Lake, Louis

From: Lake, Louis
Sent: Tuesday, November 24, 2009 9:25 AM
To: Carrion, Robert
Subject: FW: Refute 3.1 for Review
Attachments: FM 3.1.ppt; Exhibit 4 - Graph of air from tickets.pdf; Exhibit 1 - Erlin Hime Petro report 05101976.pdf; Exhibit 2 - Core Bore #5 Final CTL Petrographic Report 059169 C856.pdf; Exhibit 3 - pour ticket samples - Pour666RBElev160.pdf

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From: Williams, Charles R. [mailto:Charles.Williams@pgnmail.com]
Sent: Tuesday, November 24, 2009 7:12 AM
To: Lake, Louis; Thomas, George; nausdj@ornl.gov
Cc: Herrin, Dennis W.
Subject: Refute 3.1 for Review

Mr Lake,
I am resending due to difficulty with opening/reading the previous attachments. Again, this is prelim. Call me with questions. It looks like I will need to send each one as separate emails to keep from mixing documents.

Thank you,
Charles Williams
919-516-7417

P/205

3.1 Inadequate Air Content

Preliminary

May identify additional perspective on this issue as RCA related efforts proceeds

Description: Excessive amount of uncontrolled air contained within the concrete as a result of mixing/placing operations could cause voids. These voids of variable size and shape create weakness in the matrix. Excessive volume of air voids (entrained and entrapped) can weaken the concrete, provide an initiation zone for cracks, and increases potential for shrinkage/creep.

Data to be Collected and Analyzed:

(1) Petrographic analysis (Exhibits 1 & 2)

(2) Review pour tickets for measured air during construction (Exhibit 3). Exhibit 4 is a graph of the data from those pours.

Verified Refuting Evidence:	Verified Supporting Evidence:
1. Amount of entrained air is within acceptable range according to Petrographic analysis. 2. Pour ticket review shows the air entrained admixture (DAREX) was used in all concrete pours in accordance with the design specifications. 3. Analysis of measured air confirmed that air content was within specifications. Reviewed by: Dr. Avi Mor, 352-795-6486 , ext 1030 – PII CR3 Team Office	

5 Pages

ATTACHMENT "C"-2

ERLIN, HIME ASSOCIATES

MATERIALS AND CONCRETE CONSULTANTS

811 SKOKIE BOULEVARD
NORTHBROOK, ILLINOIS 60062

(312) 272-7730

PETROGRAPHIC STUDIES OF CONCRETE

FOR

CONSTRUCTION ENGINEERING CONSULTANTS

* * * * * * * *

SUMMARY AND DISCUSSION

The specimen represented air-entrained concrete made with crushed fossiliferous coarse aggregate and siliceous fine aggregate and a low water-cement ratio paste. There was no evidence that the aggregates had been either chemically or physically unsound.

The specimen was from an area where fractures had existed for a period of time and where moisture had been present. That was demonstrated by secondary deposits on fracture surfaces.

The specimen was relatively small. Larger specimens from different areas of the structure would be desirable for examination in order to obtain a better representation of the concrete.

* * * * * *

INTRODUCTION

Reported herein are the results of petrographic studies of a concrete fragment submitted by J. Artuso of Construction Engineering Consultants. The specimen is from the dome of the containment structure of the Florida Power Corporation, Crystal River, Unit III.

Requested by Mr. Artuso were petrographic studies for evaluating the specimen, and particularly for evidence of features that would cause volume instability.

STUDIES

Specimen - The specimen was an elongated fragment having nominal lateral dimensions of 5 inches, and a maximum thickness of about 3/4 inch.

All surfaces were fracture surfaces except for a shallow channel about 3/32 inch wide and 1/8 inch deep. The channel appears to be the terminal area of a saw cut.

Petrographic Studies - Coarse aggregate of the specimen was a buff to light brown, fine-grained, fossiliferous limestone having a maximum nominal size of 3/4 inch. The fine aggregate was a siliceous sand composed principally of quartz.

The aggregates were not particularly well graded, as evidenced by deficiencies of the finer sizes of the coarse aggregate and the coarser sizes of the fine aggregate.

There was no evidence that the aggregates had been chemically or physically unsound. Particular attention was directed to alkali-silica reactivity with respect to the coarse aggregate because a similar type of aggregate does contain a highly reactive variety of chert. Neither the chert nor the product of the reaction of the chert with alkalies (alkali-silica gel) was present.

