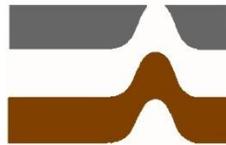


**Engineering Evaluation of Concrete Condition
and Steel Sheet Pile Wing Wall Thickness
St. Johns River Water Control Structure S-96C
Indian River County, Florida**



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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-96C
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 northwest 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 N27.821285°, W-80.742903°, respectively.

We understand that the existing structure was constructed in 1994, 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 25.0 feet in width. The concrete gate monolith is 39.0 feet in length having an upstream top of crest weir elevation of +11.8 feet dropping over an approximate horizontal distance of 9.0 feet to the downstream top of slab elevation of +9.8 feet. 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 32 sections of Type Z-27 sheet pile having a total wall length of 48.0 feet and the downstream sheet pile wing walls consist of 31 sections of Type Z-27 sheet pile having a total wall length of 46.5 feet. Type Z-27 (now known as 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 February 21, 2014 (downstream portion) and March 21, 2014 (upstream 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 +19.8 feet, respectively, based on readings made from the on-site staff gauges. Based on the water staining marks and concrete pitting, the water levels appear to typically fluctuate approximately 1.5 feet on the upstream side and 3.5 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 fair condition. Pitting within the water floatation zone and below the water surface was moderate and observed to be on the order of ¼ to ½ inch with obvious aggregate loss. 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 upstream walls appeared to be in very good condition. No evidence of corrosion or seepage between the joints was observed. The portions of the steel sheet pile walls that were below the water surface 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 fair condition. Pitting within the water floatation zone and below the water surface was observed to be ¼ to ½ inch with obvious aggregate loss. A significant “groove” on the order of 3 inches in height and 2 inches in depth was observed at the normal water level. Exposed reinforcing steel was observed at some locations within the “groove”. 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 (other than the exposed reinforcing steel) were observed.

Relative to the steel sheet pile wing walls, the downstream walls appeared to be in very good condition. No evidence of corrosion or seepage between the joints was observed. The portions of the steel sheet pile walls that were below the water surface 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 3.2 and 3.0 for the downstream and upstream walls respectively. The average rebound number value above the zone of typical water fluctuation is 4.5 and 4.0 for the downstream and upstream wall 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., 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 all walls exceeded the as-built sectional thickness of 0.375 inch.

Water Sampling

A sample of the creek water was obtained on March 21, 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 $\frac{1}{4}$ to $\frac{1}{2}$ inch on both the upstream and the downstream portions of the structures. This was consistent with our visual observations, with exception of the deeper groove on the downstream side. 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 horizontally 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 summarizes the results of the pH testing.

Location	Tested pH
Core 1B	11.8
Core 5B	12.0
Core 6B	12.3

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 negligible and that 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	4.5	4.2	6,100
Core 2A	4.8	4.3	6,220
Core 3A	4.0	3.8	6,880
Core 4A	5.0	4.7	6,660
Core 5A	4.0	3.7	5,980
Core 6A	4.2	3.7	6,150

The results indicate that the minimum and maximum compressive strengths range from 5,980 to 6,880 psi. The average and median compressive strengths are 6,330 and 6,440 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
30	7.1	5,900	<2.4	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 and the steel sheet pile wing walls has not been significantly compromised. However, the concrete element of the structure (especially the downstream portion) is exhibiting greater than normal physical erosion characteristics typical for a hydraulic structure of this age and use. Remediation of the concrete within the water fluctuation zone is recommended. While the rate of erosion can be expected to increase due to pitting and continued aggregate loss, the condition of the structure considering the years of service suggests that there should be sufficient time to plan and budget the remediation. Our observations and testing relative to the steel sheet pile wing walls indicate that the upstream and downstream wingwalls are in very good condition and no remediation is needed at this time.

The concrete degradation that is present appears to be confined to the outer approximate ¼ to ½ inch of the concrete within the water fluctuation zone on both sides of the structure and more significantly within the worn "groove" near the normal water surface (on the downstream side) that is approximately 2 inches deep. The type of degradation observed is consistent with long-term erosion. Erosion is defined in this report as the progressive disintegration of a solid by cavitation, abrasion or chemical action. We saw no visual evidence of excessive concrete cracking; spalling or chemical damage such as leaching or rusting that would indicate that the structural integrity of concrete or reinforcing steel (except as noted below) would be otherwise compromised.

