximately 1” below the top surface. The aggregate-matrix bonds were good; the concrete broke predominantly through the coarse aggregate when struck with a hammer. The matrix was observed to be porous and sandy in the upper 1” to 2”, and exhibited microfracturing to that depth only discernible after staining with phenolphthalein.

Air

The concrete was non-air entrained. Total air content was only 1.1%. Air voids were randomly distributed. Voids were generally spherical to occasionally irregular. Voids were empty of alkali-silica gels or other mineral deposits. No coalescing voids, honeycombing, or significant underside voids were present.
CORE NO. 5A (LAB NO. 4081)

Gross Characteristics

The core consisted of 3 pieces totaling approximately 25-1/2” to 26” in length. The top segment was approximately 13” to 14” in length. The top surface was smooth and slightly friable. A shallow 1/8” wide saw cut groove was present to a depth of 1/2”. The core was visibly damaged on one side to a depth of approximately 1-1/2”. The core contained two, apparently mechanical fractures at 14” and 16” depth. These fractures were oriented at a high angle (nearly normal) to the core axis. The crushed limestone coarse aggregate in this core was the coarsest of that observed in any of the cores, with a 1-1/2” maximum size. Aggregate distribution was irregular and packing density varied from loose to dense. No steel reinforcement was present in this core.

Coarse Aggregate

The coarse aggregate consisted of a somewhat unevenly distributed, loosely to densely packed, 1-1/2” maximum crushed limestone. The aggregate was angular to sub-angular, apparently unweathered, and appeared to be of good quality. No preferred particle orientation, but slight aggregate segregation was observed.

Fine Aggregate

The fine aggregate consisted almost entirely of angular to sub-angular well-graded, moderately to tightly packed quartz. The quartz occurred as discrete, non-composite, unstrained particles. No chert was apparent.

Matrix

The matrix was gray (when wetted) (Munsell color 5Y 6/1), and moderately absorbent. Cementitious materials were well hydrated, with virtually no unhydrated cement. No fly ash or slag cement was present. No carbonation of the matrix was apparent based on the results of the phenolphthalein stain test. No macro or microfracturing of the matrix was present. The aggregate-matrix bonds were good; the concrete broke predominantly through the coarse aggregate when struck with a hammer.
Air

The concrete was air entrained. Total air content was 5.8%. Air voids were randomly distributed. Voids were generally spherical to occasionally irregular. Voids were empty of alkali-silica gels or other mineral deposits. No coalescing voids, honeycombing, or significant underside voids were present.

CORE NO. 2B (LAB NO. 4082)

Gross Characteristics

The core is 26” to 26-3/4” long x 3-3/4” diameter. The exterior surface was a 1/8” asphaltic layer which had mostly delaminated from the top surface (approximately 80% of the asphalt layer was missing), resulting in iron-staining and apparent carbonation. An angular, open fracture extended from a depth of approximately 2” to 4”; the fracture was locally iron-stained. A second, apparently mechanical fracture was present at a depth of 12-1/2” and was oriented normal to the core axis. No steel reinforcement was present in this core. Exterior drilled surfaces contained large (up to 1/4” diameter), but isolated air voids. Coalescing voids or honeycombing were not apparent. The coarse aggregate consisted of 1” maximum size crushed limestone, which was somewhat irregularly distributed and varied in packing density (typically more densely packed in the lower one-half of the core).

CORE NO. 3B (LAB NO. 4083)

Gross Characteristics

The core was approximately 27” long x 3-3/4” diameter. The exterior surface was smooth and intact, with little asphaltic cover adhering to the surface, and contained an approximately 1/4” deep x 1/8” wide, clean groove of unknown purpose to the writer. The core contained an apparently mechanical, slightly angular fracture at a depth of 12-1/2” to 13”. No steel reinforcement was apparent in this core. Exterior drilled surfaces contained large (up to 1/4”), isolated air voids. Coalescing voids or honeycombing were not apparent. The coarse aggregate consisted of 1-1/2” maximum size crushed limestone, which was grossly unevenly distributed by size and on opposite sides of the core. The aggregate varied from loosely to very densely packed, with significantly decreasing aggregate size and much denser packing from 16” depth.
CORE NO. 4B (LAB NO. 4084)

