Engineering Evaluation of Concrete Condition
and Steel Sheet Pile Wing Wall Thickness
St. Johns River Water Control Structure S-96D
Indian River County, Florida

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Ardaman & Associates, Inc.

Geotechnical, Environmental and
Materials Consultants

July 30, 2014
File No. 14-6320

St. Johns River Water Management District
P.O. Box 1429
Palatka, Florida 32178

Attention: Mr. Wayne Dempsey, P.E.

Subject: Engineering Evaluation of Concrete Condition and
Steel Sheet Pile Wing Wall Thickness
St. Johns River Water Control Structure S-96D
Indian River County, Florida

Dear Mr. Dempsey:

As authorized by you, Ardaman & Associates, Inc. has completed an engineering evaluation of the subject control structure with respect to concrete condition and the steel sheet pile wing walls. The purposes of our evaluation were to observe and evaluate the concrete condition, determine the thickness of the existing steel sheet pile wing walls and to provide recommendations for remediation. This report documents our findings and presents our engineering recommendations.

SITE LOCATION AND DESCRIPTION

The subject control structure is located near the southeast corner of the Stick Marsh/Farm 13 reservoir near Fellsmere, Indian River County, Florida. The GPS coordinates obtained from Google Earth indicate that the longitude and latitude of the structure are N27.752765^{o}, W-80.708868^{o}, respectively.

We understand that the existing structure was constructed in 1996, and the concrete main structure and the steel sheet pile have not been modified except for periodic painting of the steel sheet pile wing walls.

Based on review of “As-Built” record drawings, the single gate hydraulic control structure is 15.0 feet in width. The concrete gate monolith is 49.0 feet in length having an upstream top of crest weir elevation of +15.3 feet dropping over an approximate horizontal distance of 17.0 feet to the downstream top of slab elevation of +6.0 feet. (We note that upon cursory observation, the elevations shown on the “As-Built” drawings do not appear to correspond well with the elevations marked on the on-site staff gauges that are referenced in the “Site Observations” section of the report. Therefore elevations mentioned in this report should be verified by a surveyor if deemed necessary.)

The structure is constructed entirely of reinforced concrete except for the metal gates and anchored steel sheet pile wing walls located at the upstream and downstream edges of the structure. According to the “As-Built” drawings, the upstream sheet pile wing walls consist of 35 sections of Type PZ-27 sheet pile having a total wall length of 52.5 feet and the downstream sheet pile wing walls consist of 29 sections of Type PZ-27 sheet pile having a total wall length of 43.5 feet. Type PZ-27 sheet pile has a nominal web and flange thickness of 0.375 inch.

SITE OBSERVATIONS

Site observations of the portion of the structure above the water level were made on April 25, 2014 (upstream portion) and May 30, 2014 (downstream portion) by Ardaman and Associates engineer Mr. Jason Parker, P.E. At the time of our observations, the upstream and downstream water levels were approximately at Elevation +22.0 feet and +20.2 feet, respectively, based on readings made from the on-site staff gauges. Based on the water staining marks the water levels appear to typically fluctuate approximately 1 foot on the upstream side and 2 feet on the downstream side. It is generally known that water levels during extreme hydrological events fluctuate more than typical.

Upstream Structure Observations

For the upstream side of the structure, our observations indicated that the concrete appeared to be in “very good” condition. Concrete pitting within the water fluctuation zone was observed to be minimal with no significant loss of aggregate. We were unable to observe the concrete structure below a depth of approximately 6 inches due to water clarity. We note that a crack (approximately 1/8 inch in width) was observed at the end of the southeast portion of the concrete structure. We were unable determine if the crack was due to typical concrete shrinkage or related to an impact force. No concrete spalling or rust staining were observed in the vicinity of the crack.

Relative to the steel sheet pile wing walls, the upstream walls appeared to be in “very good” condition. No evidence of corrosion or seepage between the joints was observed. We note that only portions of the first 8 sections of sheet piles were observed. The remaining portions of the steel sheet pile walls were below the water surface and could not be observed relative to their condition.

Downstream Structure Observations

For the downstream side of the structure, our observations indicated that the concrete appeared to be in “very good” condition. Concrete pitting within the water floatation zone and below the water surface was observed to be slightly more advanced than the upstream portion, however the pitting was still considered to be minimal with no significant loss of aggregate. We were unable to observe the concrete structure below a depth of approximately 6 inches due to water clarity. No spalling, significant cracking, rust staining or other indicators of potential structural defects or corrosion were observed.

Relative to the steel sheet pile wing walls, the downstream walls appeared to be in “poor” condition. Significant corrosion at the joints, rails and tieback anchors was observed. We note that portions of the first 6 sections of sheet piles were observed. The remaining portions of the steel sheet pile walls were below the water surface and could not be observed relative to their condition.

Representative photographs of our observations are included in Appendix I.

FIELD EXPLORATION PROGRAM

The field exploration program consisted of performing a series of non-destructive and destructive testing/sampling at selected locations to evaluate the concrete condition and the steel sheet pile wing wall thickness on the upstream and downstream sides of the structure. The following describes the field exploration program in detail.

Rebound Hammer Readings

Rebound hammer testing was performed in general accordance with ASTM C 805, "Standard Test Method for Rebound Number of Hardened Concrete". A rebound hammer is a non-destructive device that consists of a plunger rod and an internal spring loaded steel hammer and a latching mechanism. When the extended plunger rod is pushed against a hard surface, the spring connecting the hammer is stretched to an internal limit and then released, causing the energy stored in the stretching spring to propel the hammer against the plunger tip. The hammer strikes the shoulder of the plunger rod and rebounds a certain distance. On the outside of the unit is a slide indicator which records the distance traveled during the rebound. This indication is known as the rebound number (R-number).

At selected locations, rebound hammer readings were obtained to assess the uniformity of the in-place concrete within and above the water fluctuation zone and to delineate regions of potentially deteriorated concrete for further testing. In general, the rebound hammer testing was performed approximately 12 inches above the water level at the time of our evaluation and a second set of readings was obtained on the concrete approximately 48 inches above the water level at the time of our evaluation. The average results of 10 readings performed at each of the eight (8) selected locations are presented on Table 1.

The approximate plan view locations where the readings were obtained are shown on Figure 1.

As shown on Table 1, the average value of the rebound number within the zone of typical water fluctuation is 3.5 and 3.6 for the upstream and downstream walls respectively. The average rebound number value above the zone of typical water fluctuation is 4.3 and 4.4 for the upstream and downstream walls respectively. Though the average rebound number readings obtained above the water typical fluctuation zone is higher than the average rebound number within the typical fluctuation zone, it is our opinion that the lower rebound numbers in the zone of typical fluctuation are primarily due to the surface condition (i.e., the minimal concrete pitting present within the zone of typical water level fluctuation). No obvious areas of "softer" or "harder" concrete were distinguishable.

Concrete Coring

The field exploration program also included obtaining a series of concrete cores for evaluation. Two (2) 3-inch diameter cores were obtained from six (6) selected locations for a total of twelve (12) core samples. The cores were obtained from approximately 0.5 foot above the water level at the time of our exploration. The cores were drilled horizontally to a depth of at least 3.5 inches or until reinforcing steel were encountered in the core sample. The core samples were visually inspected and measured for length in the field and transported to our laboratory for additional testing. When reinforcing steel was encountered, observations relative to the condition of the reinforcing steel were made within the core hole. Upon completion of the coring program, all core holes were patched with high strength, rapid setting concrete patch.

A summary of the concrete core data including their length and general observations is presented as Table 2. The approximate core locations are schematically illustrated on a site plan shown on Figure 1. These locations were determined by estimating distances from existing site features and should be considered accurate only to the degree implied by the method of measurement used.

Ultrasonic Thickness Readings

Non-destructive ultrasonic thickness readings were performed at selected locations along the upstream steel sheet pile wing walls. At each of the sheet pile wing walls, evenly spaced locations were tested and readings were obtained across the sheet pile section. The readings were obtained approximately 0.5 foot above the water level at the time of the readings. The thickness readings were obtained utilizing a Krautkramer DMS Ultrasonic Thickness Gauge. A summary of the readings for the sheet pile wing walls is included as Table 3A and 3B.