Paste of the specimen was medium dark grey, firm, and contained abundant residual and relict cement. The quality of the paste reflects a low water-cement ratio.

Air occurred as small, discrete, spherical voids that occasionally were very slightly distorted, and as coarser irregularly shaped voids. The spherical voids are characteristic of entrained air voids; the irregularly shaped voids, of entrapped air. The air content of the specimen is estimated to be 5½ percent and the parameters of the air-void system are judged to be effective for protecting critically saturated concrete exposed to cyclic freezing.

On one of the lateral surfaces were secondary deposits composed of tufts of fine acicular ettringite ($3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 31H_2O$), and calcite ($CaCO_3$). Ettringite was also present as tufts in some air voids just below the fracture surface.

The fragment was not uniformly thick; it tapered to a knife-like edge. Along that edge, were fine fractures oriented subparallel to the long axis of the fragment. The fractures transected coarse aggregate particles. On those fracture surfaces were secondary deposits similar to those described above.

The secondary compounds demonstrate that the fragment was from an area where fractures present for a period of time had been exposed to moisture.

May 10, 1976

Erlin, Hime Associates, Inc.

Bernard Erlin

by Bernard Erlin, President
Petrographer

DIRECT TENSILE STRENGTH TEST RESULTS

CORE	AREA SQ. IN.	NOMINAL DIAMETER IN.	TOTAL LOAD LBS.	P.S.I.	REMARKS
Granite aggregate concrete 5000 p.s.i. value	8.19	3 1/4	3400	415	
	8.14	3 1/4	3200	390	
Crystal River Cores			Average 400 p.s.i.		
N Pour XVI	10.69	3 3/4	2500	230	All Coarse aggregate soft
M Pour XVIII	10.69	3 3/4	4600	430	Hard Coarse aggregate except two soft pieces
L Pour XV	10.69	3 3/4	5400	505	All hard coarse aggregate
L Pour 9B	10.69	3 3/4	5400	485	Most coarse aggregate hard
P Pour XIII	10.69	3 3/4	5400	505	All hard coarse aggregate
N Pour XII	10.63	3 3/4	3800	360	All small soft coarse aggregate

Average 420 p.s.i.

Note: The Granite Aggregate concrete cores fractured surfaces indicated all coarse aggregate was hard and dense and several pieces of the CA pulled out of the Matrix, indicating greater tensile strength than the Matrix. There was no pull out of the Crystal River coarse aggregate - all fractured at the fractured surface.

Attachment D

Preliminary Report of
Crystal River Coarse Aggregate

Sieve	Wgt. Ret.	% Passing	ASTM Spec # 67
1	0	100	100
3/4	1.0	97	90-100
1/2	15.8	58	------
3/8	28.4	24	20-55
4	35.8	4	0-10
8	36.3	3	0-5
Pan	37.3		

	Test	Result	ASTM Specification
C-117	200 Wash Loss	1.3% (Primarily dust of fracture)	1% Max*
C-131	Los Angeles Abrasion	42 %	50% Max
C-123	Lightweight Pieces in Aggregate	0.2%	0.5% Max
C-29	Unit Weight of Aggregate	85.68 lbs/cu. ft.	No Spec
C-142	Friable Particles	Later	5.0% Max
C-235	Soft Particles	Later	5.0% Max
C-88	Soundness (Sodium Sulphate)	Later	12.0% Max
C-127	Specific Gravity and Absorption	Later	No Spec

*This limit may be increased to 1.5% if the material finer than a No. 200 consists essential of dust from fracture

Copy No. 1

Report for
Progress Energy

CTLGroup Project No. 059169

Petrographic Examination of Concrete Half Core from Delaminated Containment Wall, Crystal River, Florida

November 2, 2009

Submitted by:
Derek Brown

COA #4731

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CTLGROUP
Building Knowledge. Delivering Results.

REPORT OF PETROGRAPHIC EXAMINATION

Date: November 2, 2009

CTLGroup Project No.: 059169

Petrographic Examination of Concrete Half Core from Delaminated Containment Wall, Crystal River, Florida

One saw cut half concrete core labeled Core #5 (Figs. 1 and 2) was received on October 27, 2009 from Mr. Jerzy Zemajtis, Project Manager, CTLGroup on behalf of Mr. Paul Fagan of Progress Energy, Crystal River, Florida. According to Mr. Zemajtis, the core represents the outer portion of concrete from a containment wall and the core is fractured at its inner surface at a delamination that was found to be present when access was gained to the wall interior. The delamination is approximately at a depth of 200 mm (8.0 in.) where horizontal post tensioning ducts are present.

