Lake, Louis

From: Lake, Louis
Sent: Tuesday, November 24, 2009 9:25 AM
To: Carrion, Robert
Subject: FW: Refute 3.3 for Review
Attachments: FM 3.3.ppt; PTL Test Cement 04011974.pdf; mill cert 04021974.pdf; all strength table.pdf; 7 and 28 day strength.pdf; all strength graph.pdf; Erlin Hime Petro report 05101976.pdf; Core Bore #5 Final CTL Petrographic Report 059169 C856 (2).pdf

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From: Williams, Charles R. [mailto:Charles.Williams@pgnmail.com]
Sent: Tuesday, November 24, 2009 7:16 AM
To: Lake, Louis; Thomas, George; nausdj@ornl.gov
Subject: Refute 3.3 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/201

3.3 Inadequate Cement Materials

Preliminary

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

Description: Cement that fails to meet specifications can contribute to failure. 1. Slow reacting cement can slow strength gain. 2. Fast reacting cement can cause rapid loss of workability and early set --- constructability 3. High C3A cement can support failure when exposed to Sulaftes 4. Low Alkali cement may be specified when ASR is suspected
Data to be Collected and Analyzed: (1) Mill certificates of cement used. (2) Records of trial-mix from laboratory (3) Original cement test records. (4) Petrographic analysis

Verified Refuting Evidence: All documents reviewed conclude cement meets all requirements. See attached sheet.	Verified Supporting Evidence:

2 Pages

3.3 Inadequate Cement Materials, Cont. (R)

Verified Refuting Evidence:

1. "Tests of Cement" dated 4/1/1974 and 4/22/1974 by PTL concludes that the cement meets all specifications and ASTM standards within acceptable standard deviation. (Exhibit 1)
2. Test found that the cement was slightly finer and faster settling than specified. However, it was concluded that the variation was acceptable. (Exhibit 1)
3. "Mill Certificate" dated 4/2/1974 from "General Portland Inc." meets all applicable ASTM standards. (Exhibit 2)
4. Original test records show satisfactory variation and strength level. (Exhibit 3)
5. Original Petrograpgy report by Bernard Erlin dated 5/10/1976 concluded the there was no evidence that the aggregates had been either chemically or physically unsound. (Exhibit 4)
6. Current CTL Petrography Report dated 11/2/2009 found no irregularities with the cement. (Exhibit 5)

Preliminary

Reviewed by: Dr. Avi Mor, 352-795-6486 , ext 1030 – PII CR3 Team Office

3 Reps

PITTSBURGH TESTING LABORATORY

FORM 124 R.E.D.

ESTABLISHED 1881
PITTSBURGH, PA.

ORDER NO. TA-7732

MAY 02 1974

LABORATORY NO. 743837

Files Cem. & Conc.

TESTS OF CEMENT

RECEIVED
APR 26 1974
CRYSTAL RIVER CONSTRUCTION

DATE April 22, 1974

FOR Florida Power Corporation

PROJECT Crystal River Florida Power Plant Job

BRAND Fla. FROM Silo 19, Tampa, Fla., Sampled by PTL 3/18/74, Received March 22, 1974 10 Samples 340A thru 340J

BIN NO. 19 CONTAINING 20,000 BARRELS SPECIFICATION ASTM C150-72 TYPE II

RESULTS OBTAINED

SAMPLE NO.	VICAT SOUNDNESS AUTOCLAVE EXPANSION%	TIME OF SETTING INITIAL HRS.-MIN.	TIME OF SETTING FINAL HRS.-MIN.	PHYSICAL TESTS Compressive STRENGTH AVE. 3 SPEC.-P.S.I. 3 Day	7 Day	28 Day	AIR CONTENT % BY VOL.	SPECIFIC SURFACE (BLAINE) SQ. CM/GM.
340-A	0.06	1:00	4:00	2290	3230	5320	7.3	4017
340-B	0.06	0:55	3:50	2290	3290	5390	8.1	4046
340-C	0.06	1:00	4:10	2340	3300	5310	7.1	4017
340-D	0.06	0:55	4:00	2380	3270	5310	7.3	4017
340-E	0.06	0:50	3:50	2230	3210	5160 *	6.8	4017
340-F	0.06	0:45	4:10	2290	3260	5180 *	7.3	4002
340-G	0.06	0:50	4:05	2220	3200	5250	7.1	3958
340-H	0.06	0:50	4:05	2180	3210	5320	6.5	4002
340-I	0.06	0:55	4:40	2360	3330	5200	6.8	4002
340-J	0.07	0:55	4:35	2330	3350	5220	6.4	4046
11								
12								
13								
14								
Project SPEC. REQ.	Specs. 0.80% ex.	1 Hr. Min. 45 Mins.	8 Hrs.	1000Min.	1800Min.	3500Min.	5.0Min. 12.0Max.	4000 Max 2800Min.

