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16. ABSTRACT

The effects of set retarders on the compressive strength and compacted density of cement treated base materials are discussed. The two most common types of set retarders, lignosulfonic acid and hydroxylated carboxylic acid, were investigated along with household sugar and a commercial "compaction aid." Laboratory tests indicate that very little benefit can be gained by the use of these set retarders.

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STATE OF CALIFORNIA—TRANSPORTATION AGENCY

RONALD REAGAN, Governor

DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT
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June 1969
Final Report
M&R No. 643455

Mr. J. A. Legarra
State Highway Engineer

Dear Sir:

Submitted herewith is a research report titled:

SET RETARDERS

FOR

CEMENT TREATED BASE

ERNEST ZUBE
Principal Investigator

CLYDE G. GATES
DONALD L. DURR
Co-Investigators
Assisted by Harvey D. Sterner

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

69-04

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ABSTRACT: The effects of set retarders on the compressive strength and compacted density of cement treated base materials are discussed. The two most common types of set retarders, lignosulfonic acid and hydroxylated carboxylic acid, were investigated along with household sugar and a commercial "compaction aid." Laboratory tests indicate that very little benefit can be gained by the use of these set retarders.

KEY WORDS: Cement treated bases, retardants, setting time, density, compressive strength.

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INTRODUCTION

It has been well established that the elapsed time between adding water to a cement treated base mix and completion of trimming and compaction is critical to both the density and compressive strength of the material. The standard specifications allow two hours to complete the initial rolling but occasionally this requirement cannot be met due to some operational or mechanical difficulty. Some aggregates require an unusually large amount of compactive effort. As the time between mixing and completion of compaction is increased, the cement continues to hydrate, which in turn makes the mix more difficult to compact and as a result, the ultimate density and compressive strength are reduced.

Other factors, such as fast setting cements or accelerated hydration caused by high temperatures, have also caused difficulties in achieving proper compaction even though the compactive effort was applied well within the specified time limit.

The purpose of this study was to determine if set retarders can be used to delay cement hydration sufficiently to increase the time of effective compactive effort. This would provide adequate densities and compressive strengths even when unforeseen delays or an accelerated hydration rate is encountered.

CONCLUSIONS

It is recognized that the data obtained in this study are quite limited when the vast number of possible combinations of aggregates, cements, admixtures and concentration of admixtures are considered. Although limited in scope, the test results do give an indication of the effects of the various types of set retarding admixtures on the density and compressive strength of a cement treated material under laboratory conditions.

1. None of the additives tested provided consistent or significant improvements in either density or compressive strength when the compactive effort was delayed.

2. Laboratory tests indicate the lignosulfonic acid admixture might allow slight delays of approximately 1/2 hour for hard to compact materials with no significant reduction of either density or compressive strength.

3. Laboratory tests also indicate the lignosulfonic acid admixture may allow slightly higher densities to be achieved, within the allowable time limit, for hard to compact materials by retarding the cement hydration.

4. The need for compacting cement treated materials as soon as possible was confirmed.

MATERIALS

Two sources of aggregates were used during this study. The first aggregate was a mixture of gravel and river sand and, as far as is known, no compaction difficulties have been encountered in the field with its use. La Vista Quarry aggregate, which was used throughout the remainder of the study, was selected specifically because of its reputation of being a difficult material to compact.

Three brands of Type II cement were used. Laboratory records indicated very little difference in the characteristics between Brands X, Y and Z, but when Brand Z was used on a recent contract, compaction difficulties were encountered which both the contractor and state personnel attributed to the fast setting characteristics of the cement during hot weather.

Several types of set retarding agents are available. The two most common types, however, are lignosulfonic acid and hydroxylated carboxylic acid. One commercially available brand of each of these two types was used and designated respectively as admixtures 1 and 2. Admixture 3 was common household sugar which is also a powerful hydration retarder. The fourth admixture used in this study was a material which had been advertised and sold as a "compaction aid." This fourth material was included in this study not only to evaluate its qualities as a retarding agent but also to determine its value as a "compaction aid."

TEST PROCEDURES

Fabrication of all test specimens was done in accordance with Test Method No. Calif. 312-D with the exception that the time between mixing and compacting was varied from none to six hours. Four percent cement was used in all of the specimens.

The admixtures were used in accordance with the manufacturers recommendations with the exception of admixture 2 on the initial series of tests. In this series the admixture was added at the recommended dosage and also in a triple dose. To insure proper dispersement of the admixtures throughout the mixture, they were added to the mixing water prior to being mixed with the aggregate and cement.

The density and seven day compressive strength was determined on each specimen. The density and strength values reported are the averages of duplicate tests on each variation.

DISCUSSION

The first series of tests was made with admixtures 1 and 2, Brand X cement, and an easily compacted aggregate which is a mixture of gravel and river sand. This combination of materials resulted in a mixture which was not seriously effected by delays in compaction with or without a retarding agent. The data from this first series of tests are plotted in Figure 1. Most of the loss in density and compressive strength of the control specimens occurred by the end of the first hour of loose curing. Very little loss occurred after one hour.

Specimens containing admixture 1 and compacted with less than two hours of loose curing attained higher compressive strengths and densities than the control specimens. Those compacted after more than two hours of loose curing attained the same or lower compressive strengths and densities than the control specimens.

The use of admixture 2 resulted in no increase in density and only an irregular increase in strength when added at the manufacturers recommended concentration of one part admixture per 750 parts cement. A triple dose of this admixture did bring about some increase in both density and compressive strength but, as with admixture 1, there seems to be very little reason to use a retarder on this type of mix where the normal setting rate is so slow.

All four of the listed admixtures were used in the second series of tests. Brand Y and Brand Z cement were used and the aggregate was a crushed, quarry rock which has had a long history as a hard to compact material.

Data from this series of tests are plotted in Figures 2 through 9. Each of these figures illustrates the need for final compaction of cement treated materials just as soon as possible in order to meet the relative compaction requirements and to assure adequate strength.

A review of these figures will show that admixture 1 is the best admixture tested in that it will allow some delay in compaction without adversely affecting either the strength or the density of the compacted material. The time extension is relatively short, but it could possibly be of benefit in attaining satisfactory compaction of hard to compact cement treated materials within the allowable time limit.

Some of the other admixtures provided very small improvements but the increases in strength and density were either inconsistent or too small to be of value.

