Sengupta, Abhijit

From: Williams, Charles R. [Charles.Williams@pgnmail.com]
Sent: Tuesday, January 05, 2010 7:50 AM
To: Lake, Louis; Thomas, George; 'nausdj@ornl.gov'; Carrion, Robert; Worthington, Wayne; 'Archer, John C. (Reading)'
Cc: Miller, Craig L; Edwards, Steven
Subject: FW: FM 3.7 - Inadequate Testing
Attachments: FM 3.7.pptx; FM 3.7 Exhbit 1 - field testing from specs - SP5618.pdf; FM 3.7 Exhibit 2 QC sp5569 Furnishing of Structural Concrete.pdf; FM 3.7 Exhibit 3 QC Procedures_PTL-10.pdf; FM 3.7 Exhibit 4 QC in Pour712RBElev210.pdf; FM 3.7 Exhibit 5 Pour 511RB-NCR95 Concrete temperature.pdf; FM 3.7 Exhibit 6 Fc in Pour712RBElev210.pdf; FM 3.7 Exhibit 7 tickets for Pour712RBElev210.pdf; FM 3.7 Exhibit 8 S00-0047 Concrete Strength.pdf; FM 3.7 Exhibit 9 Cylinder Tests exterior wall 28 days.pdf; FM 3.7 Exhibit 10 - Slump allowed - Final Dome Report.pdf

Mr Lake and other,

Attached for your review is FM 3.7 Draft and Exhibits. If you have any questions, please contact me or Craig Miller.

Thank You,
Charles Williams
919-516-7417

From: Patrick Berbon [mailto:patrickberbon@yahoo.com]
Sent: Monday, January 04, 2010 6:08 PM
To: Williams, Charles R.; Miller, Craig L
Subject: FM 3.7 - Inadequate Break Test

For Progress Energy review. Patrick

P/ 117

3.7 Inadequate Testing

Description:

Construction projects require a quality assurance (QA) program that, among other things, involves the selection of test methods, establishing test criteria, testing the fresh concrete, testing the hardened concrete, statistical analysis of test results, and follow-up procedures.
Fresh concrete is tested for its workability (Slump test), temperature, and air content.
Hardened concrete is tested for its strength under compressive loading. The purposes of strength tests of concrete are to determine compliance with a strength specification and to measure the variability of concrete (ACI 214 provides a discussion of methods and analysis for strength tests of concrete).
It is necessary to establish the quality of the test program in order to be able to evaluate its results and conclusions.

Data to be collected and Analyzed:

1.Review project QA program
2.Review test procedures and results
3.Review analysis and reporting procedures
4.Analyze follow-up procedures (NCRs,...)
5.Analyze test program for compliance with industry standards.

Verified Refuting Evidence (see following discussion):

a.The established QA program was comprehensive and covered all critical testing areas.
b.Pour records show compliance with the parameters of the QA program.
c.Although some strength test results appear to be erroneous, the overall program meets industry standards for Good Control.
When errors are found in individual strength tests it is possible to make proper evaluation of the concrete strength by analyzing earlier or later tests from the same cylinder set. It is therefore believed that no under-strength concrete was placed as a result of inadequate testing.

Verified Supporting Evidence:

None

3 pages

Conclusions:

Testing program was adequate and did not contribute to the delamination.

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

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3.7 Inadequate Testing, (cont.)

Discussion:

a)Fresh concrete is subjected to a set of "acceptance" tests that determine whether it should be used or discarded. The test criteria and procedures were established in PTL's documents shown in FM 3.7 Exhibit 3 and specifications FM 3.7 Exhibit 2.

i. The Slump test is a practical test for workability that is also useful in determining if the concrete was modified or if it was mixed for extended period of time. Project specifications called for Slump of 4.5" at the pump and 4" at the discharge (FM 3.7 Exhibit 7). Analysis of pour records indicate that a strict inspection/testing process was followed and that multiple trucks were rejected when the allowed slump was exceeded. (Selected examples of reported tests and rejection handling in FM 3.7 Exhibit 4). A more complete discussion can be found in FM 2.3.

ii. Air content was measured using the pressure meter on selective trucks. The specifications called for air in the range of 3-6%. All tests fell in that range and no concrete was rejected because of air. (Selected examples of reported tests in FM 3.7 Exhibit 4)

iii. Ambient and concrete temperatures were recorded on selected loads. Trucks were rejected (or accepted after Engineer's approval) when concrete temperature exceeded 70 degrees. (specifications at FM 3.7 Exhibit 2; examples of reported tests in FM 3.7 Exhibit 4 and rejection handling in FM 3.7 Exhibit 5). A more complete discussion can be found in FM 2.5.

b)Hardened concrete was tested for compliance with design strength over time by crushing site-made cylinders after 7, 28, and 90 days.

i. Records of Statistical analysis of compressive tests as recommended by ACI 214 were not found from original construction time.

ii. Spot checks of random test results revealed problems with laboratory strength tests. An example in FM 3.7 Exhibit 6 reports test results from two adjacent samples taken on 2/16/73 from pour 712RB. Cylinder 2181 shows normal strength gain between 7 and 28 days (28%) and very small gain between 28 and 90 days (7%). Cylinder 2182 shows small strength gain between 7 and 28 days (7%) and very large gain between 28 and 90 days (37%). At 28 days cylinder 2181 was 28% stronger than cylinder 2182, whereas at 90 days the trend reversed and 2181 was 10% weaker than 2182. The most likely explanation is testing error at 28 days.
According to the pour tickets these two loads were practically identical and in full compliance with the mix design (FM 3.7 Exhibit 7).
There is no record of concern or corrective measures arising from these tests.

iii. A design analysis was performed on concrete placed in Class I structures in the year 2000 (for unrelated purpose). Part of the report is included in FM 3.7 Exhibit 8. Its significant conclusions, after analyzing strength test data from all concrete cylinders, was that the distribution followed the expected bell shape and the various mixes used on the project were statistically similar in strength properties.

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3.7 Inadequate Testing, (cont.)

Discussion (cont.):

iv. Current analysis of all cylinders from 5000 psi concrete placed in the Reactor Building (RB) is included in FM 3.7 Exhibit 9. Besides providing a complete picture of the 28 days strength tests, it established that the test program met ACI 214's requirements for "Good" Standard of Concrete Control (ACI 214, Table 3.2 assigns Good control when Standard Deviation (StD) is in the range of 500-600 psi; Excellent control requires StD smaller than 400 psi). 200 tests for mix 727550-2 had a StD of 541 and 239 tests for mix DM-5 had a StD of 508.
The lower "Standard of Control" may be explained by the multiple mix-designs used, and by testing problems as demonstrated above. Although lower, it is considered acceptable for general construction testing.

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1 page

2. Special finish for the above surfaces shall be performed as follows:

   a. As soon as the WORK specified in Item 2:04.5 has been performed and the pointing mortar sufficiently set, the surfaces shall be wetted with a brush and rubbed with a No. 16 carborundum stone or an abrasive of equal quality, bringing the surface to a paste. The rubbing shall be continued enough to remove all form marks and projections producing a smooth dense surface without pits or irregularities. The material which, in the above process has been ground to a paste, shall be carefully spread, or brushed uniformly over the entire area and allowed to "reset." No additional mortar shall be added during this operation.

   b. The final finish shall be obtained by a thorough rubbing with a No. 30 carborundum stone or an abrasive of equal quality. This rubbing shall continue until the entire area of the surfaces is of a smooth texture and uniform in color.

   c. During the rubbing and after final rubbing is complete, curing shall proceed as herein specified.

2:05 Field Testing at Construction Site

2:05.1 During concrete placement operations, the testing laboratory will have an inspector(s) at the construction site who will inspect the concrete pour for formwork, reinforcing, cleanliness, and concrete placement. The inspector shall inspect and test the first load of concrete delivered to the site for batch ticket information, slump, air content, and temperature. Batch ticket information shall be checked on each load delivered. Slump tests will be taken at random with a minimum of one test for each 10 cubic yards of concrete placed. Air content tests and temperatures shall be taken on every 50 cubic yards placed or at the direction of the Inspector.

2:05.2 Except as noted, hereinafter, test cylinders will be molded, cured, stored, capped, and tested in accordance with ACI 301-66. A set of 4 cylinders shall be cast for each 50 cubic yards or fraction thereof placed in any one day. Two cylinders shall be tested at 7 days and two at 28 days. For the reactor building shell, a set of 6 cylinders shall be cast. Two cylinders will be tested at 7 days, 28 days, and 90 days.

2:05.3 In the event that concrete is placed during freezing weather or that a freeze is expected during the curing period, an additional cylinder will be cast for each set and shall be cured under the same conditions as the part of the structure which it represents. This cylinder shall be tested at 28 days.

FLORIDA POWER CORPORATION
POWER ENGINEERING & CONSTRUCTION DEPT.
CRYSTAL RIVER - UNIT 3
APPROVED BY:
Engineer ORIGINAL SIGNED BY Date 7-2-71
Mgr. - Power Engr. W. A. SZELISTOWSKI Date 7-2-71
Nuclear Proj. Mgr. ORIGINAL SIGNED BY J. T. RODGERS Date 7-2-71

1968

SPECIFICATION

FOR

FURNISHING AND DELIVERING OF

STRUCTURAL CONCRETE

SP-5569 OCTOBER 17, 1968

CRYSTAL RIVER - UNIT NO. 3
FLORIDA POWER CORPORATION

FPC - 321-A3.2

6-23-71
APPROVED - DEPT. PROJECT ENGR. DATE

E N Halleston 6-23-71
ISSUED FOR CRYSTAL RIVER UNIT 3 DATE

QUALITY PROGRAM
REVIEW and DOCUMENTATION
REQUIRED

REVISION	REVIEW & DOCUMENTATION REQUIRED		DESIGN ENGINEER
	YES	NO	
A			
B			
C			
D		✓	

Gilbert Associates, Inc.
525 Lancaster Avenue
Reading, Pennsylvania

S.N.D. - W.A.D.
W.O. 4203-00
Addendum A
October 17, 1968
Addendum B
January 22, 1969
Addendum C
March 13, 1969
Addendum D
June 23, 1971

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SP-5569
10-17-68

ADDENDUM D

Sheet 1 of 1
June 23, 1971

SECTION III - DETAILED SPECIFICATIONS

3:09 Admixtures

3:09.1 Air Entraining Admixture:

Subitem 1.:

Delete this subitem as written in Addendum B (dated January 22, 1969) in its entirety and replace with the following:

"1. All structural concrete shall be considered subject to potentially destructive exposure and shall contain entrained air in amounts conforming with the following:

Nominal Maximum Size of Coarse Aggregate	Total Air Content % by Volume
3/4 in	3 - 6
1-1/2 in	3 - 6 "

3:11 Mixing Concrete

3:11.2 Transit Mixing:

Third sentence - Lines 5, 6, and 7:

Delete this sentence in its entirety and replace with the following:

"The maximum number of revolutions at mixing speed shall be 110; any additional mixing shall be at agitating speed, as required by ASTM C 94-67."

proportions comply with those for the design mixes with water content modified as required by measurements to be made of content of surface moisture on the aggregates. This inspector will test periodically all mix ingredients and shall insure that a ticket is provided for each batch as specified in Item 3:11.6 of this Specification.

3:11.2 Transit Mixing:

Ready-mixed concrete shall be mixed and transported in accordance with "Ready-Mixed Concrete, Spec. for," ASTM C 94-67. The minimum amount of mixing in truck mixers loaded to maximum capacity shall be 70 revolutions of the drum or blades after all of the ingredients, including water, are in the mixer. The maximum number of revolutions at mixing speed shall be 100; any additional mixing shall be at agitating speed, as required by ASTM C 94-67. All trucks shall be equipped with a revolution counter.

3:11.3 Delivery:

The concrete shall be delivered to the site and discharge shall be completed within 1-1/2 hours or before the drum has been revolved 300 revolutions, whichever comes first, after the introduction of the mixing water to the cement and aggregates, or the introduction of the cement to the aggregates. In hot weather, the 1-1/2 hour time limit shall be reduced, as directed by the TESTING LABORATORY and/or OWNER. Concrete which does not meet this requirement may be rejected at no cost to the OWNER. However, the SUPPLIER will not be responsible for delays at the site which are beyond his control.

3:11.4 Hot Weather Concrete:

1. Except as modified herein, hot weather concrete shall comply with ACI 605. At air temperatures of 90 F or above, special procedures shall be adopted to keep the concrete as cool as possible. The temperature of the concrete when it is unloaded from the trucks shall not exceed 90 F.

2. Concrete for the containment structural walls, dome, and mat shall have a placing temperature of not more than 70 F.

3:11.5 Mixing Water:

The proportion of water in each strength mix shall be adjusted daily as required by the content of surface moisture on the aggregates. Except for this adjustment, no changes in quantity of mixing water shall be made without the approval of the OWNER.

3:11.6 Batch Record:

Each batch of concrete shall be recorded on a ticket which provides the date, actual proportions of the mix, concrete design strength, destination

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as to portion of structure, and identification of transit mixer. The truck driver shall deliver this record to the OWNER with a copy to the TESTING LABORATORY personnel at the location where the concrete is delivered. As required by ASTM C 94-67, the batch ticket shall also include the time loaded, amount of concrete, and reading of revolution counter at first addition of water.

3:12 Quality Control

3:12.1 The OWNER will obtain the services of a TESTING LABORATORY which will perform the functions hereinafter specified:

1. Sample and test cement, when required by the OWNER, to ascertain conformance with ASTM C 150-67, Type II.

2. Test samples of fine and coarse aggregates to ascertain conformance with the following ASTM specifications:

   a. C 29-67 T "Unit Weight of Aggregate, Test for."

   b. C 40-66 "Organic Impurities in Sands for Concrete, Test for."

   c. C 127-59 "Specific Gravity and Absorption of Coarse Aggregate, Test for."

   d. C 128-59 "Specific Gravity and Absorption of Fine Aggregate, Test for."

   e. C 136-67 "Sieve or Screen Analysis of Fine and Coarse Aggregates, Test for."

3. Conduct periodic tests to determine surface moisture content of aggregates.

4. During concreting operations, furnish the services of an inspector at the batch plant who will certify the mix proportions and conduct the tests itemized above.

5. Furnish the services of an inspector at the site who will make slump tests, make test cylinders, check air content, and record weather conditions. With OWNER/ENGINEER approval, he will make adjustments in the mix proportions, if necessary, to meet the requirements of this Specification. Finally, he will have the right to reject any concrete which does not meet or cannot be adjusted to meet the requirements of this Specification.

6. Maintain all quality control and test records, which will include certified copies of mill test reports for the cement and batch tickets for each batch of concrete.

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3:12.2 The evaluation of test results will be in accordance with Chapter 17 of ACI 301-66. Sufficient tests will be conducted to provide an evaluation of concrete strength in accordance with this Specification. Whenever it appears that tests of the laboratory cured cylinders fail to meet the requirements set forth in this Specification, the OWNER/ENGINEER shall have the right, at the SUPPLIER'S expense, to order changes to the proportions of the mix to increase the strength.

3:12.3 The SUPPLIER shall reimburse the OWNER for the cost of removing and replacing defective concrete including the costs of forming, form removal, reinforcing steel, embedments, and all other related WORK and materials when and if the defective concrete is the fault of the SUPPLIER.

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7 pages

PITTSBURGH TESTING LABORATORY

QUALITY CONTROL PROCEDURES

FOR PLACEMENT OF STRUCTURAL CONCRETE

QUALITY CONTROL PROCEDURE NO. PTL-Q10

"SPECIFICATIONS PLACEMENT OF STRUCTURAL CONCRETE"
GILBERT ASSOCIATES, INC.
SP-5618

MAY, 1969

COMPLETE REVISED - OCT., 1972

Approved by: _____
H. L. Bennett
Director - Gen. Const.

Date: _____

CRYSTAL RIVER - UNIT NO. 3
FLORIDA POWER CORPORATION

PITTSBURGH TESTING LABORATORY
QUALITY CONTROL PROCEDURE FOR
PLACEMENT OF STRUCTURAL CONCRETE

Quality Control Porcedure P.T.L. No. 10

I. GENERAL

A. The Independent Testing Agency - Pittsburgh Testing Laboratory will perform the first level quality control as given within the scope of test procedures. The activities of Pittsburgh Testing Laboratory will be under the supervision of the owners' project manager.

Pittsburgh Testing Laboratory shall act within themselves in matters relating to daily procedure activities.

B. Pittsburgh Testing Laboratory shall have sufficient personnel and equipment available at the project site in order to effectively, promptly and accurately carry out the routine duties prescribed within these procedures. The personnel shall be authorized by the owners' project manager. He shall also authorize any work to be performed off-site by Pittsburgh Testing Laboratory.

C. Reports and Records - Reporting generated by Pittsburgh Testing Laboratory will be as required within the following specific procedures. These reports shall be submitted to the owners' project manager and will become part of the Quality Control File.

D. Notification of each concrete placement shall be given to the Testing Laboratory on day prior to placement which shall consist of a copy of the concrete placement check-out sheet (copy attached) to make arrangements for necessary inspections and testing during placement. Two hour notice can be made for special circumstances when proper arrangements can be made.

E. Pittsburgh Testing Laboratory shall review prior to placement to assure that completed concrete pour sheet is valid. Deviations shall be noted on Pittsburgh Testing Laboratory summary field report. Pittsburgh Testing Laboratory inspector shall perform final sign off. Pittsburgh Testing Laboratory inspector shall verify placement of embedded items including reinforcement. Exact positioning of all embedded items except rebars shall be performed by J. A. Jones Construction Company.