Gross Characteristics

The core was approximately 26” long x 3-3/4” diameter and terminated along an angular, apparently mechanical fracture from 22” to 26”. The top surface was plane, sandy, slightly worn and slightly iron-stained. A single, apparently mechanical fracture oriented normal to the core axis was present at a depth of 14”. No steel reinforcement was present in the core. The concrete represented by this core was notably different than that in Cores 2B and 3B. The exterior 2” to 4” was nearly devoid of coarse aggregate. The coarse aggregate throughout the core consisted of only ½” maximum size (as opposed to 1” to 1-1/2” maximum size) crushed limestone, was very unevenly distributed, with widely variable packing density. Drilled surfaces again contained isolated entrapped air voids, but voids were notably smaller than in Cores 2B and 3B. A large, irregular 1” x 1-1/4” inclusion of apparent slag concrete was present at a depth of approximately 9”, and small zones of similar color were apparent in the upper 3” of the sample.

CORE NO. 5B (LAB NO. 4085)

Gross Characteristics

The core was approximately 26-1/4” long x 3-3/4” diameter. The exterior surface was dark brown and appeared to contain remnants of an asphaltic coating. However, the surface, to a depth of approximately ¼” was soft and friable, especially when wetted. An apparent mechanical fracture, oriented normal to the core axis, was present at a depth of 14”. No steel reinforcement was present in this core. The exterior drilled surfaces contained large (up to ¾” x 1/4”) isolated entrapped air voids. No coalescing voids or honeycombing were apparent. The coarse aggregate was similar to that in Core 3B. The aggregate consisted of 1/2” maximum size crushed limestone, which was irregularly distributed and highly variable (generally loose) in packing density. Portions of the upper 3-1/2” of the core are nearly devoid of coarse aggregate, and coarse aggregate was similarly lacking to a depth of nearly 4” below the referenced mechanical fracture.
CHEMICAL ANALYSIS

Select portions of each sample (0-3/4", 1-1/2" to 2-1/2", 3-1/2" to 4-1/2" and 5-1/2" to 6-1/2") were analyzed for the presence of water soluble chloride, water-extractable sulfate, and elemental Na and K (as Na₂O and K₂O) by independent chemist, Mr. Mike Pistilli. Results are summarized in Table II and Mr. Pistilli’s report is presented in Appendix II.