Admixture 2 and admixture 4, the supposed "compaction aid," provided no appreciable increase in the density of the compacted material.

Household sugar, admixture 3, increased the density of the compacted material slightly, but the compressive strengths of the specimens were inconsistent in their relationship with the control specimens.

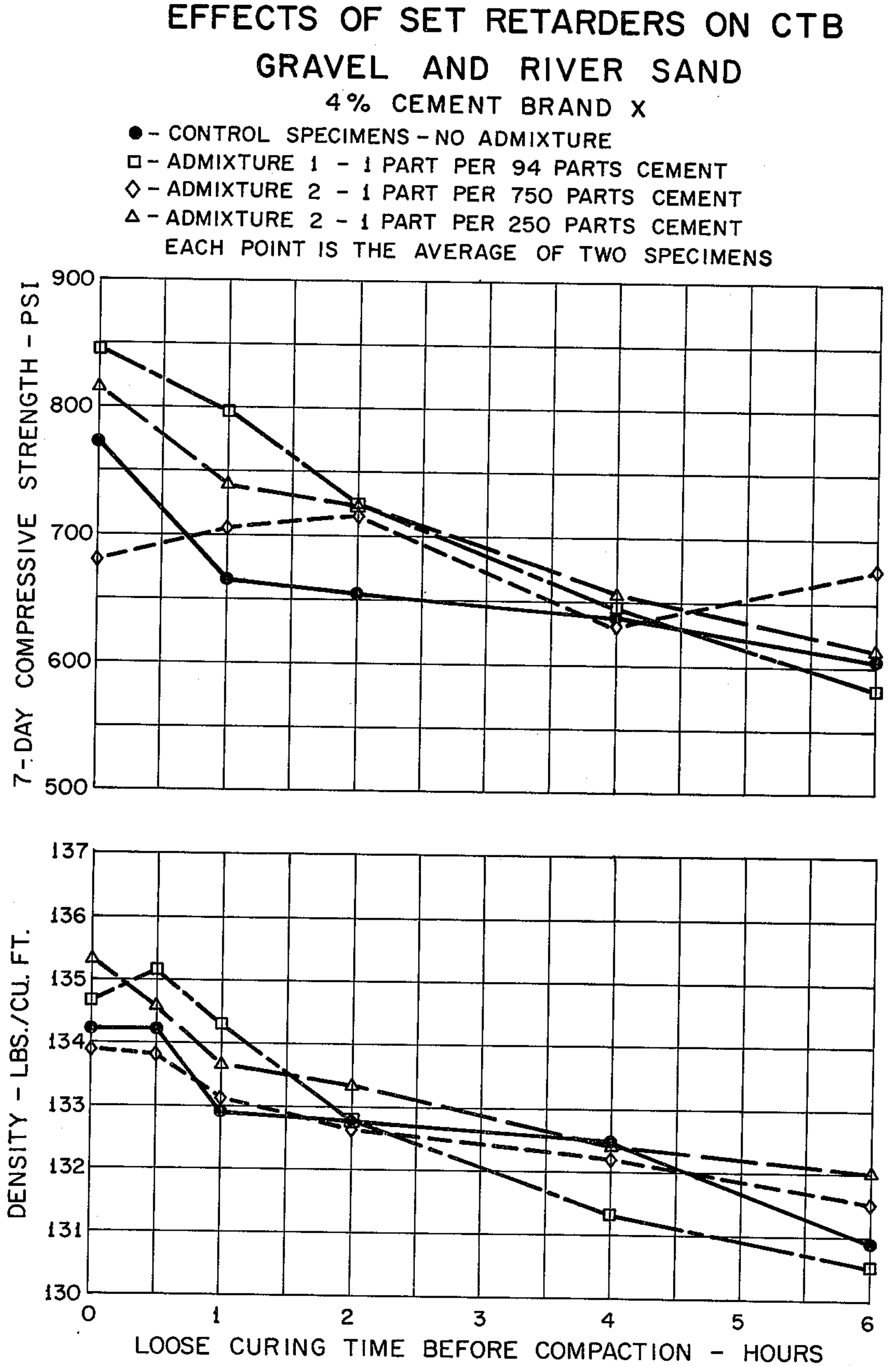
On the basis of this study, it can be concluded that none of the admixtures tested retard the hydration of the cement enough to allow an appreciable extension of the allowable time for completing initial compaction. Use of admixture 1, however, may help in compacting hard to compact mixes by retarding the cement hydration during the specified compaction time.

A final series of tests was made to determine whether admixture 4 would have any long term detrimental effects on the quality of cement treated base.

Four sets of specimens were prepared using admixture 4, La Vista Quarry aggregate and 4% of Brand X cement. The admixture was added to the mixing water at the manufacturers recommended rate of 1:1000 and also at the rate of 3:1000. Duplicate specimens were fabricated by routine test methods and tested for compressive strength after curing periods of 7 days, 14 days, 28 days and 90 days. The data from these tests, shown in Figure 10, indicate there may be some long term benefit by using this admixture, but the percentage increase in strength is small. The average densities of the compacted specimens used in this series of tests are shown in Table I.

TABLE I

	Density-lbs./cu.ft.
No additive	137.8
1:1000 admixture-water ratio	137.9
3:1000 admixture-water ratio	138.0



EFFECTS OF SET RETARDERS ON CTB
GRAVEL AND RIVER SAND
4% CEMENT BRAND X
● - CONTROL SPECIMENS - NO ADMIXTURE
□ - ADMIXTURE 1 - 1 PART PER 94 PARTS CEMENT
◇ - ADMIXTURE 2 - 1 PART PER 750 PARTS CEMENT
△ - ADMIXTURE 2 - 1 PART PER 250 PARTS CEMENT
EACH POINT IS THE AVERAGE OF TWO SPECIMENS
7-DAY COMPRESSIVE STRENGTH - PSI
900
800
700
600
500
DENSITY - LBS./CU. FT.
137
136
135
134
133
132
131
130
0
1
2
3
4
5
6
LOOSE CURING TIME BEFORE COMPACTION - HOURS