Petrographic examination (ASTM C856-04) of the core was requested in order to determine, if possible, if the delamination is a recent feature, or alternatively if it occurred at some earlier time in the age of the structure.

FINDINGS AND CONCLUSIONS

The following findings result from the petrographic examination.

Based on the general appearance, and both the physical and microstructural properties, the fracture at the point of delamination is most likely a fairly recent event. However, it is not possible to be completely definitive about the time frame since an older fracture, if subsequently well protected from air and moisture ingress, may also have similar characteristics.

The fracture surface passes through, not around the aggregates particles, is moderately hard, and does not exhibit loose surface debris. There is an absence of significant microcracking in the general vicinity of the fracture, and only limited evidence of surface deposits (slight efflorescence).

Carbonation to any significant depth from the fracture surface into the outer concrete is not observed (Fig. 3). Incipient carbonation is exhibited in thin section at the immediate fracture surface (Fig. 6a). However, an older delamination surface that was not exposed to air due to the depth of outer concrete, and other possible wall coverings, may also have such an absence of carbonation.

The cement hydration adjacent to the fracture is well advanced and comparable to that of the body of the core (Figs. 6b and 6c). This suggests that there was no moisture ingress to the fracture surface, over a period of time long enough, to change the general degree of hydration. This is supported by an absence of secondary deposits within air voids adjacent to the fracture surface.

Additional Comments

The concrete represented by Core #5 is well consolidated and free of any cracks or excessive microcracks (Fig. 4). The concrete consists of crushed carbonate rock coarse aggregate and natural sand fine aggregate, well distributed in a portland cement paste. No evidence is exhibited of any deleterious chemical reactions involving the cement paste and / or aggregates. The concrete could be considered marginally air entrained based on an approximate volume of 1 to 2% of small, spherical entrained air voids in the hardened cement paste (Fig. 5).

Based on the physical properties and microstructure of the hydrated cement paste, and the tight aggregate to paste bond, lack of major cracks and microcracks, and absence of a materials-related distress mechanism, the concrete is considered to be in good condition.

Further details of the petrographic examination are given in the following image and data sheets.

METHODS OF TEST

Petrographic examination of the provided sample was performed in accordance with ASTM C 856-04, "Standard Practice for Petrographic Examination of Hardened Concrete." The core was visually inspected and photographed as received. The core half was ground (lapped) on the saw cut surface to produce a smooth, flat, semi-polished surface. Lapped and freshly broken surfaces of the concrete were examined using a stereomicroscope at magnifications up to 45X.

For thin-section study, small rectangular blocks were cut from the core inner surface fracture region and within the body of the core. One side of each block was lapped to produce a smooth, flat surface. The blocks were cleaned and dried, and the prepared surfaces mounted on separate ground glass microscope slides with epoxy resin. After the epoxy hardened, the thickness of the mounted blocks was reduced to approximately 20 μm (0.0008 in.). The resulting thin sections were examined using a polarized-light (petrographic) microscope at magnifications up to 400X to study aggregate and paste mineralogy and microstructure.

Estimated water-cement ratio (w/c), when reported, is based on observed concrete and paste properties including, but not limited to: 1) relative amounts of residual (unhydrated and partially hydrated) portland cement clinker particles, 2) amount and size of calcium hydroxide crystals, 3) paste hardness, color, and luster, 4) paste-aggregate bond, and 5) relative absorbency of paste as indicated by the readiness of a freshly fractured surface to absorb applied water droplets. These techniques have been widely used by industry professionals to estimate w/c.