In general, the thickness readings for the upstream walls were slightly less than the nominal sectional thickness of 0.375 inch. The thickness readings for the downstream walls were close to the nominal sectional thickness of 0.375 inch.

Water Sampling

A sample of the creek water was obtained on May 30, 2014 downstream of the weir within the stilling basin and near the north wall. This sample was transported to our laboratory for analysis relative to corrosive properties (i.e.; pH, conductivity, chlorides and sulfates).

LABORATORY PROGRAM

Visual Evaluation of Concrete Core Samples

Selected core samples were chosen for examination to assess the depth of the erosion and examine for evidence of corrosion of embedded reinforcing steel. The selected core samples were saw-cut longitudinally and polished for examination.

In general, evidence of erosion (pitting) was measured to be on the order of 1/8 to 1/4 inch on both the upstream and the downstream portions of the structures. This was consistent with our visual observations. Within the cores we observed no evidence of rust bleeding (as would be expected from corroding reinforcing steel) or leaching of paste due to acid attack. These results also are consistent with our field observations.

Representative photographs depicting the polished core samples are included in Appendix II.

Chemical Evaluation of Concrete Core Samples

Selected core samples were also tested for carbonation and pH to assess the potential for corrosion. The pH of new concrete is typically within the range of 12 to 13 mostly due to calcium hydroxide, which is a normally occurring by-product of cement hydration. As a concrete surface reacts with carbon dioxide in air or water, the pH of the surface gradually is reduced to about 7 to 8 through a process called carbonation. Gradually the process penetrates deeper into the concrete. Once the internal pH drops below 10, the reinforcing steel passivation is dissolved, promoting corrosion.

To verify the pH, the top 1-inch of selected cores were cut horizontaly from the core samples. The 1-inch sections were crushed into a powder and mixed with distilled water and tested with a pH meter. The following Table summaries the results of the pH testing.

Location	Tested pH
Core 1B	11.7
Core 2B	11.8
Core 3B	11.4
Core 4B	11.5
Core 5B	11.5
Core 6B	11.5

The affected depth of carbonation from the surface can be readily shown by the use of phenolphthalein indicator solution. The phenolphthalein indicator solution is applied to the fresh cut surface of the concrete core. If the indicator solution turns purple, the pH is above 10.

The results of the indicator solution and pH testing indicate that carbonation is minor and on the order of 0.2 inch from the surface of the concrete. Beneath the minor zone of carbonation, the pH of the concrete cores remains high and consistent with depth. These characteristics indicate that concrete within the areas explored has not undergone significant chemical attack.

Representative photographs depicting the carbonation testing using the phenolphthalein are included in Appendix II.

Concrete Compressive Strength Testing

The core samples were trimmed and capped in accordance with ASTM C-42 for compressive strength testing. The results of the compressive strength testing are presented in the following table:

Location	Original Length (in)	Trimmed and Capped Length (in)	Corrected Compressive Strength (psi)
Core 1A	4.3	4.5	6,000
Core 2A	4.1	4.0	7,480
Core 3A	3.6	3.5	6,380
Core 4A	3.6	3.7	6,120
Core 5A	4.2	4.0	5,670
Core 6A	3.5	3.7	5,760

The results indicate that the minimum and maximum compressive strengths range from 5,670 to 7,480 psi. The average and median compressive strengths are 6,235 and 6,060 psi, respectively.

Chemical Analyses of Water

A water sample collected from the downstream stilling basin was tested for its corrosion properties. Properties tested included pH, resistivity, chloride and sulfate content. The properties and their classification according to the FDOT Structures Design Manual are presented below.

Tested Property				Environmental Classification	
Chloride (ppm)	pH	Resistivity (ohm-cm)	Sulfate (ppm)	Steel	Concrete
200	7.4	860	180	Extremely Aggressive	Extremely Aggressive

The environmental classification criteria are based on Table 1.3.2-1 for Substructure Environmental Classification from the Florida Department of Transportation Structural Design Manual dated January, 2012. It is noted that the Florida Department of Transportation Substructures Environmental Classification system includes three categories (i.e.; slightly aggressive, moderately aggressive and extremely aggressive). Therefore, the water test results fall into the most aggressive category.

CONCLUSIONS AND RECOMMENDATIONS

Based on our visual observations and the results of our field exploration and laboratory testing programs, it is our opinion that the structural integrity of the concrete element of the structure is in “very good” condition and is exhibiting normal physical erosion characteristics typical for a hydraulic structure of this age and use. Remediation of the concrete within the water fluctuation zone is not required at this time. The condition of the concrete, considering the years of service, suggests that the concrete should continue to perform for many years before remediation is required. We do however suggest that the crack observed on the southeast end of the structure be repaired to limit potential corrosion and/or spalling. Based on the current condition of the crack, a typical two-part injection epoxy should be sufficient.

Our observations and testing relative to the steel sheet pile wing walls indicate that the upstream wingwalls are in “very good” condition and that remediation is not needed at this time. However, the downstream wingwalls are in “poor” condition and are exhibiting advanced corrosion. The downstream wingwalls should be remediated as soon as it is feasible. We recommend that the corrosion be removed (i.e. sand blasted/ground, washed, etc.) and then repaired/coated. Depending on the severity of the corrosion that will only be evident after corrosion is removed, joint reinforcement (i.e. welded metal plating) may be required.

Other Considerations

The remedial sheet pile remediation contractor should specialize in remedial contracting of this nature and have at least 10 years of experience with similar projects, and should have successfully completed at least 10 hydraulic structure remedial projects similar to this project.

CLOSURE

The analyses and recommendations submitted herein are based on our observations and on the data obtained from our field and laboratory programs. This report does not reflect any variations which may occur adjacent to or between the test locations, or in the areas that could not be observed.

This report has been prepared for the exclusive use of St. Johns River Water Management District in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made.

We are pleased to be of assistance to you on this phase of the project. When we may be of further service to you or should you have any questions, please contact us.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.
Certificate of Authorization No. 5950

7/30/14

JASON MICHAEL PARKER LICENSE No 65928 STATE OF FLORIDA PROFESSIONAL ENGINEER

Jason M. Parker, P.E.
Senior Project Engineer
Florida License No. 65928

Charles H. Cunningham, P.E.
Orlando Branch Manager
Florida License No. 38189

JMP/CHC/ksb
14-6320 Water Control Structure S-96D (2014 Geo)

TABLE 1
Summary of Rebound Hammer Data
Water Control Structure S-96D
SJRWMD, Indian River County, Florida

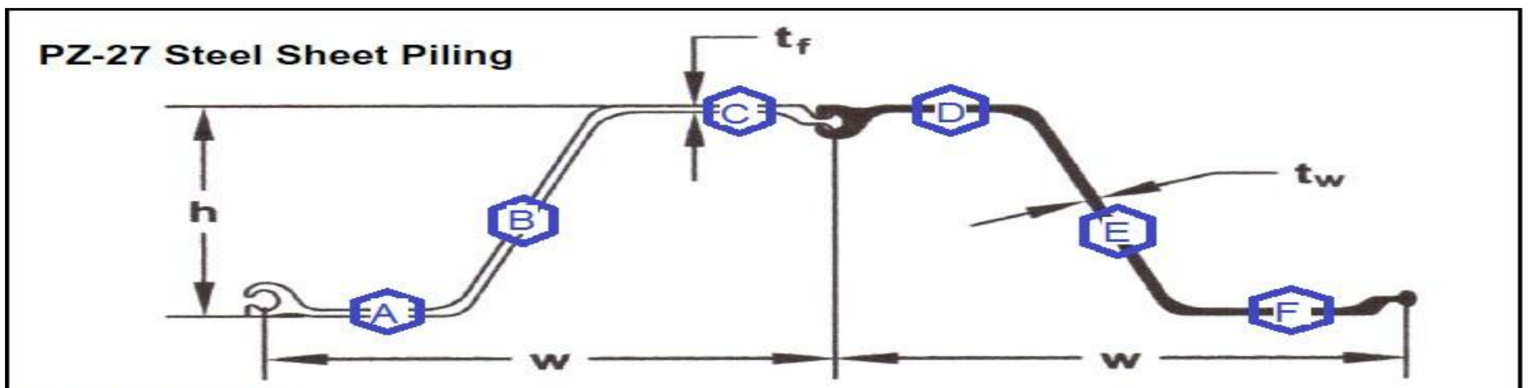
R-Number Location	Description	Average R-Number	
		Within Zone of Typical Water Fluctiation	Above Zone of Typical Water Fluctuation
R1	Upstream - West Wall	3.6	4.4
R2	Upstream - East Wall	3.4	4.2
R3	Downstream - West Wall, North Half	3.6	4.6
R4	Downstream - West Wall, South Half	3.8	4.8
R5	Downstream - East Wall, North Half	3.6	4.6
R6	Downstream - East Wall, South Half	3.4	4.2
	Average (Upstream/Downstream)	3.5/3.6	4.3/4.4