CHEMICAL ANALYSIS

	Si O2	Al 2O3	Fe2 O3	Mg O	S O3	Loss on Ign.	Insol. Res.	C3 S	$C_3A + C_3S$	C3 A
340-A	22.46	4.53	2.85	1.12	2.52	1.84	0.40	47.6	54.8	7.2
340-B	22.44	4.34	3.00	1.09	2.46	1.81	0.48	49.4	55.8	6.4
340-C	22.52	4.37	2.93	1.09	2.54	1.81	0.41	48.5	55.1	6.6
340-D	22.32	4.43	2.89	1.07	2.60	1.84	0.40	49.5	56.3	6.8
340-E	22.44	4.50	2.82	1.07	2.61	1.83	0.42	48.3	55.4	7.1
340-F	22.52	4.33	2.93	1.06	2.46	1.76	0.42	49.5	56.0	6.5
340-G	22.54	4.40	3.04	1.12	2.54	1.83	0.41	47.2	53.8	6.6
340-H	22.56	4.36	3.04	1.09	2.49	1.76	0.40	47.9	54.4	6.5
340-I	22.32	4.55	2.85	1.08	2.48	1.78	0.43	49.5	56.8	7.3
340-J	22.38	4.35	2.97	1.09	2.52	1.76	0.45	50.2	56.7	6.5
11										
12										
13										
14										
Project SPEC. REQ.	Specifications Minimum 21.0Min.	6.0Max.	Maximum 6.0Max.	5.0Max.	3.0Max.	3.0Max.	0.75Max.	42.0Min.	58.0Max.	8.0Max.

REMARKS (CONTINUED ON PAGE 2)

MATERIAL DOES ☐ DOES NOT ☐ COMPLY WITH SPECIFICATIONS.

PITTSBURGH TESTING LABORATORY

REG/mb 3-Florida Power Corp.
1-Mr. Bennett Brown
1-Mr. C. Hiatt
2-PTL, Tampa

A-1-3

R. E. Gardner, Manager,
Cement & Concrete Department

PITTSBURGH TESTING LABORATORY
ESTABLISHED 1901
850 POPLAR STREET, PITTSBURGH, PA. 15220
PLEASE REPLY TO:
P. O. BOX 1646
PITTSBURGH, PA. 15230

AREA CODE 412 TELEPHONE 922-4000

LABORATORY No. 743837

CLIENT'S No.

ORDER No. TA-7732

REPORT

April 22, 1974

Sample No.	Chlorides %
340-A	0.01
340-B	0.01
340-C	0.01
340-D	0.01
340-E	0.01
340-F	0.01
340-G	0.01
340-H	0.01
340-I	0.01
340-J	0.01

REMARKS: Vicat initial setting time is slightly below 1 Hour Minimum Project Specification, but above minimum ASTM Requirement, and tests are well within standard deviation for this test. Similarly, Blaine Surface is slightly over Project Specification, but within standard deviation limits. We recommend the cement be released for use on the Project based on the above results.

* Two of the samples did not achieve 5200 P.S.I. Project Requirements by a slight amount.

General Portland Inc.

MILL TEST CERTIFICATE

Consignee:

Mr. Edwin Froats, Quality Engineer
FLORIDA POWER CORPORATION
P. O. Box 276
Crystal River, Fla. 32629

Copy: West Coast Concrete, Inc.
1500 South Street
Leesburg, Fla. 32748

Destination:

Date Shipped

SEALS TOP 83646 83647
No. BOTTOM 83853 83854

TONS 1686.925

Type II

Shipped from Silo 2

DATA SHOWN BELOW IS TYPICAL OF CEMENT CURRENTLY BEING SHIPPED

PHYSICAL TESTS

Specific Surface

Wagner ____ SQ. CM./GM.

Blaine 4109 SQ. CM./GM.

Soundness, Expansion 0.07 %

Time of Setting, Gillmore

Initial 2 Hrs. 10 Min.

Final 4 Hrs. 10 Min.

Compressive Strength

1 Day ____ PSI

3 Days 2300 PSI

7 Days 3470 PSI

Air Entrainment 7.1 %

CHEMICAL COMPOSITION

Silicon Dioxide (SiO_2)	2.6
Aluminum Oxide (Al_2O_3)	4.6
Ferric Oxide (Fe_2O_3)	2.7
Magnesium Oxide (MgO)	1.1
Sulfur Trioxide (SO_3)	2.5
Loss on Ignition	1.1
Insoluble Residue	0.31
Alkalis (% Na_2O + 0.658 K_2O)	0.37
Tricalcium Silicate	47
Dicalcium Silicate	29
Tricalcium Aluminate	7.5
Tetracalcium Alumino Ferrite	8

This cement meets or exceeds all applicable A.S.T.M. and/or Federal Specifications.