Figure 1

EFFECTS OF SET RETARDERS ON CTB

LA VISTA QUARRY AGGREGATE

4% CEMENT BRAND Y

● – CONTROL SPECIMENS – NO ADMIXTURE

□ – ADMIXTURE 1 – 1 PART PER 94 PARTS OF CEMENT

EACH POINT IS THE AVERAGE OF TWO SPECIMENS

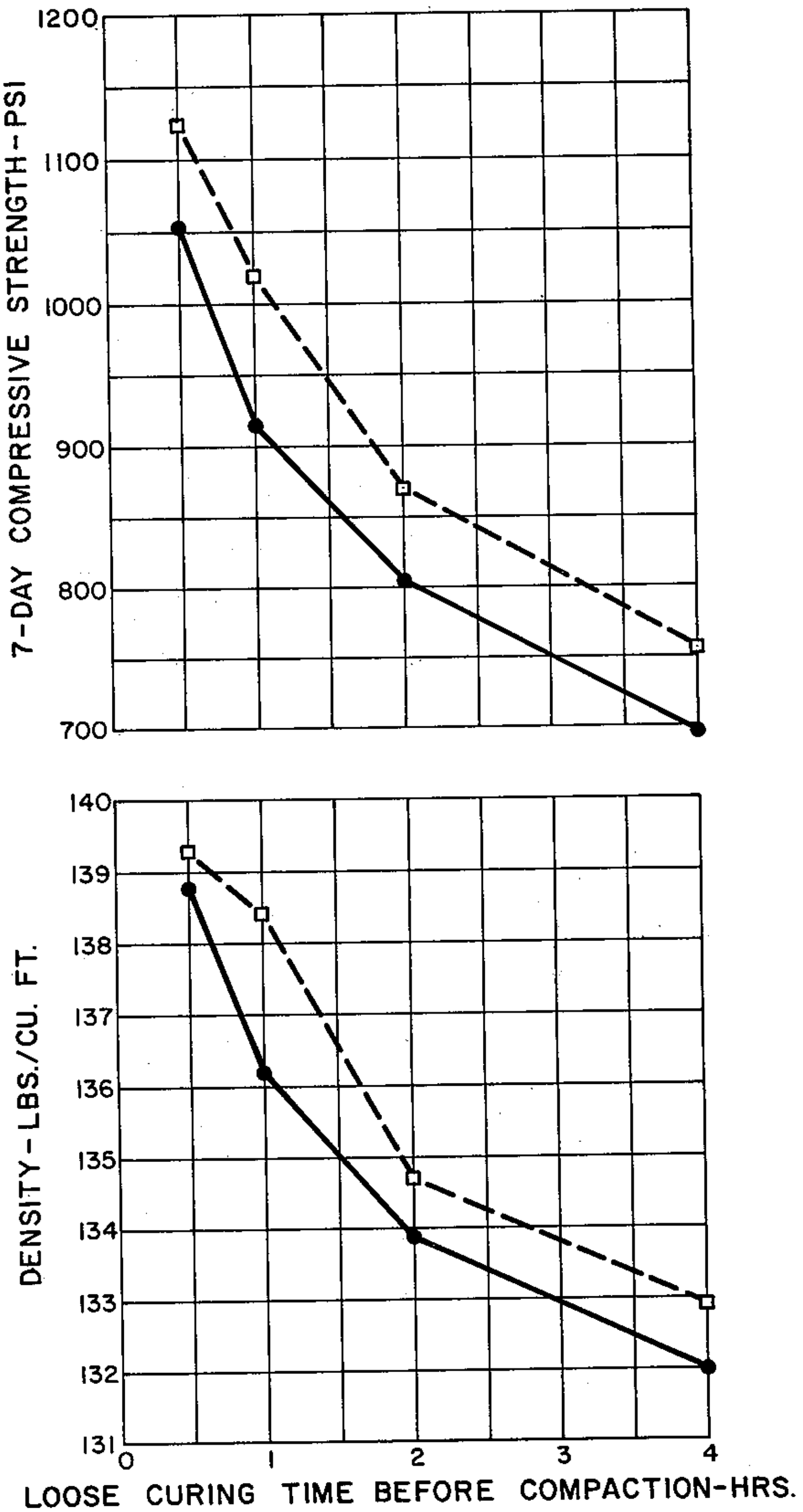


Figure 2

EFFECTS OF SET RETARDERS ON CTB

LA VISTA QUARRY AGGREGATE

4% CEMENT BRAND Y

● – CONTROL SPECIMENS – NO ADMIXTURE
□ – ADMIXTURE 2 – 1 PART PER 750 PARTS CEMENT
EACH POINT IS THE AVERAGE OF TWO SPECIMENS