The following sections provide additional detail relative to our findings and present our recommendations for continued use.

Concrete Remediation

As previously stated, the majority of the erosion was observed on the portion of the structure walls where the turbulence associated with the flow and the apparent height of water level fluctuation. Therefore it is our conclusion that the pitting and the worn groove present on the downstream side of structure is the result of physical deterioration caused by cavitation and abrasion/impingement erosion. The evidence does not suggest that chemical erosion (i.e.; severe acid attack, carbonation, chloride-related deterioration and/or sulfate attack) is occurring. The following is a brief description of the physical deterioration causes.

Cavitation Erosion

Cavitation attack involves the explosive collapse of gas entrapped bubbles in liquids when there is turbulent or disruptive flow of the liquid. The resultant pressures impact the concrete, causing pitting and erosion. This generally affects the cement paste first and then works on the aggregate. Once the aggregate is carried away, newly exposed paste continues to be attacked. Once erosion has begun, the rate of erosion may be expected to increase because protruding pieces of aggregate become new generators of vapor cavities. The erosion rate is often accelerated further by the high water velocities striking the irregular surface.

Abrasion and Impingement Erosion

Abrasion erosion damage results from the abrasive impacts of waterborne silt, sand, gravel, rock and debris impinging on a concrete surface. The rate of erosion is dependent on a number of factors including the size, shape, quantity and hardness of the particles being transported, the velocity of the water and the quality of the concrete.

Water flowing over or impinging on concrete inevitably leads to erosion of the cement paste, aggregate exposure and removal of the concrete surface. The rate of erosion depends on the velocity, temperature, pH and suspended solids levels of the impinging or flowing water. The size, concentration and hardness of the suspended solids also affect the erosion or "water-blasting" effects on the concrete.

Repair Alternatives

It is generally desirable to eliminate the cause of erosion whenever possible. However in this case, that will likely not be possible. A variety of materials and material combinations can be used for repair of hydraulic concrete structures undergoing the type of deterioration observed. Consideration should be given to the time available, access points, logistics in material supply, ventilation, nature of work, equipment available, and skill and experience of the local labor force. ACI Report 210R-93 provides remedial recommendations for steel plating, epoxy resins, acrylics and other polymer systems. Also included are more conventional fiber reinforced concretes, silica-fume concrete, and shotcretes.

Reinforcing Steel Corrosion

Corrosion of reinforcing steel is one of the most important and prevalent mechanisms of deterioration for concrete structures. The laboratory testing of the cores for pH and carbonation indicate that the alkalinity of the concrete is within the normal range to be expected for a facility of this type and age. However, as mentioned previously there are several isolated areas within the worn "groove" on the downstream side of the structure where the steel reinforcement was visibly exposed. While the exposed reinforcing steel did not appear to be obviously corroded at the time of our observations, the potential for future corrosion is very high.

Steel Sheet Pile Remediation

Based on our observations and thickness readings, it is our opinion that the steel sheet pile wing walls have not experienced excessive erosion or corrosion due to physical or chemical conditions. It appears that the wing walls have been treated with corrosion inhibiting paint/coatings in the past. Routine periodic applications of additional paint/coatings should continue.

Other Considerations

The remedial concrete repair and 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