II. PROCEDURES

A. Subgrade Inspection

1. Notification shall be given to the testing laboratory prior to placing concrete on subgrade.

2. Testing laboratory shall make following checks:

   a. Subgrade compacted to density of 95% Minimum Modified AASHO Max. density unless other wise specified.

   b. Subgrade thoroughly wetted - No frozen subgrade or organic and deleterious materials.

   c. Concrete placed against rock - rock is carefully cleaned of all dirt and loose particles by air and or water jetting and brooming - rock thoroughly wetted.

   d. Vapor barrier, if required, shall be installed in accordance with specifications and drawings.

B. Field Testing at Construction Site

1. Testing laboratory inspectors shall inspect and test first load of concrete to the site: for compliance with job specifications.

2. The water-cement ratio shall be checked to verify it has not been exceeded on each load.

3. Slump tests will be taken every 10 cubic yards or every load of concrete placed. Concrete exceeding the specified maximum slump shall be rejected.

4. Air content and temperature tests shall be taken every 50 cubic yards placed or more frequently if found necessary. Concrete not in conformance with air and temperature requirements shall be rejected.

5. Test cylinders will be molded, cured, stored, capped and tested in accordance with ASTM C-31 and C39. Four cylinders shall be cast for each 50 cubic yards or fraction thereof placed in any day. Two cylinders shall be tested at 7 days and two at 28 days. One additional cylinder made for each set during cold weather concreting as defined by ACI or whenever requested.

6. The concrete shall be sampled in accordance with ASTM C-172. Slump tests may be taken at other points in accordance with ASTM C-94 for uniformity evaluation.

7. The field inspector shall check that the time of the concrete in the truck mixer does not exceed 1 1/2 hours after batching and that total revolutions do not exceed 300.

8. The field inspector shall make the necessary notations on the delivery slips which shall include:

   a. Time of concrete placement.

   b. No. of revolutions.

   c. Slump.

   d. Temperature when tested.

   e. Air content when tested.

   f. Cylinder identifications when made.

   g. Location of concrete placement.

9. Collect and submit to FPC project manager all PTL concrete batch slips for each placement.

10. Prepare reports of daily field concrete operations and testing which shall include:

    a. Date

    b. Location of placement

    c. Class and amount of concrete placed

    d. Number and identification of test cylinders including air content and slump of said test batch.

    e. Number of cu. yds. of concrete rejected and disposition.

    f. Weather conditions.

    g. Time of beginning and end of pour.

    h. Unusual conditions such as rejections or other pertinent remarks.

    i. Results of other slump, air content, temperature, mixing date will be given on the batch slip for the respective placement.

C. Field Placement Inspection

1. Testing laboratory inspectors shall perform the following inspections and shall document this inspection on each placement. (Sample inspection form attached.)

   a. Formwork for cleanliness, tight joints, form oiling and exposed edges chamfered.

   b. Reinforcement for cleanliness, adequate securing and clearances to forms and subgrades.

   c. Construction joint surfaces except as noted otherwise hereinafter shall be prepared for the placement of concrete there on by cleaning thoroughly with wire brushes, water under pressure, or by other means to remove all coatings, stains, debris, or other foreign material.

   d. Horizontal and vertical construction joints in the reactor building cylinderical shell below 250'0 level shall be prepared for receiving next pour by either sandblasting, air water jet, bush hammering, or other means to remove all coatings, stains, debris or other foreign material. The horizontal joints shall be dampened, then thoroughly covered with cement - sand mortar, of similar proportions in concrete, of approximately 1/2 inch thick and concrete placed before initial set of mortar. Vertical joints shall be dampened before concreting.

   e. Construction joint surface in the Ring Girder and Dome at and above 250'0 of the Reactor Bldg. are to be prepared by sandblasting to produce a clean rough surface and the applying an evenly distributed film of Colma Fix 8% adhesive.

   f. Conveyance equipment in accordance with ACI 301 Chapter 8 and ASTM C94. All transporting to point of deposit to be without segregation of concrete.

   g. Concrete deposited in horizontal layer not exceeding 18" avoiding inclined joints with maximum free fall of 3 feet. Each layer vibrated together.

   h. Placing of concrete shall not cause movement or damage to embedded items.

   i. Concrete vibrated adequately and concrete of proper workability to avoid seams or planes of weakness.

j. Vibrations adequate to thoroughly work around reinforcement, embedded items, corner, eliminating air or rock pockets, honeycombing, pitting or planes or weakness.

k. Adequate vibrators used at a minimum frequency of 7000 rpms when immersed in concrete.

D. Curing

1. Curing methods shall be in accord with ACI-301 except that curing compound shall not be used on concrete of containment shell.

2. A curing log shall be set up to keep a record of each structure cured, methods and duration.

3. The following checks and documentation shall be made by the testing laboratory inspectors:

a. Location of part of the structure placed.

b. Date of placement.

c. Weather.

d. Curing of unformed surfaces - start immediately after final set.

e. Date forms removed.

f. Type of curing on formed and unformed surfaces.

g. Number of days of curing performed as compared to specified minimum per ACI-301.

h. Structure protected from stresses and rain or water during curing period.

4. During cold weather concreting as defined by ACI a detailed report of each part of structure cold weather protection and curing shall be made as shown on attached sample report form.

5. Concrete finishes shall be inspected and noticeable defects shall be reported.

E. Reports and Records

Completed records generated on each phase enumerated herein shall be submitted to the Quality Engineer within one week following the activity.

1. Batch delivery slips with field data included.

2. Concrete placement report.

3. Concrete curing report.

4. Summary of field tests and daily field concrete operations.

5. Laboratory tests of aggregates.
6. Laboratory test results of 28 day cylinders - Note 7 day

F. Deficiencies: results to be reported with 28 day results.

Results of all tests and inspections that do not meet specification requirements shall be immediately reported to the FPC project manager and Quality Engineer. Recommendations shall be made for remedial actions or measures required to bring the production within standard quality control and the limits of the engineering specifications. Final recourse for action shall be made by the FPC Project Manager.

Attachments: Cylinder Report Form FP-1
Concrete Placement Form FP-4
Daily Concrete Curing and Form Removal Form FP-3
Daily Concrete Pour Record-Cold Weather Form FP-2
Field Report of each load
Concrete surface defect form

Appendix A
Attachment #6a

1 page

March 6, 1973

Mr. W. S. O'Brien,
Nuclear Project Co-ordinator
Florida Power Corporation
P. O. Box 14042
St. Petersburg, Florida 33733

FPC - #7839

Re: Concrete Acceptance Criteria
Crystal River - Unit #3
Florida Power Corporation
FPC File: 321-B4.1

Dear Mr. O'Brien:

This is in reply to Mr. R. W. Buck's TeleCopy, BT-9-73, dated March 1, 1973.

Previously, in reference to letter, FPC #7358, approval was given to accept slump tests made simultaneously with strength samples at the concrete pump discharge pipe, not to exceed 4" slump and at the truck, not more than 4½" slump. At that time, it was established that the present design mix called for 7.50 bags of Type II Cement per batch. Since the actual cement content in the production concrete was stated to be 8 bags, a slight change in the water content for slump control will not significantly change the design W/C ratio. As long as these same conditions exist in future concrete deliveries, we have no objection to apply the same acceptance criteria for slump.

In regard to temperature, we suggest that every effort shall be made to keep the concrete temperature as low as possible. However, we will accept 75° F temperature as a maximum criteria for acceptance of concrete. Keeping in mind that we are approaching the most complicated and critical construction phase, the "ring girder", we hope that this temperature criteria will be more of an exception rather than a steady occurrence.

Very truly yours,

S. N. Dobreff,
Project Structural Engineer

SND:bl

cc: W. S. O'Brien (2)

15 page

Cylinder Tests exterior wall - 28 days

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
RB	Structure Summary:		Standard Variation: 605.23	451	Samples	Ave. Fc: 5650
727550-2	Mix Summary:		Standard Variation: 541.071	200	Samples	Ave. Fc: 5774
727550-2	641	132	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2071	C	5360
727550-2	641	132	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2071	D	5550
727550-2	641	132	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2072	D	5750
727550-2	641	132	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2072	C	5040
727550-2	641	132	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2073	D	5570
727550-2	641	132	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2073	C	5130
727550-2	641	132	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2074	C	5320
727550-2	641	132	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2074	D	5520
641	Pour Summary:		Standard Variation: 238.627	8	Samples	Ave. Fc: 5405
727550-2	642	122	EXTERIOR WALL BUTTRESS 1 - 6, PERSONNEL	2077	D	5590
727550-2	642	122	EXTERIOR WALL BUTTRESS 1 - 6, PERSONNEL	2077	C	5780
727550-2	642	122	EXTERIOR WALL BUTTRESS 1 - 6, PERSONNEL	2078	C	5500
727550-2	642	122	EXTERIOR WALL BUTTRESS 1 - 6, PERSONNEL	2078	D	5340
642	Pour Summary:		Standard Variation: 183.553	4	Samples	Ave. Fc: 5553
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2117	C	5840
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2117	D	5570
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2118	C	5820
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2118	D	5780
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2119	C	5590
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2119	D	5750
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2120	C	5570
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2120	D	5700
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2121	D	5320
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2121	C	5430
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2122	D	5640
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2122	C	5710
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2123	D	5640
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2123	C	5660
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2124	C	6170
727550-2	666	160	EXTERIOR WALL BUTTRESS 3 - 4, EQUIPMENT	2124	D	5780
666	Pour Summary:		Standard Variation: 189.56	16	Samples	Ave. Fc: 5686
727550-2	742	160	SECONDARY SHIELD WALL, SE QUADRANT	2224	C	5850
727550-2	742	160	SECONDARY SHIELD WALL, SE QUADRANT	2224	D	6420
742	Pour Summary:		Standard Variation: 403.051	2	Samples	Ave. Fc: 6135
727550-2	743	240	EXTERIOR WALL BUTTRESS 3 - 4	2225	C	5470
727550-2	743	240	EXTERIOR WALL BUTTRESS 3 - 4	2225	D	5750
727550-2	743	240	EXTERIOR WALL BUTTRESS 3 - 4	2226	D	6230
727550-2	743	240	EXTERIOR WALL BUTTRESS 3 - 4	2226	C	5680

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
743	Pour Summary:		Standard Variation: 321.183	4 Samples	Ave. Fc:	5783
727550-2	746	160	SECONDARY SHIELD WALL, NORTH	2231	D	4630
727550-2	746	160	SECONDARY SHIELD WALL, NORTH	2231	C	5520
746	Pour Summary:		Standard Variation: 629.325	2 Samples	Ave. Fc:	5075
727550-2	747	250	EXTERIOR WALL BUTTRESS 3 - 4	2232	C	6740
727550-2	747	250	EXTERIOR WALL BUTTRESS 3 - 4	2232	D	5640
727550-2	747	250	EXTERIOR WALL BUTTRESS 3 - 4	2233	C	5780
727550-2	747	250	EXTERIOR WALL BUTTRESS 3 - 4	2233	D	5730
727550-2	747	250	EXTERIOR WALL BUTTRESS 3 - 4	2234	D	5520
727550-2	747	250	EXTERIOR WALL BUTTRESS 3 - 4	2234	C	5750
747	Pour Summary:		Standard Variation: 441.316	6 Samples	Ave. Fc:	5860
727550-2	753	160	SECONDARY SHIELD WALL & INCORE PIT	2239	C	5870
727550-2	753	160	SECONDARY SHIELD WALL & INCORE PIT	2239	D	6010
727550-2	753	160	SECONDARY SHIELD WALL & INCORE PIT	2240	C	5220
727550-2	753	160	SECONDARY SHIELD WALL & INCORE PIT	2240	D	5680
727550-2	753	160	SECONDARY SHIELD WALL & INCORE PIT	2241	D	5310
727550-2	753	160	SECONDARY SHIELD WALL & INCORE PIT	2241	C	5310
727550-2	753	160	SECONDARY SHIELD WALL & INCORE PIT	2242	C	5130
727550-2	753	160	SECONDARY SHIELD WALL & INCORE PIT	2242	D	5130
753	Pour Summary:		Standard Variation: 346.276	8 Samples	Ave. Fc:	5458
727550-2	754	160	SECONDARY SHIELD WALL, NW QUADRANT	2243	C	5470
727550-2	754	160	SECONDARY SHIELD WALL, NW QUADRANT	2243	D	5660
754	Pour Summary:		Standard Variation: 134.350	2 Samples	Ave. Fc:	5565
727550-2	759	170	SECONDARY SHIELD WALL, SE QUADRANT	2249	C	6080
727550-2	759	170	SECONDARY SHIELD WALL, SE QUADRANT	2249	D	5910
759	Pour Summary:		Standard Variation: 120.208	2 Samples	Ave. Fc:	5995
727550-2	765	170	SECONDARY SHIELD WALL, NE QUADRANT	2257	C	5500
727550-2	765	170	SECONDARY SHIELD WALL, NE QUADRANT	2257	D	5980
727550-2	765	170	SECONDARY SHIELD WALL, NE QUADRANT	2258	C	5750
727550-2	765	170	SECONDARY SHIELD WALL, NE QUADRANT	2258	D	5680
765	Pour Summary:		Standard Variation: 198.557	4 Samples	Ave. Fc:	5728
727550-2	768	170	SECONDARY SHIELD WALL, SE QUADRANT	2261	C	5130
727550-2	768	170	SECONDARY SHIELD WALL, SE QUADRANT	2261	D	5240
768	Pour Summary:		Standard Variation: 77.7817	2 Samples	Ave. Fc:	5185
727550-2	769	250	EXTERIOR WALL BUTTRESS 1 - 6	2262	C	5840
727550-2	769	250	EXTERIOR WALL BUTTRESS 1 - 6	2262	D	5480
727550-2	769	250	EXTERIOR WALL BUTTRESS 1 - 6	2263	C	5310
727550-2	769	250	EXTERIOR WALL BUTTRESS 1 - 6	2263	D	5680
769	Pour Summary:		Standard Variation: 231.283	4 Samples	Ave. Fc:	5578
727550-2	774	180	SECONDARY SHIELD WALL, NE QUADRANT	2270	D	5310

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
727550-2	774	180	SECONDARY SHIELD WALL, NE QUADRANT	2270	C	5730
727550-2	774	180	SECONDARY SHIELD WALL, NE QUADRANT	2271	D	5480
727550-2	774	180	SECONDARY SHIELD WALL, NE QUADRANT	2271	C	5480
774	Pour Summary:		Standard Variation: 173.013	4 Samples	Ave. Fc:	5500
727550-2	776	131	CFT-1A ROOM NORTH WALL	2273	D	5700
727550-2	776	131	CFT-1A ROOM NORTH WALL	2273	C	6070
776	Pour Summary:		Standard Variation: 261.63	2 Samples	Ave. Fc:	5885
727550-2	783	160	FUEL HANDLING CANAL NORTH WALL	2280	C	5640
727550-2	783	160	FUEL HANDLING CANAL NORTH WALL	2280	D	5180
727550-2	783	160	FUEL HANDLING CANAL NORTH WALL	2281	C	5680
727550-2	783	160	FUEL HANDLING CANAL NORTH WALL	2281	D	5380
783	Pour Summary:		Standard Variation: 234.663	4 Samples	Ave. Fc:	5470
727550-2	795	160	SECONDARY SHIELD WALL, SE QUADRANT	2290	C	6300
727550-2	795	160	SECONDARY SHIELD WALL, SE QUADRANT	2290	D	6120
727550-2	795	160	SECONDARY SHIELD WALL, SE QUADRANT	2291	C	5240
727550-2	795	160	SECONDARY SHIELD WALL, SE QUADRANT	2291	D	5500
795	Pour Summary:		Standard Variation: 501.863	4 Samples	Ave. Fc:	5790
727550-2	797	170	FUEL HANDLING CANAL NORTH WALL	2295	C	5310
727550-2	797	170	FUEL HANDLING CANAL NORTH WALL	2295	D	6720
727550-2	797	170	FUEL HANDLING CANAL NORTH WALL	2297	C	6190
727550-2	797	170	FUEL HANDLING CANAL NORTH WALL	2297	D	6010
797	Pour Summary:		Standard Variation: 582.373	4 Samples	Ave. Fc:	6058
727550-2	805	160	FUEL HANDLING CANAL SOUTH & WEST WALL	2303	D	5660
727550-2	805	160	FUEL HANDLING CANAL SOUTH & WEST WALL	2303	C	5340
727550-2	805	160	FUEL HANDLING CANAL SOUTH & WEST WALL	2304	D	5320
727550-2	805	160	FUEL HANDLING CANAL SOUTH & WEST WALL	2304	C	5360
805	Pour Summary:		Standard Variation: 160.831	4 Samples	Ave. Fc:	5420
727550-2	810	109	RETAINING WALL, SW	2308	D	5480
727550-2	810	109	RETAINING WALL, SW	2308	C	5480
810	Pour Summary:		Standard Variation: 0	2 Samples	Ave. Fc:	5480
727550-2	813	180	FUEL HANDLING CANAL NORTH WALL	2312	C	6010
727550-2	813	180	FUEL HANDLING CANAL NORTH WALL	2312	D	5480
727550-2	813	180	FUEL HANDLING CANAL NORTH WALL	2313	C	5480
727550-2	813	180	FUEL HANDLING CANAL NORTH WALL	2313	D	6040
813	Pour Summary:		Standard Variation: 314.894	4 Samples	Ave. Fc:	5753
727550-2	815	131	SOUTH WALL CFT-1A ROOM	2315	D	5310
727550-2	815	131	SOUTH WALL CFT-1A ROOM	2315	C	5340
815	Pour Summary:		Standard Variation: 21.2132	2 Samples	Ave. Fc:	5325
727550-2	817	170	SECONDARY SHIELD WALL, SW QUADRANT	2317	C	5660
727550-2	817	170	SECONDARY SHIELD WALL, SW QUADRANT	2317	D	6310