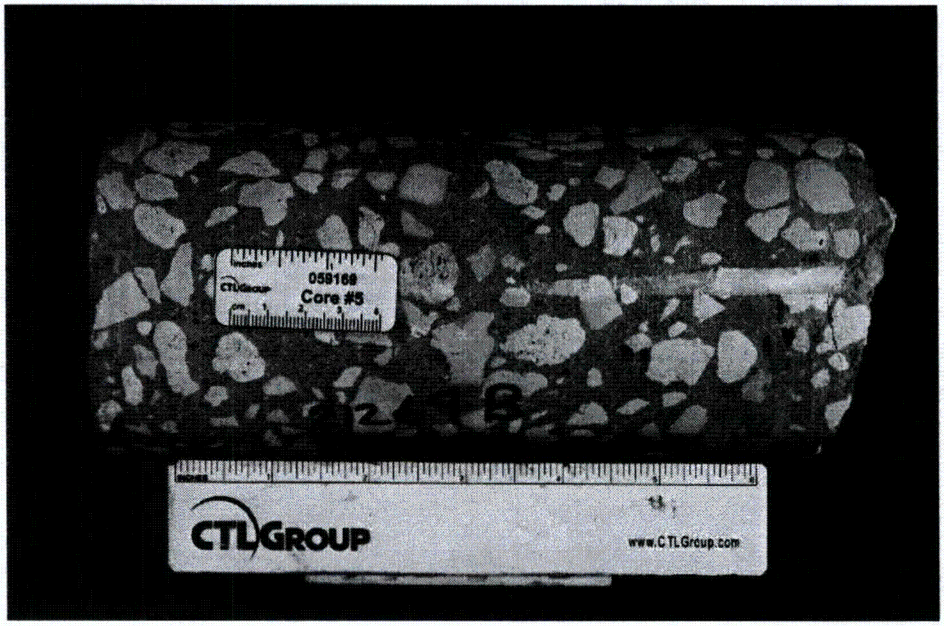
Depth and pattern of paste carbonation was initially determined by application of a pH indicator solution (phenolphthalein) to freshly cut and original fractured concrete surfaces. The solution imparts a deep magenta stain to high pH, non-carbonated paste. Carbonated paste does not change color. The extent of paste carbonation was confirmed in thin-section.

Derek Brown

Derek Brown
Senior Microscopist
Microscopy Group

DB/DB

Notes:
1. Results refer specifically to the sample submitted.
2. This report may not be reproduced except in its entirety.
3. The sample will be retained for 30 days, after which it will be discarded unless we hear otherwise from you.

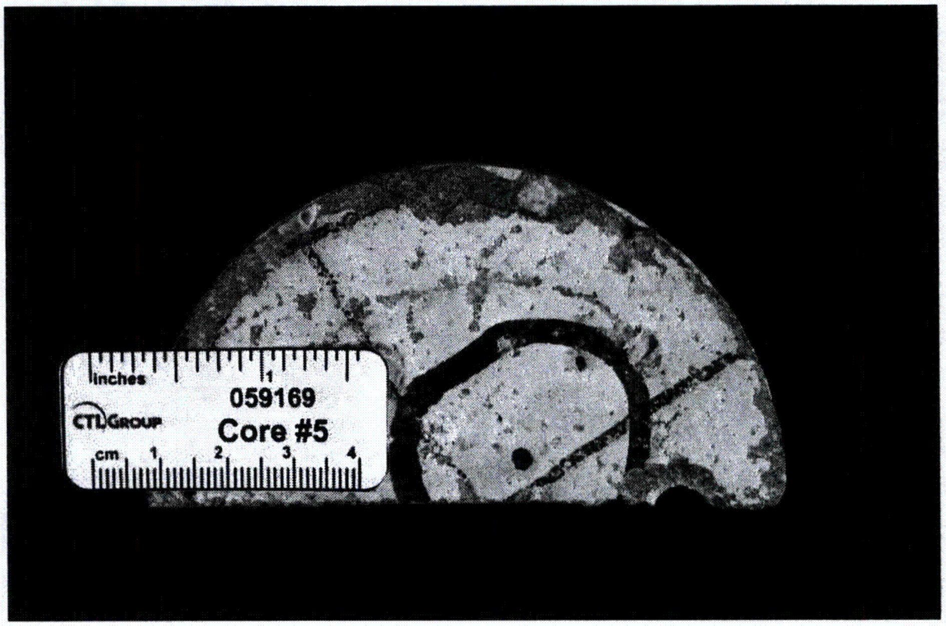


1a. Curved surface. Outer end is to the left.