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

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

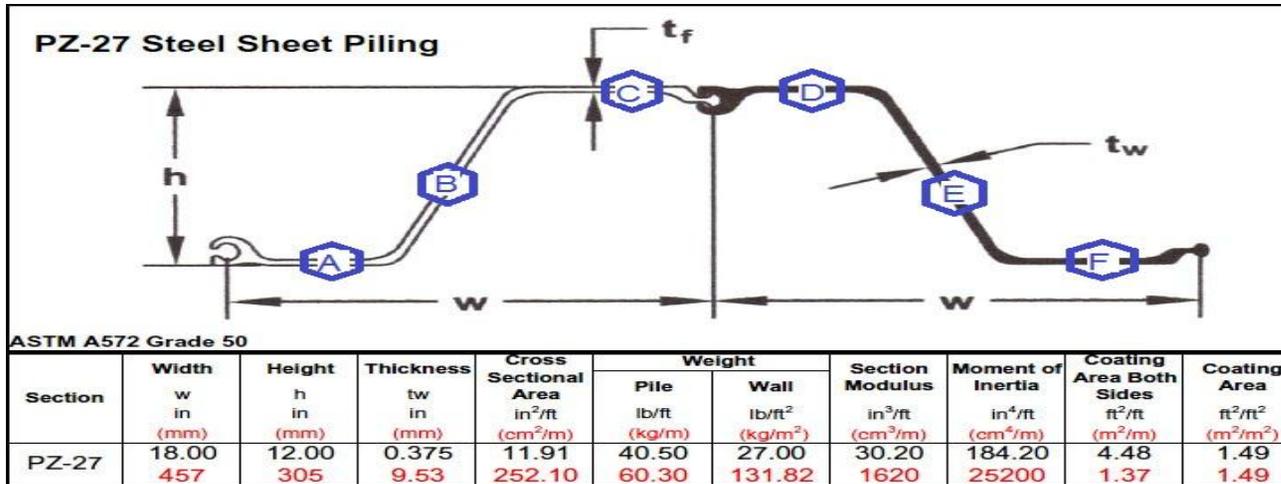
R-Number Location	Description	Average R-Number	
		Within Zone of Typical Water Fluctiation	Above Zone of Typical Water Fluctuation
R1	Downstream - North Wall, East Half	2.9	4.8
R2	Downstream - North Wall, West Half	3.2	4.2
R3	Downstream - South Wall, West Half	3.5	4.7
R4	Downstream - South Wall, East Half	3.2	4.2
R5	Upstream - South Wall, East Half	3.2	4.0
R6	Upstream - North Wall, East Half	2.8	4.0
R7	Upstream - South Wall, West Half	3.0	3.8
R8	Upstream - North Wall, West Half	3.0	4.0
	Average (Downstream/Upstream)	3.2/3.0	4.5/4.0

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

Location	Core Designation	Length (in)	Rebar Encountered	General Condition/Observations
Downstream - North Wall, East Half	C-1A	4.5	No	
	C-1B	2.7	Yes	Rebar in good condition. No corrosion observed.
Downstream - North Wall, West Half	C-2A	4.8	No	
	C-2B	4.5	No	
Downstream - South Wall, West Half	C-3A	4.0	No	
	C-3B	4.8	No	
Downstream - South Wall, East Half	C-4A	5.0	No	
	C-4B	4.3	No	
Upstream - South Wall	C-5A	4.0	No	
	C-5B	2.8	Yes	Rebar in good condition. No corrosion observed.
Upstream - North Wall	C-6A	4.2	No	
	C-6B	2.8	Yes	Rebar in good condition. No corrosion observed.

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

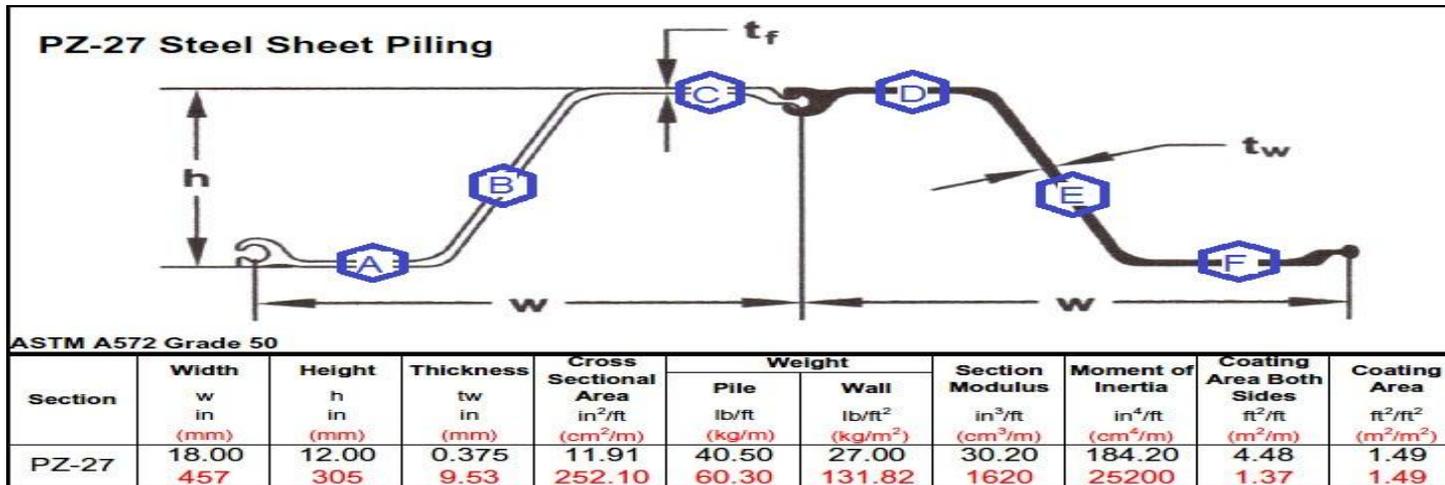
Reading Designation	Wing Wall Average Thickness Reading (inches)					
	North Wall (Upstream)			South Wall (Upstream)		
	1	2	3	1	2	3
A	0.398	0.399	0.416	0.403	0.429	0.430
B	0.386	0.398	0.404	0.404	0.427	0.405
C	0.394	0.406	0.411	0.392	0.373	0.409
D	0.985	0.404	0.412	0.403	0.427	0.427
E	0.393	0.411	0.420	0.411	0.422	0.416
F	0.406	0.427	0.454	0.404	0.428	0.407
Maximum Value	0.985	0.427	0.454	0.411	0.429	0.430
Minimum Value	0.386	0.398	0.404	0.392	0.373	0.405
Average Value	0.494	0.408	0.420	0.403	0.418	0.416
Median Value	0.396	0.405	0.414	0.404	0.427	0.413