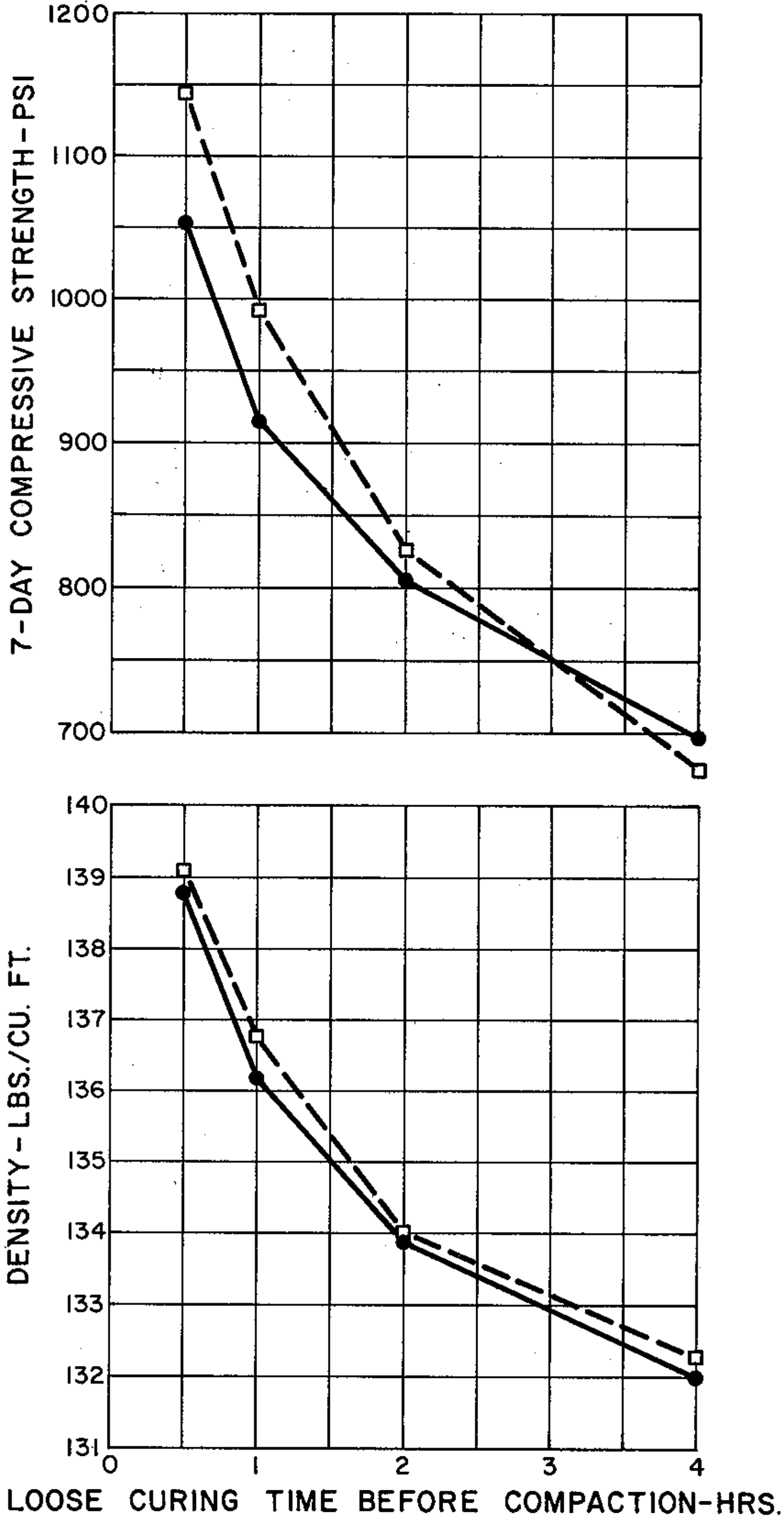


Figure 3

EFFECTS OF SET RETARDERS ON CTB

LA VISTA QUARRY AGGREGATE

4% CEMENT BRAND Y

● – CONTROL SPECIMENS – NO ADMIXTURE
