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56-DAY REPORT

PHASE II MIX DESIGN PROGRAM

LEVY NUCLEAR PLANT

Engineering & Construction Management
Hydro-Nuclear-Fossil

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Environmental Engineering & Permitting

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56-DAY REPORT
PHASE II MIX DESIGN PROGRAM
LEVY NUCLEAR PLANT

PROJECT NO. 07-3935
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CHANGE MANAGEMENT RECORD

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0	April 18, 2011	Initial Submittal	N/A	N/A
1	April 19, 2011	Removed references to years of ASTM standards (Pages 2 and 3).	MJE	mje

Note:

[1] Changes are marked with a revision mark in margin, beginning with Rev. 1.

[2] Person authorizing change shall sign here for latest revision.

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EXECUTIVE SUMMARY

A Roller Compacted Concrete (RCC) bridging mat bearing on the Avon Park Formation will support each of the Levy Nuclear Plant (LNP) AP1000 nuclear island basemats. The purpose of this mix design program is to develop a suite of RCC mixes and conventional concrete bedding mixes for use in a laboratory test program to evaluate the strength and thermal characteristics of the mixes and associated lift joint properties, which will be used later in construction. A five phase RCC test program is planned, including the following:

- Phase I – Evaluation of previous commercial RCC projects and preliminary mixes (completed)
- Phase II – Mix Design Program (16 RCC mixes and 5 bedding mixes) (underway)
- Phase III – Specialty Testing Program to evaluate RCC joint strength and thermal properties (one RCC mix and one bedding mix) (underway)
- Phase IV – On-site test pad to verify production and contractor methodology (just prior to construction)
- Phase V – Quality Control Inspection Program (during bridging mat construction)

Phases I, II, and III are pre-COL activities; Phases IV and V are post-COL activities.

The Phase II Mix Design Program, the subject of this report, was undertaken to evaluate the strength and workability of various RCC mixes and bedding mixes. The mix designs were developed by Paul C. Rizzo Associates, Inc. (RIZZO) and batched by Fall Line Testing, LLC (Fall Line) at their laboratory in Tucson, Arizona. The objective of the mix design process was to determine the mix component proportions that will produce a workable RCC mix with mechanical and thermal properties satisfying project requirements. The mix design for RCC mixes and bedding mixes has addressed the effects of the water-cementitious materials ratio, fly ash replacement, fly ash source, and admixtures with respect to mixture strength and workability.

Sixteen RCC mixes were designed to meet design compressive strength requirements of either 3,000 pounds per square inch (psi) (primary group of mixes) or 3,500 psi (backup group of mixes). Five bedding mixes were designed to exceed 4,000 psi compressive strength. This mix design program concluded with the selection of a single RCC mix and a bedding mix for further evaluation in the subsequent phase of testing, based on the maximization of strength versus the minimization of cement.

Constituent materials used in this program were procured by RIZZO and certified by an independent laboratory (MACTEC Testing, Inc.) based on their physical and chemical properties. The results of this mix design program, and the results of the independent certification of the constituent materials, will be used for the development of a mix design specification for the construction of the LNP RCC bridging mats.

1.0 INTRODUCTION

An RCC bridging mat will support each of the two LNP AP1000 nuclear island basemats. RCC is zero-slump concrete delivered and placed by conventional earth moving equipment (trucks, conveyors, bull dozers) and compacted by large vibratory rollers. Properties of cured RCC are the same as conventional concrete (Unites States Army Corp of Engineers [USACE], Engineering Manual 1110-2-2006, "Roller Compacted Concrete"). RCC is mixed using high-capacity continuous mixing or batching equipment, delivered to the placement area with trucks or conveyor belt systems, and spread in 12- to 15-inch (in.) layers using standard construction equipment, such as bulldozers, prior to vibratory compaction by smooth steel drum rollers.

Bedding mix used between lifts, i.e., at lift joints, is a high-slump conventional concrete that is placed in thin layers (usually ½ inch to 1 inch thick). Bedding mix is generally used to improve the shear and tensile strength between RCC layers.

RIZZO performed an initial RCC mix design program to evaluate and determine the strength and workability of different mix proportions to be considered for the RCC bridging mats. Laboratory work associated with this mix design program was performed by Fall Line and the physical and chemical properties of the individual constituent materials was performed by MACTEC, Inc. (MACTEC), Charlotte, North Carolina and its subcontractor, CTL Group (CTL), Skokie, Illinois, both under subcontract to RIZZO. Fall Line prepared the trial batches of RCC under the supervision and direction of RIZZO.

This report describes the materials, presents the laboratory testing results, and makes recommendations for the mix proportions for the Phase III Specialty Testing Program.

2.0 LABORATORY TESTING

Fall Line completed the testing on the component materials for the RCC and bedding mixes at their laboratory in Tucson, Arizona. Fall Line performed testing on physical properties of materials required for developing RCC and bedding mix design proportions. MACTEC and CTL performed comprehensive physical and chemical testing to provide data for evaluation of long-term performance durability. All component materials aggregate, cement, fly ash, and admixtures were procured during the Materials Qualification stage of the Phase II Mix Design Program. Fall Line work was performed under the RIZZO Quality Assurance Program. MACTEC and CTL performed their work under their respective 10 Code of Federal Regulations (CFR) 50, Appendix B, and ASME NQA-1 Quality Assurance Programs.

2.1 TESTS AND PROCEDURES

Laboratory testing on aggregate was performed according to the following American Society for Testing and Materials (ASTM) International standard procedures:

- ASTM D 75 — Standard Practice for Sampling Aggregates
- ASTM C 40 — Organic Impurities in Fine Aggregate
- ASTM C 127 — Specific Gravity of Coarse Aggregate
- ASTM C 128 — Specific Gravity of Fine Aggregate
- ASTM C 131 — Los Angeles Abrasion Test for Coarse Aggregate
- ASTM C 136 — Sieve Analysis of Fine and Coarse Aggregate
- ASTM D 4791 — Flat and Elongated Particle Analysis
- ASTM C 566 — Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying

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Laboratory testing on RCC and bedding mix was performed according to the following standard procedures:

- ASTM C 192 — Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
- ASTM C 684 — Standard Test Method for Making, Accelerated Curing, and Testing Concrete Compression Test Specimens

•	ASTM C 39	Compressive Strength of Concrete Cylinders
•	ASTM C 143	Slump of Hydraulic-Cement Concrete
•	ASTM C 231	Air Content of Concrete by the Pressure Method
•	ASTM C 469	Static Modulus of Elasticity and Poisson's Ratio of Concrete
•	ASTM C 496	Splitting Tensile Strength of Concrete Cylinders
•	ASTM C 1064	Temperature of Freshly Mixed Concrete
•	ASTM C 1170	Consistency and Density of RCC Using a Vibrating Table
•	ASTM C 1435	Standard Practice for Molding Roller Compacted Concrete in Cylinder Molds Using a Vibrating Hammer
•	ASTM C 617	Standard Practice for Capping Cylindrical Concrete Specimens

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3.0 RCC MIX DESIGN PROGRAM

This report describes the work completed to date in Phase II of a five phase RCC test program. Prior to beginning Phase II, potential materials and material suppliers were evaluated. A commercial testing program was implemented, upon which the plan for Phase II was developed.

3.1 MATERIAL SUPPLIER EVALUATION

Prior to the commencement of the Phase II Mix Design Program, potential material suppliers were evaluated. Different suppliers and sources of aggregate, cement, commercial fly ash, and concrete admixture suppliers were assessed for the consistency of their product as well as their long-term viability.

Aggregates from nine different quarries in the southeastern United States were evaluated with the objective to identify two sources that quarry material from the same geologic formation. To qualify these two sources, materials with physical properties that showed high specific gravity, low absorption, and low loss to abrasion were selected. These properties were established based on previous commercial project experience. It was identified that sources extracting material from the Stone Mountain Granite Formation in central Georgia met all these requirements. In addition to these sources meeting the physical property requirements, it was required that the sources identified had produced aggregates for a substantial amount of time and continue to have the capacity of producing aggregates in the future. Based on these requirements, Martin Marietta Camak Quarry and Aggregates USA Macon Quarry were the two aggregate sources selected for further evaluation in the Phase II Mix Design Program.

Commercial Class F fly ash sources from five different locations in the southeastern United States were evaluated to select two potential suppliers. The results from the physical and chemical property analysis of each source were studied to identify and rank the sources with the most beneficial results. Class F fly ash from SEFA's McMeekin Station and Wateree Station were selected for use in Phase II as these sources had material with low expansion potential, high strength development and low heat generation.

A similar study of the physical and chemical properties was performed on Portland cement from four different sources in the southeastern United States. Based on the most beneficial results, such as low expansion potential, high strength development, and low heat generation, one cement source was identified. Type II Portland cement from the Titan America (TITAN) Pennsuco plant in Medley, Florida was selected for use in the mix design program.

Based on previous commercial project experience, Concrete admixture from Grace Construction Products (Grace) was selected for use during Phase II, from two sources that were evaluated.

3.2 COMMERCIAL TESTING OF PRELIMINARY MIXES

After the material suppliers were evaluated and before the start of Phase II Mix Design Program, commercial testing was performed at the Fall Line laboratory. Component materials were procured, sampled, tested, and delivered to the Fall Line laboratory in accordance with the Phase II Material Qualification Work Plan. Fall Line performed non-safety-related commercial testing in October and November 2010 using both Macon USA and Camak Martin Marietta aggregate sources. TITAN's Type II Portland cement from the Pennsuco plant was used and SEFA's Class F fly ash from Wateree plant was used as cement substitute. Potable water from the Tucson's municipal source was used in this commercial testing phase.

A suite of four RCC mixes was prepared for each aggregate with cement + fly ash weights of 175+175, 200+200, 225+225, and 225+275 pounds per cubic yard. Strength testing of the resulting mixes showed that all mixes would be expected to attain the specified strength (f'c) of 3,000 psi for the primary mixes and 3,500 psi for the backup mixes, at age 365 days. These results also demonstrated that aggregate quarried from the same rock formation by separate suppliers does not appreciably impact the strength gain results for the range of cementitious materials tested. Since the Camak aggregate resulted in slightly lower strengths, it was recommended that the Camak aggregate be used for the Phase II mixes to be conservative.

A suite of six trial bedding mixes was also prepared using the Camak aggregates with water/cement ratios of 0.45, 0.50, and 0.55. Three mixes were proportioned to yield a 7- to 9-in. slump without admixture, and three mixes were proportioned for a 3- to 4-in. slump with admixture added to achieve a 7- to 9-in. slump. All mixes achieved desired strengths.

3.3 PHASE II MIX DESIGN

The Phase II Mix Design Program started in December 2010 after the results of the commercial testing were evaluated. This Phase II was performed by RIZZO with batching and testing of RCC and bedding mix laboratory samples performed by Fall Line under subcontract to RIZZO.

The laboratory trial batches used admixtures, aggregates, and cement from one source and fly ash from two sources. The materials were stored at Fall Line's facilities in Tucson, Arizona. ***Table 3-1*** below lists the materials used during Phase II Mix Design Program.

Based on previous commercial project experience and commercial testing work, the conceptual mix matrix presented in ***Table 3-2*** was developed to evaluate the effect of varying cementitious content, water content, fly ash source, and percent fines on the RCC properties.

TABLE 3-1
MATERIALS FOR USE IN PHASE II MIX DESIGN

MATERIAL	SUPPLIER	SOURCE	PRODUCT
Aggregates	Martin Marietta	Camak Quarry	#4, #67, M-10, W-10
Cement	Titan America	Pennsuco Cement Mill	Type II
Fly Ash #1	SEFA	Wateree Station	Class F
Fly Ash #2	SEFA	McMeekin Station	Class F
Admixture #2	Grace	Lithonia, GA	ADVA 140M (Type A)

A suite of 16 RCC mixes was developed by RIZZO with varying proportions of water and cementitious materials. Mix proportions were selected in accordance with the procedure given by the United States Army Corps of Engineers (USACE) Engineer Manual (EM) 1110-2-2006. Only materials listed in ***Table 3-1*** were used for the Phase II Mix Design Program. ***Table 3-2*** below shows the RCC mix matrix. Two groups of mixes were developed to meet two target compressive strengths. The first group has a design strength target of 3,000 psi, while the second group of mixes has a design strength target of 3,500 psi.

TABLE 3-2
RCC MIX MATRIX

SPECIFIED STRENGTH (f'$_c$)	**3,000 psi** (f'$_c$= 3,710 psi)			**3,500 psi** (f'$_c$= 4,450 psi)		
CEMENTITIOUS CONTENT	**175#+225# (C+FA)**	**200#+225# (C+FA)**	**200#+250# (C+FA)**	**200#+275# (C+FA)**	**225#+275# (C+FA)**	**250#+300# (C+FA)**
Lower H_2O		Mix 4		Mix 13	Mix 11	
Target H_2O	Mix 2	Mix 1 (Baseline) Mix 6 (+fines) Mix 7 (alt. fly ash)	Mix 3	Mix 9	Mix 8 (baseline) Mix 15 (+fines) Mix 16 (alt. fly ash)	Mix 10
Higher H_2O		Mix 5		Mix 14	Mix 12	

3.4 RCC TARGET MIX DESIGN PARAMETERS

RIZZO has evaluated the static demand, capacity, and margin for compressive strength in the RCC Bridging mat. This evaluation included two compressive strengths (f'$_c$) with the primary mix being at 3,000 psi and a backup mix with 3,500 psi. The target or required compressive strength (f'$_{cr}$) for each mix was selected based upon the acceptance criteria for concrete tests that are provided in ACI 349-01, Section 5.6.2.3:

(a) Every arithmetic average of any three consecutive strength tests equals or exceeds f'$_c$, and

(b) No individual strength test (average of two cylinders) falls below f'$_c$ by more than 500 psi.

Guidance for calculating the f'$_{cr}$ is provided in ACI 214.R-02, Sections 4.3.2 and 4.3.3. Furthermore, based on the experience of previous commercial projects, a coefficient of variation (CV) of 14 percent was estimated. A CV is more commonly used in RCC quality control production rather than the standard deviation, as is normally done for conventional concrete.

Two compressive strengths were considered, allowing the flexibility for the design team to select a mix that balances between the desire for increased strength (providing margin for static and dynamic loading) with the desire for decreased cementitious content for controlling potentially undesirable thermal effects.

Additionally, the mix must be workable such that it produces minimal segregation, is able to withstand the weight of heavy placement equipment, and is able to be compacted to the required density with reasonable effort before initial set occurs.

- Baseline 1: One year design compressive strength (f'_c) = 3,000 psi
- Baseline 2: One year design compressive strength (f'_c) = 3,500 psi
- Vebe time = 15 to 25 seconds
- Aggregate gradation in general accordance with ***Table 3-3.***
- Freshly mixed density (unit weight) greater or equal to 145 pounds per cubic foot (pcf).

The Vebe time measures the workability of concrete mixes with a slump less than two inches. RCC has zero slump. The Vebe time results indicate the remolding ability of a stiff mix under vibration; this test was used in lieu of the slump cone test used in conventional concrete mixes. Typical Vebe times for RCC range between 15 and 30 seconds, with wet mixes having lower Vebe times and dry mixes having higher Vebe times.

Aggregate blends were proportioned to achieve the gradation specification listed in ***Table 3-3***. The selected variation in material proportions in ***Table 3-2*** was devised to produce data for the selection of the final mix to be used in the sample lifts to be constructed in Phase III for RCC specialty testing and to provide information regarding sensitivity of the mixes to variations in proportions that might occur during production.

TABLE 3-3
BLENDED COARSE AND FINE AGGREGATE SPECIFICATION

U.S. STANDARD SIEVE SIZE	SPECIFICATION PERCENT FINER BY WEIGHT (WASHED)
2 inch	100
1 ½ inch	95-100
1 inch	75-87
¾ inch	68-80
½ inch	56-70
⅜ inch	49-63
# 4	38-50
# 8	28-38
# 16	21-31
# 30	15-24
# 50	10-18
# 100	7-13
# 200	4-10

3.5 RCC AND BEDDING MIX DESIGN MATERIALS

The cement, fly ash, aggregate, admixtures, and water used in the Phase II Mix Design Program are described in the following subsections. MACTEC and their subcontractor, CTL, performed the physical and chemical testing for the certification of these materials working under their respective 10CFR50 and ASME NQA-1 Quality Assurance Program.

3.5.1 Cement

The Type II Portland cement used in Phase II was supplied by TITAN from the Pennsuco Plant located in Medley, Florida. The cement was procured in standard 94-pound (lb) sacks and transported under chain of custody control to the Fall Line facilities in Tucson, Arizona, where it was stored under laboratory conditions.

The chemical and physical analysis performed by MACTEC's subcontractor CTL shows that all physical and chemical requirements under ASTM C 150 for Type II cement were met, with one exception. The sulfur trioxide (SO_3) content of 3.42 percent obtained for sample LCR 012/019, exceeded the 3.0 sulfur trioxide limit listed under ASTM C 150. The December 2010 results provided by TITAN show an average SO_3 value of 3.09 percent. In some cases, as stated in ASTM C 563, the optimum SO_3 may be close to or in excess of the values listed in ASTM C 150. It is permissible that SO_3 values be higher than the ASTM C 150 listed values, as long as the increased SO_3 does not develop expansion in water greater than 0.020 percent as described in ASTM C 1038. Further testing of the cement is needed to insure the expansion values of cement bars submerged under water do not exceed a value of 0.02 percent in accordance with ASTM C-1038. TITAN has performed this testing and verified acceptability. MACTEC has also verified under their QA program.

3.5.2 Fly Ash

Fly ash was supplied by the South Eastern Fly Ash Association (SEFA) from the South Carolina Electric and Gas (SCE&G) McMeekin Station and Wateree Station. Both fly ash materials obtained comply with the standard requirements of ASTM C 618 for Class F fly ash. The values for the 7-day strength activity index are slightly under the minimum values as indicated in the physical requirements for ASTM C 618. The values for the 28-day strength activity index meet the ASTM C 618, indicating compliance for the physical requirements.

The fly ash was procured in standard 2,000-lb "supersacks" and transported under chain of custody control to the Fall Line facilities in Tucson, Arizona, where it was stored under laboratory conditions.

3.5.3 Aggregates

Aggregates for the LNP Phase II Mix Design Program were supplied by Martin Marietta from the Camak Quarry in Georgia. The aggregates were procured at the Camak Quarry under RIZZO personnel supervision. Each of the individual aggregates used was loaded into a highway-approved tandem truck and transported under chain of custody control to the Fall Line Laboratory in Tucson, Arizona, where it was stored under laboratory conditions. The granite aggregate supplied by Martin Marietta Camak Quarry comes from the Stone Mountain Granite Formation. The granite aggregate obtained from the Stone Mountain Formation has a high specific gravity, low absorption, and low loss values with respect to the LA Abrasion test. These values are presented in ***Table 3-4.*** The results presented below indicate that the granite aggregate obtained from the Stone Mountain Formation is of good quality and is suitable for use in RCC and bedding mixes.

TABLE 3-4
SPECIFIC GRAVITY AND ABSORPTION OF AGGREGATES

MATERIAL	QUARRY	SUPPLIER	SPECIFIC GRAVITY	ABSORPTION	LA ABRASION
#4 (19-63 mm)	Camak Quarry	Martin Marietta	2.67	0.52	21%
#67 (4.75-19 mm)	Camak Quarry	Martin Marietta	2.66	0.8	29%
M-10 (0-4.75 mm)	Camak Quarry	Martin Marietta	2.69	0.3	N/A
W-10 (0-4.75 mm)	Camak Quarry	Martin Marietta	2.68	0.4	N/A

The grain size distribution for aggregates from the Camak Quarry is shown in ***Table 3-5*** below. These gradations were used to determine the proportions of aggregates required to achieve the target gradation for the mixes.

TABLE 3-5
CAMAK AGGREGATE GRAIN SIZE DISTRIBUTION

SIEVE	#4% PASSING	#67 % PASSING	#M-10* % PASSING	W-10** % PASSING
2"	100.0			
1 1/2"	98.8	100.0		
1"	49.4	100.0		
3/4"	15.1	99.2		
1/2"	3.1	68.1	100.0	
3/8"	1.7	27.9	100.0	100.0
#4		1.5	99.7	99.4
#8		1.0	89.6	81.5
#16			70.8	55.5
#30			56.7	39.6
#50			42.6	24.8
#100			29.8	12.7
#200			18.9	5.5

Notes:

* High fines content specified for use in roller compacted concrete (M-10 used in RCC only).