Approximate Reading Designation Location

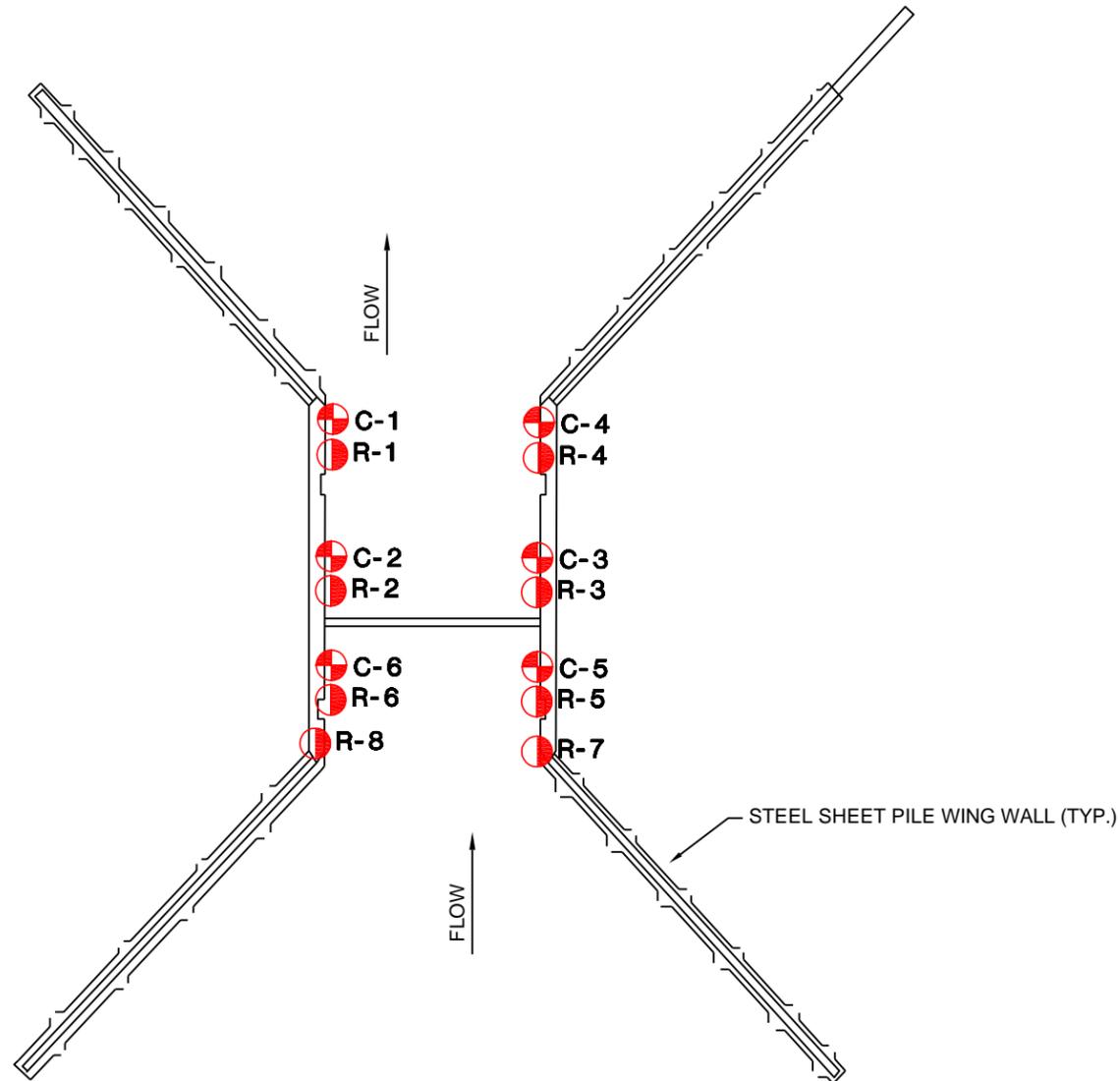
TABLE 3B
Ultrasonic Thickness Readings
Steel Sheet Pile Wing Walls
Water Control Structure S-96C
SJRWMD, Indian River County, Florida