TABLE 2
Summary of Concrete Coring
Water Control Structure S-96D
SJRWMD, Indian River County, Florida

Location	Core Designation	Length (in)	Rebar Encountered	General Condition/Observations
Upstream - West Wall	1A	4.3	No	
	1B	4.5	No	
Upstream - East Wall	2A	4.1	No	
	2B	3.5	Yes	Rebar in good condition. No Corrosion observed.
Downstream - West Wall, North Half	3A	3.6	No	
	3B	3.4	Yes	Rebar in good condition. No Corrosion observed.
Downstream - West Wall, South Half	4A	3.6	No	
	4B	3.4	Yes	Rebar in good condition. No Corrosion observed.
Downstream - East Wall, North Half	5A	4.2	No	
	5B	3.5	No	
Downstream - East Wall, South Half	6A	3.5	No	
	6B	3.6	No	

TABLE 3A
Ultrasonic Thickness Readings
Steel Sheet Pile Wing Walls
Water Control Structure S-96D
SJRWMD, Indian River County, Florida

Reading Designation	Wing Wall Average Thickness Reading (inches)					
	West Wall (Upstream)			East Wall (Upstream)		
	1	2	3	1	2	3
A	0.353	0.368	N/A	0.359	0.361	N/A
B	0.340	0.355	N/A	0.351	0.347	N/A
C	0.357	0.369	N/A	0.365	0.366	N/A
D	0.349	0.366	N/A	0.351	0.351	N/A
E	0.326	0.352	N/A	0.353	0.357	N/A
F	0.325	0.364	N/A	0.353	0.363	N/A
Maximum Value	0.357	0.369	N/A	0.365	0.366	N/A
Minimum Value	0.325	0.352	N/A	0.351	0.347	N/A
Average Value	0.342	0.362	N/A	0.355	0.358	N/A
Median Value	0.345	0.365	N/A	0.353	0.359	N/A



ASTM A572 Grade 50

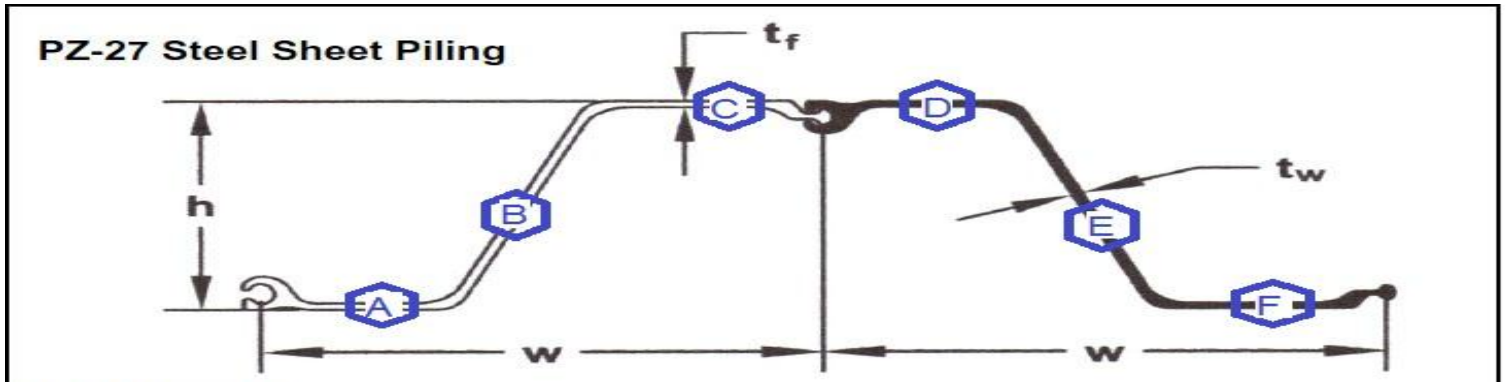
Section	Width w in (mm)	Height h in (mm)	Thickness tw in (mm)	Cross Sectional Area in²/ft (cm²/m)	Weight: Pile lb/ft (kg/m)	Weight: Wall lb/ft² (kg/m²)	Section Modulus in³/ft (cm³/m)	Moment of Inertia in⁴/ft (cm⁴/m)	Coating Area Both Sides ft²/ft (m²/m)	Coating Area ft²/ft² (m²/m²)
PZ-27	18.00 457	12.00 305	0.375 9.53	11.91 252.10	40.50 60.30	27.00 131.82	30.20 1620	184.20 25200	4.48 1.37	1.49 1.49


Approximate Reading Designation Location

TABLE 3B
Ultrasonic Thickness Readings
Steel Sheet Pile Wing Walls
Water Control Structure S-96D
SJRWMD, Indian River County, Florida

Reading Designation	Wing Wall Average Thickness Reading (inches)					
	West Wall (Downstream)			East Wall (Downstream)		
	1	2	3	1	2	3
A	0.377	0.381	N/A	0.376	0.372	N/A
B	0.358	0.365	N/A	0.375	0.368	N/A
C	0.377	0.372	N/A	0.370	0.372	N/A
D	0.355	0.366	N/A	0.365	0.360	N/A
E	0.386	0.372	N/A	0.359	0.376	N/A
F	0.359	0.361	N/A	0.345	0.355	N/A
Maximum Value	0.386	0.381	N/A	0.376	0.376	N/A
Minimum Value	0.355	0.361	N/A	0.345	0.355	N/A
Average Value	0.369	0.370	N/A	0.365	0.367	N/A
Median Value	0.368	0.369	N/A	0.368	0.370	N/A

