PHYSICAL PROPERTIES OF PORTLAND CEMENT CONCRETE WITH SILICONE ADDITIVE

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ABSTRACT

PHYSICAL PROPERTIES OF PORTLAND CEMENT CONCRETE WITH SILICONE ADDITIVE

by Paul Phillip Sulprizio

In the manufacture of concrete as a structural material, various types of admixtures are added to the concrete mix to alter the mix characteristics as well as the characteristics of the hardened concrete. These admixtures may be classified as air-entraining agents, retarders, accelerators, workability agents, and water-repellent agents. In this study the area of water-repellent concrete will be investigated using several silicone solutions as admixtures. The purpose of the study is to determine the effect of these silicone additives on the physical properties of the concrete.

Preliminary tests were conducted using four types of silicone additives in three basic concrete mixes having different cement contents. The additive coupled with the mix yielding the best performance was selected for more detailed investigation.

Data from flexure and compression tests revealed that mixes containing the selected additive were initially stronger than plain concrete, but as age increased, the effect of the additive decreased. It was also noted that an increase in the water-cement ratio brought about an increase in flexural and compressive strength of mixes with the silicone additive.

Based on a limited number of freezing and thawing specimens, the addition of the silicone additive to concrete mixes caused an increase in durability.

Use of the silicone additive in concrete mixes retarded both initial and final time of set. In addition, no effect on the change of volume of concrete was observed.

Fatigue tests showed that the stress level factor had no effect on the probability of failure when the specimen contained the silicone additive.

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by

Paul Phillip Sulprizio

A THESIS

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f_c'	ultimate strength in compression (psi)
f_r	modulus of rupture (psi)
E	dynamic modulus of elasticity (psi)
W	weight of the specimen (lbs)
C	a constant shape factor for a freeze-thaw specimen
N'	actual life of a freeze-thaw specimen (cycles)
M	expected life of an air-entrained specimen (cycles)
P	percent reduction of the dynamic modulus of elasticity at which failure occurs (percent)
DF	durability factor (number)
p	probability of failure of a fatigue specimen (percent)
m	total number of fatigue specimens (number)
u	a rank ranging from one to m in order of increasing fatigue life for fatigue specimens tested at one stress level (number)
N	number of cycles to failure of fatigue specimen

I. REVIEW OF LITERATURE

Silicone solutions in liquid form have been used as a spray or dip to improve the resistance of poured concrete, brick, sandstone, and other building materials to freezing and thawing action. This process has proven to be quite effective on both plain and air-entrained concrete (1). More recently, limited investigations of the effect of silicone solutions as admixtures in Portland Cement concrete have been made both here and abroad.

In 1957, Scheribel and Supinger (2) conducted preliminary studies on the effect of silicone additives DC-772 and DC-771 when used as an admixture. Compression tests were performed at two, seven, and twenty-eight days of age on a total of sixteen specimens. One control mix and three mixes each of the silicone additives were made with varying concentrations of the silicone solids. Water absorption and time of set tests were also carried out. Results indicated that the addition of small amounts of the silicone additives increased the compressive strength considerably. It was also noted that the silicone additives produced a retarding effect on the concrete mix. Neither of the silicone additives had any effect on the water absorption properties of the concrete mixes. Of the two silicone additives, DC-772 yielded better results. The optimum amount of dosage appeared to be between 0. 2 and 0. 4 percent of the total solids of the solution based on the weight of the cement used in the mix.

In the same year Peterson (3) carried out laboratory compression tests on mixes containing the silicone additive DC-772. In addition, field compressive tests were performed on specimens taken from an experimental highway section which was poured with varying concentrations of the silicone additive. Once again the optimum amount of the silicone additive was in the range 0.2 to 0.4 percent of total solids based on the weight of cement in the mix. A later study made by Peterson confirmed the compression strength data obtained earlier and also revealed that the silicone additive DC-772 did not lose its effectiveness at ages of sixty-one and one hundred and twenty-four days. The control mix was tested at seven and twenty-eight days of age and was assumed to gain in compressive strength thereafter.

In 1959, Professor V. M. Moskveen, Director of Technical Sciences of the Academy of Building and Architecture in the USSR (4), conducted experiments on the effect of varying concentrations of the silicone additive GKJ-94 on the compressive strength, density, water absorption, time of set, and durability of concrete mixes. The water absorption was determined by weighing saturated concrete beams which had been previously dried out to a constant weight. No information is available on the control mixes, number of specimens tested or the methods used to determine density and time of set. Prior to the freezing and thawing tests the specimens were saturated in a five percent solution of sodium chloride. They were then placed in pans containing the five percent sodium chloride solution, transferred to the freezing device for a period of sixteen hours and then allowed to thaw for eight hours.

Moskveen observed from these experiments that the compressive strength of the concrete containing silicone additive GKJ-94 was greater than that of the control mixes for test ages of three, seven, and twenty-eight days. He noted that small quantities of the silicone additive GKJ-94 did not influence the normal density of the mortar; however, with the introduction of the silicone additive in amounts of five percent of the weight of the cement, normal density increased. The water absorption remained unchanged. The time of both initial and final set for mixes containing the silicone additive was more than doubled and the durability varied according to the concentration of the silicone additive used in the mix. With a silicone additive concentration of one percent of the weight of cement, the highest durability and the largest gain in compressive strength were achieved. Density and water absorption were not affected by this dosage.

Farbenfabriken Bayer AG, in Leverkusen, Germany (5), conducted moisture penetration and water absorption experiments on plaster and cement mortar containing the silicone additive Bayer F. After curing for an unspecified length of time the disk-shaped water penetration specimens were dried to a constant weight. A glass tube containing a moisture-absorbing medium, "Silicagel," was firmly attached to one side of the specimen. The specimen was then placed in a moist room with a constant humidity of ninety percent and removed periodically to weigh the moisture-absorbing medium. To measure the water absorption, the air-dried specimens were submerged in a glass jar filled with water to a depth of six centimeters. The hydrostatic pressure of five centimeters was presumed to provide the equivalent of a hundred kilometer per hour rain and wind storm. Specimens for both experiments were five centimeters in diameter and one centimeter thick.

The silicone additive Bayer F had no effect upon the resistance of concrete to moisture penetration. It was established that specimens treated with silicone additive Bayer F absorbed considerably less moisture than the control specimens. This phenomenon can be attributed to the fact that the silicone additive closes minute pores in the specimens which otherwise would accept and retain the moisture.

While silicone compounds have been used in the form of a spray or dip for concrete surfaces, they have not been used as additives in concrete mixtures. The purpose of this study is to explore this latter possibility.

II. INTRODUCTION

Previous investigations revealed that silicone solutions when used as admixtures have desirable effects upon the hardened concrete with regard to compressive strength, density, and durability. On the other hand, the investigators did not agree on water absorption studies. In all experiments it was observed that silicone additives produced a retarding effect on the concrete mixes which is highly desirable where mixing at the construction site is not feasible.

Because of the versatility of concrete as a structural material, new methods are constantly sought to improve its physical characteristics. It is yet to be determined what effects silicone admixtures have on the properties of creep, bond, durability, fatigue, and strength. The corrosive effect of silicone additives on reinforcing bars and prestressing cables likewise needs evaluation.

The purpose of this study is to determine the effect of four silicone additives, DC-772, DC-771, XR-8-0036, and QZ-6208, on the physical properties of Portland Cement concrete. Within the scope of this thesis, it was possible to investigate the effect of silicone additives on: compressive strength, flexural strength, shrinkage, durability, time of set, and fatigue.

III. MATERIALS AND MIX DESIGN

Both the fine and coarse aggregates used in this study were subjected to a sieve analysis and a fineness modulus of 2.76 was obtained for the fine aggregate and 5.90 for the coarse aggregate. Since small-sized specimens were used in the investigation, the maximum size of the coarse aggregate was limited to three-quarters of an inch.

The method of design used was that outlined by the Portland Cement Association (6). In order to avoid undue variations in data, equally mixed proportions of three different commercial brands of Portland Cement Type I were used.

The silicone additives, which were 0.3 percent total solids of solution based on the weight of cement, were combined with water and then introduced into the mix; by using this procedure concentration of the additives was prevented. Control mixes and additives used may be found on page 35 of the appendix.

VI. PROCEDURE OF INVESTIGATION

In the preliminary investigation two series of mixes, A and B, were subjected to compressive and flexural tests along with freezing and thawing tests. The primary purpose of this portion of the program was to determine which of the four different silicone additives combined with any of three different cement contents yielded the most promising results with respect to economy of design and overall performance. A constant water-cement ratio was maintained in this initial survey in order to obtain a comparison of the silicone additives. A total of forty cylindrical specimens four inches in diameter and eight inches long representing eight control specimens and four groups of eight specimens each containing the four types of silicone additives, were tested at seven and twenty-eight days of age for compressive strength. Cement content levels of five, six and one-half, and eight sacks per cubic yard were used in the mixes. The same procedure was followed for three inch by four inch by sixteen inch flexural and durability specimens.

After establishing the superiority of one silicone additive, a more comprehensive investigation was undertaken. The chosen additive and cement content were duplicated in mixes C, D, and E and subjected to the tests mentioned above, so that the data obtained in the preliminary investigation would be confirmed. In addition, a study of time of set and shrinkage was conducted on mixes C, D, and E. An investigation was also made on fatigue properties using the selected additive. This series of mixes was designated as I through Q. The water-cement ratio was varied in the detailed investigation while the slump was held constant. A total of forty-four control specimens and forty-four specimens containing the chosen additive were tested for compressive strength and flexural strength at ages of three, seven, and twenty-eight days. In addition, six control specimens and six specimens containing the silicone additive were tested for durability. The fatigue investigation employed twenty-seven control specimens three inch by three inch by eleven inch at three levels of applied stress, and the same number for specimens containing the silicone additive. The fatigue specimens had both compressive and flexural strength companions.

All specimens used in the program were moist cured prior to their respective tests and the experiments were conducted according to the procedures prescribed by ASTM specifications. In the instance of both freezing and thawing, and fatigue, only general methods are discussed in the above specifications, consequently, a detailed explanation of procedure is described herein. Prior to placing in the Brown freeze-thaw machine, all specimens were moist cured for fourteen days. After removal from the moist curing room, specimens were allowed to dry and their weights were recorded. They were then placed in the freezing and thawing apparatus and frozen, after which they were thawed and sonic modulus measurements were made when the specimens reached a temperature of forty degrees Fahrenheit. The specimens were then placed in metal containers, returned to the freeze-thaw machine and complete submerged under water. The temperature was then rapidly reduced to zero degrees

Fahrenheit. Specimens were tested for their dynamic modulus of elasticity every six to eighteen cycles depending upon the amount of air present in the beam. One cycle corresponded to a four hour period. A thirty percent reduction in the dynamic modulus of elasticity was regarded as failure. Normally, an air-entrained concrete specimen is expected to pass through three hundred cycles of freezing and thawing without having a thirty percent reduction occur in the dynamic modulus of elasticity. A ratio may then be formed between the expected life of a specimen (three hundred cycles or M), actual life of a specimen (N'), and the percent reduction in the dynamic modulus of elasticity at which failure occurred, thirty percent or P. This is defined as the Durability Factor.

$$\text{D. F.} = \frac{PN'}{M}$$

The number of cycles at which failure occurred was obtained graphically by plotting the number of cycles versus percent reduction of the dynamic modulus of elasticity.

The fatigue study was conducted on three different levels of applied stress, the same stress levels being applied to beams with and without the silicone additive. A total of nine specimens were tested at each stress level. Three specimens were tested in flexure to failure in order to determine the modulus of rupture, f_r. Three compression tests were also made so that the effect of the silicone additive could be observed at the age of testing. The age of these specimens varied from ninety to one hundred and ten days. The stress levels used were forty percent, forty-two and one-half percent, and forty-five percent of the modulus of rupture.

Although the modulus of rupture varied from mix to mix, the level of stress applied was always constant.

A Sonntag fatigue testing machine was used for the flexural fatigue study. The dynamic force was applied at a rate of eighteen hundred cycles per minute and subjected the specimens to reversal of flexural stress. The design of the machine is such that only a vertical force was transmitted to the third points of the specimen. The probability of failure, p, due to fatigue, was computed by using the following equation:

$$p = \frac{u}{m+1}$$

where u is a ranked specimen belonging to a total of m specimens which were tested at one stress level.

V. DISCUSSION OF RESULTS

Experimental results of the preliminary investigation revealed that silicone additives DC-772 and DC-771 when combined with a five sacks per cubic yard mix were superior to the other two silicone additives in both compressive and flexural strength. The study also indicated that the effects of the silicone additives decreased somewhat as the cement content increased. Figures 1, 2, and 3 show the average flexural results for five, six and one-half, and eight sacks per cubic yard mixes when combined with the silicone additives. Likewise, Figures 4, 5, and 6 illustrate the compression results.

Freezing and thawing results for this initial study indicated that the durability of concrete mixes with less cement appeared to be influenced more by the silicone additives. The one notable exception was silicone additive DC-771. Concrete specimens cast from duplicate mixes yielded varied results when subjected to freezing and thawing action. Woods (7) stated that a poor distribution of air could very well account for this behavior. Although relationships developed for three of the silicone additives when used with varying cement contents, no such trend was established for the silicone additive QZ-6208. Figure 7 shows the relationship between D. F. and the cement content for the various mixes.

Since the greatest gain in strength and durability was experienced at the five sacks per cubic yard level with silicone additive DC-772, this mix was selected for the detailed investigation.

The results of the detailed investigation confirmed the data obtained in the initial study with respect to the combination of silicone additive DC-772 and a five sacks per cubic yard cement content. In addition, the modulus of rupture and the ultimate compressive strength were determined for ages of three, seven, twenty-eight, and ninety to one hundred and ten days. Very little variation in compressive and flexural strength was noted for all of the fatigue companion specimens. Figures 10 and 13 show the average results of flexure and compression tests for ages of three, seven, twenty-eight, and ninety days. Tables 19 and 22 list the percent gain in compressive and flexural strength for silicone additive DC-772 mixes over plain concrete mixes when combined with a cement content of five sacks per cubic yard. The results of compressive and flexural tests show that the influence of silicone additive DC-772 decreased at the age of ninety days for the five sacks per cubic yard mix.

No definite trend developed where freezing and thawing of silicone additive mixes was concerned, but it does appear that the durability of low cement content mixes was increased. Silicone additive DC-772 in a five sacks per cubic yard mix improved the durability approximately two and one-half times. Table 25 and Figure 14 illustrate the effectiveness of the silicone additive DC-772 when combined with a five sacks per cubic yard mix to resist the action of freezing and thawing. Moskveen reported a gain in durability of approximately one and one-half times that of plain concrete, however, no information was given on the control mixes.

The time of initial and final set was increased when additive DC-772 was introduced into mixes. Table 27 lists the time of initial set and the time of final set for plain concrete mixes and concrete mixes containing silicone additive DC-772. The study directed by Moskveen also showed that silicone additives act as a retarder.

A comparison of the change of volume during the critical twenty-four hour period after mixing was not possible due to the retarding effect of silicone additive DC-772. Therefore, the procedure outlined by ASTM specifications for shrinkage was not employed and another test was resorted to. A rubber balloon was placed in a glass tube and was partially filled with mortar from a mix and then completely filled with water. A rubber stopper was inserted into the glass tube and the edges were sealed with wax. A graduated pipette was placed through the rubber stopper and filled with water. This test revealed that silicone additive DC-772 increased shrinkage by a maximum amount of 0. 3 percent when compared to plain mortar. These measurements are listed in Table 26.

