EXHIBIT A-9: LABORATORY TESTING
Laboratory Testing Procedures

Corrosion Series Testing
Corrosion series testing has been conducted on soil samples obtained in the soil test borings. The series includes the following:
- Three (3) Chloride- Water Soluble Tests (AASHTO T-291 / ASTM D1140)
- Three (3) pH Tests (AASHTO T298-91)
- Three (3) Resistivity Tests (AASHTO T288-91)
- Three (3) Sulfate- Water Soluble Tests (AASHTO T290-91 / ASTM D4327)

Petrographic Analysis
Petrographic analysis has been conducted following ASTM C856 Petrographic Analysis of Concrete with ASTM C457 Hardened Air Content.

Compressive Strength of Concrete Cores
Compressive strength testing of concrete cores has been conducted following ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

Density of Hardened Concrete
Density of concrete cores has been obtained following ASTM C642 Standard Test Method for Density, Absorption and Voids in Hardened Concrete.
## Analytical Results

**TASK NO:** 150729010

**Report To:** Jason Hatch  
**Company:** Terracon, Inc. - North Charleston, SC  
**Address:** 1460 Fifth St. West  
**City, State, Zip:** North Charleston SC 29405

**Bill To:** Accounts Payable  
**Company:** Terracon, Inc. - Lenexa  
**Address:** 13910 W. 96th Terrace  
**City, State, Zip:** Lenexa KS 66215

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### Task No. 150729010
**Client PO:**  
**Client Project:** Battery Seawell EN155074

**Matrix:** Soil - Geotech

**Date Received:** 7/29/15  
**Date Reported:** 8/5/15

### Customer Sample ID: B-11 13-15  
**Lab Number:** 150729010-01

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride - Water Soluble</td>
<td>0.0053%</td>
<td>AASHTO T291-91/ ASTM D4327</td>
</tr>
<tr>
<td>pH</td>
<td>8.5 units</td>
<td>AASHTO T289-91</td>
</tr>
<tr>
<td>Resistivity</td>
<td>9166 ohm.cm</td>
<td>AASHTO T288-91</td>
</tr>
<tr>
<td>Sulfate - Water Soluble</td>
<td>0.007%</td>
<td>AASHTO T290-91/ ASTM D4327</td>
</tr>
</tbody>
</table>

### Customer Sample ID: B-11 23.5 - 25  
**Lab Number:** 150729010-02

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride - Water Soluble</td>
<td>0.8278%</td>
<td>AASHTO T291-91/ ASTM D4327</td>
</tr>
<tr>
<td>pH</td>
<td>7.5 units</td>
<td>AASHTO T289-91</td>
</tr>
<tr>
<td>Resistivity</td>
<td>91 ohm.cm</td>
<td>AASHTO T288-91</td>
</tr>
<tr>
<td>Sulfate - Water Soluble</td>
<td>0.084%</td>
<td>AASHTO T290-91/ ASTM D4327</td>
</tr>
</tbody>
</table>

### Customer Sample ID: B-11 3-5  
**Lab Number:** 150729010-03

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride - Water Soluble</td>
<td>0.0140%</td>
<td>AASHTO T291-91/ ASTM D4327</td>
</tr>
<tr>
<td>pH</td>
<td>7.7 units</td>
<td>AASHTO T289-91</td>
</tr>
<tr>
<td>Resistivity</td>
<td>575 ohm.cm</td>
<td>AASHTO T288-91</td>
</tr>
<tr>
<td>Sulfate - Water Soluble</td>
<td>0.008%</td>
<td>AASHTO T290-91/ ASTM D4327</td>
</tr>
</tbody>
</table>

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**Abbreviations/References:**

- AASHTO - American Association of State Highway and Transportation Officials.
- ASA - American Society of Agronomy.

**DATA APPROVED FOR RELEASE BY**

240 South Main Street / Brighton, CO 80601-0507 / 303-659-2313  
Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Page 1 of 2
REPORT OF CONCRETE ANALYSIS

PROJECT: BATTERY SEA WALL
JOB NO.: EN155074

REPORTED TO: TERRACON, INC.
1450 FIFTH STREET W
NORTH CHARLESTON, SC 29405

ATTN: THOMAS SMOAK

AET PROJECT NO: 24-01380
DATE: AUGUST 27, 2015

INTRODUCTION

This report presents the results of laboratory work performed by our firm on four concrete core samples submitted by Thomas Smoak of Terracon, Inc. on July 23, 2015. We understand the concrete cores were obtained from a battery sea wall of unknown age. The cores were labeled 04+79, 18+26, 18+26 Wall and 40+12. The scope of our work was limited to performing petrographic analysis on the sample to document the general overall condition of the concrete samples.