Reading Designation	Wing Wall Average Thickness Reading (inches)									
	North Wall (Downstream)					South Wall (Downstream)				
	1	2	3	4	5	1	2	3	4	5
A	0.396	0.387	0.390	0.390	0.399	0.419	0.409	0.393	0.403	0.397
B	0.388	0.388	0.390	0.387	0.397	0.428	0.394	0.384	0.383	0.397
C	0.409	0.399	0.425	0.415	0.400	0.396	0.385	0.389	0.429	0.401
D	0.426	0.401	0.427	0.419	0.403	0.419	0.407	0.384	0.407	0.401
E	0.398	0.392	0.406	0.405	0.411	0.399	0.398	0.403	0.374	0.397
F	0.388	0.390	0.416	0.416	0.408	0.384	0.386	0.390	0.375	0.407
Maximum Value	0.426	0.401	0.427	0.419	0.411	0.428	0.409	0.403	0.429	0.407
Minimum Value	0.388	0.387	0.390	0.387	0.397	0.384	0.385	0.384	0.374	0.397
Average Value	0.401	0.393	0.409	0.405	0.403	0.408	0.397	0.391	0.395	0.400
Median Value	0.397	0.391	0.411	0.410	0.402	0.409	0.396	0.390	0.393	0.399



Approximate Reading Designation Location

T:\Orlando\14\14-6319\14631901.dwg 6/13/2014 11:10:24 AM, Brenda.Helms



LEGEND

-  **C** CORE LOCATION
-  **R** REBOUND HAMMER READING LOCATION



0 10 20
 APPROXIMATE SCALE: 1"=20'

CORE LOCATION PLAN		
 Ardaman & Associates, Inc. Geotechnical, Environmental and Materials Consultants		
ENGINEERING EVALUATION OF SJRWMD STRUCTURE S-96C BREVARD COUNTY, FLORIDA		
DRAWN BY: CD	CHECKED BY:	DATE: 05/14/14
FILE NO. 14-6319	APPROVED BY:	FIGURE: 1

APPENDIX I

Photographs of Site Observations

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



Downstream - View of Structure and Portion of Wing Walls.



Downstream - North Structure Wall. Note Pitting and "Groove" at Normal Water Level.

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



Downstream - North Structure Wall. Note Pitting and "Groove" at Normal Water Level.



Downstream -South Structure Wall. Note Pitting and "Groove" at Normal Water Level.

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



Downstream - South Structure Wall. Note Exposed Steel Reinforcement in "Groove".



Downstream - South Wing Wall.

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



Downstream - North Wing Wall.



Upstream - Structure and South Wing Wall.

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



Upstream - South Structure Wall.