** W-10 used in bedding mix only.

The coarse aggregate (#4 and #67) used in Phase II meets all the requirements of ASTM C 33. The fine aggregate (M-10 and W-10) meets all the ASTM C 33 requirements, with the exception of a minor grading conformance deviation in the #8 (2.36 millimeter [mm]) sieve. This minor deviation in gradation does not change the relevant properties of the RCC and bedding mixes and is not considered detrimental to the final concrete product. The aggregate blends used in the RCC mix proportions include a percentage of the M-10 fine aggregates; these blends conform to the specified limits shown in ***Table 3-3***. Furthermore, bedding mix proportions were not significantly affected by the small conformance change in the #8 (2.36 mm) sieve. The fineness modulus of the W-10 fine aggregate, one of the critical values that changes proportioning in the bedding mix, is within the 2.3 to 3.1 range required by ASTM C 33. In general, the relevant properties of the bedding mix were not affected by the small grading conformance change, and the laboratory results exceed the project requirements.

Coarse and fine aggregate samples were tested for the presence of deleterious substances, namely lightweight pieces that can suggest the presence of coal or lignite and the presence of flat or elongated particles, and clay lumps and friable particles. Coarse aggregates were also subjected to petrographic examination to identify the presence of minerals that may affect the long term performance of the concrete.

No flat or elongated particles were found in the coarse aggregates.

The percentage of lightweight pieces in coarse aggregates ranged from 0 to 0.003% while the amount of lightweight pieces in the fine aggregate tested at 0.04%. These values are well below the maximum of 1% specified in ASTM C33. Lightweight particles are not a concern with the Camak aggregates.

The amount of clay lumps and other friable particles in the coarse aggregates ranged from 0.06% to 0.1% and from 0.2% to 0.3% in the fine aggregates. These values are well below the maximum of 10% specified in ASTM C33. Friable particles are not a concern with the Camak aggregates.

The petrographic examination characterized the coarse aggregate as fresh (unweathered) angular particles in good condition with little internal fracturing. No forms of potentially alkali-reactive quartz were observed in significant amounts. Biotite mica occurs, but it is well bounded within the aggregate particles rather than appearing as free flakes; its presence is considered nondetrimental. No accumulation of sericite of sufficient mass or extent to be considered problematic was observed.

The bedding mixes produced with this aggregate demonstrate that the aggregate will produce concrete with the specified target properties, though the average gradation of samples of the W-10 aggregate (LCR 015) tested were out of the specified range on the #8 (2.36 mm) sieve (77% actual vs 80% to 100 % specified in ASTM C-33).

M-10 aggregate is generally not used as a conventional concrete aggregate, but was selected to provide the fines needed to meet the specified combined RCC aggregates range shown in ***Figure 3-1***. Aggregates that do not meet the normal standards or requirements for conventional concrete have been successfully used in RCC construction, which was the basis for this aggregate specification. The average gradations of samples of the M-10 aggregate (LCR 028) were out of the specified range on the #50 (0.300 mm) and the # 100 (0.150 mm) sieves and have more than 10% material passing the #200 (0.075 mm) sieve, however an increased amount of fines passing the #200 sieve is generally used in RCC. This mix design program was intended to evaluate the performance of these readily available materials in the production of RCC.

Based on the performance of mixes to date, RIZZO concludes that Camak aggregates are suitable for use in both Roller Compacted Concrete and conventional Portland cement concrete.

3.5.4 Water

Mixes were batched using municipal potable water from Tucson, Arizona, as obtained at Fall Line Laboratory. Under ASTM C 1602, potable water can be used in the production of hydraulic cement concrete without testing or qualification.

3.5.5 Admixtures

Chemical admixtures used during Phase II of this project were provided by Grace Construction Products. Grace ADVA-140M was used as a high-range water reducer in the bedding mixes. Grace ADVA-140M meets the standard requirements of ASTM C494. The admixture was procured in standard 5-gallon (gal) pails and transported under chain of custody control to the Fall Line Laboratory in Tucson, Arizona, where it was stored under laboratory conditions. Grace ADVA-140M was only used with bedding mixes.

3.6 TRIAL MIXES

The RCC mixes were prepared in two groups, as shown in ***Table 3-2*** above. ***Table 3-6*** below shows the Saturated Surface Dry (SSD) batch quantities for each RCC mix prepared.

TABLE 3-6
BATCH QUANTITIES FOR RCC MIXES

MIX ID	CEMENT (LB/CY)	FLY ASH (LB/CY)	WATER (LB/CY)	W/C	#4 (LB/CY) (SSD)	#67 (LB/CY) (SSD)	M-10 (LB/CY) (SSD)
Mix-1	200	225	243	0.57	913	1146	1309
Mix-2	175	225	243	0.61	919	1153	1317
Mix-3	200	250	243	0.54	905	1136	1298
Mix-4	200	225	233	0.55	920	1155	1320
Mix-5a[1]	200	225	253	0.60	906	1137	1299
Mix-5	200	225	280	0.66	886	1112	1271
Mix-6	200	225	243	0.57	812	1146	1410
Mix-7	200	225	243	0.57	916	1149	1313
Mix-8	225	275	275	0.55	868	1089	1245
Mix-9	200	275	267	0.56	880	1104	1261
Mix-10	250	300	267	0.49	860	1079	1233
Mix-11	225	275	257	0.51	881	1106	1263
Mix-12	225	275	280	0.56	865	1085	1240
Mix-13a[2]	200	275	277	0.58	889	1114	1253
Mix-13	200	275	255	0.54	888	1115	1274
Mix-14	200	275	275	0.58	874	1095	1253
Mix-15	225	275	270	0.54	775	1094	1340
Mix-16	225	275	275	0.55	872	1093	1250

Note:

[1] Mix-5a is Mix 5 with lower moisture content. The mix was drier than expected. Decreased water came from moisture variability in stockpile.

[2] Mix-13a is Mix 13 with higher moisture content. The mix was wetter than expected. Increased water came from moisture variability in stockpile.

3.7 ENGINEERING PROPERTIES

Compressive strength, splitting tensile strength, and elastic modulus tests were (or will be) performed for the RCC mixes cylindrical samples at 3-, 7-, 14-, 28-, 56-, 90-, 180-, and 365-day testing ages. Accelerated curing used to estimate the long-term strength of the RCC was also performed on some cylinders to provide estimated 180-day compressive strength. Thus far samples at ages 3-, 7-, 14- (accelerated curing), 28-, and 56-days have been tested. These test results and plots of the test results for each mix are described in the following subsections and supplemented by information contained in ***Appendix A***.

3.7.1 RCC Mix Properties

Table 3-7 shows the blend proportions of aggregates used to compose the combined aggregate gradation used for the RCC mixes.

TABLE 3-7
AGGREGATE PROPORTIONS

SIZE NUMBER	PERCENT (BY WEIGHT) MIXES 1-5, 7-14 & 16	PERCENT (BY WEIGHT) MIXES 6 & 15
#4	27%	24%
#67	34%	34%
M-10*	39%	42%

Note:
* Manufacturer's designation

The resultant combined gradation used for all RCC mixes, with the exception of Mix 6 and Mix 15, is shown on ***Figure 3-1***. Mix 6 and Mix 15 used a higher percentage of fine aggregate, as shown on ***Figure 3-2***, in order to evaluate the effects of additional fines content on the strength properties of the mix. The specified range shown on ***Figure 3-1 and Figure 3-2*** is given in ***Table 3-3.*** The specified range was determined based on limits used on previous large commercial projects, such as Taum Sauk Upper Reservoir and Saluda Dam Rehabilitation. The combined volume of RCC placed in both projects is in excess of three million cubic yards. This range has demonstrated that a workable and consistent mix can be produced with acceptable mechanical properties.

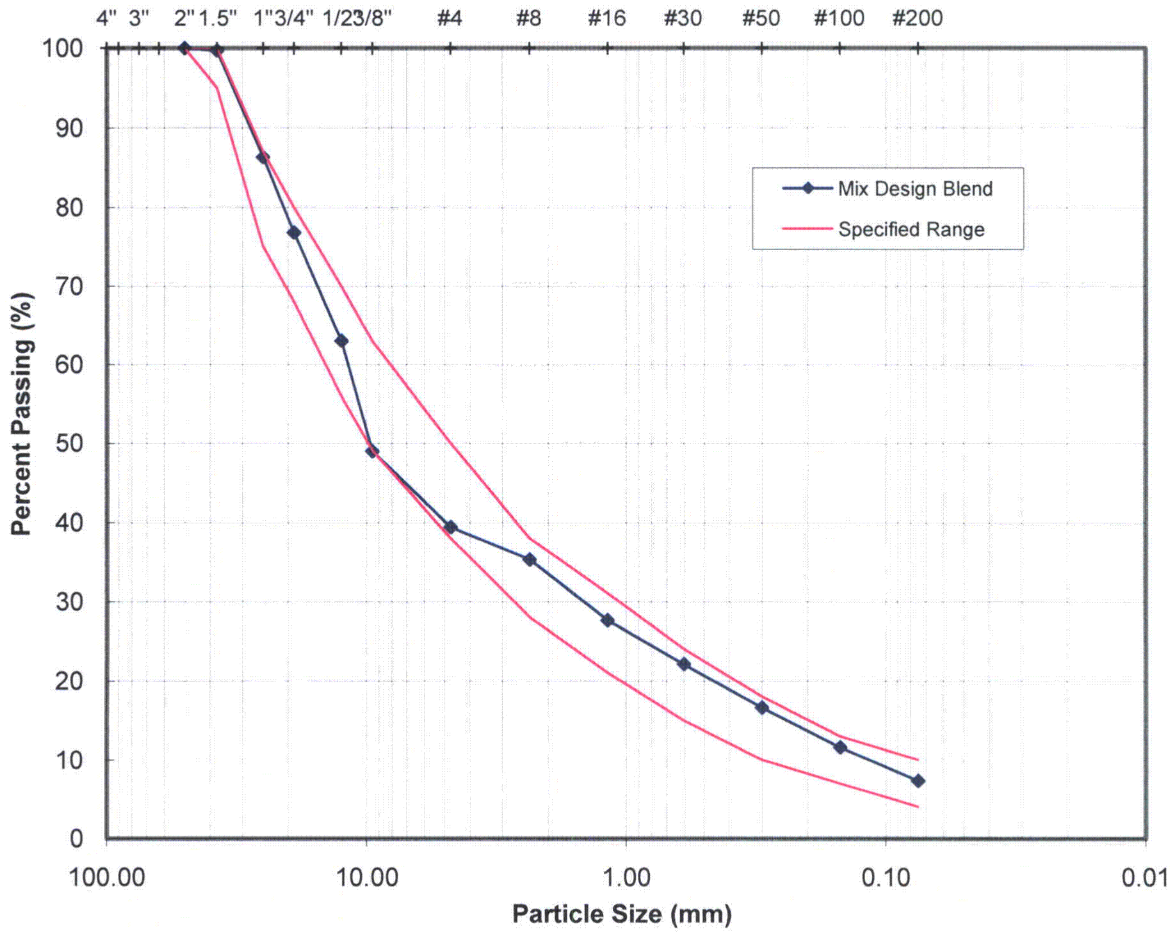


FIGURE 3-1
COMBINED AGGREGATE GRADATION (27-34-39)
(MIXES 1-5, 7-14 & 16)

Materials used to batch Mixes 1 through 16 were transported to Fall Line's facilities in August 2010. Three individual gradations were performed on each aggregate in accordance with ASTM C 136, and an average of the three gradations was obtained to create the actual combined gradation curve for the Camak aggregate.

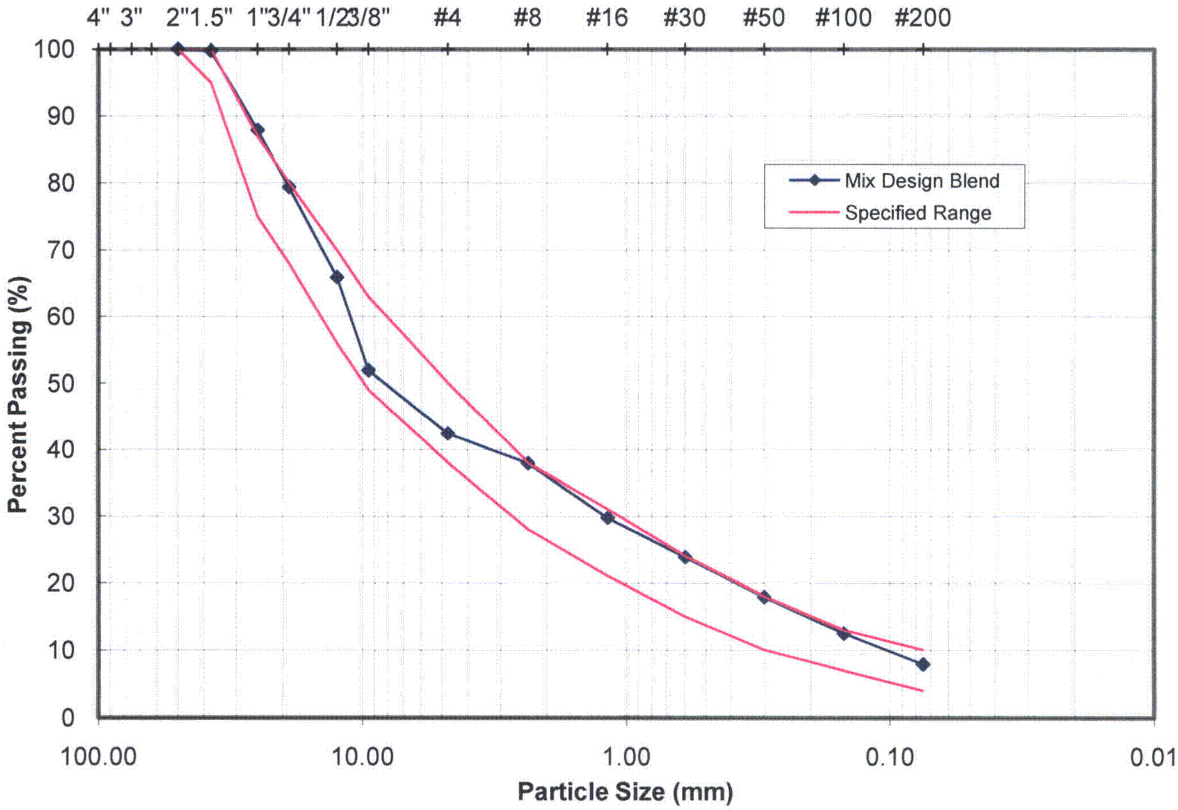


FIGURE 3-2
COMBINED AGGREGATE GRADATION (24-34-42)
(MIXES 6 & 15)

The data in ***Table 3-8*** show the RCC mix properties obtained for the trial batches. To minimize segregation in the RCC mix and to improve lift bond strength, the mix proportioning targeted a Vebe time of 20 ± 5 seconds. The Vebe time for all mixes was between 15 and 25 seconds, except for Mix 14 with a Vebe time of 11 seconds, Mix 5 with a Vebe time of 12 seconds, and Mix 1 with a Vebe time of 26 seconds. In general, the mixes showed acceptable workability. The best behavior was observed in the mixes with Vebe time in the 20 ± 5 seconds range. During mix preparation, RCC temperatures ranged from 61 to 71 degrees Fahrenheit. A higher RCC mix temperature would be expected to result in a less workable mix with higher Vebe times. Temperature control of the RCC during production may be required to maintain a workable mix under severe job conditions.

The unit weight of the mixes averaged 146.6 lb/cubic foot, with a range of 144.8 to 148.8 lb/cubic foot. Air content ranged from 1.5 to 2.5 percent, with an average value of 2.2 percent. Mixes with reduced fly ash content exhibited slightly higher densities and lower air contents.

TABLE 3-8
FRESH MIX PROPERTIES FOR RCC MIXES

DATE	MIX ID	CEMENT (lbs/cy)	FLY ASH (lbs/cy)	FA (%)	W/ (C+FA)	AIR TEMP (°F)	MIX TEMP (°F)	VEBE TIME (sec.)	UNIT WEIGHT (pcf)	AIR (%)	MOIST (%)
12/10/10	1	200	225	53	0.57	74.7	69.3	26	148.1	2.2	6.2
12/11/10	2	175	225	56	0.61	60.4	62.7	23	147.8	1.9	6.1
12/11/10	3	200	250	56	0.54	67.7	64.2	22	146.2	2.3	6.8
12/11/10	4	200	225	53	0.55	73.1	68.1	24	148.2	2.2	6.7
12/12/10	5a	200	225	53	0.60	61.2	61.1	22	147.1	2.2	6.9
12/12/10	5	200	225	53	0.66	69.6	65.3	12	145.4	2.1	7.7
12/12/10	6	200	225	53	0.57	71.9	67.7	22	145.7	2.5	7.4
12/12/10	7	200	225	53	0.57	74.7	69.5	21	146.6	2.3	6.6
12/13/10	8	225	275	55	0.55	68.7	64.5	22	147.3	2.2	7.4
12/13/10	9	200	275	58	0.56	76.7	68.5	22	145.7	2.3	7.6
12/13/10	10	250	300	55	0.49	78.5	69.1	21	145.0	2.5	6.8
12/13/10	11	225	275	55	0.51	79.4	71.4	20	146.1	2.4	6.6
12/14/10	12	225	275	55	0.56	63.9	63.5	15	145.3	2.5	7.5
12/14/10	13a	200	275	58	0.58	71.5	66.9	15	147.7	1.9	7.2
12/14/10	13	200	275	58	0.54	77.7	70.6	20	148.8	1.7	6.9
12/15/10	14	200	275	58	0.58	63.0	67.7	11	146.6	2.1	7.5
12/15/10	15	225	275	55	0.54	72.9	69.9	20	147.2	2.2	7.1
12/15/10	16	225	275	55	0.55	72.7	71.0	23	144.8	2.5	6.7

3.7.2 Compressive Strength

Compressive strength testing was performed in accordance with ASTM C 39. The compressive strength for each age was determined by averaging the results from three compressive strength test cylinders. Modulus of elasticity test measurements were performed on one of the three compressive strength test specimens for each break date. To allow for production variability, the required compressive strength (f'_{cr}) values were selected based on ACI 349-01, as described in ***Section 3.3***.

Figure 3-3 depicts compressive strength gain over time for the 3,000 psi mixes. The 14-day accelerated curing values are an indication of the potential strength developed for each particular mix comparable to 180-day standard curing.