CONCLUSIONS

Based on our observations and testing, we believe:

1. The concrete samples were in fair, 04+79, 18+26, and 40+12 to poor, 18+26 Wall, condition. Deterioration observed on the top surface of cores 04+79, 18+26, and 40+12 and the outer surface of core 18+26 Wall was due to sulfate attack caused by exposure to sea water. Very soft paste observed in the top/outer few millimeters of each sample along with the presence of sulfate based secondary deposits of ettringite and/or gypsum was characteristic of marine-sulfate attack of concrete. The effects of sulfate attack appear to be confined to a maximum depth of 38 mm (1-1/2") from the outer/top surface of the samples. We believe the concrete will continue to deteriorate with exposure to sea water.

2. Core 18+26 Wall was further compromised by severe corrosion of the rebar members observed at depth in the core. A macrocrack which appears to have originated from the rebar, proceeds at high angle toward the outer surface of the sample, terminating at approximately 35 mm (1-3/8") from the outer surface of the core. Thick linings of secondary ettringite observed within the macrocrack are an indication that the crack was not induced by coring procedures and has been exposed to saturated conditions for extended periods of time.
3. Each of the concrete samples was placed with a moderately high water-to-cement ratio (w/cm) estimated to be between 0.50 to 0.60. Evidence of incomplete mixing of the concrete was observed in samples 04+79, 18+26 and 40+12. Large "balls" of neat cement were observed in samples 04+79 and 40+12 along with the mottled paste color in sample 04+79 and 18+26 are signs that concrete constituents were not evenly distributed through the samples.

4. In general, the coarse and fine aggregate was hard, sound, and durable. The residual cement particles observed in thin section of each of the samples were relatively coarse in comparison to modern cement samples. Assuming the each of the concrete samples is 60+ years old, the depth of carbonation in each of the samples relatively minor for the age of the concrete. The concrete was not purposefully air entrained in all four cores.

**SAMPLE IDENTIFICATION**

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Sample Type</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>04+79</td>
<td>Hardened Concrete Core</td>
<td>95 mm (3-3/4&quot;) diameter by 114 mm (4-1/2&quot;) long</td>
</tr>
<tr>
<td>18+26</td>
<td>Hardened Concrete Core</td>
<td>95 mm (3-3/4&quot;) diameter by 114 mm (4-1/2&quot;) long</td>
</tr>
<tr>
<td>18+26 Wall</td>
<td>Hardened Concrete Core</td>
<td>95 mm (3-3/4&quot;) diameter by 171 mm (6-3/4&quot;) long</td>
</tr>
<tr>
<td>40+12</td>
<td>Hardened Concrete Core</td>
<td>95 mm (3-3/4&quot;) diameter by 102 mm (4&quot;) long</td>
</tr>
</tbody>
</table>

**TEST RESULTS**

Our complete petrographic analysis documentation appears on the attached sheets entitled 24-LAB-001 "Petrographic Examination of Hardened Concrete, ASTM C856." A brief summary of the general physical characteristics of the concrete is as follows:

1. The coarse aggregate in samples 04+79, 18+26 and 18+26 Wall was comprised of 38 mm (1-1/2") nominal sized naturally-occurring gravel that appeared fairly well graded and exhibited good to fair overall distribution. The fine aggregate in these three samples was a natural siliceous sand with few feldspar and meta-granite particles. The coarse aggregate in sample 40+12 was a 38 mm (1-1/2") nominal sized quarried and crushed product made up of meta-granite and crush breccia. The fine aggregate in this sample was a natural siliceous sand with several shell fragments and few iron oxide particles.
2. The paste color ranged from very light gray to light gray to mottled grayish blue and yellowish gray. The paste hardness in each of the samples was soft (Mohs’ ≈ 2.5) overall becoming very soft (Mohs’ < 2) proximate the top/outer surface, up to 16 mm (5/8") maximum depth. Overall, the paste/aggregate bond was considered fair to poor.

3. The top/outer surface condition of each of the samples was rough irregular scaled/mortar eroded. The depth of carbonation ranged from negligible in sample 04+79 to 21 mm (13/16") depth in sample 40+12.

4. The w/cm of the four cores was similar and was estimated to be between 0.50 and 0.60 with approximately 2 to 6% residual portland cement clinker particles. No supplementary cementitious materials were observed in the concrete samples.