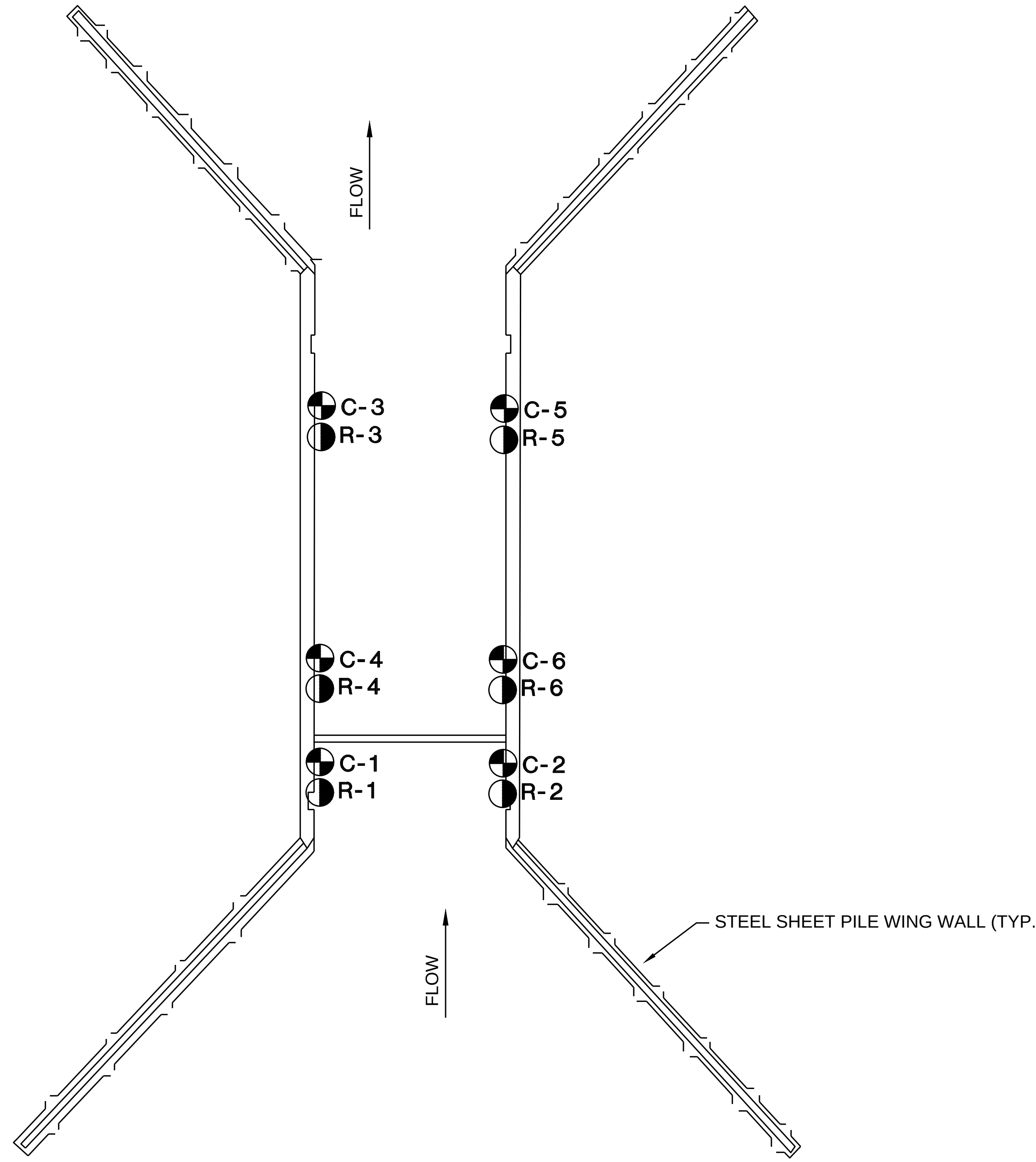
PZ-27 Steel Sheet Piling



ASTM A572 Grade 50

Section	Width w in (mm)	Height h in (mm)	Thickness tw in (mm)	Cross Sectional Area in^2/ft (cm^2/m)	Weight: Pile lb/ft (kg/m)	Weight: Wall lb/ft^2 (kg/m^2)	Section Modulus in^3/ft (cm^3/m)	Moment of Inertia in^4/ft (cm^4/m)	Coating Area Both Sides ft^2/ft (m^2/m)	Coating Area ft^2/ft^2 (m^2/m^2)
PZ-27	18.00 457	12.00 305	0.375 9.53	11.91 252.10	40.50 60.30	27.00 131.82	30.20 1620	184.20 25200	4.48 1.37	1.49 1.49

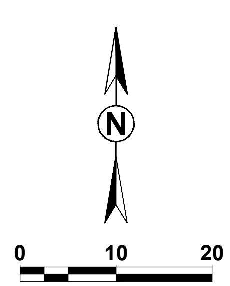
 Approximate Reading Designation Location



LEGEND

C CORE LOCATION

R REBOUND HAMMER READING LOCATION



APPROXIMATE SCALE: 1"=20'

CORE LOCATION PLAN

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

ENGINEERING EVALUATION OF SJRWMD STRUCTURE S-96D INDIAN RIVER COUNTY, FLORIDA

DRAWN BY: CD	CHECKED BY:	DATE: 05/14/14
FILE NO. 14-6320	APPROVED BY:	FIGURE: 1

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APPENDIX I

Photographs Taken on April 25, 2014 (Upstream)
and
May 30, 2014 (Downstream)

APPENDIX I
Water Control Structure S-96D
SJRWMD, Indian River County

Upstream - West Wing Wall and Structure Wall.

Upstream - East Structure Wall.

APPENDIX I
Water Control Structure S-96D
SJRWMD, Indian River County

Upstream - East Structure Wall. Note Crack at Construction Joint.

Upstream - East Wing Wall.

APPENDIX I
Water Control Structure S-96D
SJRWMD, Indian River County

Downstream - Structure Overview and Portion of Wing Wall.

Downstream - West Wing Wall.

APPENDIX I
Water Control Structure S-96D
SJRWMD, Indian River County

Downstream - West Wing Wall.

Downstream - East Wing Wall.

APPENDIX I
Water Control Structure S-96D
SJRWMD, Indian River County

Downstream - East Structure Wall, North Half.

Downstream - East Structure Wall, South Half.

APPENDIX I
Water Control Structure S-96D
SJRWMD, Indian River County

Downstream - East Structure Wall, North Half.

Downstream - East Structure Wall, South Half.

APPENDIX II

Petrographic and Carbonation Examination Photographs

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

3925 Coconut Palm Dr.
Suite 115
Tampa, Florida 33619
Florida CA 00005950

Report of Petrographic Examination of Concrete
ASTM C-856

Project:	**Structure 96D**	**Date:**	**May 12, 2014**
Location:			
Client:	**SJRWMD**	**Project No.**	**14-60-6320**

Sample Nos.	1	**Sample Size:**	2 ½ in. wide, 4 ¼ in. long
	2		2 ½ in. wide, 3 ½ in. long

Core 1

Core 2

Coarse Aggregate
- White to tan to crushed fossiliferous limestone and siliceous limestone.
- Nominal maximum particle size is ¾ inch graded down to ⅛ inch.
- The particles are equidimensional with a sub-rounded to sub-angular texture.
- Volume of coarse aggregate appears reasonable.
- Coarse aggregate relatively well distributed.
- Aggregate paste bond is good.
- No indications of cement-aggregate reactions were noted within the coarse aggregate.

Fine Aggregate
- Natural sand, gray, white and clear quartz.
- Maximum particle size ⅛ inch, graded down to fine sand sizes.
- Particles have sub-rounded texture.
- No indications of cement-aggregate reactions were noted within the fine aggregate.

Matrix (cement paste)

- Paste is light to medium gray. Both samples have a light tan layer at the surface which can be attributed to carbonation which was measured to be on the order of 0.2 inch deep at the surface as determined by the application of a phenolphthalein indicator solution.
- Paste moderately hard when scratched with steel point.
- Paste to aggregate bond appears good.

Air Voids

- Air voids are spherical to irregular in shape and are not well distributed, visually estimated at 1 to 2 percent between the two samples

Surface

- The surface of the sample is relatively smooth and appears to be a formed surface

Cracking

- No cracking observed.

Embedded Items

- A No 6 reinforcng steel bar was observed to be 2 ¾ inches down from the surface of the Core Sample 2.

Conclusions:

1. Quality of concrete is relatively good.
2. The paste is moderately hard to hard when scratched with a steel point.
3. Concrete is not air entrained but does contain entrapped air.
4. The exposed surface of the core is eroded.

