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COMPRESSIVE TESTS OF HIGH
EARLY STRENGTH CEMENTS

THESIS FOR THE DEGREE OF M. S.

M. C. Peterson

1930

THESIS

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COMPRESSIVE TESTS OF HIGH EARLY STRENGTH CEMENTS

A Thesis Submitted to the Faculty
of
Michigan State College
of
Agriculture and Applied Science

by
M. C. Peterson

Candidate for Degree
of
Master of Science

June, 1930

THESIS

cap. 1

PREFACE

Acknowledgement is made to Professor C. L. Allen of the Department of Civil Engineering and Mr. L. J. Rothgery of the College Experiment Station for advice and kind criticism offered in developing this problem.

M.C.P.

East Lansing, June, 1930

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INTRODUCTION

In answer to a demand which has existed for several years, a number of cement manufacturers have placed on the market a new product known as high early strength cement. Although there are quite a number of different types, they are all intended to attain the same ultimate result -- namely, a concrete of early maximum strength.

The advent of these new cements has been natural and necessary. Concrete as a building material has been in use for some 20-30 years. It has of late, however, been losing favor due to its slowness in attaining maximum strength. It is not reasonable that in this day and age a building material should be used which requires a curing period of 21-28 days before it has the proper strength. To keep a thoroughfare closed whether it be a highway or a city street, for a month or thereabouts, may entail dangers and losses as well as inconvenience. Traffic is tied up as a result of such blocked streets, fire hazards are increased, and the public is greatly inconvenienced. However, not alone in

pavement work, but in construction in general, is work handicapped by the three week curing process of concrete.

Realizing this handicap and endeavoring to overcome it, the cement manufacturers have attempted for sometime to improve their product. The American Society for Testing Materials has also added an impetus by raising the minimum strength requirements as rapidly as the manufacturers have been able to meet them.

Concrete Research

The research work which has, and is still being carried on, has aided materially in increasing the knowledge of cement and its behavior in concrete. The point has finally been reached where much of the vagueness in the latter material has been clarified.

It has been found that the strength of concrete may be hastened by using any of four different methods. They are as follows:

1. Control of Water Cement Ratio
2. Slight Increase in Amount of Cement Used
3. Longer Period of Mixing
4. Special Cements

Control of Water Cement Ratio

The work of D. A. Abrams (1) with relation to the water cement ratio has been widely discussed and published and consequently is well known. It has been proved beyond a doubt that with a lower water-cement ratio, the strength of the concrete is increased. This is shown conclusively in Table 1.

It should be kept in mind, however, that the values in this table are based on a minimum temperature of 70°F and minimum time of mixing of one minute.

Increase in Amount of Cement Used

Without exception very nearly every manufacturer of Portland cement today advertises the fact that by using a small amount more than usual of that certain cement, the strength will be increased. This, of course, is nothing more than the water-cement ratio proposition, since a greater amount of cement is being used with the same portion of water. This method is used to a great extent and is finding considerable favor. There is, of course, one thing to be considered in this method, and that is the additional cost. However, neglecting the latter condition, this is applicable to any case.

Table I

BASIC STRENGTH WITH STANDARD PORTLAND CEMENTS

Refer- ence No.	Water- Cement Ratio (Gal. per sack)	Compressive Strength (cured wet until test)			Typical Mixes (Illustrating range for a particular set of (aggregates)		Cement (Bbl. per cu. yd.)
		1 da.	3 da.	7 da.	Slump (In inches)	Mix	
1	7 $\frac{1}{2}$	100	500	1100	6-7	1:2:3 $\frac{1}{2}$	1.40
2	6 $\frac{3}{4}$	230	830	1530	2-4	1:2:3 $\frac{1}{2}$	1.40
3	6	300	1000	1800	1/2	1:2:3 $\frac{1}{2}$	1.40
4	6	300	1000	1800	6-7	1:1 $\frac{1}{2}$:3	1.65
5	5 $\frac{1}{2}$	370	1230	2070	2-4	1:1 $\frac{1}{2}$:3	1.65
6	5	470	1500	2400	1/2	1:1 $\frac{1}{2}$:3	1.65
7	5	470	1500	2400	6-7	1:1:2	2.25
8	4 $\frac{1}{2}$	600	1800	2800	2-4	1:1:2	2.25
9	4	830	2130	3170	1/2	1:1:2	2.25

Longer Period of Mixing

Much work has been done concerning the effect mixing has on the strength of concrete, and it has been found that an increase of time of mixing will increase the strength. Mr. Abrams (1), who has constructed tables based on his experiments and bearing out the above statement, has found that concrete mixed two minutes is 40% stronger at 7 days than that mixed one minute using a water cement ratio of .6 to 1.1. H. H. Scofield (2) found that at the end of 28 days a dry gravel concrete had increased 300 lbs. after mixing an extra minute. Authorities are of the opinion that time of mixing has a greater effect on the early strength of concrete than on its later strength.

Special Cements

For several years now there have been available various brands of special high early strength cements. There are at present a number of manufacturers who are placing products of this kind on the market. These special cements used for the purpose of obtaining high early strength concrete are of two general types -- high alumina and special portland.

The alumina cements are more generally known as the 24 hour type, while the special portland and

those taken up in this paper, are of the 3 day cements, that is, they gain strength rapidly and at three days have attained a strength far above that reached by the ordinary portland cement in the same length of time.

Just what processes these cements are subjected to is not known. It is true in some cases, however, that they receive additional grindings than the standard portland. In other words, after the first grinding of the clinker, it is put through the kiln again and then ground in the usual manner. It may or may not be true that certain of these cements contain admixtures. However, not in all cases have the exact methods used been divulged by the manufacturers.