### Air Content Testing

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>04+79</th>
<th>18+26</th>
<th>18+26 Wall</th>
<th>40+12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Air Content (%)</td>
<td>1.5</td>
<td>3.3</td>
<td>2.2</td>
<td>3.7</td>
</tr>
<tr>
<td>&quot;Entrained&quot; Air (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>voids &lt; 1mm (0.040&quot;)</td>
<td>1.3</td>
<td>2.0</td>
<td>1.7</td>
<td>2.5</td>
</tr>
<tr>
<td>&quot;Entrapped&quot; Air (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>voids &gt; 1mm (0.040&quot;)</td>
<td>0.2</td>
<td>1.3</td>
<td>0.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Spacing Factor, in.</td>
<td>0.015</td>
<td>0.016</td>
<td>0.017</td>
<td>0.015</td>
</tr>
</tbody>
</table>

### TEST PROCEDURES

Laboratory testing was performed on July 24, 2015 and subsequent dates. Our procedures were as follows:

#### Petrographic Analysis

A petrographic analysis was performed in accordance with AET Standard Operating Procedure 24- LAB-001, "Petrographic Examination of Hardened Concrete," ASTM C856-latest revision. The petrographic analysis consisted of reviewing the cement paste and aggregate qualities on a whole basis on saw cut and lapped, and fractured sections. Reflected light microscopy was performed under an Olympus SZX-12 binocular stereozoom microscope at magnifications up to 160x. The depth of carbonation was documented using a phenolphthalein pH indicator solution applied on freshly fractured surfaces of the concrete sample. The paste-coarse aggregate bond quality was determined by fracturing a sound section of the concrete in the laboratory with a rock hammer.

The water/cementitious of the concrete was estimated by viewing a thin section of each concrete under an Olympus BX-51 polarizing light microscope at magnifications of up to 1000x. Thin section analysis was performed in accordance with Standard Operating Procedure 24-LAB-009, "Determining the Water/Cement of Portland Cement Concrete, AET Method." An additional, smaller, saw cut subdivision of the concrete sample is epoxy impregnated, highly polished, and then attached to a glass slide using an optically clear epoxy. Excess sample is saw cut from the
glass and the thin slice remaining on the slide is lapped and polished until the concrete reaches 25 microns or less in thickness. Thin section analysis allows for the observation of portland cement morphology, including: phase identification, an estimate of the amount of residual material, and spatial relationships. Also, the presence and relative amounts of supplementary cementitious materials and pozzolans may be identified and estimated.

**Air Content Testing**
Air content testing was performed using Standard Operating Procedure 24-LAB-003, "Microscopical Determination of Air Void Content and Parameters of the Air Void System in Hardened Concrete, ASTM C457-latest revision." The linear traverse method was used. The concrete core was saw cut perpendicular with respect to the horizontal plane of the concrete as placed and then lapped prior to testing.

**REMARKS**

The test samples will be retained for a period of at least sixty days from the date of this report. Unless further instructions are received by that time, the samples may be discarded. Test results relate only to the items tested. No warranty, express or implied, is made.

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I. General Observations

1. Sample Dimensions: Our analysis was performed on both sides of the 114 mm (4-1/2") x 95 mm (3-3/4") x 19 mm (3/4") thick lapped profile section, a 114 mm (4-1/2") x 91 mm (3-9/16") x 34 mm (1-5/16") thick lapped profile section and a 76 mm (3") x 52 mm (2") thin section that were sawcut and prepared from the original 95 mm (3-3/4") diameter by 114 mm (4-1/2") long concrete core.

2. Surface Conditions:
   Top: A rough, irregular scaled/mortar eroded surface
   Bottom: A smooth, planar, saw-cut surface.

3. Reinforcement: None observed

4. General Physical Conditions: The top surface was scaled/eroded away to an unknown depth exposing several coarse aggregate particles. The top surface of the concrete was partially covered by a discontinuous, up to 13 mm (1/2") thick coating of light gray to medium gray (Munsell® N7 to N3) carbonate scale and carbonate mud, often containing many fine sand particles and few shell fragments. A thin undulatory ribbon of dark gray carbonate scale was observed within the top 5 mm (3/16") of the sample. The top up to 10 mm (3/8") of the concrete was characterized by its very soft paste. A "cement ball" measuring approximately 47 mm (1-7/8") by 16 mm (5/8") was observed at 16 mm (5/8") depth from the current top surface of the concrete. Several large, entrapped-sized consolidation voids were observed within the top 68 mm (2-11/16") of the sample.