William R. Goodson, PE
Senior Materials Engineer
Florida License 37935

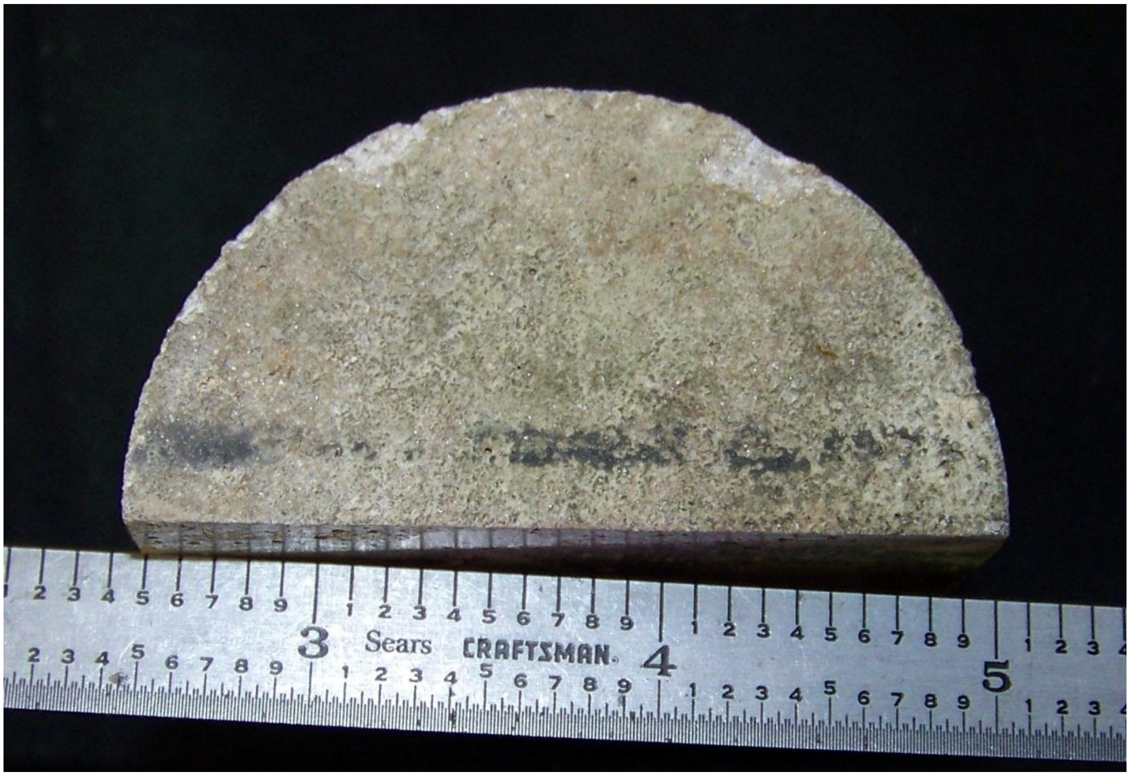

Photo 2 – Sample 1 – end view.

Photo 3 – Sample 2 – end view.

Photo 4 – Sample 2 – magnified view of typical coarse aggregate piece, note no signs of cement-aggregate reactions.

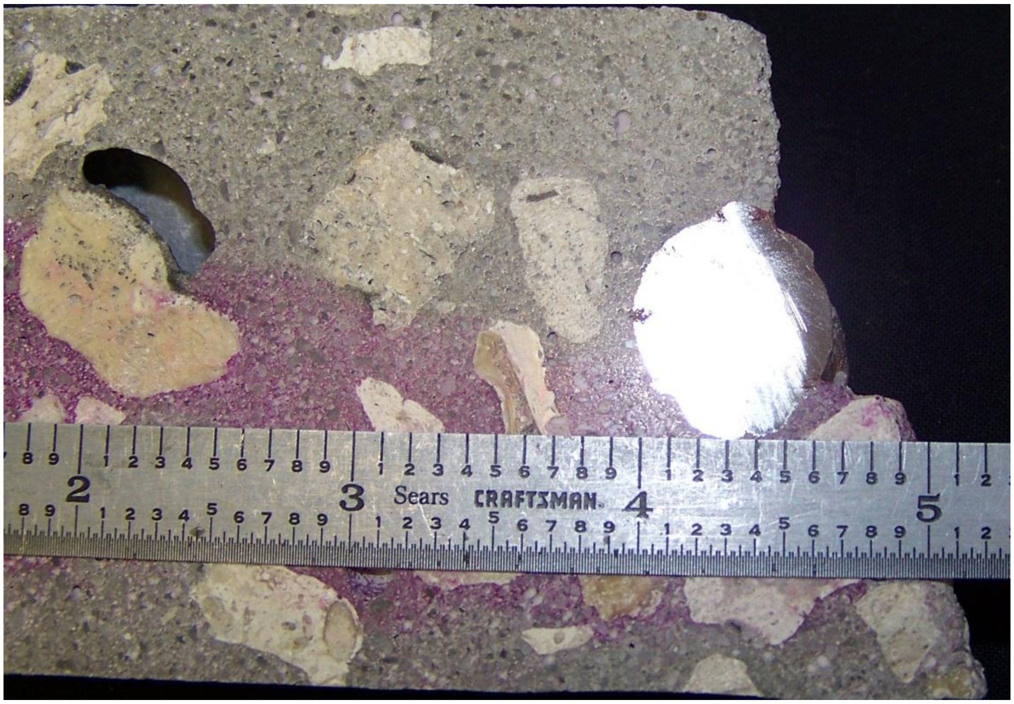

Photo 5 – Sample 2 – No. 6 reinforcing steel bar, located 2 ¾ inch from surface. No evidence of corrosion noted on steel.

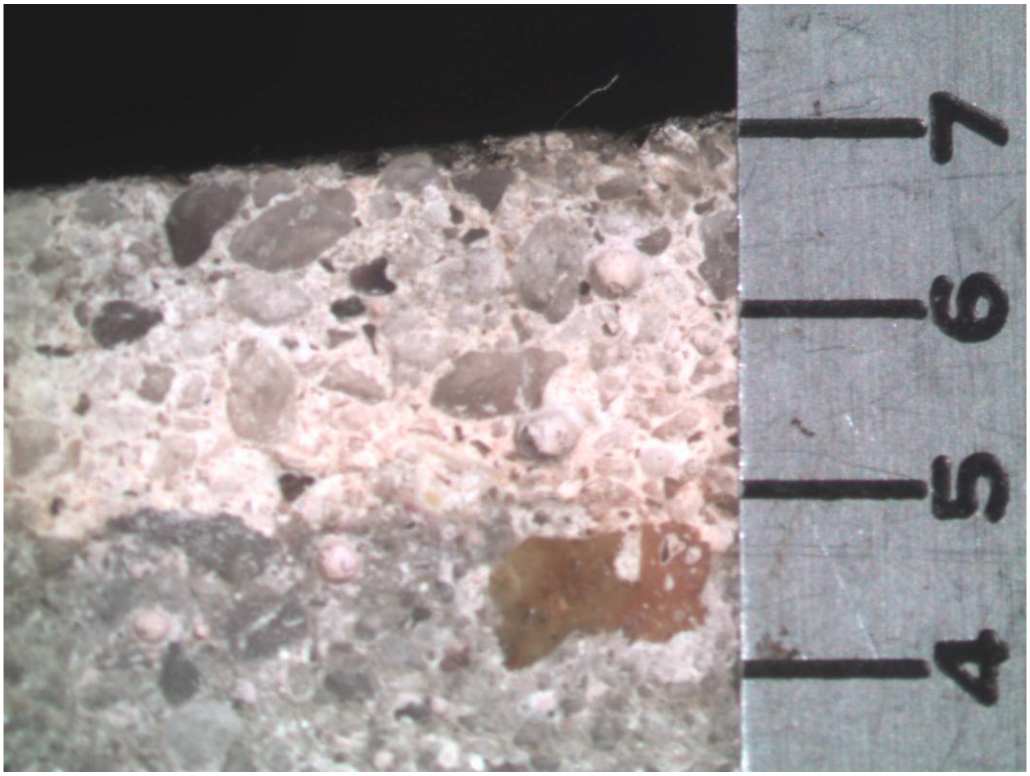

Photo 6 – Sample 1 – magnified view of surface, note light colored zone of carbonated concrete. Scale is 0.1 inch.