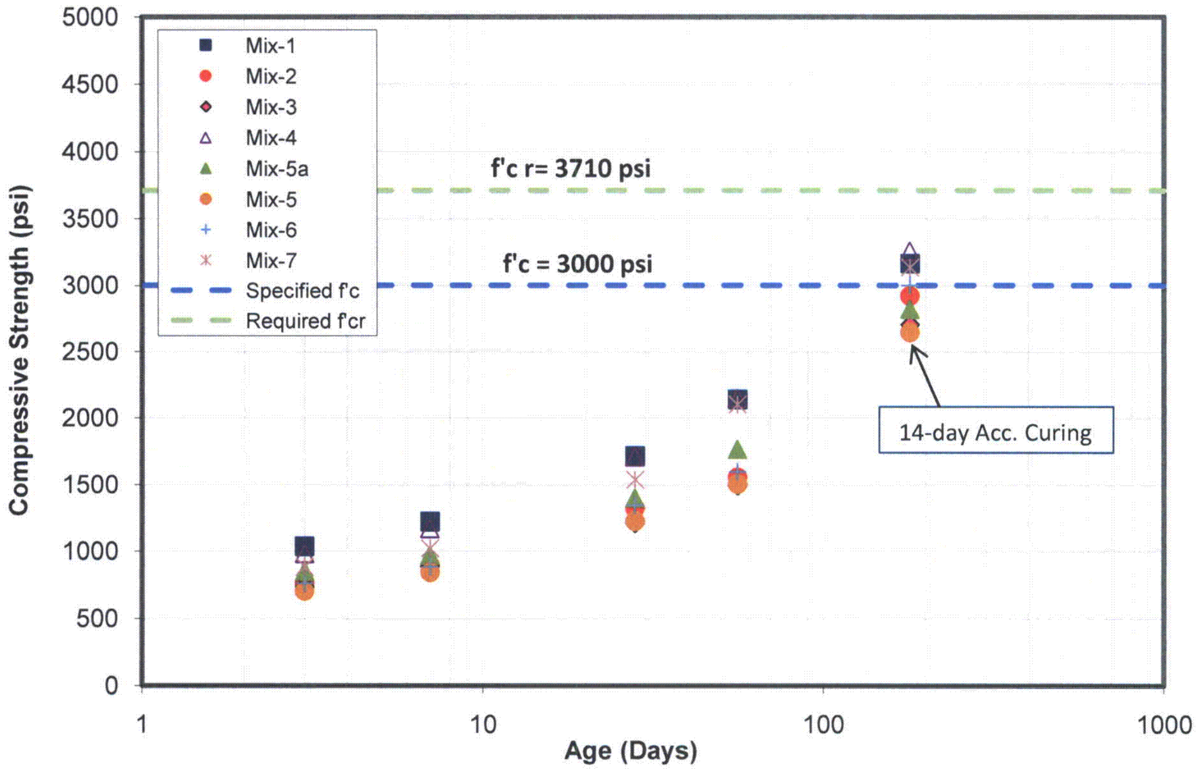


FIGURE 3-3
COMPRESSIVE STRENGTH GAIN FOR 3,000 PSI MIXES

Figure 3-4 shows compressive strength gain over time for the 3,500 psi mixes.

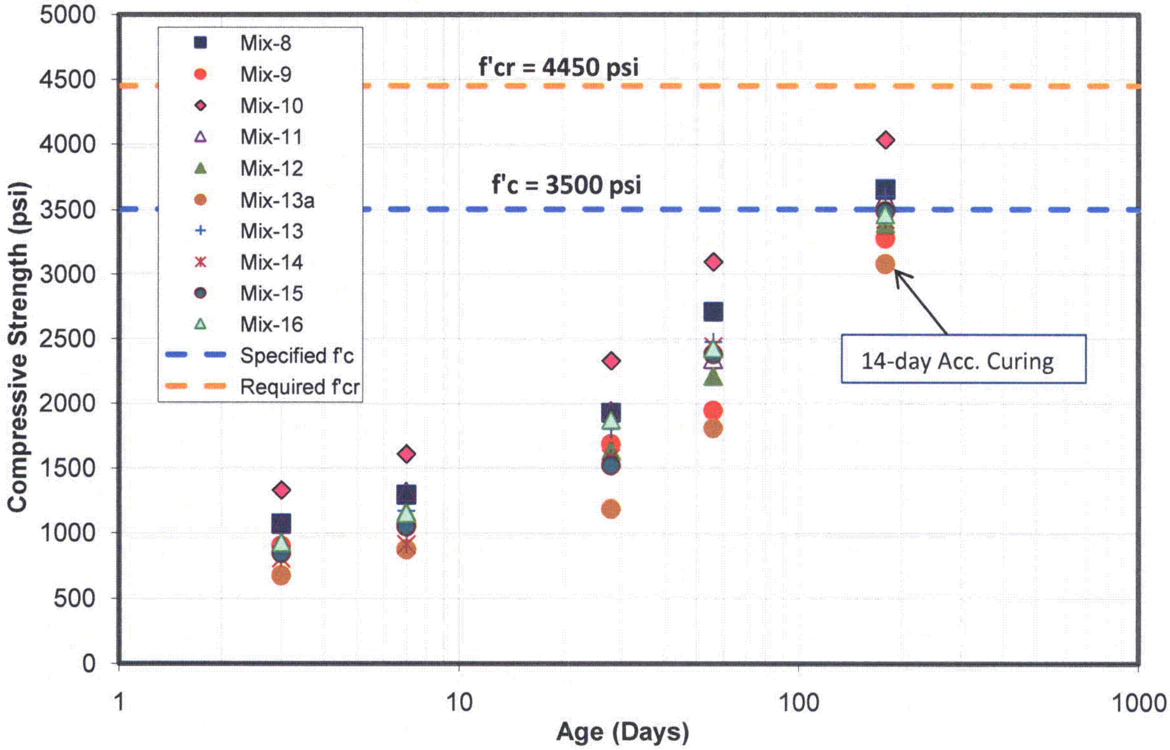


FIGURE 3-4
COMPRESSIVE STRENGTH GAIN FOR 3,500 PSI MIXES

On other commercial projects, it is typical for the required compressive strength (f'cr) to be obtained after 365 days if the specified compressive strength (f'c) is obtained after 14 days of accelerated curing.

3.7.2.1 Influence of Water-Cementitious Ratio on Strength

The influence of water to cementitious ratio on the 14-day accelerated compressive strength results is shown on ***Figure 3-5***.

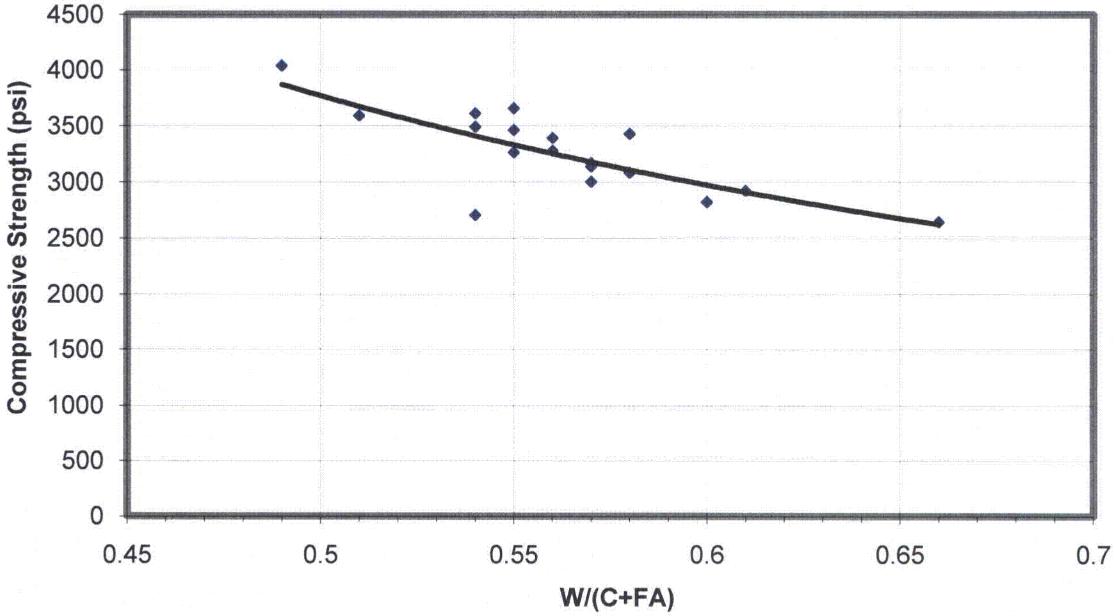


FIGURE 3-5
EFFECT OF W/C RATIO ON 14-DAY ACCELERATED COMPRESSIVE STRENGTH (ALL MIXES)

The effect of the water-cementitious ratio to the compressive strength of the RCC is the same as the effect of the water-cement ratio to the compressive strength of conventional concrete (i.e., the lower the ratio, the higher the compressive strength at any given age). For the mixes prepared during Phase II, a plot of the compressive strengths of the RCC at 14 days (***Figure 3-5***) and the compressive strengths of the conventional bedding concrete at 28 days (***Figure 4-3***) show almost parallel relationships. ***Figure 3-6*** shows the relationship between compressive strength and water-cementitious ratio for 56-day standard curing. ***Figures 3-5 and 3-6*** show that both the standard and accelerated curing of RCC samples follow the same pattern.

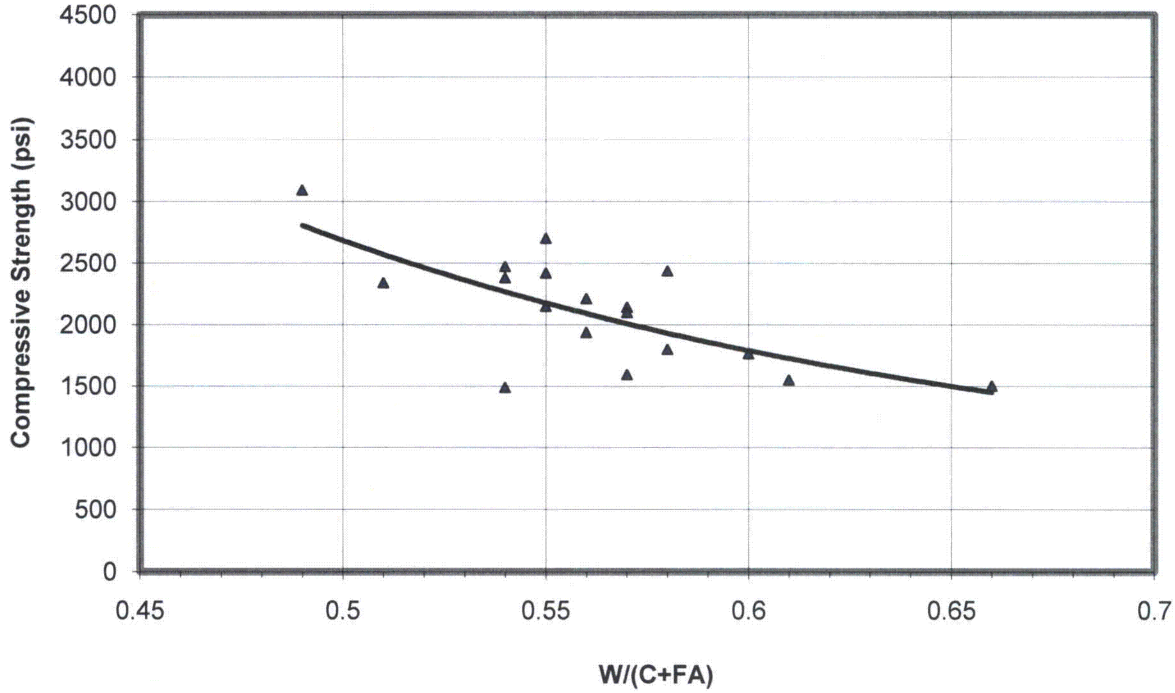


FIGURE 3-6
EFFECT OF W/C RATIO ON 56-DAY COMPRESSIVE STRENGTH
(STANDARD CURING)

3.7.2.2 Influence of Fly Ash/Cement Content on Strength

Figures 3-7 and 3-8 show the effect of fly ash on the compressive strength of the RCC. ***Figure 3-7*** compares the compressive strength attained by the 3,000 psi baseline mix containing Wateree fly ash (Mix 1) and the same mix made with the alternate McMeekin fly ash (Mix 7). ***Figure 3-8*** compares the compressive strength attained by the 3,500 psi baseline mix containing Wateree fly ash (Mix 8) and the same mix made with the alternate McMeekin fly ash (Mix 16). In both cases, the Wateree fly ash produced a slightly stronger mix at all stages of testing. The difference in strength generally decreases with age.

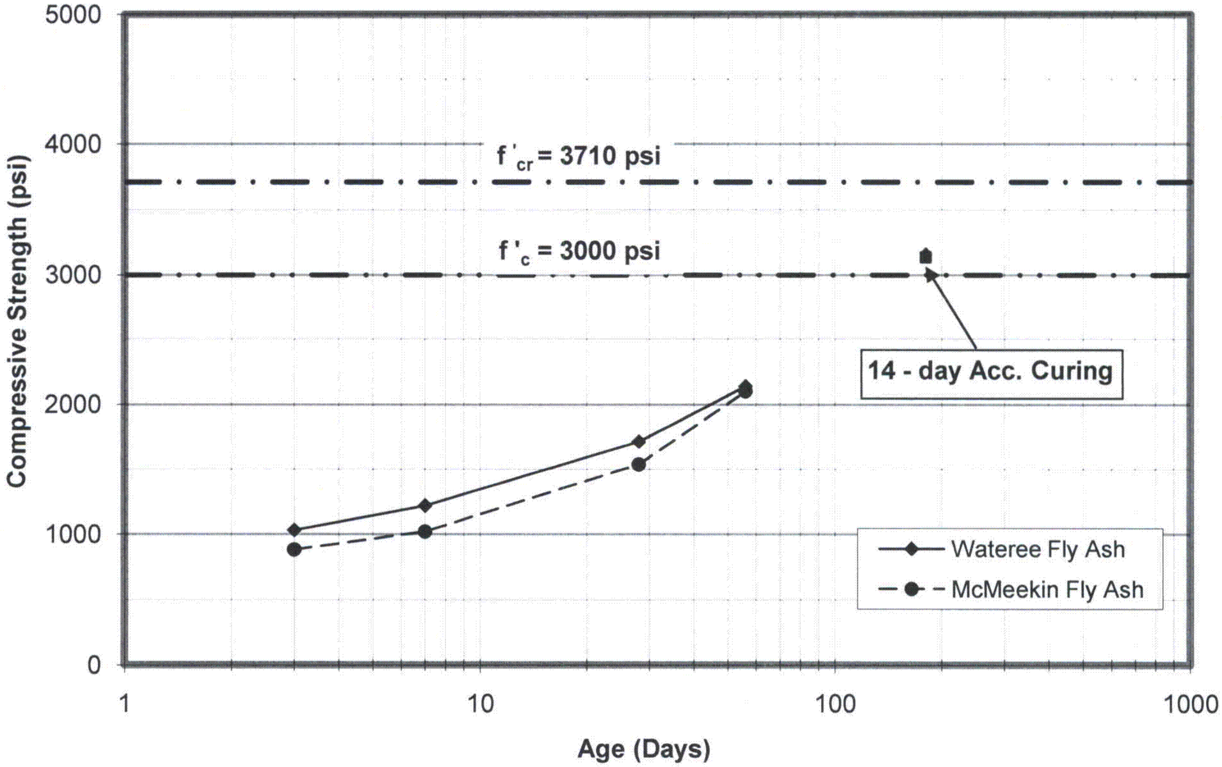


FIGURE 3-7
EFFECT OF FLY ASH TYPE ON COMPRESSIVE STRENGTH – 3,000 PSI MIXES

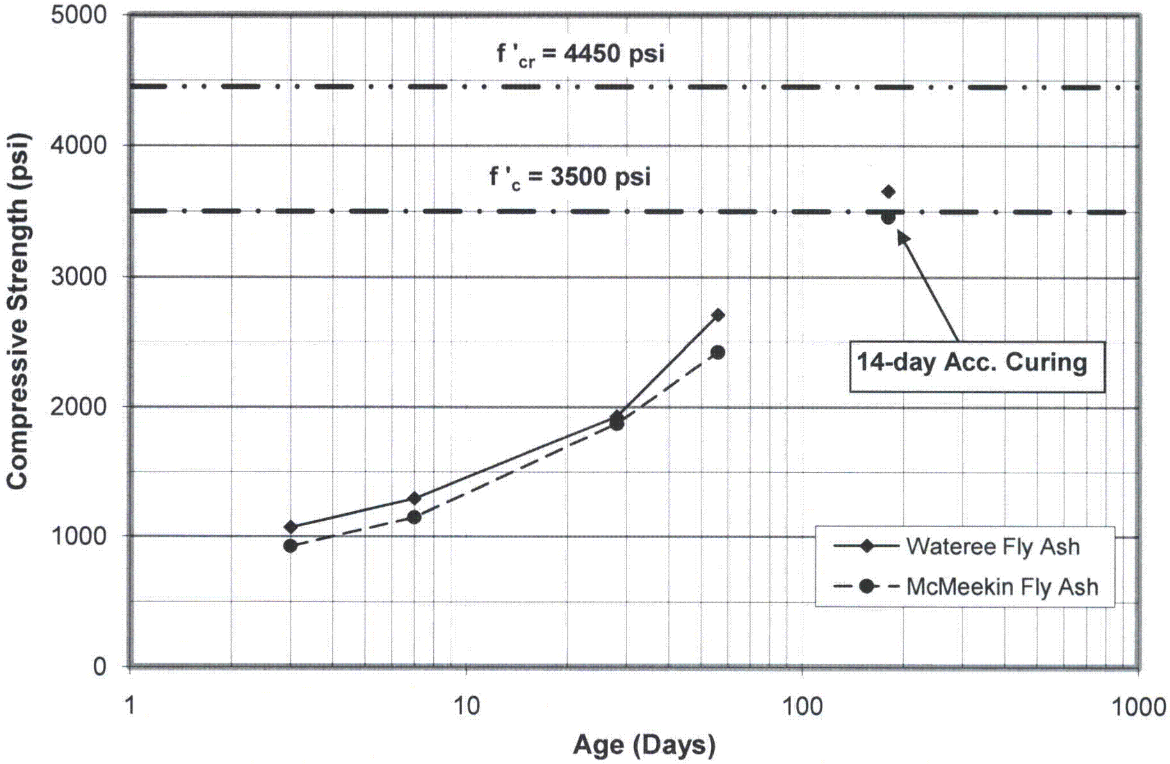


FIGURE 3-8
EFFECT OF FLY ASH TYPE ON COMPRESSIVE STRENGTH – 3,500 PSI MIXES

Fly ash content of the RCC mixes ranged from 52.9 to 57.9 percent of the cementitious material. In general, compressive strength test results showed an inverse relationship between the percentage of fly ash in the mix and the compressive strength at all ages through 56 days. ***Figure 3-9*** shows the effect of the amount of fly ash on the averages of the 14-day accelerated and the 56-day compressive strength for both the 3,000 psi and the 3,500 psi mixes.

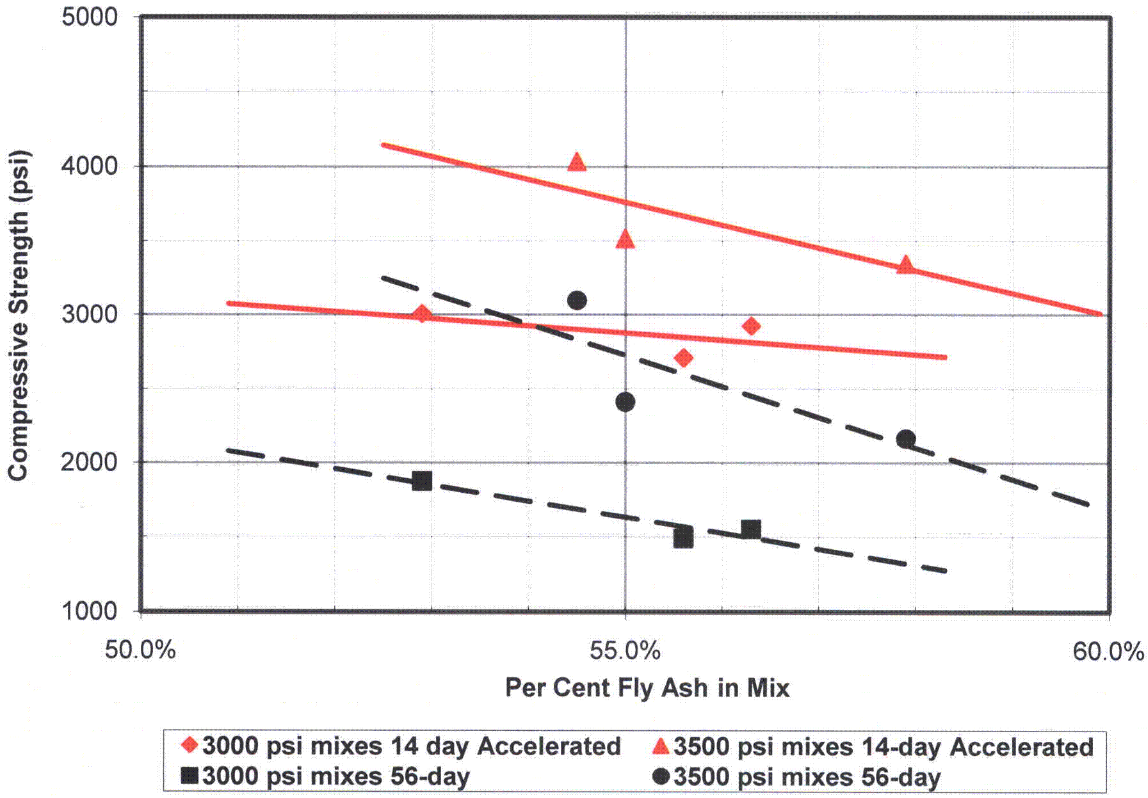


FIGURE 3-9
EFFECT OF FLY ASH CONTENT ON COMPRESSIVE STRENGTH

3.7.3 Splitting Tensile Strength

Split cylinder tensile strength tests were performed, in accordance with ASTM C 496, by applying a diametrical compressive force to the horizontal axis of the RCC cylinders. The splitting tensile strength value can be correlated with the direct tensile strength of the parent RCC material through the use of a reduction factor. The direct tension values obtained in RCC, and similarly for conventional concrete, are normally lower than the values obtained in the splitting tensile test. In general, the direct tension values are 25 to 30 percent lower than the splitting tensile results (US Army Corp of Engineers, RCC Manual EM-1100-2-2006). A strength reduction factor of 0.75 is generally applied to the splitting tensile test to reflect results that would be obtained by direct tensile tests. One cylinder was tested for each mix at each testing interval. The split tensile strength gain for the 3,000 psi and 3,500 psi mixes are presented on ***Figures 3-10 and 3-11.*** The target splitting tensile strength values of 153 psi for the 3,000 psi RCC mixes and 160 psi for the 3,500 psi RCC mixes are factored values based on the tension demand values divided by the 0.75 strength reduction factor.