The concrete contained some entrained-sized, spherical air voids but did not contain an air void system consistent with current American Concrete Institute (ACI) recommendations for freeze-thaw resistance. A mass of medium gray repair concrete containing only few 10 mm (3/8") sized coarse aggregate particles and measuring approximately 80 mm (3-1/8") x 55 mm (2-1/8") x 47 mm (1-7/8") was observed within the bottom 47 mm (1-7/8") of the sample.

II. Aggregate

1. Coarse: 25 mm (1") nominal sized gravel made up of meta-granite, quartzite, granite and crush breccia. The coarse aggregate appeared fairly well graded and exhibited fair overall distribution.

2. Fine: A natural siliceous sand made up to quartz and quartzite particles with a few feldspar and meta-granite particles. The sand grains were mostly sub-rounded to sub-angular. The fine aggregate appeared fairly well graded and exhibited poor distribution.

III. Cementitious Properties

1. Air Content: 3.3% total
2. Depth of carbonation: Carbonation, observed on a freshly fractured surface, was negligible.
3. Paste/aggregate bond: Poor
4. Paste color: Mottled grayish blue (Munsell® 5PB 5/2) and yellowish gray (Munsell® 5Y8/1) and similar to dusky blue (Munsell® 5PB 3/2).
5. Paste hardness: Soft (Mohs' ≈ 2.5) overall; very soft (Mohs' <2) within the top 5 mm (3/16") of the concrete
6. Microcracking: None observed in the polished profiles.
7. Secondary deposits: None observed
8. w/cm: Estimated at between 0.50 and 0.60 with approximately 4 to 6% residual portland cement clinker particles.
   Belites: Well to fully; low in large cement grains composed of nested belite grains
I. General Observations
1. Sample Dimensions: Our analysis was performed on a 169 mm (6-5/8") x 91 mm (3-9/16") x 37 mm (1-7/16") thick lapped profile section and a 76 mm (3") x 52 mm (2") thin section that were sawcut and prepared from the original 95 mm (3-3/4") diameter by 171 mm (6-3/4") long concrete core.

2. Surface Conditions:
   Outer: A rough, irregular scaled/mortar eroded surface
   Inner: A fairly smooth, planar, saw-cut surface.

3. Reinforcement: A 16 mm (5/8") diameter rebar was observed between 60 mm (2-3/8") and 95 mm (3-3/4") depth from the current top surface and a second 16 mm (5/8") diameter rebar was observed between 89 mm (3-1/2") and 97 mm (3-13/16") depth from the top surface. Severe corrosion was observed.

4. General Physical Conditions: The outer surface was scaled/eroded away to an unknown depth, exposing a few coarse aggregate particles and was partially covered by up to 3 mm (1/8") of greenish gray algae and carbonate scale containing a few white shell fragments. The outer up to 16 mm (5/8") of the concrete was characterized by its very soft paste which was shallowly scoured during sample preparation. A macrocrack occurring at high angle to the outer surface was observed between 35 mm (1-3/8") and 105 mm (4-1/8") depth from the current outer surface, intersecting the plane of the rebar members. Corrosion product was observed within the macrocrack between 77 mm (3-1/16") and 82 mm (3-1/4") depth from the outer surface. Corrosion product was observed proceeding from the upper most rebar member up to 17 mm (11/16") into the macrocrack on a saw-cut surface of the sample. Many microcracks were observed at various depths, splaying from the macrocrack. Numerous fine microcracks, oriented sub-parallel to the outer surface, were observed in thin section, within the outer approximately 38 mm (1-1/2") of the sample.

The concrete contained some entrained-sized, spherical air voids but did not contain an air void system consistent with current American Concrete Institute (ACI) recommendations for freeze-thaw resistance.

II. Aggregate
1. Coarse: 38 mm (1-1/2") nominal sized gravel made up of meta-granite, quartzite, granite and crush breccia. The coarse aggregate appeared fairly well graded and exhibited good overall distribution.

2. Fine: A natural siliceous sand made up to quartz and quartzite particles with a few feldspar and meta-granite particles. The sand grains were mostly sub-rounded to sub-angular. The fine aggregate appeared fairly well graded and exhibited poor distribution.

III. Cementitious Properties
1. Air Content: 2.2% total

2. Depth of carbonation: Carbonation, observed on a freshly fractured surface, proceeded to 17 mm (11/16") depth from the current outer surface and ranged from 6 mm (1/4") to 11 mm (7/16") from the inner surface of the sample.

3. Paste-aggregate bond: Poor

4. Paste color: Similar to very light gray (Munsell® N8) overall becoming medium dark gray (Munsell® N8) within the inner 4 mm (3/16").