□ – ADMIXTURE 3 - 1 PART PER 2000 PARTS OF CEMENT
EACH POINT IS THE AVERAGE OF TWO SPECIMENS

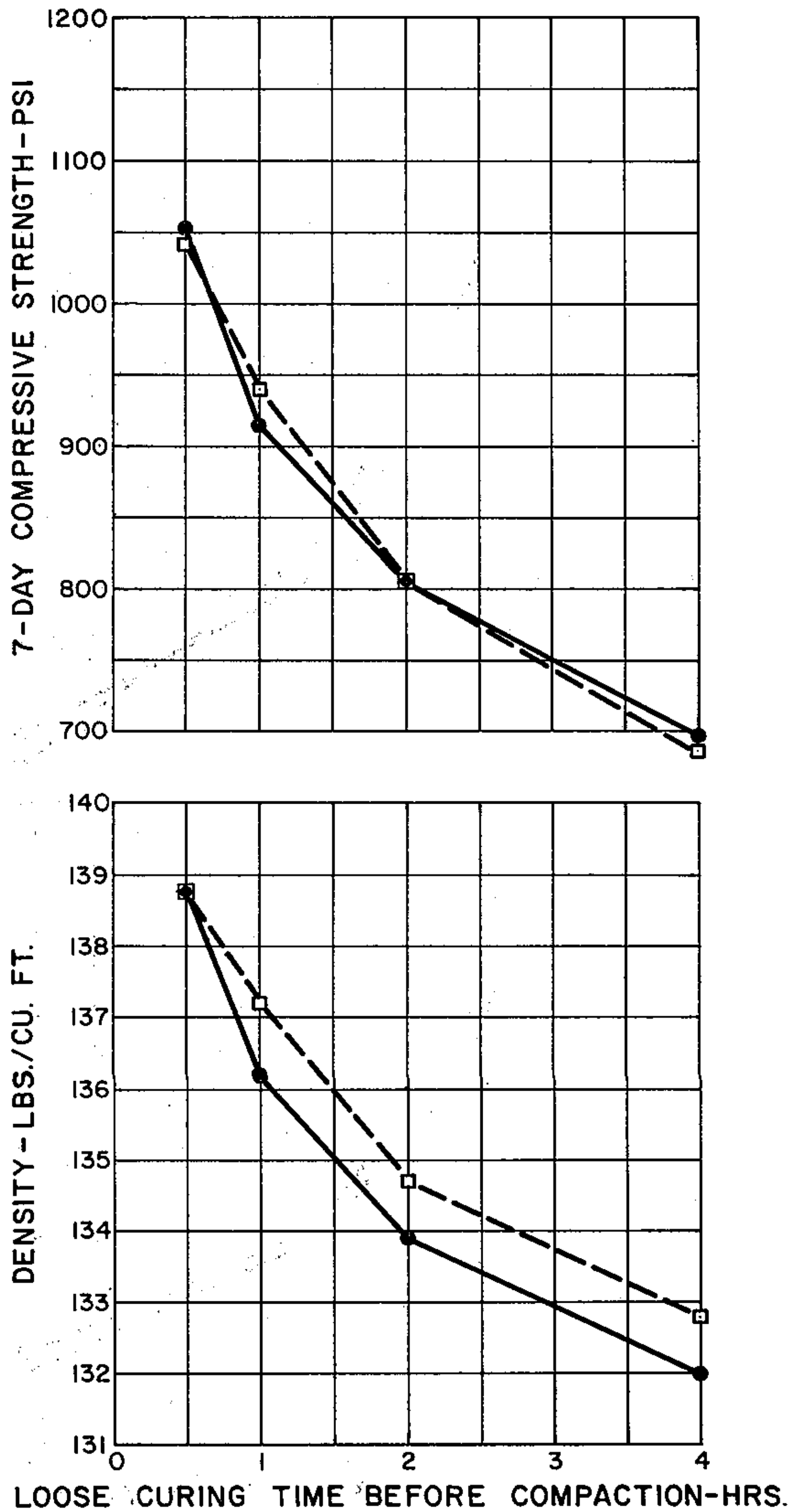
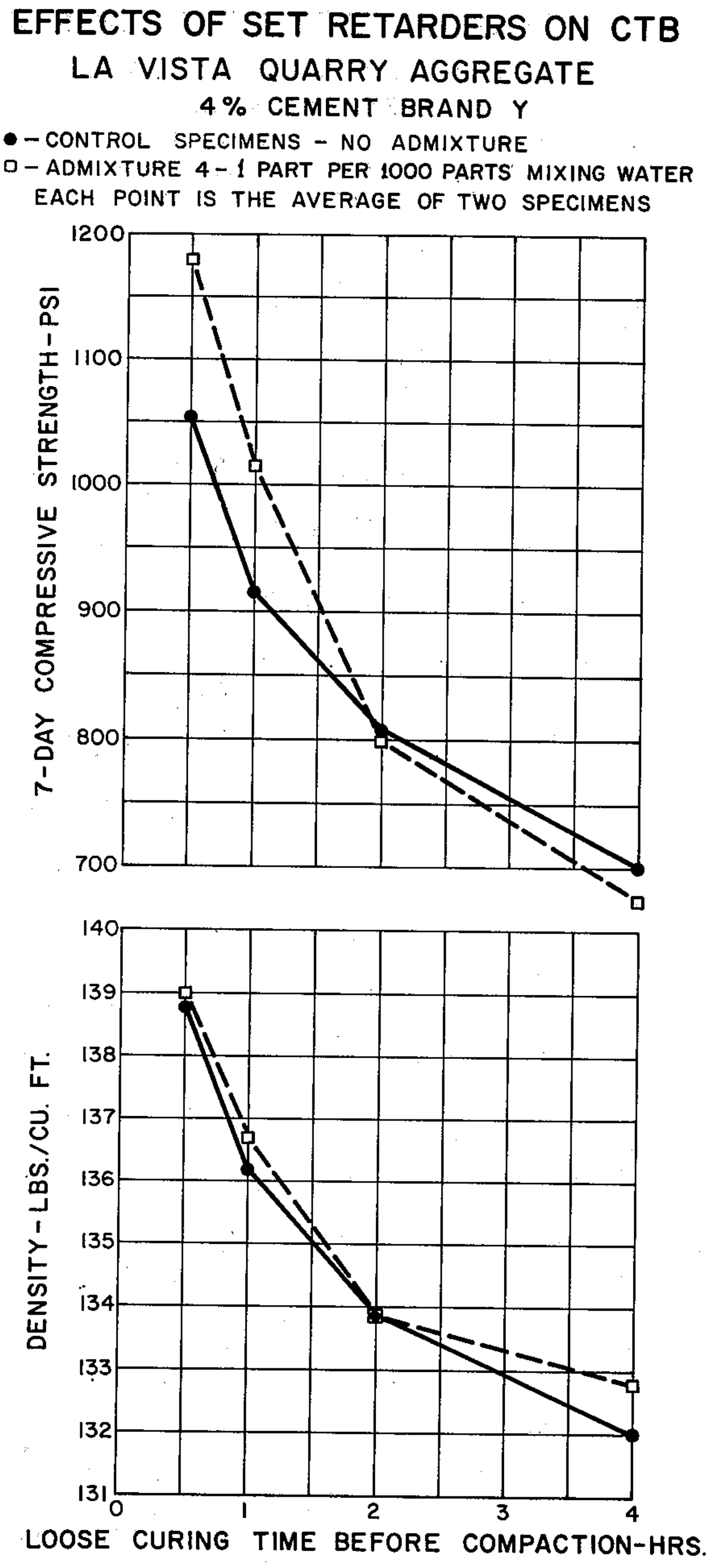