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
727550-2	817	170	SECONDARY SHIELD WALL, SW QUADRANT	2318	C	5940
727550-2	817	170	SECONDARY SHIELD WALL, SW QUADRANT	2318	D	5960
817	Pour Summary:		Standard Variation: 266.255	4	Samples Ave. Fc:	5968
727550-2	820	135	CFT-1A ROOM SLAB & WALL	2321	C	5570
727550-2	820	135	CFT-1A ROOM SLAB & WALL	2321	D	5610
820	Pour Summary:		Standard Variation: 28.2843	2	Samples Ave. Fc:	5590
727550-2	821	118	RETAINING WALL, SW	2322	C	6190
727550-2	821	118	RETAINING WALL, SW	2322	D	6350
821	Pour Summary:		Standard Variation: 113.137	2	Samples Ave. Fc:	6270
727550-2	825	255	RING GIRDER, BUTTRESS 6	2329	C	6540
727550-2	825	255	RING GIRDER, BUTTRESS 6	2329	D	6370
825	Pour Summary:		Standard Variation: 120.208	2	Samples Ave. Fc:	6455
727550-2	826	255	RING GIRDER, BUTTRESS 4	2330	C	4700
727550-2	826	255	RING GIRDER, BUTTRESS 4	2330	D	4930
826	Pour Summary:		Standard Variation: 162.635	2	Samples Ave. Fc:	4815
727550-2	827	180	SECONDARY SHIELD WALL, SW QUADRANT	2331	C	5660
727550-2	827	180	SECONDARY SHIELD WALL, SW QUADRANT	2331	D	5520
727550-2	827	180	SECONDARY SHIELD WALL, SW QUADRANT	2332	C	5590
727550-2	827	180	SECONDARY SHIELD WALL, SW QUADRANT	2332	D	5660
827	Pour Summary:		Standard Variation: 67.0199	4	Samples Ave. Fc:	5608
727550-2	828	115	RETAINING WALL, SW	2335	D	5710
727550-2	828	115	RETAINING WALL, SW	2335	C	5710
828	Pour Summary:		Standard Variation: 0	2	Samples Ave. Fc:	5710
727550-2	829	255	RING GIRDER, BUTTRESS 2	2333	D	5310
727550-2	829	255	RING GIRDER, BUTTRESS 2	2333	C	5940
829	Pour Summary:		Standard Variation: 445.477	2	Samples Ave. Fc:	5625
727550-2	830	143	CFT-1A ROOM WALLS	2334	D	6190
727550-2	830	143	CFT-1A ROOM WALLS	2334	C	5660
830	Pour Summary:		Standard Variation: 374.767	2	Samples Ave. Fc:	5925
727550-2	841	170	FUEL HANDLING CANAL SOUTH WALL	2349	C	6370
727550-2	841	170	FUEL HANDLING CANAL SOUTH WALL	2349	D	6380
727550-2	841	170	FUEL HANDLING CANAL SOUTH WALL	2350	D	6080
727550-2	841	170	FUEL HANDLING CANAL SOUTH WALL	2350	C	6300
841	Pour Summary:		Standard Variation: 139.613	4	Samples Ave. Fc:	6283
727550-2	843	172	SECONDARY SHIELD WALL, NW QUADRANT	2351	C	6010
727550-2	843	172	SECONDARY SHIELD WALL, NW QUADRANT	2351	D	6230
843	Pour Summary:		Standard Variation: 155.563	2	Samples Ave. Fc:	6120
727550-2	844	180	SECONDARY SHIELD WALL, NW QUADRANT	2352	D	6560
727550-2	844	180	SECONDARY SHIELD WALL, NW QUADRANT	2352	C	6310

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
844	Pour Summary:		Standard Variation: 176.777		2 Samples	Ave. Fc: 6435
727550-2	846	180	FUEL HANDLING CANAL, SOUTH WALL	2354	C	6560
727550-2	846	180	FUEL HANDLING CANAL, SOUTH WALL	2354	D	6540
727550-2	846	180	FUEL HANDLING CANAL, SOUTH WALL	2355	D	5660
727550-2	846	180	FUEL HANDLING CANAL, SOUTH WALL	2355	C	5780
846	Pour Summary:		Standard Variation: 481.768		4 Samples	Ave. Fc: 6135
727550-2	853	160	EL 160 FLOOR SLAB, NW	2361	D	6560
727550-2	853	160	EL 160 FLOOR SLAB, NW	2361	C	6190
727550-2	853	160	EL 160 FLOOR SLAB, NW	2362	D	5660
727550-2	853	160	EL 160 FLOOR SLAB, NW	2362	C	5840
853	Pour Summary:		Standard Variation: 398.026		4 Samples	Ave. Fc: 6063
727550-2	865	206	ELEVATOR SHAFT	2382	D	5480
727550-2	865	206	ELEVATOR SHAFT	2382	C	5500
865	Pour Summary:		Standard Variation: 14.1421		2 Samples	Ave. Fc: 5490
727550-2	946	267	RING GIRDER; 0 - 60 DEGREES	2509	C	5550
727550-2	946	267	RING GIRDER; 0 - 60 DEGREES	2509	D	5540
946	Pour Summary:		Standard Variation: 7.07107		2 Samples	Ave. Fc: 5545
727550-2	951	267	RING GIRDER; 180 - 240 DEGREES	2519	D	6170
727550-2	951	267	RING GIRDER; 180 - 240 DEGREES	2519	C	6260
951	Pour Summary:		Standard Variation: 63.6396		2 Samples	Ave. Fc: 6215
727550-2	953	267	RING GIRDER; 0 - 300 DEGREES	2521	D	6770
727550-2	953	267	RING GIRDER; 0 - 300 DEGREES	2521	C	6930
953	Pour Summary:		Standard Variation: 113.137		2 Samples	Ave. Fc: 6850
727550-2	954	267	RING GIRDER; 60 - 120 DEGREES	2522	C	5700
727550-2	954	267	RING GIRDER; 60 - 120 DEGREES	2522	D	5770
954	Pour Summary:		Standard Variation: 49.4975		2 Samples	Ave. Fc: 5735
727550-2	974	270	RING GIRDER; 90 - 150 DEGREES	2560	C	6370
727550-2	974	270	RING GIRDER; 90 - 150 DEGREES	2560	D	5280
974	Pour Summary:		Standard Variation: 770.746		2 Samples	Ave. Fc: 5825
727550-2	976		DOME POUR G1, AZ 45 - 135	2579	C	6560
727550-2	976		DOME POUR G1, AZ 45 - 135	2579	D	6190
727550-2	976		DOME POUR G1, AZ 45 - 135	2580	D	6030
727550-2	976		DOME POUR G1, AZ 45 - 135	2580	C	6470
976	Pour Summary:		Standard Variation: 245.544		4 Samples	Ave. Fc: 6313
727550-2	978		DOME POUR G1, AZ 225 - 315	2586	C	6330
727550-2	978		DOME POUR G1, AZ 225 - 315	2586	D	6690
978	Pour Summary:		Standard Variation: 254.558		2 Samples	Ave. Fc: 6510
727550-2	980		DOME POUR G2, AZ 135 - 225	2595	C	4600
727550-2	980		DOME POUR G2, AZ 135 - 225	2595	D	5910

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
980	Pour Summary:		Standard Variation: 926.31	2 Samples	Ave. Fc:	5255
727550-2	981		DOME POUR G2, AZ 315 - 45	2598	D	6010
727550-2	981		DOME POUR G2, AZ 315 - 45	2598	C	5550
981	Pour Summary:		Standard Variation: 325.269	2 Samples	Ave. Fc:	5780
727550-2	983		DOME POUR H3, AZ 180 - 270	2610	C	5270
727550-2	983		DOME POUR H3, AZ 180 - 270	2610	D	5680
727550-2	983		DOME POUR H3, AZ 180 - 270	2612	D	4630
727550-2	983		DOME POUR H3, AZ 180 - 270	2612	C	4830
983	Pour Summary:		Standard Variation: 468.713	4 Samples	Ave. Fc:	5103
727550-2	987		DOME POUR H4, AZ 90 - 180	2628	C	6030
727550-2	987		DOME POUR H4, AZ 90 - 180	2628	D	4930
987	Pour Summary:		Standard Variation: 777.817	2 Samples	Ave. Fc:	5480
727550-2	988		DOME POUR H4, AZ 270 - 360	2629	D	5320
727550-2	988		DOME POUR H4, AZ 270 - 360	2629	C	5800
988	Pour Summary:		Standard Variation: 339.411	2 Samples	Ave. Fc:	5560
727550-2	994	269	DOME POUR R2, AZ 70 - 160	2652	C	5310
727550-2	994	269	DOME POUR R2, AZ 70 - 160	2652	D	4790
727550-2	994	269	DOME POUR R2, AZ 70 - 160	2653	C	4880
727550-2	994	269	DOME POUR R2, AZ 70 - 160	2653	D	4780
994	Pour Summary:		Standard Variation: 250.732	4 Samples	Ave. Fc:	4940
727550-2	996	269	DOME POUR R2, AZ 250 - 340	2666	C	4920
727550-2	996	269	DOME POUR R2, AZ 250 - 340	2666	D	5040
727550-2	996	269	DOME POUR R2, AZ 250 - 340	2667	C	5180
727550-2	996	269	DOME POUR R2, AZ 250 - 340	2667	D	4970
996	Pour Summary:		Standard Variation: 112.953	4 Samples	Ave. Fc:	5028
727550-2	998	269	DOME POUR R1, AZ 160 - 250	2684	C	5090
727550-2	998	269	DOME POUR R1, AZ 160 - 250	2684	D	4560
727550-2	998	269	DOME POUR R1, AZ 160 - 250	2685	C	5360
727550-2	998	269	DOME POUR R1, AZ 160 - 250	2685	D	4900
998	Pour Summary:		Standard Variation: 336.291	4 Samples	Ave. Fc:	4978
727550-2	999	269	DOME POUR R1, AZ 340 - 70	2686	D	4810
727550-2	999	269	DOME POUR R1, AZ 340 - 70	2686	C	4950
999	Pour Summary:		Standard Variation: 98.9949	2 Samples	Ave. Fc:	4880
727550-2	1012		DOME POUR P12	2885	C	6560
727550-2	1012		DOME POUR P12	2885	D	6670
727550-2	1012		DOME POUR P12	2886	D	5910
727550-2	1012		DOME POUR P12	2886	C	6230
1012	Pour Summary:		Standard Variation: 343.645	4 Samples	Ave. Fc:	6343
727550-2	1045	118	EQUIP HATCH SHIELD FLOOR SLAB	3080	C	6630
727550-2	1045	118	EQUIP HATCH SHIELD FLOOR SLAB	3080	D	6610

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
727550-2	1045	118	EQUIP HATCH SHIELD FLOOR SLAB	3081	D	6580
727550-2	1045	118	EQUIP HATCH SHIELD FLOOR SLAB	3081	C	7000
727550-2	1045	118	EQUIP HATCH SHIELD FLOOR SLAB	3082	D	6510
727550-2	1045	118	EQUIP HATCH SHIELD FLOOR SLAB	3082	C	6670
1045	**Pour Summary:**		Standard Variation: **171.891**	**6** Samples	Ave. Fc:	**6667**
727550-2	1047		EQUIP HATCH SHIELD SLAB & EAST WALL	3083	C	6210
727550-2	1047		EQUIP HATCH SHIELD SLAB & EAST WALL	3083	D	6790
1047	**Pour Summary:**		Standard Variation: **410.122**	**2** Samples	Ave. Fc:	**6500**
727550-2	1052	129	EQUIP HATCH SHIELD WALL & ROOF	3086	D	6840
727550-2	1052	129	EQUIP HATCH SHIELD WALL & ROOF	3086	C	6760
727550-2	1052	129	EQUIP HATCH SHIELD WALL & ROOF	3087	D	6260
727550-2	1052	129	EQUIP HATCH SHIELD WALL & ROOF	3087	C	6000
1052	**Pour Summary:**		Standard Variation: **402.451**	**4** Samples	Ave. Fc:	**6465**
727550-2	1062	146	EQUIP HATCH SHIELD WEST WALL	3090	C	6350
727550-2	1062	146	EQUIP HATCH SHIELD WEST WALL	3090	D	6670
1062	**Pour Summary:**		Standard Variation: **226.274**	**2** Samples	Ave. Fc:	**6510**
727550-2	1069	149	EQUIP HATCH SHIELD ROOF	3094	D	7150
727550-2	1069	149	EQUIP HATCH SHIELD ROOF	3094	C	7090
727550-2	1069	149	EQUIP HATCH SHIELD ROOF	3095	D	6140
727550-2	1069	149	EQUIP HATCH SHIELD ROOF	3095	C	5860
1069	**Pour Summary:**		Standard Variation: **657.115**	**4** Samples	Ave. Fc:	**6560**
727550-2	1089		EQUIP HATCH SHIELD REMOVABLE WALL SEC	3110	C	6210
727550-2	1089		EQUIP HATCH SHIELD REMOVABLE WALL SEC	3110	D	6470
1089	**Pour Summary:**		Standard Variation: **183.848**	**2** Samples	Ave. Fc:	**6340**
727550-2	**Mix Summary:**		Standard Variation: **541.071**	**200** Samples	Ave. Fc:	**5774**
DM-5	**Mix Summary:**		Standard Variation: **508.316**	**239** Samples	Ave. Fc:	**5640**
DM-5	51	93	RB6A	731	D	5390
DM-5	51	93	RB6A	731	C	5360
DM-5	51	93	RB6A	732	D	5520
DM-5	51	93	RB6A	732	C	5470
DM-5	51	93	RB6A	733	D	4850
DM-5	51	93	RB6A	733	C	4880
DM-5	51	93	RB6A	734	C	4990
DM-5	51	93	RB6A	734	D	5060
DM-5	51	93	RB6A	735	D	5160
DM-5	51	93	RB6A	735	C	4920
DM-5	51	93	RB6A	736	C	4670
DM-5	51	93	RB6A	736	D	4760
DM-5	51	93	RB6A	737	D	4790
DM-5	51	93	RB6A	737	C	4740
DM-5	51	93	RB6A	738	D	5590

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
DM-5	51	93	RB6A	738	C	5240
DM-5	51	93	RB6A	739	C	5340
DM-5	51	93	RB6A	739	D	5240
DM-5	51	93	RB6A	740	D	4920
DM-5	51	93	RB6A	740	C	4920
DM-5	51	93	RB6A	741	D	5130
DM-5	51	93	RB6A	741	C	5200
DM-5	51	93	RB6A	742	C	4530
DM-5	51	93	RB6A	742	D	5010
DM-5	51	93	RB6A	743	C	5340
DM-5	51	93	RB6A	743	D	5220
DM-5	51	93	RB6A	744	D	4880
DM-5	51	93	RB6A	744	C	4930
DM-5	51	93	RB6A	745	D	5480
DM-5	51	93	RB6A	745	C	5340
DM-5	51	93	RB6A	746	D	5240
DM-5	51	93	RB6A	746	C	5130
DM-5	51	93	RB6A	747	C	5480
DM-5	51	93	RB6A	747	D	5390
DM-5	51	93	RB6A	748	C	5780
DM-5	51	93	RB6A	748	D	5870
51	Pour Summary:		Standard Variation: **312.748**	**36**	Samples	Ave. Fc: **5160**
DM-5	184	103	SECONDARY SHIELD & LETDOWN HX WALLS	1226	D	5040
DM-5	184	103	SECONDARY SHIELD & LETDOWN HX WALLS	1226	C	4990
DM-5	184	103	SECONDARY SHIELD & LETDOWN HX WALLS	1228	C	6030
DM-5	184	103	SECONDARY SHIELD & LETDOWN HX WALLS	1228	D	5940
184	Pour Summary:		Standard Variation: **561.605**	**4**	Samples	Ave. Fc: **5500**
DM-5	219	114	SECONDARY SHIELD WALL & LETDOWN HX WA	1291	D	5870
DM-5	219	114	SECONDARY SHIELD WALL & LETDOWN HX WA	1291	C	5870
DM-5	219	114	SECONDARY SHIELD WALL & LETDOWN HX WA	1292	C	5730
219	Pour Summary:		Standard Variation: **80.8290**	**3**	Samples	Ave. Fc: **5823**
DM-5	276	120	EXTERIOR WALL BUTTRESS 1 - 2	1437	C	5360
DM-5	276	120	EXTERIOR WALL BUTTRESS 1 - 2	1437	D	5200
DM-5	276	120	EXTERIOR WALL BUTTRESS 1 - 2	1438	D	5480
DM-5	276	120	EXTERIOR WALL BUTTRESS 1 - 2	1438	C	5480
276	Pour Summary:		Standard Variation: **132.665**	**4**	Samples	Ave. Fc: **5380**
DM-5	281	120	EXTERIOR WALL BUTTRESS 5 - 6	1443	D	6370
DM-5	281	120	EXTERIOR WALL BUTTRESS 5 - 6	1443	C	5180
DM-5	281	120	EXTERIOR WALL BUTTRESS 5 - 6	1444	D	5080
DM-5	281	120	EXTERIOR WALL BUTTRESS 5 - 6	1444	C	5020
281	Pour Summary:		Standard Variation: **641.736**	**4**	Samples	Ave. Fc: **5413**