5. Paste hardness: Soft (Mohs' ≈ 2.5) overall; very soft (Mohs' <2) within the top 5 mm (3/16") of the concrete

6. Microcracking/:
   A macrocrack occurring at high angle to the outer surface was observed between 35 mm (1-3/8") and 105 mm (4-1/8") depth from the current outer surface, intersecting the plane of the rebar members. Many microcracks were observed at various depths, splaying from the macrocrack. Numerous fine microcracks, oriented sub-parallel to the outer surface, were observed in thin section, within the outer approximately 38 mm (1-1/2") of the sample.

7. Secondary deposits: White, acicular ettringite partially to completely fills many void spaces and microcracks within the non-carbonated paste. Ettringite also lines much of the macrocrack. Fine microcracks observed within the carbonated paste (in thin section) were filled with secondary carbonate. Most fine microcracks observed in the non-carbonated paste of the thin section were lined or filled by secondary ettringite.

8. w/cm: Estimated at between 0.50 and 0.60 with approximately 2 to 4% residual portland cement clinker particles.

   Belites: Well to fully; Low in large cement grains composed of nested belite grains
I. General Observations

1. Sample Dimensions: Our analysis was performed on both sides of the 110 mm (4-5/16") x 95 mm (3-3/4") x 19 mm (3/4") thick lapped profile section, a 114 mm (4-1/2") x 91 mm (3-9/16") x 35 mm (1-3/8") thick lapped profile section and a 76 mm (3") x 52 mm (2") thin section that were sawcut and prepared from the original 95 mm (3-3/4") diameter by 114 mm (4-1/2") long concrete core.

2. Surface Conditions:
   Top: A rough, irregular scaled/mortar eroded surface
   Bottom: A smooth, planar, saw-cut surface.

3. Reinforcement: None observed

4. General Physical Conditions: The top surface was scaled/eroded away to an unknown depth and covered by up to 8 mm (5/16") of yellowish gray (Munsell® 5Y 7/2) carbonate scale and carbonate mud which often contained much fine sand and few shell fragments. The bottom up to 1 mm (1/32") of the carbonate scale is dark gray (Munsell® N3) in color. The top up to 5 mm (3/16") of the concrete was characterized by its very soft paste. A cement ball measuring approximately 12 mm (1/2") by 6 mm (1/4") was observed at 38 mm (1-1/2") depth from the current top surface of the concrete.

The concrete contained some entrained-sized, spherical air voids but did not contain an air void system consistent with current American Concrete Institute (ACI) recommendations for freeze-thaw resistance.

II. Aggregate

1. Coarse: 38 mm (1-1/2") nominal sized gravel made up of meta-granite, quartzite, granite and crush breccia. The coarse aggregate appeared fairly well graded and exhibited good overall distribution.

2. Fine: A natural siliceous sand made up to quartz and quartzite particles with a few feldspar and meta-granite particles. The sand grains were mostly sub-rounded to sub-angular. The fine aggregate appeared fairly well graded and exhibited poor distribution.

III. Cementitious Properties

1. Air Content: 3.3% total
2. Depth of carbonation: Carbonation, observed on a freshly fractured surface, ranged from negligible up to 2 mm (1/16") depth from the current top surface.
3. Paste/aggregate bond: Poor
4. Paste color: Mottled grayish blue (Munsell® 5PB 5/2) and yellowish gray (Munsell® 5Y8/1).
5. Paste hardness: Soft (Mohs' ≈ 2.5) overall; very soft (Mohs' <2) within the top 5 mm (3/16") of the concrete
6. Microcracking: None observed in the polished profiles.
7. Secondary deposits: None observed
8. w/cm: Estimated at between 0.50 and 0.60 with approximately 3 to 5% residual portland cement clinker particles.
   Belites: Well to fully; Low in large cement grains composed of nested belite grains
I. General Observations

1. Sample Dimensions: Our analysis was performed on both sides of the 102 mm (4") x 95 mm (3-3/4") x 23 mm (7/8") thick lapped profile section, a 102 mm (4") x 89 mm (3-1/2") x 32 mm (1-1/4") thick lapped profile section and a 76 mm (3") x 52 mm (2") thin section that were sawcut and prepared from the original 95 mm (3-3/4") diameter by 102 mm (4") long concrete core.

2. Surface Conditions:
   Top: A rough, irregular scaled/mortar eroded surface
   Bottom: A smooth, planar, saw-cut surface.