Figure 4



EFFECTS OF SET RETARDERS ON CTB
LA VISTA QUARRY AGGREGATE
4% CEMENT BRAND Y
● – CONTROL SPECIMENS – NO ADMIXTURE
□ – ADMIXTURE 4 - 1 PART PER 1000 PARTS MIXING WATER
EACH POINT IS THE AVERAGE OF TWO SPECIMENS
7-DAY COMPRESSIVE STRENGTH - PSI
1200
1100
1000
900
800
700
DENSITY - LBS./CU. FT.
140
139
138
137
136
135
134
133
132
131
0
1
2
3
4
LOOSE CURING TIME BEFORE COMPACTION - HRS.

Figure 5

EFFECTS OF SET RETARDERS ON CTB

LA VISTA QUARRY AGGREGATE

4% CEMENT BRAND Z

● – CONTROL SPECIMENS – NO ADMIXTURE
□ – ADMIXTURE 1 - 1 PART PER 94 PARTS CEMENT
EACH POINT IS THE AVERAGE OF TWO SPECIMENS

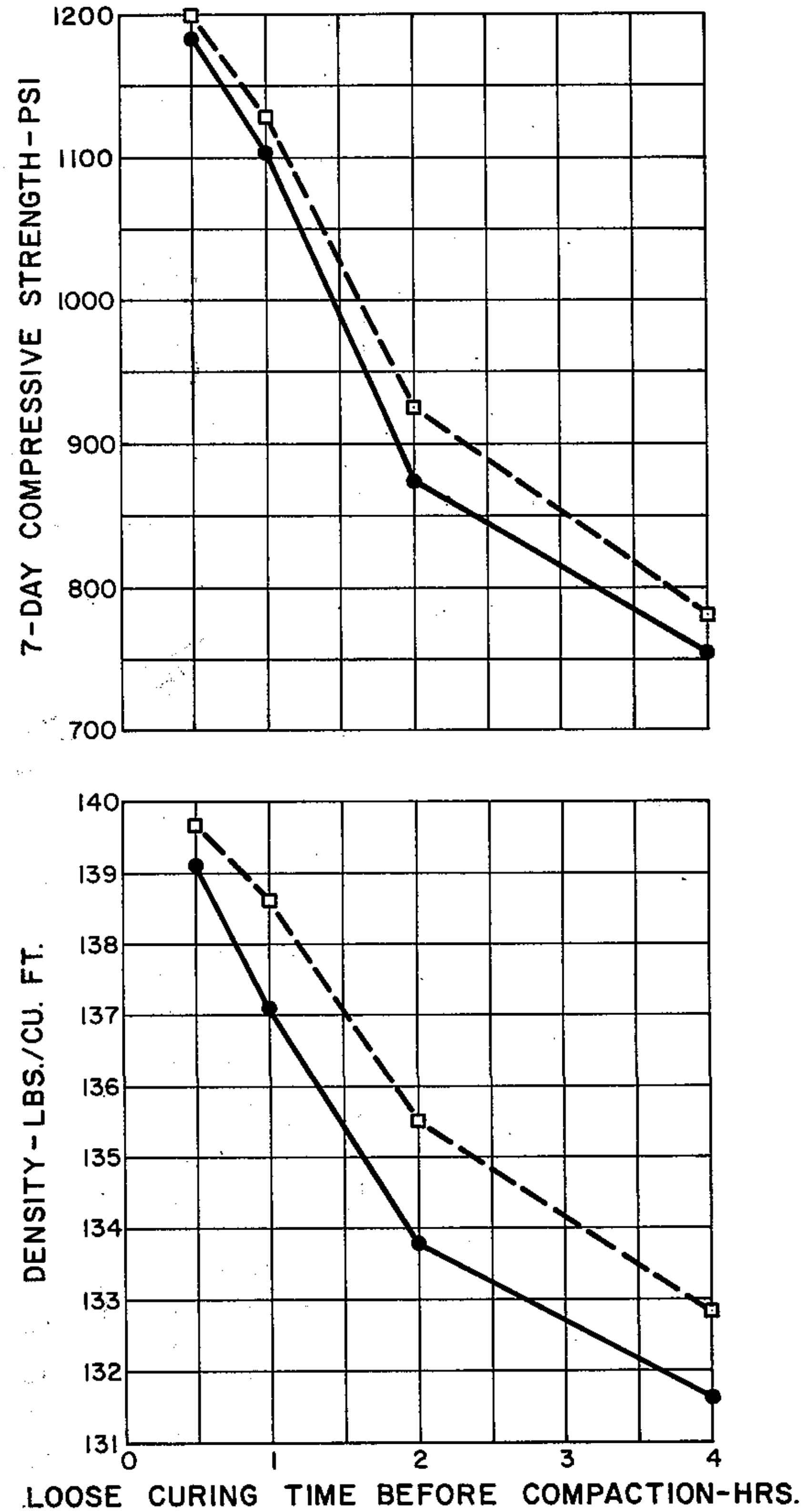


Figure 6