____ Copies

Date of Report 4/2/74

CHIEF CHEMIST

Mills at Tampa and Miami, Florida A-1-5 P. O. Box 1002, Tampa, Florida 33601

General Portland Inc.

MILL TEST CERTIFICATE

Consignee:

Mr. Edwin Froats, Quality Engineer
FLORIDA POWER CORPORATION
P. O. Box 276
Crystal River, Fla. 32629

Copy: West Coast Concrete, Inc.
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Aluminum Oxide (Al_2O_3)	4.6
Ferric Oxide (Fe_2O_3)	2.7
Magnesium Oxide (MgO)	1.1
Sulfur Trioxide (SO_3)	2.5
Loss on Ignition	1.1
Insoluble Residue	0.31
Alkalis (% Na_2O + 0.658 K_2O)	0.37
Tricalcium Silicate	47
Dicalcium Silicate	29
Tricalcium Aluminate	7.5
Tetracalcium Alumino Ferrite	8

This cement meets or exceeds all applicable A.S.T.M. and/or Federal Specifications.

____ Copies

Date of Report 4/2/74

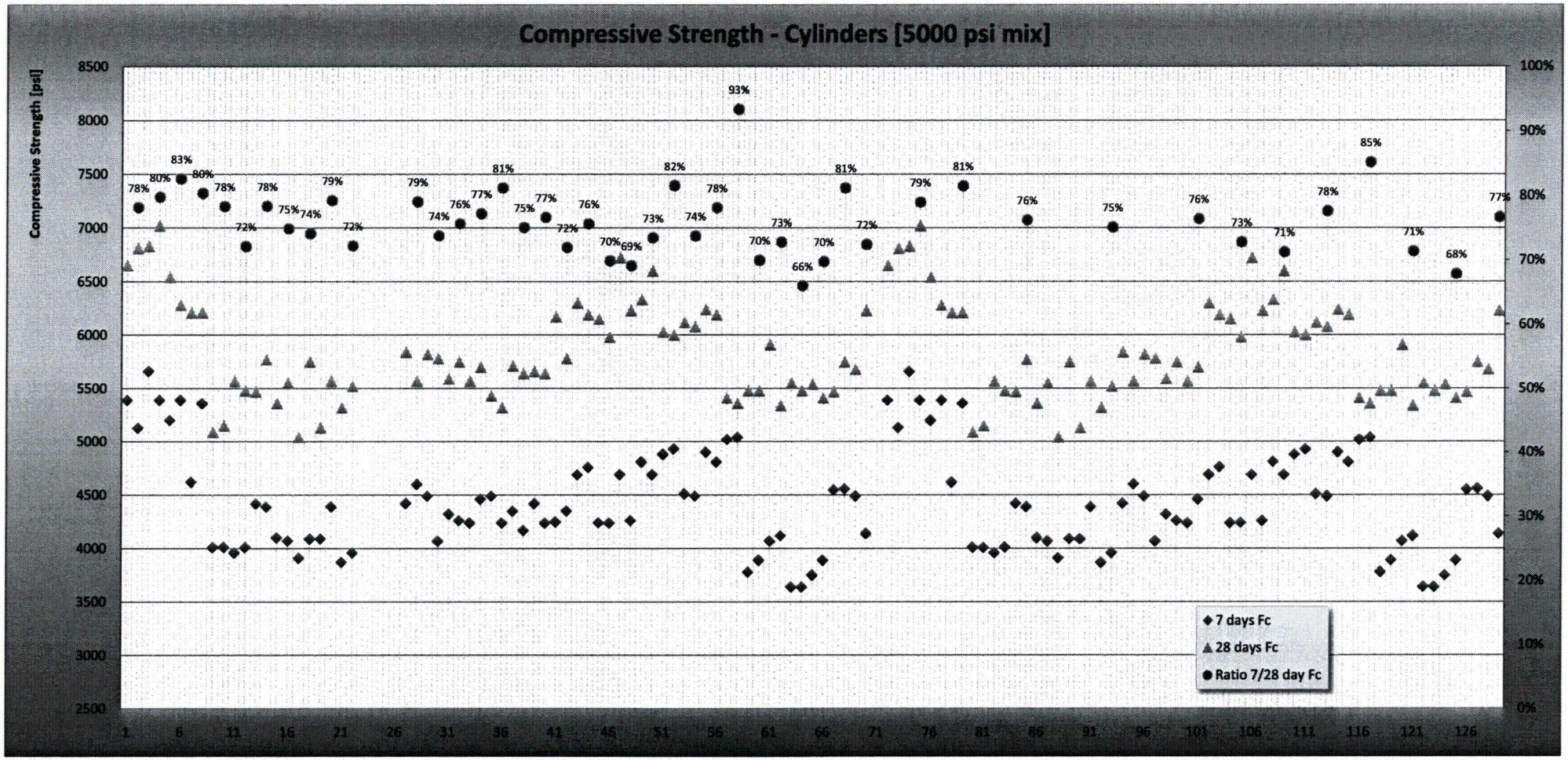
CHIEF CHEMIST

Concrete Strength Over Time

	Pour Number		7 days		28 days		90 days		Current		Ratios 7/28 days	Ratios 90/28 days
1		1926	5390		6650		7070					
2		DM-5	5130	5260	6810	6730	6950	7010			78%	104%
3		1927	5660		6830		7160					
4		DM-5	5390	5525	7020	6925	7380	7270			80%	105%
5		1932	5200		6540		6920					
6		DM-5	5390	5295	6280	6410	7200	7060			83%	110%
7		1934	4620		6210		7040					
8		DM-5	5360	4990	6210	6210	6830	6935			80%	112%
9		2064	4010		5090		5870					
10		727550-2	4010	4010	5150	5120	6080	5975			78%	117%
11		2065	3960		5570		6070					
12		727550-2	4010	3985	5480	5525	5660	5865			72%	106%
13		2066	4420		5470		5590					
14		727550-2	4390	4405	5770	5620	6150	5870			78%	104%
15		2071	4100		5360		6130					
16		727550-2	4070	4085	5550	5455	6210	6170			75%	113%
