RETARDERS - INFLUENCE OF

VARIABLE QUANTITIES

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VERMONT DEPARTMENT OF HIGHWAYS

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ABSTRACT

This study was undertaken to evaluate the effects on concrete of extended retardation through increased dosages of admixtures. Results indicate that retarding admixtures do increase compressive strength and time of set of concrete. However, increases in admixture addition rates and setting times vary in relation to each other as do similar chemicals manufactured by different producers.

INTRODUCTION

On occasion, the use of retarding admixtures in structural concrete has failed to produce the desired results. The most serious failures occur with inadequate retardation as may be encountered on continuous span bridge decks being placed in a single operation. This failure or premature time of set hampers finishing operations and results in "cold joints" and deflection cracking.

The cause of these undesirable results is presumed to be the use of insufficient quantities of retarding admixtures. Inexperience, changeable weather conditions, and changes in materials may also be contributing factors. In order to eliminate many of these factors, a laboratory program was initiated to study and evaluate the effects of extended retardation through increased dosages of admixtures.

Information obtained from the tests relative to setting times, compressive strengths, air contents, etc., was helpful in establish schedules for using the admixtures in the field.

MATERIALS

The materials in this investigation, with the exception of those used to control air content, were representative of those proposed for use in the field. The admixtures used to control air content were:

Air Entraining Admixture

Neutralized Vinsol Resin (NVX), manufactured by Hercules Inc., Wilmington, Delaware

Air De-entraining Admixture

Octyl alcohol, manufacturer unknown.

Following is a list of all other materials used in the designated tests:

<u>TEST A</u>

Aggregate - J. P. Carrara & Sons Inc. - No. Clarendon, Vermont

Cement - Type I - Glens Falls Portland Cement Co., Glens Falls, New York

Retarding Admixture - Daratard - Grace Construction Materials, Cambridge, Massachusetts.

TEST B

Aggregate - Calkins Construction Inc., Coventry, Vermont

Cement - Type I - Northeast Cement Co. Inc., Syracuse, New York

Retarding Admixture - Plastiment - Sika Chemical Corp., Passaic, New Jersey

TEST C

Aggregate - Calkins Construction Inc., Coventry, Vermont

Cement - Type I - Northeast Cement Co. Inc., Syracuse, New York

Retarding Admixture - Daratard HC - Grace Construction Materials, Cambridge, Massachusetts.

PROCEDURES

One series of tests was performed for each type of retarder under study. These tests differ from AASHO in that only one batch was mixed for each condition of concrete, i.e. one reference batch and one batch for each progressive dosage of retarder. This deviation from the usual three batches for each condition of concrete required by AASHO was due to the limited number of molds available, acquisition of materials required and time, manpower and demands outside the scope of this report.

Progressive Dosages of Retarder

Test	Oz/Sk	Trade Name
A	15, 18, 21, 24	Daratard
B	4, 5, 6, 7, 8	Plastiment
C	6, 7, 8, 9, 10	Daratard HC

Aggregates for all batches were weighed in the field and transported to the Laboratory for mixing. This practice, while saving considerable time, resulted in non-uniform moisture contents. Hence, the comparison of water contents, normally required, was disregarded.

All batches of concrete were mixed in the Laboratory under standard conditions using the Lancaster mixer. Adjustments were made as necessary to provide concrete with properties meeting specifications.

The following tests were performed:

(1) Slump of Portland Cement Concrete

(2) Air content of freshly mixed concrete by Chace Air Indicator

(3) Time of Setting of Concrete Mixtures by Penetration Resistance

(4) Making and Curing Concrete Test Specimens in the Laboratory

The compressive strength test specimens were, in all cases, cast in standard six inch diameter cardboard molds. The four cylinders cast from each batch were tested at ages of three, seven and twenty-eight days and six months.

RESULTS & DISCUSSION

The tests, although conducted similarly, yielded wide ranges of results depending on the quantity and type of admixture used. Although their results are displayed collectively in charts and graphs, each test should be considered singularly.

CONSISTENCY

The slump, with one exception, was maintained within specified tolerances. Minor deviations within these tolerances appeared to have a negligible affect upon other properties. See Fig. I.

AIR ENTRAINMENT

The retarding admixture used in Test A was of the Lignosulfonic Acid type which, when used in large quantities, entrains an excessive amount of air. Therefore, it was necessary to reduce the air content in the extreme cases by using octyl alcohol -- an air de-entraining admixture. Initially, lower air contents than desired were obtained through unfamiliarity with the product. No further attempts were made at controlling the air in these batches.