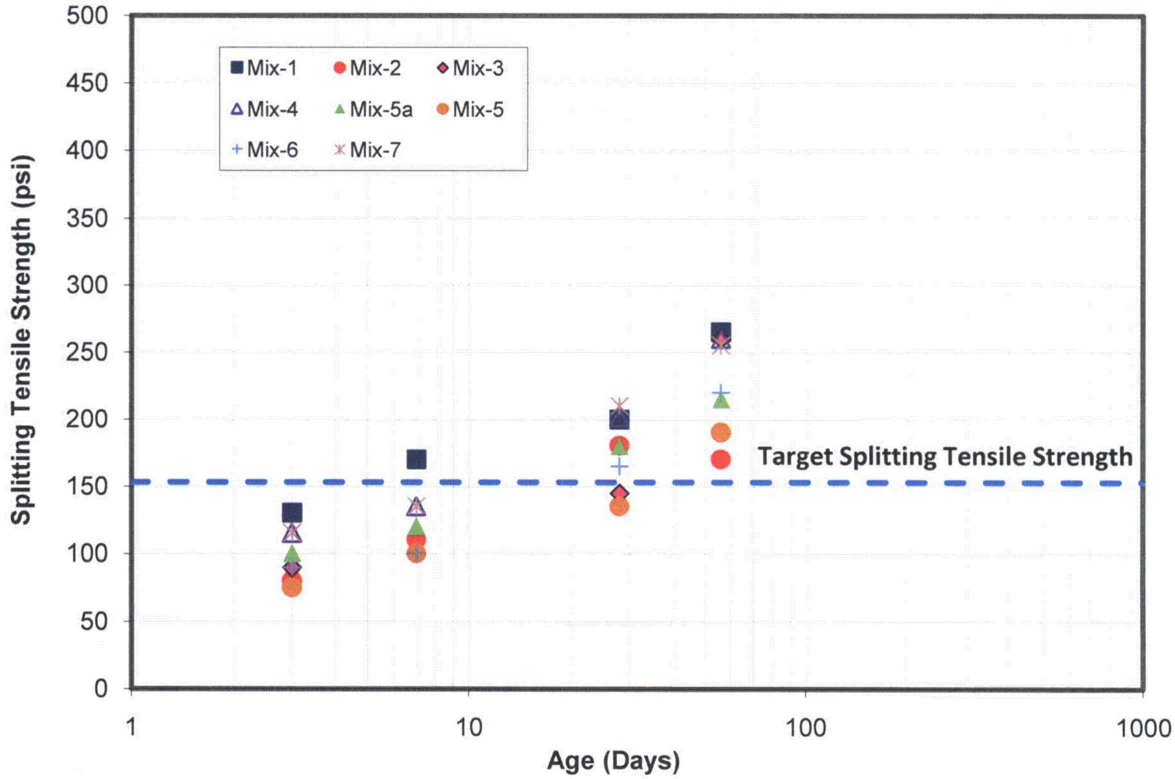


FIGURE 3-10
SPLITTING TENSILE STRENGTH GAIN FOR 3,000 PSI MIXES

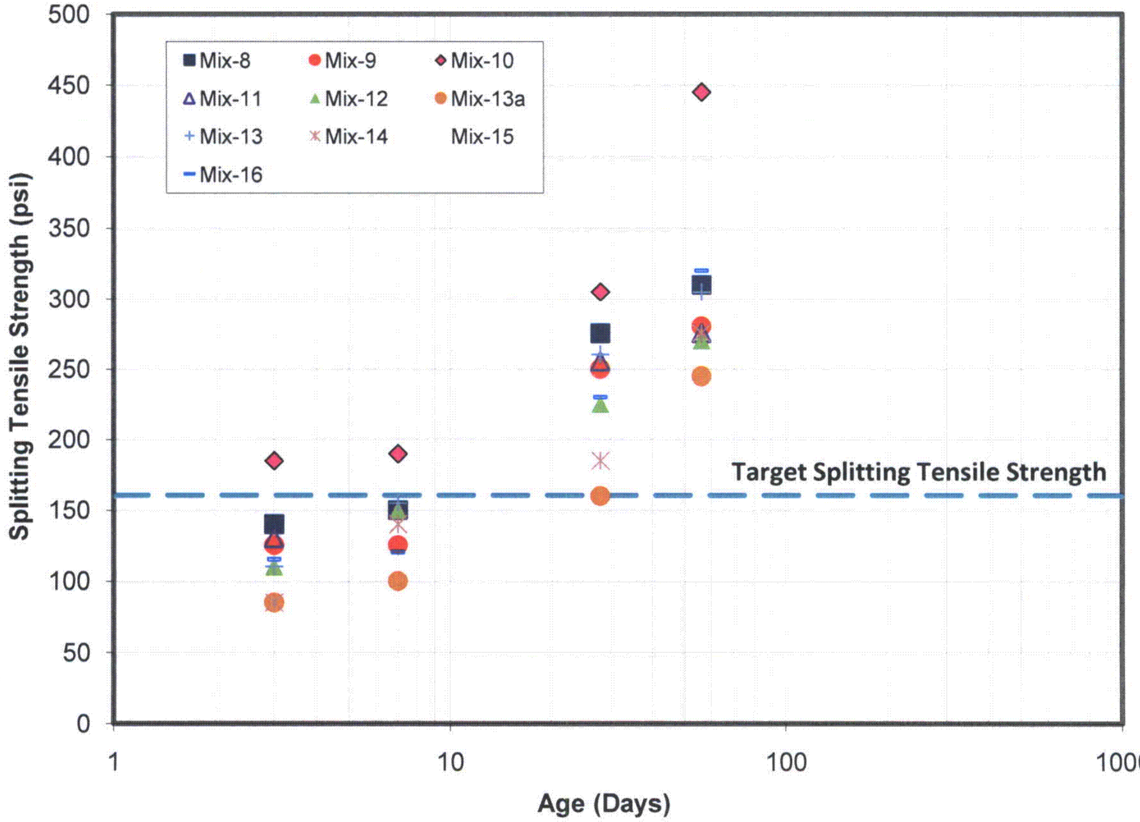


FIGURE 3-11
SPLITTING TENSILE STRENGTH GAIN FOR 3,500 PSI MIXES

3.7.4 Modulus of Elasticity

Modulus of elasticity testing was performed in accordance with ASTM C 469. ***Figure 3-12*** depicts the relationship between compressive strength and elastic modulus for all mixes. Results shown below include samples tested up to 56 days, including the 14-day accelerated curing, plotted as the estimated 180-day value. ***Figure 3-12*** shows the plot of the ACI 349 (Section 8.5) equation for estimating the modulus of elasticity in concrete ($Ec = 57{,}000\ (f_c)^{0.5}$), in addition to the regression curve of the laboratory test results.

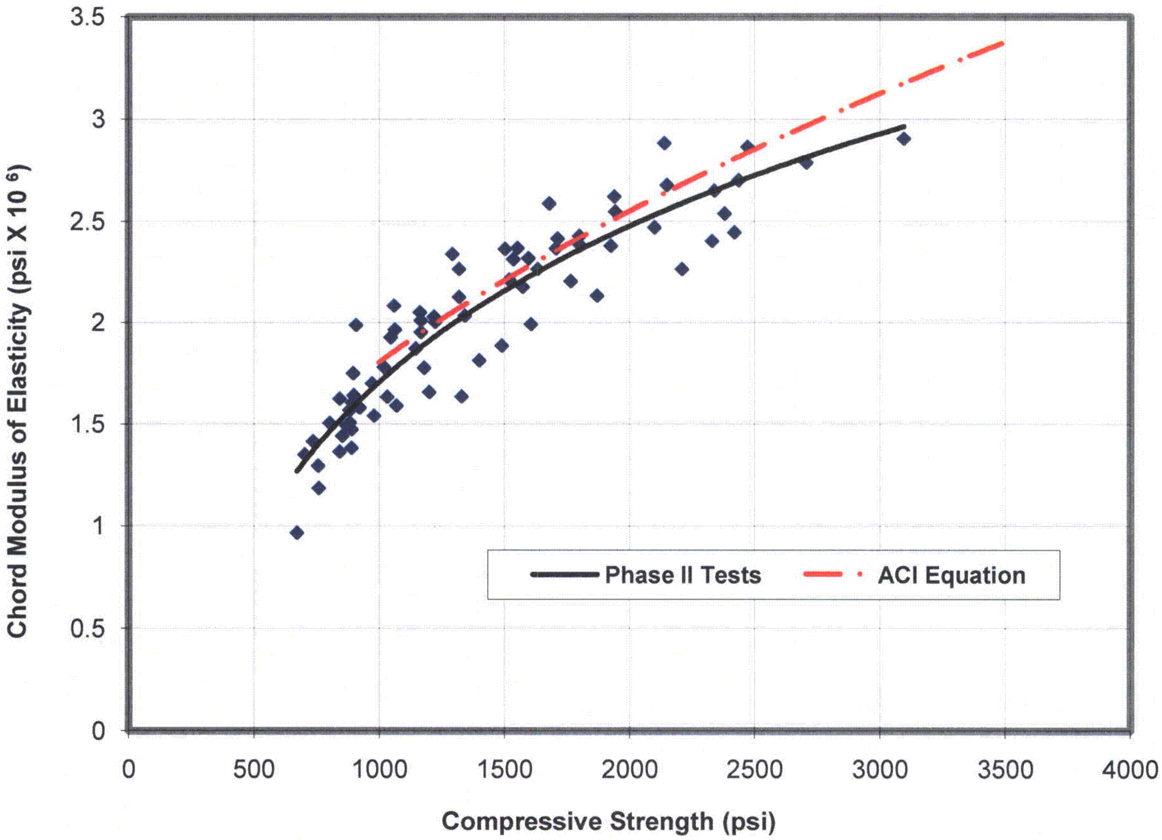


FIGURE 3-12
ELASTIC MODULUS VS COMPRESSIVE STRENGTH

4.0 BEDDING MIX DESIGN PROGRAM

The Phase II bedding mix design was performed by RIZZO with batching and testing of the bedding mix laboratory samples performed by FALL LINE. All laboratory trial batches used the TITAN Pennsuco Mill Type II Portland cement, the Martin Marietta Camak Quarry #67, W-10 aggregates, Tucson water, and Grace ADVA 140M admixture.

A suite of five bedding mixes with varying water-cement ratios was prepared in accordance with the procedures of ACI 211.1-91, "Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete." The coarse aggregate content and the mixing water were held constant for each batch while the cement and fine aggregate contents varied depending on the water/cement ratio. The mix was proportioned to produce a three to four inch slump before the incorporation of water reducing admixtures. Water reducing admixture was added at the manufacturer's recommended rates to produce a seven to nine inch slump in the concrete

Table 4-1 presents the batching weights for one cubic yard of each if the five bedding mixes. Aggregate weights are for SSD conditions.

TABLE 4-1
BEDDING MIX PROPORTIONS – SSD AGGREGATES

MIX NUMBER	1A	2A	3A	4A	5A
w/c	0.45	0.50	0.55	0.60	0.65
Water (Lb/CY)	370	370	370	370	370
Cement (Lb/CY)	823	740	673	617	569
#67 Agg (Lb/CY)	1624	1624	1624	1624	1624
W-10 Agg (Lb/CY)	1101	1171	1228	1276	1316

4.1 BEDDING MIX MATERIALS

The cement, aggregate, admixture, and water used in the Phase II Mix Design Program are described in ***Section 3.2***

4.2 BEDDING MIX PROPERTIES

The data in ***Table 4-2*** summarizes the properties obtained for the trial batches. All mixes showed acceptable workability. Strength of the mixes exceeded expected strengths predicted by Table 6.3.4(a) of ACI 211.1. ***Figure 4-1*** depicts compressive strength gain over 28 days for all bedding mixes. ***Figure 4-2*** depicts tensile strength gain over 28 days for all bedding mixes. ***Figure 4-3*** shows the relationship between 28-day compressive strengths and water-cement ratio. ***Figure 4-4*** presents the relationship between compressive strength and tensile strength of the bedding mixes at all ages tested.

TABLE 4-2
BEDDING MIX PROPERTIES

MIX NO.	1A	2A	3A	4A	5A
Slump without Admixture (in)	3.25	3.00	3.50	3.75	3.75
Slump with Admixture (in)	8.25	8.5	8.5	8.75	8.75
Entrapped Air (%)	1.2	1.1	1.1	1.0	0.9
Unit Weight (pcf)	145.9	145.2	145.0	144.9	144.3
Concrete Temp (^oF)	72.9	73.7	72.7	71.7	71.9
Ambient Temp (^oF)	75.7	73.8	72.3	67.6	68.7
Initial Set Time (minutes)	175	197	202	210	214
Final Set Time (minutes)	228	252	259	279	270
3-day Compressive Strength (psi)	4,195	3,850	3,335	3,005	2,645
7-day Compressive Strength (psi)	5,150	4,565	3,950	3,675	3,240
28-day Compressive Strength (psi)	5,985	5,740	5,070	4,891	4,300
3-day Splitting Tensile Strength (psi)	455	355	285	270	285
7-day Splitting Tensile Strength (psi)	460	435	340	345	305
28-day Splitting Tensile Strength (psi)	550	490	450	430	440