1b. Saw cut surface. Outer end is to the left

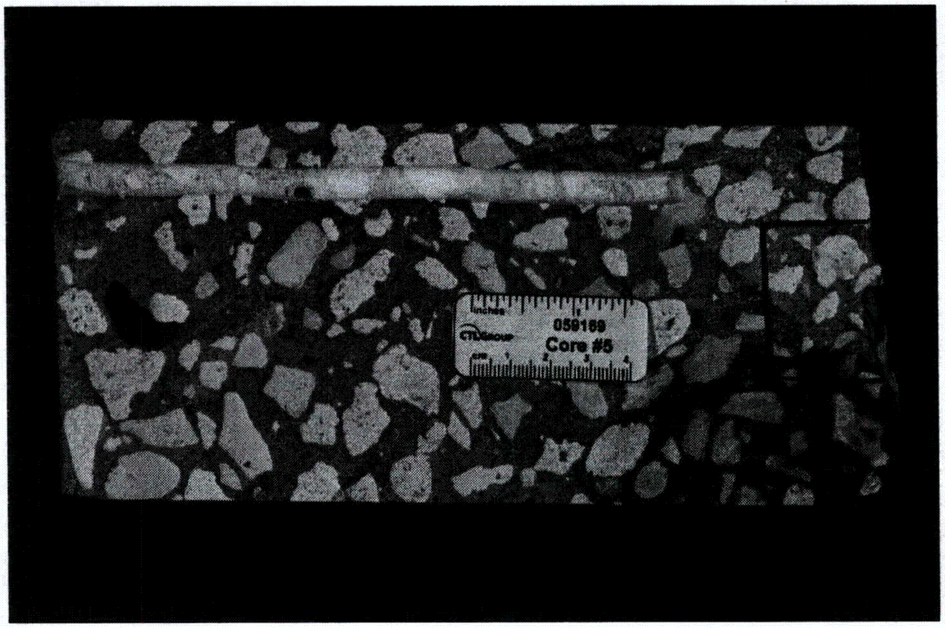
Fig. 1 Side views of Core #5, as received for examination.

2a. Inner end.

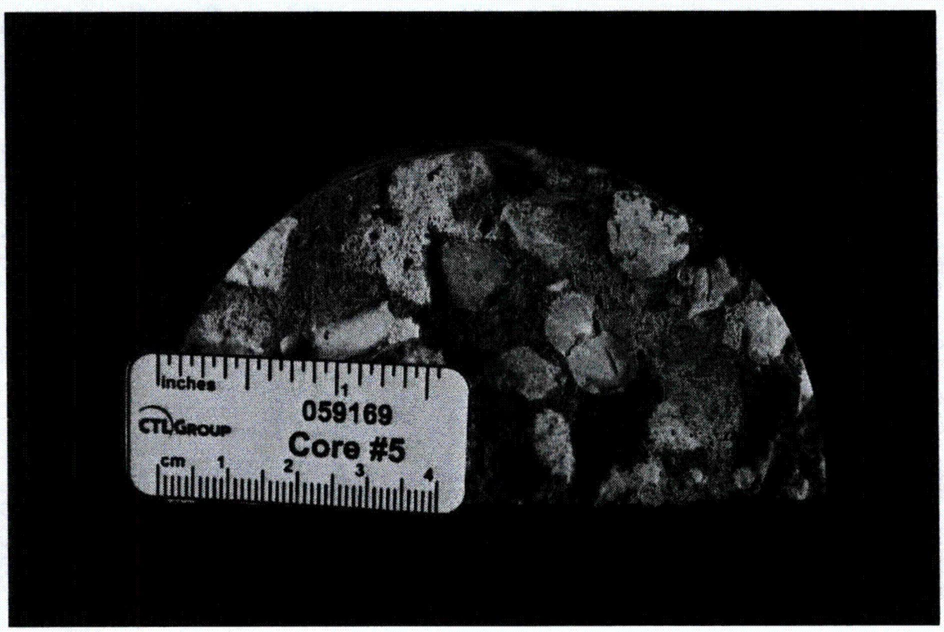


2b. Outer end.

Fig. 2 End views of Core #5, as received for examination.



3a. Saw cut side. Outer surface is to the left.



3b. Fractured inner end.

Fig. 3 Views of the portions of Core #5 treated with phenolthalein, a pH indicator. All the pink regions exhibited denote the limits of where the indicator was applied. No colorless, low pH (carbonated) regions were observed at the fractured end regions.