17		2072	3910		5040		6460					
18		727550-2	4090	4000	5750	5395	6540	6500			74%	120%
19		2073	4090		5130		5910					
20		727550-2	4390	4240	5570	5350	6280	6095			79%	114%
21		2074	3870		5320		5850					
22		727550-2	3960	3915	5520	5420	6010	5930			72%	109%
23		2075										
24		727550-2										
25		2076										
26		727550-2										
27		2117	4420		5840		6070					
28		727550-2	4600	4510	5570	5705	6050	6060			79%	106%
29		2118	4490		5820		6240					
30		727550-2	4070	4280	5780	5800	6050	6145			74%	106%
31		2119	4320		5590		6170					
32		727550-2	4260	4290	5750	5670	6050	6110			76%	108%
33		2120	4240		5570		6130					
34		727550-2	4460	4350	5700	5635	6230	6180			77%	110%
35		2121	4490		5430		6880					
36		727550-2	4240	4365	5320	5375	6400	6640			81%	124%
37		2122	4350		5710		6010					
38		727550-2	4170	4260	5640	5675	5870	5940			75%	105%
39		2123	4420		5660		6050					
40		727550-2	4240	4330	5640	5650	6010	6030			77%	107%
41		2124	4250		6170		6230					
42		727550-2	4350	4300	5780	5975	6000	6115			72%	102%
43		2157	4690		6300		6280					
44		DM-5	4760	4725	6190	6245	6760	6520			76%	104%
45		2158	4240		6150		6230					
46		DM-5	4240	4240	5980	6065	6600	6415			70%	106%
47		2166	4690		6720							
48		DM-5	4260	4475	6230	6475	6560	6560			69%	101%
49		2167	4810		6330		6760					
50		DM-5	4690	4750	6600	6465	6630	6695			73%	104%
51		2171	4880		6030		6600					
52		DM-5	4930	4905	6000	6015	6560	6580			82%	109%
53		2172	4510		6120		6670					
54		DM-5	4490	4500	6080	6100	6690	6680			74%	110%
55		2181	4900		6240		6650					
56			4810	4855	6190	6215	6650	6650			78%	107%