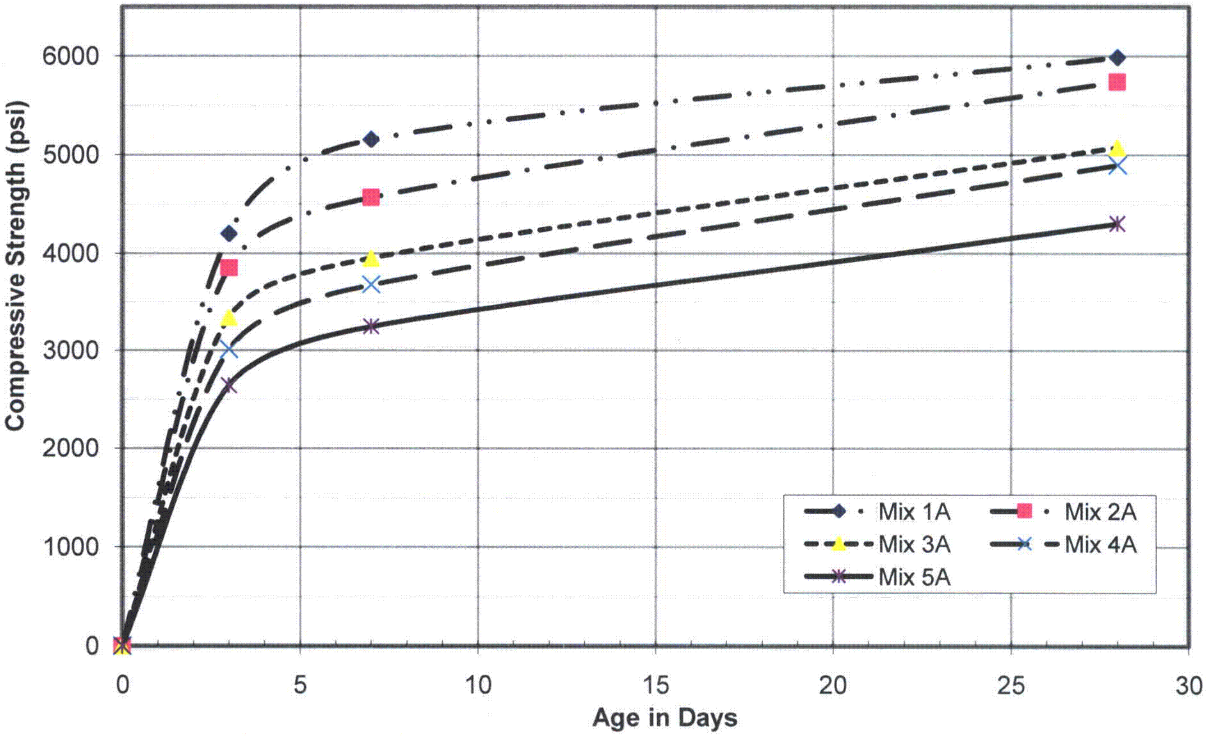


FIGURE 4-1
BEDDING MIX COMPRESSIVE STRENGTH GAIN

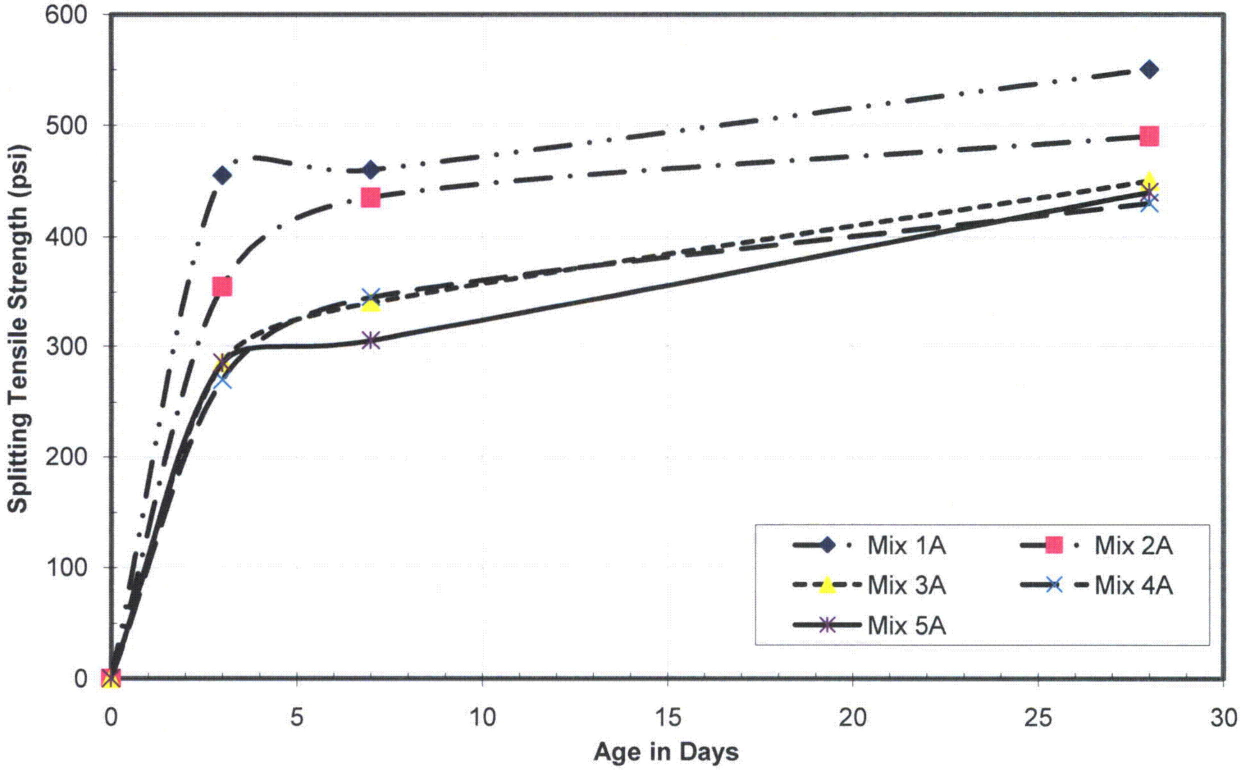


FIGURE 4-2
BEDDING MIX TENSILE STRENGTH GAIN

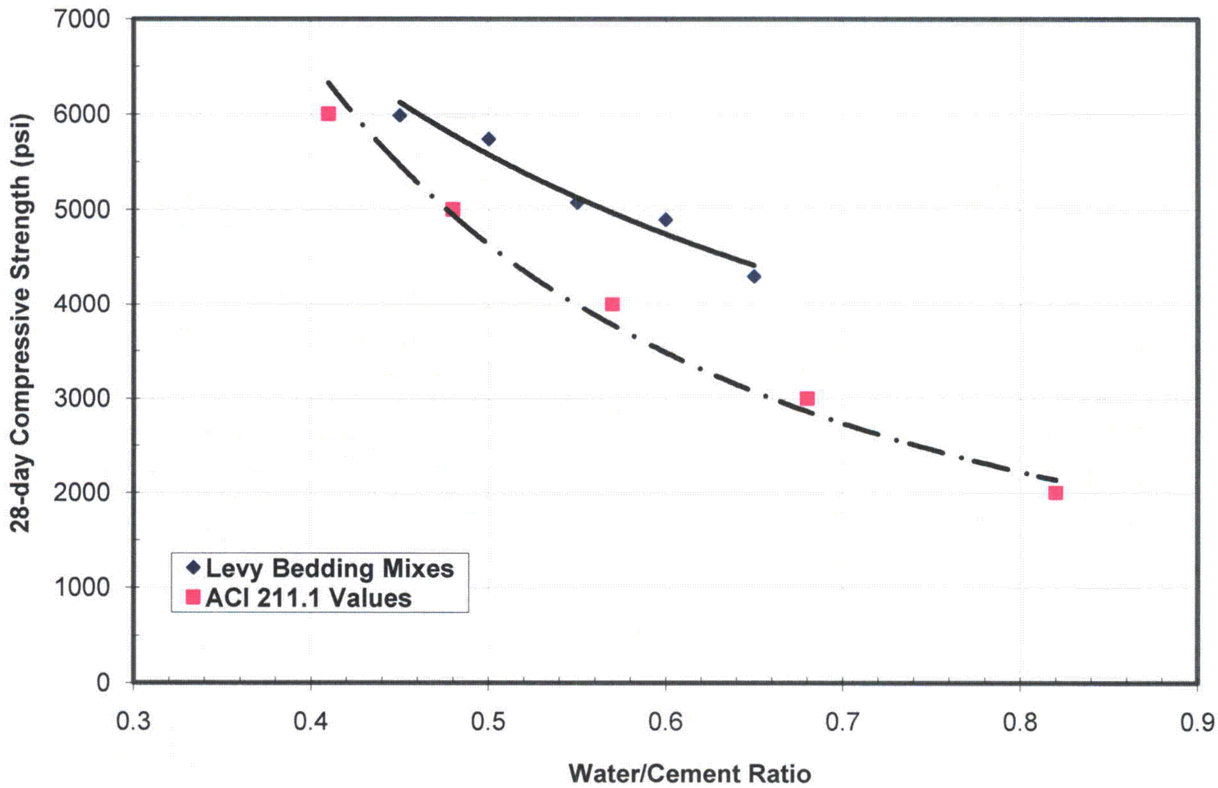


FIGURE 4-3
BEDDING MIX 28-DAY COMPRESSIVE STRENGTH VS W/C RATIO

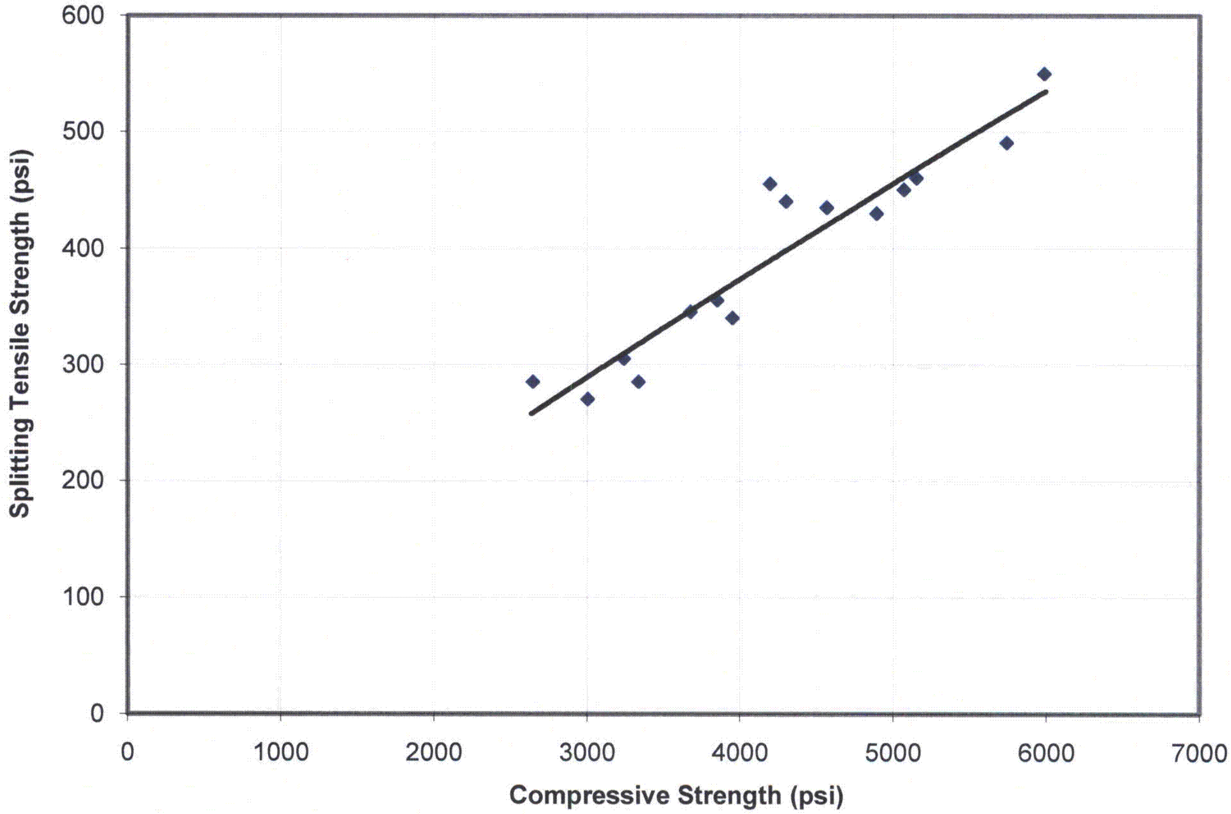


FIGURE 4-4
BEDDING MIX COMPRESSIVE STRENGTH VS TENSILE STRENGTH

5.0 CONCLUSIONS AND RECOMMENDATIONS

A total of 16 RCC mixes and 5 bedding mixes were produced and tested during the Phase II Mix Design Program.

As of the date of this revision, testing has continued through 56-day accelerated curing tests on the RCC mixes and through 28-day tests on the bedding mixes. After RCC accelerated testing at 14 days and 7-day bedding mix testing, mixes were evaluated for use in the Phase III Specialty Testing Program. The goal was to select the Phase III mix from the RCC mixes that achieved the specified f'_c value in the 14-day accelerated tests with the assumption that the target f'_{cr} value would be achieved after 365 days. Mix 1, the baseline 3,000 psi mix, achieved a 14-day accelerated strength of 3,165 psi compressive strength. Mix 8, the baseline 3,500 psi mix, achieved a 14-day accelerated strength of 3,655 psi compressive strength.

Combining the cementitious content of Mix 3 with the low moisture content of Mix 1, the mix parameters specified for the RCC and bedding mixes to be used in the Phase III Specialty Testing Program are:

- RCC mix: Mix 1 and Mix 3 combination
- f'_c: 3,000 psi
- RCC cement content: 200 pounds per cubic yard
- RCC fly ash content: 250 pounds per cubic yard
- RCC moisture content: 6.2 percent to 6.6 percent by weight
- Bedding mix: Mix 5A

These mixes will be evaluated for performance during the Phase III Specialty Testing Program, after which time a construction specification will be produced to indicate the properties and proportions of the raw materials to be used for construction of the LNP bridging mats.

APPENDIX A

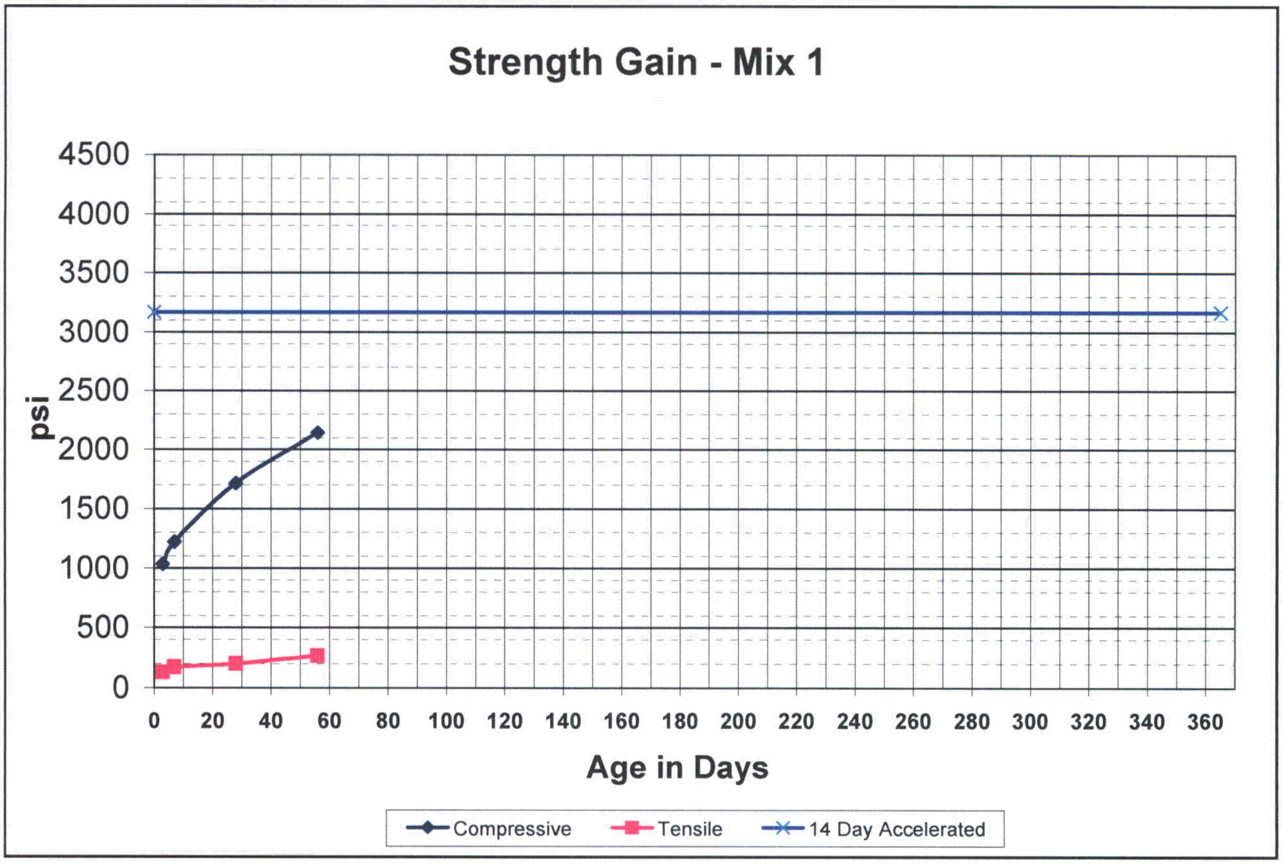
RCC STRENGTH GAIN PLOTS

PHASE II LEVY MIX DESIGN PROGRAM - MIX 1

TEST RESULTS			
Age Tested (Days)	C Test (psi)	T Test (psi)	14-Day Accelerated (psi)
3	1033	130	3165
7	1220	170	
28	1713	200	
56	2140	265	
90			
180			
365			

MIX INFORMATION		
Cementitious Content	200+225	C + FA
Air Temp	74.7	°F
RCC Temp	69.3	°F
Vebe	26	sec
Unit Weight	148.1	pcf
Moisture	6.2	%
Air	2.2	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

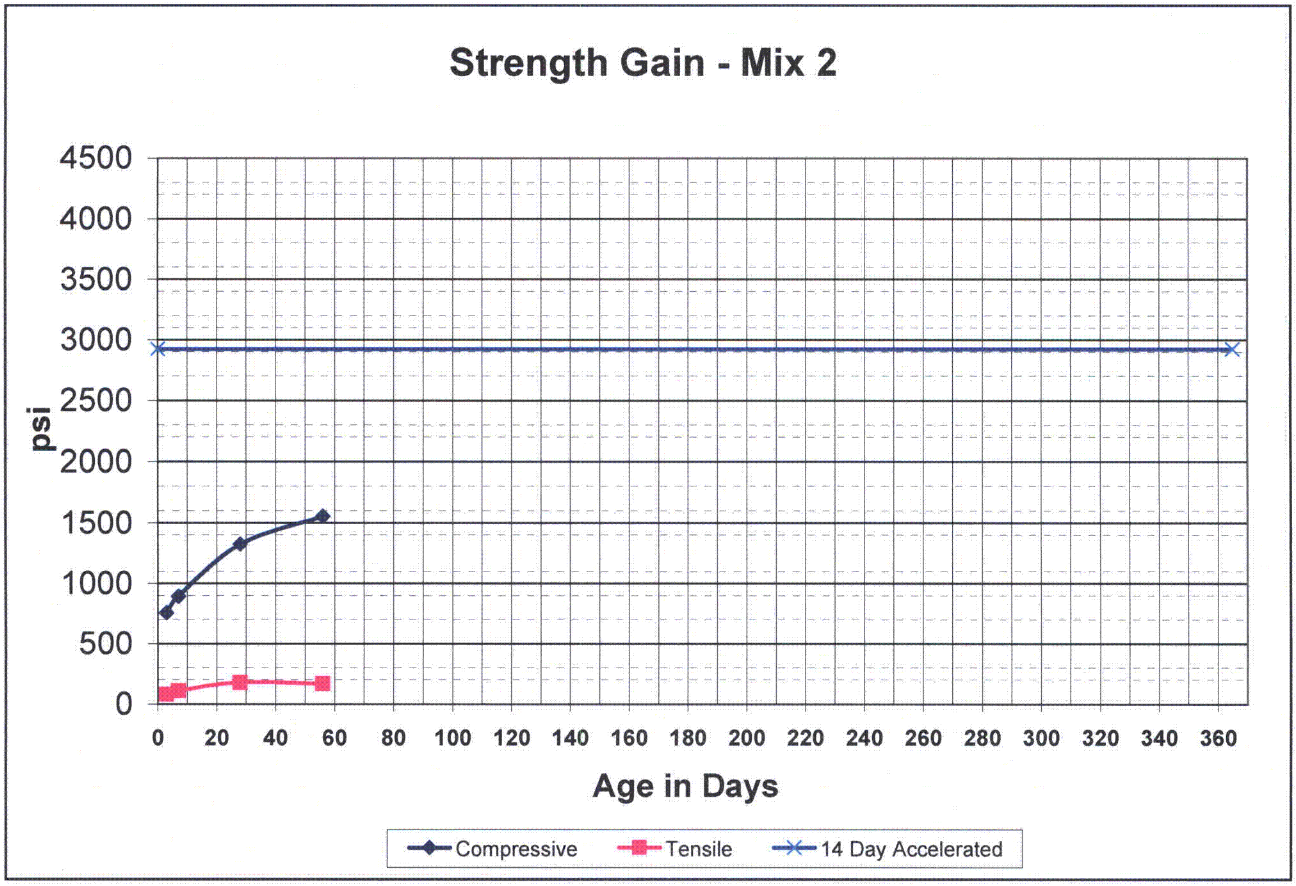


PHASE II LEVY MIX DESIGN PROGRAM - MIX 2

TEST RESULTS			
Age Tested (Days)	C Test (psi)	T Test (psi)	14-Day Accelerated (psi)
3	757	80	2920
7	893	110	
28	1320	180	
56	1553	170	
90			
180			
365			

MIX INFORMATION		
Cementitious Content	175+225	C + FA
Air Temp	60.4	°F
RCC Temp	62.7	°F
Vebe	23	sec
Unit Weight	147.8	pcf
Moisture	6.1	%
Air	1.9	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

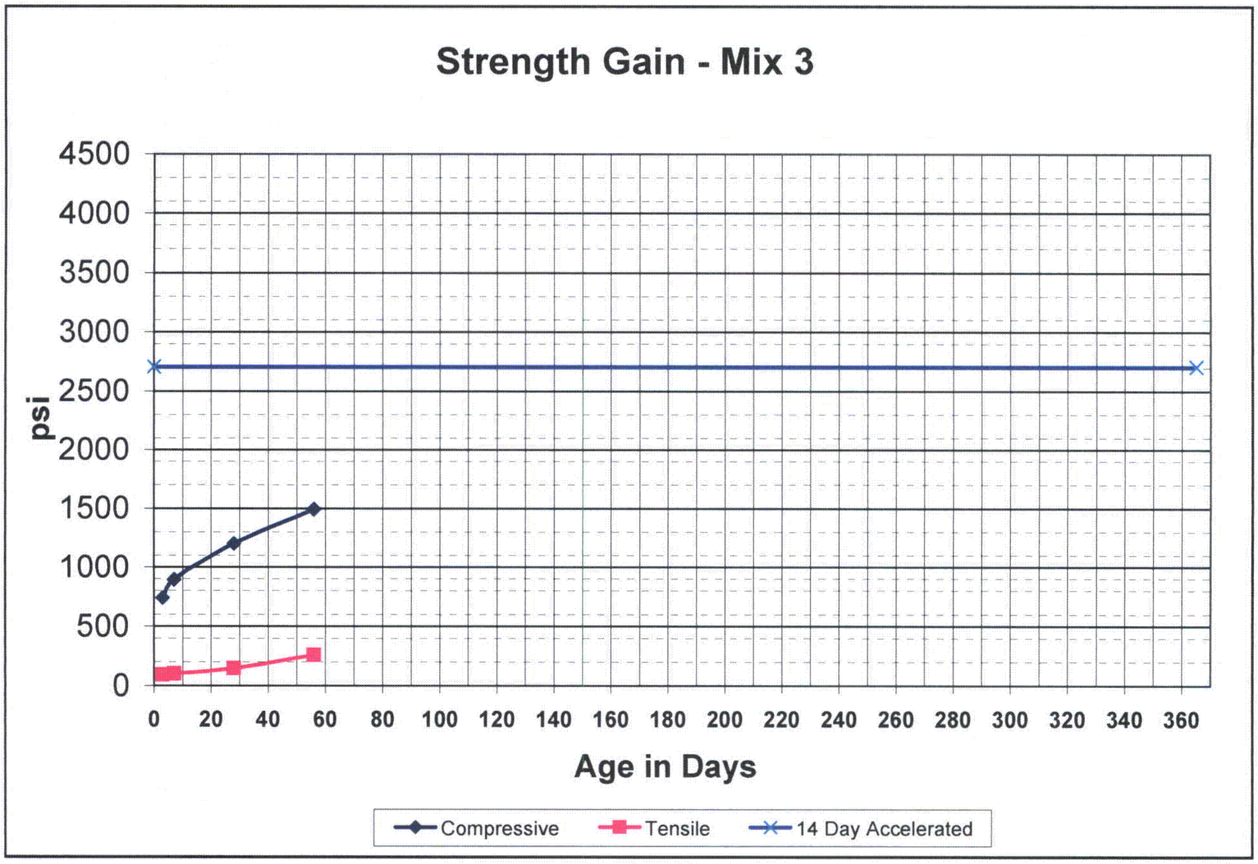


PHASE II LEVY MIX DESIGN PROGRAM - MIX 3

TEST RESULTS			
Age Tested (Days)	C Test (psi)	T Test (psi)	14-Day Accelerated (psi)
3	737	90	2705
7	890	100	
28	1200	145	
56	1490	260	
90			
180			
365			

