Sengupta, Abhijit

From: Williams, Charles R. [Charles.Williams@pgnmail.com]
Sent: Thursday, December 31, 2009 2:51 PM
To: Lake, Louis; Thomas, George; Carrion, Robert
Subject: FW: Fm 5.2 Draft for Review
Attachments: FM 5.2.pptx; FM 5.2 Exhibit 3 - CTL Petrographic Report.pdf; FM5.2 Exhibit 1 - Erlin Hime Petro report.pdf

Resending due to file size. I will send Exhibit 2 separately. The first one delivered to Dan.

From: Williams, Charles R.
Sent: Thursday, December 31, 2009 2:41 PM
To: 'louis.lake@nrc.gov'; 'George.Thomas2@nrc.gov'; 'nausdj@ornl.gov'; 'rpc1@nrc.gov'
Subject: Fm 5.2 Draft for Review

Mr Lake and others,

Attached for your review is the draft of FM 5.2 and its exhibits. If you have any comments or questions, please contact me or Craig Miller.

Thank you,
Charles Williams
919-516-7417

P/128

5.2 Salt Water related distress

Description:	
Concrete exposed to salt water can, over time, lose its ability to protect the embedded iron from corrosion. Concrete exposed to wetting/drying by salt water can suffer deterioration related to chemical reactions and cycles of shrinkage/expansion.	
Data to be collected and Analyzed: 1.Determine areas where salt water is utilized. 2.Evaluate concrete samples for effects of salt water exposure. (Petrographic reports in FM 5.2 Exhibit 1, 2 and 3)	
Verified Refuting Evidence: a.Salt water used for cooling is separate from the containment structure. There is no direct exposure of the containment concrete to raw sea water. b.Review of inspection reports over the years did not reveal any reference to rebar corrosion. c.Visual observations during and after demolition in 2009 did not note any significant corrosion of rebar. d.Concrete cores obtained from the structure showed no evidence of salt water exposure. (FM 5.2 Exhibit 1, 2 and 3 – Petrographic reports by CTL, Mactech, and Erlin & Hime)	**Verified Supporting Evidence:** None
Discussion: Petrographic analysis did not note any signs of salt water related distress. CTL (FM 5.2 Exhibit 3) concluded that "no evidence is exhibited of any deleterious chemical reactions involving the cement paste and/or aggregates." The other two Petrographic reports are included as exhibits for completeness and do not include direct reference to distress typical of sea water exposure. **Conclusions:** Salt water did not impact the structure and did not cause distress related to the delamination.	

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

Draft

Copy No. 1

11 pages

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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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.

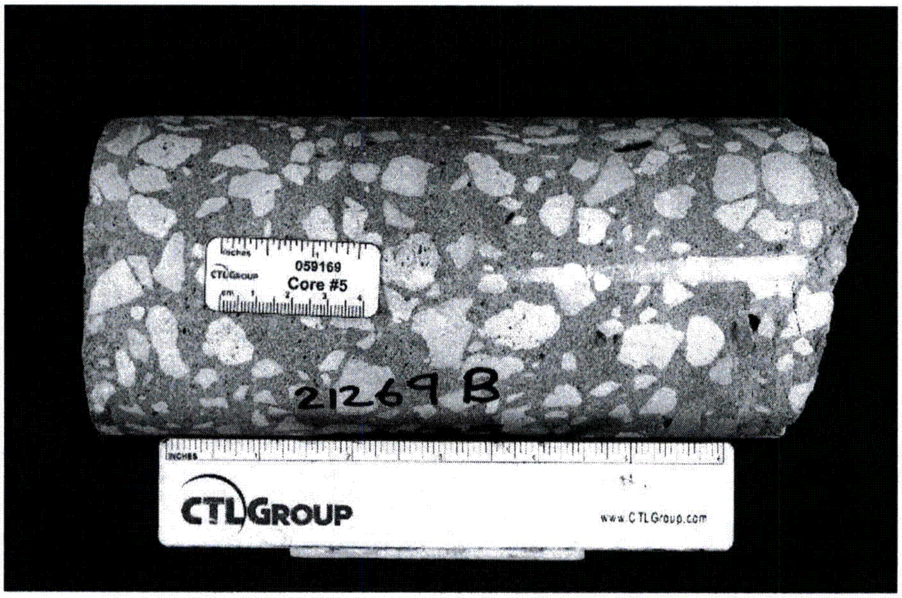
Depth and pattern of paste carbonation was initially determined by application of a pH indicator solution (phenolphthalein) to freshly cut and original fractured concrete surfaces. The solution imparts a deep magenta stain to high pH, non-carbonated paste. Carbonated paste does not change color. The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