Both Tests B and C were performed using hydroxylated carboxylic acid as a retarder. This type has little effect upon air entrainment which was controlled by an admixture for that purpose. See Fig. I.

RETARDATION

The procedure used to determine retardation followed the Standard Method of Test for Time of Setting of Concrete Mixtures by Penetration Resistance (ASTM C 403-68) modified as mentioned in the introduction.

All results relative to initial set (500 psi) and final set (4000 psi) are graphically presented as a time sequence for each variable per test. See Figs. II, III, and IV.

Note that the setting times of cement may vary from sample to sample as well as from brand to brand as is indicated in the reference mixes.

The retarder test results clearly show that there is no straight line relationship between increases in time of set and increases in admixture addition rates. This correlates with field observations.

Two of the retarders under study were of the same chemical hydroxylated carboxylic acid. (Test B and Test C). The performance of each of these admixtures was entirely different from the other. The other retarder (Test A) is of the chemical lignosulfonic acid. It should be reiterated that the results shown concern one test only for each condition and are not an average of several trials.

COMPRESSIVE STRENGTH

In all cases, the compressive strength was increased when retarder was used. The results of compressive strengths are shown in Figs. I, V, VI, and VII. The percent of increase due to retarder is shown in Fig. VIII.

CONCLUSIONS AND RECOMMENDATIONS

1. This type of testing should be continued, and expanded to include other properties e.g., bleeding.

2. Information obtained from these tests is useful as an aid in determining adequate field quantities of retarder.

3. There is no straight line relationship between increases in admixture addition rates and increases in setting times.

4. It was found that admixtures of the same chemical type but produced by different companies performed dissimilarly with respect to each other.

5. The Lignosulfonic Acid retarders do entrain air and large dosages should be used with caution.

6. The use of retarders in all cases resulted in an increase in compressive strength.

7. Mixing one batch per condition of concrete appears adequate for this type of test as long as other laboratory conditions are met.

8. Variations in slump within Specifications limits appear to have little or no effect on setting time.

TEST A (DARATARD)

ADMIXTURE OZ/SK	SLUMP INCHES	AIR CONTENT PERCENT	COMPRESSIVE STRENGTH, PSI 3 DAY	7 DAY	28 DAY	6 MONTH
0	3	6 1/2	2600	3307	4678	5736
15	3 1/4	6 1/2	3227	4191	5491	6375
18	2 3/4	6 3/4	3218	4226	5296	6295
21	3 1/2	5	3448	4476	5192	6835
24	2 1/4	3	3334	4244	5880	7074

TEST B (PLASTIMENT)