MIX INFORMATION		
Cementitious Content	200+250	C + FA
Air Temp	67.7	°F
RCC Temp	64.2	°F
Vebe	22	sec
Unit Weight	146.2	pcf
Moisture	6.8	%
Air	2.3	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

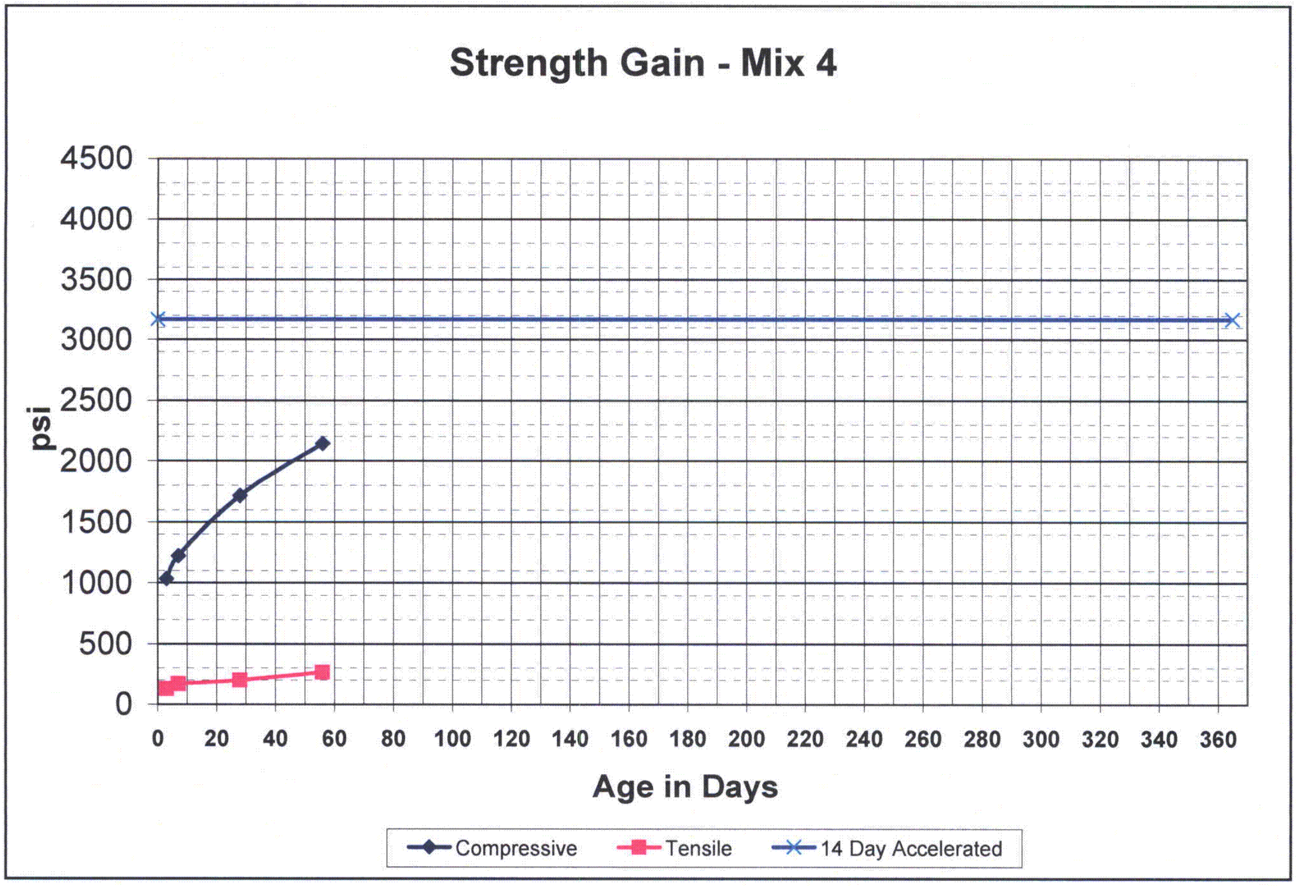


PHASE II LEVY MIX DESIGN PROGRAM - MIX 4

TEST RESULTS				
Age Tested (Days)	C Test (psi)	T Test (psi)		14-Day Accelerated (psi)
3	980	115		3260
7	1167	135		
28	1706	220		
56	2150	260		
90				
180				
365				

MIX INFORMATION		
Cementitious Content	200+225	C + FA
Air Temp	73.1	°F
RCC Temp	68.1	°F
Vebe	24	sec
Unit Weight	148.2	pcf
Moisture	6.7	%
Air	2.2	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

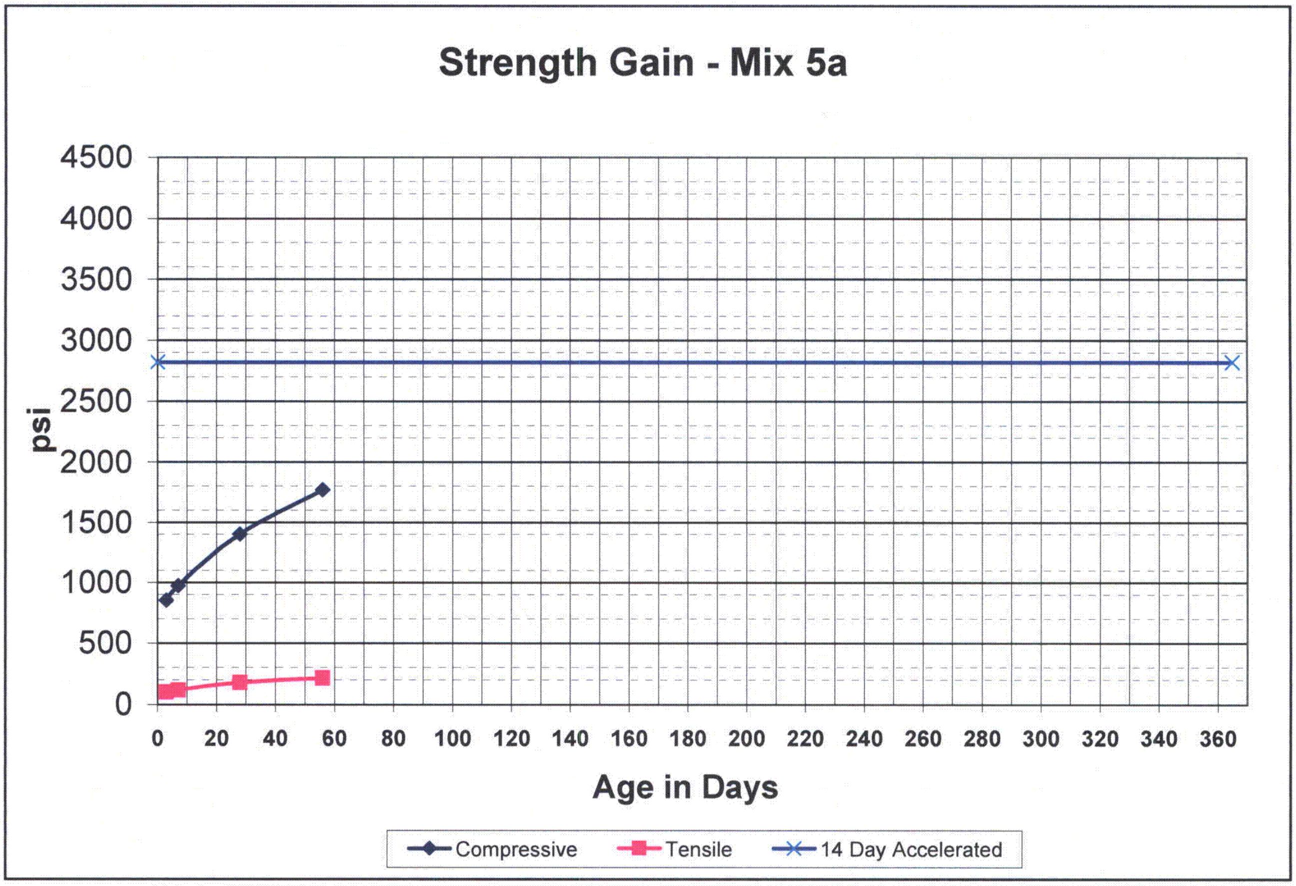


PHASE II LEVY MIX DESIGN PROGRAM - MIX 5a

TEST RESULTS			
Age Tested (Days)	C Test (psi)	T Test (psi)	14-Day Accelerated (psi)
3	853	100	2820
7	973	120	
28	1400	180	
56	1766	215	
90			
180			
365			

MIX INFORMATION		
Cementitious Content	200+225	C + FA
Air Temp	61.2	°F
RCC Temp	61.1	°F
Vebe	22	sec
Unit Weight	147.1	pcf
Moisture	6.9	%
Air	2.2	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

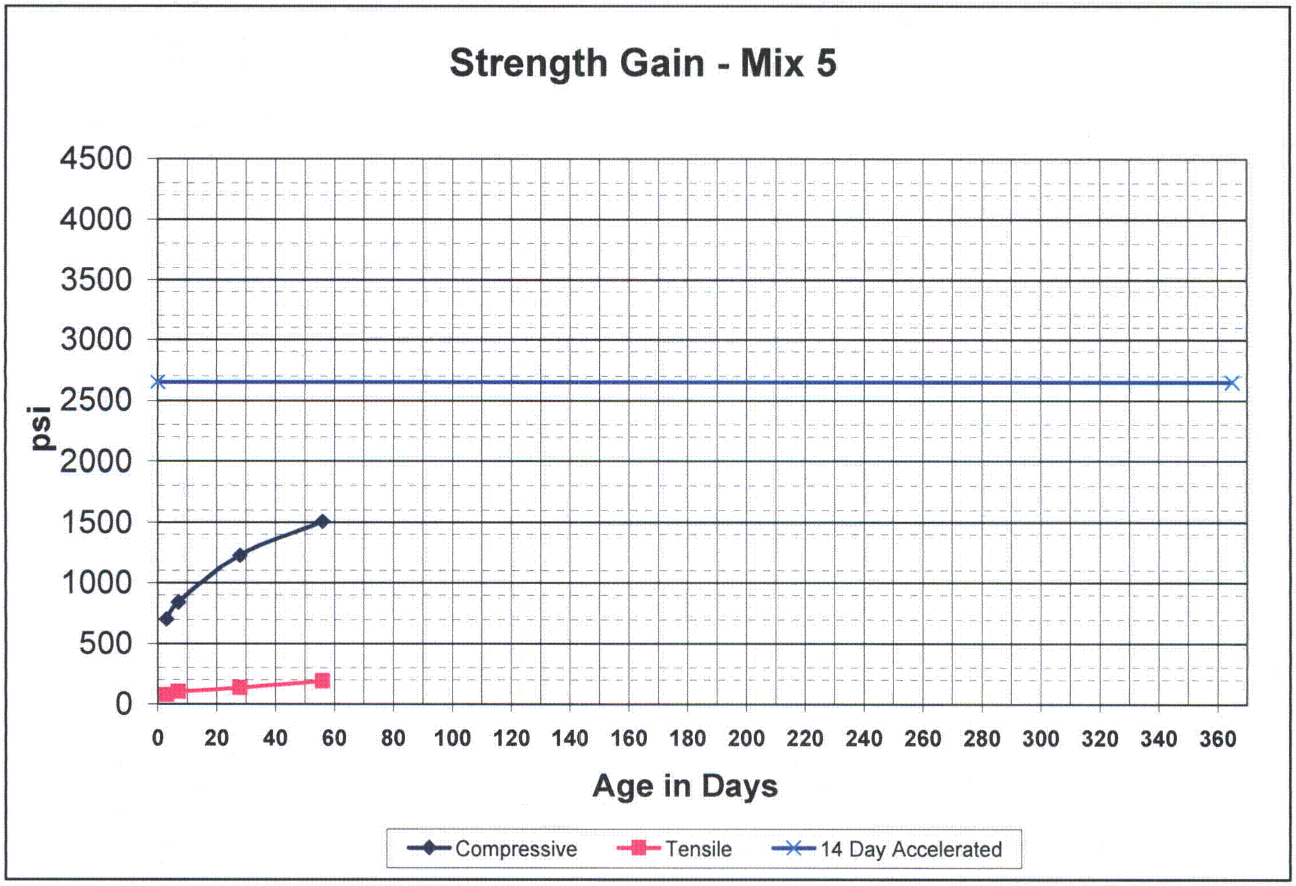


PHASE II LEVY MIX DESIGN PROGRAM - MIX 5

TEST RESULTS				
Age Tested (Days)	C Test (psi)	T Test (psi)		14-Day Accelerated (psi)
3	703	75		2645
7	843	100		
28	1223	135		
56	1503	190		
90				
180				
365				

MIX INFORMATION		
Cementitious Content	200+225	C + FA
Air Temp	69.6	°F
RCC Temp	65.3	°F
Vebe	12	sec
Unit Weight	145.4	pcf
Moisture	7.7	%
Air	2.1	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.



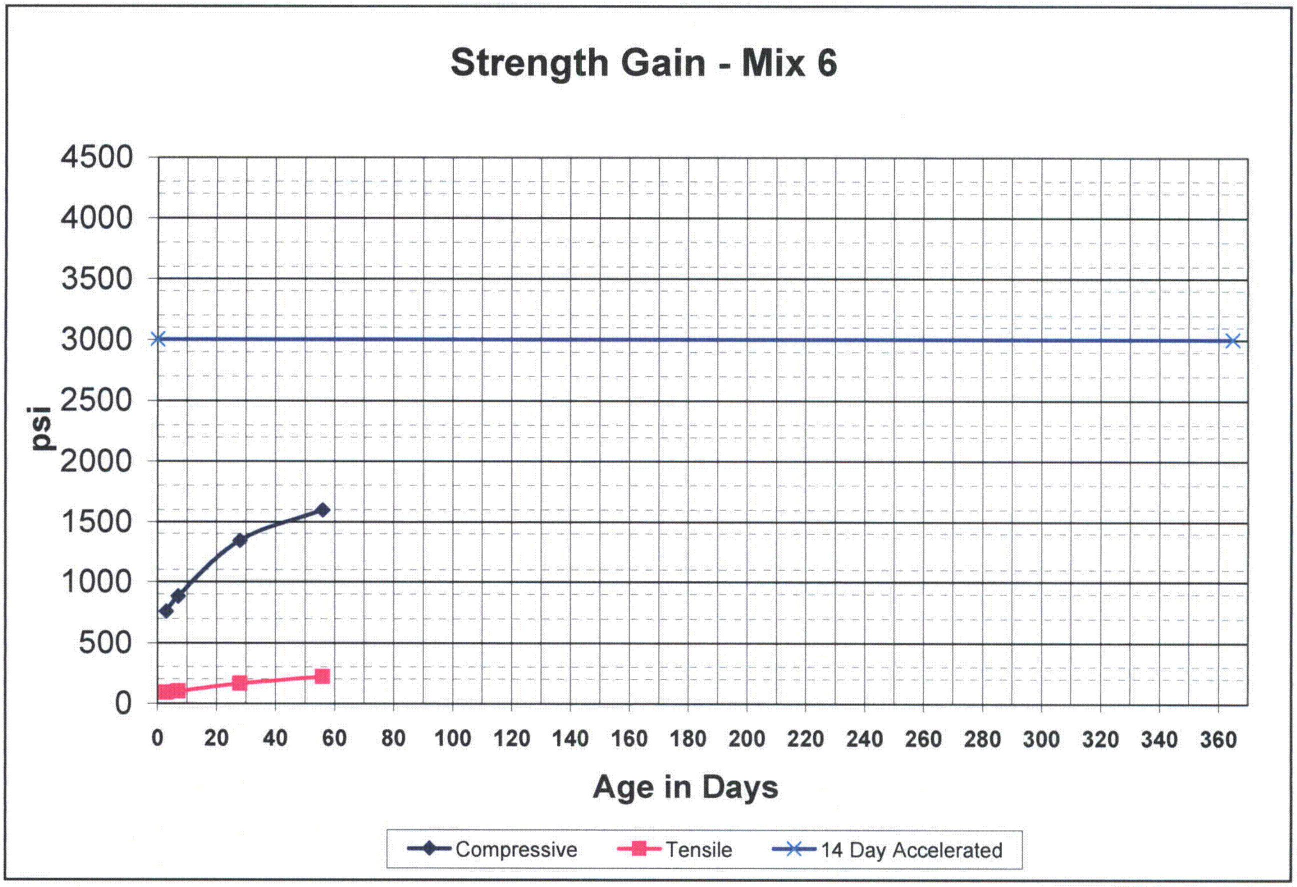
PHASE II LEVY MIX DESIGN PROGRAM - MIX 6

TEST RESULTS		
Age Tested (Days)	C Test (psi)	T Test (psi)
3	760	90
7	883	100
28	1343	165
56	1597	220
90		
180		
365		

14-Day Accelerated (psi)
3000

MIX INFORMATION		
Cementitious Content	200+225	C + FA
Air Temp	71.9	°F
RCC Temp	67.7	°F
Vebe	22	sec
Unit Weight	145.7	pcf
Moisture	7.4	%
Air	2.5	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.



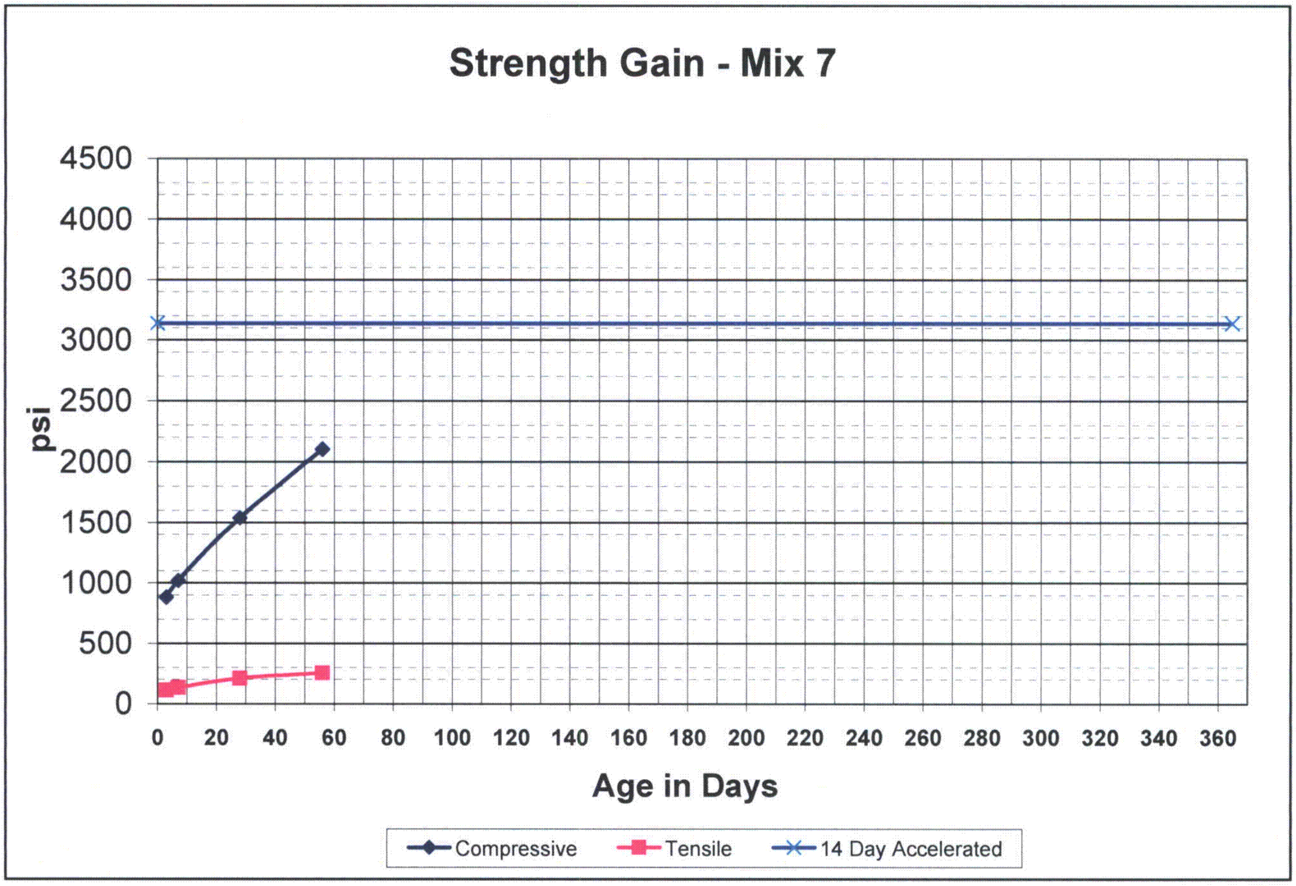
PHASE II LEVY MIX DESIGN PROGRAM - MIX 7

TEST RESULTS		
Age Tested (Days)	C Test (psi)	T Test (psi)
3	883	115
7	1020	135
28	1536	210
56	2100	255
90		
180		
365		

14-Day Accelerated (psi)
3135

MIX INFORMATION		
Cementitious Content	200+225	C + FA
Air Temp	74.7	°F
RCC Temp	69.5	°F
Vebe	21	sec
Unit Weight	146.6	pcf
Moisture	6.6	%
Air	2.3	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.