Early investigations made by Clemmer (8), Ewing (9), and others (10), indicated that the fatigue limit for plain concrete fell in the range of fifty to fifty-four percent of the modulus of rupture, and that this range was somewhat dependent upon the cement content, rate of load application, and range of the applied loads. Kesler (11, 12) later found that the rate of loading had little effect on the fatigue strength of plain concrete, but came to no definite conclusions concerning the fatigue limit. McCall (13) subsequently conducted a study of fatigue and noted that no endurance limit could be established for a stress level of forty-seven and one-half percent of the modulus of rupture when applied to a five and six-tenths sacks per cubic yard mix.

The results of this study indicated that no endurance limit could be definitely established for a five sacks per cubic yard mix with the lowest applied stress level of forty percent of the modulus of rupture. The addition of silicone additive DC-772 appeared to improve the fatigue strength at a low stress level, but upon approaching a higher stress level, the effect of the silicone additive was less evident. This is shown in Figure 19. This fatigue study was based on fifty-four specimens.

VI. CONCLUSIONS

On the basis of observations made in this investigation the following conclusions may be drawn:

1) Silicone additive improved compressive and flexural strength when used in concrete mixes having a cement content of five sacks per cubic yard,

but their effectiveness decreased as the cement content increased to six and one-half and eight sacks per cubic yard. Figures 1 to 6 inclusive illustrate the decreasing effect of the silicone additive on flexural and compressive strength with increasing cement contents.

2) When used in a five sacks per cubic yard concrete mix, the silicone additive DC-772 was more effective than the other silicone additives in increasing the flexural strength and compressive strength. The gain in flexural and compressive strength decreased as the specimens increased in age. Figures 10 and 13 show the decrease in flexural strength and compressive strength up to the age of ninety days. The effect of silicone additives on concrete for a period longer than ninety days was not determined.

3) The durability of concrete was improved when silicone additives were present in the concrete. However, as the cement content of a mix increased, the influence of the silicone additives decreased. This may be seen in Figure 14. A combination of the silicone additive DC-772 and a cement content of five sacks per cubic yard proved to be superior to other additives at the same cement content level.

4) The use of silicone additive DC-772 in a five sacks per cubic yard mix increased the time of set. Results of the time of set study are tabulated in Table 27.

5) Shrinkage measurements performed over a period of four days indicated that the addition of the silicone additive DC-772 to a five sacks per cubic yard concrete mix produced about the same shrinkage as plain concrete. Table 26 contains the results of the shrinkage measurements.

6) Within the range of the fatigue study conducted, silicone additive DC-772 when used in a five sacks per cubic yard mix, appeared to improve fatigue strength at a stress level of forty percent of the modulus of rupture. Upon the application of a higher stress level, forty-five percent of the modulus of rupture, the fatigue life of the specimens with silicone additive DC-772 was shorter than that of plain concrete specimens. Figures 18 and 19 show the probability of failure for fatigue cycles of plain concrete and specimens containing additive DC-772 subjected to three different stress levels.

APPENDIX

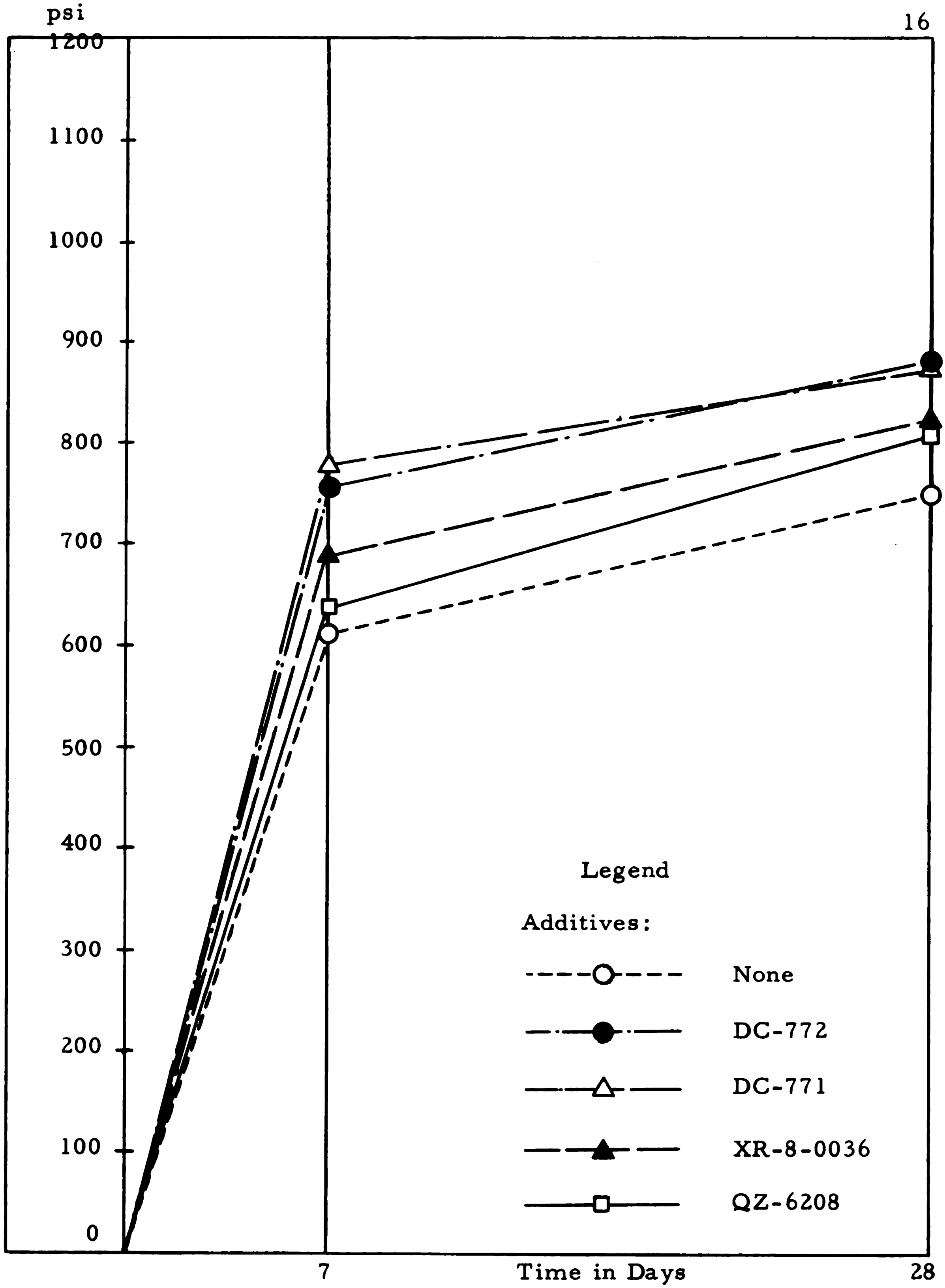

Figure 1. Flexure-age curve, 5 sacks/yd^3, average of mixes A and B, plain concrete and silicone additives DC-772, DC-771, XR-8-0036, QZ-6208

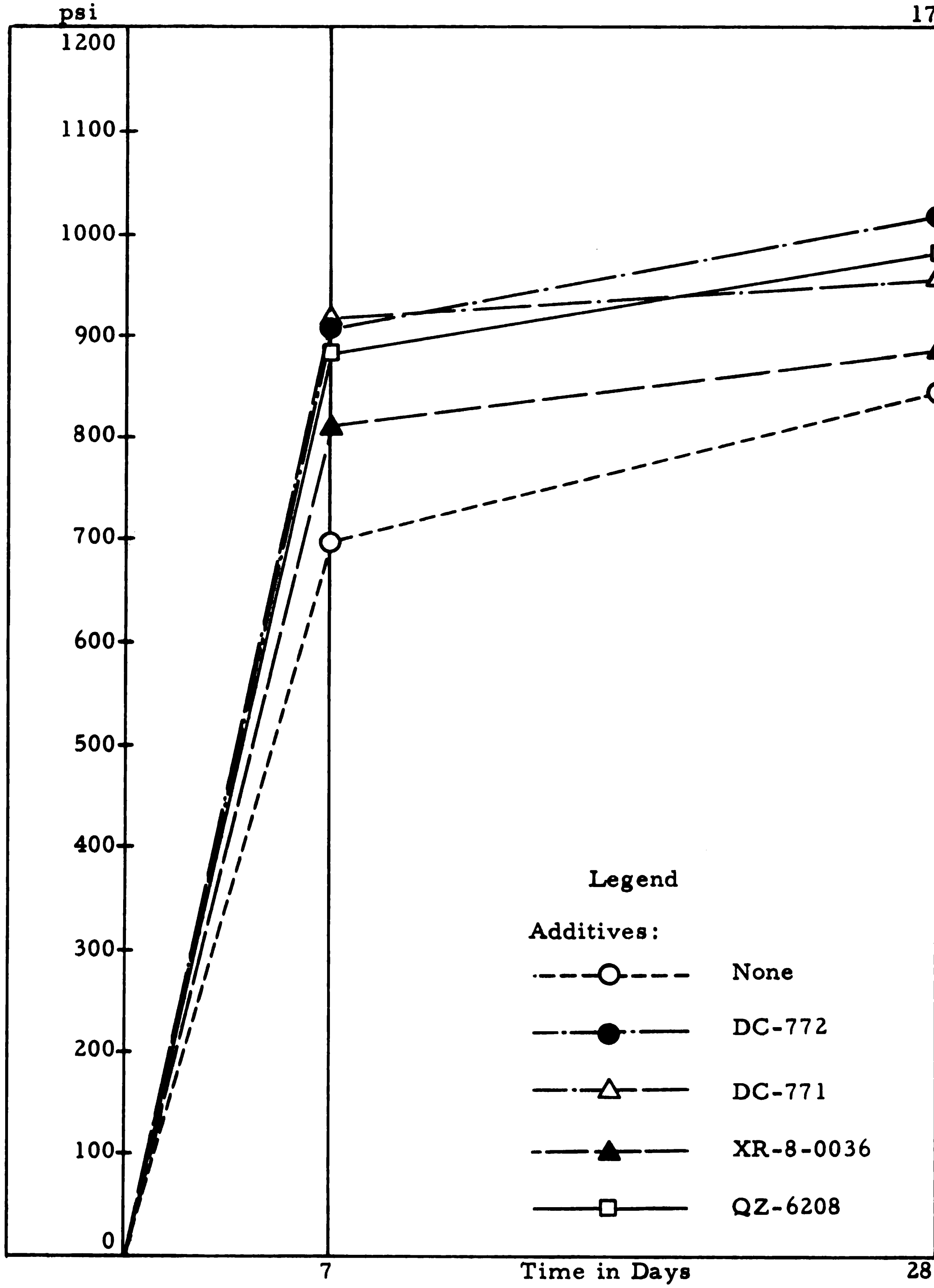

Figure 2. Flexure-age curve, 6-1/2 sacks/yd^3, average of mixes A and B, plain concrete and silicone additives DC-772, DC-771, XR-8-0036, QZ-6208

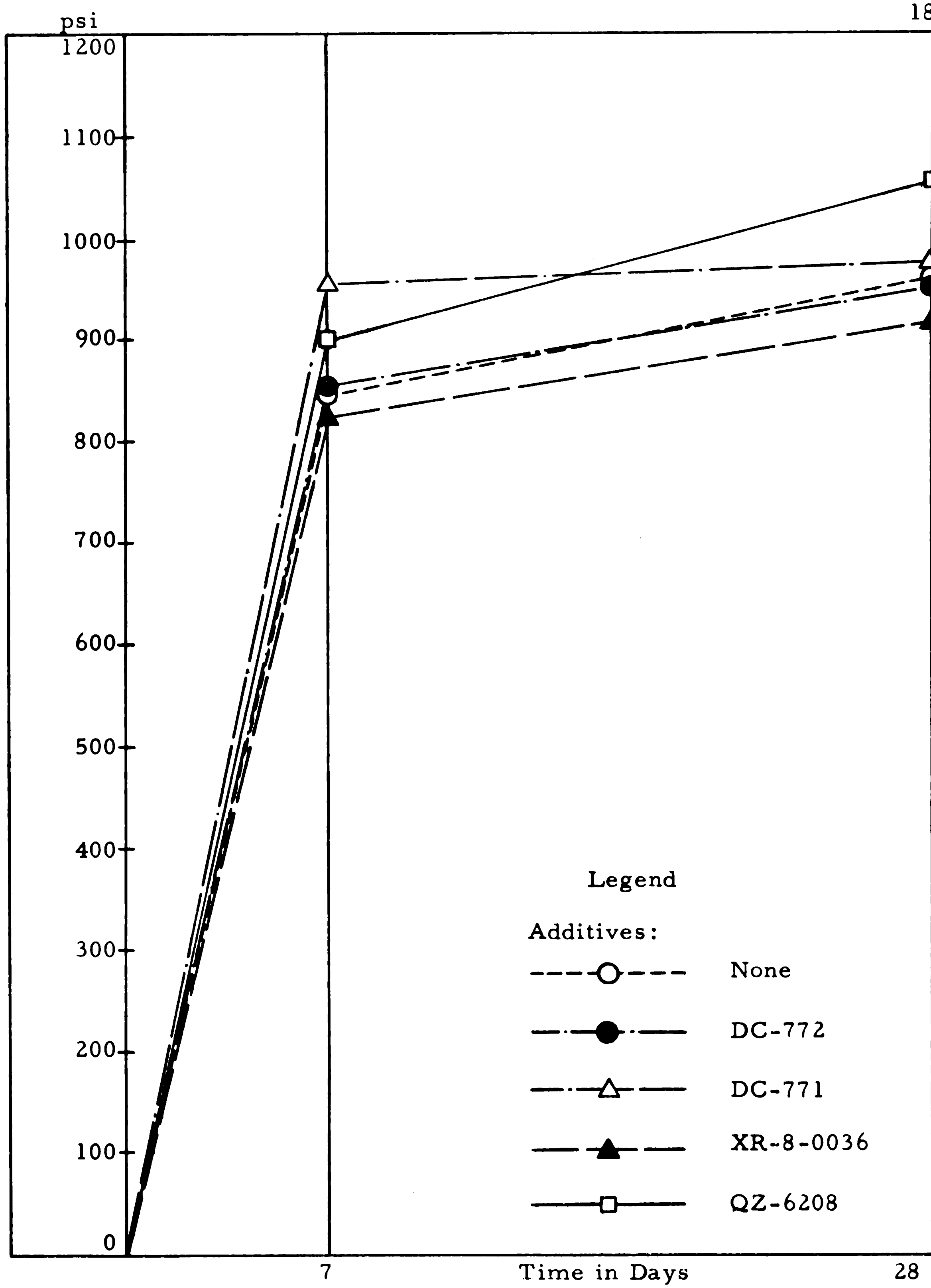

Figure 3. Flexure-age curve, 8 sacks/yd^3, average of mixes A and B, plain concrete and silicone additives DC-772, DC-771, XR-8-0036, QZ-6208