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
DM-5	282	120	EXTERIOR WALL BUTTRESS 4 - 5	1445	C	6280
DM-5	282	120	EXTERIOR WALL BUTTRESS 4 - 5	1445	D	6050
DM-5	282	120	EXTERIOR WALL BUTTRESS 4 - 5	1446	D	5610
DM-5	282	120	EXTERIOR WALL BUTTRESS 4 - 5	1446	C	5660
282	Pour Summary:		Standard Variation: 320.728	4 Samples	Ave. Fc:	5900
DM-5	290	130	EXTERIOR WALL BUTTRESS 2 - 3	1459	D	6600
DM-5	290	130	EXTERIOR WALL BUTTRESS 2 - 3	1459	C	6350
DM-5	290	130	EXTERIOR WALL BUTTRESS 2 - 3	1460	D	5590
DM-5	290	130	EXTERIOR WALL BUTTRESS 2 - 3	1460	C	5480
290	Pour Summary:		Standard Variation: 554.046	4 Samples	Ave. Fc:	6005
DM-5	296	120	EXTERIOR WALL BUTTRESS 1 - 6	1485	C	5130
DM-5	296	120	EXTERIOR WALL BUTTRESS 1 - 6	1485	D	6010
DM-5	296	120	EXTERIOR WALL BUTTRESS 1 - 6	1486	D	6370
DM-5	296	120	EXTERIOR WALL BUTTRESS 1 - 6	1486	C	5470
296	Pour Summary:		Standard Variation: 552.178	4 Samples	Ave. Fc:	5745
DM-5	300	130	EXTERIOR WALL BUTTRESS 1 - 2	1487	C	5910
DM-5	300	130	EXTERIOR WALL BUTTRESS 1 - 2	1487	D	5590
DM-5	300	130	EXTERIOR WALL BUTTRESS 1 - 2	1488	D	6300
DM-5	300	130	EXTERIOR WALL BUTTRESS 1 - 2	1488	C	5380
300	Pour Summary:		Standard Variation: 401.040	4 Samples	Ave. Fc:	5795
DM-5	305	130	EXTERIOR WALL BUTTRESS 5 - 6	1497	C	6770
DM-5	305	130	EXTERIOR WALL BUTTRESS 5 - 6	1497	D	6510
DM-5	305	130	EXTERIOR WALL BUTTRESS 5 - 6	1498	C	6650
DM-5	305	130	EXTERIOR WALL BUTTRESS 5 - 6	1498	D	6770
305	Pour Summary:		Standard Variation: 123.693	4 Samples	Ave. Fc:	6675
DM-5	310	130	EXTERIOR WALL BUTTRESS 4 - 5	1504	C	5800
DM-5	310	130	EXTERIOR WALL BUTTRESS 4 - 5	1504	D	5850
DM-5	310	130	EXTERIOR WALL BUTTRESS 4 - 5	1505	D	5570
DM-5	310	130	EXTERIOR WALL BUTTRESS 4 - 5	1505	C	5430
310	Pour Summary:		Standard Variation: 197.21	4 Samples	Ave. Fc:	5663
DM-5	325	140	EXTERIOR WALL BUTTRESS 5 - 6	1525	D	5680
DM-5	325	140	EXTERIOR WALL BUTTRESS 5 - 6	1525	C	5660
DM-5	325	140	EXTERIOR WALL BUTTRESS 5 - 6	1526	C	6190
DM-5	325	140	EXTERIOR WALL BUTTRESS 5 - 6	1526	D	6190
325	Pour Summary:		Standard Variation: 300.333	4 Samples	Ave. Fc:	5930
DM-5	349	109	RETAINING WALL	1561	D	5910
DM-5	349	109	RETAINING WALL	1561	C	6100
DM-5	349	109	RETAINING WALL	1562	C	6170
DM-5	349	109	RETAINING WALL	1562	D	6050
349	Pour Summary:		Standard Variation: 109.962	4 Samples	Ave. Fc:	6058

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
DM-5	350	109	RETAINING WALL	1563	D	6120
DM-5	350	109	RETAINING WALL	1563	C	5820
350	**Pour Summary:**		Standard Variation: **212.132**	**2** Samples	Ave. Fc:	**5970**
DM-5	361	103	INCORE ROOM ENTRANCE WALLS	1576	C	5940
DM-5	361	103	INCORE ROOM ENTRANCE WALLS	1576	D	5480
361	**Pour Summary:**		Standard Variation: **325.269**	**2** Samples	Ave. Fc:	**5710**
DM-5	364	140	EXTERIOR WALL BUTTRESS 2 - 3	1579	D	5520
DM-5	364	140	EXTERIOR WALL BUTTRESS 2 - 3	1579	C	5320
DM-5	364	140	EXTERIOR WALL BUTTRESS 2 - 3	1580	D	5680
DM-5	364	140	EXTERIOR WALL BUTTRESS 2 - 3	1580	C	5820
364	**Pour Summary:**		Standard Variation: **215.019**	**4** Samples	Ave. Fc:	**5585**
DM-5	367	170	EXTERIOR WALL BUTTRESS 1 - 2	1582	C	6650
DM-5	367	170	EXTERIOR WALL BUTTRESS 1 - 2	1582	D	6240
DM-5	367	170	EXTERIOR WALL BUTTRESS 1 - 2	1583	C	6300
DM-5	367	170	EXTERIOR WALL BUTTRESS 1 - 2	1583	D	6190
367	**Pour Summary:**		Standard Variation: **208.247**	**4** Samples	Ave. Fc:	**6345**
DM-5	379	107	INCORE ROOM ENTRANCE	1600	C	5700
DM-5	379	107	INCORE ROOM ENTRANCE	1600	D	5750
379	**Pour Summary:**		Standard Variation: **35.3553**	**2** Samples	Ave. Fc:	**5725**
DM-5	385	103	SECONDARY SHIELD WALL, SE QUADRANT	1613	D	5390
DM-5	385	103	SECONDARY SHIELD WALL, SE QUADRANT	1613	C	6230
DM-5	385	103	SECONDARY SHIELD WALL, SE QUADRANT	1614	C	6000
DM-5	385	103	SECONDARY SHIELD WALL, SE QUADRANT	1614	D	5520
385	**Pour Summary:**		Standard Variation: **396.022**	**4** Samples	Ave. Fc:	**5785**
DM-5	395	103	SECONDARY SHIELD WALL, NE QUADRANT	1630	C	5250
DM-5	395	103	SECONDARY SHIELD WALL, NE QUADRANT	1630	D	5520
395	**Pour Summary:**		Standard Variation: **190.919**	**2** Samples	Ave. Fc:	**5385**
DM-5	415	200	EXTERIOR WALL BUTTRESS 2 - 3	1655	C	5540
DM-5	415	200	EXTERIOR WALL BUTTRESS 2 - 3	1655	D	5480
DM-5	415	200	EXTERIOR WALL BUTTRESS 2 - 3	1656	D	5610
DM-5	415	200	EXTERIOR WALL BUTTRESS 2 - 3	1656	C	5570
415	**Pour Summary:**		Standard Variation: **54.7723**	**4** Samples	Ave. Fc:	**5550**
DM-5	417	114	SECONDARY SHIELD WALL, SE QUADRANT	1660	C	4950
DM-5	417	114	SECONDARY SHIELD WALL, SE QUADRANT	1660	D	5480
DM-5	417	114	SECONDARY SHIELD WALL, SE QUADRANT	1661	D	5060
DM-5	417	114	SECONDARY SHIELD WALL, SE QUADRANT	1661	C	5280
417	**Pour Summary:**		Standard Variation: **235.708**	**4** Samples	Ave. Fc:	**5193**
DM-5	442	114	SECONDARY SHIELD WALL, NE QUADRANT	1706	C	5750
DM-5	442	114	SECONDARY SHIELD WALL, NE QUADRANT	1706	D	6190
DM-5	442	114	SECONDARY SHIELD WALL, NE QUADRANT	1707	D	5430

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
DM-5	442	114	SECONDARY SHIELD WALL, NE QUADRANT	1707	C	5520
442	Pour Summary:		Standard Variation: 339.546		4 Samples	Ave. Fc: 5723
DM-5	450	103	SECONDARY SHIELD WALL, SW QUADRANT	1708	D	6150
DM-5	450	103	SECONDARY SHIELD WALL, SW QUADRANT	1708	C	6130
DM-5	450	103	SECONDARY SHIELD WALL, SW QUADRANT	1709	D	5840
DM-5	450	103	SECONDARY SHIELD WALL, SW QUADRANT	1709	C	5570
450	Pour Summary:		Standard Variation: 274.393		4 Samples	Ave. Fc: 5923
DM-5	461	114	PRIMARY SHIELD WALL	1733	D	5520
DM-5	461	114	PRIMARY SHIELD WALL	1733	C	5640
DM-5	461	114	PRIMARY SHIELD WALL	1734	D	5750
DM-5	461	114	PRIMARY SHIELD WALL	1734	C	5090
DM-5	461	114	PRIMARY SHIELD WALL	1735	D	5980
DM-5	461	114	PRIMARY SHIELD WALL	1735	C	5520
DM-5	461	114	PRIMARY SHIELD WALL	1736	D	6100
DM-5	461	114	PRIMARY SHIELD WALL	1736	C	5680
461	Pour Summary:		Standard Variation: 309.146		8 Samples	Ave. Fc: 5660
DM-5	477	103	SECONDARY SHIELD WALL, NW QUADRANT	1821	C	5750
DM-5	477	103	SECONDARY SHIELD WALL, NW QUADRANT	1821	D	5660
DM-5	477	103	SECONDARY SHIELD WALL, NW QUADRANT	1822	C	5310
DM-5	477	103	SECONDARY SHIELD WALL, NW QUADRANT	1822	D	4780
DM-5	477	103	SECONDARY SHIELD WALL, NW QUADRANT	1823	D	5130
DM-5	477	103	SECONDARY SHIELD WALL, NW QUADRANT	1823	C	5130
477	Pour Summary:		Standard Variation: 363.355		6 Samples	Ave. Fc: 5293
DM-5	478	114	SECONDARY SHIELD WALL, SW QUADRANT	1824	C	5660
DM-5	478	114	SECONDARY SHIELD WALL, SW QUADRANT	1824	D	5590
DM-5	478	114	SECONDARY SHIELD WALL, SW QUADRANT	1825	D	5310
DM-5	478	114	SECONDARY SHIELD WALL, SW QUADRANT	1825	C	5240
478	Pour Summary:		Standard Variation: 206.074		4 Samples	Ave. Fc: 5450
DM-5	482	123	SECONDARY SHIELD WALL, SE QUADRANT	1846	C	4850
DM-5	482	123	SECONDARY SHIELD WALL, SE QUADRANT	1846	D	5150
482	Pour Summary:		Standard Variation: 212.132		2 Samples	Ave. Fc: 5000
DM-5	483	123	SECONDARY SHIELD WALL, NE QUADRANT	1847	C	5310
DM-5	483	123	SECONDARY SHIELD WALL, NE QUADRANT	1847	D	5610
483	Pour Summary:		Standard Variation: 212.132		2 Samples	Ave. Fc: 5460
DM-5	484	123	SECONDARY SHIELD WALL, EAST SIDE	1848	C	4860
DM-5	484	123	SECONDARY SHIELD WALL, EAST SIDE	1848	D	5040
484	Pour Summary:		Standard Variation: 127.279		2 Samples	Ave. Fc: 4950
DM-5	488	118	PRIMARY SHIELD WALL	1853	D	5340
DM-5	488	118	PRIMARY SHIELD WALL	1853	C	5360
488	Pour Summary:		Standard Variation: 14.1421		2 Samples	Ave. Fc: 5350

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
DM-5	492	122	PRIMARY SHIELD WALL	1858	C	5250
DM-5	492	122	PRIMARY SHIELD WALL	1858	D	5340
DM-5	492	122	PRIMARY SHIELD WALL	1859	C	5520
DM-5	492	122	PRIMARY SHIELD WALL	1859	D	5040
492	Pour Summary:		Standard Variation: 199.562	4	Samples Ave. Fc:	5288
DM-5	495	114	SECONDARY SHIELD WALL, NW QUADRANT	1877	C	4970
DM-5	495	114	SECONDARY SHIELD WALL, NW QUADRANT	1877	D	5570
DM-5	495	114	SECONDARY SHIELD WALL, NW QUADRANT	1878	C	4970
DM-5	495	114	SECONDARY SHIELD WALL, NW QUADRANT	1878	D	5570
DM-5	495	114	SECONDARY SHIELD WALL, NW QUADRANT	1879	D	5520
DM-5	495	114	SECONDARY SHIELD WALL, NW QUADRANT	1879	C	5310
495	Pour Summary:		Standard Variation: 286.386	6	Samples Ave. Fc:	5318
DM-5	498	115	NORTH WALL INCORE INSTR PIT	1883	C	6190
DM-5	498	115	NORTH WALL INCORE INSTR PIT	1883	D	6120
498	Pour Summary:		Standard Variation: 49.4975	2	Samples Ave. Fc:	6155
DM-5	499	131	EAST END FUEL TRANSFER CANAL	1884	D	5750
DM-5	499	131	EAST END FUEL TRANSFER CANAL	1884	C	6000
DM-5	499	131	EAST END FUEL TRANSFER CANAL	1885	D	5680
DM-5	499	131	EAST END FUEL TRANSFER CANAL	1885	C	5730
499	Pour Summary:		Standard Variation: 143.062	4	Samples Ave. Fc:	5790
DM-5	502	240	EXTERIOR WALL BUTTRESS 1 - 2	1886	D	5770
DM-5	502	240	EXTERIOR WALL BUTTRESS 1 - 2	1886	C	5410
DM-5	502	240	EXTERIOR WALL BUTTRESS 1 - 2	1887	C	5780
DM-5	502	240	EXTERIOR WALL BUTTRESS 1 - 2	1887	D	5850
502	Pour Summary:		Standard Variation: 198.221	4	Samples Ave. Fc:	5703
DM-5	507	123	NORTH WALL INCORE INSTR PIT	1892	D	6510
DM-5	507	123	NORTH WALL INCORE INSTR PIT	1892	C	6330
507	Pour Summary:		Standard Variation: 127.279	2	Samples Ave. Fc:	6420
DM-5	511	228	EXTERIOR WALL BUTTRESS 5 - 6	1913	D	6720
DM-5	511	228	EXTERIOR WALL BUTTRESS 5 - 6	1913	C	6460
DM-5	511	228	EXTERIOR WALL BUTTRESS 5 - 6	1914	D	6930
DM-5	511	228	EXTERIOR WALL BUTTRESS 5 - 6	1914	C	7160
511	Pour Summary:		Standard Variation: 298.482	4	Samples Ave. Fc:	6818
DM-5	521	123	SECONDARY SHIELD WALL, SW QUADRANT	1925	C	6830
DM-5	521	123	SECONDARY SHIELD WALL, SW QUADRANT	1925	D	7060
521	Pour Summary:		Standard Variation: 162.635	2	Samples Ave. Fc:	6945
DM-5	526	123	SECONDARY SHIELD WALL, NW QUADRANT	1930	D	6350
DM-5	526	123	SECONDARY SHIELD WALL, NW QUADRANT	1930	C	6560
DM-5	526	123	SECONDARY SHIELD WALL, NW QUADRANT	1931	D	5980
DM-5	526	123	SECONDARY SHIELD WALL, NW QUADRANT	1931	C	6370

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
526	Pour Summary:		Standard Variation: 242.556		4 Samples	Ave. Fc: 6315
DM-5	534	123	SECONDARY SHIELD WALL, WEST SIDE	1950	D	6510
DM-5	534	123	SECONDARY SHIELD WALL, WEST SIDE	1950	C	6280
534	Pour Summary:		Standard Variation: 162.635		2 Samples	Ave. Fc: 6395
DM-5	537	131	SECONDAY SHIELD WALL, EAST SIDE	1953	D	6130
DM-5	537	131	SECONDAY SHIELD WALL, EAST SIDE	1953	C	6120
DM-5	537	131	SECONDAY SHIELD WALL, EAST SIDE	1954	C	6030
DM-5	537	131	SECONDAY SHIELD WALL, EAST SIDE	1954	D	6100
537	Pour Summary:		Standard Variation: 45.0925		4 Samples	Ave. Fc: 6095
DM-5	559	131	SECONDARY SHIELD WALL, NW QUADRANT	1988	D	6540
DM-5	559	131	SECONDARY SHIELD WALL, NW QUADRANT	1988	C	6300
DM-5	559	131	SECONDARY SHIELD WALL, NW QUADRANT	1989	D	6050
DM-5	559	131	SECONDARY SHIELD WALL, NW QUADRANT	1989	C	6050
559	Pour Summary:		Standard Variation: 235.018		4 Samples	Ave. Fc: 6235
DM-5	566	131	SECONDARY SHIELD WALL, SW QUADRANT	1997	D	6370
DM-5	566	131	SECONDARY SHIELD WALL, SW QUADRANT	1997	C	5980
DM-5	566	131	SECONDARY SHIELD WALL, SW QUADRANT	1998	D	5590
DM-5	566	131	SECONDARY SHIELD WALL, SW QUADRANT	1998	C	5980
566	Pour Summary:		Standard Variation: 318.434		4 Samples	Ave. Fc: 5980
DM-5	568	131	SECONDARY SHIELD WALL, WEST SIDE	1994	C	5240
DM-5	568	131	SECONDARY SHIELD WALL, WEST SIDE	1994	D	5750
568	Pour Summary:		Standard Variation: 360.624		2 Samples	Ave. Fc: 5495
DM-5	570	104	RC DRAIN TANK ROOM WALLS	1999	D	5220
DM-5	570	104	RC DRAIN TANK ROOM WALLS	1999	C	5220
570	Pour Summary:		Standard Variation: 0		2 Samples	Ave. Fc: 5220
DM-5	585	135	FLOOR SLAB, EAST SIDE	2012	D	5640
DM-5	585	135	FLOOR SLAB, EAST SIDE	2012	C	5220
DM-5	585	135	FLOOR SLAB, EAST SIDE	2013	C	5620
DM-5	585	135	FLOOR SLAB, EAST SIDE	2013	D	6010
DM-5	585	135	FLOOR SLAB, EAST SIDE	2014	C	5750
DM-5	585	135	FLOOR SLAB, EAST SIDE	2014	D	5750
585	Pour Summary:		Standard Variation: 258.515		6 Samples	Ave. Fc: 5665
DM-5	595	107	ROOF SLAB, RC DRAIN TANK ENTRY	2022	C	6050
DM-5	595	107	ROOF SLAB, RC DRAIN TANK ENTRY	2022	D	5800
595	Pour Summary:		Standard Variation: 176.777		2 Samples	Ave. Fc: 5925
DM-5	607	133	SECONDARY SHIELD WALL, SE QUADRANT	2035	D	5270
DM-5	607	133	SECONDARY SHIELD WALL, SE QUADRANT	2035	C	5010
607	Pour Summary:		Standard Variation: 183.848		2 Samples	Ave. Fc: 5140
DM-5	611	138	SECONDARY SHIELD WALL, SW QUADRANT	2039	C	5610
DM-5	611	138	SECONDARY SHIELD WALL, SW QUADRANT	2039	D	5500