<table>
<thead>
<tr>
<th>Core</th>
<th>Depth (in)</th>
<th>Chloride (ASTM C-1218)</th>
<th>Sulfate (ASTM C-265)</th>
<th>Na/K (ASTM C-114)</th>
<th>Total Alkalis as Na₂O Equivalent</th>
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</thead>
<tbody>
<tr>
<td>1A</td>
<td>0-3/4</td>
<td>0.2060</td>
<td>0.0030</td>
<td>0.46/1.01</td>
<td>1.12</td>
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<td></td>
<td>1-2</td>
<td>0.1281</td>
<td>&lt;0.0025</td>
<td>0.39/0.70</td>
<td>0.85</td>
</tr>
<tr>
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<td>2.5-3.5</td>
<td>0.0775</td>
<td>&lt;0.0025</td>
<td>0.25/0.64</td>
<td>0.67</td>
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<td></td>
<td>5.5-6.5</td>
<td>0.0153</td>
<td>&lt;0.0025</td>
<td>0.20/0.31</td>
<td>0.40</td>
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<tr>
<td>2A</td>
<td>0-3/4</td>
<td>0.0380</td>
<td>&lt;0.0025</td>
<td>0.28/0.64</td>
<td>0.70</td>
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<tr>
<td></td>
<td>1-2</td>
<td>0.0110</td>
<td>&lt;0.0025</td>
<td>0.26/0.63</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>2.5-3.5</td>
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<td>&lt;0.0025</td>
<td>0.22/0.58</td>
<td>0.60</td>
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<td>0.0015</td>
<td>&lt;0.0025</td>
<td>0.15/0.40</td>
<td>0.41</td>
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<td>0-3/4</td>
<td>0.0650</td>
<td>&lt;0.0025</td>
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<td>0.0420</td>
<td>&lt;0.0025</td>
<td>0.21/0.33</td>
<td>0.43</td>
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<tr>
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<td>0.0330</td>
<td>0.0033</td>
<td>0.19/0.30</td>
<td>0.39</td>
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<tr>
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<td>5.5-6.5</td>
<td>0.0160</td>
<td>&lt;0.0025</td>
<td>0.11/0.29</td>
<td>0.30</td>
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<td>4A</td>
<td>0-3/4</td>
<td>0.0575</td>
<td>&lt;0.0025</td>
<td>0.31/0.55</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>1-2</td>
<td>0.0269</td>
<td>&lt;0.0025</td>
<td>0.30/0.55</td>
<td>0.66</td>
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<tr>
<td></td>
<td>2.5-3.5</td>
<td>0.0220</td>
<td>&lt;0.0025</td>
<td>0.21/0.48</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>5.5-6.5</td>
<td>0.0010</td>
<td>&lt;0.0025</td>
<td>0.12/0.45</td>
<td>0.42</td>
</tr>
<tr>
<td>5A</td>
<td>0-3/4</td>
<td>0.0188</td>
<td>&lt;0.0025</td>
<td>0.14/0.52</td>
<td>0.48</td>
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<td></td>
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<td>&lt;0.0025</td>
<td>0.25/0.55</td>
<td>0.61</td>
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<td>0.55</td>
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<td>5.5-6.5</td>
<td>0.0009</td>
<td>&lt;0.0025</td>
<td>0.11/0.48</td>
<td>0.43</td>
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UNIT WEIGHTS AND COMPRESSION STRENGTHS

Unit weights and compressive strengths were determined on Cores 2B, 3B, 4B and 5B. Unit weights only for Cores 1A through 5A were also obtained. Results are presented in Table III, below and in Appendix III, along with unit weights (density and moisture contents).

### TABLE III
COMPRESSIVE STRENGTHS AND UNIT WEIGHTS

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Core</th>
<th>Unit Weight (Dry Density) (lbs./ft³)</th>
<th>Compressive Strength (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4077</td>
<td>1A</td>
<td>137.5</td>
<td></td>
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<td>4078</td>
<td>2A</td>
<td>138.7</td>
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</tr>
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<tr>
<td>4080</td>
<td>4A</td>
<td>135.4</td>
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<td>4081</td>
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<td>135.5</td>
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<td>4B</td>
<td>139.1</td>
<td>5490</td>
</tr>
<tr>
<td>4085</td>
<td>5B</td>
<td>131.7</td>
<td>4040</td>
</tr>
</tbody>
</table>

**FINDINGS**

1. The concrete represented by these cores was a plain Portland cement concrete. No fly ash or slag cement was apparent, although Core 4B had slag cement inclusions. The Portland cement was well hydrated. The concrete varied from non-air entrained (Cores 1A, 2A and 4A) to highly air entrained (Cores 3A and 5A). Air contents varied from 0.4% to 7.5%.

2. Overall the concrete represented by these cores appeared to be in very good condition with the exception of only 2 cores (Cores 4A & 5A), which exhibited near-surface damage and/or internal fractures. Almost all observed fractures appeared to be mechanical in nature (coring-induced).
3. While all coarse aggregates in the cores appeared to consist of crushed limestone, disparities in aggregate size (from ½" maximum to 1-1/2" maximum), packing density and aggregate distribution/ segregation were notably apparent. In several cores (2A, 4A/4B, 5B), sections of the concrete were entirely or nearly entirely devoid of coarse aggregate.

4. Carbonation of the concrete was minimal. In no case did carbonation extend below a depth of 1/4".

5. While surface damage/deterioration was present in several of the cores, only Cores 4A and 5A exhibited any internal deterioration, as evidenced by fracturing or other discernible deterioration observed on sawn and/or chemically stained surfaces. These fractures did not extend below a depth of 2" in any of the cores examined.