Derek Brown

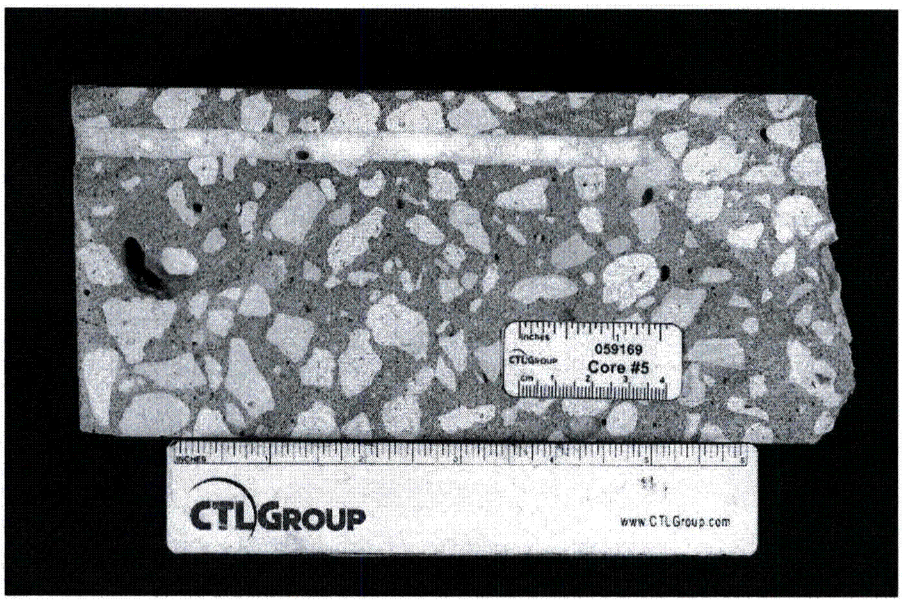
Derek Brown
Senior Microscopist
Microscopy Group

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.

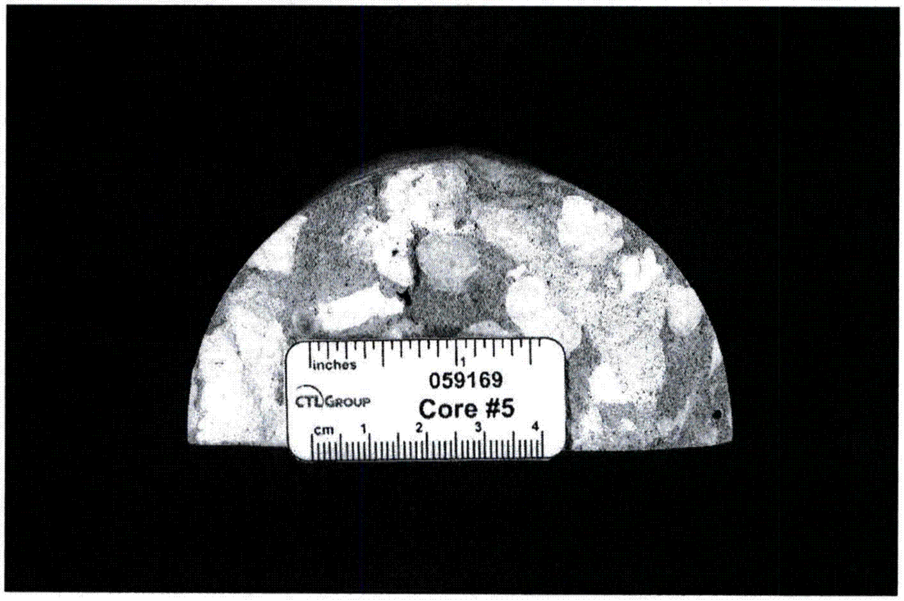


1a. Curved surface. Outer end is to the left.