3. Reinforcement: None observed

4. General Physical Conditions: The top surface was scaled/eroded away to an unknown depth exposing a few coarse aggregate particles. The top surface of the concrete was partially covered by a discontinuous, up to 8 mm (5/16") of light gray to medium gray (Munsell® N7 to N3) carbonate scale and carbonate mud which often contained fine sand and shell fragments. A thin undulatory ribbon of dark gray carbonate scale was observed at the bottom of the layer of scale. The top up to 3 mm (1/8") of the concrete was characterized by its very soft paste. A "cement ball" measuring approximately 30 mm (1-3/16") by 12 mm (1/2") was observed at in thin section proximate to the top surface of the concrete. Several microcracks which crosscut the cement ball were filled with white gypsum and calcium hydroxide.

The concrete contained some entrained-sized, spherical air voids but did not contain an air void system consistent with current American Concrete Institute (ACI) recommendations for freeze-thaw resistance. Several segments of plant matter were observed scattered throughout the sample.

II. Aggregate

1. Coarse: 25 mm (1") nominal sized gravel made up of meta-granite and crush breccia. The coarse aggregate appeared poorly graded and exhibited good overall distribution.

2. Fine: A natural siliceous sand made up to quartz and quartzite particles with several shell fragments and few iron oxide particles. The sand grains were mostly sub-rounded to sub-angular, becoming increasingly angular (shell fragments) as the material fines. The fine aggregate appeared fairly well graded and exhibited fair distribution.

III. Cementitious Properties

1. Air Content: 1.5% total
2. Depth of carbonation: Carbonation, observed on a freshly fractured surface, ranged from negligible to 21 mm (13/16") from the top surface of the concrete.
3. Paste/aggregate bond: Poor
4. Paste color: Light gray (Munsell® N7) becoming very light gray (Munsell® N8) within the top 22 mm (7/8") of the concrete.
5. Paste hardness: Soft (Mohs' ≈ 2.5) overall; very soft (Mohs' <2) within the top 3 mm (1/8") of the concrete
6. Microcracking: None observed in the polished profiles.
7. Secondary deposits: Microcracking within a cement ball proximate to the top surface of the sample was filled with gypsum and calcium hydroxide. White acicular ettringite lines several void spaces scattered throughout the non-carbonated paste.
8. w/cm: Estimated at between 0.50 and 0.60 with approximately 2 to 4% residual portland cement clinker particles.
   Belites: Well to fully; low in large cement grains composed of nested belite grains
PROJECT: BATTERY SEA WALL
JOB NO.: EN155074

REPORTED TO: TERRACON, INC
1450 FIFTH ST W
NORTH CHARLESTON, SC 29405

AET PROJECT NO: 24-01380
DATE: AUGUST 27, 2015

Sample Number: 04+79 1st
Conformance: The sample contains an air void system which is not consistent with current American Concrete Institute (ACI) recommendations for freeze-thaw resistance.

Sample Data
Description: Hardened Concrete Core
Dimensions: 95 mm (3-3/4") diameter by 114 mm (4-1/2") long

Test Data: By ASTM C457, Procedure A
Air Void Content % 3.7
Entrained, % < 0.040"(1mm) 2.5
Entrapped, % > 0.040"(1mm) 1.2
Air Voids/inch 2.8
Specific Surface, in²/in³ 300
Spacing Factor, inches 0.015
Paste Content, % estimated 19
Magnification 50x
Traverse Length, inches 101.5
Test Date 8/4/2015
Test Performed By S. Massignan

Magnification: 30x
Description: Hardened air void system.
PROJECT: BATTERY SEA WALL
JOB NO.: EN155074

REPORTED TO: TERRACON, INC
1450 FIFTH ST W
NORTH CHARLESTON, SC 29405

ATTN: THOMAS SMOAK

AET PROJECT NO: 24-01380
DATE: AUGUST 27, 2015

Sample Number: 18+26 Wall
Conformance: The sample contains an air void system which is not consistent with current American Concrete Institute (ACI) recommendations for freeze-thaw resistance.

Sample Data
- Description: Hardened Concrete Core
- Dimensions: 95 mm (3-3/4") diameter by 171 mm (6-3/4") long

Test Data:
- By ASTM C457, Procedure A
- Air Void Content % 2.2
- Entrained, % < 0.040"(1mm) 1.7
- Entrapped, %> 0.040"(1mm) 0.5
- Air Voids/inch 2.0
- Specific Surface, in²/in³ 370
- Spacing Factor, inches 0.017
- Paste Content, % estimated 21
- Magnification 50x
- Traverse Length, inches 96
- Test Date 7/30/2015
- Test Performed By S. Massignan

Magnification: 30x
Description: Hardened air void system.
PROJECT: BATTERY SEA WALL
JOB NO.: EN155074

REPORTED TO: TERRACON, INC
1450 FIFTH ST W
NORTH CHARLESTON, SC 29405

ATTN: THOMAS SMOAK

AET PROJECT NO: 24-01380
DATE: AUGUST 27, 2015

Sample Number: 18+26
Conformance: The sample contains an air void system which is not consistent with current American Concrete Institute (ACI) recommendations for freeze-thaw resistance.