6. Compressive strengths in the test cores ranged from 4040 psi to 5490 psi. Dry unit weights of all the cores ranged from 131.7 lbs./ft³ to 139.1 lbs./ft³. Since no mix design information was provided, the writer is unable to compare current results to mix design information.

7. There was no visible or microscopic evidence of alkali-silica reactivity.

8. Although all cores show variable amounts of chloride intrusion, the only core showing apparently significant intrusion was Core 2A, where the water soluble chloride content at the surface (0-3/4") was 0.206% by mass of concrete. Chloride contents were higher in all cores in the upper 0-3/4", and dropped off sharply with depth as shown in Table III. Based on apparent chloride penetration depths since construction, 43 to 45 years ago (Caissons 2,3,4,5) and 27 years ago (Caisson 1) the chloride penetration rates varied from 0.078" per year (Core 4A) to 0.176 per year (Core 1A).

9. Water soluble sulfate contents were negligible to non-detect in all cores.

10. Water soluble sodium and potassium were present in all samples, and again generally followed a decreasing pattern with depth. Total alkali as Na₂O (which is used to determine whether cement is 'high' or 'low' alkali) ranged from 0.30 to 1.12% by mass. Core 1A exhibited the highest total alkali content. For cement, a total alkali content above 0.60% renders the cement a 'high alkali' cement. It should be noted, however, that the pulverized samples consisted of both cement and aggregate, plus any free alkalis supplied by sea water intrusion.
11. Relatively large variations in dry unit weights (from 131.7 lbs./ft$^3$ in Core 5B to 139.1 lbs./ft$^3$ in Core 4B) were noted.

12. The single examined sample containing reinforcing steel (Core 1A) exhibited virtually no corrosion of the reinforcement.

**CONCLUSIONS**

Based on the foregoing examinations and testing we conclude that the concrete represented by these cores is generally in good condition, with no significant physical damage, limited chemical intrusion, limited near-surface carbonation, and no visible or physical evidence of alkali-silica reactivity.

Although total alkali contents varied from moderate to high, the coarse aggregate consisted of limestone, and the fine aggregate of discrete particles (non-composite) of unstrained quartz, with no chert. The potential for the development of deleterious alkali-silica reactivity is considered remote. Based on current chloride penetration rates, chloride ions are unlikely to penetrate to the depth of the first row of piles (30’ per provided information) using the projected additional design life of the caisson (75 years).

Relatively large variations in dry unit weights and aggregate size, distribution and packing density suggest less than optimal construction quality control.

General American Concrete Institute (ACI) recommendations for concrete exposed to seawater are for minimum cement content of 600 lbs./cu.yd., a maximum water-cement ratio of 0.40 to 0.45 depending on concrete location, cement tri-calcium aluminate content of 4%-10% and soluble chloride contents not exceeding 0.1% by weight of cement. In the absence of this information, Terracon is unable to further evaluate the quality of the concrete or predict future behavior.
Terracon appreciates the opportunity to have been of service. Please contact either of the undersigned with any questions.

Sincerely,

Terracon Consultants, Inc.

Terry E. Stransky, P.G.
Senior Geologist / Manager Petrographic Services

Jason Sander, P.E.
Principal / CMET Manager
APPENDIX I

PHOTOGRAPHS
Results of Petrographic Examination
Michael Maltzan Architecture, Inc. ■ St. Petersburg Pier ■
St. Petersburg, FL ■ Terracon Project No. H4135006

Responsive ■ Resourceful ■ Reliable

Photo #1  Core 1A, as received.

Photo #2  Same core, exterior surface

Photo #3  Apparently corroded steel reinforcement in Core 1A.

Photo #4  Close-up of apparently corroded steel reinforcement in Core 1A.
Results of Petrographic Examination
Michael Maltzan Architecture, Inc. ■ St. Petersburg Pier ■
St. Petersburg, FL ■ Terracon Project No. H4135006

Photo 5  Actual condition of reinforcing steel in Core 1A. Reinforcing steel exhibits virtually no corrosion.

Photo 6  Core 2A, as received.