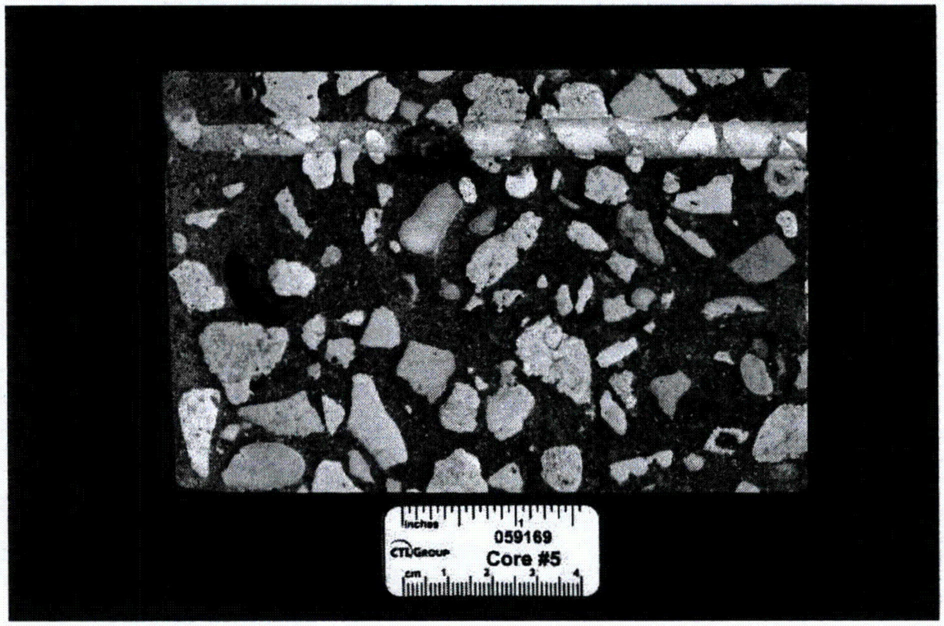
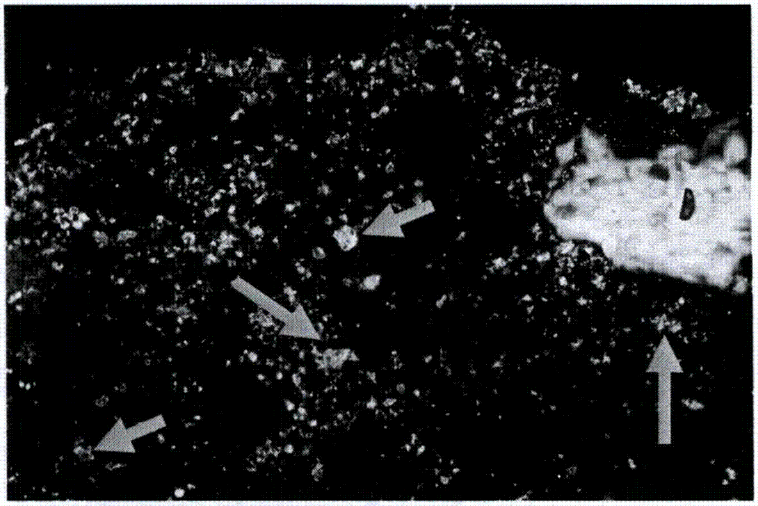


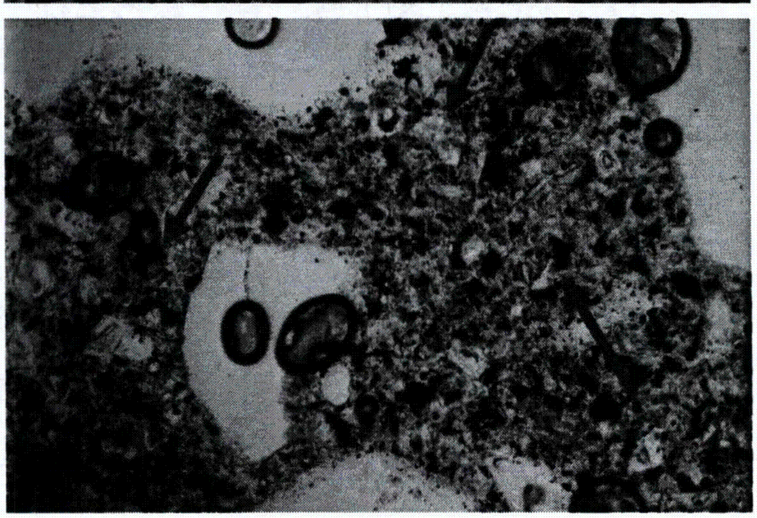
Fig. 4 View of the lapped surface of a portion of Core #5 showing the general appearance of the concrete.