Sample Data
- Description: Hardened Concrete Core
- Dimensions: 95 mm (3-3/4") diameter by 114 mm (4-1/2") long

Test Data:
- By ASTM C457, Procedure A
- Air Void Content % 3.3
- Entrained, % < 0.040"(1mm) 2.0
- Entrapped, % > 0.040"(1mm) 1.3
- Air Voids/inch 2.4
- Specific Surface, in²/in³ 280
- Spacing Factor, inches 0.016
- Paste Content, % estimated 17
- Magnification 50x
- Traverse Length, inches 101.5
- Test Date 8/3/2015
- Test Performed By S. Massignan

Magnification: 30x
Description: Hardened air void system.
PROJECT: BATTERY SEA WALL
JOB NO.: EN155074

REPORTED TO: TERRACON, INC
1450 FIFTH ST W
NORTH CHARLESTON, SC 29405

ATTN: THOMAS SMOAK

AET PROJECT NO: 24-01380
DATE: AUGUST 27, 2015

Sample Number: 40+12 1st
Conformance: The sample contains an air void system which is not consistent with current American Concrete Institute (ACI) recommendations for freeze-thaw resistance.

Sample Data
Description: Hardened Concrete Core
Dimensions: 95 mm (3-3/4") diameter by 102 mm (4") long

Test Data:
- By ASTM C457, Procedure A
- Air Void Content % 1.5
- Entrained, % < 0.040"(1mm) 1.3
- Entrapped, %> 0.040"(1mm) 0.2
- Air Voids/inch 2.0
- Specific Surface, in²/in³ 510
- Spacing Factor, inches 0.015
- Paste Content, % estimated 23
- Magnification 50x
- Traverse Length, inches 113.75
- Test Date 8/4/2015
- Test Performed By S. Massignan

Magnification: 30x
Description: Hardened air void system.
PHOTO: 1

SAMPLE ID: 04+79  DESCRIPTION: Profile view of the core as received with the top surface to the left.

PHOTO: 2

SAMPLE ID: 04+79  DESCRIPTION: Top surface of the sample as received.
SAMPLE ID: 18+16  DESCRIPTION: Profile view of the core as received with the top surface to the left.

SAMPLE ID: 18+26  DESCRIPTION: Top surface of the sample as received.
SAMPLE ID: 18+16 Wall  DESCRIPTION: Profile view of the core as received with the outer surface to the left. Note the macrocrack which intersects the corroded rebar members.

SAMPLE ID: 18+26 Wall  DESCRIPTION: Outer surface of the sample as received; covered by algae, carbonate scale and shell fragments.
SAMPLE ID: 40+12
DESCRIPTION: Profile view of the core as received with the top surface to the left.

SAMPLE ID: 40+12
DESCRIPTION: Top surface of the sample as received.
The top up 10 mm (3/8") of the concrete contained very soft paste that was partially scoured away during sample preparation. Dark colored paste in the bottom half of the photograph is part of a "cement ball" or cement that remained clumped and did not disperse into the concrete.

Up to 12 mm (1/2") of carbonate scale filled a topographic low area in the top surface of the concrete. Blue arrows indicate shell fragments.
PHOTO: 11

SAMPLE ID: 04+79  
MAG: 50x  
DESCRIPTION: The surface of a lab-induced fracture that was treated with phenolphthalein pH indicator (pink color). Arrows indicate irregular shaped voids lined or filled by white, acicular secondary ettringite.

PHOTO: 12

SAMPLE ID: 04+79  
MAG: 200x  
DESCRIPTION: Fully hydrated residual alite portland cement particles (red arrows) and moderately to fully hydrated residual belite portland cement particles observed in thin section of concrete paste viewed with transmitted plain polarized light.
Up to 7 mm (1/4”) of carbonate scale, in this field of view, covers the top surface of the concrete. The top up to 5 mm (3/16”) of the concrete contained very soft paste.