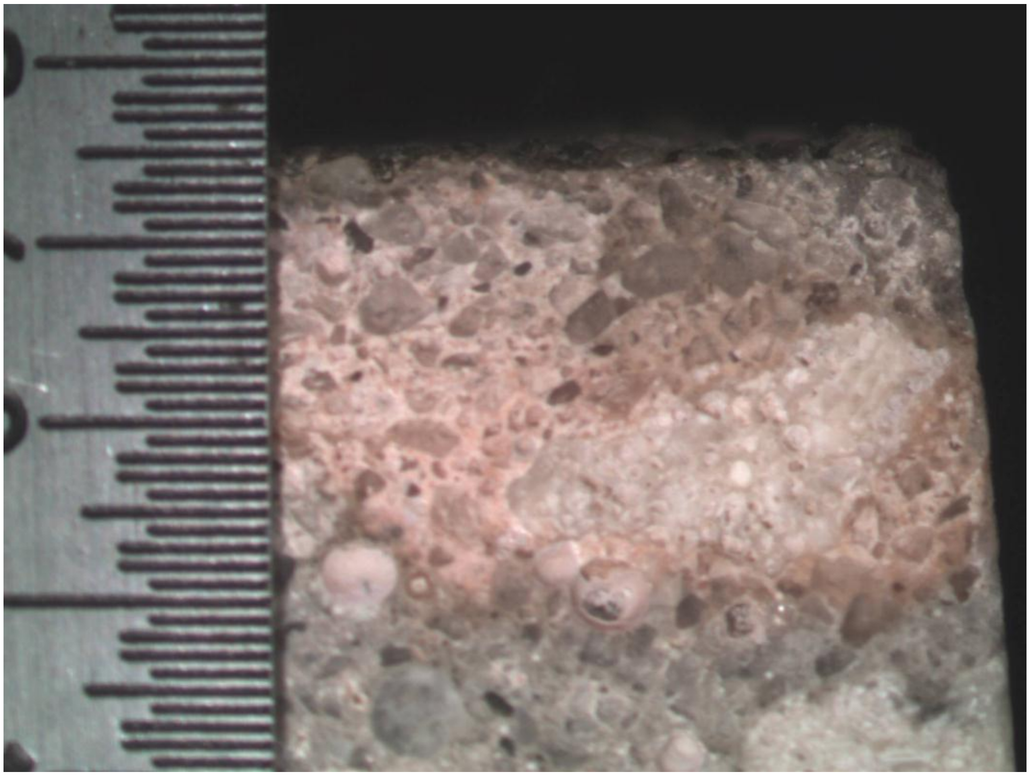

Photo 7 – Sample 1 – magnified view of surface, note light colored zone of carbonated concrete. Scale is 0.01 inch.

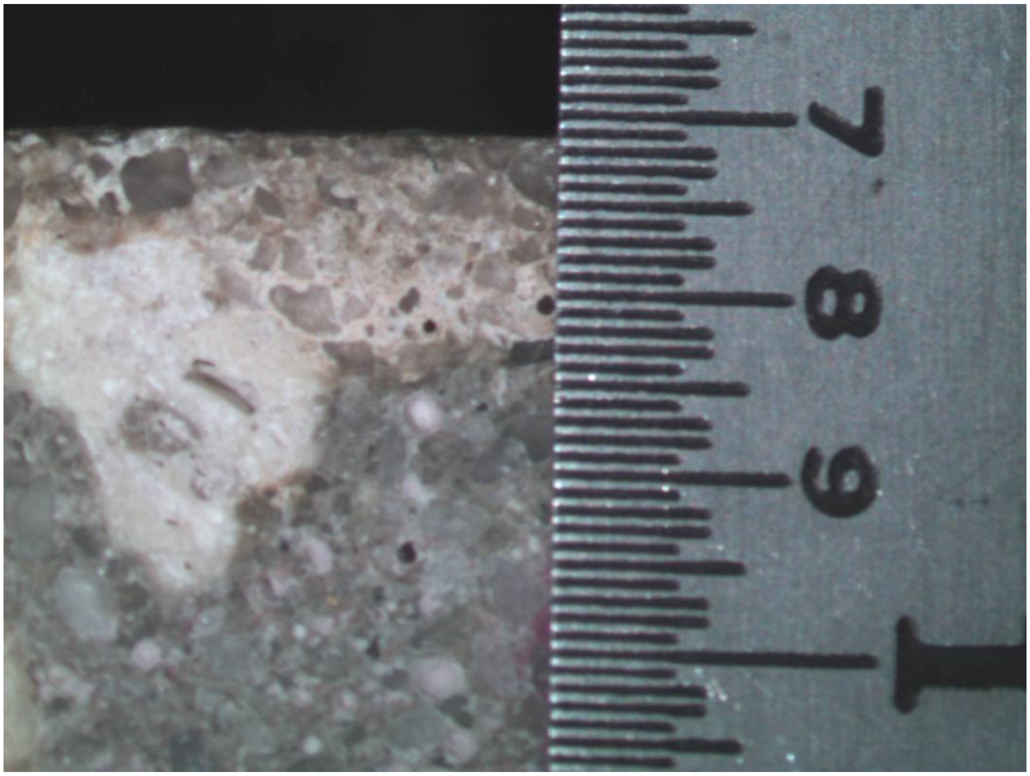

Photo 8 – Sample 2 – magnified view of surface, note light colored zone of carbonated concrete. Scale is 0.01 inch.

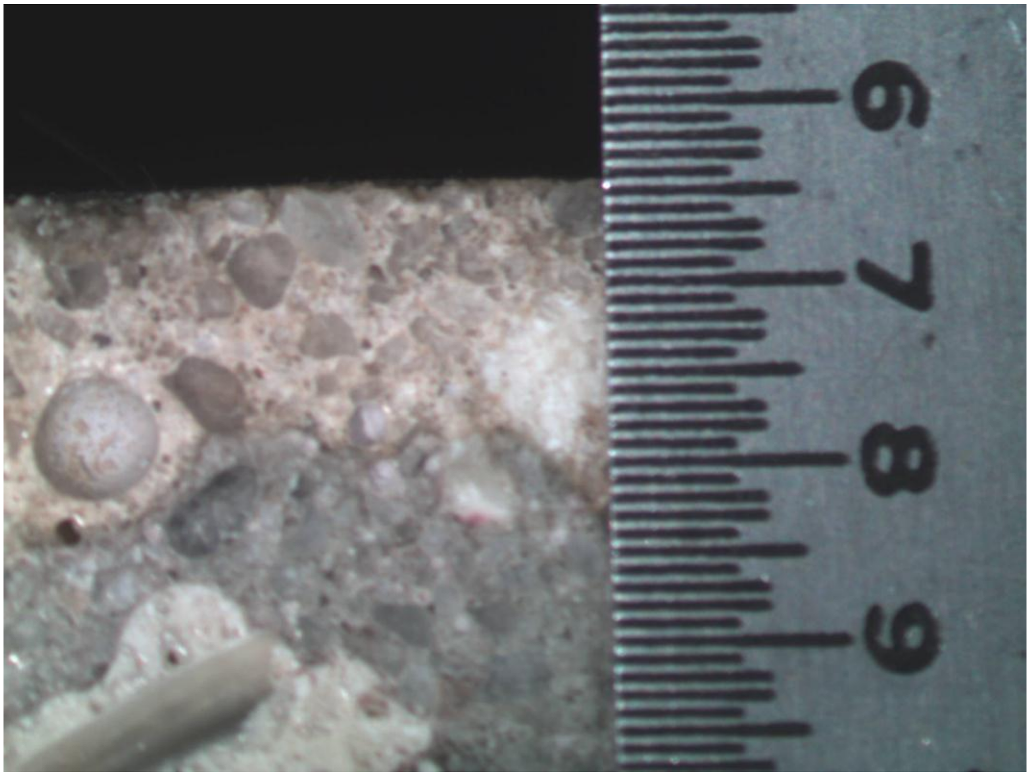

Photo 9 – Sample 2 – magnified view of surface, note light colored zone of carbonated concrete. Scale is 0.01 inch.