Photo 7  Core 2A showing significant aggregate segregation.

Photo 8  Vertically sawn section of Core 2A showing small coarse aggregate, aggregate segregation, and matrix discoloration near top of core.
Results of Petrographic Examination
Michael Maltzan Architecture, Inc. ■ St. Petersburg Pier ■
St. Petersburg, FL ■ Terracon Project No. H4135006

Photo 9  Core 3A, as received.

Photo 10  Top surface of Core 3A.

Photo 11  Core 4A, as received.

Photo 12  Top portion of Core 4A. Note complete lack of coarse aggregate in part of this section, and small size coarse aggregate.
Results of Petrographic Examination
Michael Maltzan Architecture, Inc. ■ St. Petersburg Pier ■ St. Petersburg, FL ■ Terracon Project No. H4135006

Photo 13  Core 4A exhibiting open void, fracturing and matrix discoloration in upper 1" to 2".

Photo 14  Top surface of core 4A.

Photo 15  Core 5A, as received.

Photo 16  Top portion of Core 5A showing large size (1-1/2" maximum size) coarse aggregate, and discolored, friable zone with wood inclusion.
Results of Petrographic Examination
Michael Maltzan Architecture, Inc. ■ St. Petersburg Pier ■
St. Petersburg, FL ■ Terracon Project No. H4135006

Photo 17 Core 5A. Close-up of friable discolored zone.

Photo 18 Core B2, as received.

Photo 19 Top surface of Core B2, as received.

Photo 20 Core B3 as received. Note variation in size and distribution of coarse aggregate.

Wood inclusion
Results of Petrographic Examination
Michael Maltzan Architecture, Inc.  ■  St. Petersburg Pier  ■  St. Petersburg, FL  ■  Terracon Project No. H4135006

Photo 21  Top surface of core B3.

Photo 22  Core 4B, as received.

Photo 23  Top portion of Core 4B showing lack of coarse aggregate.

Photo 24  Another portion of Core 4B exhibiting relatively fine (1/2” maximum size) coarse aggregate and slag cement inclusion(s) (green).
Photo 25  Top surface of Core 4B.

Photo 26  Core 5B, as received.

Photo 27  Upper portion of Core 5B showing aggregate segregation and areas devoid of coarse aggregate.

Photo 28  Top surface of Core 5B.
Results of Petrographic Examination
Michael Maltzan Architecture, Inc. ■ St. Petersburg Pier ■
St. Petersburg, FL ■ Terracon Project No. H4135006

Responsive ■ Resourceful ■ Reliable

**Photo 29** Longitudinally sawn top portion of Core 1A after application of phenolphthalein stain. Although stain uptake is uneven, no carbonation is apparent.

**Photo 30** Longitudinally sawn top portion of Core 2A after application of phenolphthalein stain. Note discolored, carbonated zone at the top of the core (approximately 1/4”). Also note relatively fine coarse aggregate (1/2” maximum size), aggregate segregation, and several areas devoid of coarse aggregate.
Results of Petrographic Examination
Michael Maltzan Architecture, Inc. ■ St. Petersburg Pier ■
St. Petersburg, FL ■ Terracon Project No. H4135006

Photo 31  Longitudinally sawn top portion of Core 3A after application of phenolphthalein stain. Only near-surface carbonation is apparent.

Photo 32  Longitudinally sawn top portion of Core 4A, after application of phenolphthalein stain. Note small coarse aggregate size (1/2” maximum size) and significant aggregate segregation, with large areas near top devoid of coarse aggregate. No carbonation apparent.
Results of Petrographic Examination
Michael Maltzan Architecture, Inc. ■ St. Petersburg Pier ■
St. Petersburg, FL ■ Terracon Project No. H4135006

Photo 33 Close-up of upper portion of Core 4A. These additional fractures and friable zones were identified by variable phenolphthalein stain uptake.