EFFECTS OF SET RETARDERS ON CTB

LA VISTA QUARRY AGGREGATE

4% CEMENT BRAND Z

● – CONTROL SPECIMENS – NO ADMIXTURE

□ – ADMIXTURE 2 –.1 PART PER 750 PARTS CEMENT

EACH POINT IS THE AVERAGE OF TWO SPECIMENS

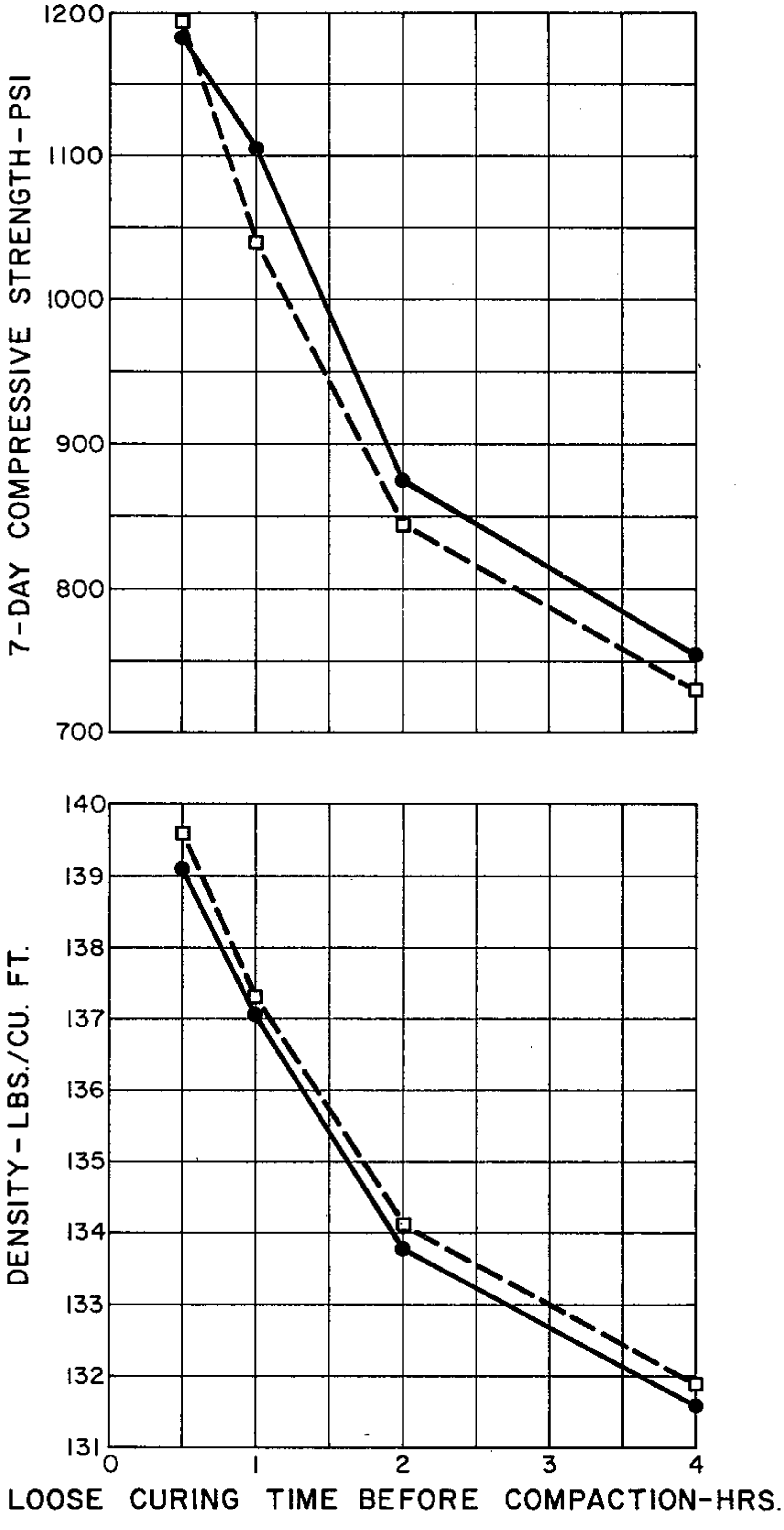


Figure 7

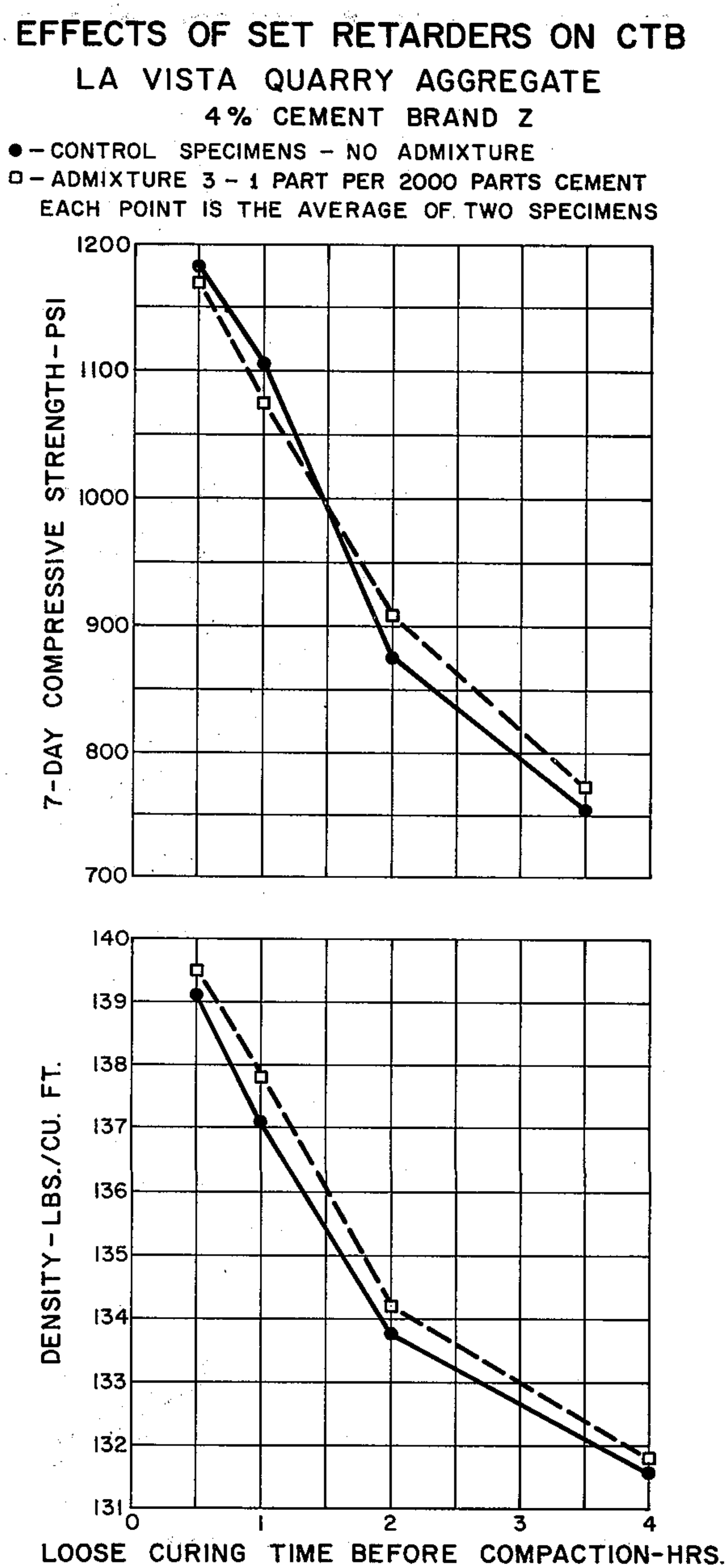

EFFECTS OF SET RETARDERS ON CTB
LA VISTA QUARRY AGGREGATE
4% CEMENT BRAND Z
● – CONTROL SPECIMENS – NO ADMIXTURE
□ – ADMIXTURE 3 – 1 PART PER 2000 PARTS CEMENT
EACH POINT IS THE AVERAGE OF TWO SPECIMENS
7-DAY COMPRESSIVE STRENGTH – PSI
1200
1100
1000
900
800
700
DENSITY – LBS./CU. FT.
140
139
138
137
136
135
134
133
132
131
0
1
2
3
4
LOOSE CURING TIME BEFORE COMPACTION – HRS.