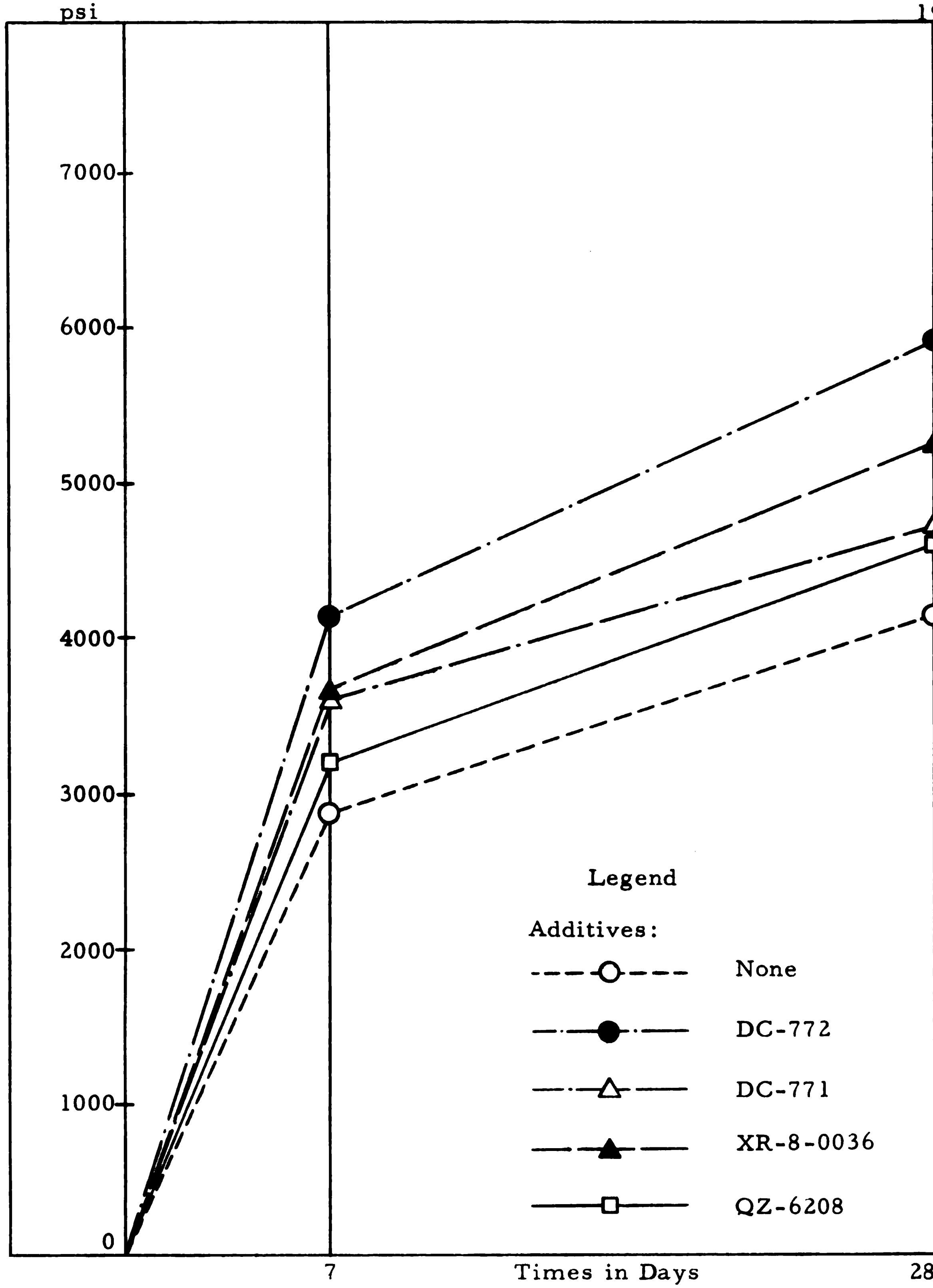

Figure 4. Compression-age curve, 5 sacks/yd^3, average of mixes A and B, plain concrete and silicone additives DC-772, DC-771, XR-8-0036, QZ-6208

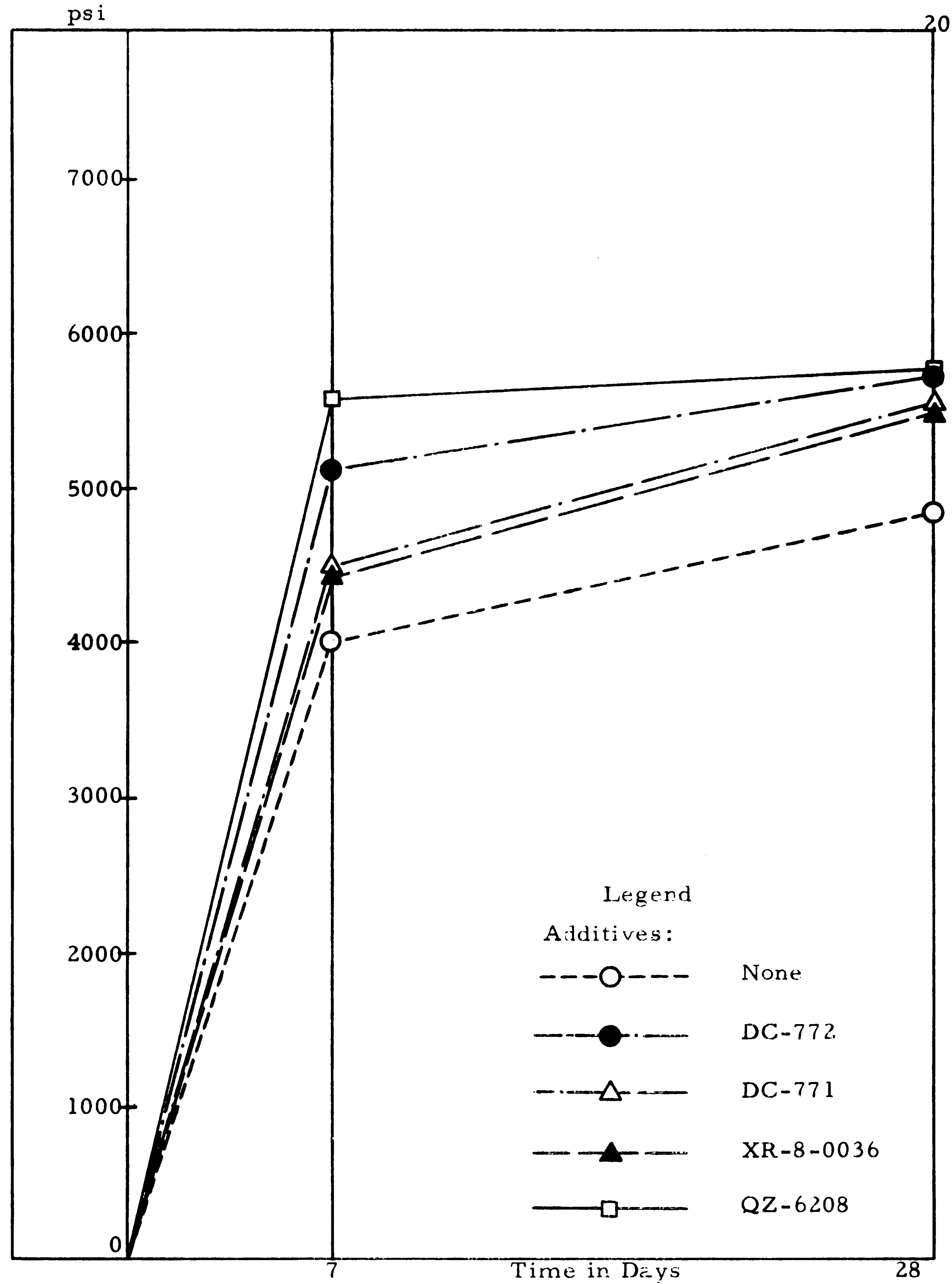

Figure 5. Compression-age curve, 6-1/2 sacks/yd^3, average of mixes A and B, plain concrete and silicone additives DC-772, DC-771, XR-8-0036, QZ-6208

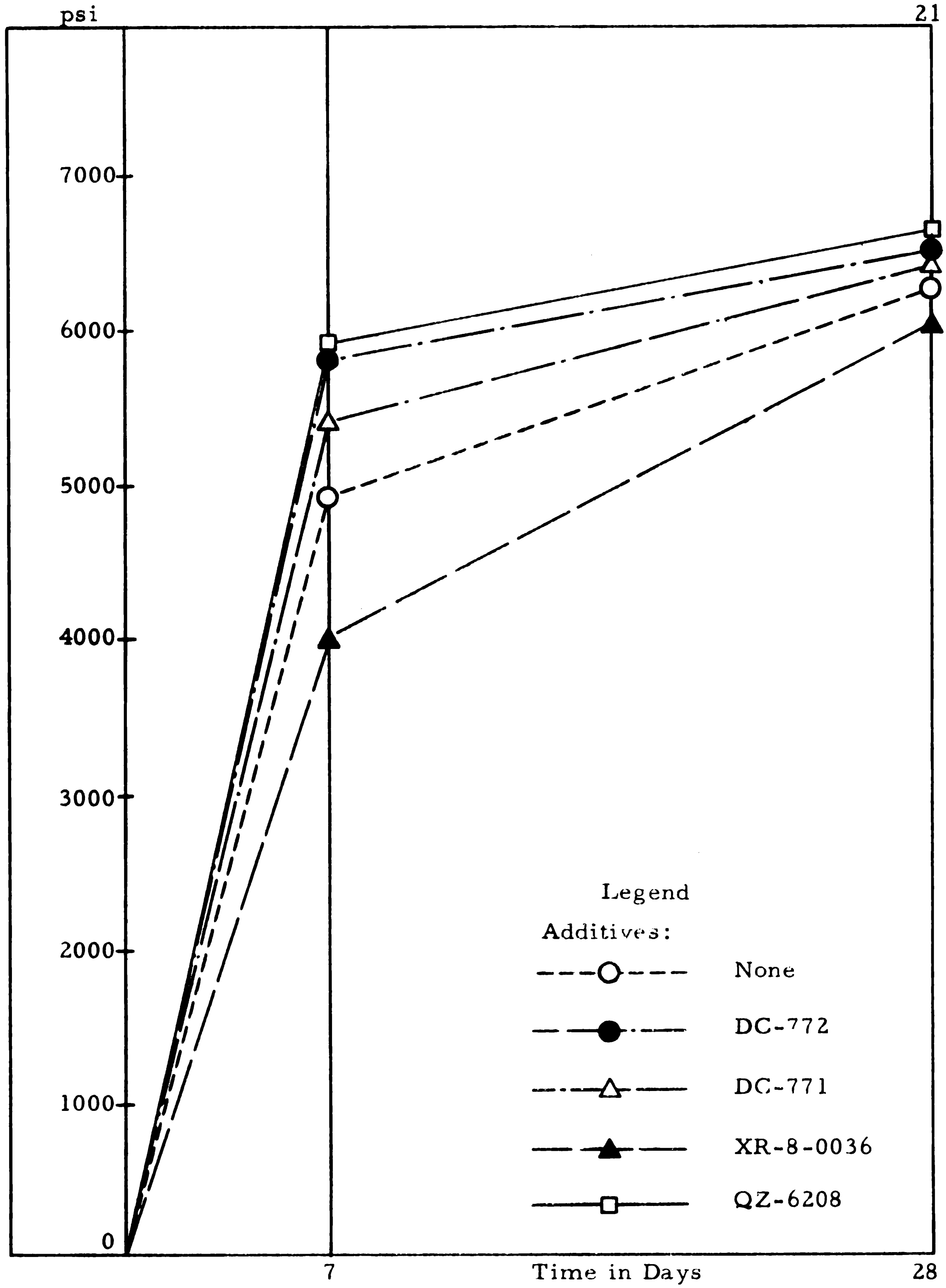

Figure 6. Compression-age curve, 8 sacks/yd^3, average of mixes A and B, plain concrete and silicone additives DC-772, DC-771, XR-8-0036, QZ-6208

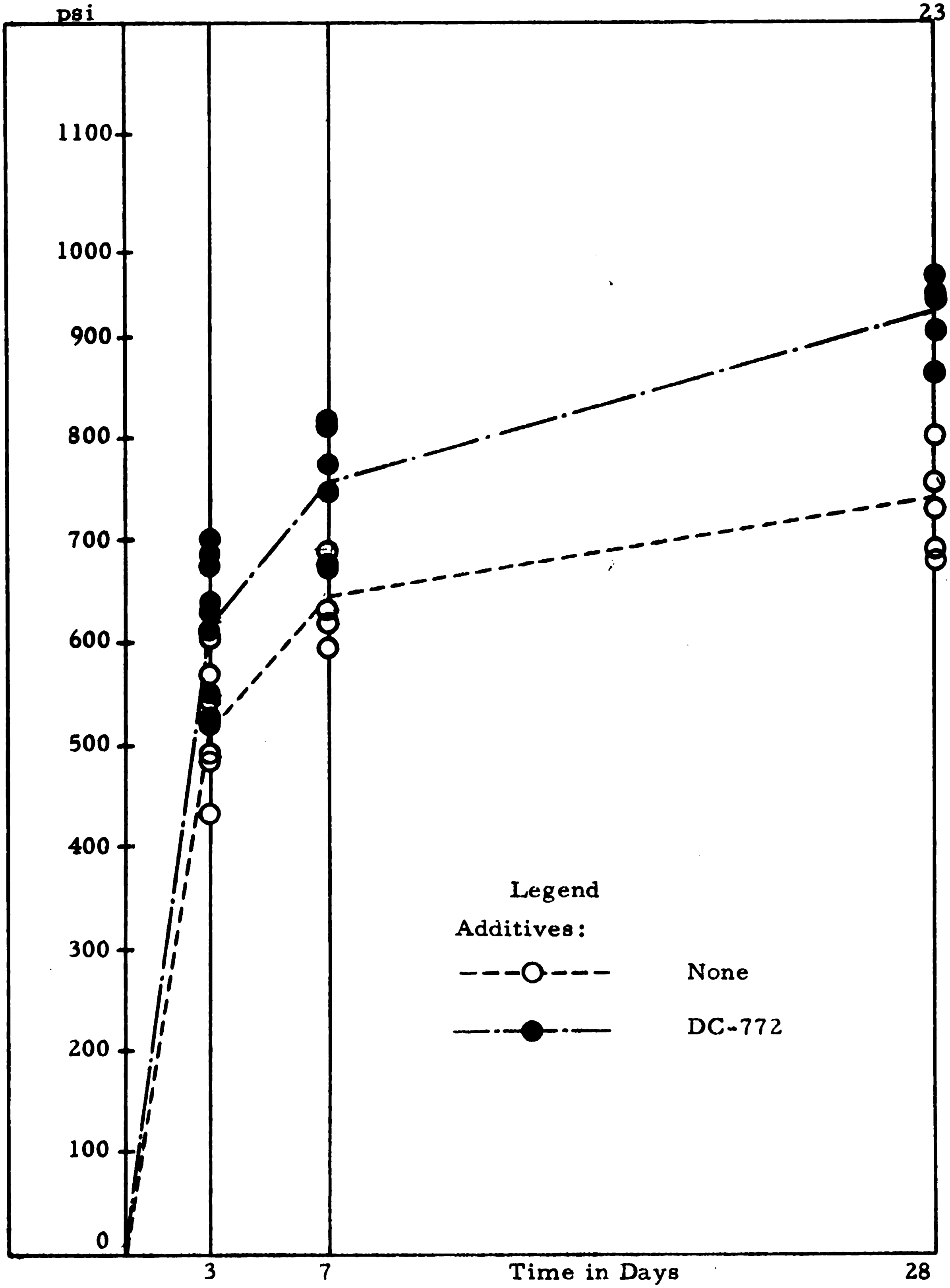

Figure 8. Flexure-age curve, 5 sacks/yd^3, mixes C, D, and E, plain concrete and silicone additive DC-772