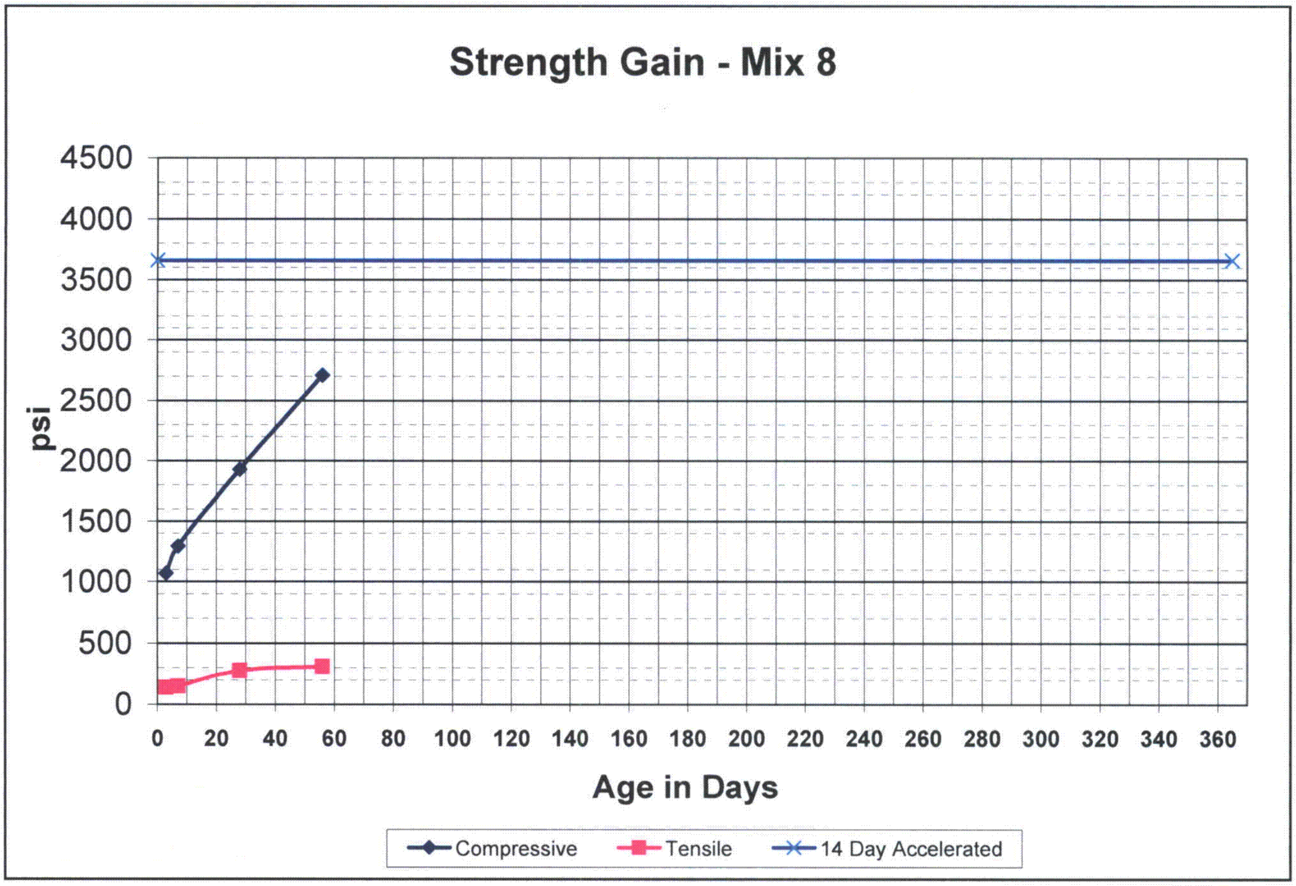
PHASE II LEVY MIX DESIGN PROGRAM - MIX 8

TEST RESULTS		
Age Tested (Days)	C Test (psi)	T Test (psi)
3	1070	140
7	1293	150
28	1926	275
56	2707	310
90		
180		
365		

14-Day Accelerated (psi)
3655

MIX INFORMATION		
Cementitious Content	225+275	C + FA
Air Temp	68.7	°F
RCC Temp	64.5	°F
Vebe	22	sec
Unit Weight	147.3	pcf
Moisture	7.4	%
Air	2.2	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

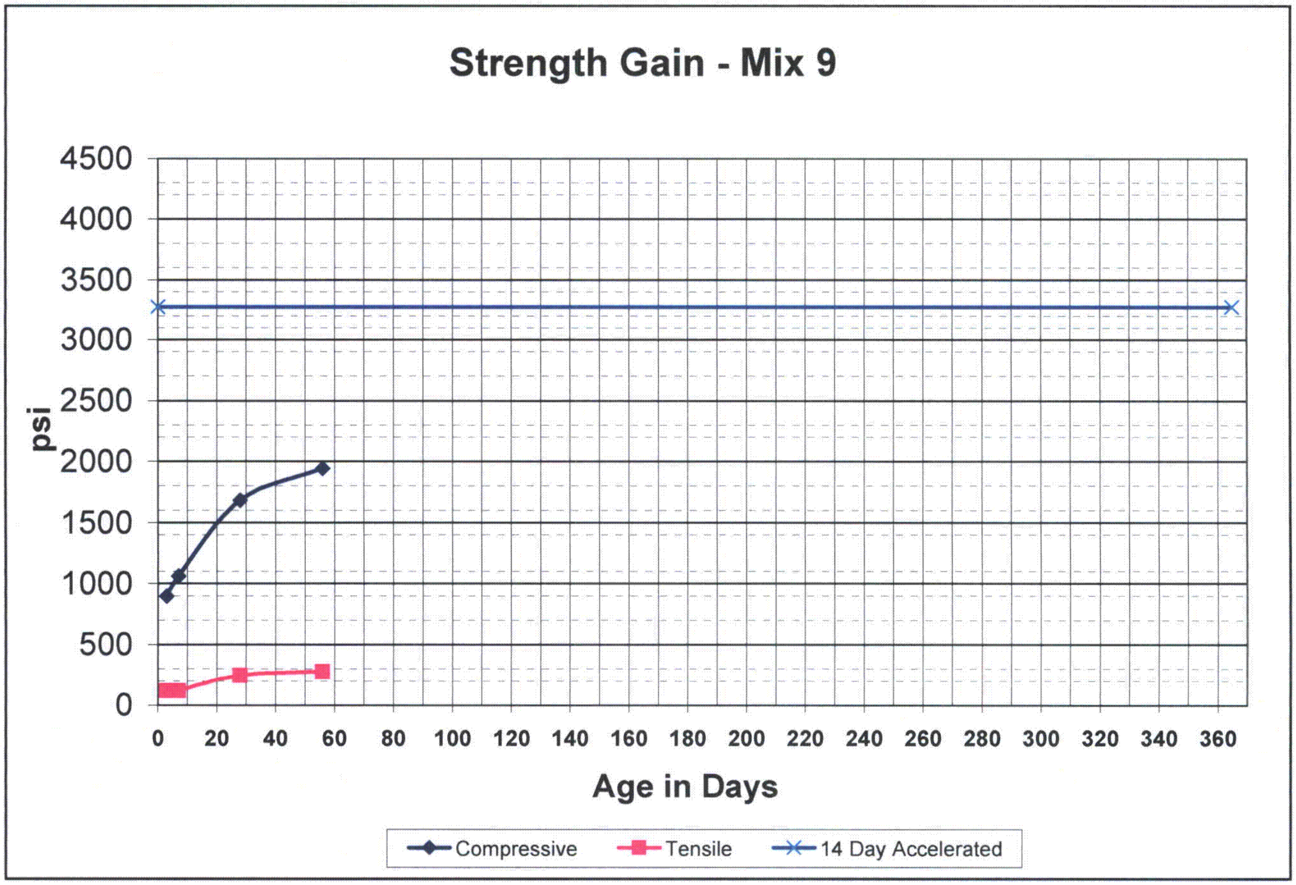


PHASE II LEVY MIX DESIGN PROGRAM - MIX 9

TEST RESULTS			
Age Tested (Days)	C Test (psi)	T Test (psi)	14-Day Accelerated (psi)
3	897	125	3275
7	1060	125	
28	1680	250	
56	1940	280	
90			
180			
365			

MIX INFORMATION		
Cementitious Content	200+275	C + FA
Air Temp	76.7	°F
RCC Temp	68.5	°F
Vebe	22	sec
Unit Weight	145.7	pcf
Moisture	7.6	%
Air	2.3	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

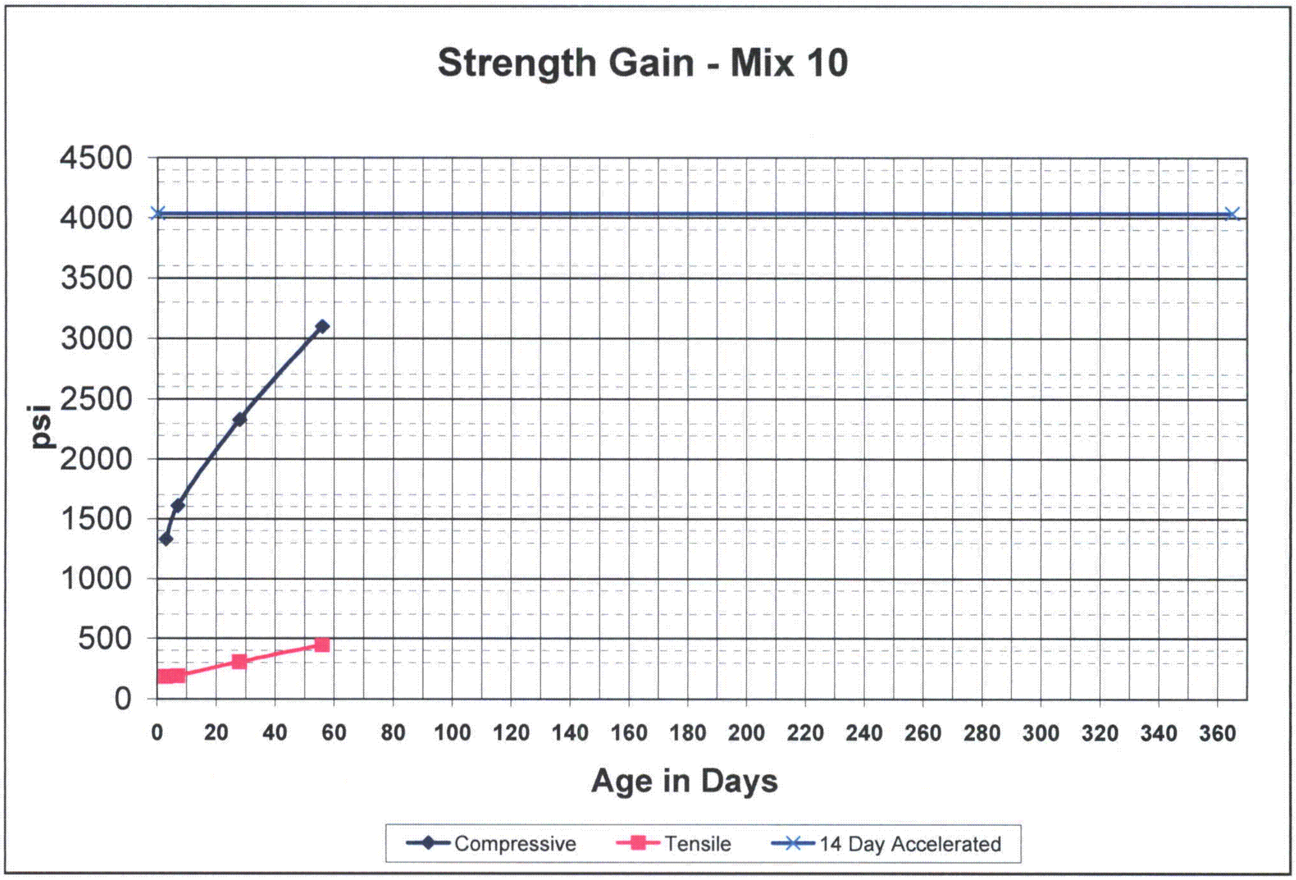


PHASE II LEVY MIX DESIGN PROGRAM - MIX 10

TEST RESULTS			
Age Tested (Days)	C Test (psi)	T Test (psi)	14-Day Accelerated (psi)
3	1330	185	4035
7	1607	190	
28	2330	305	
56	3097	445	
90			
180			
365			

MIX INFORMATION		
Cementitious Content	250+300	C + FA
Air Temp	78.5	°F
RCC Temp	69.1	°F
Vebe	21	sec
Unit Weight	145	pcf
Moisture	6.8	%
Air	2.5	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

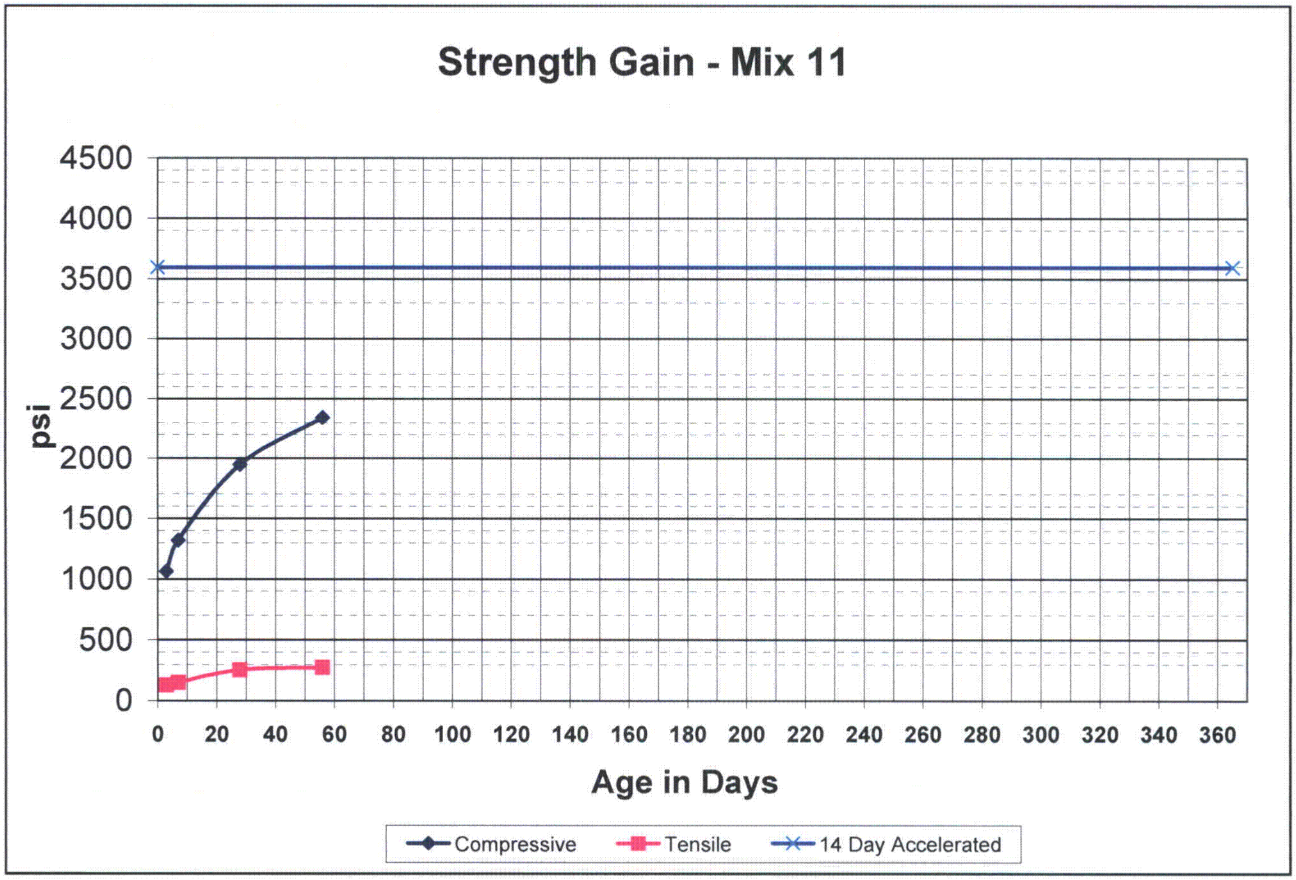


PHASE II LEVY MIX DESIGN PROGRAM - MIX 11

TEST RESULTS				
Age Tested (Days)	C Test (psi)	T Test (psi)		14-Day Accelerated (psi)
3	1063	130		3590
7	1320	150		
28	1943	255		
56	2340	275		
90				
180				
365				

MIX INFORMATION		
Cementitious Content	225+275	C + FA
Air Temp	79.4	°F
RCC Temp	71.4	°F
Vebe	20	sec
Unit Weight	146.1	pcf
Moisture	6.6	%
Air	2.4	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