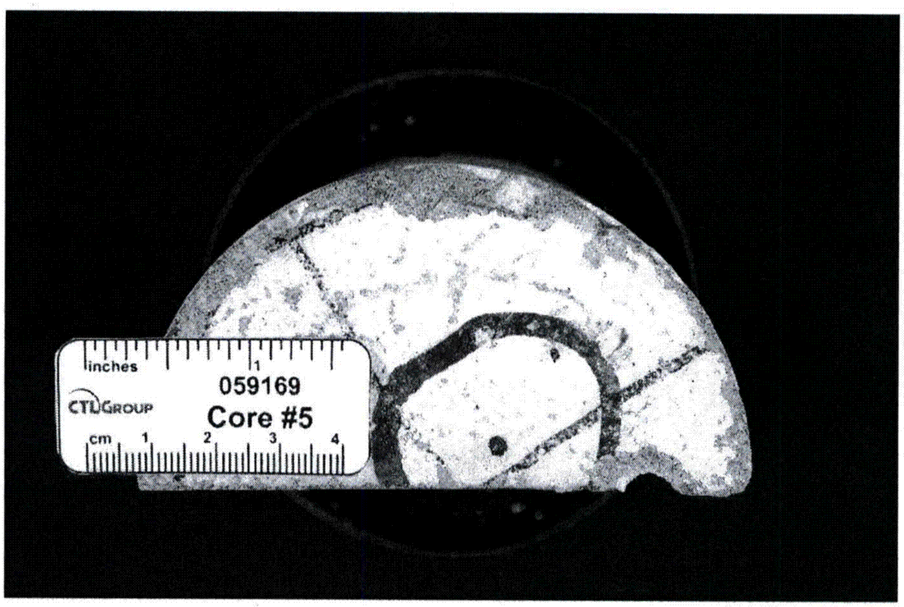


1b. Saw cut surface. Outer end is to the left

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

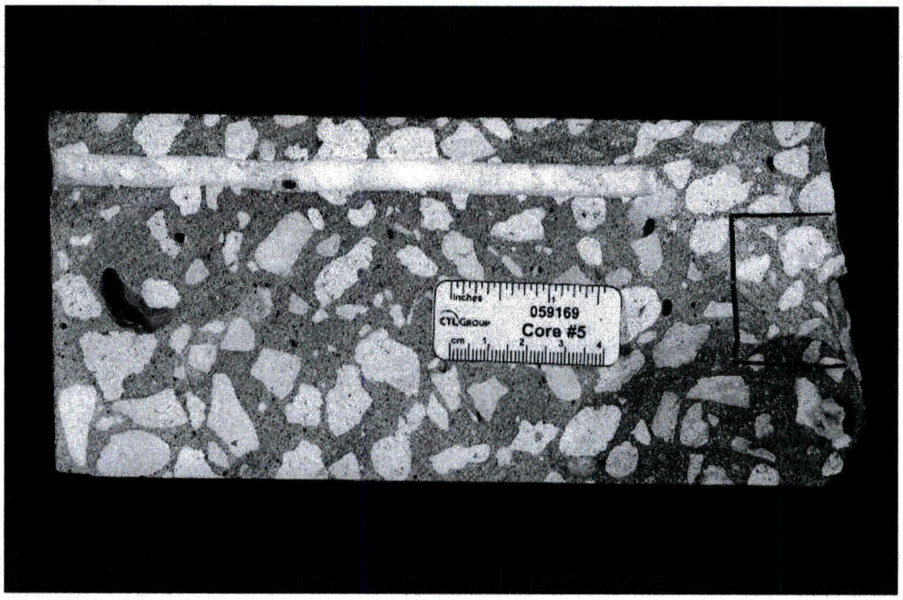


2a. Inner end.