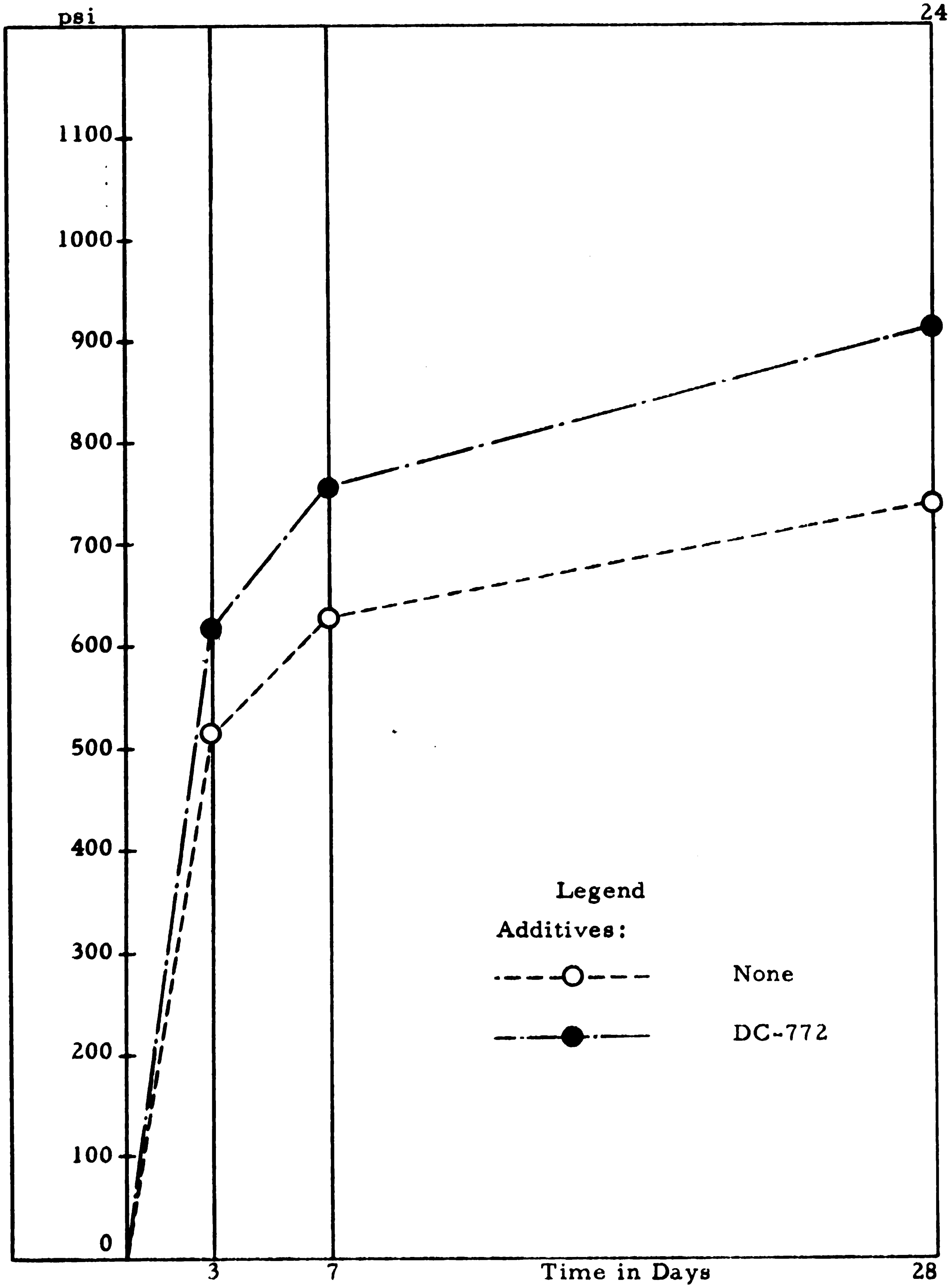

Figure 9. Flexure-age curve, 5 sacks/yd^3, average of mixes A, B, C, D, and E, plain concrete and silicone additive DC-772

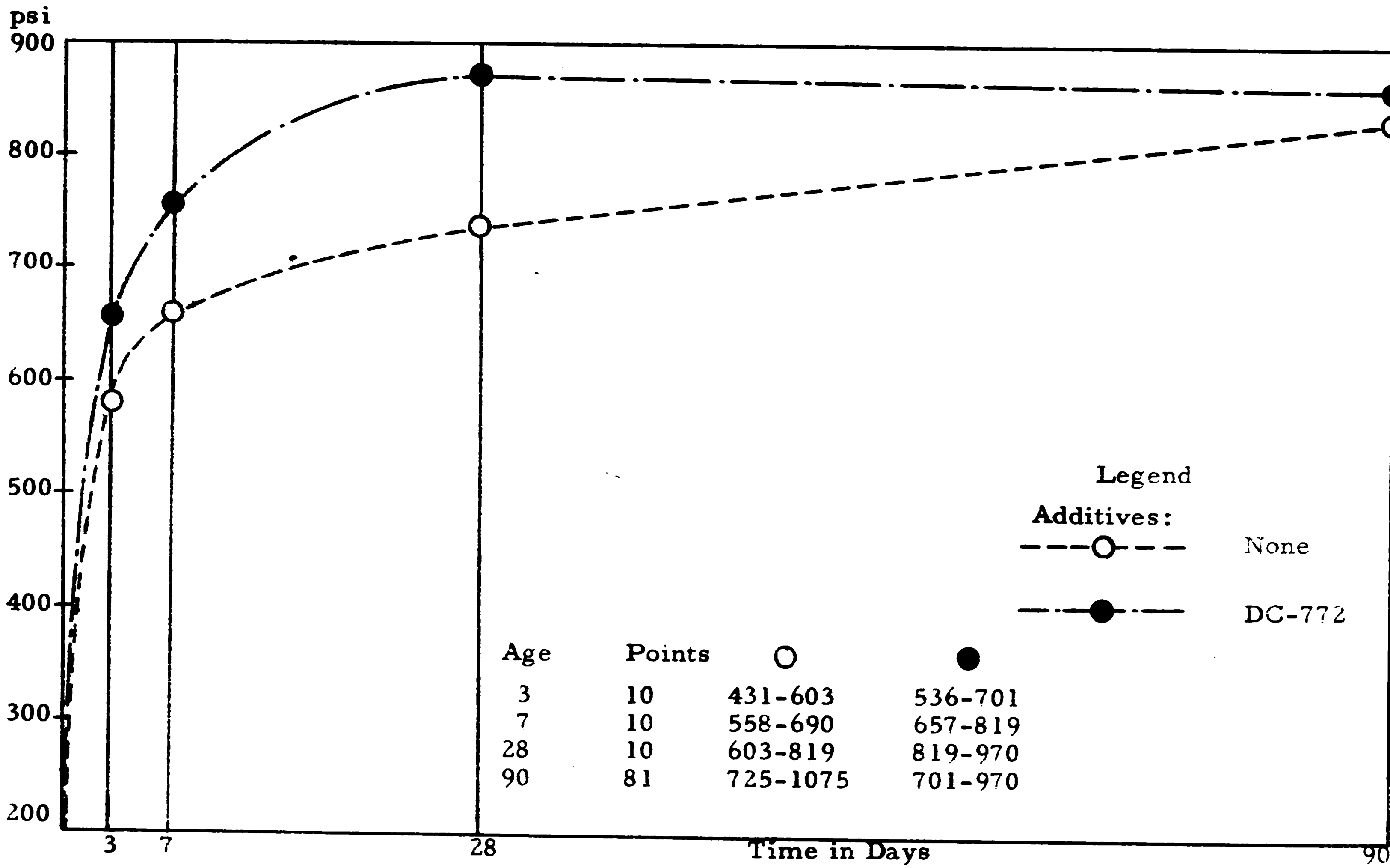

Figure 10. Flexure-age curve, 5 sacks/yd^3, average of mixes A, B, C, D, E, and I through Q, plain concrete and silicone additive DC-772

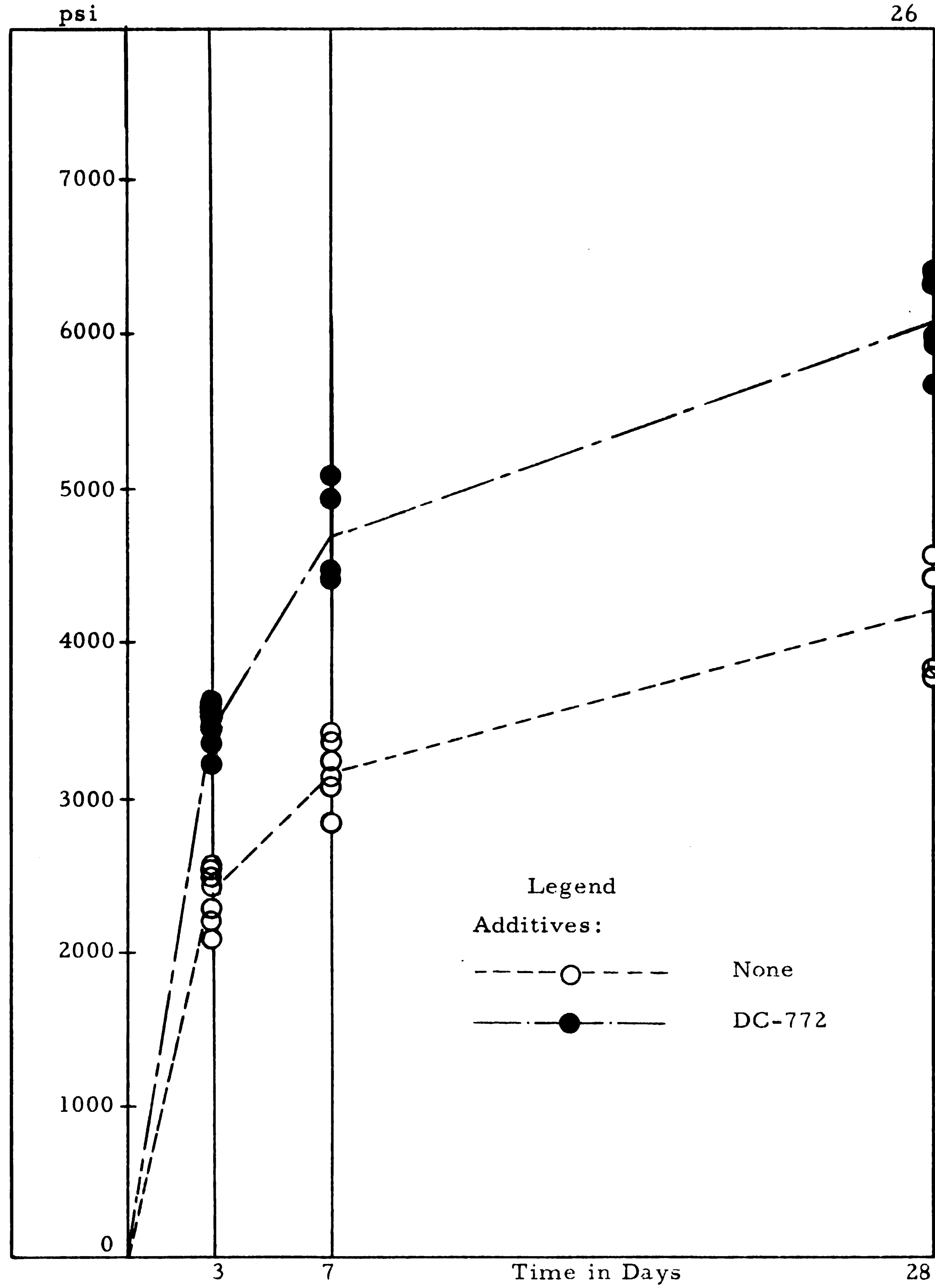

Figure 11. Compression-age curve, 5 sacks/yd^3, mixes C, D, and E, plain concrete and silicone additive DC-772

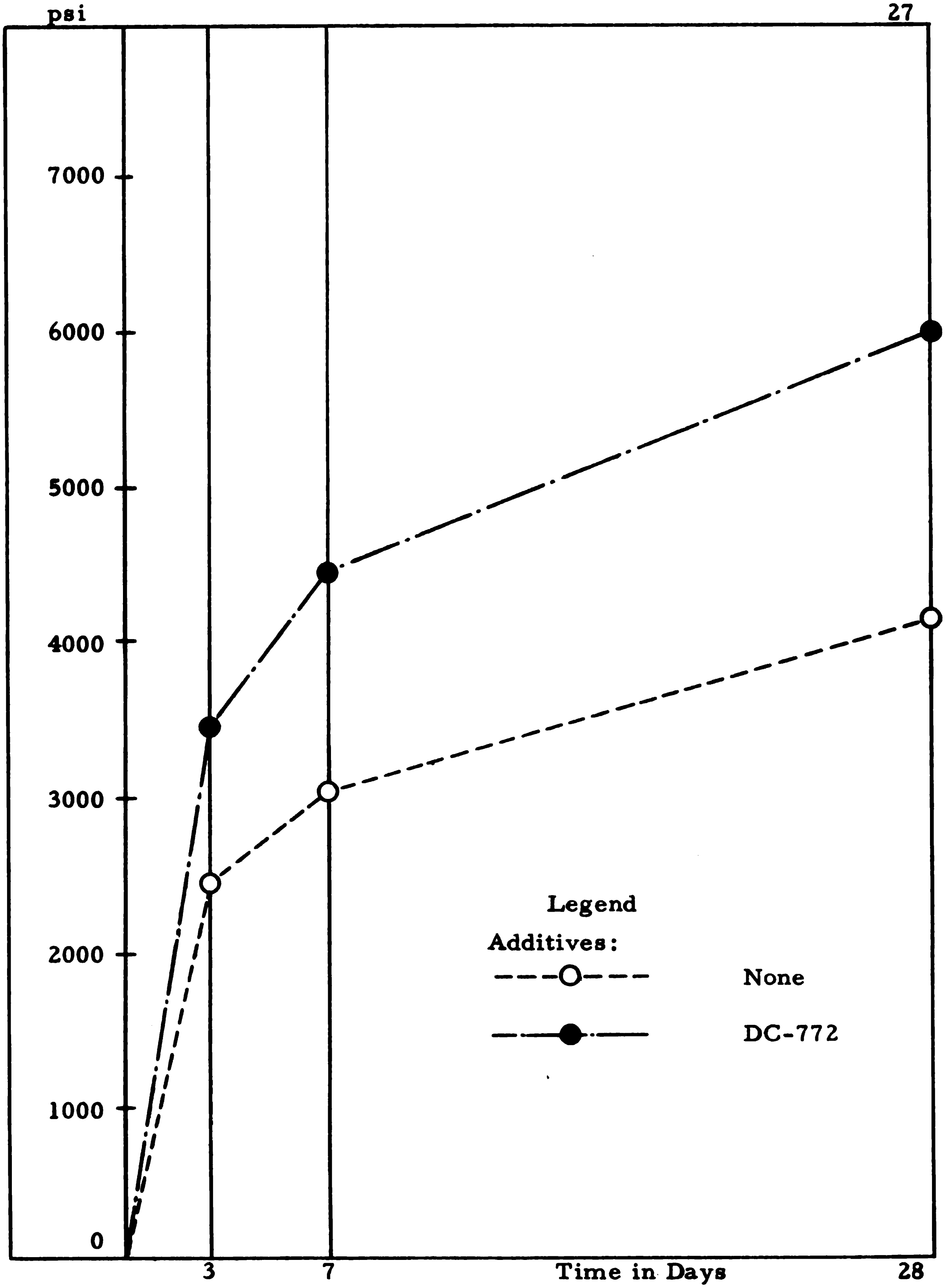

Figure 12. Compression-age curve, 5 sacks/yd^3, average of mixes A, B, C, D, and E, plain concrete and silicone additive DC-772