Photo 34 Longitudinally sawn top portion of Core 5A after application of phenolphthalein stain. No carbonation is apparent.
APPENDIX II

CHEMICAL ANALYSIS
TERRACON PROJECT #H4135006

Date: July 17, 2013

Re: Chemical Analysis for
Sulfate Contents (ASTM C265),
Chloride Contents (ASTM C1218),
and Alkali Contents (ASTM C114)
in Twenty Concrete Samples

Project: #H4135006 – Lab No.’s 4077, 4078, 4079, 4080, & 4081

Gentlemen:

Enclosed herewith are two copies of our report of the results of chemical analysis to determine the water-extractable sulfate contents, water-soluble chloride contents and water-soluble alkali contents in twenty (20) pulzerized concrete samples from the referenced project.

Terracon appreciates the opportunity to have been of service. Should you have any questions concerning this report, or wish to discuss the results further, please do not hesitate to contact the undersigned.

Respectfully submitted,

Terracon Consultants, Inc.

Terry Stransky
Senior Geologist/Petrographer

Timothy Goodall
Senior Associate
Dept. Manager, Laboratory Svcs.
Cincinnati, Ohio

Michael F. Pistilli
Chemist, Petrographer
RESULTS OF:
CHEMICAL ANALYSIS TO DETERMINE:
WATER-EXTRACTABLE SULFATE CONTENTS,
WATER-SOLUBLE CHLORIDE CONTENTS,
AND
WATER-SOLUBLE ALKALI CONTENTS
IN TWENTY PULVERIZED CONCRETE SAMPLES

TERRACON PROJECT NO. H4135006
LAB Numbers 4077, 4078, 4079, 4080, & 4081

July 17, 2013
CHEMICAL ANALYSIS FOR SULFATE, CHLORIDE & ALKALI CONTENTS IN CONCRETE SAMPLES
TERRACON PROJECT NO. H4135006

INTRODUCTION
Twenty (20) pulverized concrete samples were received on July 11, 2013 for chemical analysis to
determine the water-extractable sulfate, water-soluble chloride, and water-soluble alkali contents
(sodium, potassium oxides). The samples were received from Mr. Terry Stransky, Senior Geologist/
Petrographer, Terracon Consultants, Inc.; Cincinnati, Ohio. Project: “Terracon Project H4135006”.

METHODS OF ANALYSIS
ASTM C265: The water-extractable sulfate contents of the samples were determined according to ASTM

ASTM C1218: The water-soluble chloride contents of the samples were determined according to ASTM
C1218, “Standard Test Method for Water-Soluble Chloride Content in Concrete and Mortar.”

ASTM C114: The water-soluble alkali contents of the samples were determined according to ASTM

SAMPLES RECEIVED FOR ANALYSIS
The samples, consisting of 70-to-80 grams each of pulverized concrete, had the following identifications:

<table>
<thead>
<tr>
<th>Lab Number</th>
<th>Depth (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Lab No. 4077 (1A)</td>
<td>0 - ¾&quot;</td>
</tr>
<tr>
<td>2) Lab No. 4077 (1A)</td>
<td>1.0 - 2.0&quot;</td>
</tr>
<tr>
<td>3) Lab No. 4077 (1A)</td>
<td>2.5 - 3.5&quot;</td>
</tr>
<tr>
<td>4) Lab No. 4077 (1A)</td>
<td>5.5 - 6.5&quot;</td>
</tr>
<tr>
<td>5) Lab No. 4078 (2A)</td>
<td>0 - ¾&quot;</td>
</tr>
<tr>
<td>6) Lab No. 4078 (2A)</td>
<td>1.0 - 2.0&quot;</td>
</tr>
<tr>
<td>7) Lab No. 4078 (2A)</td>
<td>2.5 - 3.5&quot;</td>
</tr>
<tr>
<td>8) Lab No. 4078 (2A)</td>
<td>5.5 - 6.5&quot;</td>
</tr>
<tr>
<td>9) Lab No. 4079 (3A)</td>
<td>0 - ¾&quot;</td>
</tr>
<tr>
<td>10) Lab No. 4079 (3A)</td>
<td>1.0 - 2.0&quot;</td>
</tr>
<tr>
<td>11) Lab No. 4079 (3A)</td>
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<tr>
<td>12) Lab No. 4079 (3A)</td>
<td>5.5 - 6.5&quot;</td>
</tr>
<tr>
<td>13) Lab No. 4080 (4A)</td>
<td>0 - ¾&quot;</td>
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<tr>
<td>14) Lab No. 4080 (4A)</td>
<td>1.0 - 2.0&quot;</td>
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<tr>
<td>15) Lab No. 4080 (4A)</td>
<td>2.5 - 3.5&quot;</td>
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<tr>
<td>16) Lab No. 4080 (4A)</td>
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<td>20) Lab No. 4081 (5A)</td>
<td>5.5 - 6.5&quot;</td>
</tr>
</tbody>
</table>
RESULTS – CHEMICAL ANALYSIS