Fig. 5 View of the concrete hardened air-void system of Core #5 illustrating the moderate quantity of both coarse and fine air voids. Scale is millimeter increments.



6a. Crossed-polarized light view of the paste adjacent to the inner fractured surface. Only incipient carbonation is indicated by the speckled high birefringence colors in the paste. Carbonate fines are arrowed yellow. Width of view is approximately 0.5 mm.

6b. Plane-polarized light view of the paste adjacent to the inner fractured surface (same field of view as 6a.). A low to moderate number of unhydrated and partially hydrated cement particles (arrowed red) are exhibited by the paste. The amount is comparable to that in the body of the core in Fig. 6c. below. Width of view is approximately 0.5 mm.



6c. Plane-polarized light view of the paste in the body of the core. A low to moderate number of unhydrated and partially hydrated cement particles (arrowed red) are exhibited by the paste. The amount is comparable to that near the fracture surface in Fig. 6b. above Width of view is approximately 0.5 mm.

Fig. 6 Transmitted light photomicrographs of the thin sections of Core #5 illustrating significant features.

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE, ASTM C 856

STRUCTURE: Containment wall

DATE RECEIVED: October 27, 2009

LOCATION: Crystal River

EXAMINED BY: Derek Brown

SAMPLE

Client Identification: Core #5.

CTLGroup Identification: 2452601.

Dimensions: Core diameter = 95 mm (3.75 in.). Core length = approximately 197 mm (7.75 in.); partial wall thickness.

Top End: Even, slightly rough formed surface.

Bottom End: Uneven and rough, fractured core end.

Cracks, Joints, Large Voids: Text.

Reinforcement: None observed in the core supplied.

AGGREGATES

Coarse: Crushed rock composed of carbonate rock type.

Fine: Natural quartz sand.

Gradation & Top Size: Visually appears evenly graded to an observed top size of 18 mm (0.75 in.).

Shape, Texture, Distribution: Coarse- Sub rounded to angular, slightly irregular to rough, evenly distributed. Fine- Rounded to sub angular, slightly smooth to somewhat rough, evenly distributed

PASTE

Color: Medium gray, uniform coloration throughout the length of the core.

Hardness: Moderately hard at the outer surface and in the body of the core. At the fracture surface the paste is also moderately hard.

Luster: Subvitreous.

Paste-Aggregate Bond: Tight. Freshly fractured surfaces pass through aggregate particles.

Air Content: Estimated 2 to 4% total. Approximately 1 to 2% of the total air is larger entrapped air voids of up to 3 mm (0.12 in.) in size, plus a few large voids of 4 to 10 mm (0.16

to 0.4 in.). Somewhat uneven distribution of voids. Marginally air entrained based on the very low volume of moderate to small sized spherical air voids in the hardened cement paste.

Depth of Carbonation: 4 to 5 mm (0.16 to 0.20 in.) as measured from the outer surface. Negligible when measured from the inner fractured core surface.

Calcium Hydroxide*: Estimated 6 to 12% of small to medium sized crystals evenly distributed throughout the paste, and around aggregate to paste interfaces. Estimation of the volume is difficult due to the presence of calcite fines in the cement paste.

Residual Portland Cement Clinker Particles*: Estimated 4 to 8%. Some large cement particles, particularly belite clusters, of up to 0.15 mm in size suggest a portland cement as produced more than 30 years ago.

Supplementary Cementitious Materials*: None observed by the core supplied.

Secondary Deposits: None observed either in the body of the core and or near the fracture surface.

MICROCRACKING: A small number of medium length (5 to 10 mm), randomly orientated microcracks are evenly distributed throughout the body of the core. At the fractured end of the core there was no observed increase in microcracking relative to the body of the core.

ESTIMATED WATER-CEMENT RATIO: Moderate to moderately high (0.50 to 0.60) but estimation may be biased upwards due to the well advanced degree of hydration / apparent old age of the concrete.