Figure 8

EFFECTS OF SET RETARDERS ON CTB

LA VISTA QUARRY AGGREGATE

4% CEMENT BRAND Z

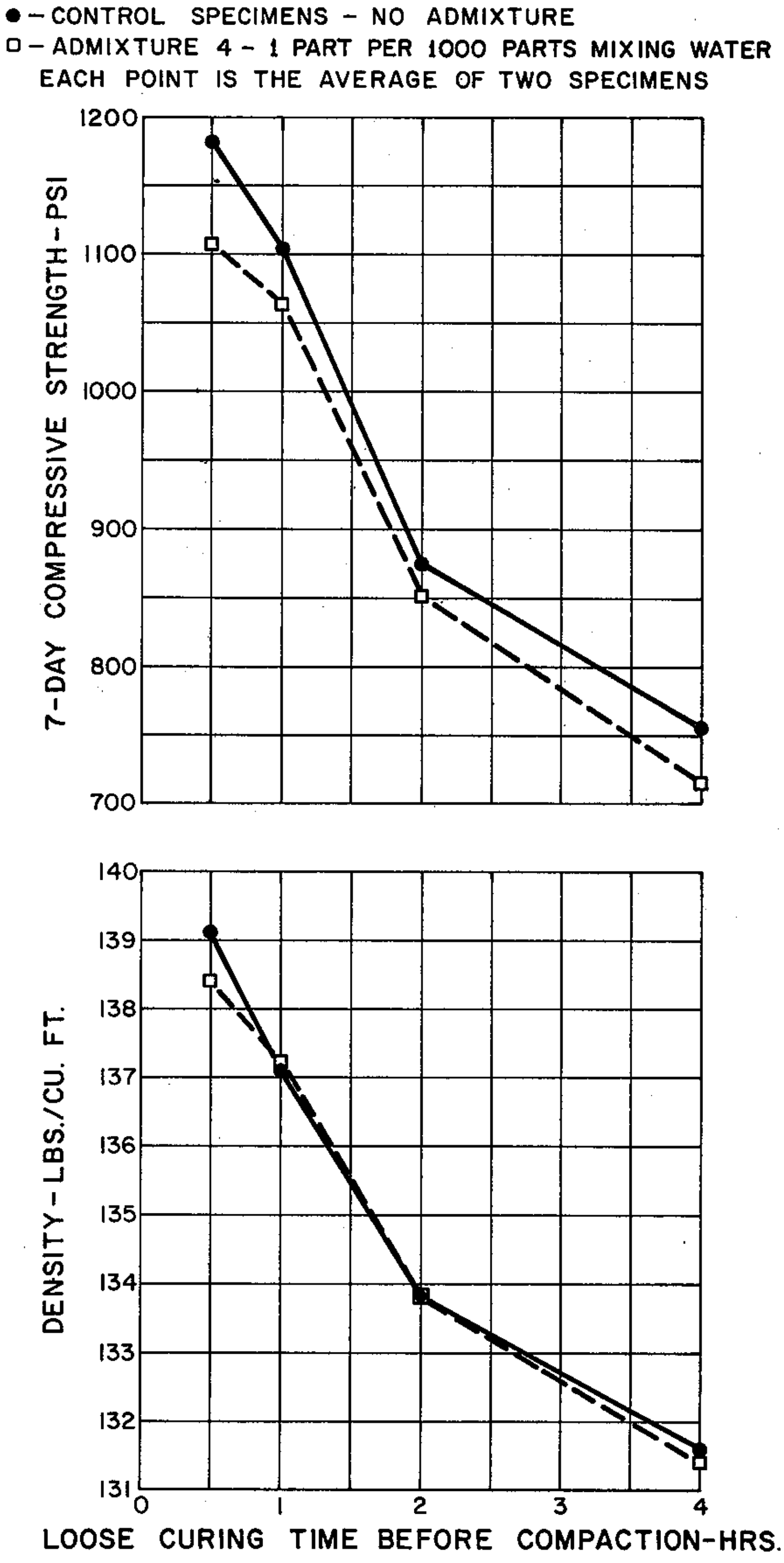


Figure 9

EFFECTS OF SET RETARDERS ON CTB
LA VISTA QUARRY AGGREGATE
4% CEMENT BRAND X

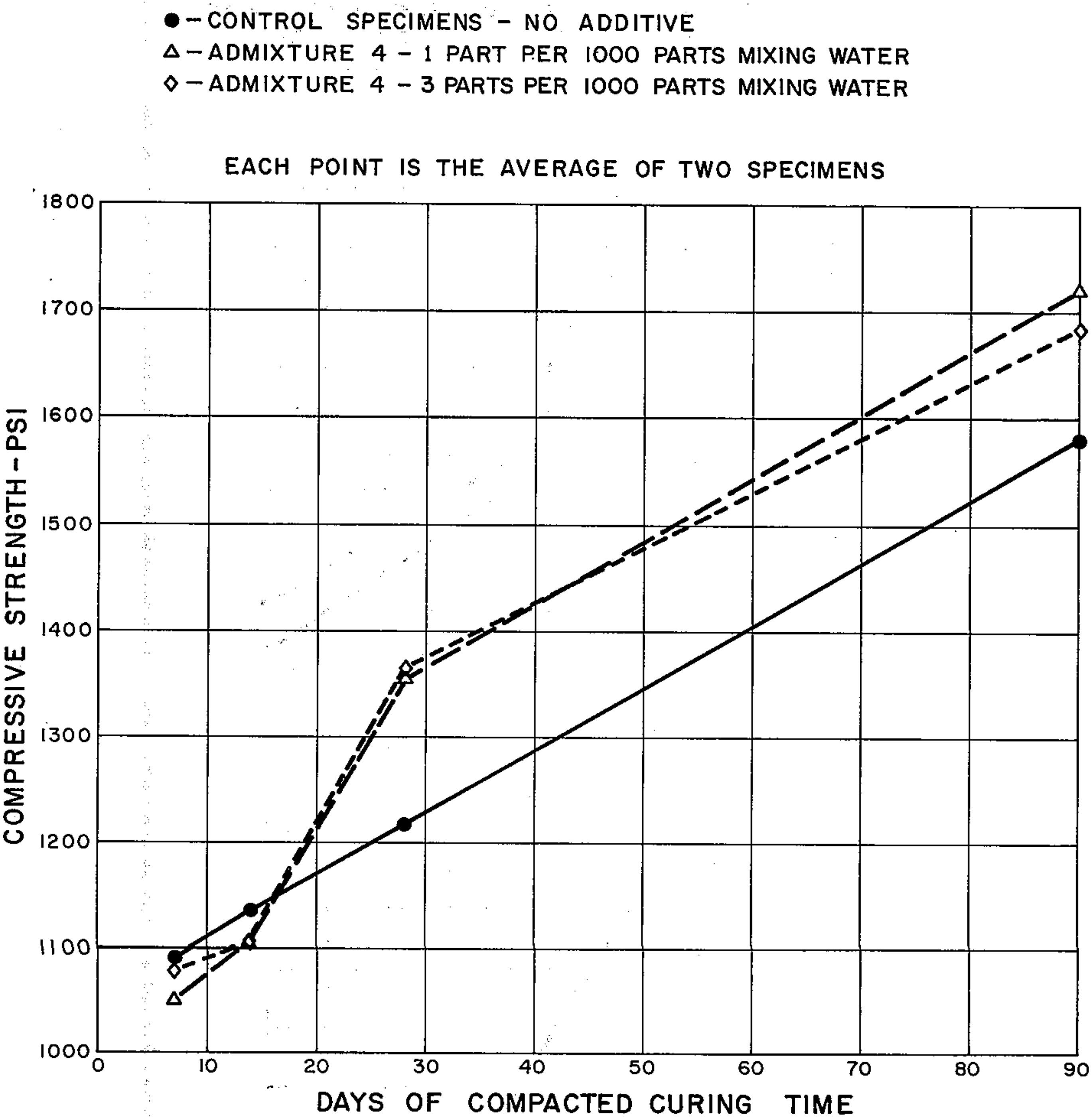


Figure 10