	Number		7 days		28 days		90 days		Current		7/28 days	90/28 days
57		2182	5020		5410		7290					
58			5040	5030	5360	5385	7470	7380			93%	137%
59		2196	3780		5480		7320					
60			3890	3835	5480	5480	7340	7330			70%	134%
61		2197	4070		5910		7260					
62			4120	4095	5340	5625	7090	7175			73%	128%
63		2219	3640		5550		6070					
64			3640	3640	5480	5515	6260	6165			66%	112%
65		2220	3750		5540							
66			3890	3820	5410	5475	5940	5940			70%	108%
67		2225	4550		5470		6540					
68		727550-2	4560	4555	5750	5610	6460	6500			81%	116%
69		2226	4490		5680		7220					
70		727550-2	4140	4315	6230	5955	7010	7115			72%	119%
71												
72	522	1926	5390		6650		7070					
73	522	1926	5130		6810		6950					
74	522	1927	5660		6830		7160					
75	522	1927	5390	5393	7020	6828	7380	7140			79%	105%
76	528	1932	5200		6540		6920					
77	528	1932	5390		6280		7200					
78	528	1934	4620		6210		7040					
79	528	1934	5360	5143	6210	6310	6830	6998			81%	111%
80	634	2064	4010		5090		5870					
81	634	2064	4010		5150		6080					
82	634	2065	3960		5570		6070					
83	634	2065	4010		5480		5660					
84	634	2066	4420		5470		5590					
85	634	2066	4390	4133	5770	5422	6150	5903			76%	109%
86	641	2071	4100		5360		6130					
87	641	2071	4070		5550		6210					
88	641	2072	3910		5040		6460					
89	641	2072	4090		5750		6540					
90	641	2073	4090		5130		5910					
91	641	2073	4390		5570		6280					
92	641	2074	3870		5320		5850					
93	641	2074	3960	4060	5520	5405	6010	6174			75%	114%
94	666	2117	4420		5840		6070					
95	666	2117	4600		5570		6050					
96	666	2118	4490		5820		6240					
97	666	2118	4070		5780		6050					
98	666	2119	4320		5590		6170					
99	666	2119	4260		5750		6050					
100	666	2120	4240		5570		6130					
101	666	2120	4460	4358	5700	5703	6230	6124			76%	107%
102	685	2157	4690		6300		6280					
103	685	2157	4760		6190		6760					
104	685	2158	4240		6150		6230					
105	685	2158	4240	4483	5980	6155	6600	6468			73%	105%
106	695	2166	4690		6720							
107	695	2166	4260		6230		6560					
108	695	2167	4810		6330		6760					
109	695	2167	4690	4613	6600	6470	6630	6650			71%	103%
110	700	2171	4880		6030		6600					
111	700	2171	4930		6000		6560					
112	700	2172	4510		6120		6670					
113	700	2172	4490	4703	6080	6058	6690	6630			78%	109%

	Number		7 days		28 days		90 days		Current		7/28 days	90/28 days
114	712	2181	4900		6240		6650					
115	712	2181	4810		6190		6650					
116	712	2182	5020		5410		7290					
117	712	2182	5040	4943	5360	5800	7470	7015			85%	121%
118	722	2196	3780		5480		7320					
119	722	2196	3890		5480		7340					
120	722	2197	4070		5910		7260					
121	722	2197	4120	3965	5340	5553	7090	7253			71%	131%
122	737	2219	3640		5550		6070					
123	737	2219	3640		5480		6260					
124	737	2220	3750		5540		5410					
125	737	2220	3890	3730	5410	5495	5940	5920			68%	108%
126	743	2225	4550		5470		6540					
127	743	2225	4560		5750		6460					
128	743	2226	4490		5680		7220					
129	743	2226	4140	4435	6230	5783	7010	6808			77%	118%
130												
131									7900			
132									7380	7393		
133									6900			
134									7530			
135									7650			
136									5990			
137									6800			
138									6830			
139									6370			
140									8220			
141									8030			
142									7520			
143									6600			
144									6610			
145									6100			
146												
147												
148												
149												
150												
151												
152												
153												
154												
155												
156												
157												
158												
159												
160			7 days		28 days		90 days		Current		Ratios	
161		average:	4436	4446	5837	5850	6491	6504	7095	7393	76%	111%
162		Std:	473	459	464	440	494	470	705	#DIV/0!	5%	8%
163		Max:	5660	5525	7020	6925	7470	7380	8220	7393	93%	137%
164		Min:	3640	3640	5040	5120	5410	5865	5990	7393	66%	101%


Compressive Strength - Cylinders [5000 psi mix]
Compressive Strength [psi]
8500
8000
7500
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
6
11
16
21
26
31
36
41
46
51
56
61
66
71
76
81
86
91
96
101
106
111
116
121
126
7 days Fc
28 days Fc
Ratio 7/28 day Fc

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

5400 Old Orchard Road
Skokie, Illinois 60077-1030
(847) 965-7500

9030 Red Branch Road, Suite 110
Columbia, Maryland 21045

www.CTLGroup.com

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.