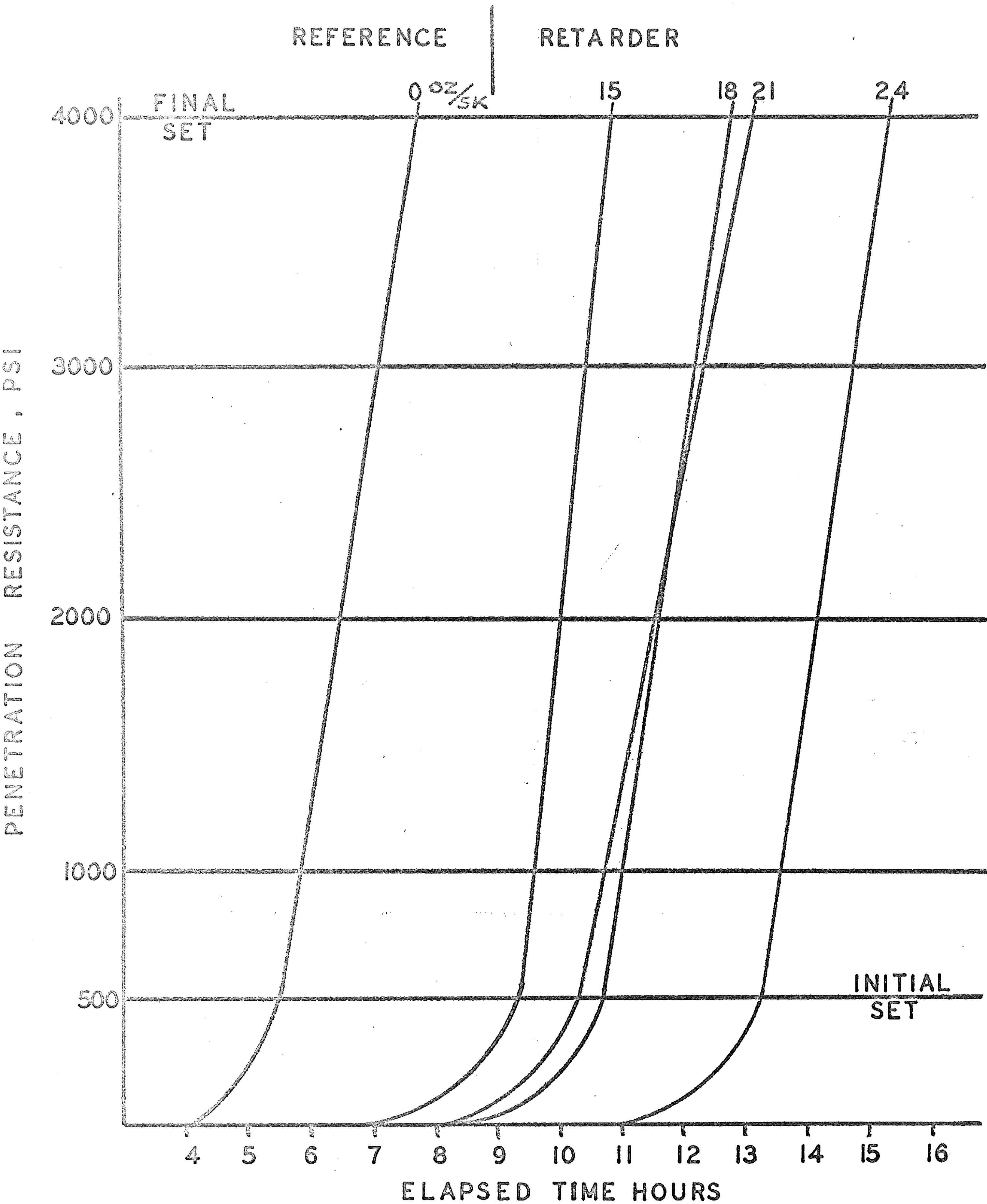
ADMIXTURE OZ/SK	SLUMP INCHES	AIR CONTENT PERCENT	COMPRESSIVE STRENGTH, PSI 3 DAY	7 DAY	28 DAY	6 MONTH
0	4	5 1/2	2387	2715	3281	4466
4	3 3/4	6 3/4	2723	3068	3546	4952
5	3 1/2	6 1/2	3143	3581	4191	5261
6	3 1/2	6	3272	3696	4288	5535
7	2 3/4	6 1/2	3581	4165	4235	6137
8	4	7	3493	4006	4739	6075

TEST C (DARATARD)

ADMIXTURE OZ/SK	SLUMP INCHES	AIR CONTENT PERCENT	COMPRESSIVE STRENGTH, PSI 3 DAY	7 DAY	28 DAY	6 MONTH
0	4	6 1/2	2493	2891	3192	4377
6	2 1/2	6 1/2	2909	3289	4067	5181
7	1 3/4	6 1/2	3431	3882	4678	5730
8	3 1/2	7	3316	3820	4456	5668
9	2 1/4	6	3678	4112	4856	6013
10	3 1/4	6 1/2	3378	3873	3236	5818