MISCELLANEOUS:

1. Water droplets applied to freshly fractured surfaces were somewhat slowly absorbed by the hardened cement paste.
2. Some small areas of the inner fractured surface of the core, as received, exhibit a thin white haze of efflorescence-like substance suggesting leaching of lime in solution from within the core, or alternatively, moisture on or flowing past the fractured surface at the delamination position within the wall.
3. A moderate volume of fine calcite particles is present within the hardened cement paste, most likely from coarse aggregate crusher fines.

---

*percent by volume of paste

Supplier's Delivery

Serial No. 24561

REPORTED TO: FLORIDA POWER CORP.
PROJECT: CRYSTAL RIVER PLANT UNIT NO. 3
Concrete Supplier: West Coast Concrete, Inc.
Arch-Engineer: Gilbert Assoc., Inc.
General Contractor: J. A. Jones

Date 1-7-73 Time Loaded 2 20 Class 5000 Mass ☐ Other ☐
Truck No. 256 Load No. 38 Cu. Yds. 6 Counter to 0 ☑
Cum. Cu. Yds. 228 °F Moisture: F.A. 2.5 % 159 Lbs; C.A. 1.25 % 137 Lbs.

	Design S.S.D. Wt.	Adj. Batch Wt.	
Cement (Type) II	4172	4506	
C.A. (Size 67)	10800	11040	
(Size)			
F.A.	6360	6420	
Daratard HCF	128	138	
Darex AEA	28	78	
Water, Gals. 165	1216 Total	525	525 ACWW Added
Ice		900 Lbs.	Gals.
Total Moisture		294 Lbs.	Gals.
Total Water		1719	Gals.

Rev. at Mixing Speed: Start 0 Finish 70 Diff. 70 (100 Max.)

Signature of Batch Plant Inspector: Bill Sterling

Portion of Structure Where Placed: 666R13
Time of Arr. 2:29 Total Rev. 192 (300 Max.)
Time Placement Comp. 3:15 Elapsed Time 65 (1½ Hr. Max.)
Ambient Temp. 71 °F Concrete Temp. 56 °F Slump 4¼ (1-4")

Remarks: Cylinder No's Air % AW

Water Added in Field: 10 Gal./Cu. Yd.
Rev. Start: 107 Finish: 137 Difference 30 (30 Min.)
Remarks:

1916

Field Inspectors Signature: [signature]

PITTSBURGH TESTING LABORATORY
PITTSBURGH, PA.

Order No. TA-7732
Supplier's Delivery
Serial No. 24565

REPORTED TO: FLORIDA POWER CORP.
PROJECT: CRYSTAL RIVER PLANT UNIT NO. 3
Concrete Supplier: West Coast Concrete, Inc.
Arch-Engineer: Gilbert Assoc., Inc.
General Contractor: J. A. Jones

Date 1-7-73 Time Loaded 2 06 Class 5000 Mass ☐ Other ☐
Truck No. 183 Load No. 42 Cu. Yds. 6 Counter to 0 ☑
Cum. Cu. Yds. 252 °F Moisture: F.A. 2.5 % 159 Lbs; C.A. .60 % 108 Lbs.

	Design S.S.D. Wt.	Adj. Batch Wt.
Cement (Type) II	4572	4482
C.A. (Size 67)	10800	11010
(Size)		
F.A.	6560	6420
Darataed HCF	128	138
Darex AEA .61	21	39
Water, Gals.	1716	Total 900 549

Added
Ice 600 Lbs. Gals.
Total Moisture 267 Lbs. Gals.
Total Water 1716 Gals.

Rev. at Mixing Speed: Start 0 Finish 20 Diff. 20 (100 Max.)

Signature of Batch Plant Inspector: [signature]

Portion of Structure Where Placed: 666RB
Time of Arr. 3:23 Total Rev. 126 (300 Max.)
Time Placement Comp. 415 Elapsed Time 1hr 9min (1½ Hr. Max.)
Ambient Temp. 70 °F Concrete Temp. 54 °F Slump 4½ (1-4")

Remarks:

Cylinder No's.	Air %
2121ABCDEF	3.4

Water Added in Field: None Gal./Cu. Yd.
Rev. Start: Finish: Difference (30 Min.)
Remarks: Composite Slump - 3¾
320 Concrete Temp - 62

Field Inspectors Signature: [signature]