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
611	Pour Summary:		Standard Variation: **77.7817**		**2** Samples	Ave. Fc: **5555**
DM-5	613	135	REFUEL CANAL FLOOR SLAB	2042	C	5750
DM-5	613	135	REFUEL CANAL FLOOR SLAB	2042	D	5590
DM-5	613	135	REFUEL CANAL FLOOR SLAB	2043	C	5470
DM-5	613	135	REFUEL CANAL FLOOR SLAB	2043	D	5680
DM-5	613	135	REFUEL CANAL FLOOR SLAB	2044	D	5010
DM-5	613	135	REFUEL CANAL FLOOR SLAB	2044	C	5850
DM-5	613	135	REFUEL CANAL FLOOR SLAB	2045	D	5820
DM-5	613	135	REFUEL CANAL FLOOR SLAB	2045	C	5840
DM-5	613	135	REFUEL CANAL FLOOR SLAB	2046	D	5110
DM-5	613	135	REFUEL CANAL FLOOR SLAB	2046	C	5220
613	Pour Summary:		Standard Variation: **316.832**		**10** Samples	Ave. Fc: **5534**
DM-5	619	138	SECONDARY SHIELD WALL, NE QUADRANT	2053	D	5160
DM-5	619	138	SECONDARY SHIELD WALL, NE QUADRANT	2053	C	5430
619	Pour Summary:		Standard Variation: **190.919**		**2** Samples	Ave. Fc: **5295**
DM-5	638	143	SECONDARY SHIELD WALL, SE QUADRANT	2070	D	5310
DM-5	638	143	SECONDARY SHIELD WALL, SE QUADRANT	2070	C	5450
638	Pour Summary:		Standard Variation: **98.9949**		**2** Samples	Ave. Fc: **5380**
DM-5	648	143	SECONDARY SHIELD WALL, SW QUADRANT (N	2094	D	4790
DM-5	648	143	SECONDARY SHIELD WALL, SW QUADRANT (N	2094	C	5380
648	Pour Summary:		Standard Variation: **417.193**		**2** Samples	Ave. Fc: **5085**
DM-5	649	143	SECONDARY SHIELD WALL, NE QUADRANT	2095	C	5020
DM-5	649	143	SECONDARY SHIELD WALL, NE QUADRANT	2095	D	4530
649	Pour Summary:		Standard Variation: **346.482**		**2** Samples	Ave. Fc: **4775**
DM-5	650	140	SECONDARY SHIELD WALL, NW QUADRANT (N	2096	D	5550
DM-5	650	140	SECONDARY SHIELD WALL, NW QUADRANT (N	2096	C	5540
DM-5	650	140	SECONDARY SHIELD WALL, NW QUADRANT (N	2097	D	6190
DM-5	650	140	SECONDARY SHIELD WALL, NW QUADRANT (N	2097	C	5320
650	Pour Summary:		Standard Variation: **375.322**		**4** Samples	Ave. Fc: **5650**
DM-5	653	143	FUEL TRANSFER CANAL WALL	2100	D	5770
DM-5	653	143	FUEL TRANSFER CANAL WALL	2100	C	6240
DM-5	653	143	FUEL TRANSFER CANAL WALL	2101	C	5680
DM-5	653	143	FUEL TRANSFER CANAL WALL	2101	D	5500
DM-5	653	143	FUEL TRANSFER CANAL WALL	2102	D	6400
DM-5	653	143	FUEL TRANSFER CANAL WALL	2102	C	6150
653	Pour Summary:		Standard Variation: **356.127**		**6** Samples	Ave. Fc: **5957**
DM-5	662	119	ROOF SLAB, RC DRAIN TANK	2112	C	6130
DM-5	662	119	ROOF SLAB, RC DRAIN TANK	2112	D	6000
662	Pour Summary:		Standard Variation: **91.9239**		**2** Samples	Ave. Fc: **6065**
DM-5	669	143	SECONDARY SHIELD WALL, NW QUADRANT	2128	D	5020

Detail and Summary of 28 days Cylinder Tests for Containment Building

Mix	Pour	Elev	Description	Cylinder	A	Fc
DM-5	669	143	SECONDARY SHIELD WALL, NW QUADRANT	2128	C	4860
669	Pour Summary:		Standard Variation: 113.137	2	Samples Ave. Fc:	4940
DM-5	Mix Summary:		Standard Variation: 508.316	239	Samples Ave. Fc:	5640
T-21510	Mix Summary:		Standard Variation: 213.604	12	Samples Ave. Fc:	3791
T-21510	230	114	TEMPORARY & SECONDARY SHIELD WALL	1322	D	4000
T-21510	230	114	TEMPORARY & SECONDARY SHIELD WALL	1322	C	3890
230	Pour Summary:		Standard Variation: 77.7817	2	Samples Ave. Fc:	3945
T-21510	608	119	EL. 119 MEZZANINE FLOOR, SOUTH	2036	C	3590
T-21510	608	119	EL. 119 MEZZANINE FLOOR, SOUTH	2036	D	3770
608	Pour Summary:		Standard Variation: 127.279	2	Samples Ave. Fc:	3680
T-21510	740	119	EL 119 MEZZANINE FLOOR, WEST	2222	D	3630
T-21510	740	119	EL 119 MEZZANINE FLOOR, WEST	2222	C	3590
740	Pour Summary:		Standard Variation: 28.2843	2	Samples Ave. Fc:	3610
T-21510	760	168	ELEVATOR WALLS	2250	D	3700
T-21510	760	168	ELEVATOR WALLS	2250	C	3590
760	Pour Summary:		Standard Variation: 77.7817	2	Samples Ave. Fc:	3645
T-21510	780	160	EL 160 FLOOR SLAB, NE	2276	C	3710
T-21510	780	160	EL 160 FLOOR SLAB, NE	2276	D	3710
780	Pour Summary:		Standard Variation: 0	2	Samples Ave. Fc:	3710
T-21510	807	119	MEZZANINE EL 119, WEST	2306	C	4240
T-21510	807	119	MEZZANINE EL 119, WEST	2306	D	4070
807	Pour Summary:		Standard Variation: 120.208	2	Samples Ave. Fc:	4155
T-21510	Mix Summary:		Standard Variation: 213.604	12	Samples Ave. Fc:	3791
RB	Structure Summary:		Standard Variation: 605.23	451	Samples Ave. Fc:	5650

19 pages

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Title: "As-Built Concrete Strength for Class I Structures"

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I. Purpose

The purpose of this calculation is to determine the in-place strength of concrete for use in evaluating concrete anchor spacing issues. This calculation applies to major Class I structures with the exception of the Emergency Feedwater Tank Enclosure and Diesel Driven Emergency Feedwater Pump Enclosure.

II. Results / Conclusions

A statistical evaluation of concrete test cylinder results for Class 3000 concrete was performed in accordance with current American Concrete Institute codes and standards to determine the as-placed concrete compressive strength. Samples of test cylinder data were evaluated to determine the concrete strength gain due to short term curing/aging. The CR3 test data was compared to long-term aging research to determine the magnitude of strength gain due to aging at CR3. All of the previous factors were combined to determine the in-place concrete strength at CR3.

The in-place compressive strength for concrete in Class I structures is as shown below. Exception areas for Class 3000 concrete are shown in Attachment J. There are several areas where Class 3000 concrete was specified on the structural drawings, but Class 5000 concrete was actually placed. Those areas can be identified through review of Attachment B. The Class 5000 in-place compressive strength value can be used in those areas for evaluation of local effects, such as concrete anchor spacing violations.

Class 3000 (other than in exception areas)	5460 psi
Class 3000 in exception areas	4860 psi
Class 5000	6720 psi

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III. Design Input

Concrete Pour records are located in the Construction Microfiche files starting with 1P02032 through 1P10096 and continuing at 1C01001 through 1C10033A.

No active CR3 plant drawings relating the Pour designations used in the construction records to specific plant locations were located. Many of the Pours have sketches in the microfiche records, and there are references to "CR3-S" series drawings that were not retained after construction.

Design Strength of Concrete (Refs. 1, 2, & 3)

- The specified 28-day design strength for Class I Structures is as follows:

Containment & Containment Interior Structures	5000 psi
except Floors at El 119 & 160 and Elevator	3000 psi
All other Class I Structures	3000 psi

- Class I Structures are as defined in the EDBDs (Refs. 1, 2,& 3)
- Type II cement was specified for all structural concrete (Ref. 4)
- Concrete testing was performed in accordance with ACI 301-66 (Ref. 4, SP-5569).
- Concrete design was performed in accordance with ACI 318-63 (Refs. 1, 2, & 3)

IV. Assumptions

None requiring later verification

The average compressive strength and standard deviation statistics calculated were based on the results of individual cylinder break results, rather than the average of two cylinder break tests. This was done for convenience because the construction data for CR3 had a few pours with only one valid cylinder break. The effect on average strength in insignificant for populations of sufficient size. The effect of this methodology on the standard deviation of the population being evaluated is conservative, because it always results in a larger value for the standard deviation. However, for large sample sizes the difference in standard deviation is small and does not effect the results of this evaluation.

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V. References

1. "Design Basis Document for the Containment", Rev. 2, Tab 1/1
2. "Design Basis Document for the Containment Interior Structures", Rev. 1, Tab 1/2
3. "Design Basis Document for Major Class I Structures", Rev. 1, Tab 1/3
4. SP-5569 through Addendum D, "Specification for Furnishing and Delivering of Structural Concrete"
5. ACI 214-77, "Recommended Practice for Evaluation of Strength Test Results of Concrete", Reapproved 1989
6. ACI 214.3R-88, "Simplified Version of the Recommended Practice for Evaluation of Strength Test Results of Concrete"
7. ACI-225R-91, "Guide to the Selection and Use of Hydraulic Cements"
8. ACI 301-89, "Specifications for Structural Concrete for Buildings"
9. ACI 318-89,"Building Code Requirements for Reinforced Concrete", Revised 1992
10. ACI 349-90, "Code Requirements for Nuclear Safety Related Concrete Structures"
11. ACI 363R-92, "State-of-the-Art Report on High-Strength Concrete"
12. Waddell, Joseph J.(Editor), "Concrete Construction Handbook", McGraw-Hill Book Co., 1968

VI. Detailed Calculations

Background

The compressive strength of concrete increases with age if moisture is present. Strength increases have been documented for aging up to 50 years, generally following a logarithmic curve (Ref. 12). At early ages, higher-strength concrete shows a higher rate of strength gain (in terms of absolute strength) as compared to lower-strength concrete. However, after approximately 95 days the differences in normalized strength gain are not significant (Ref. 11). When normalized to 90-day compressive strength, typical concrete made from Type II cement shows a strength gain of approximately 25% after 5 years (Ref. 7, Fig. 6.1).

Variations in strength test results are due to differences in the strength-producing properties of the concrete mixture and ingredients, and apparent differences due to variations inherent in testing. It is well established that concrete strength is governed to a large extent by the water-cement ratio. The results of concrete cylinder tests for a specific mix design produced over time with good quality control are expected to fall into a pattern similar to the normal frequency distribution curve. (Ref. 5)

The required average compressive strength f'_{cr} to be used for selection of a concrete mix is the larger of the following (ACI 318-89 5.3.2.1 & ACI 349-90 4.3.2.1):

$$f'_{cr} = f'_c + 1.34\ s$$

or

$$f'_{cr} = f'_c + 2.33\ s - 500$$

where f'_c is the specified design compressive strength, and s is the standard deviation of the compressive strength test results. These equations provide a probability of about 1% that the averages of 3 consecutive strength test results will be below the specified f'_c, and a similar probability that any individual test will be more than 500 psi below the specified compressive strength. The standard deviation s is to be determined from a minimum of 30 tests. However, 100 tests are recommended. Each test is the average of at least 2 cylinders made from the same batch of concrete, cured under the same conditions, and tested at the same age (Ref. 6).

The strength level of an individual class of concrete is considered satisfactory if both of the following requirements are met (ACI 318-89 5.6.2.3 & ACI 349-90 4.7.2.3):

(a) average of all sets of three consecutive strength tests $\geq f'_c$

and

(b) no individual strength test (average of two cylinders) $< (f'_c - 500$ psi)

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Methodology

Structural concrete for Class I structures at CR3 is either Class 3000 or Class 5000 (the lone exception being the RB Dome repair which utilized Class 6000 concrete). Although several different mixes were used for the Class 5000 concrete, the materials used were the same as the Class 3000 concrete. Type II cement was used to minimize heat development and the subsequent volume changes and cracking during hydration of the cement. All of the structural concrete used the same admixtures (Darex and Daratard). The major difference between the Class 3000 and Class 5000 concrete mixes are the water-cement ratio.

The concrete mixes most often used for Class I concrete at CR3 are as follows:

Mix	Class	Comments
658550-2	6000	RB Dome repair only
727550-2	5000	
736441	5000	Primarily used in Ring Girder
DM-5	5000	
DM-7	5000	Primarily used for repairs
T-21510	3000	

The three mixes used for the bulk of the large structural pours are T-21510, DM-5, and 727550-2. It appears that DM-5 was the Class 5000 concrete mix early in the job, and 727550-2 replaced DM-5 for later pours. Mix 727550-2 had a higher cement factor.

As would be expected for a concrete construction job as large as CR3, all of the mixes underwent small modifications during the project. Cursory review indicates that the mix modifications were to the cement factor (bag/cu yd), and that water-cement ratios were held constant. Since the water-cement ratio is the single most important factor influencing concrete strength, any minor effects on compressive strength and the rate of strength gain due to the mix modifications are not considered in this calculation. A mix designation as used in this calculation includes all modifications of the mix.

This calculation will evaluate two different aspects of concrete strength at CR3:

1. Long-term strength gain for Class 3000 and Class 5000 concrete
   a. 28 to 90-day strength gain
   b. Post 90-day strength gain
   c. Discussion of conservatism
2. As-placed concrete strength for Class 3000 concrete

The specified compressive strengths for concrete at CR3 were 28-day strengths. For the purposes of this calculation, long-term strength gains are considered as those occurring after 28 days. The strength gain over a time increment will be determined as ratio f_{cT1} / f_{cT0} . The use of the ratio essentially normalizes the data, and breaks the strength vs. time curve into linear segments.

Ample data exists for Class 5000 concrete to determine the 28-day and 90-day average compressive strengths from statistically significant samples. Class 3000 concrete has only limited 90-day test data, which will be evaluated to determine its validity. Strength gains from 7 to 28 to 90 days for the limited data set will be compared to 7 to 28 day strength gains for a statistically significant sample of Class 3000 cylinder test data.

There is no test data for CR3 concrete past 90 days. Strength gains past 90 days will be conservatively estimated by comparison of CR3 concrete to research presented in the literature.

Concrete mixes are conservatively designed to exceed the compressive strength required, due to the inherent strength variations of the as-placed mixture caused by a many conditions that vary in the field. The ACI codes recognize the potential for strength variations, and specify the margin required for a concrete mix design. The codes allow for a statistically small amount of concrete that may be less than the specified design strength. If good quality control is used during construction, the concrete placed may be significantly stronger than required by the design specifications.

For calculations where concrete strength is a critical factor, such as for anchor spacing evaluations, there is a large benefit to taking advantage of higher concrete strengths. Therefore, the 28-day test data for Class 3000 concrete placed for the Class I structures of interest will be reviewed to determine the strength of concrete that was actually placed. A statistical evaluation of the data will be performed and each set of data will be checked against the ACI compressive strength acceptability criteria previously discussed.

Sufficient data also exists to determine the as-placed compressive strength for Class 5000 concrete. However, due to the effort required to retrieve the test data and the already higher specified strength, the evaluation is not warranted for Class 5000 concrete.

In order to evaluate the concrete used in Class I structures at CR3, the concrete pour records were reviewed. The structures of interest are primarily the RB, AB, CC, IB, and DGB, since those buildings are where the vast majority of safety related concrete anchorages are located. Concrete pours for Berm Protection (wave steps) and Hurricane Protection walls were included in the review only to the extent that test data from those pours was relevant to the structures of interest. Also note that only the east side of the Intake Structure is considered Class I.