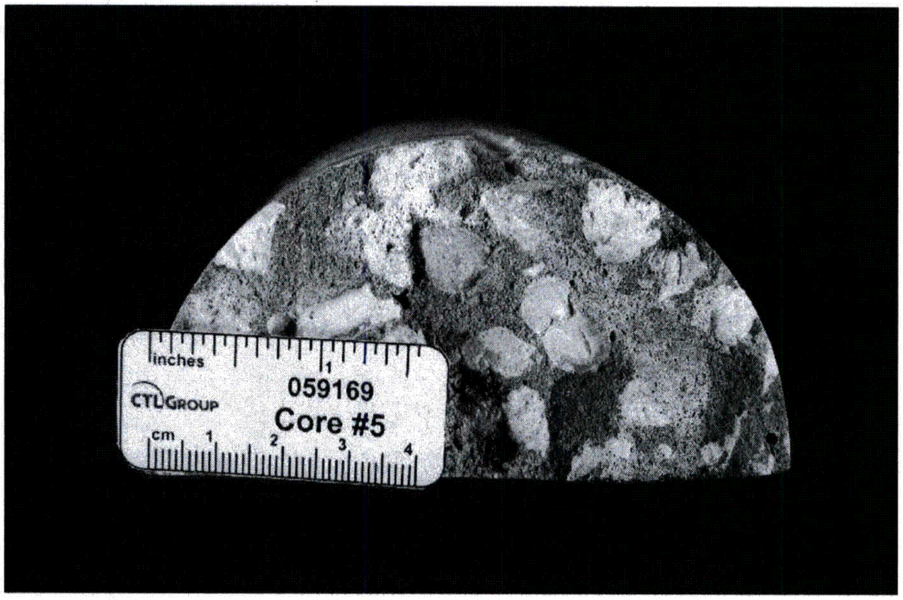


2b. Outer end.

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.

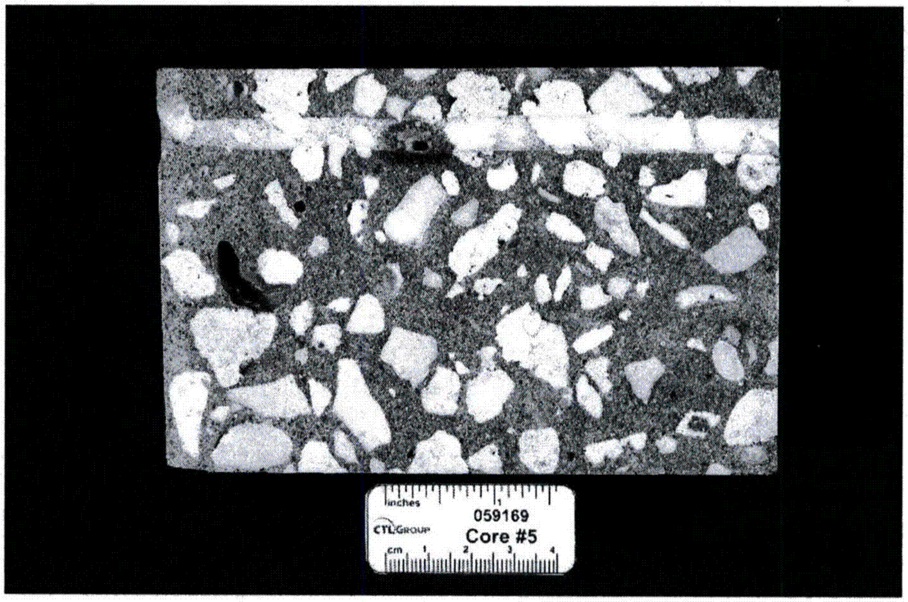


Fig. 4 View of the lapped surface of a portion of Core #5 showing the general appearance of the concrete.