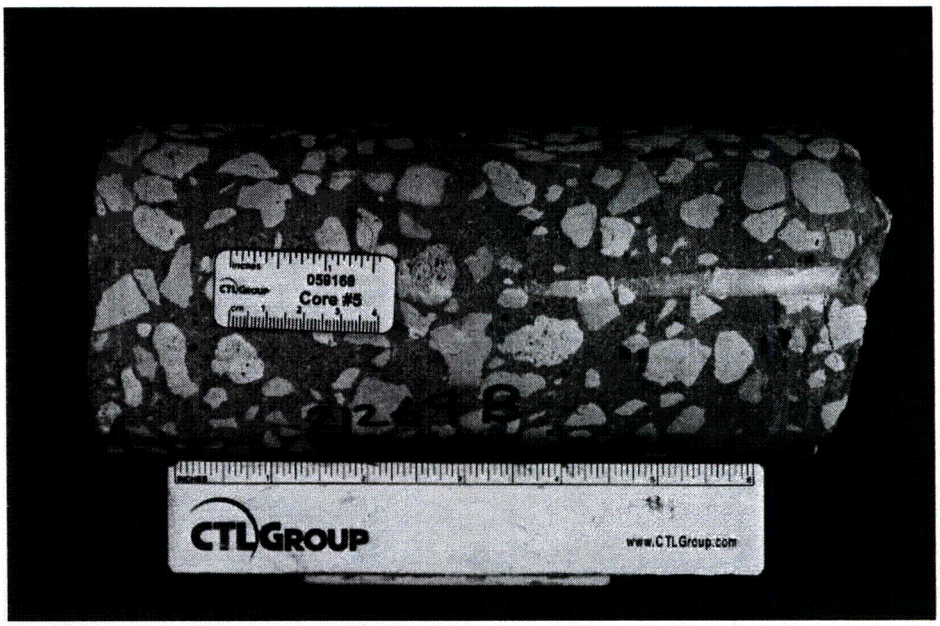
Estimated water-cement ratio (w/c), when reported, is based on observed concrete and paste properties including, but not limited to: 1) relative amounts of residual (unhydrated and partially hydrated) portland cement clinker particles, 2) amount and size of calcium hydroxide crystals, 3) paste hardness, 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
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.

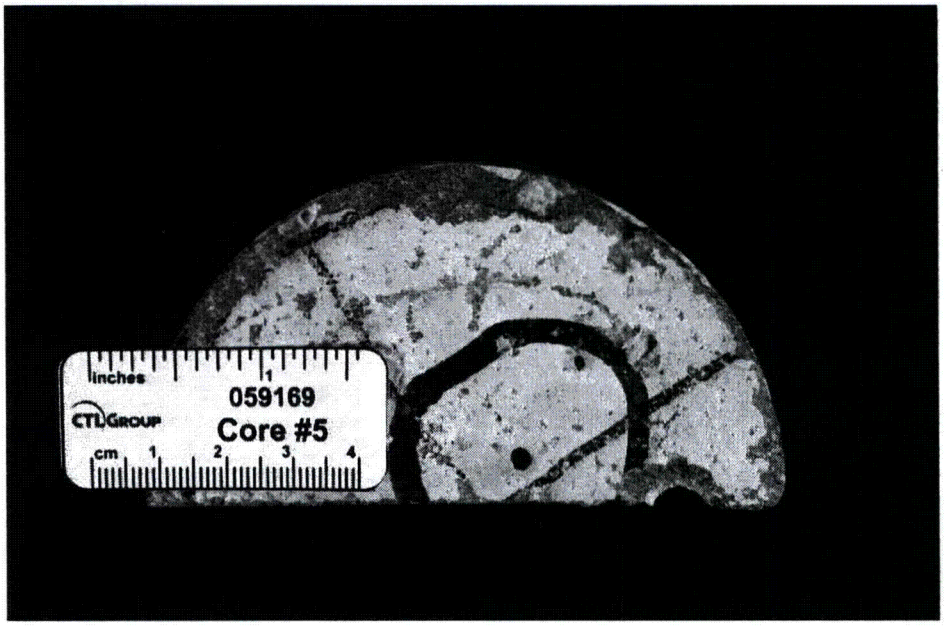


1a. Curved surface. Outer end is to the left.