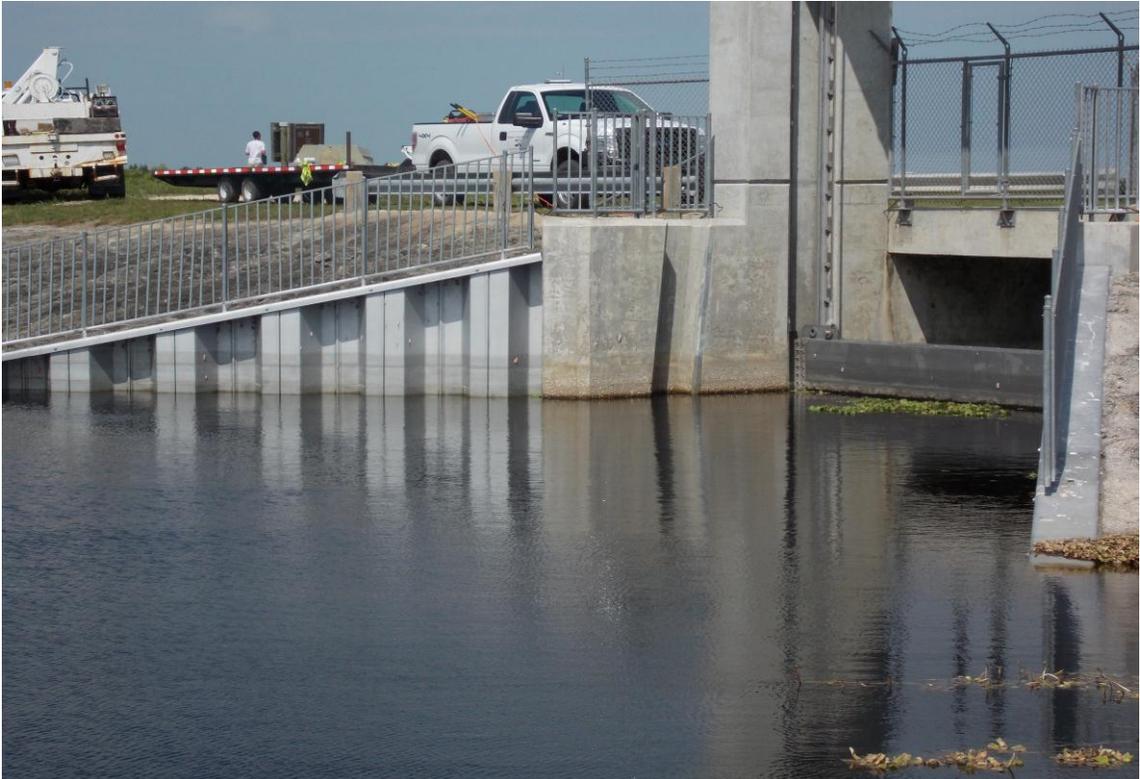


Upstream - North Structure and Wing Wall.

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



Upstream - South Wing Wall.



Upstream - South Wing Wall and Structure.

APPENDIX II

Petrographic and Carbonation Examination Photographs



Report of Petrographic Examination of Concrete ASTM C-856

Project: Structure 96C

Date: May 12, 2014

Location:

Client: SJRWMD

Project No. 14-60-6319

Sample Nos. 2B
3B

Sample Size: 2 ½ in. wide, 4 ½ in. long
2 ½ in. wide, 4 ¾ in. long



Core 2B



Core 3B

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.

Report of Petrographic Examination of Concrete (Cont'd.)

Structure 96C

Core Samples 2B and 3B

Page 2 of 5

Matrix (cement paste)

- Paste is light to medium gray with some dark gray zones through the depth of the cores. The application of a phenolphthalein indicator solution shows negligible carbonation.
- 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 3 percent between the two samples

Surface

- The surface of the sample is eroded.

Cracking

- No cracking was observed.

Embedded Items

- No embedded reinforcing steel was observed.

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 2B – end view, note surface erosion.



Photo 3 – Sample 3B – end view, note surface erosion.



Photo 4 – Sample 2B – magnified view of eroded surface.



Photo 5 – Sample 3B – magnified view of eroded surface.