Fully hydrated residual alite portland cement particles (red arrows) and moderately to fully hydrated residual belite portland cement particles observed in thin section of concrete paste viewed with transmitted plain polarized light.
SAMPLE ID: 18+26  
MAG: 100x  
**DESCRIPTION:** Very fine microcracks observed in thin section of concrete viewed with transmitted plane polarized light. The large void space at the left of the photograph is lined by needle-like, secondary ettringite.

SAMPLE ID: 18+26  
MAG: 100x  
**DESCRIPTION:** Same area as above, viewed with transmitted cross polarized light. Many of the microcracks and the air void near the center of the photo were filled with secondary ettringite.
PHOTO: 17

SAMPLE ID: 40+12
MAG: 100x
DESCRIPTION: Up to 4 mm (3/16") of carbonate scale, in this field of view, coats the top surface of the concrete. Very soft paste was observed within the top 3 mm (1/8") of the concrete.

PHOTO: 18

SAMPLE ID: 40+12
MAG: 400x
DESCRIPTION: Fully hydrated residual alite portland cement particles observed in thin section of concrete paste viewed with transmitted plane polarized light.
**SAMPLE ID:** 16+28  
**DESCRIPTION:** Top surface of the sample coated with carbonate mud, shell fragments and fine sand.  
**MAG:** 20x

**SAMPLE ID:** 04+79  
**DESCRIPTION:** Brightly colored secondary carbonate and detrital sand partially fill a consolidation void at the surface of the concrete. The dashed line shows the top of the concrete.  
**MAG:** 40x
AET PROJECT NO: 24-01380
PROJECT: BATTERY SEA WALL
JOB NO.: EN155074

PHOTO: 21

SAMPLE ID: 10+226 Wall
MAG: 5x
DESCRIPTION: The outer up 16 mm (5/8") of the concrete contained very soft paste that was partially scoured away during sample preparation.

PHOTO: 22

SAMPLE ID: 18+26 Wall
MAG: 50x
DESCRIPTION: White bladed gypsum crystals observed in the surface of a lab-induced fracture.
SAMPLE ID: 18+26 Wall
MAG: 40x
DESCRIPTION: Many fine microcracks, oriented sub-parallel to the outer surface of the sample, were observed in thin section of concrete viewed with transmitted plane polarized light.

SAMPLE ID: 18+26 Wall
MAG: 200x
DESCRIPTION: A large residual portland cement grain is outline in red. The outer most alite and belite crystals are fully hydrated; the core of nested belite crystals (blue arrow) has not yet hydrated. The black arrow indicates secondary ettringite which partially fills a microcrack. Observed in thin section of concrete paste viewed with transmitted plane polarized light.
CONCRETE CORE TEST REPORT

Report Number: EN155074.0001
Service Date: 07/16/15
Report Date: 07/23/15

Client

Johnson, Mirmiran & Thompson (JMT)
Attn: James O'Connor
1 Poston Road
Suite 230
Charleston, SC 29407

Project

Battery Seawall
Murray Boulevard
Charleston, SC

Project Number: EN155074

Material Information

Specified Strength:

Specified Length: Unknown
Mix ID: Unknown
Nominal Maximum Size Aggregate: Unknown

Sample Information

Placement Date:
Date Tested: 07/21/15
Time: 0000

Sampled By: Griffin Pack
Drill Directions: Vertical

Date Core Obtained: 07/23/15
Time: 0000

Date Ends Trimmed: 07/23/15
Time: 0000

Moisture Conditioning History: According to ASTM C-42

Laboratory Test Data

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<th>Core ID</th>
<th>Location</th>
<th>Cored Length (in)</th>
<th>Trim Length (in)</th>
<th>Capped Length (in)</th>
<th>Diam. (in)</th>
<th>Area (sq in)</th>
<th>Length / Diam. Ratio</th>
<th>Max Load (lbs)</th>
<th>Corr. Factor</th>
<th>Comp. Strength (psi)</th>
<th>Fracture Type</th>
<th>Density (pcf)</th>
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<td>7.7</td>
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Comments:

Services:
Terracon Rep.: Thomas Smoak
Reported To: Dave Osgood with JMT
Contractor: NA
Report Distribution:

Test Methods: ASTM C42

The tests were performed in general accordance with applicable ASTM, AASHTO, or DOT test methods. This report is exclusively for the use of the client indicated above and shall not be reproduced except in full without the written consent of our company. Test results transmitted herein are only applicable to the actual samples tested at the location(s) referenced and are not necessarily indicative of the properties of other apparently similar or identical materials.

Reviewed By: [Signature]
Thomas Smoak
Project Manager

CR0004, 11-16-12, Rev.5

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