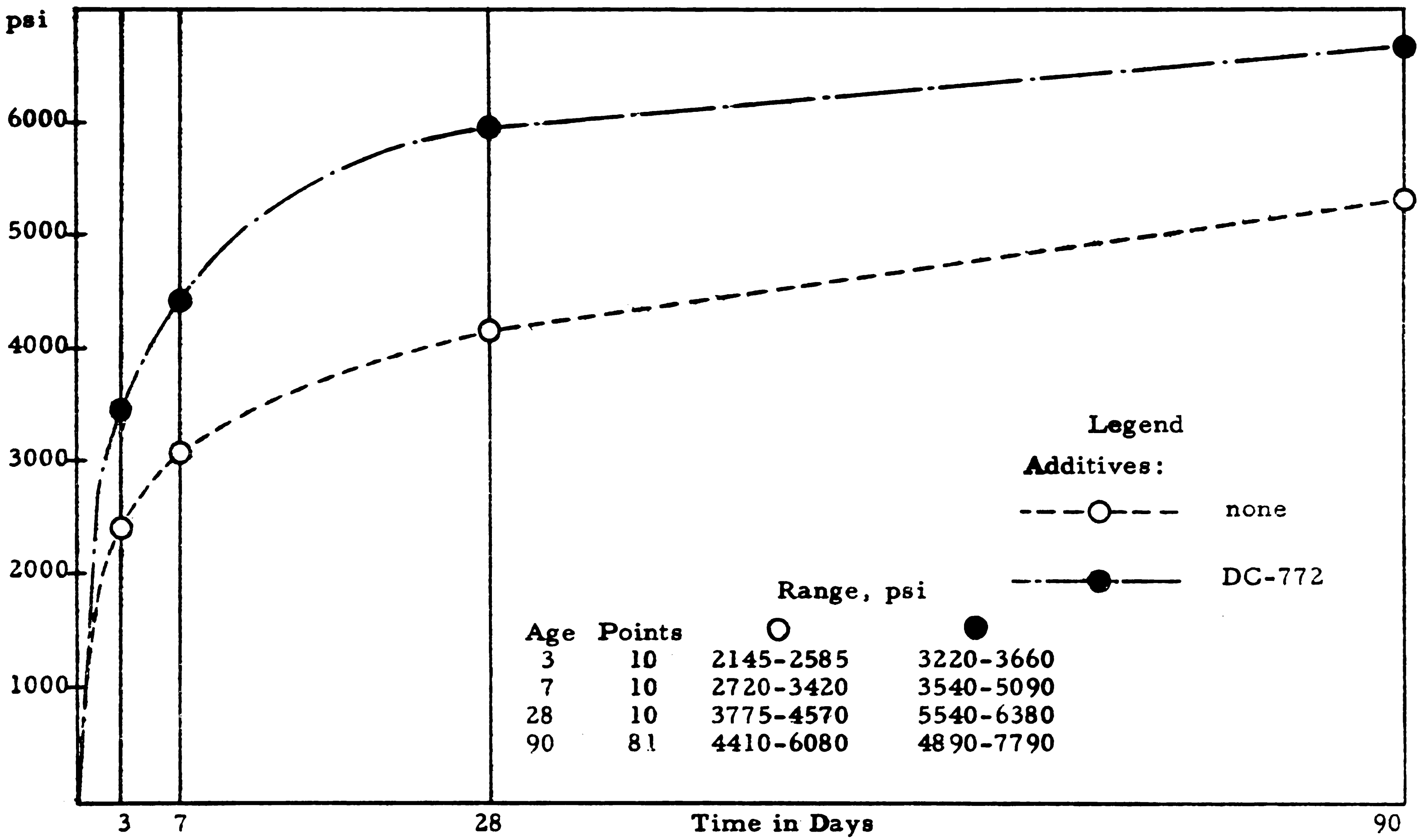

Figure 13. Compression-age curve, 5 sacks/yd^3, average of mixes A, B, C, D, E, and I through Q, plain concrete and silicone additive DC-772

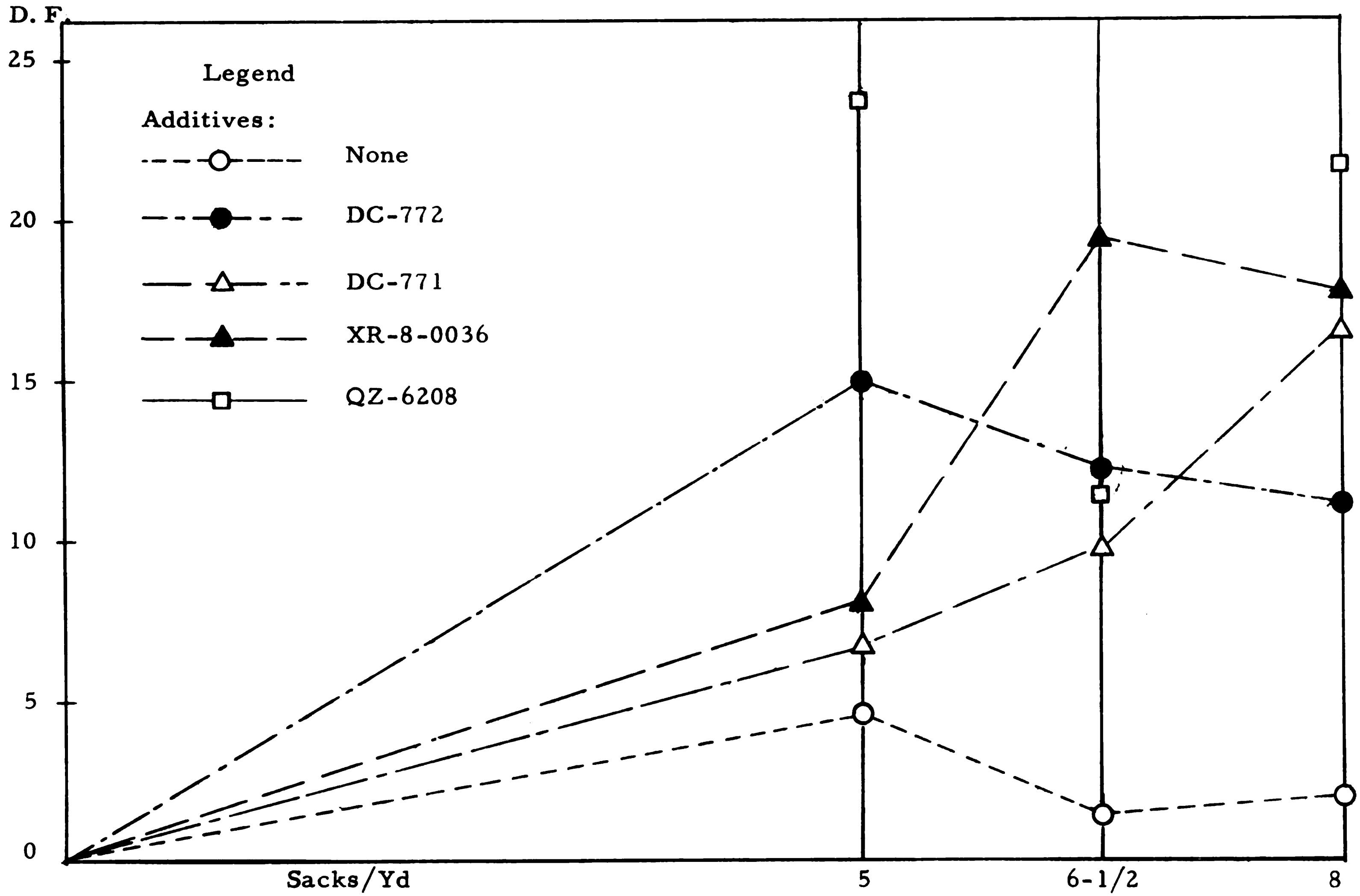

Figure 14. Durability-sacks/yd^3 curve, 5, 6-1/2, and 8 sacks/yd^3, average of mixes A, B, C, and D, plain concrete and silicone additives DC-772, DC-771, XR-8-0036, QZ-6208

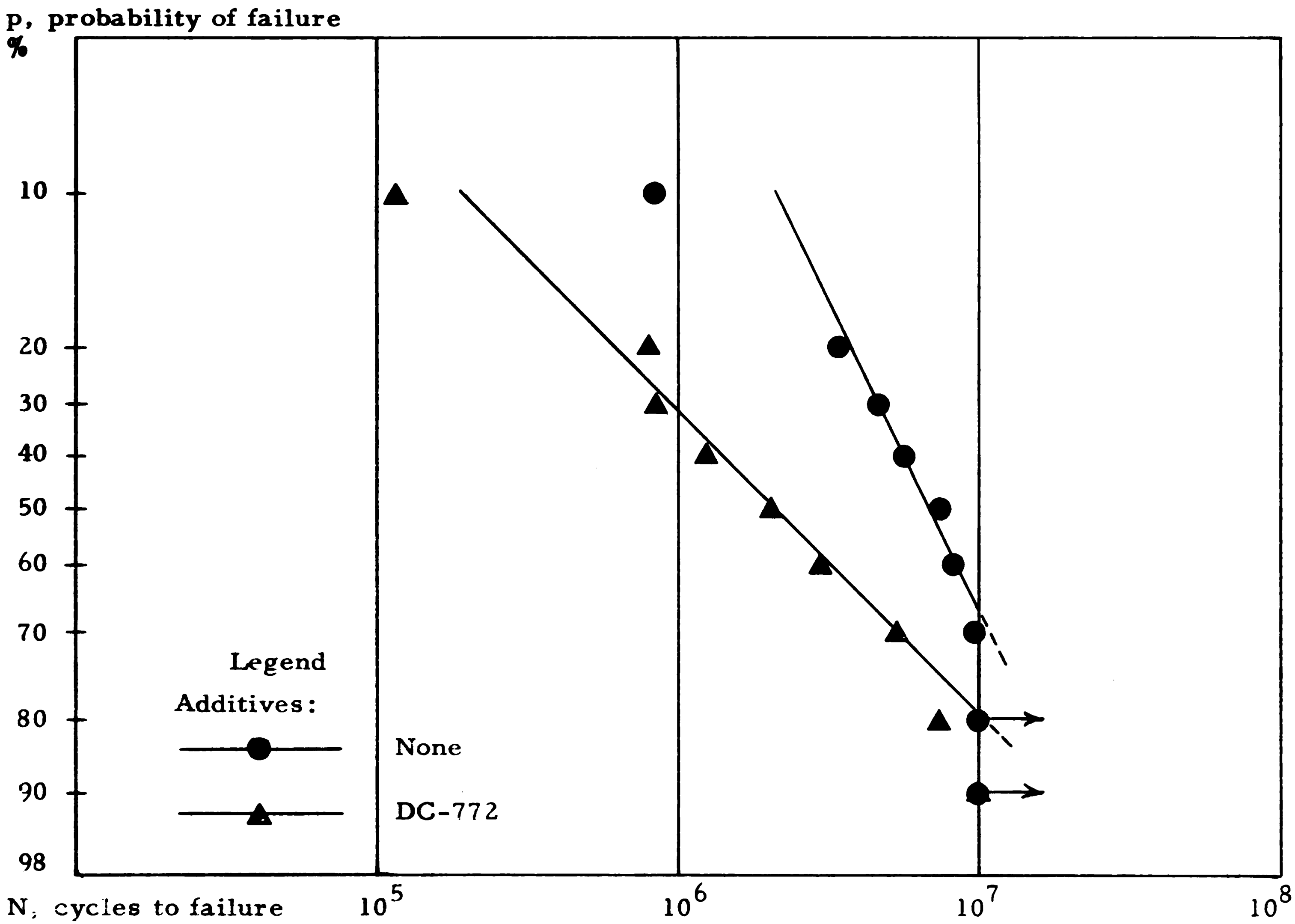

Figure 15. Probability of failure-cycles to failure curve, fatigue failure of concrete using a complete stress reversal of .4 f_r, 5 sacks/yd^3, mixes I through Q, plain concrete and silicone additive DC-772

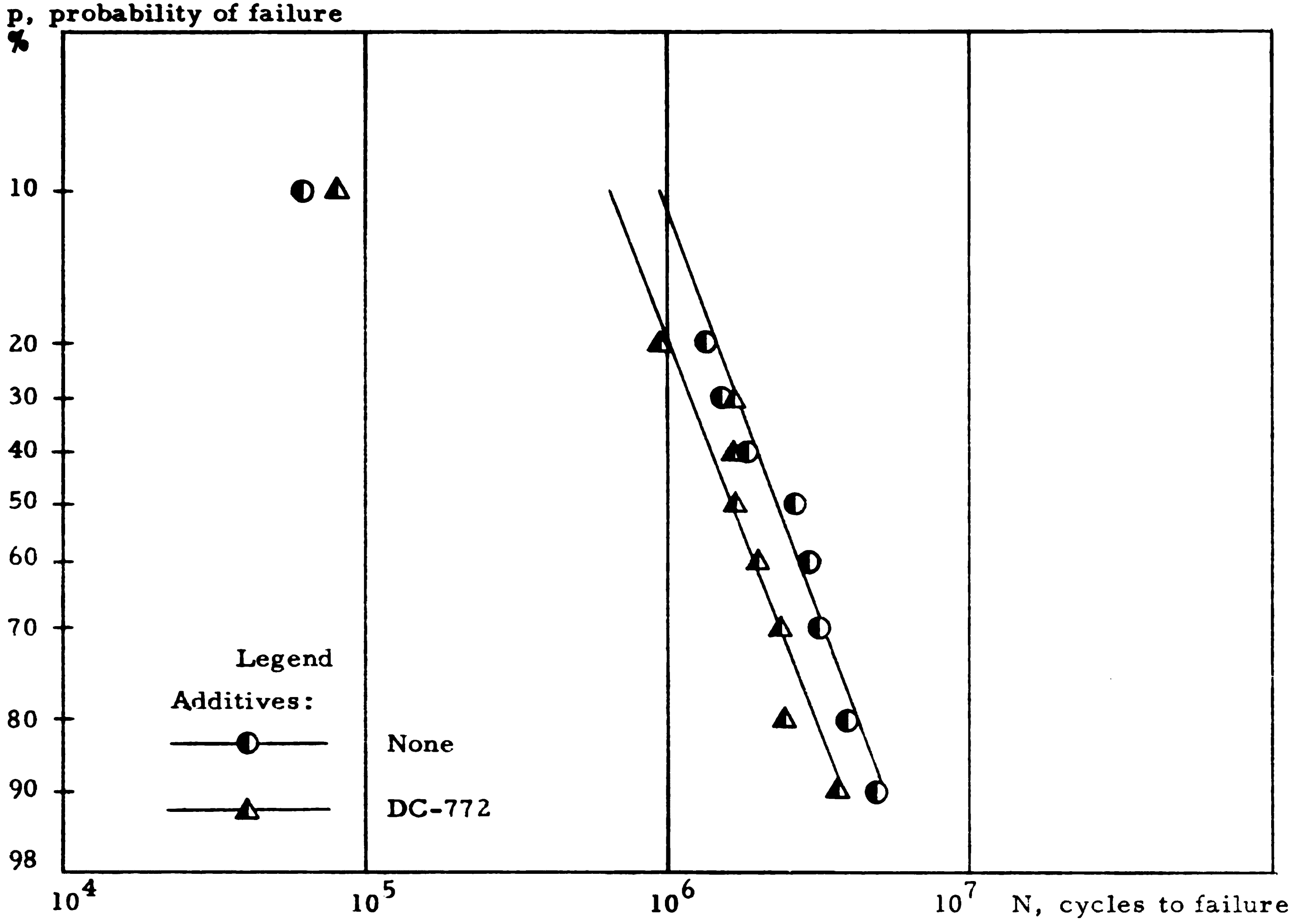

Figure 16. Probability of failure-cycles to failure curve, fatigue failure of concrete using a complete stress reversal of .425 f_r, 5 sacks/yd^3, mixes I through Q, plain concrete and silicone additive DC-772