The concrete pours for the buildings of interest were generally numbered in sequential order, with a suffix indicating the building or structure. The pour records reviewed generally have a pour slip with data about the pour, truck slips and QC reports, usually a sketch showing the specific pour location, and test data for test cylinders associated with the pour.

A listing of the concrete pours reviewed is shown in Attachment A. The location description and elevations shown for the top of the pour should be considered reference only; for specific details the pour records should be consulted.

Attachment B shows concrete pours generally grouped by building and location. Again, the descriptions used for the list are not precise and the construction records should be consulted for specific details.

Long-term Strength Gain

A. 28 to 90-Day Strength Gain

The specified concrete strengths for concrete at CR3 were 28-day strengths. Class 5000 concrete generally had test cylinders broken at 7, 28, and 90 days. The Class 3000 concrete generally had only 7 and 28 day test cylinders. However, two sets of test cylinders for Mix T-21510 (Pours 28-DHP and 29-DHP) had 90 day tests.

Test cylinder data was retrieved for approximately 100 sets of cylinders each for Mixes T-21510, DM-5, and 727550-2. The sample size of at least 100 tests is per ACI recommendations for determination of compressive strength statistics. The average break strengths for the test cylinders were analyzed to determine the average strength gain from 7 to 28 to 90 days, as applicable. The data and strength gain evaluations are presented in Attachments C, D, E, and F. The results of a statistical analysis of the test cylinder samples are show in Attachment G (Note: Statistics for Mix T-21510 on Attachment G, Page 5 are for a larger sample discussed later).

Comparison of the two Class 5000 mixes show that they are virtually identical regarding strength and strength development. At 90 days the average compressive strength of the two mixes is within 100 psi and the standard deviations vary by only 20 psi. The 28-day test results show considerable scatter when compared to the expected normal distribution, but the normal distribution curve is a reasonably good fit for the 90-day tests (see Figures 1 & 2). From 28 to 90 days, the standard deviations of both samples decreased significantly. This is possibly an indication of differences due to curing rates or modifications to the mix, and that those differences are not significant after 90 days. The apparent variations from the norm due to testing technique would not be expected to change according to test cylinder age.

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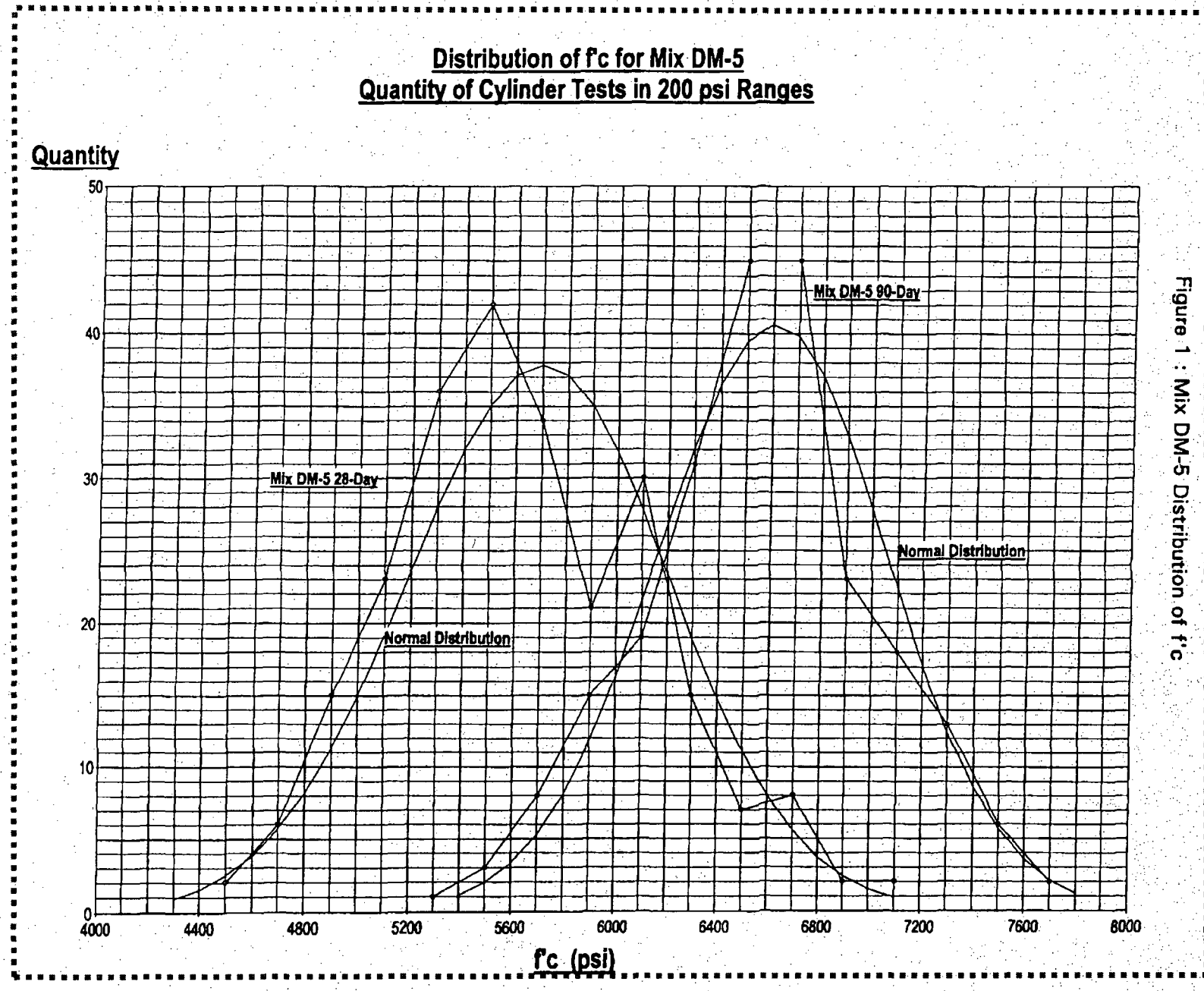

Figure 1 : Mix DM-5 Distribution of f'c

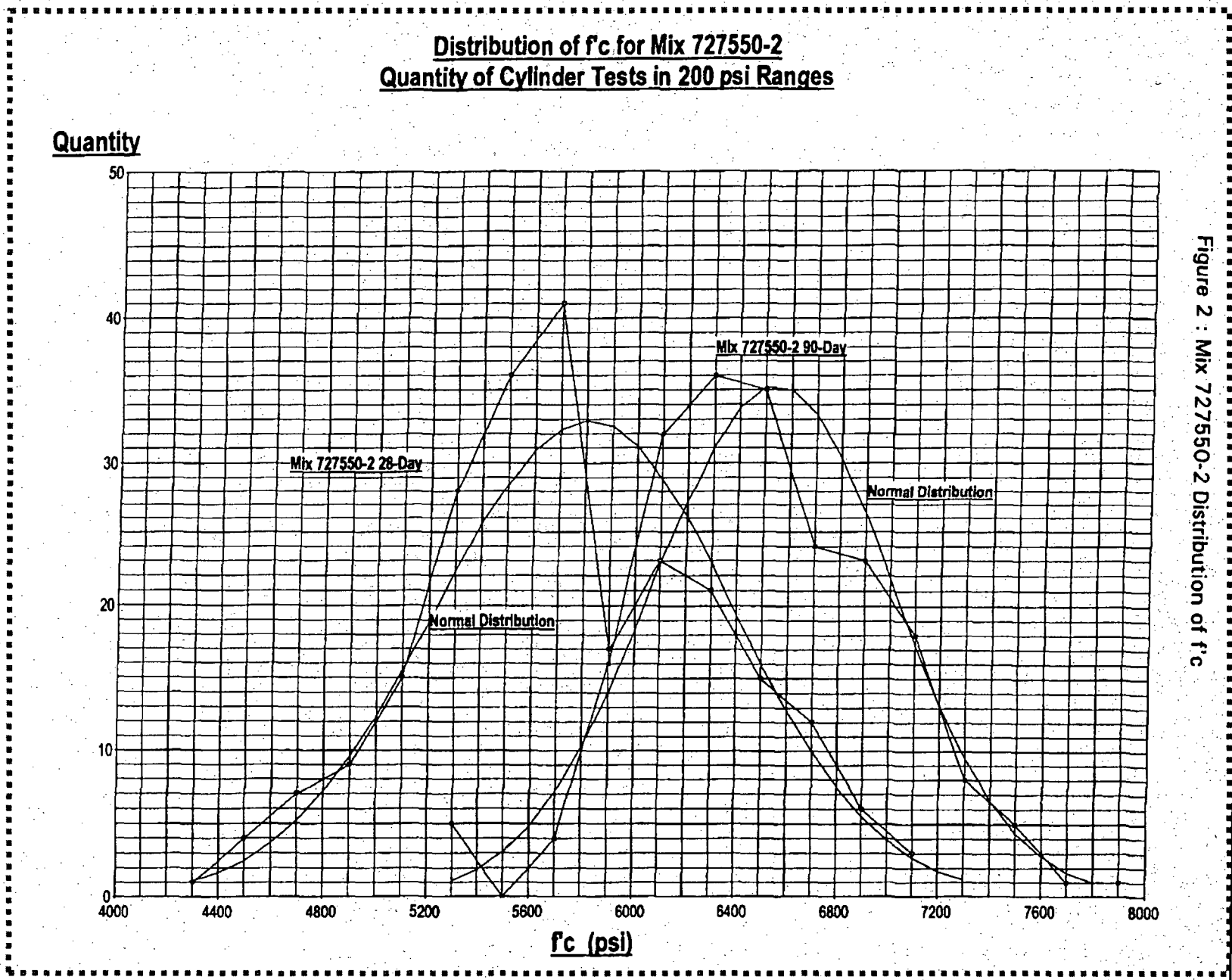

Figure 2 : Mix 727550-2 Distribution of f'c

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Figure 3 shows the average strength gains for the samples analyzed in Attachments C through F. The data in the attachments show the strength gain ratios for each set of cylinders, cured under the same conditions. The average of the gain ratios from the cylinder sets is slightly higher than the gain ratio calculated the average strengths of the samples for all of the samples. The more conservative (lower) gain ratios calculated from average compressive strengths are presented in Figure 3 and the table below.

	Days	Avg. f'c	f'c-90 / f'c-28
Mix DM-5	7	4265	
(Attachment D)	28	5641	
	90	6558	1.16
Mix 727550-2	7	4249	
(Attachment E)	28	5791	
	90	6489	1.12
Mix T-21510	7	2911	
(Attachment C)	28	4535	
DHP Pours 28 & 29	7	2808	
(Attachment F)	28	4340	
	90	5805	1.34

Although the differences between the two Class 5000 concrete mixes are not statistically significant, the strength gain from 28 days to 90 days will be conservatively considered to follow the Mix 727550-2 curve due to its slightly flatter slope. The gain from 28 days to 90 days for Class 5000 concrete is 12%.

Comparison of the data for Mix T-21510 from Attachment C to the data from the two pours in the Decay Heat Pit (Attachment F) for the same concrete mix leads to the conclusion that Pours 28-DHP and 29-DHP are representative of all of the Class 3000 concrete. The strength gain from 7 to 28 days is parallel for both samples, so a projection of the T-21510 sample average compressive strength at 28 days out to a 90-day compressive strength based on the two DHP pours is justified. A conservative straight-line extrapolation of the T-21510 data would give a 90-day compressive strength of approximately 5900 psi, as shown on Figure 3. That is equivalent to a gain from 28 days to 90 days of

$$(5900 - 4535) / 4535 = 30\%$$

The straight line extrapolation is considered conservative because it results in lower gain ratio than the data from the two DHP pours.

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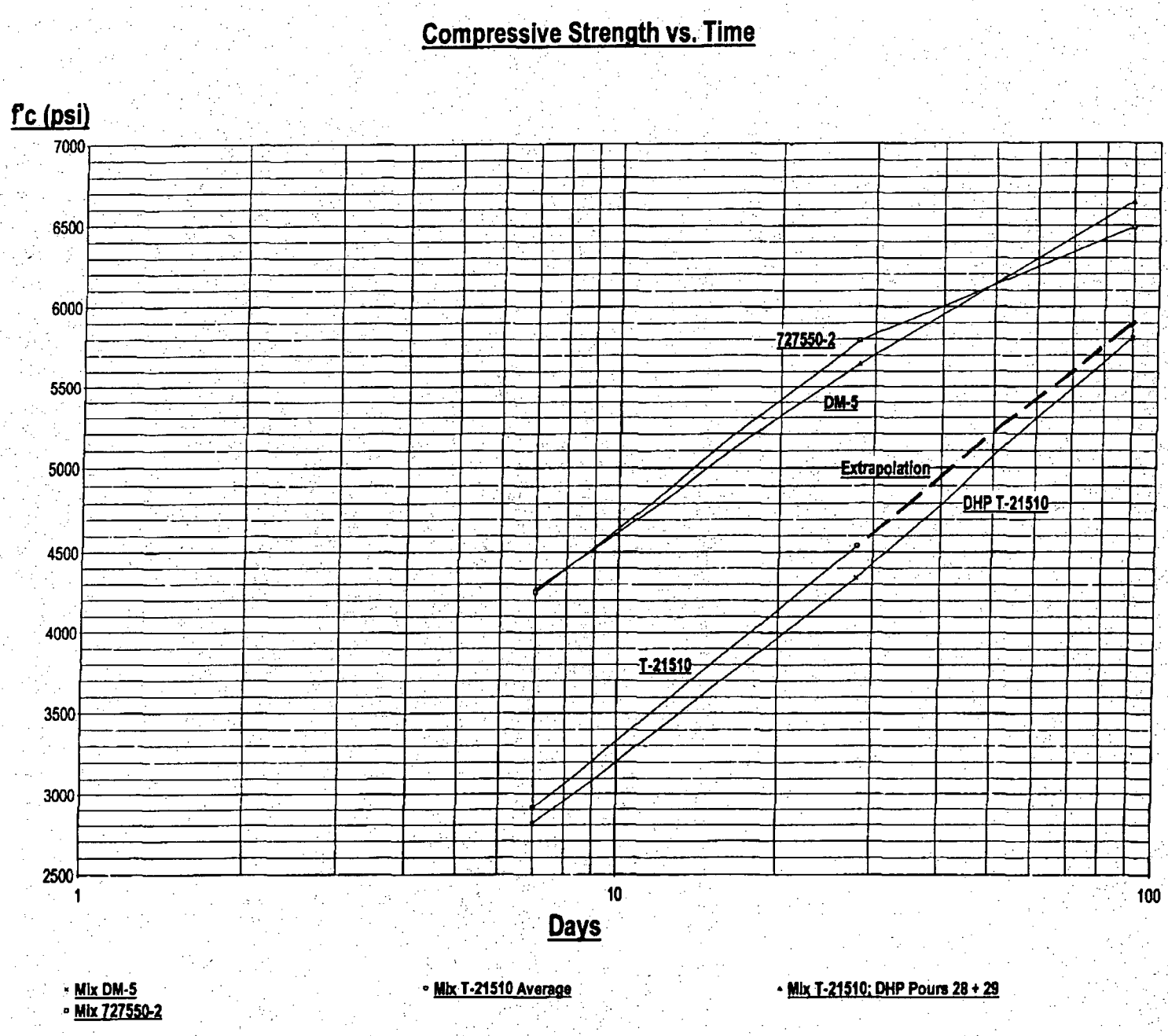

Figure 3 : Strength Gain for CR3 Concrete

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B. Post 90-Day Strength Gain

The rate of compressive strength gain for a typical concrete made from Type II cement is shown in ACI 225R-91 Fig. 6.1 (Ref. 7):

Typical Strength Development for Type II Cement		
Time		
Days	Yrs	f'c
7		2550
28		3450
90		4200
180		5200
365	1	5650
730	2	6200
1095	5	6500

Note: Fig. 6.1 in ACI 225R-91 has mislabeled the time axis, showing the 5 year data as 3 years. The error is apparent if the data is plotted to scale. The "Concrete Construction Handbook" (Ref. 12) presents the same graph showing the data at 5 years.

The comparison of the three CR3 mixes to the typical Type II curve is shown in Figure 4. All of the CR3 mixes have a higher rate of strength gain from 28 days to 90 days than the ACI curve. The CR3 concrete mixes are higher strength than the typical Type II data.

Higher-strength concrete would be expected to gain strength more quickly than lower strength concrete. The use of admixtures could also affect the rate of strength gain. Therefore, deviations of sample data from the typical curve would be expected, but differences might be expected to diminish with time. After 90 days the strength gain due to aging should be similar for concretes made from the same type of cement. This would be indicated on a graph such as Figure 4 by parallel lines. More scatter would be expected for data from early ages, with a trend toward more consistency with increasing time.