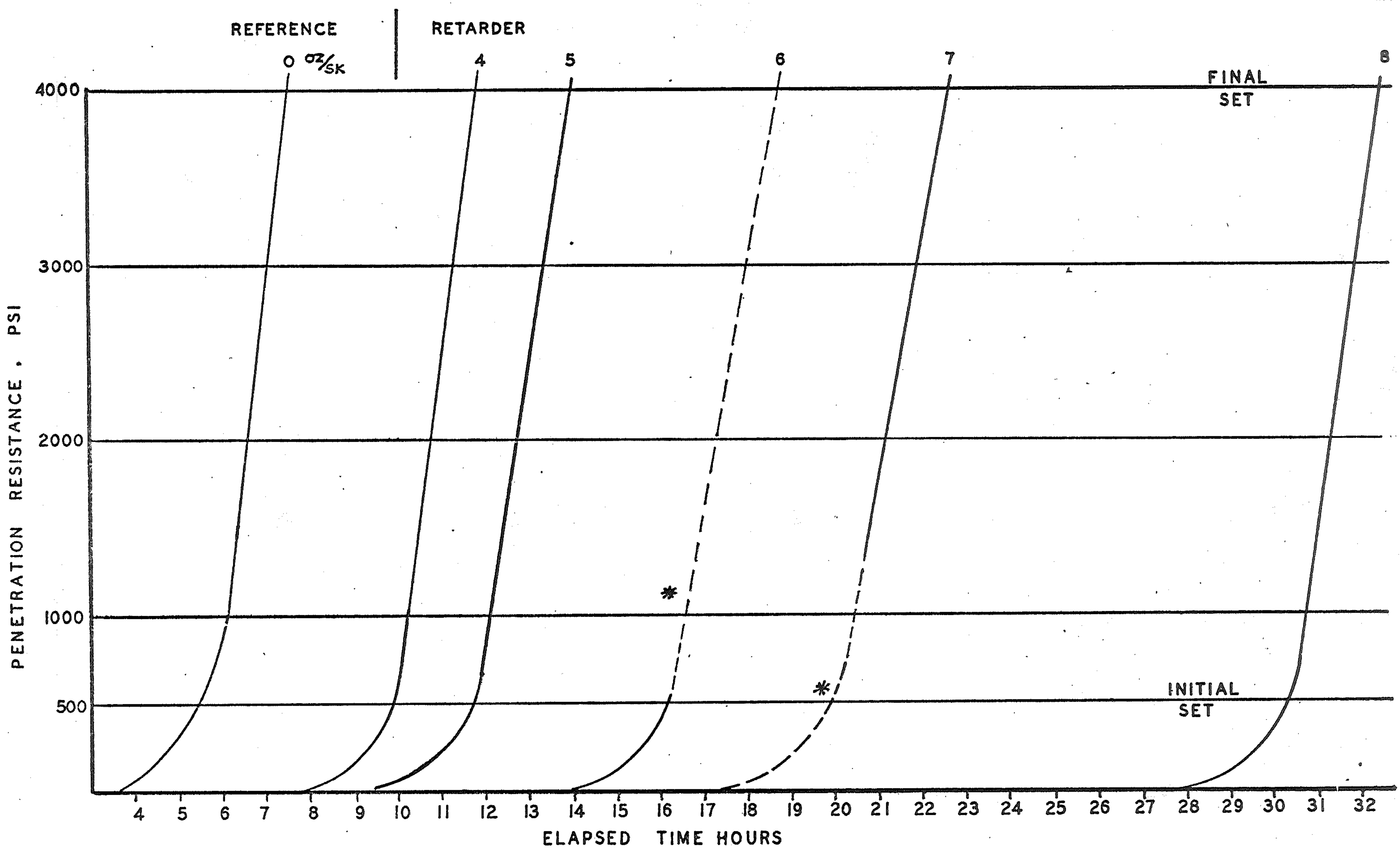
COMPRESSIVE STRENGTH TABLES

FIGURE I



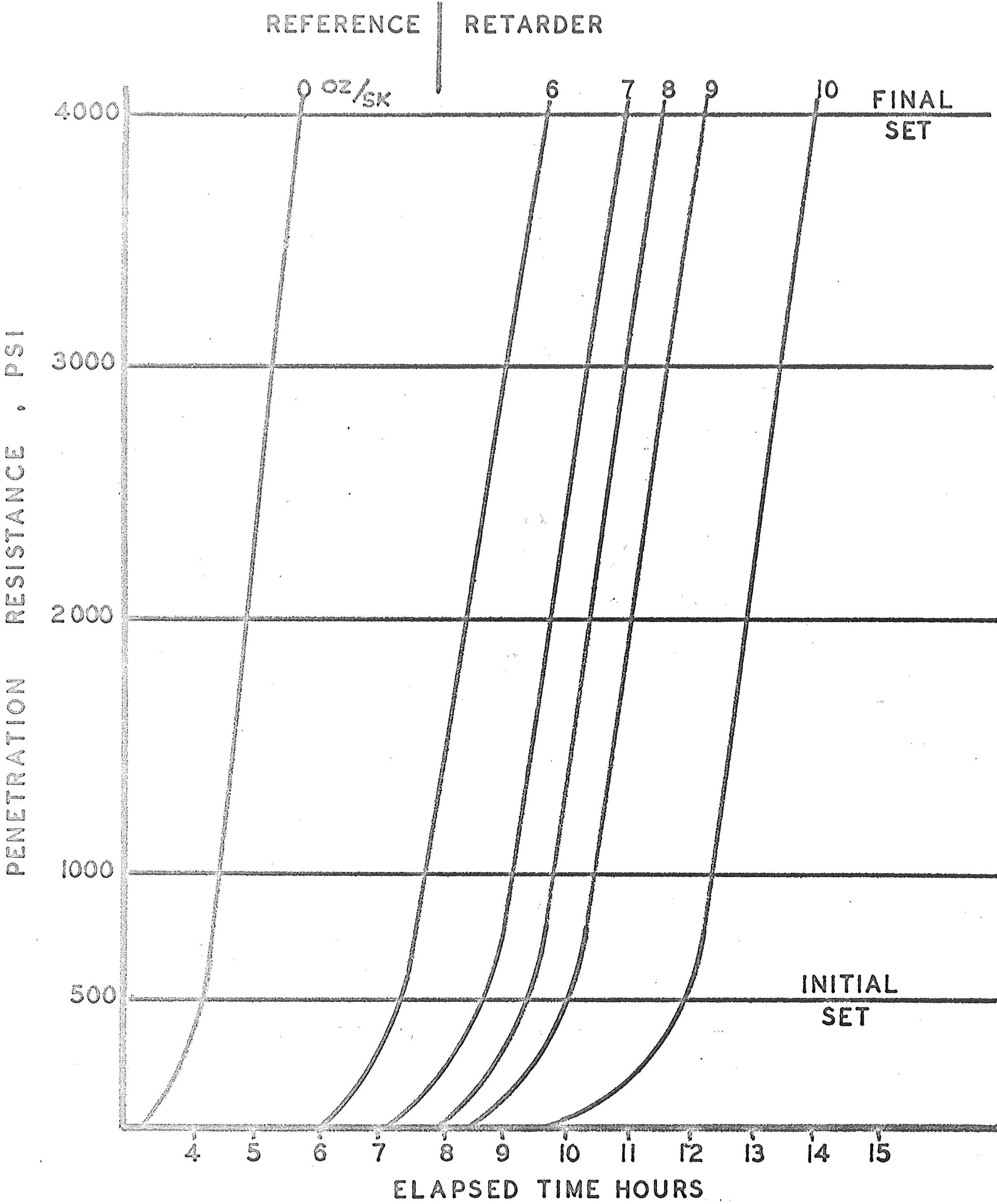