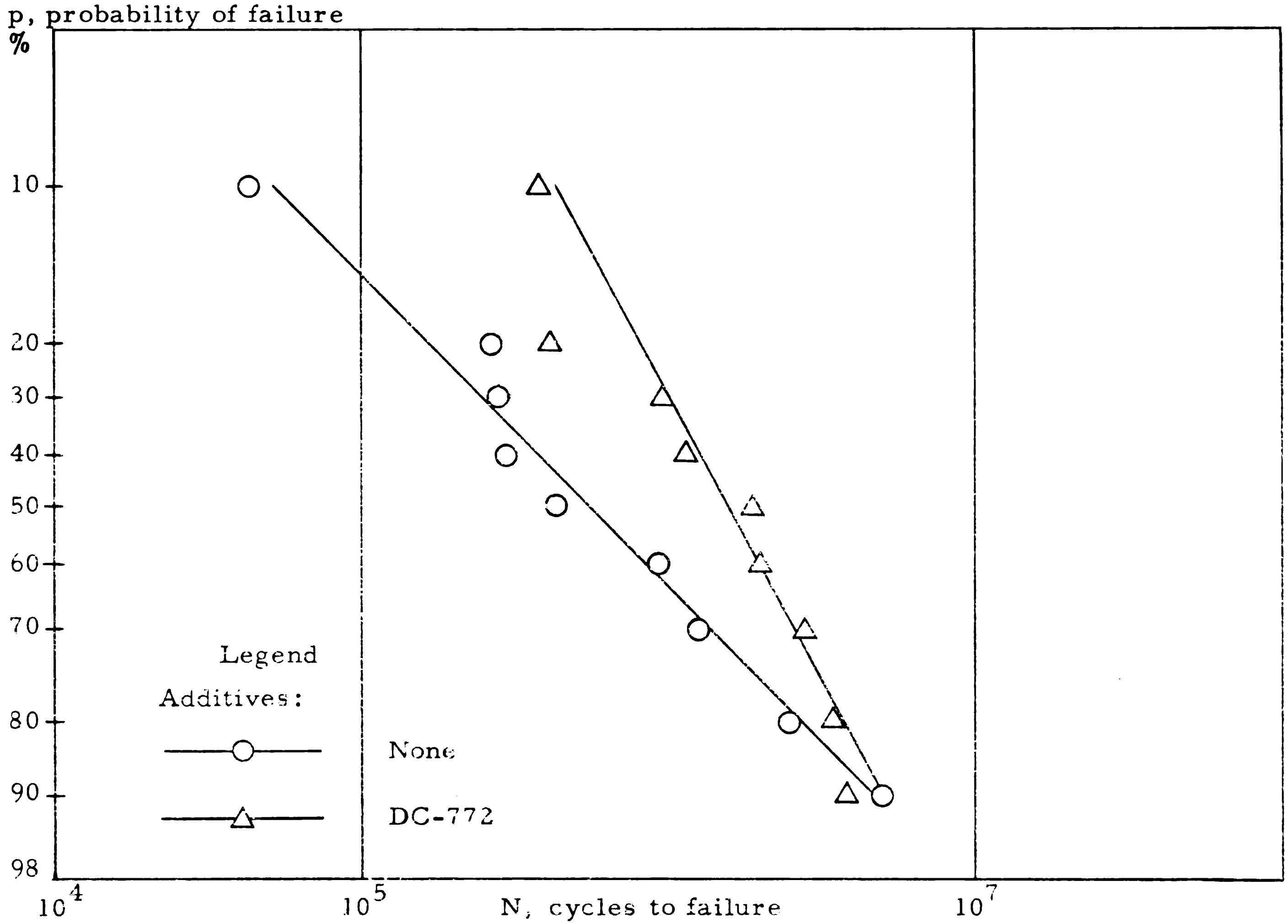

Figure 17. Probability of failure-cycles to failure curve, fatigue failure of concrete using a complete stress reversal of .45 f_r, 5 sacks/yd^3, mixes I through Q, plain concrete and silicone additive DC-772

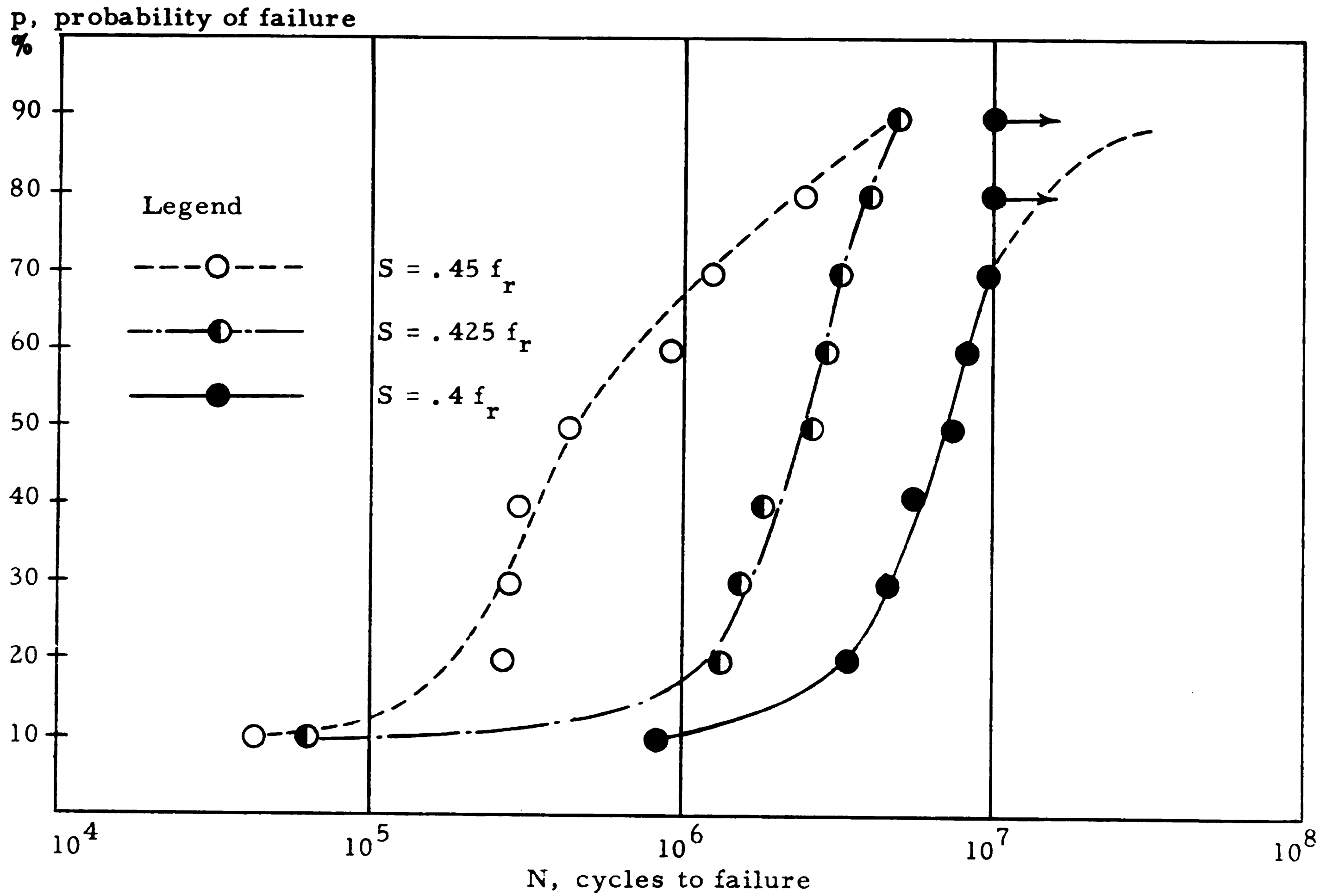

Figure 18. Probability of failure-cycles to failure curve, fatigue failure of plain concrete using three complete stress reversals of .4 f_r, .425 f_r, and .45 f_r, 5 sacks/yd^3, mixes I through Q

Table 1. Control mix proportions for 5, 6-1/2 and 8 sacks/yd^3

	5 sacks/yd	6-1/2 sacks/yd	8 sacks/yd
water	10.94 lb.	10.74 lb.	11.34 lb.
gravel	66.6 lb.	66.6 lb.	66.6 lb.
sand	66.8 lb.	65.5 lb.	58.9 lb.
cement	18.8 lb.	24.4 lb.	30.0 lb.
water/cement	.582	.439	.377
gal/sack	6.56	4.95	4.26

Table 2. Amount of silicone additives used based upon the weight of cement per mix

DC-772	36.7 ml per 10 lb. of cement
DC-771	78.0 ml per 10 lb. of cement
XR-8-0036	43.1 ml per 10 lb. of cement
QZ-6208	37.1 ml per 10 lb. of cement

Table 3. Physical properties of the silicone additives

Property	DC-772	DC-771	XR-8-0036	QZ-6208
% total solids	30	24.3	31.0	100
% silicone	21	10.1	18.4	24.5
sp. gr.	1.24	1.20-1.22	1.204	1.05
solvent	water	water	water	---
thinner	water	water	water	water
pH	12-13	12-13	11.2	5

Table 1. Control mix proportions for 5, 6-1/2 and 8 sacks/yd^3

	5 sacks/yd	6-1/2 sacks/yd	8 sacks/yd
water	10.94 lb.	10.74 lb.	11.34 lb.
gravel	66.6 lb.	66.6 lb.	66.6 lb.
sand	66.8 lb.	65.5 lb.	58.9 lb.
cement	18.8 lb.	24.4 lb.	30.0 lb.
water/cement	.582	.439	.377
gal/sack	6.56	4.95	4.26

Table 2. Amount of silicone additives used based upon the weight of cement per mix

DC-772	36.7 ml per 10 lb. of cement
DC-771	78.0 ml per 10 lb. of cement
XR-8-0036	43.1 ml per 10 lb. of cement
QZ-6208	37.1 ml per 10 lb. of cement

Table 3. Physical properties of the silicone additives

Property	DC-772	DC-771	XR-8-0036	QZ-6208
% total solids	30	24.3	31.0	100
% silicone	21	10.1	18.4	24.5
sp. gr.	1.24	1.20-1.22	1.204	1.05
solvent	water	water	water	---
thinner	water	water	water	water
pH	12-13	12-13	11.2	5

Table 4. Flexure, compression, and durability data, 5, 6-1/2, and 8 sacks/yd^3, mixes A and B, plain concrete

Sacks per yard	Batch	Specimen	Compression (psi) 7 day	Compression (psi) 28 day	Flexure (psi) 7 day	Flexure (psi) 28 day	Freeze-Thaw cycles	Freeze-Thaw D.F.	Dynamic modulus of elasticity (psi)
5	A	1	2825	3900	558	744	8*	0.8	6.48×10^6
		2	2720	3780	613	603	9	0.9	6.31×10^6
		Avg.	2773	3840	586	674	8	0.85	
		% Diff.	1.91	1.56	4.78	10.53	12.50	5.88	
	B	1	3100	4410	680	819	24	2.4	6.68×10^6
		2	2860	4370	594	819	23	2.3	7.01×10^6
		Avg.	2980	4390	637	819	23	2.35	
		% Diff.	4.03	0.46	6.75	0.00	4.17	2.13	
6-1/2	A	1	4100	5375	593	808	13	1.3	7.13×10^6
		2	3740	3900	583	798	14	1.4	7.19×10^6
		Avg.	3920	4638	588	803	13	1.35	
		% Diff.	4.59	15.91	0.85	0.62	7.69	3.70	
	B	1	4135	5050	819	895	172**	17.2	6.05×10^6
		2	4055	4970	798	873	260	26.0	6.19×10^6
		Avg.	4090	5010	809	884	216	21.60	
		% Diff.	0.49	0.80	1.36	1.24	20.37	20.37	
8	A	1	4940	7040	841	1024	32	3.2	7.27×10^6
		2	5290	6160	830	981	42	4.2	7.40×10^6
		Avg.	5115	6600	836	1003	37	3.70	
		% Diff.	3.42	6.67	0.72	2.19	13.51	13.51	
	B	1	4810	6120	884	1035	7	0.7	6.62×10^6
		2	4650	5725	819	808	4	0.4	6.66×10^6
		Avg.	4730	5922	851	921	5	0.55	
		% Diff.	1.69	3.33	3.76	12.27	40.00	27.27	

*Note: Lower values taken for an average. **Note: Excluded from computations.

Table 5. **Flexure, compression, and durability data, 5, 6-1/2, and 8 sacks/yd^3, mixes A and B, silicone additive DC-772**

Sacks per yard	Batch	Specimen	Compression (psi) 7 day	Compression (psi) 28 day	Flexure (psi) 7 day	Flexure (psi) 28 day	Freeze-Thaw cycles	Freeze-Thaw D. F.	Dynamic modulus of elasticity (psi)
5		1	3660	5540	657	863	29	2.9	$7.05x10^6$
		2	3540	5540	787	819	21	2.1	$6.84x10^6$
	A	Avg.	3600	5540	722	841	25	2.5	
		% Diff.	1.67	0.00	9.00	2.62	16.0	16.0	
		% Gain	29.82	44.27	23.20	24.78	212.50	194.12	
		1	4650	6320	808	927	169	16.9	$6.22x10^6$
		2	4650	6160	776	927	155	15.5	$6.30x10^6$
	B	Avg.	4650	6240	792	927	162	16.2	
		% Diff.	0.00	1.28	2.02	0.00	4.32	4.32	
		% Gain	56.04	42.14	24.33	13.19	604.35	589.36	
6-1/2		1	5375	4928	927	1046	86	8.6	$7.63x10^6$
		2	5490	6956	819	981	83	8.3	$7.25x10^6$
	A	Avg.	5433	5940	873	1014	84	8.45	
		% Diff.	1.07	17.06	6.18	3.25	1.19	1.78	
		% Gain	38.60	28.12	48.50	26.28	546.15	525.93	
		1	5605	7195	992	1057	159	15.9	$6.95x10^6$
		2	3975	3895	884	992	163	16.3	$7.24x10^6$
	B	Avg.	4790	5545	938	1020	161	16.1	
		% Diff.	17.01	29.76	5.76	2.75	1.24	1.24	
		% Gain	17.11	10.68	15.95	15.38	1138.46	1092.51	
8		1	5490	7320	960	1003	92	9.2	$7.16x10^6$
		2	5340	6650	895	981	96	9.6	$7.39x10^6$
	A	Avg.	5415	6985	928	992	94	9.4	
		% Diff.	1.38	4.80	3.56	1.11	2.13	2.13	
		% Gain	5.87	5.83	11.00	-1.10	154.05	154.05	
		1	6360	7235	765	981	133	13.3	$6.56x10^6$
		2	6080	4890	798	862	125	12.5	$6.79x10^6$
	B	Avg.	6220	6062	781	921	129	12.9	
		% Diff.	2.25	19.33	2.05	6.41	3.10	3.10	
		% Gain	31.50	2.36	-8.23	0.00	2480.00	2245.45	

Table 6. **Flexure, compression, and durability data, 5, 6-1/2, and 8 sacks/yd^3, mixes A and B, silicone additive DC-771**

Sacks per yard	Batch	Specimen	Compression (psi) 7 day	Compression (psi) 28 day	Flexure (psi) 7 day	Flexure (psi) 28 day	Freeze-Thaw cycles	Freeze-Thaw D. F.	Dynamic modulus of elasticity (psi)
		1	3900	5170	776	927	23	2.3	7.27×10^6
		2	4175	4770	755	852	20	2.0	7.07×10^6
	A	Avg.	4038	4970	766	890	21	2.15	
		% Diff.	3.42	4.02	1.44	4.27	4.76	6.98	
5		% Gain	45.61	29.43	27.30	32.05	162.50	152.94	
		1	3540	4650	841	884	115	11.5	6.05×10^6
		2	2820	4290	745	830	109	10.9	6.55×10^6
	B	Avg.	3180	4470	793	857	112	11.2	
		% Diff.	11.32	4.03	6.05	3.15	2.68	2.68	
		% Gain	6.71	1.82	24.49	4.64	386.96	376.60	
		1	4425	5720	970	1046	50	5.0	7.26×10^6
		2	4850	5680	895	1024	50	5.0	7.52×10^6
	A	Avg.	4638	5700	933	1035	50	5.0	
		% Diff.	4.59	0.35	4.07	1.06	0.00	0.00	
6-1/2		% Gain	18.32	22.90	60.00	28.89	284.62	270.37	
		1	4380	5445	902	927	137	13.7	5.68×10^6
		2	4370	5205	884	808	153	15.3	5.65×10^6
	B	Avg.	4375	5325	893	868	145	14.5	
		% Diff.	0.11	2.25	1.01	6.91	5.52	5.52	
		% Gain	6.97	6.29	10.38	-1.81	1015.38	974.07	
		1	5090	6160	916	981	176	17.6	7.38×10^6
		2	5140	6010	841	949	153	15.3	7.12×10^6
	A	Avg.	5115	6085	879	965	164	16.4	
		% Diff.	0.49	1.23	4.32	1.66	6.71	6.71	
8		% Gain	0.00	-7.80	5.14	-3.79	343.24	343.24	
		1	5765	6720	1035	1014	162	16.2	6.53×10^6
		2	5685	6720	*	960	174	17.4	6.47×10^6
	B	Avg.	5715	6720	1035	987	168	16.8	
		% Diff.	0.52	0.00	0.00	2.74	3.57	3.57	
		% Gain	20.82	13.48	20.77	7.17	3260.00	2954.54	

*Note: Specimen failed to fracture properly, consequently the test result was deleted.