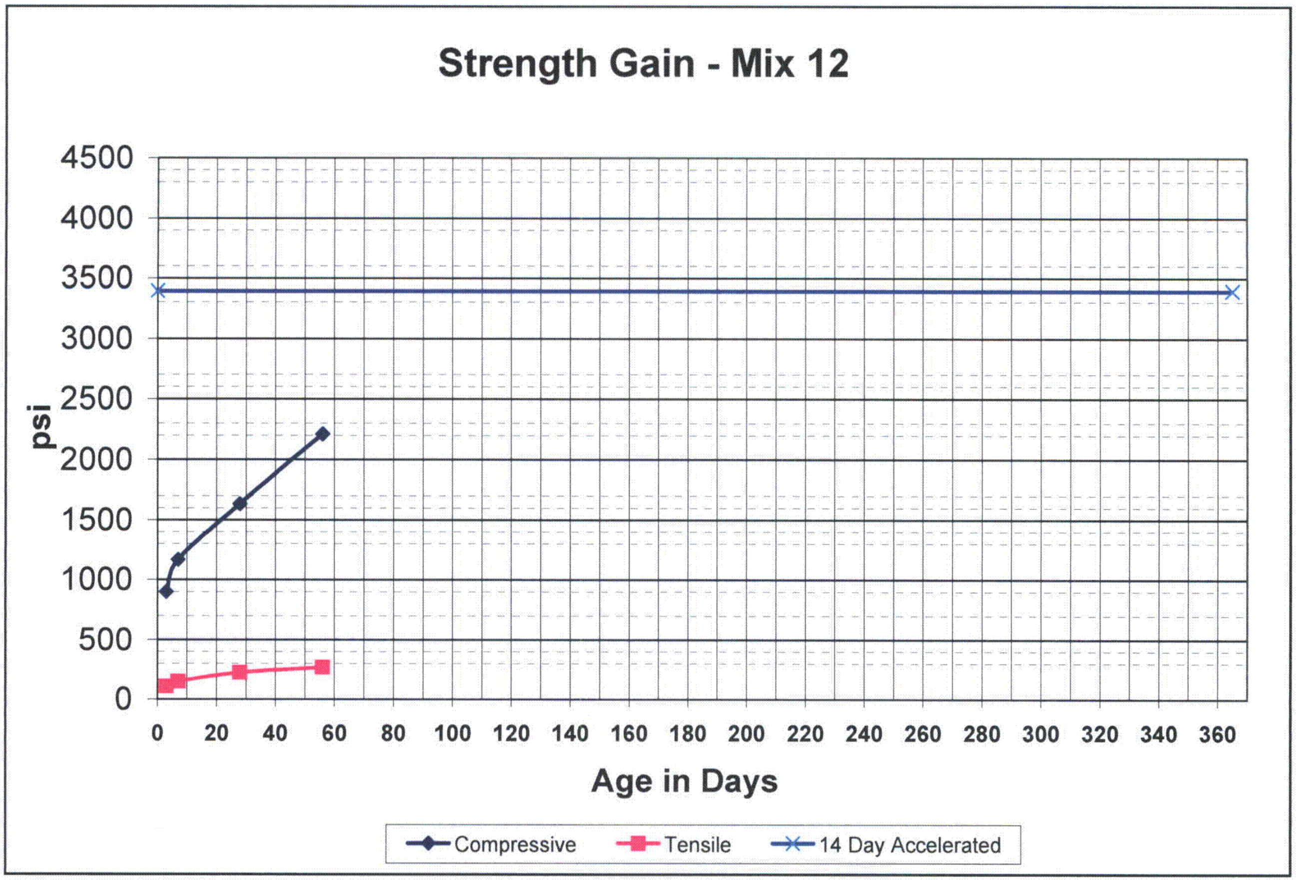


PHASE II LEVY MIX DESIGN PROGRAM - MIX 12

TEST RESULTS			
Age Tested (Days)	C Test (psi)	T Test (psi)	14-Day Accelerated (psi)
3	900	110	3390
7	1163	150	
28	1633	225	
56	2210	270	
90			
180			
365			

MIX INFORMATION		
Cementitious Content	225+275	C + FA
Air Temp	63.9	°F
RCC Temp	63.5	°F
Vebe	15	sec
Unit Weight	145.3	pcf
Moisture	7.5	%
Air	2.5	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

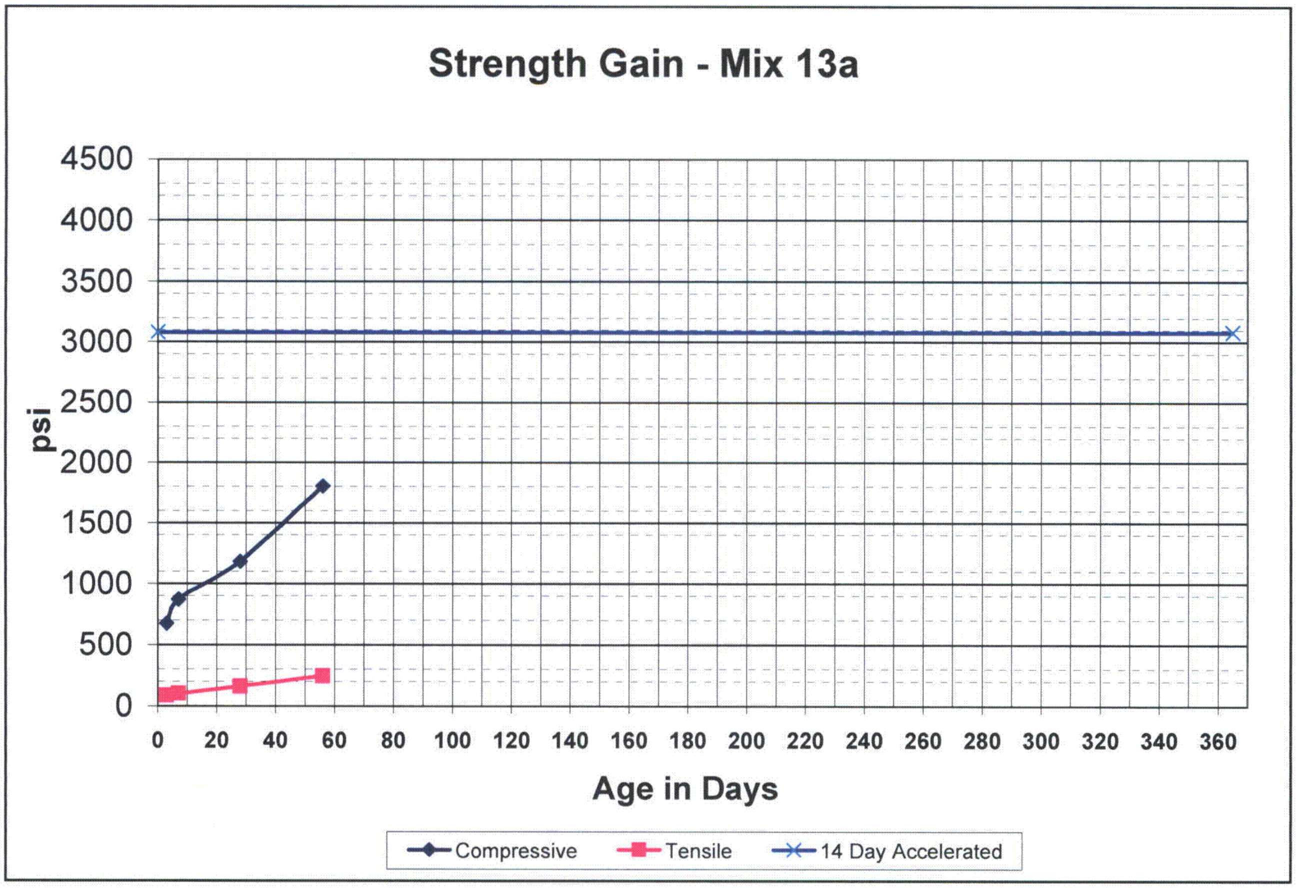


PHASE II LEVY MIX DESIGN PROGRAM - MIX 13a

TEST RESULTS			
Age Tested (Days)	C Test (psi)	T Test (psi)	14-Day Accelerated (psi)
3	673	85	3080
7	870	100	
28	1180	160	
56	1803	245	
90			
180			
365			

MIX INFORMATION		
Cementitious Content	200+275	C + FA
Air Temp	71.5	°F
RCC Temp	66.9	°F
Vebe	15	sec
Unit Weight	147.7	pcf
Moisture	7.2	%
Air	1.9	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

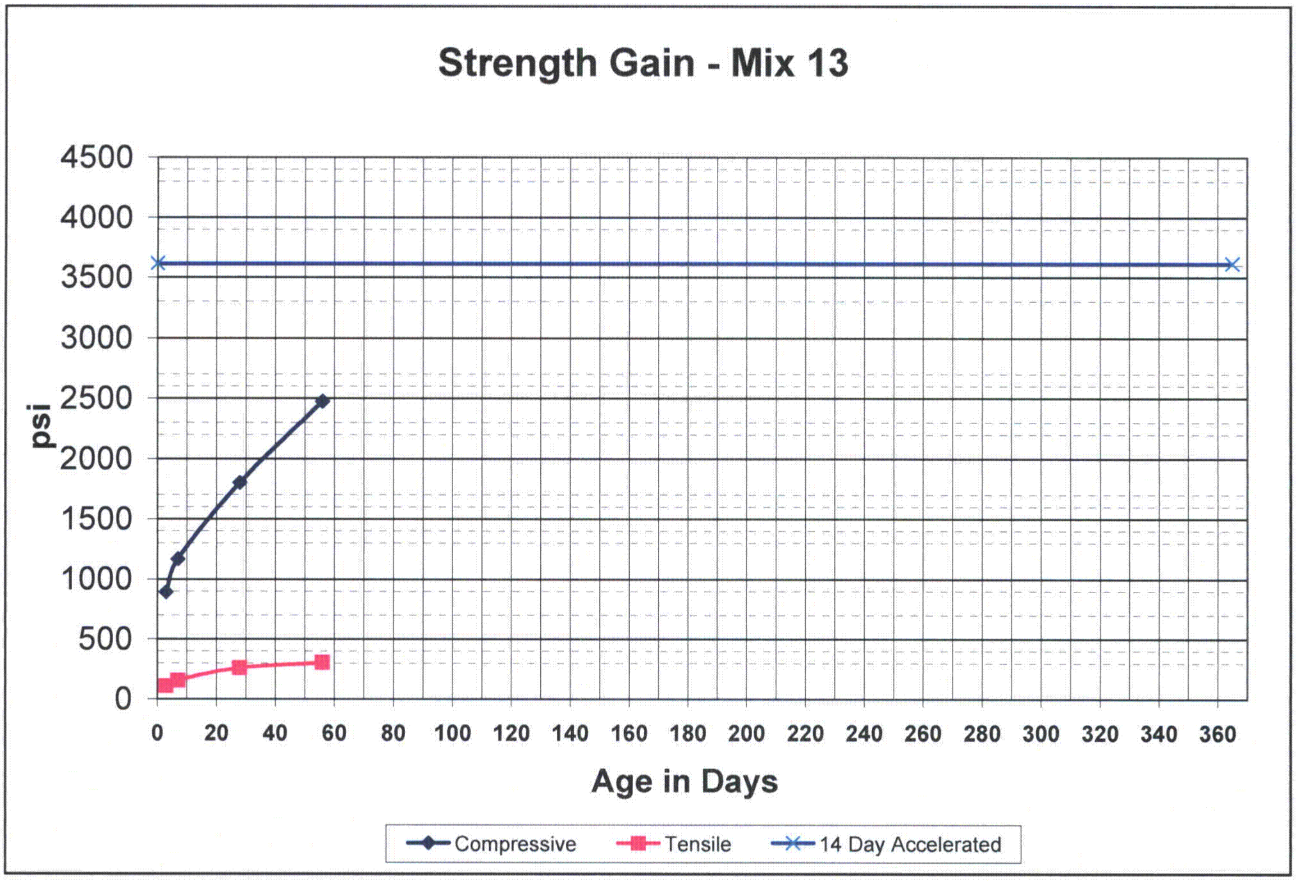


PHASE II LEVY MIX DESIGN PROGRAM - MIX 13

TEST RESULTS				
Age Tested (Days)	C Test (psi)	T Test (psi)		14-Day Accelerated (psi)
3	890	110		3610
7	1167	155		
28	1800	260		
56	2473	305		
90				
180				
365				

MIX INFORMATION		
Cementitious Content	200+275	C + FA
Air Temp	77.7	°F
RCC Temp	70.6	°F
Vebe	20	sec
Unit Weight	148.8	pcf
Moisture	6.9	%
Air	1.7	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

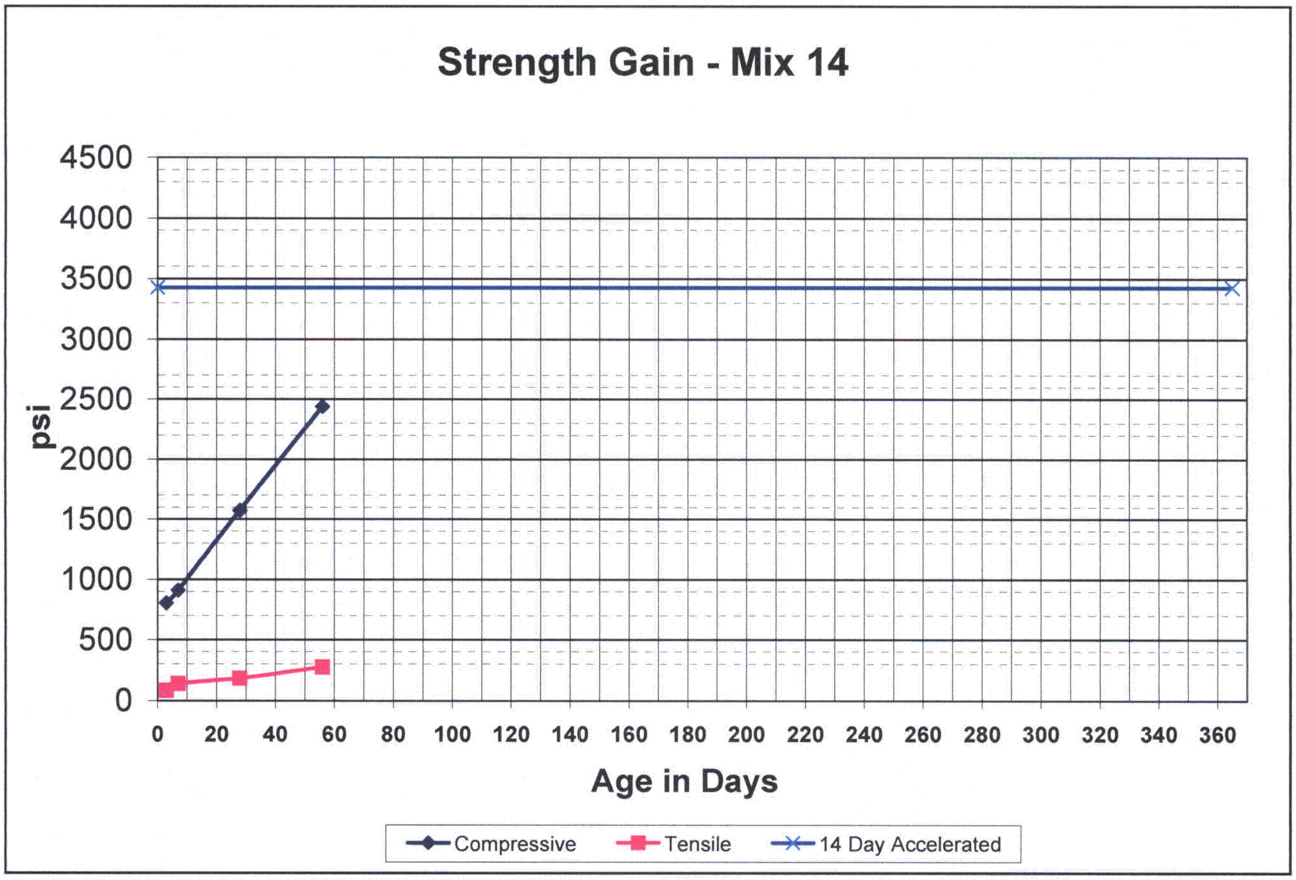


PHASE II LEVY MIX DESIGN PROGRAM - MIX 14

TEST RESULTS			14-Day Accelerated (psi)
Age Tested (Days)	C Test (psi)	T Test (psi)	
3	803	85	3425
7	909	140	
28	1573	185	
56	2437	275	
90			
180			
365			

MIX INFORMATION		
Cementitious Content	200+275	C + FA
Air Temp	63	°F
RCC Temp	67.7	°F
Vebe	11	sec
Unit Weight	146.6	pcf
Moisture	7.5	%
Air	2.1	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.

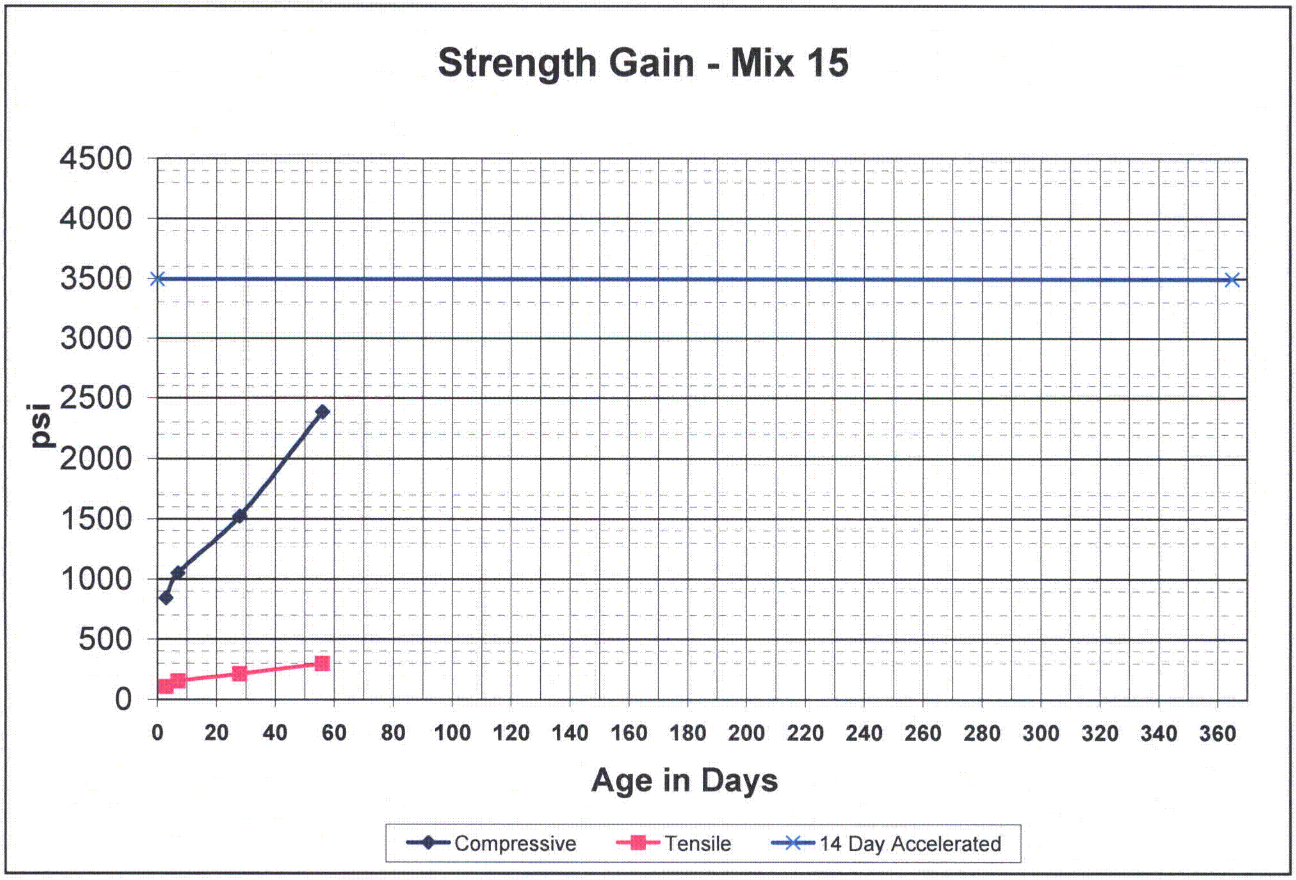


PHASE II LEVY MIX DESIGN PROGRAM - MIX 15

TEST RESULTS			
Age Tested (Days)	C Test (psi)	T Test (psi)	14-Day Accelerated (psi)
3	843	105	3490
7	1047	150	
28	1520	210	
56	2380	295	
90			
180			
365			

MIX INFORMATION		
Cementitious Content	225+275	C + FA
Air Temp	72.9	°F
RCC Temp	69.9	°F
Vebe	20	sec
Unit Weight	147.2	pcf
Moisture	7.1	%
Air	2.2	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.



PHASE II LEVY MIX DESIGN PROGRAM - MIX 16

TEST RESULTS			
Age Tested (Days)	C Test (psi)	T Test (psi)	14-Day Accelerated (psi)
3	923	115	3460
7	1147	120	
28	1870	230	
56	2420	320	
90			
180			
365			

MIX INFORMATION		
Cementitious Content	225+275	C + FA
Air Temp	72.7	°F
RCC Temp	71	°F
Vebe	23	sec
Unit Weight	144.8	pcf
Moisture	6.7	%
Air	2.5	%

NOTE: The 14-day accelerated curing test was used to estimate 180-day compressive strength. The 14-day value is generally in the range of 75% of the 365-day compressive strength.