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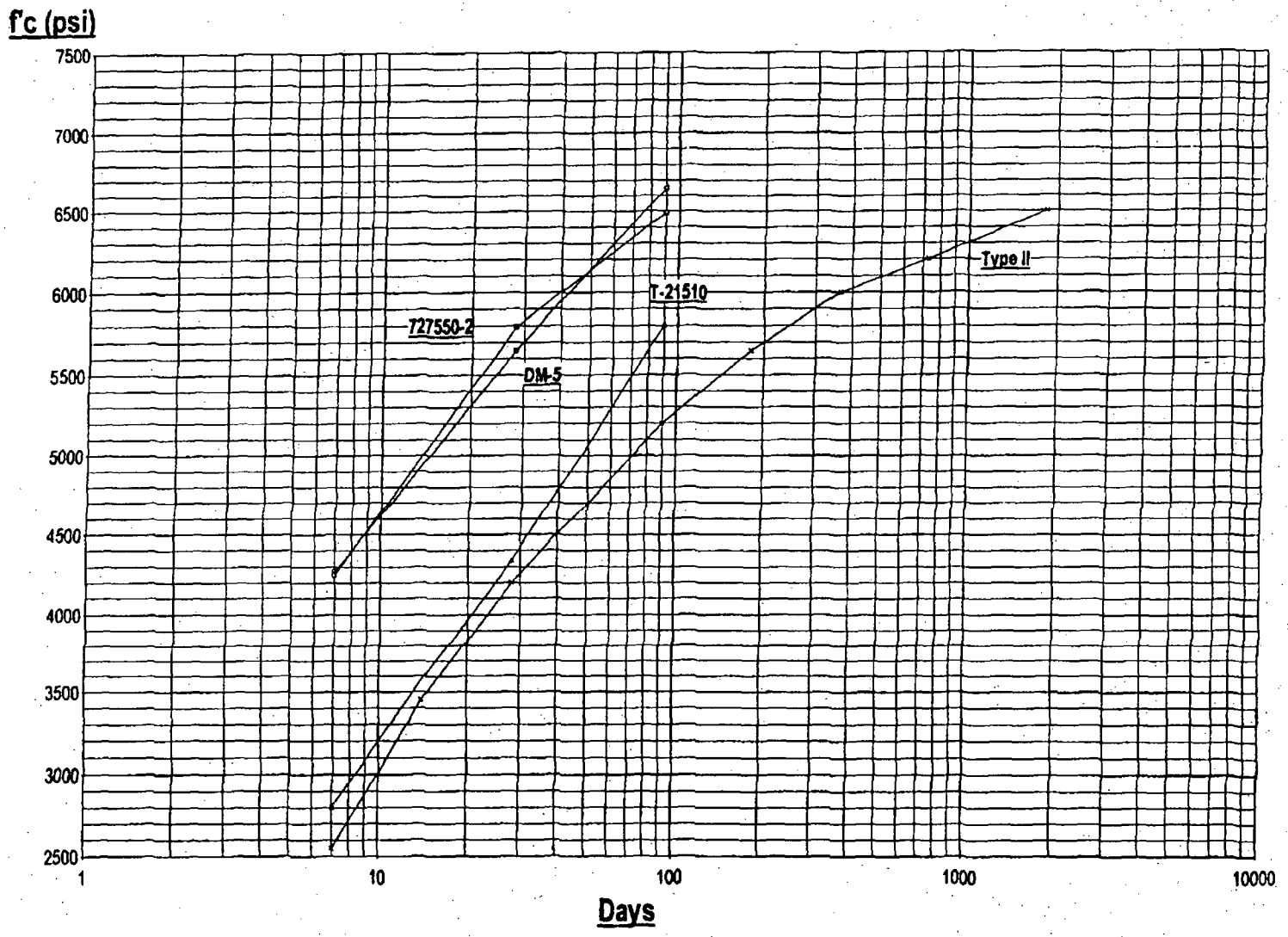
Compressive Strength vs. Time



- Typical Type II Cement
- Mix 727550-2
- Mix DM-5
- Mix T-21510 in DHP

Figure 4 : Strength Gain for Typical Type II Cement Mixtures

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To eliminate the effects of different design compressive strengths on the comparison, the data has been normalized to 90 days and replotted in Figure 5. The data as presented in this format show a reasonable agreement with the typical Type II curve when consideration is given to the higher early strength gain expected for higher strength mixes. Although the data, by definition, converge at 90 days due to normalization, the trend agrees with the typical Type II cement curve.

The typical Type II cement curve from ACI shows a strength gain from 90 days to 5 years of 25%. A conservative extrapolation of the data from the CR3 mixes past 90 days, giving consideration to the decreasing slope of the strength gain curve, leads to the conclusion that a 20% strength gain from 90 days to 5 years could reasonably be expected for CR3 concrete.

Concrete strength gains due to aging have been documented to occur out to 50 years. However, after about 5 years the strength gains become small and relevant data in the literature was not located. Neglecting strength gains that may occur after 5 years is conservative. The earliest Class I concrete pours at CR3 were started in June 1970. The major structural elements were completed by early 1976. Given the age of the CR3 concrete, a strength gain of 20% from 90 days to the present would appear to be a conservative projection, based on the supporting data.

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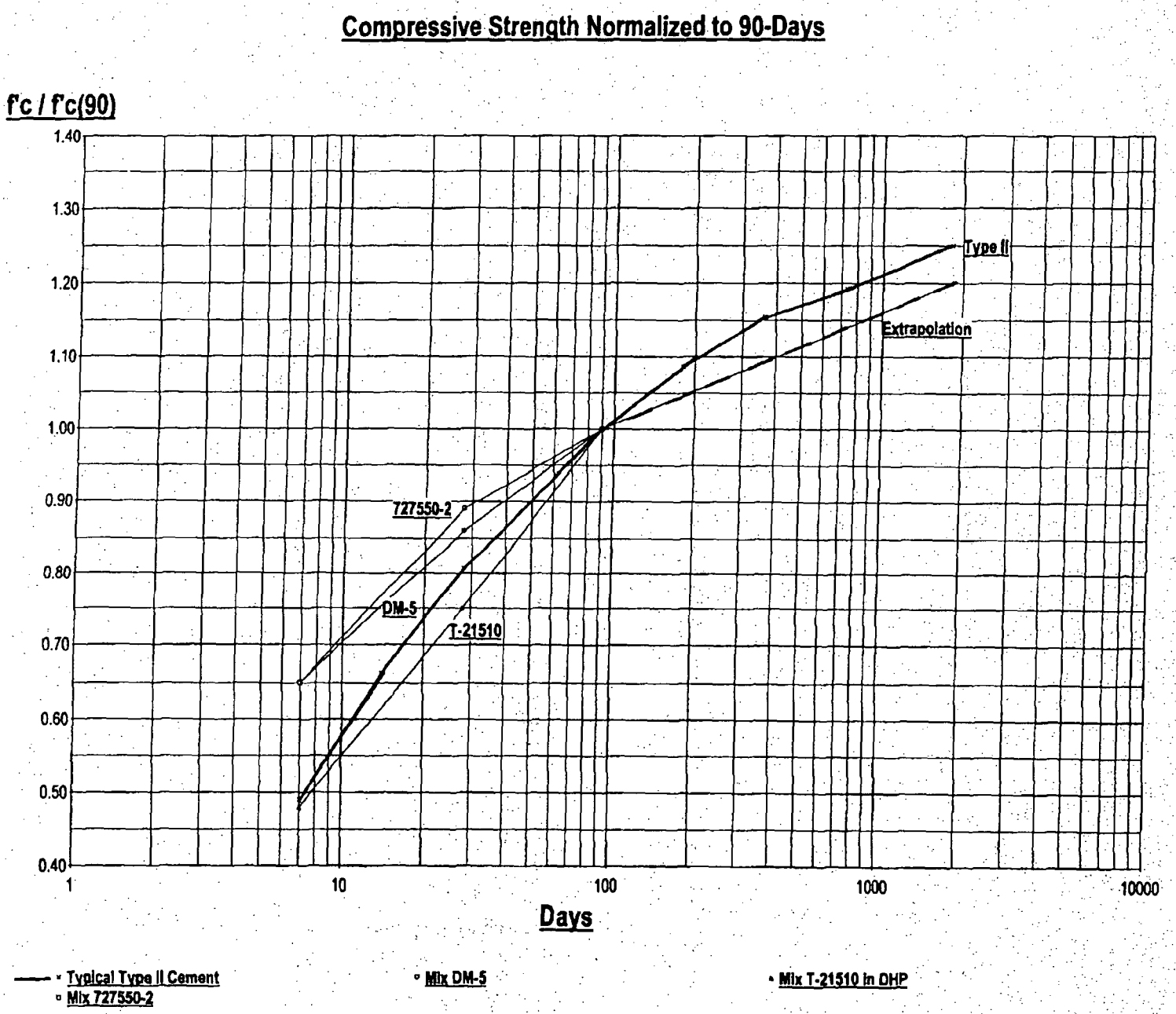
Figure 5 : Compressive Strength Normalized to 90 Days



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C. Discussion of Conservatism

The compressive strength vs. time curve for concrete has been approximated by straight line segments on a semi-logarithmic graph. Based on existing test data, extrapolations, and comparison with typical concrete aging data in the literature, the slopes of the line segments (or "gain ratios") have been conservatively determined. For the purposes of this calculation, a conservative gain ratio is one that results in a lower compressive strength. The conservatism for each gain ratio has been previously discussed.

The strength vs. time curve that is represented by the line segments describes the behavior of **average** compressive strength (designated as $f_{c\ Avg}$). The CR3 cylinder test data and the typical Type II cement curve from which the gain ratios were determined use average concrete strength from cylinder compression tests.

ACI codes require that concrete mixes be selected such that the average compressive strength required (f'_{cr}) exceeds the compressive strength used for design (f'_c). This is done so that only a statistically small amount of concrete would be expected to be understrength. The margin required is related to the standard deviation "s" of the results of a population of cylinder tests for the proposed mix. The more restrictive of the following two requirements applies:

$$f'_{cr} = f'_c + 1.34\ s$$

or

$$f'_{cr} = f'_c + 2.33\ s - 500$$

If the standard deviation of the selected mix is known and assumed to remain constant for jobs with good quality control, then the margin required for both requirements above is essentially a multiple of s. For simplicity, the margin will be considered as 1.34 s for the remainder of this discussion.

After concrete has been placed and cylinder tests have been completed, $f_{c\ Avg}$ and s are known. The maximum design compressive strength that can be credited can be found by rearranging the equation, using $f_{c\ Avg}$ for f'_{cr} :

$$f'_c = f_{c\ Avg} - 1.34\ s$$

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Typically the design strength f'_c for concrete is specified at 28 days. If the long-term design strength is predicted using "gain ratios" derived from average strength data, the result will be conservative because of the 1.34 s term in the above equation.

Consider the following example, for a concrete with 28-day test results of $f_{c\ Avg}$ = 5670 psi and s = 500 psi (s assumed constant over time). The 28-day design strength is back-calculated as

$$f'c = 5670 - 1.34 \times 500 = 5000 \text{ psi}$$

In the table below, the 90-day and 5-year values of $f_{c\ Avg}$ and f'_c are predicted using the gain ratios shown, and the third column is calculated from $f_{c\ Avg}$ and the constant s.

t	Gain Ratio	fc Avg	Predicted f'c	fc Avg - 1.34 s
28 days		5670	5000	5000
90 days	1.12	6350	5600	5680
5 yrs	1.20	7620	6720	6950

Figure 6 shows the conservatism that results from predicting f'c using average strength gain ratios. If the gain ratios properly predict the average strength of the concrete and the standard deviation of the sample remains constant, the design compressive strength that could be utilized is represented by the line parallel to the average strength curve, and is always (1.34 x s) less than the average strength. The predicted f'c curve is always lower, and the difference becomes greater if larger gain ratios are utilized for any line segment. Note that the 28 to 90-day gain ratio for Class 3000 concrete was determined to be 1.30.

The discussion above has considered that the standard deviation is constant over time. As noted previously when evaluating the test result sample population statistics for Class 5000 concrete, the standard deviations decreased significantly between 28 and 90 days. This is reasonable as small differences in curing rates would be expected to diminish with time, and the sample population would therefore become more uniform. If s decreases with time then the term (1.34 x s) also decreases, which results in a larger difference (more conservative) between the predicted design compressive strength and the maximum value that could be utilized.

Summarizing the discussion above:

Use of the conservative average compressive strength "gain ratios" to predict long term design strength results in even more conservatism.

Florida Power CORPORATION

DESIGN ANALYSIS/CALCULATION

Crystal River Unit 3

DESA-C.FRM

DOCUMENT IDENTIFICATION NO. S-00-0047

REVISION 0

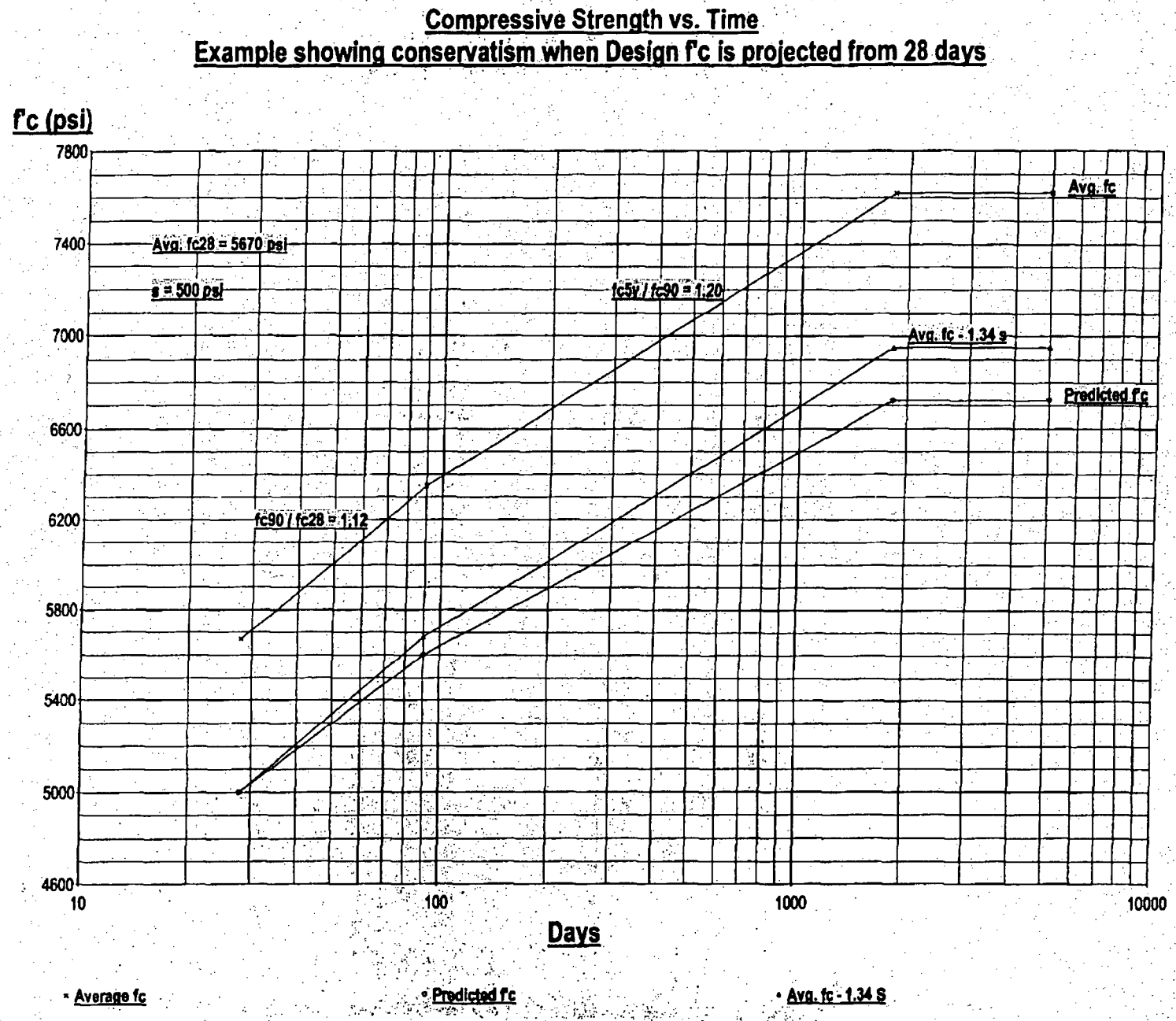

Figure 6 : Example Showing Conservatism of Strength Projections

PITTSBURGH TESTING LABORATORY

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Order No. TA-7732

1 pg

REPORT

Date _____

REPORT OF TEST ON CONCRETE CYLINDERS
6 DIAMETER BY 12 LENGTH

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

LOGGED

Inspector A. Von Nyvenheim
A. VON NYVENHEIM, PTL

POUR: 712 RB

Date Cast 2-16-73 Concrete Class 5000 P.S.I. Area 28.27 Sq. In.

Cement Factor 7.25 Brand Fla. Portland Type II Aggregate Size ASTM# 67

DEL. S/N.	CYLINDER IDENT.	W/C GAL.-SACK	SLUMP INCHES	AIR %	CONCRETE TEMP. °F.	DATE TESTED	AGE DAYS	TOTAL LOAD LBS.	COMP. ST. P.S.I.	SPECIFIC LOCATION
02432	2181 A	4.57	1 3/4	3.4	60	2-23-73	7	138,500	4900	50' E-Butt #
	B					"	"	136,000	4810	3, Elev. 202'
	C					3-16-73	28	176,500	6240	
	D					"	"	175,000	6190	
	E					5-17-73	90	188,000	6650	
	F					"	"	188,000	6650	
02441	2182 A	4.59	2 1/2	3.5	59	2-23-73	7	142,000	5020	20' W-Butt #
	B					"	"	142,500	5040	4, Elev. 205'
	C					3-16-73	28	153,000	5410	
	D					"	"	151,500	5360	
	E					5-17-73	90	206,000	7290	
	F					"	"	211,000	7470	

REMARKS: _____

cc: 2 - FPC Quality Records
3 - P T L

T13-21-3-7

PITTSBURGH TESTING LABORATORY

Robert T. McFillingy

ROBERT T. McFILLINGY, P.E.