The results of the Chemical Analysis for Sulfate Contents are given in the attached Table 1, Chloride Contents are given in Table 2, and Alkali Contents are given in Table 3.
APPENDIX III

CORE REPORTS
**CORE REPORT - ASTM C-42**

**Client:** Michael Maltzan Architecture, Inc.  
**Project:** The St. Petersburg, Pier  
**Location:** St. Petersburg, Florida  
**Order No.:** H4135006  
**Date Typed:** 7-24-13  
**Date Drilled:** 7-5-13  
**Page:** 1 of 1  

**Description of Pavement or Structure:**

<table>
<thead>
<tr>
<th>Lab No.</th>
<th>Core 2B</th>
<th>Core 3B</th>
<th>Core 4B</th>
<th>Core 5B</th>
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<tbody>
<tr>
<td>Identification</td>
<td>4082</td>
<td>4083</td>
<td>4084</td>
<td>4085</td>
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<tr>
<td>Location of Core</td>
<td>Core 2B</td>
<td>Core 3B</td>
<td>Core 4B</td>
<td>Core 5B</td>
</tr>
<tr>
<td>Condition of Core</td>
<td>10&quot;</td>
<td>14.25&quot;</td>
<td>14.25&quot;</td>
<td>13&quot;</td>
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<tr>
<td>Length of Core (Approx)</td>
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<td>14.25&quot;</td>
<td>14.25&quot;</td>
<td>13&quot;</td>
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<tr>
<td>Thickness Required</td>
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<tr>
<td>Depth of Reinforcement</td>
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<tr>
<td>Type of Coarse Agg.</td>
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<tr>
<td>Mixture Used</td>
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<tr>
<td>Condition of Sub Soil</td>
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<td></td>
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<tr>
<td>Date Concrete Placed</td>
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**COMPRESSION TESTS**

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<th>7-10-13</th>
<th>7-10-13</th>
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<tr>
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<tr>
<td>Age of Concrete</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of Core (in.)</td>
<td>7.38</td>
<td>7.43</td>
<td>7.47</td>
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<tr>
<td>Diameter of Core (in.)</td>
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<td>3.71</td>
<td>3.70</td>
<td>3.70</td>
</tr>
<tr>
<td>Area of Core (sq.in.)</td>
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<td>10.81</td>
<td>10.75</td>
<td>10.81</td>
</tr>
<tr>
<td>Capped Length (in.)</td>
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<td>7.61</td>
<td>7.55</td>
<td>7.54</td>
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<tr>
<td>Ratio Length to Dia.</td>
<td>2.04</td>
<td>2.05</td>
<td>2.04</td>
<td>1.65</td>
</tr>
<tr>
<td>Correction Factor</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0.96</td>
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<tr>
<td>Total Load, Lbs.</td>
<td>49,570</td>
<td>47,192</td>
<td>59,038</td>
<td>45,479</td>
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<tr>
<td>Uncorrected Strength (psi)</td>
<td>4,610</td>
<td>4,370</td>
<td>5,490</td>
<td>4,210</td>
</tr>
<tr>
<td>Corrected Strength (psi)</td>
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<td>4,370</td>
<td>5,490</td>
<td>4,040</td>
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<tr>
<td>Type of Fracture</td>
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<td>4</td>
<td>4</td>
<td>4</td>
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</table>

**Remarks:**

Respectfully submitted

Tim Goodall,  
Laboratory Manager

**Driller:**