TIME OF SET CURVES — TEST A

FIGURE II



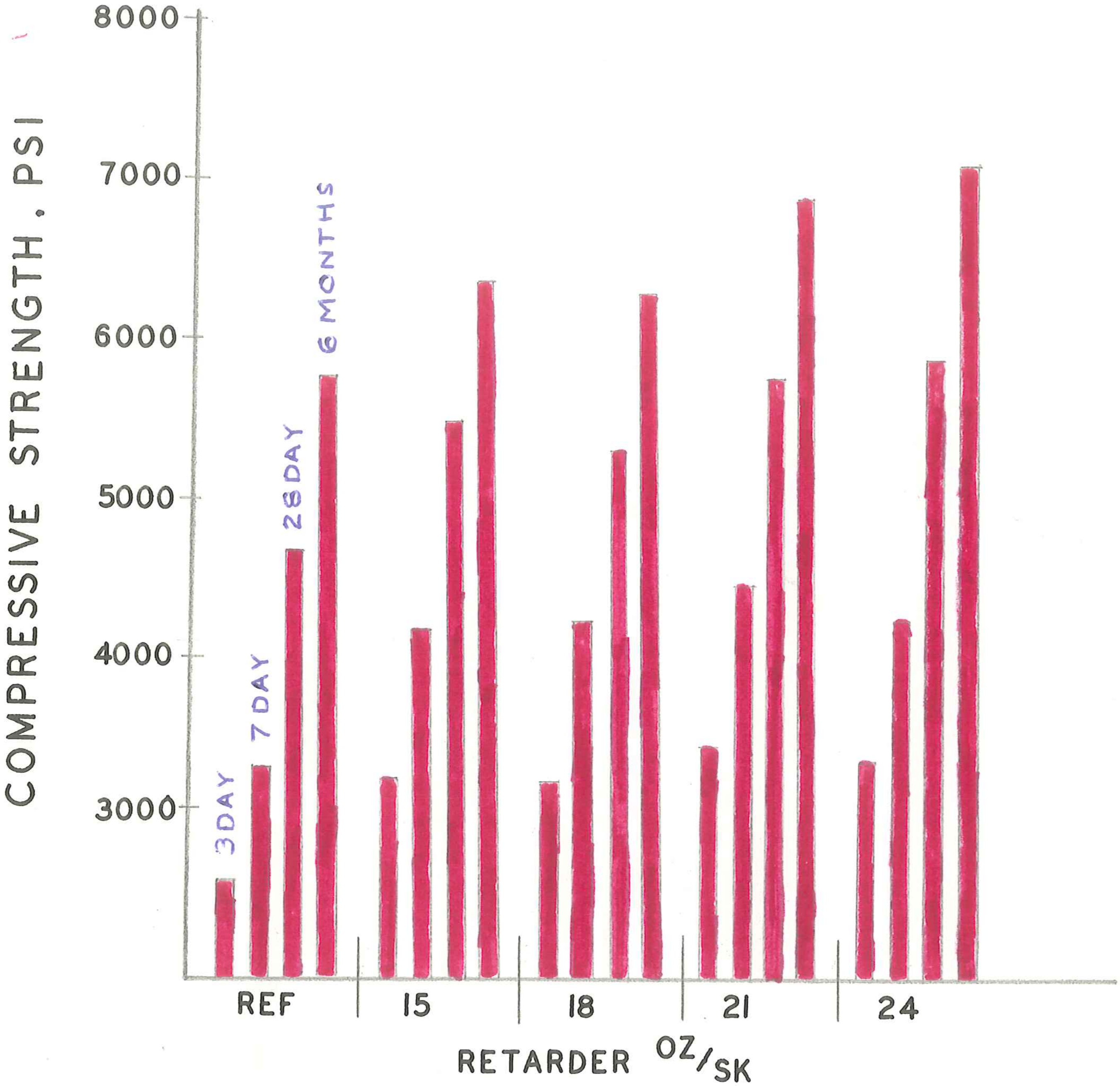
TIME OF SET CURVES — TEST B

FIGURE III.