10 pus

FLORIDA POWER CORPORATION

J. A. JONES CONSTRUCTION CO.

CRYSTAL RIVER UNIT #3

CONCRETE POUR SLIP

POUR NO. 712 RB

ACCOUNT NO. 3120410

REQUIRED MIX DM-5

QUANTITY 99 [redacted] c.y.

BUILDING REACTOR

DRAWING NO. SC 421-032-8 ✓

ENGINEER [signature]

LINE & GRADE OK

DIMENSIONS SKETCH TO BE SUBMITTED

DATE 16 Feb 19 73

WEATHER CLEAR

TEMPERATURE 43° (8:00 A.M.)

LOCATION EQUIPMENT EXTERIOR WALL BUTT 3 to 4 EL 209' to 210'

IRONWORKER FOREMAN [signature]

REINFORCING STEEL OK

EMBEDDED ITEMS OK

CARPENTER FOREMAN [signature]

FORMS OK

CHAMFER STRIPS OK

KEY WAYS OK

ANCHOR BOLTS OK

WHALERS & STRONG BACKS None

BLOCK OUTS None

LABOR FOREMAN [signature]

LAITANCE REMOVED OK

SURFACE PREPARED OK

GROUT IN PLACE OK

ELECTRICAL SUPT. OR FOREMAN [signature]

PENETRATIONS None

EMBEDDED ITEMS None

GROUNDING O.K. Tender Conduit

MECHANICAL SUPT. OR FOREMAN NA

PENETRATIONS NA

EMBEDDED ITEMS NA

REMARKS

INDEPENDENT AGENCY [signature]

F.P.C. SUPERVISOR(s) C. Pachos

ALL SIGN-OFFS MUST BE MADE BEFORE CONCRETE OR GROUT IS ORDERED.

QUALITY ENGINEER

FORM NO. FPC - 30

PITTSBURGH TESTING LABORATORY

PITTSBURGH, PA.

Order No. TA-7732
Supplier's Delivery
Serial No. 02432

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 2-15-73 Time Loaded 10:12 Class ~~AA~~ 5 mod Mass ☐ Other ☐
Truck No. 152 Load No. 6 Cu. Yds. 6 Counter to 0 ☐
Cum. Cu. Yds. 36 °F Moisture: F.A. 3.5 % 231 Lbs; C.A. 2.85 % 318 Lbs.

	Design S.S.D. Wt.	Adj. Batch Wt. BBS	
Cement (Type) ~~II~~	4092	4098	
C.A. (Size 67)	10800	11100	
(Size ____)			
F.A.	6600	6780	
Daratard HCF	126	126	
Darex AEA	28 BBS	28	
Water, ~~Gals.~~ lbs	1656 Total	987	Added
Ice		200 Lbs.	Gals.
Total Moisture		BBS 494 Lbs.	Gals.
Total Water		1661	Gals.

Rev. at Mixing Speed: Start 0 Finish 20 Diff. 20 (100 Max.)
Signature of Batch Plant Inspector: Bill Stanley

Portion of Structure Where Placed: 712 RB
Time of Arr. 10:33 Total Rev. 133 (300 Max.)
Time Placement Comp. 10:57 Elapsed Time 45 (1½ Hr. Max.)
Ambient Temp. 50° °F Concrete Temp. 56 °F Slump 3 (1-4")

Remarks:

Cylinder No's.	Air %
2781ABCDEF	3.4

Water Added in Field: N/A Gal./Cu. Yd.
Rev. Start: N/A Finish: Difference (30 Min.)
Remarks: Composite Slump 3 1/4
Temp 60°

30
Field Inspectors Signature: Carlson

PITTSBURGH TESTING LABORATORY

PITTSBURGH, PA.

Order No. TA-7732
Supplier's Delivery
Serial No. 02441

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 2-16-13 Time Loaded 11 30 Class Am-5 Mod Mass ☐ Other ☐
Truck No. 181 Load No. 13 Cu. Yds. 6 Counter to 0 ☒
Cum. Cu. Yds. 76 °F Moisture: F.A. 3.5 % 231 Lbs; C.A. 2.0 % 216 Lbs.

	Design S.S.D. Wt.		Adj. Batch Wt.	
Cement (Type) II	4092		4080	
C.A. (Size 67)	10800		11070	
(Size)				
F.A.	6660		6810	
Daratard HCF	126		126	
Darex AEA	28 SBS		28	
Water, Gals. 51	1656	Total	915	Added
Ice			300 Lbs.	Gals.
Total Moisture			447 Lbs.	Gals.
Total Water			1662	Gals.

Rev. at Mixing Speed: Start 0 Finish 20 Diff. 20 (100 Max.)
Signature of Batch Plant Inspector: Lee Stanley

Portion of Structure Where Placed: 712RB
Time of Arr. 11:53 Total Rev. 128 (300 Max.)
Time Placement Comp. 12:10 Elapsed Time 40 (1½ Hr. Max.)
Ambient Temp. 52 °F Concrete Temp. 57 °F Slump 2 (1-4")

Remarks:

Cylinder No's.	Air %
2182ABCDEF	3.5

Water Added in Field: None Gal./Cu. Yd.
Rev. Start: Finish: Difference (30 Min.)
Remarks: Composite Slump - 2½
Temp - 59

60
Field Inspectors Signature: [illegible]

OWP File → POWR 717
120410

GILBERT ASSOCIATES, INC.
QUALITY ASSURANCE REPORT

SURVEILLANCE OF CONCRETE PLACEMENT

CLIENT FLA. POWER CORP

UNIT CRYSTAL RIVER No. 3

PREPARED BY T. SOCKACI SHEET 1 OF 3

DATE FEB. 16, 1973 CONTRACTOR PTL, J. A. JONES

AREA OF PLACEMENT REACT. BLDG EXT, BUTT. 3-4

A. EQUIPMENT	COMPLIANCE YES	COMPLIANCE NO
1. Are hoppers spaced close enough to prevent concrete from moving laterally more than a short distance	N/A	
2. Are conveyors free of dry mortar and foreign matter	N/A	
3. Are chutes rounded and clean (no build-up on sides)	N/A	
4. Are wheelbarrows and buggies clean	N/A	
5. Are buckets clean and free of old concrete in corners	N/A	
6. Is equipment placed to cover entire placement without delay for repositioning equipment	X	
7. Are pump hoppers free of concrete build-up	X	
8. Are elephant trunks long enough to reach bottom of a deep wall form	X	
9. Are vibrators of proper size for this type of placement	X	
10. Are sufficient numbers of vibrators at placement site	X	
11. Are spare vibrators available	X	

B. PLACING	COMPLIANCE YES	COMPLIANCE NO
1. Are the old surfaces and forms wetted down before placement	NOT CHECKED	
2. Is grout used before placement on old surface	NOT CHECKED	
3. Are personnel watching for form movement	X	
4. Is area clear for placement (no stored material or other debris that may cause delays or hinder the operation)	X	
5. If chutes are used, is the slope approximately 1 : 2 or 2½	N/A	
6. If conveyor belts are used are baffles placed at the end of each section	N/A	
7. Are long lines of belts covered to prevent drying	N/A	
8. When chutes and belts are flushed, is the water diverted away from the forms	N/A	
9. When concrete is pumped, is the concrete at the point of ejection of a uniform consistency	X	
10. When concrete is pumped is a communication system set-up between the pump and point of placement	X	
11. Is concrete placed on a slope placed from the bottom to the top of the slope.	N/A	

POUR 712
120410

GILBERT ASSOCIATES, INC.
QUALITY ASSURANCE REPORT

SURVEILLANCE OF CONCRETE PLACEMENT

CLIENT FPC

UNIT CR#3

PREPARED BY TAS SHEET 2 OF 3

DATE 2/16/73 CONTRACTOR PTL, J.A. JONES

AREA OF PLACEMENT REACT. BLDG EXT. DUTT. 3-4

	COMPLIANCE YES	COMPLIANCE NO
12. Is finishing delayed on slope till concrete does not sag under finishing tools	N/A	
13. Is concrete dropped vertically into forms	X	
14. Is concrete dropped between form ties	X	
15. Are chutes and tremies raised only as high as necessary to distribute the next load of concrete without causing segregation (freefall 3 to 5 feet max.)	X	
16. Is concrete deposited as near to its final location as practiced	X	
17. Is concrete dropped between reinforcing to prevent segregation	X	
18. Is concrete placed working away from corners and ends of walls	X	
19. In slab construction is concrete dumped against concrete that is in place	N/A	
20. Is only enough concrete dumped in one place that can be vibrated effectively	X	
21. Is concrete placed in horizontal layers 2' thick (max.)	X	
22. Is any segregated rock scattered or removed before new concrete is deposited on it	X	
23. Is time allowed for settlement when slabs and beams are placed above columns and walls of fresh concrete	N/A	
24. Are vibrators left running and slowly withdrawn	X	
25. Are vibrator insertions close together (approx. 18 inches apart)	X	
26. Is concrete worked well around reinforcing	X	
27. Is concrete vibrated until top surface develops a sheen and large aggregates are totally embedded	X	
28. Are form separations removed as concrete rises in form	X	
29. Is top surface level and with the proper finish according to drawings or specifications	NOT CHECKED	
30. Is a floor hardener required and used	N/A	
31. Is the Quality Control Inspector present at placement site	X	

POUR 712
120410

GILBERT ASSOCIATES, INC
QUALITY ASSURANCE REPORT

SURVEILLANCE OF CONCRETE PLACEMENT

CLIENT FPC

UNIT CR#3

PREPARED BY TAS SHEET 3 OF 3

DATE 2/16/73 CONTRACTOR PTL, J.A. JONES

AREA OF PLACEMENT REACT. BLDG. EXT., BUTT. 3-4

COMMENTS THE PLACEMENT WAS OBSERVED FROM APPROXIMATELY EL. 202' TO EL. 206'. THE CONCRETE WAS BEING PLACED IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS AND PROCEDURES.

M. Sockaci
STRUCTURAL ENGINEER
QUALITY ASSURANCE

NOTE: USE SUPPLEMENTARY SHEET GAI/QA(F)11.8 FOR ADDITIONAL COMMENTS

GAI/QA(F)11.7B
6-1-71

~~DWP~~ FIA → POUR 712
120410

GILBERT ASSOCIATES, INC.
QUALITY ASSURANCE REPORT

SURVEILLANCE OF SAMPLING METHOD FOR FRESH CONCRETE

(ASTM C-172)

CLIENT FLA. POWER CORP.

UNIT CRYSTAL RIVER No. 3

PREPARED BY T. SOCKACI SHEET 1 OF 1

DATE FEB. 16, 1973 CONTRACTOR PTL

AREA REACT. BLDG. EXTERIOR, BUTT. 3-4.

		COMPLIANCE YES	COMPLIANCE NO
A.	PRIOR TO SAMPLING		
1.	Was all of the mixing water added to the mixer	X	
2.	Was concrete completely mixed	X	
3.	Was the very first portion of the batch discharged	X	
B.	SAMPLING		
1.	Taken by repeatedly passing a receptacle through the entire discharge stream	N/A	
2.	Taken by completely diverting the discharge stream into a sample container	X	
3.	Was sample combined and remixed with a shovel to ensure uniformity	X	
C.	SAMPLING RESTRICTIONS		
1.	Was elapse time between samples within 15 minutes	X	
2.	Were slump and/or air tests started within 5 minutes of sampling	X	
3.	Was the sample protected from rapid evaporation conditions (sun, wind, etc.)	N/A	
4.	Was sample protected from other contaminating elements	N/A	
5.	Was sample taken only from middle portion of the batch	X	

COMMENTS

T. Sockaci
STRUCTURAL ENGINEER
QUALITY ASSURANCE.

NOTE: USE SUPPLEMENTARY SHEET NO. GAI/QA(F)11.5 FOR ADDITIONAL COMMENTS

PITTSBURGH TESTING LABORATORY

FORM 9003-A-TA

ESTABLISHED 1891

512 NORTH DELAWARE AVENUE., TAMPA, FLORIDA 33606

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Order No. TA 7732

REPORT OF BATCH PLANT OPERATIONS

At CRYSTAL RIVER, FLORIDA Date 2-16-73
Project CRYSTAL RIVER UNIT # 3, GENERATING PLANT
Contractor J. A. JONES, INCORPORATED
Reported to FLORIDA POWER CORPORATION
Location of Concrete Placed (per information from job site) POUR: 712 RB

SPECIFICATION REQUIREMENTS

Strength 5000 psi Min. @ 28 days; Slump 3 In. Max.; Entr. Air 3 % to 6 %
Cement Type II (Mod. Heat); Amt. N/A bags/cu. yd. Min.; W/C 5.0 Gal./bag Max.
Aggregate: (Kind and Size Range) Coarse ASTM # 67 Fine ASTM # C-33 mod.
Admixture: DAREX and DARATARD

SOURCE OF MATERIALS

Cement FLORIDA PORTLAND Admixture W. R. GRACE
Fine Aggregate W. S. W. SAND MINE
Coarse Aggregate BROOKSVILLE STONE

DESIGN BATCH QUANTITIES per CUBIC YARD – MIX DESIGN NO. DM-5 Mod.

Cement 682 lbs. 7.25 bags; Fine Aggregate (S.S.D.) 1100 lbs.
Coarse Aggregate (S.S.D.) 1800 lbs. lbs.
Admixture (Kind) DAREX ; Amount 3.6 oz. ; Total Water 33.1 Gals.
Admixture (Kind) DARATARD ; Amount 21.0 oz. " " 276 lbs.

SURFACE MOISTURE IN AGGREGATES

Fine Aggregate 3.5 % %
Coarse Aggregate 2.0 - 2.5 % %

ACTUAL BATCH WEIGHTS per CUBIC YARD
(Adjusted for Surface Moisture on Aggs.)

Cement 677-684 lbs.
Fine Agg. 1130-1140 lbs.
Coarse Agg. 1830-1855 lbs.
Coarse Agg. XXXXX N/A XXXXX lbs.
Admix. DAREX 4.6-5.0 oz.
Admix. DARATARD 21.0 oz.
Free Water in Agg. 75-84 lbs.
Added Water 210-192 lbs.
Total Water 275-278 lbs.

Batching Started 8:55 AM Finished 1:33 PM
Concrete batched this report 108 cu. yds.
Rejected: 6 cu.yds. Not used: 0 cu.yds.
Yield: 140.6
Transfer 3 yds. to 713 RB

GRADING OF AGGREGATES

Sieve	Percent (Passing) Coarse Agg.		Fine Agg.
2"			
1½"			
1"	100.0	100.0	
¾"	97.5	98.6	
½"	55.5	72.8	
⅜"	25.0	42.4	
No. 4	5.0	8.5	100.0
No. 8			99.6
No. 16			92.1
No. 30			57.0
No. 50			24.0
No. 100			2.5
Mat'l. finer than No. 200			2.25

Inspector: Bill Starling
Bill Starling, P & L

0 Tankers Cement Delivered Today
From Silo # MA Type II
cc: 2 - FPC Quality Records
3 - P T L

T:2-20-3-55

PITTSBURGH TESTING LABORATORY

Ross T. McGillivray

Ross T. McGillivray, P. E.

PITTSBURGH TESTING LABORATORY

ESTABLISHED 1901

PITTSBURGH, PA.

Order No. TA-7732

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REPORT

Date _____

REPORT OF TEST ON CONCRETE CYLINDERS
6 DIAMETER BY 12 LENGTH

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

LOGGED

Inspector A. Von Nyvenheim
A. VON NYVENHEIM, PTL

POUR: 712 RB

Date Cast 2-16-73 Concrete Class 5000 P.S.I. Area 28.27 Sq. In.

Cement Factor 7.25 Brand Fla. Portland Type II Aggregate Size ASTM# 67

DEL. S/N.	CYLINDER IDENT.	W/C GAL.-SACK	SLUMP INCHES	AIR %	CONCRETE TEMP. °F.	DATE TESTED	AGE DAYS	TOTAL LOAD LBS.	COMP. ST. P.S.I.	SPECIFIC LOCATION
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REMARKS: _____

cc: 2 - FPC Quality Records
3 - P T L

213-21-3-7

PITTSBURGH TESTING LABORATORY

Ross T. McGillivray

ROSS T. McGILLIVRAY, P.E.

WEEKLY COMMENTS ON CONSTRUCTOR'S QUALITY CONTROL

CLIENT Florida Power Corporation

UNIT Crystal River Unit #3

CONSTRUCTOR E.C.Ernst,J.A.Jones,Livsey

DATE February 24, 1973 SHEET NO. 1 OF 2

PREPARED BY GAI/QA Personnel

COMMENTS

Week Ending: February 24, 1973

Mechanical

Ventilation Duct Cleanliness.

Structural

Review of Florida Steel Corp. Structural Steel Drawings
Sampling Fresh Concrete
Preparation of Concrete Test Specimens

General

Review of Work Procedure

1. Mechanical

1.1 Control of ventilation ducting cleanliness was observed this week in the Auxiliary Building and the Control Complex. Openings in the ducts are covered with polyethylene. This provides adequate protection from dust, etc. in accordance with para. 3:02.7 of SP-5833.

2. - Structural

2.1 A surveillance of Florida Steel Corporation's Drawings for the Reactor Building Structural Steel was made this week. Several Drawings were not marked as approved by the Engineer. This is in violation of R.O. 2968. CAR 0077 was written to document the condition.

2.2 The sampling of concrete and the making of concrete test specimens were observed this week. The sampling of concrete and making of the test specimens were done in accordance with the project specifications.