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

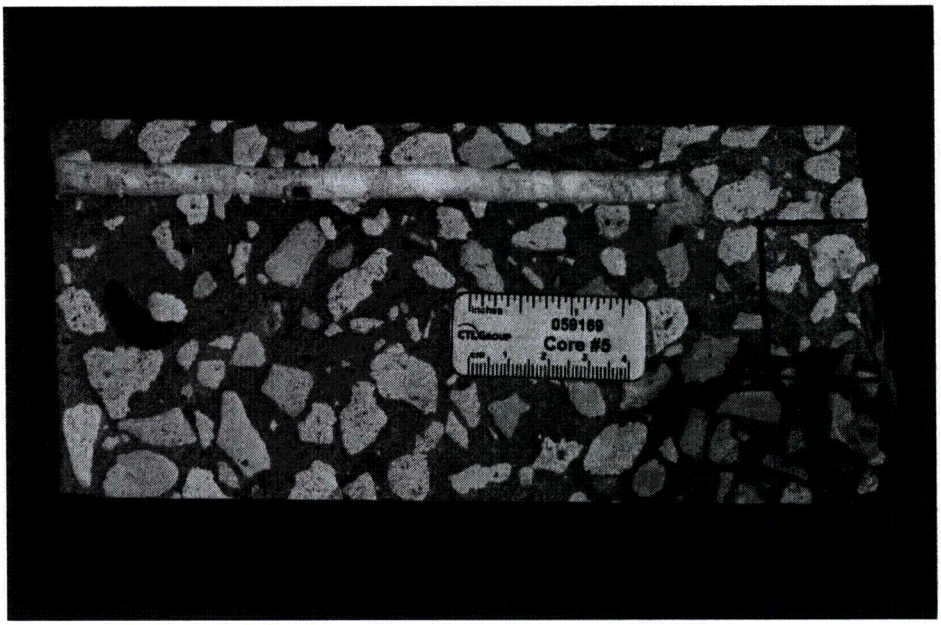
Fig. 1 Side views of Core #5, as received for examination.

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.

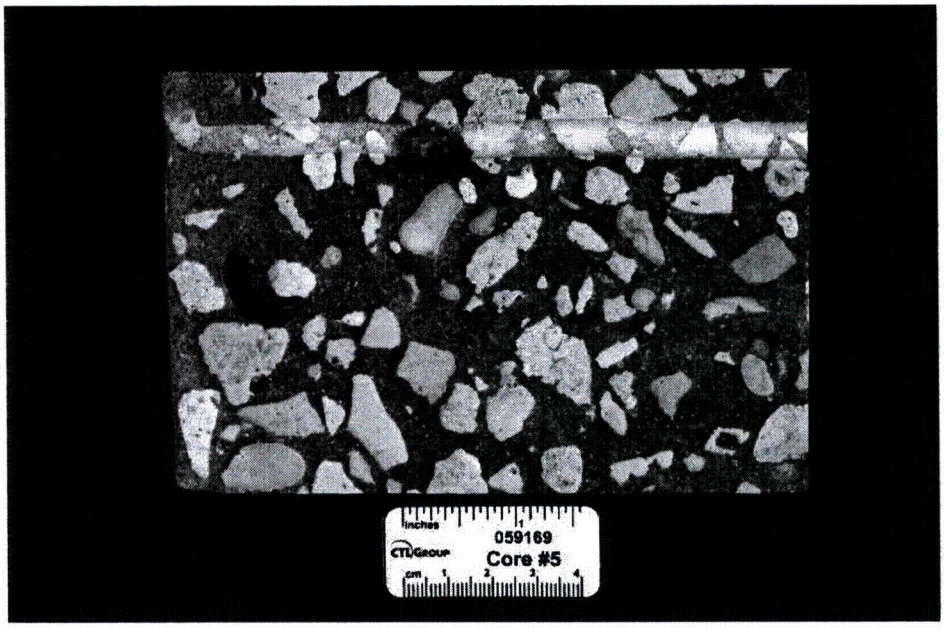


Fig. 4 View of the lapped surface of a portion of Core #5 showing the general appearance of the concrete.