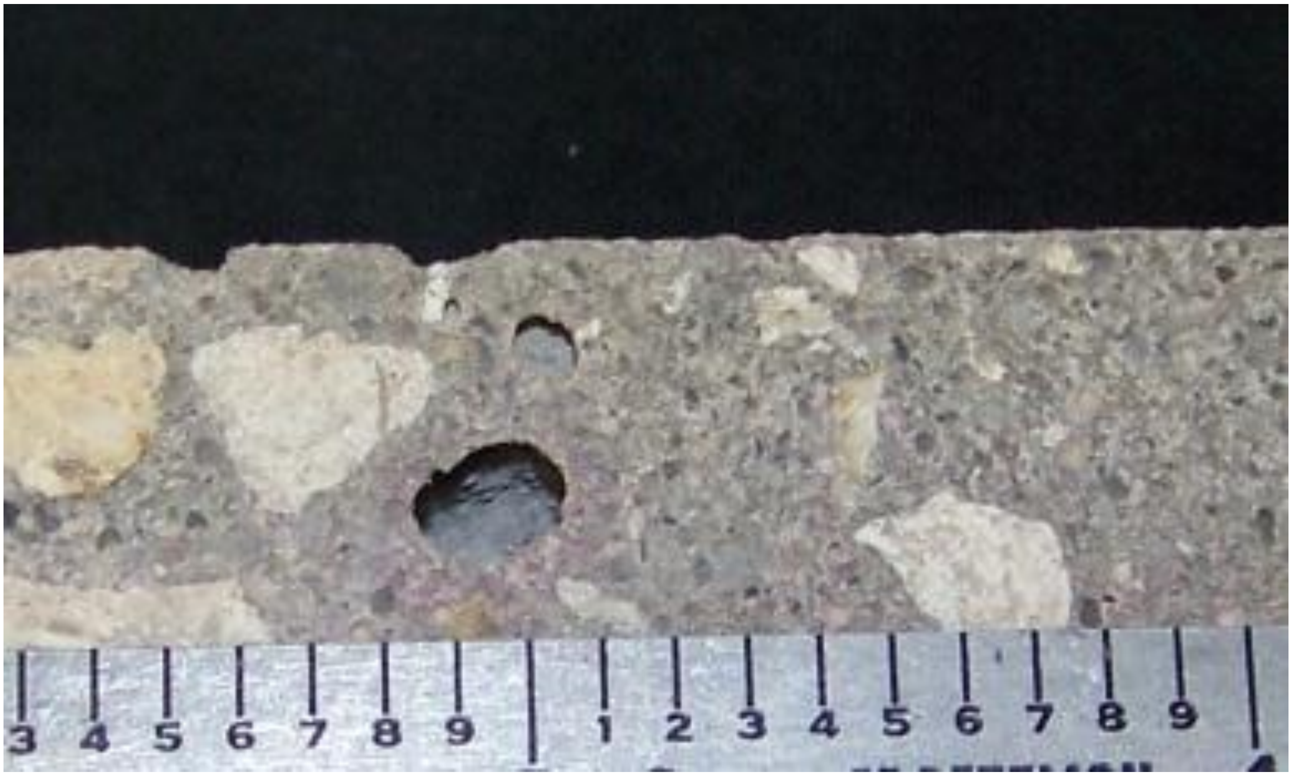

Photo 10 – Sample 1 – magnified view of entrapped air void.

Photo 11 – Sample 2 – magnified view of entrapped air void.

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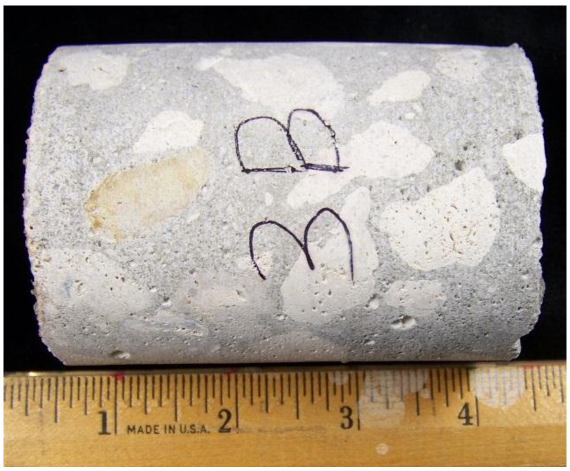
Report of Petrographic Examination of Concrete
ASTM C-856

Project: **Structure 96D** **Date:** **June 20, 2014**
Location:
Client: **SJRWMD** **Project No.** **14-60-6320**

Sample Nos. 3B
6B

Sample Size: 2 ½ in. wide, 3 ¼ in. long
2 ½ in. wide, 4 in. long



Core 3B

Core 6B

Coarse Aggregate
- White to tan crushed fossiliferous limestone and siliceous limestone.
- Nominal maximum particle size is ¾ inch graded down to ⅛ inch.
- The particles are equidimensional with a sub-rounded to sub-angular texture.
- Volume of coarse aggregate appears reasonable.
- Coarse aggregate relatively well distributed.
- Aggregate paste bond is good.
- No indications of cement-aggregate reactions were noted within the coarse aggregate.

Fine Aggregate
- Natural sand, gray, white and clear quartz.
- Maximum particle size ⅛ inch, graded down to fine sand sizes.
- Particles have sub-rounded texture.
- No indications of cement-aggregate reactions were noted within the fine aggregate.

Matrix (cement paste)

- Paste is light to medium gray. Both samples have a light tan layer at the surface which can be attributed to carbonation which was measured to be on the order of 0.2 inch deep at the surface as determined by the application of a phenolphthalein indicator solution.
- Paste moderately hard when scratched with steel point.
- Paste to aggregate bond appears good.

Air Voids

- Air voids are spherical to irregular in shape and are not well distributed, visually estimated at 2 ± percent between the two samples

Surface

- The surface of the samples is coarse and starting to show signs of erosion.

Cracking

- No cracking observed.

Embedded Items

- No embedded reinforcing steel was observed in the samples, however the fractured end of core 3B did show a partial impression of a reinforcing bar. Based on the partial impression the bar size was estimated to be a No. 5 or No. 6 bar.

Conclusions:

1. Quality of concrete is relatively good.
2. The paste is moderately hard to hard when scratched with a steel point.
3. Concrete is not air entrained but does contain entrapped air.
4. The exposed surface of the cores are showing signs of erosion.

William R. Goodson, PE
Senior Materials Engineer
Florida License 37935

Photo 2 – Sample 3B – end view.

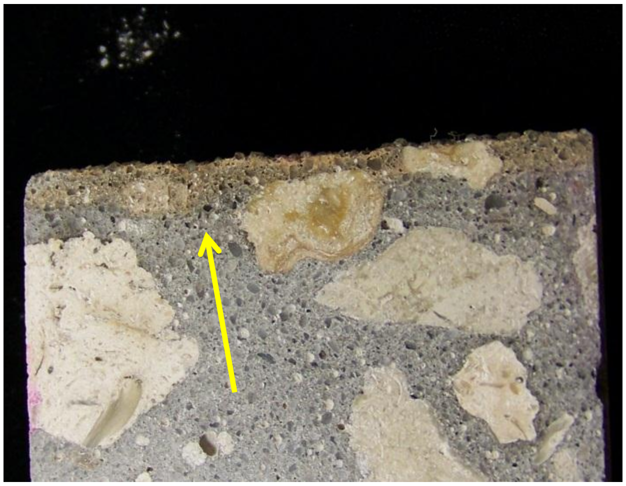
Photo 3 – Sample 3B – Inside fractured face (end) – note reinforcing bar impression.

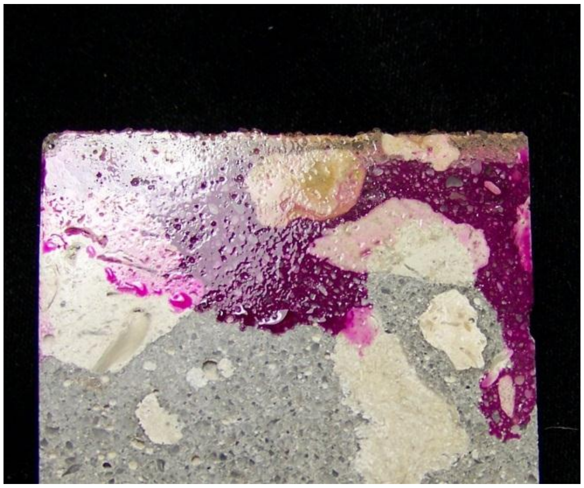
Photo 4 – Sample 6B – end view.

Photo 5 – Sample 6B – Inside fractured face (end).

Photo 6 – Sample 3B – polished surface of core.

Photo 7 – Sample 6B – Polished surface of core..





Photos 8a & b – Sample 3B – Polished section showing zone of tan colored paste at surface. Application of a phenolphthalein indicator solution confirms the tan zone to be carbonated.