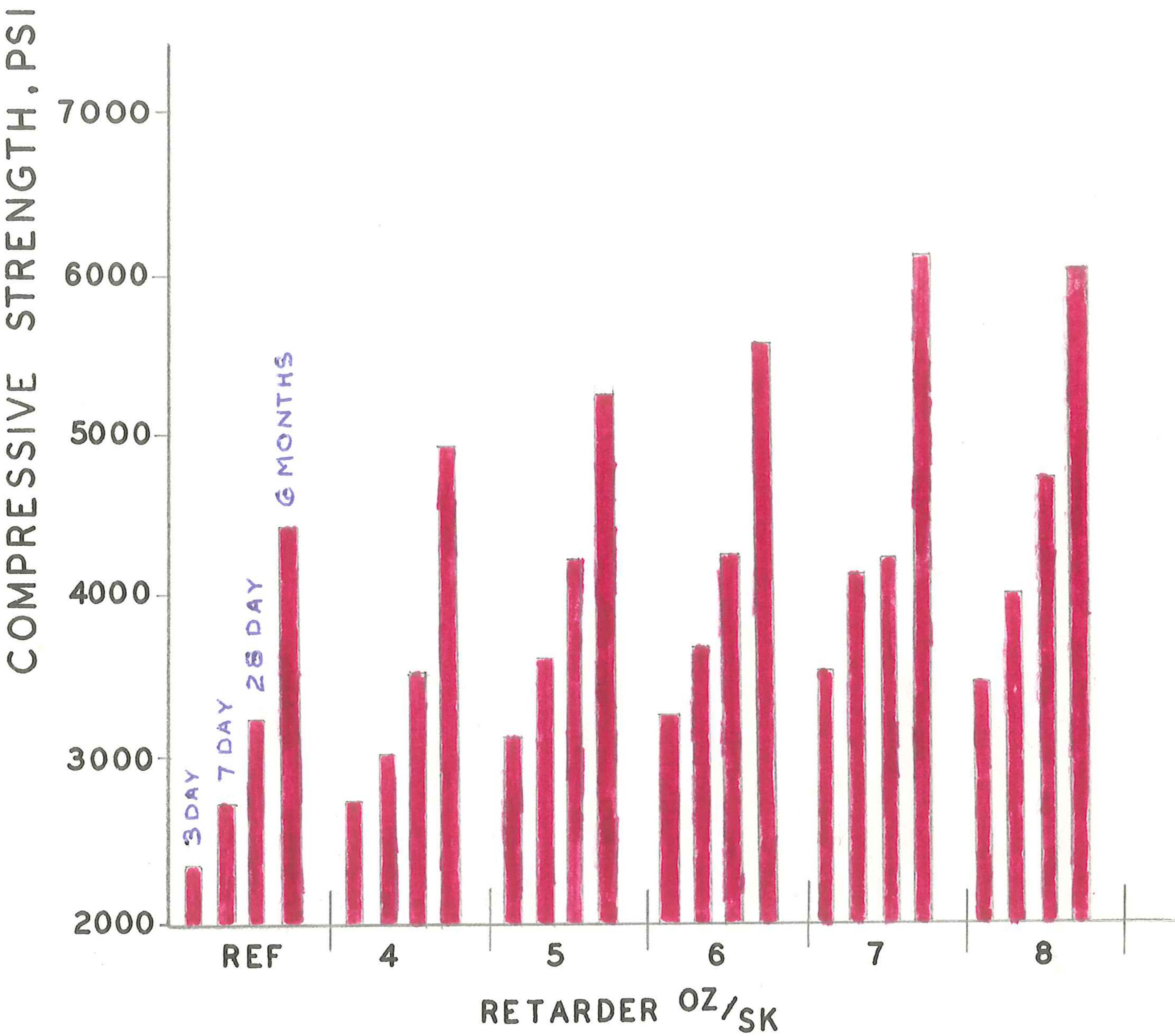
TIME OF SET CURVES — TEST C

FIGURE IV



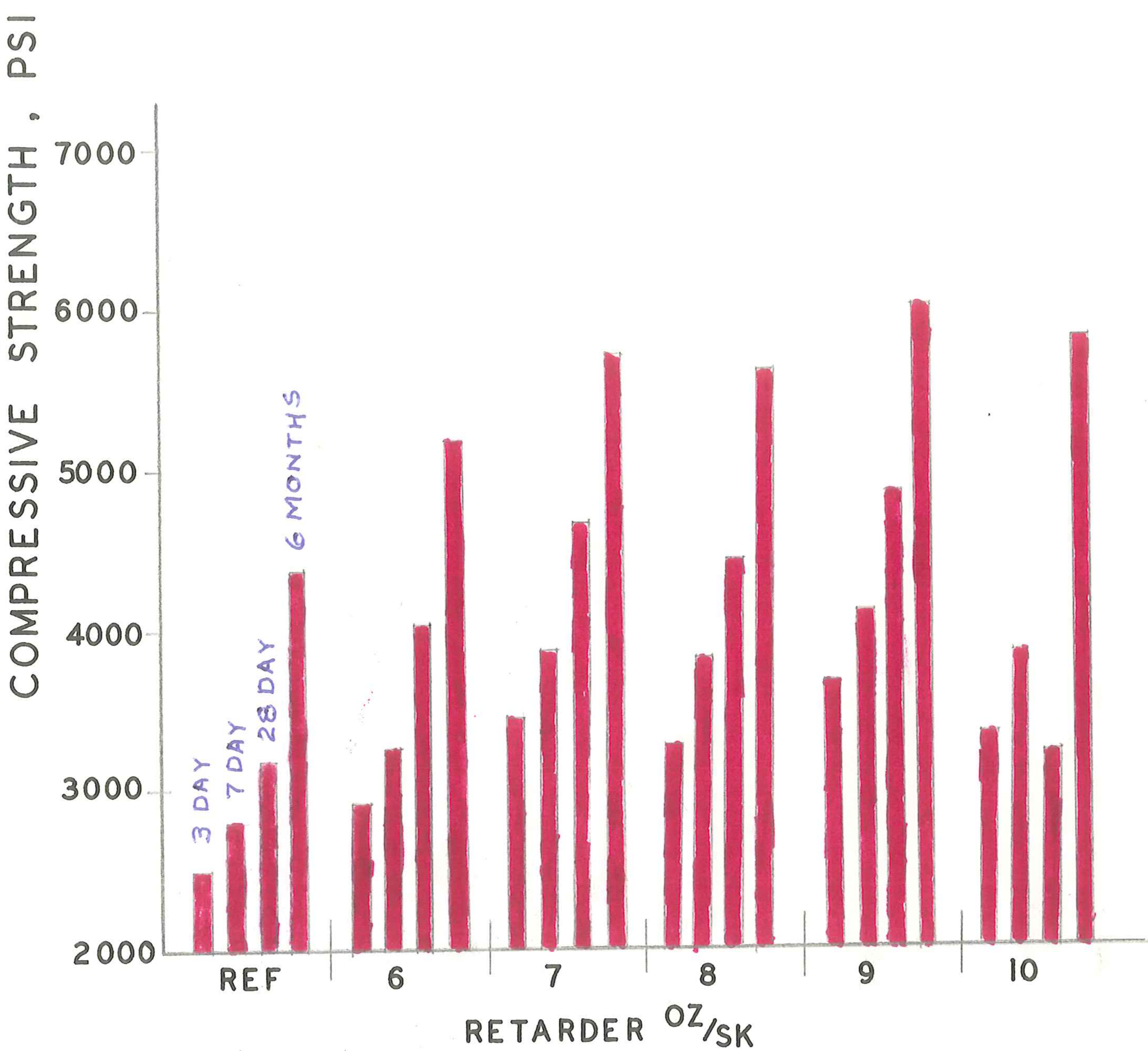