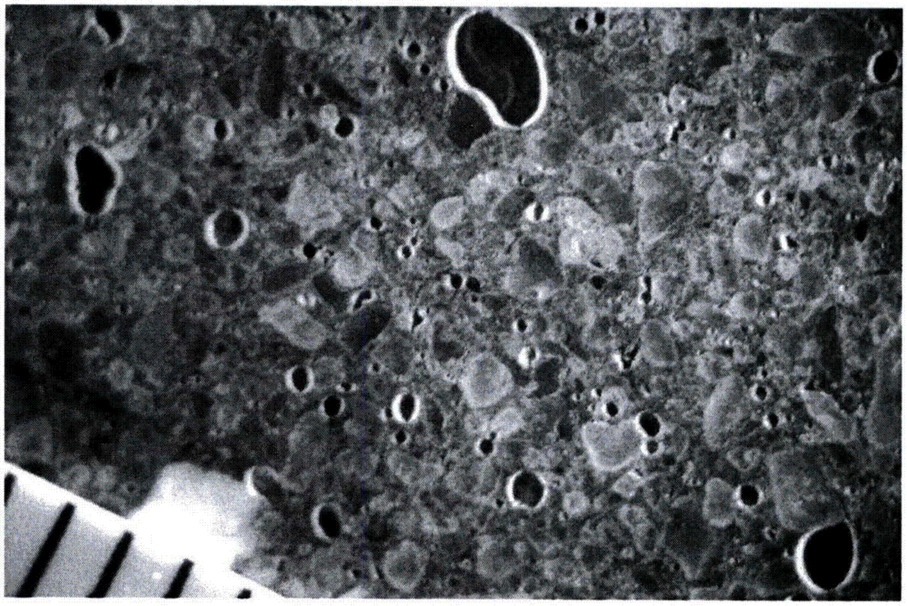
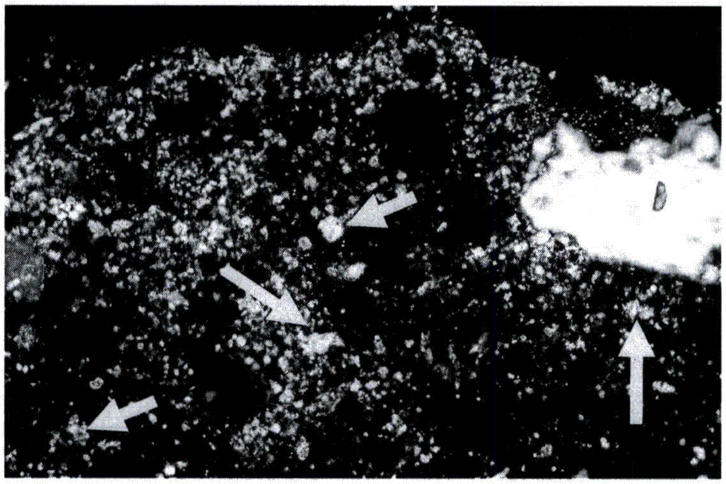
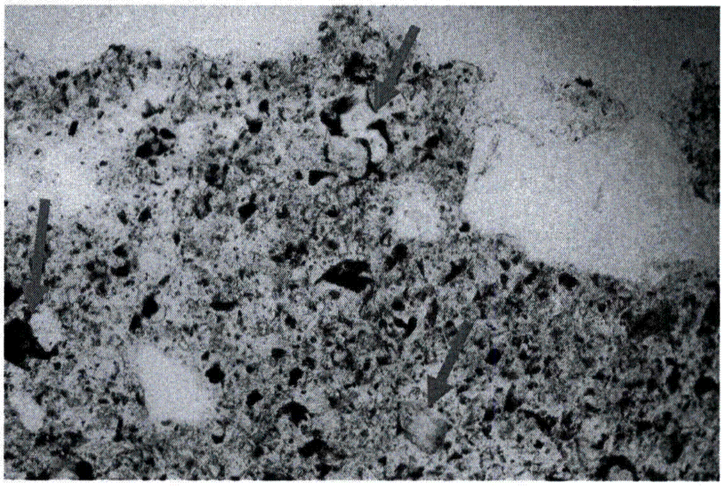


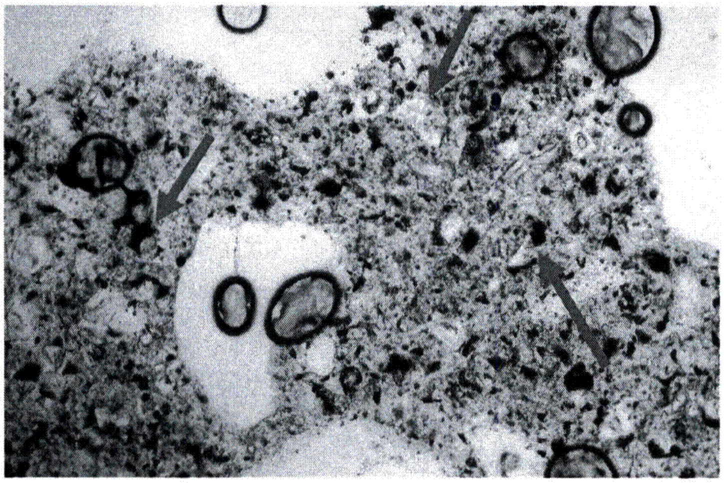
Fig. 5 View of the concrete hardened air-void system of Core #5 illustrating the moderate quantity of both coarse and fine air voids. Scale is millimeter increments.



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.

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*percent by volume of paste

FM 5.2 Exhibit 1

3 pages

ATTACHMENT "C" - 2

ERLIN, HIME ASSOCIATES

MATERIALS AND CONCRETE CONSULTANTS

311 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.

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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·Al_2O_3·3$CaSO_4$·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

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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 wgl

by Bernard Erlin, President
Petrographer