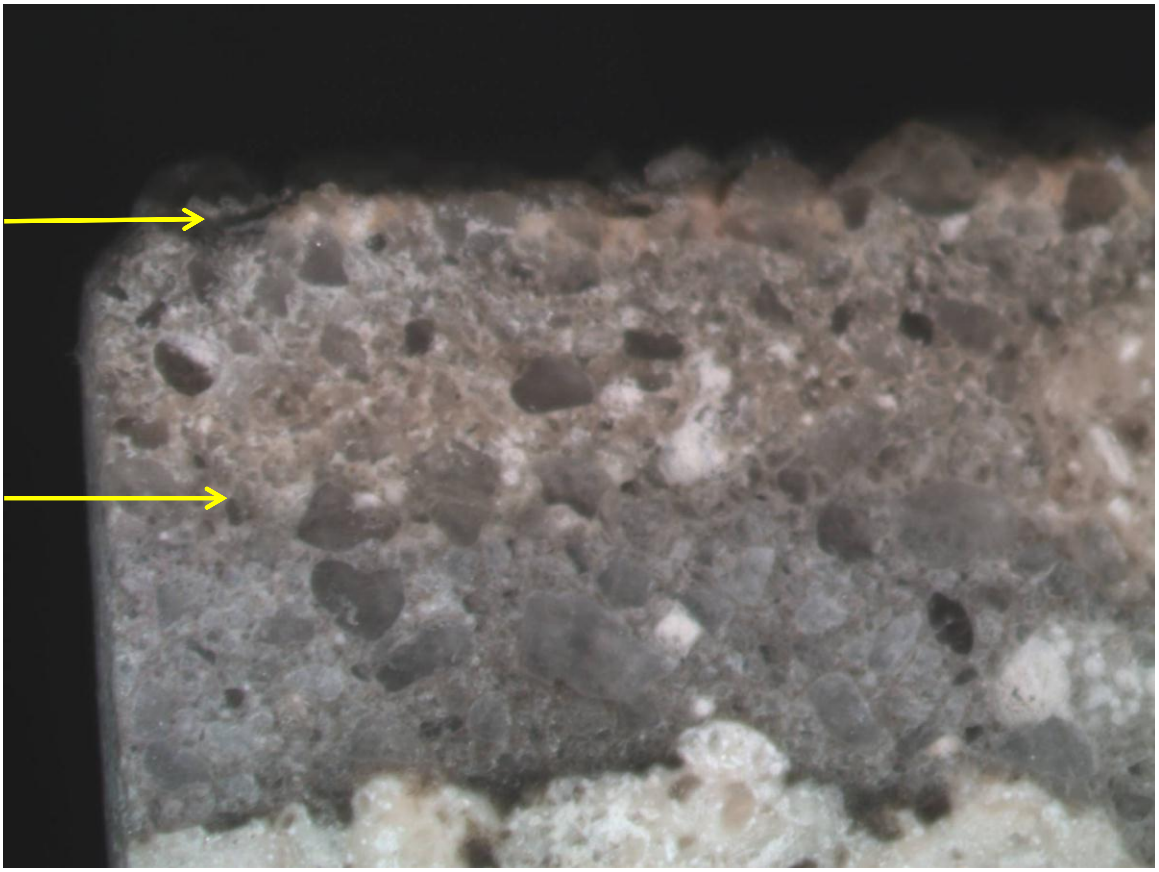
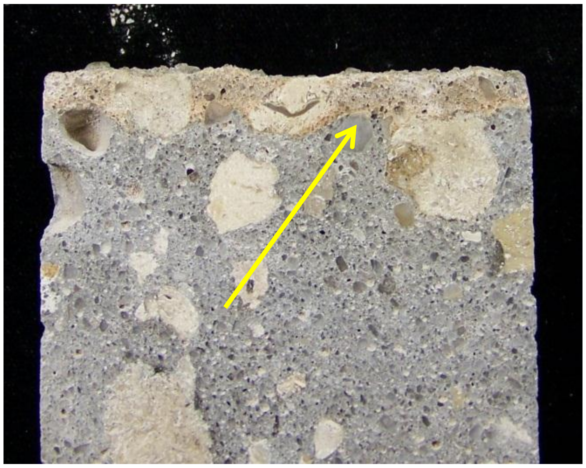
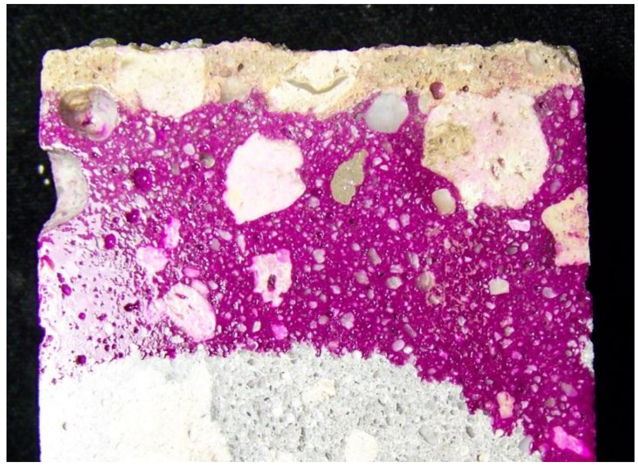


Photo 9 – Sample 3B – magnified view of carbonated paste at surface of core





Photos 10a & b – Sample 6B – Polished section showing zone of tan colored paste at surface. Application of a phenolphthalein indicator solution confirms the tan zone to be carbonated.

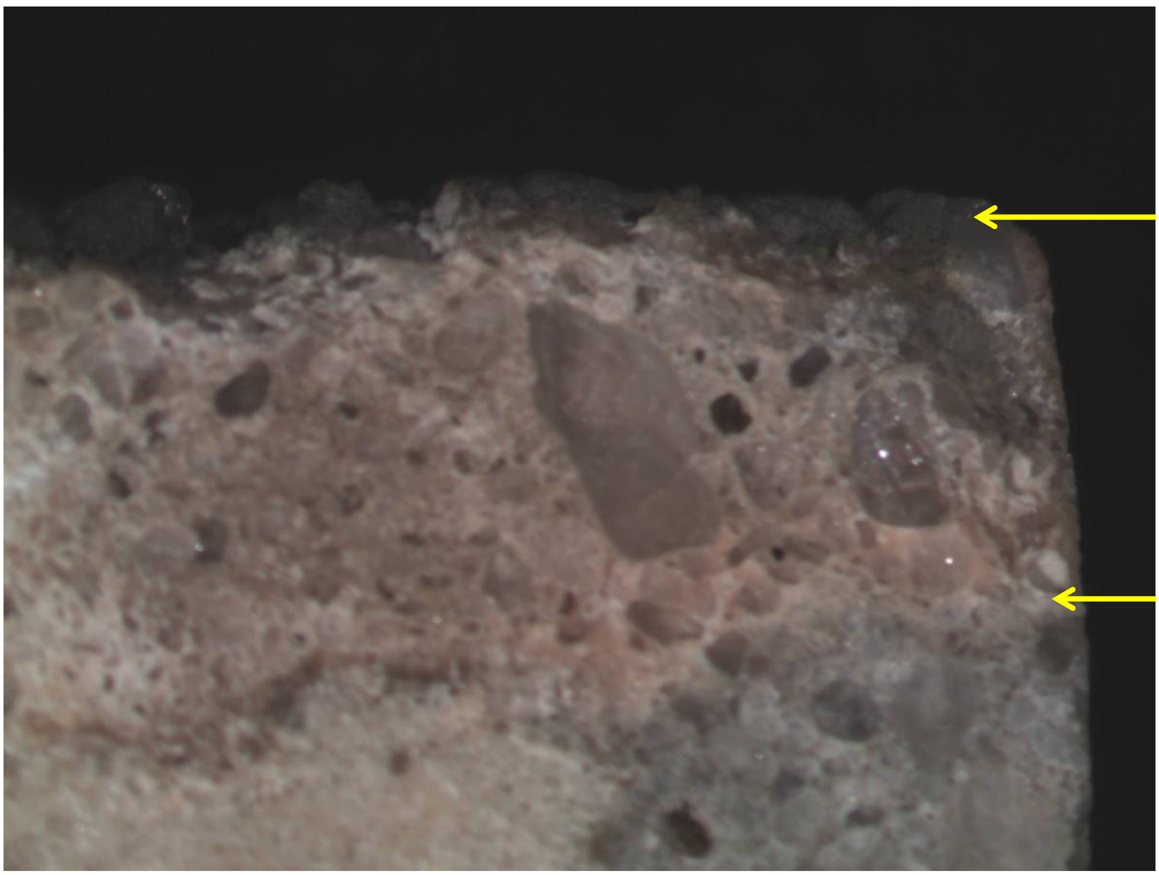


Photo 11 – Sample 6B – magnified view of carbonated paste at surface of core.

Photo 11 – Sample 2 – magnified view of entrapped air void near surface of core.