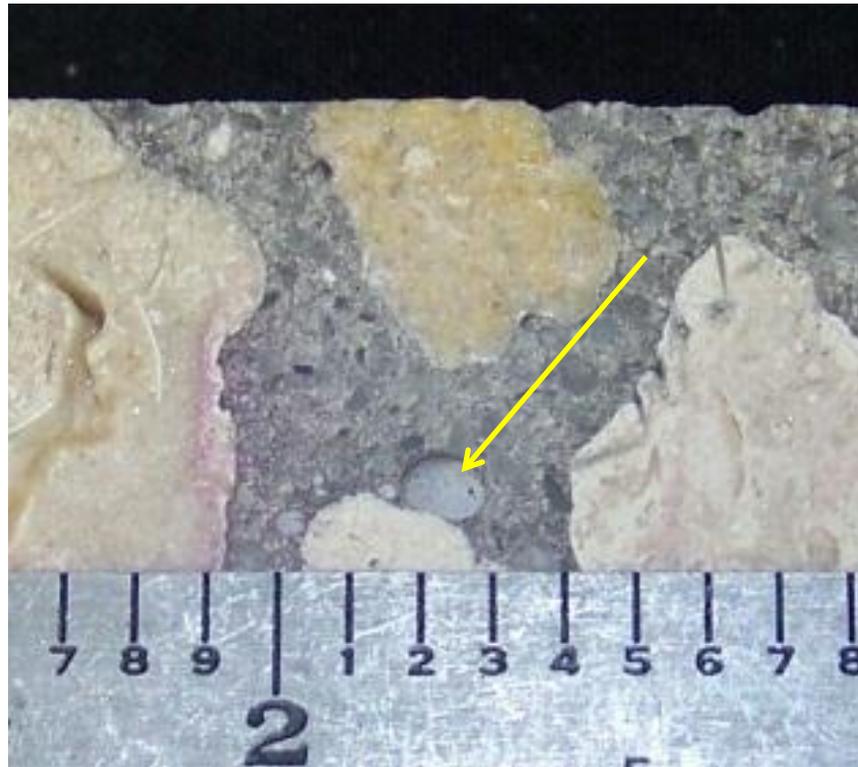


Photo 6 – Sample 3B – magnified view of entrapped air void

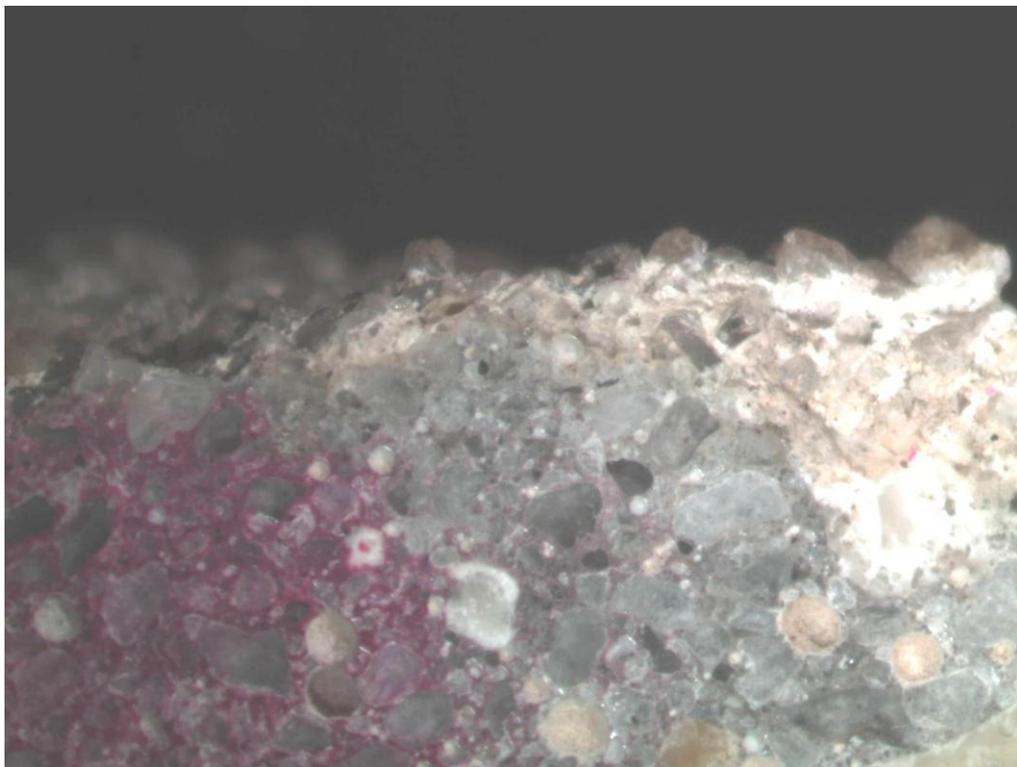


Photo 7 – Sample 3B – magnified view of light colored paste at surface.