Table 7. **Flexure, compression, and durability data, 5, 6-1/2, and 8 sacks/yd^3, mixes A and B, silicone additive XR-8-0036**

Sacks per yard	Batch	Specimen	Compression (psi) 7 day	Compression (psi) 28 day	Flexure (psi) 7 day	Flexure (psi) 28 day	Freeze-Thaw cycles	Freeze-Thaw D. F.	Dynamic modulus of elasticity (psi)
		1	3700	4940	657	819	66	6.6	7.05×10^6
		2	3780	4850	603	744	102	10.2	6.66×10^6
	A	Avg.	3740	4895	630	781	84	8.4	
		% Diff.	1.07	0.92	4.28	4.74	21.43	21.43	
5		% Gain	34.87	27.47	7.51	15.88	950.00	988.24	
		1	3790	5645	819	862	82	8.2	6.17×10^6
		2	3340	5485	679	852	72	7.2	6.59×10^6
	B	Avg.	3565	5565	749	857	77	7.7	
		% Diff.	6.31	1.44	9.35	0.58	6.49	6.49	
		% Gain	19.63	26.77	17.58	4.64	234.78	227.66	
		1	3780	5485	787	874	207	20.7	7.28×10^6
		2	4500	5285	669	820	191	19.1	7.03×10^6
	A	Avg.	4140	5385	728	847	199	19.9	
		% Diff.	8.70	1.86	8.10	3.19	4.52	4.52	
6-1/2		% Gain	5.61	16.11	23.80	5.48	1430.77	1374.07	
		1	4810	5605	906	949	184	18.4	5.66×10^6
		2	4770	5365	862	906	198	19.8	5.61×10^6
	B	Avg.	4790	5485	884	927	191	19.1	
		% Diff.	0.42	2.19	2.49	2.27	3.66	3.66	
		% Gain	17.11	9.48	9.27	4.86	1369.73	1314.81	
		1	4650	5605	884	917	140	14.0	7.47×10^6
		2	2742	5405	755	863	156	15.6	7.42×10^6
	A	Avg.	3696	5505	820	890	148	14.8	
		% Diff.	25.81	1.82	7.93	3.03	5.41	5.41	
8		% Gain	-27.74	-16.59	-1.91	-11.27	300.00	300.00	
		1	5165	6680	830	1003	211	21.1	5.59×10^6
		2	3460	6560	819	852	205	20.5	6.43×10^6
	B	Avg.	4312	6620	824	927	208	20.8	
		% Diff.	19.76	0.91	0.61	8.09	1.44	1.44	
		% Gain	-8.84	11.79	-3.17	0.65	4060.00	3681.82	

Table 8. **Flexure, compression, and durability data, 5, 6-1/2, and 8 sacks/yd^3, mixes A and B, silicone additive QZ-6208**

Sacks per yard	Batch	Specimen	Compression (psi) 7 day	Compression (psi) 28 day	Flexure (psi) 7 day	Flexure (psi) 28 day	Freeze-Thaw cycles	Freeze-Thaw D.F.	Dynamic modulus of elasticity (psi)
		1	2580	4290	571	733	274	27.4	$5.78x10^6$
		2	2385	3775	517	701	347	34.7	$5.88x10^6$
	A	Avg.	2483	4033	544	717	310	31.2	
		% Diff.	3.85	6.40	4.96	2.23	11.61	11.70	
5		% Gain	-10.46	5.03	-7.17	6.38	3775.00	3570.06	
		1	3935	5485	753	906	170	17.0	$7.19x10^6$
		2	3895	5010	711	884	210	21.0	$6.70x10^6$
	B	Avg.	3915	5248	732	895	190	19.0	
		% Diff.	0.51	4.54	2.87	1.23	10.53	10.53	
		% Gain	31.38	19.54	14.91	9.28	726.09	708.51	
		1	5010	6400	841	1057	54	5.4	$7.19x10^6$
		2	5250	5525	819	992	59	5.9	$6.70x10^6$
	A	Avg.	5130	5963	830	1025	56	5.65	
		% Diff.	2.34	7.35	1.33	3.22	3.57	4.25	
6-1/2		% Gain	30.87	28.57	41.16	27.65	330.77	318.52	
		1	6120	6280	938	1014	160	16.0	$5.36x10^6$
		2	6040	4810	927	884	189	18.9	$5.66x10^6$
	B	Avg.	6080	5545	933	949	174	17.5	
		% Diff.	0.66	13.26	0.64	6.85	8.05	8.29	
		% Gain	48.66	10.68	15.33	6.85	1238.46	1196.29	
		1	5960	7355	928	1100	192	19.2	$6.46x10^6$
		2	5765	6995	917	1089	166	16.6	$7.51x10^6$
	A	Avg.	5863	7175	923	1095	179	17.9	
		% Diff.	1.67	2.51	0.65	0.55	7.26	7.26	
8		% Gain	14.62	8.71	10.41	9.17	383.78	383.78	
		1	5960	6240	981	1057	300	30.0	$5.72x10^6$
		2	5960	6120	776	992	172	17.2	$6.13x10^6$
	B	Avg.	5960	6180	878	1024	236	23.6	
		% Diff.	0.00	0.97	11.62	3.13	27.12	27.12	
		% Gain	26.00	4.36	3.17	11.18	4620.00	4190.91	

Table 9. Summary of flexure results, percent gain of silicone additive mixes over plain concrete, 5, 6-1/2, and 8 sacks/yd^3, mixes A and B

Sacks/yd	Mix	Age (days)	Additive DC-772	DC-771	XR-80036	QZ-6208
5	A	7	23.20	27.30	7.51	-7.17
		28	24.78	32.05	15.88	6.38
	B	7	24.33	24.49	17.58	14.91
		28	13.19	4.64	4.64	9.28
6-1/2	A	7	48.50	60.00	23.80	41.16
		28	26.28	28.89	5.48	27.65
	B	7	15.95	10.40	9.27	15.33
		28	15.38	-1.81	4.86	7.35
8	A	7	11.00	5.14	-1.91	10.41
		28	-1.10	-3.79	-11.27	9.17
	B	7	-8.22	17.79	-3.18	3.18
		28	0.00	7.24	0.65	10.04

Table 10. Summary of compression results, percent gain of silicone additive mixes over plain concrete, 5, 6-1/2, and 8 sacks/yd^3, mixes A and B

Sacks/yd	Mix	Age (days)	Additive DC-772	DC-771	XR-8-0036	QZ-6208
5	A	7	29.82	45.61	34.87	-10.46
		28	44.27	29.43	27.47	5.03
	B	7	56.04	6.71	19.63	31.38
		28	42.14	1.82	26.77	19.54
6-1/2	A	7	38.60	18.32	5.61	30.87
		28	28.12	22.90	16.11	28.57
	B	7	17.11	6.97	17.11	48.66
		28	10.68	6.29	9.47	10.69
8	A	7	5.87	0.00	-27.74	14.62
		28	5.83	-7.80	-16.59	8.71
	B	7	31.50	20.83	-8.84	25.48
		28	2.36	13.49	11.70	4.36

Table 11. Summary of flexure results using averages of mixes A and B, average percent gain of silicone additive mixes over plain concrete, 5, 6-1/2, and 8 sacks/yd^3.

Sacks /yd	Mix	Age (days)	Additive DC-772	DC-771	XR-8-0036	QZ-6208
5	A and B	7	23.77	25.90	12.55	3.87
		28	18.98	18.35	10.26	7.83
6-1/2	A and B	7	32.23	35.20	16.54	28.25
		28	20.83	13.54	5.17	17.50
8	A and B	7	1.89	11.47	-2.55	6.80
		28	-0.55	1.73	-5.31	9.61

Table 12. Summary of compression results using averages of mixes A and B, average percent gain of silicone additive mixes over plain concrete, 5, 6-1/2, and 8 sacks/yd^3.

Sacks /yd	Mix	Age (days)	Additive DC-772	DC-771	XR-8-0036	QZ-6208
5	A and B	7	42.93	26.16	20.24	31.13
		28	43.21	15.63	21.44	24.06
6-1/2	A and B	7	27.86	12.65	11.36	39.77
		28	19.40	14.60	12.79	19.63
8	A and B	7	18.69	10.42	-18.29	20.05
		28	4.10	2.85	-2.45	6.54

Table 13. Air content and slump for all silicone additive mixes and plain concrete, mixes A and B.

Sacks /yd	Mix	variable	Additive: none	DC-772	DC-771	XR-8-0036	QZ-6208
5	A	% air	1.75	0.95	1.45	2.65	4.85
		slump	1-1/4"	3"	1-1/4"	3/4"	4-1/2"
	B	% air	2.10	2.10	3.20	2.50	3.03
		slump	1-1/2"	1-1/2"	1-3/4"	3/4"	3-1/4"
6-1/2	A	% air	1.62	1.48	1.76	2.66	3.11
		slump	1"	2-1/4"	1-1/4"	1-3/4"	2"
	B	% air	2.45	1.85	2.60	1.70	2.33
		slump	1-1/2"	1-1/2"	3-1/2"	3"	1"
8	A	% air	2.80	1.10	1.20	2.05	1.93
		slump	2-1/2"	2"	2-1/4"	5"	3"
	B	% air	1.35	1.48	2.75	2.35	3.43
		slump	4"	3"	4"	3-3/4"	3-1/4"

Table 14. Flexure and compression data, 5 sacks/yd^3, plain concrete, mixes A, B, C, D, and E.

Sacks/yd	Batch w/c	Specimen	Compression (psi) 3	7	28	Flexure (psi) 3	7	28
		1		2825	3900		558	744
	A	2		2720	3780		613	603
	.582	average		2773	3840		586	674
		% diff		1.91	1.56		4.78	10.53
		1		3100	4410		680	819
	B	2		2860	4370		594	819
	.582	average		2980	4390		637	819
		% diff		4.03	0.46		6.75	0
		1	2585	3420	4570	431	636	798
		2	2425	3340	4370	496	614	755
5	C	3	2225	3220	4370	571	593	722
	.448	average	2410	3325	4437	499	614	758
		% diff	7.68	3.16	3.00	14.43	3.58	5.28
		1	2465	3140	4370	517	690	755
		2	2425	3060	3815	517	679	690
	D	3	2305	2820	3775	485	636	679
	.468	average	2398	3007	3985	506	668	708
		% diff	3.88	6.22	9.66	4.15	4.79	6.64
		1	2585			603		
		2	2545			524		
	E	3	2505			524		
	.502	4	2145			539		
		average	2445			547		
		% diff	12.27			10.24		

Table 15. Flexure and compression data, 5 sacks/yd^3, silicone additive DC-772, mixes A, B, C, D, and E.

Sacks	Batch		Compression (psi)			Flexure (psi)		
/yd	w/c	Specimen	3	7	28	3	7	28
		1		3660	5540		657	863
		2		3540	5540		787	819
	A	average		3600	5540		722	841
	.582	% diff		1.67	0		9.00	2.62
		% gain		29.82	44.27		23.20	24.78
		1		4650	6320		808	927
		2		4650	6160		776	927
	B	average		4650	6240		792	927
	.582	% diff		0	1.28		2.02	0
		% gain		56.04	42.14		24.33	13.19
		1	3660	4490	5960	550	744	970
		2	3380	4490	5920	529	679	949
		3	3220	4370	5685	529	*	862
5	C	average	3420	4450	5855	536	711	927
	.443	% diff	7.02	1.80	2.90	2.61	4.50	7.01
		% gain	41.91	33.83	31.96	7.41	15.80	22.30
		1	3460	5090	6360	679	819	970
		2	3380	5090	6280	647	808	938
		3	3340	4930	5960	647	776	906
	D	average	3393	5037	6200	658	801	938
	.433	% diff	1.97	2.12	3.87	3.19	3.12	3.41
		% gain	41.49	67.51	55.58	30.03	19.91	32.49
		1	3615			701		
		2	3540			690		
		3	3540			636		
		4	3340			614		
	E	average	3510			660		
	.479	% diff	4.84			6.97		
		% gain	43.56			20.66		

*Specimen failed improperly.

Table 16. Summary of flexure and compression data, 5 sacks/yd^3, plain concrete and silicone additive DC-772, Mixes A, B, C, D, and E.

Sacks /yd	Batch	Additive	Compression (psi) 3	7	28	Flexure (psi) 3	7	28
	A	none		2773	3840		586	674
		DC772		3600	5540		722	841
	B	none		2980	4390		637	819
		DC772		4650	6240		792	927
	C	none	2410	3325	4437	499	614	758
		DC772	3420	4450	5855	536	711	927
	D	none	2398	3007	3985	506	668	708
5		DC772	3393	5037	6200	658	801	938
	E	none	2445			547		
		DC772	3510			660		
	A, B	none		2876	4115		611	746
		DC772		4125	5890		757	884
	C,D,E	none	2418	3166	4211	517	641	733
		DC772	3441	4733	6027	618	756	932
	A→E	none	2418	3021	4163	517	626	739
		DC772	3441	4429	5958	618	756	908

Table 17. Flexure and compression data for fatigue companion specimens, 5 sacks/yd^3, plain concrete, mixes I through Q.

Sacks/yd	Batch	Specimen	Compression (psi)	Flexure (psi)
		1	5285	830
		2	5010	884
		3	4410	841
		average	4900	852
		% diff	10.00	3.76
		1	5050	841
		2	4770	841
	I	3	4690	755
		average	4837	812
		% diff	4,40	7.09
		1	5130	884
		2	5050	819
		3	*	733
		average	5090	812
		% diff	0.79	9.75
5		1	5285	862
		2	5170	949
		3	5170	927
		average	5208	913
		% diff	1.48	5.52
		1	5365	830
		2	5365	*
	J	3	5010	798
		average	5245	814
		% diff	4.48	1.97
		1	5645	895
		2	5525	927
		3	5285	852
		average	5485	891
		% diff	3.65	4.44
		1	5130	701
		2	5285	755
		3	4890	787
		average	5102	747
		% diff	4.16	6.26
		1	4890	790
		2	4810	852
	K	3	4850	862
		average	4850	835
		% diff	0.82	5.33
		1	4930	830
		2	4930	840
		3	5050	*
		average	4970	835
		% diff	1.61	0.65

*Note: Improper failure.