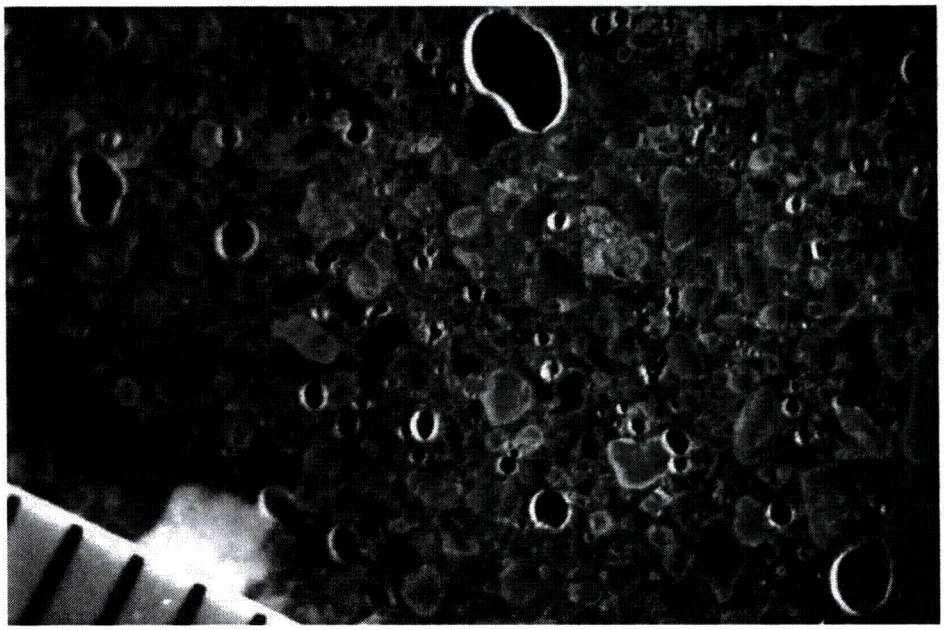
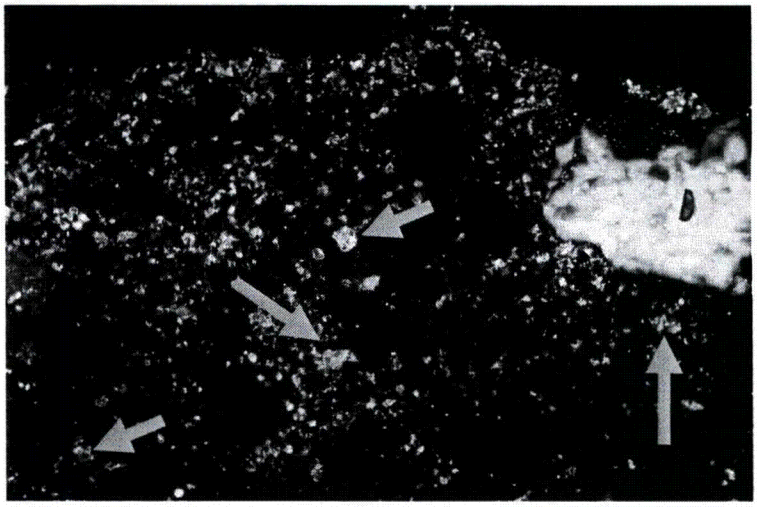
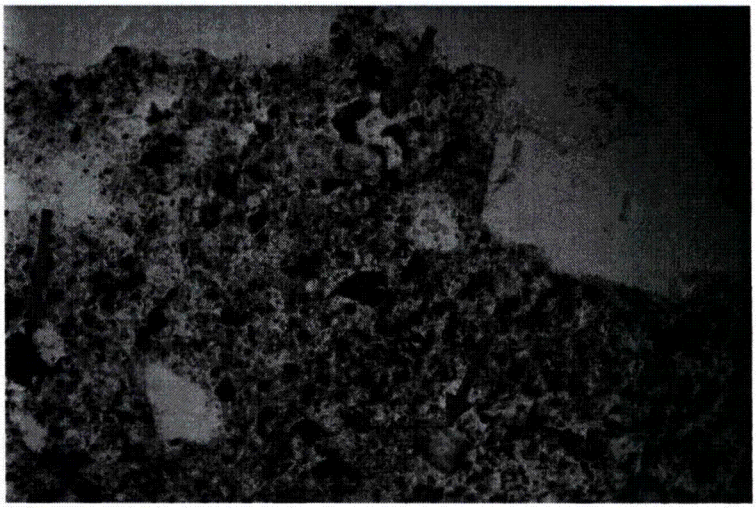


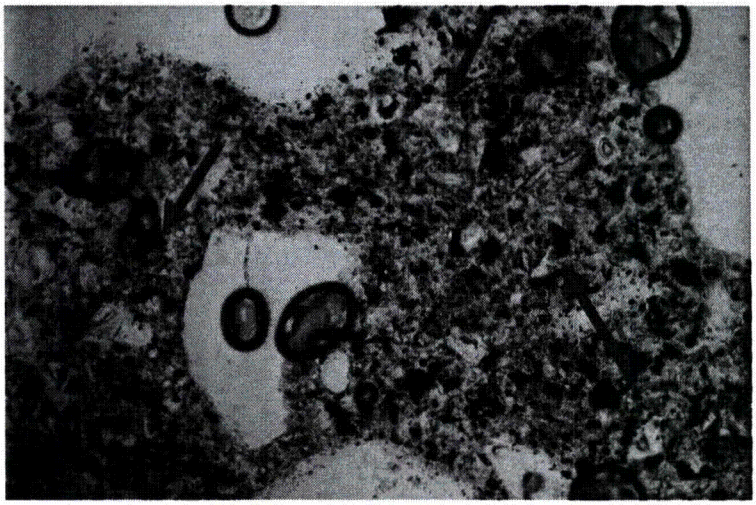
Fig. 5 View of the concrete hardened air-void system of Core #5 illustrating the moderate quantity of both coarse and fine air voids. Scale is millimeter increments.



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
LOCATION: Crystal River

DATE RECEIVED: October 27, 2009
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