COMPRESSIVE STRENGTH-TEST A

FIGURE V



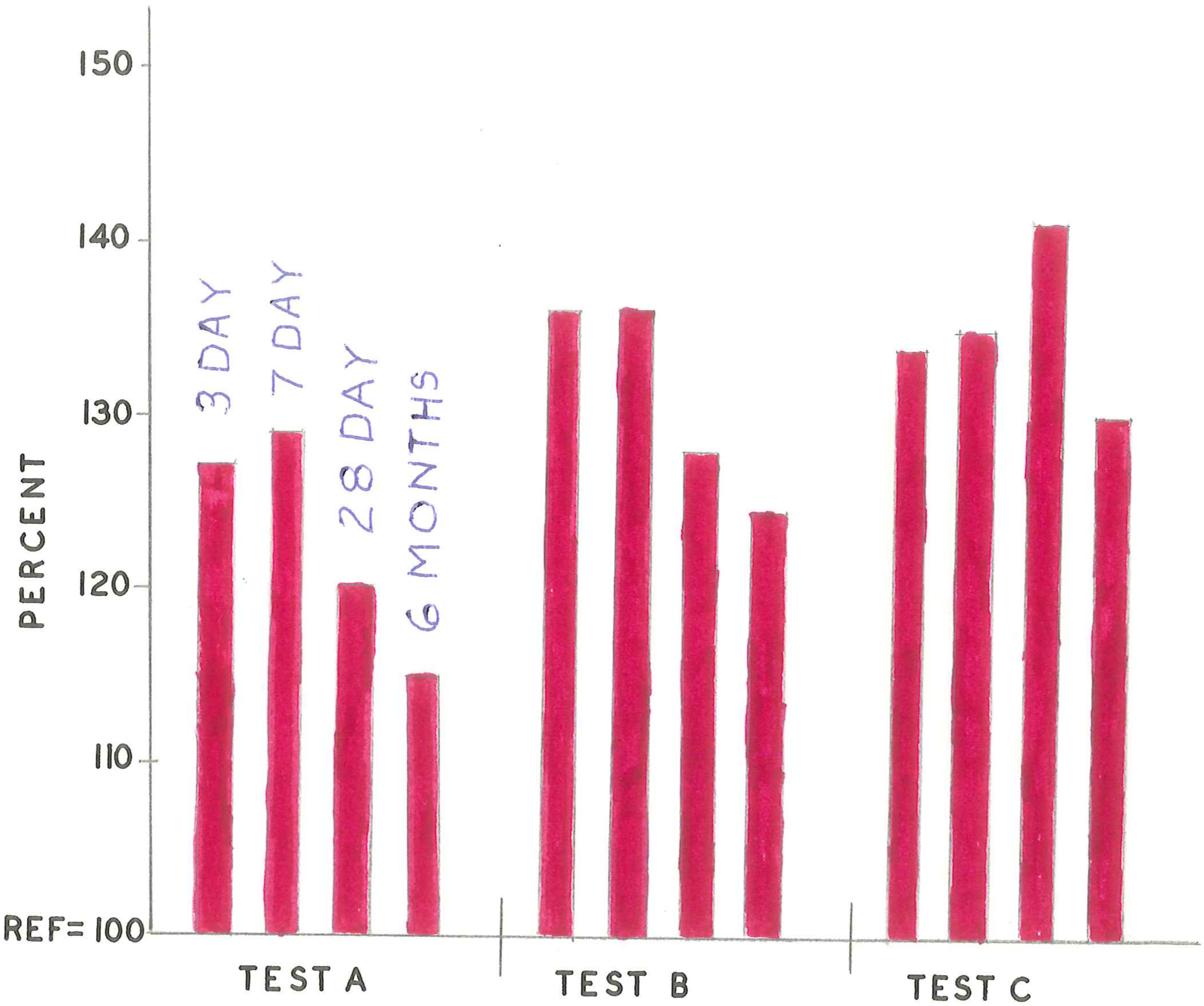
COMPRESSIVE STRENGTH - TEST B

FIGURE VI



COMPRESSIVE STRENGTH - TEST C

FIGURE VII



AVERAGE PERCENT OF STRENGTH INCREASE DUE TO RETARDER

FIGURE VIII