Table 17 (Continued)

Sacks/yd	Batch	Specimen	Compression (psi)	Flexure (psi)
5		1	5365	765
		2	5365	960
		3	5125	830
		average	5285	852
		% diff	3.03	12.64
		1	5485	798
		2	5325	798
	L	3	5365	862
		average	5392	819
		% diff	1.72	5.27
		1	5445	852
		2	5285	819
		3	5205	862
		average	5312	844
		% diff	2.50	2.98
		1	5445	819
		2	5405	873
		3	5365	873
		average	5405	855
		% diff	0.74	4.21
		1	5765	819
		2	5565	916
	M	3	5525	809
		average	5618	848
		% diff	2.62	8.00
		1	5485	906
		2	5465	819
		3	5605	755
		average	5578	827
5		% diff	1.67	9.55
		1	5645	852
		2	5485	841
		3	5125	949
		average	5418	880
		% diff	5.41	7.84
		1	5805	895
		2	6080	884
	N	3	5525	884
		average	5803	888
		% diff	4.79	0.81
		1	5445	927
		2	5800	852
		3	5605	906
		average	5617	895
		% diff	3.26	4.80

Table 17 (Continued)

Sacks/yd	Batch	Specimen	Compressor (psi)	Flexure (psi)
		1	5365	900
		2	5205	860
		3	5125	847
		average	5232	869
		% diff	2.54	3.57
		1	5285	850
		2	5565	892
	0	3	5800	902
		average	5550	881
		% diff	4.77	3.52
		1	5460	864
		2	5050	870
		3	4930	848
		average	5147	861
		% diff	6.08	1.51
5		1	*4610	927
		2	5605	916
		3	5605	776
		average	5605	873
		% diff	0.00	11.11
		1	5565	960
		2	5525	895
	P	3	5525	927
		average	5538	927
		% diff	0.49	3.56
		1	5685	873
		2	5645	970
		3	5525	960
		average	5618	934
		% diff	1.66	6.53
		1	5205	852
		2	5165	938
		3	5010	970
		average	5127	920
		% diff	2.28	7.39
		1	5050	927
		2	4810	916
5	Q	3	4730	916
		average	4863	920
		% diff	3.85	0.76
		1	5445	875
		2	5445	875
		3	5485	925
		average	5458	892
		% diff	0.49	3.70

*Specimen failed improperly.

Table 18. Flexure and compression data for fatigue companion specimens, 5 sacks/yd^3, silicone additive DC-772, mixes I through Q

Sacks/yd	Batch	Specimen	Compression (psi)	Flexure (psi)
		1	7630	1075
		2	6795	1050
		3	6640	1000
		average	7022	1042
		% diff.	8.66	4.03
		% gain	43.31	22.30
		1	7470	975
		2	7550	1025
	I	3	6795	975
		average	7272	992
		% diff.	6.56	3.33
		% gain	50.34	22.17
		1	7790	1095
		2	6755	1100
		3	7035	955
		average	7193	1050
		% diff.	8.30	9.05
5		% gain	41.32	29.31
		1	6915	995
		2	6520	950
		3	6995	938
		average	6810	961
		% diff.	4.26	3.54
		% gain	30.76	5.26
		1	7000	950
		2	6440	900
	J	3	6755	950
		average	6738	933
		% diff.	4.42	3.54
		% gain	28.47	14.62
		1	6915	900
		2	6400	900
		3	6360	950
		average	6558	917
		% diff.	5.44	3.60
		% gain	19.56	2.92
		1	5960	725
		2	5920	825
		3	5125	800
		average	5668	783
		% diff.	9.58	7.41
		% gain	11.09	4.83

Table 18. (continued)

Sacks/yd	Batch	Specimen	Compression (psi)	Flexure (psi)
		1	4890	875
		2	5485	850
	K	3	5880	750
		average	5418	825
		% diff.	9.75	9.09
		% gain	11.71	-1.20
		1	6040	900
		2	5050	900
		3	5005	850
		average	5365	883
		% diff.	12.58	3.74
		% gain	6.24	5.75
5		1	6875	858
		2	7115	853
		3	6955	870
		average	6982	860
		% diff.	1.89	1.16
		% gain	32.11	0.94
		1	6520	850
		2	6440	900
	L	3	6560	775
		average	6507	842
		% diff.	1.03	7.96
		% gain	20.68	2.81
		1	6120	805
		2	6995	955
		3	6635	793
		average	6583	851
		% diff.	7.03	12.22
		% gain	23.93	0.83
		1	6795	868
		2	6280	913
		3	6560	788
		average	6545	856
		% diff.	4.05	7.94
		% gain	21.09	0.12
		1	6955	920
		2	6675	875
	M	3	7075	743
		average	6902	846
		% diff.	3.29	12.17
		% gain	22.86	-0.24

Table 18 (continued)

Sacks/yd	Batch	Specimen	Compression (psi)	Flexure (psi)
		1	6240	900
		2	6800	875
		3	6755	800
		average	6598	858
		% diff.	5.03	6.76
5		% gain	18.29	3.75
		1	6955	825
		2	6755	900
		3	6160	975
		average	6623	900
		% diff.	7.00	8.34
		% gain	22.24	2.28
		1	6795	825
		2	6955	838
	N	3	6835	788
		average	6862	817
		% diff.	1.36	3.55
		% gain	18.25	-8.00
		1	6620	850
		2	6560	888
		3	6040	900
		average	6407	879
		% diff.	5.73	3.30
		% gain	14.06	-1.79
		1	6955	875
		2	6955	875
		3	7075	950
		average	6995	900
		% diff.	1.14	5.56
		% gain	33.70	3.57
		1	6795	875
		2	6595	875
	O	3	6520	900
		average	6637	883
		% diff.	2.38	1.93
		% gain	19.59	0.23
		1	7075	850
		2	6835	825
		3	6755	900
		average	6888	858
		% diff.	2.71	4.90
5		% gain	33.83	-0.35

Table 18. (continued)

Sacks/yd	Batch	Specimen	Compression (psi)	Flexure (psi)
		1	7550	875
		2	7670	900
		3	7590	875
		average	7603	883
		% diff	0.88	3.96
		% gain	35.65	1.15
		1	7315	913
		2	7035	938
		3	6440	900
	P	average	6930	917
		% diff	7.07	2.29
		% gain	25.14	-1.08
		1	7395	1000
		2	7395	950
		3	7315	925
		average	7368	958
		% diff	0.72	4.38
		% gain	31.15	2.57
		1	7025	968
		2	6995	950
		3	6995	800
		average	7005	906
		% diff	0.29	11.69
		% gain	36.63	-1.52
		1	7035	920
		2	7035	875
		3	7075	800
5	Q	average	7048	865
		% diff	3.83	7.51
		% gain	44.93	-5.98
		1	6995	925
		2	6795	920
		3	6715	920
		average	6835	922
		% diff	2.34	0.33
		% gain	25.23	3.36

Table 19. Summary of flexure and compression results, percent gain of mixes with silicone additive DC-772 over plain concrete, 5 sacks/yd^3, mixes I through Q.

	Compression (psi)			Flexure (psi)		
Additive	3	7	28	3	7	28
None	2445	3021	4163	517	626	739
DC-772	3441	4434	5958	618	748	908
% Gain	40.74	46.77	43.12	11.80	19.49	22.87

Table 20. Flexure and compression data for fatigue companion specimens, average results for plain concrete and silicone additive DC-772 mixes, 5 sacks/yd^3, mixes I through Q.

			Compression (psi)		Flexure (psi)	
Sacks/yd	Batch	Group	None	DC-772	None	DC-772
		1	4900	7022	852	1042
		2	4837	7272	812	992
	I	3	5090	7193	812	1050
		average	4942	7162	825	1028
		% diff	3.00	1.95	3.28	3.51
		1	5208	6810	913	961
		2	5245	6738	814	933
	J	3	5285	6558	891	917
		average	5269	6702	873	937
		% diff	1.16	2.15	6.76	2.56
		1	4890	5668	747	783
		2	4850	5418	835	825
	K	3	4970	5365	835	883
		average	4903	5484	806	830
		% diff	1.37	3.36	7.32	6.39
		1	5125	6982	852	860
		2	5392	6507	819	842
	L	3	5312	6583	844	851
		average	5276	6691	838	851
		% diff	2.86	4.35	2.27	1.06
		1	5405	6545	855	856
		2	5618	6902	848	846
	M	3	5578	6598	827	858
		average	5534	6682	843	853
		% diff	2.34	3.29	1.90	0.82
		1	5418	6623	880	900
		2	5803	6862	888	817
	N	3	5617	6407	895	879
		average	5613	6631	888	865
		% diff	3.48	3.48	0.90	5.55
		1	5232	6995	869	900
		2	5550	6637	881	883
5	O	3	5147	6888	861	858
		average	5310	6840	870	880
		% diff	4.52	2.97	1.26	2.50
		1	5605	7603	873	883
		2	5538	6930	927	917
	P	3	5618	7368	934	958
		average	5587	7300	911	919
		% diff	0.88	5.07	4.17	4.13
		1	5127	7005	920	906
		2	4863	7048	920	865
	Q	3	5458	6835	892	922
		average	5149	6963	910	898
		% diff	6.00	1.84	1.98	3.67

Table 21. Average flexure and compression results for fatigue companion specimens, plain concrete and silicone additive DC-772 mixes, 5 sacks/yd^3, mixes I through Q.

Sacks/yd	Batch	Additive	Compression (psi)	Flexure (psi)
	I	none	4942	825
		DC-772	7162	1028
	J	none	5269	873
		DC-772	6702	937
	K	none	4903	806
		DC-772	5484	830
	L	none	5276	838
		DC-772	6691	851
5	M	none	5534	843
		DC-772	6682	853
	N	none	5613	888
		DC-772	6631	865
	O	none	5310	870
		DC-772	6840	880
	P	none	5587	911
		DC-772	7300	919
	Q	none	5149	910
		DC-772	6963	898

Table 22. Summary of flexure and compression results for fatigue companion specimens, percent gain of mixes with silicone additive DC-772 over plain concrete, 5 sacks/yd^3, mixes I through Q.

Additive	Compression (psi)	Flexure (psi)
none	5287	863
DC-772	6717	896
% gain	27.05	3.82

Table 23. Durability data for plain concrete, 5 sacks/yd^3, mixes A, B, C, and D.

Sacks/yd	Batch	Specimen	Freeze and Thaw Cycles	D. F.	Dynamic Modulus of Elasticity
		1	8	.8	$6.48X10^6$
	A	2	9	.9	$6.31X10^6$
		average	8	.85	
		% diff	12.50	5.88	
		1	24	2.4	$6.68X10^6$
	B	2	23	2.3	$7.01X10^6$
		average	23	2.35	
		% diff	4.17	2.13	
5		1	10	1.0	$5.71X10^6$
		2	9	.9	$5.75X10^6$
	C	3	11	1.1	$5.72X10^6$
		average	9.0	.90	
		% diff	11.11	11.11	
		1	115	11.5	$5.60X10^6$
		2	133	13.3	$5.60X10^6$
	D	3	118	11.8	$5.60X10^6$
		average	122	12.20	
		% diff	3.28	3.28	

Table 24. Durability data for silicone additive DC-772 mixes, 5 sacks /yd^3, mixes A, B, C, and D.

Sacks/yd	Batch	Specimen	Freeze and Thaw Cycles	D. F.	Dynamic Modulus of Elasticity
		1	29	2.9	$7.05X10^6$
		2	21	2.1	$6.84X10^6$
	A	average	25	2.5	
		% diff	16.0	1.6	
		% gain	212.50	194.12	
		1	169	16.9	$6.22X10^6$
		2	155	15.5	$6.30X10^6$
	B	average	162	16.2	
		% diff	4.32	4.32	
		% gain	604.35	589.36	
5		1	104	10.4	$5.69X10^6$
		2	86	8.6	$5.64X10^6$
		3	40	4.0	$5.08X10^6$
	C	average	76	7.7	
		% diff	47.40	47.88	
		% gain	426.67	432.00	
		1	300	30	$5.76X10^6$
		2	300	30	$5.62X10^6$
		3	300	30	$5.64X10^6$
	D	average	300	30	
		% diff	0.00	0.00	
		% gain	145.90	145.90	

Table 25: Summary of durability data, average percent gain in durability of silicone additive DC-772 mixes over plain concrete, 5 sacks/yd^3, mixes A, B, C, and D.

Sacks/yd	Additive	Freeze and Thaw Cycles	D. F.
5	none	40	4.1
	DC-772	140	14.1
% Gain in D. F.		250.00	243.90

Table 26. Average percent of volume change for plain concrete and silicone additive DC-772 mixes, 5 sacks/yd^3.

Time	Additive None	DC-772
2 day	1.45	1.54
3 day	1.58	1.85
4 day	1.68	1.98

Table 27. Air-content, slump, water-cement ratio, and time of set for plain concrete and silicone additive DC-772 mixes, 5 sacks/yd^3, mixes C, D, and E.

Sacks/yd	Additive	Variable		Mix C	D	E
5	None	w/c		0.448	0.468	0.502
		% air		2.15	2.65	2.95
		slump		1-1/4"	1"	1-1/4"
		time of set	I	1'-30"	1'-55"	2'-45"
			F	3'-45"	4'-30"	5'-10"
	DC-772	w/c		0.444	0.433	0.479
		% air		2.60	3.35	3.00
		slump		1-1/2"	1"	1"
		time of set	I	3'-0"	3'-0"	2'-45"
			F	7'-30"	9'-15"	9'-0"

Table 28. Air-content, slump, water-cement ratio for plain concrete and silicone additive DC-772 mixes, 5 sacks/yd^3, mixes I through Q.

Sacks/yd	Mix	Additive	w/c	% Air	Slump
	I	none	.492	2.50	3/4"
		DC-772	.468	2.95	1/2"
	J	none	.530	3.10	1-1/4"
		DC-772	.506	2.35	3/4"
	K	none	.524	3.00	1-1/2"
		DC-772	.552	2.13	1"
	L	none	.484	3.65	1-1/4"
		DC-772	.508	2.53	1/2"
5	M	none	.431	3.55	1-1/4"
		DC-772	.543	1.93	3/4"
	N	none	.522	2.55	3/4"
		DC-772	.523	2.20	1-1/4"
	O	none	.520	2.50	3/4"
		DC-772	.523	2.30	1"
	P	none	.476	2.20	1"
		DC-772	.486	2.70	3/4"
	Q	none	.486	2.60	3/4"
		DC-772	.509	2.63	1"

Table 29. Number of cycles, N, to failure and probability of failure, p, for three stress levels, plain concrete and silicone additive DC-772 fatigue specimen mixes, 5 sacks/yd^3, mixes I through Q.

	None Stress Level	ADDITIVE		DC-772 Stress Level	
.4fr	.425fr	.45fr	.4fr	.425fr	.45fr
827	63	43	115	82	382
3457	1346	268	793	949	414
4635	1546	281	835	1673	965
5590	1833	300	1234	1686	1145
7491	2661	436	2031	1697	1870
8241	2948	935	2911	2017	2012
9732	3233	1277	5325	2402	2803
10000+	4063	2511	7322	2455	3431
10000+	4941	5003	10000+	3694	3842

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