The costs of these special cements amount to \$1.00 to \$1.50 more per barrel than do the standard brands, or as noted in a paper entitled "High Early Strength Concrete" by Edward E. Bauer of the University of Illinois, this would amount to an extra cost of 30¢ to 45¢ per square yard of a 7 inch pavement.

PURPOSE

Although these cements have been on the market for sometime, very little is known concerning them. There are few in any long time tests available. It is because of this lack of data, especially over a period of time, that this research has been made. The writer has endeavored to find out just how a concrete containing one of these cements will hold up over a long period of time. The data in this report covers a period of 12 months.

PLAN OF INVESTIGATION

Four commercial brands of cements were used in this investigation. Of these four, one was a standard portland and the other three high early strength cements. They were all received directly from the manufacturers and therefore represented their product as marketed.

These cements and their form of designation

as used in this problem are given herewith. The first named is a standard portland cement.

- A - Alpha Cement (Alpha Portland Cement Co.)
- B - New Wyandotte Brand (Huron Portland Cement Co.)
- C - Miami (Southwestern Portland Cement Co.)
- D - Peerless-Egyptian (Peerless-Egyptian Cement Co.)

The design used for this concrete was for a strength of 3000 lbs. and a water-cement ratio of 6 gallons per cu. ft. of cement. The mix was 1:1.66:2.42 with a slump of 3" - 4". All the concrete was mixed in a 2½ cu. ft. power driven mixer, one batch being sufficient for about 40 cylinders. All materials were measured by weight and the aggregates used were dry. Approximately 700 cylinders were made. Complete design data is contained in pages 27 to 32.

The molds used were heavy paper containers 6 inches in length and 3 inches in diameter. These were placed on granite slabs while being molded, thus providing for a level surface.

Standard practice was followed in filling the molds. One-fourth of the depth was first placed, and then thoroughly rodded, after which one-half, three-quarters, and finally the entire cylinder was filled.

Each portion was rodded as soon as it was filled. The molds were removed after 24 hours and the cylinders placed in water for 3 days. This was done in order to approximate actual field conditions.

At the end of these three days all of the cylinders were removed from the water. Half of these were placed on the floor in the laboratory and allowed to stand there unmolested. The temperature of the laboratory was constant at about 70°F. The remaining cylinders were taken to the roof of the Olds Hall of Engineering where they were subjected to all weather conditions from June, 1929 to June, 1930. Table 4 contains the average weekly temperatures and precipitation for this period.

Cylinders were tested for compression at 3, 7, 14, 21 and 28 days, and then at 2 and 3 months and each succeeding 3 months for a period of one year. As each test was made, five cylinders of each cement from both the laboratory and roof storage were broken. A total of 20 cylinders were therefore tested at each of the stated intervals. The results of all these tests will be found in pages 32-42 and Tables 2 and 3 contain the final averages.

Instead of capping the cylinders with neat cement or plaster of paris, which is the customary procedure with larger cylinders, a small piece of wall-board was used. As a rule only one was necessary but both ends were capped if they were not true. This method is in accordance with the report of H. F. Gonnerman (3), who has found that commercial Beaver Board serves the purpose with but a slight variation. The machine used in testing these specimens was a 100,000 lb. Riehle electrically driven testing machine.

RESULTS

The average results of all tests are tabulated in Tables 2 and 3 and Figures 1 and 2 contain the curves for this data. A single glance at these graphs will show two significant facts; (1) That the high-early strength cements have a greater compressive strength at all ages than the standard portland; and (2) the roof specimens show a greater strength than do those which have been stored in the laboratory. It will also be noticed that all cements of either series show a fluctuating strength. Inasmuch as the writer

TABLE II

SPECIMENS STORED IN LABORATORY

Compressive Strength of One Brand Standard Portland and Three Brands High Early Strength Cements.

Average Compressive Strength # per sq. in.

All Results are Averages of 5-3x6 Cylinders.

Age at Test:	CEMENTS			
	A	B	C	D
3 days	1,530	2,300	2,400	1,980
7 "	2,450	3,650	3,810	3,030
14 "	3,130	4,680	4,280	4,010
21 "	3,170	4,940	4,560	4,670
28 "	3,950	4,160	4,440	4,490
2 months	3,090	4,210	4,380	3,950
3 "	3,975	4,790	5,110	4,710
6 "	3,460	4,740	4,740	4,580
9 "	4,140	4,895	5,760	5,500
12 "	4,140	5,040	4,925	4,875
Average	3,300	4,340	4,340	4,180
High	1,530	2,300	2,400	1,980
Low	4,140	5,040	5,760	5,500

These results plotted in Figure 2.

TABLE III

SPECIMENS STORED ON ROOF

Compressive Strength of One Brand Standard Portland and Three Brands High Early Strength Cements.

Average Compressive Strength # per sq. in.

All Results are Averages of 5-3x6 Cylinders.

Age at Test:	CEMENTS			
	A	B	C	D
3 days	1,530	2,300	2,400	1,980
7 "	2,630	3,710	3,890	3,430
14 "	3,470	4,600	4,570	4,000
21 "	3,040	4,370	4,750	3,730
28 "	2,860	3,750	4,760	4,520
2 months	3,530	5,700	4,940	4,560
3 "	5,110	5,500	5,880	5,130
6 "	4,570	4,740	5,190	4,640
9 "	5,160	5,685	5,530	5,450
12 "	4,830	5,830	5,090	5,560
Average	3,675	4,620	4,700	4,300
High	5,160	5,830	5,880	5,560
Low	1,530	2,300	2,400	1,980

These results plotted in Figure 1.

FIG. 1—SPECIMENS STORED ON ROOF

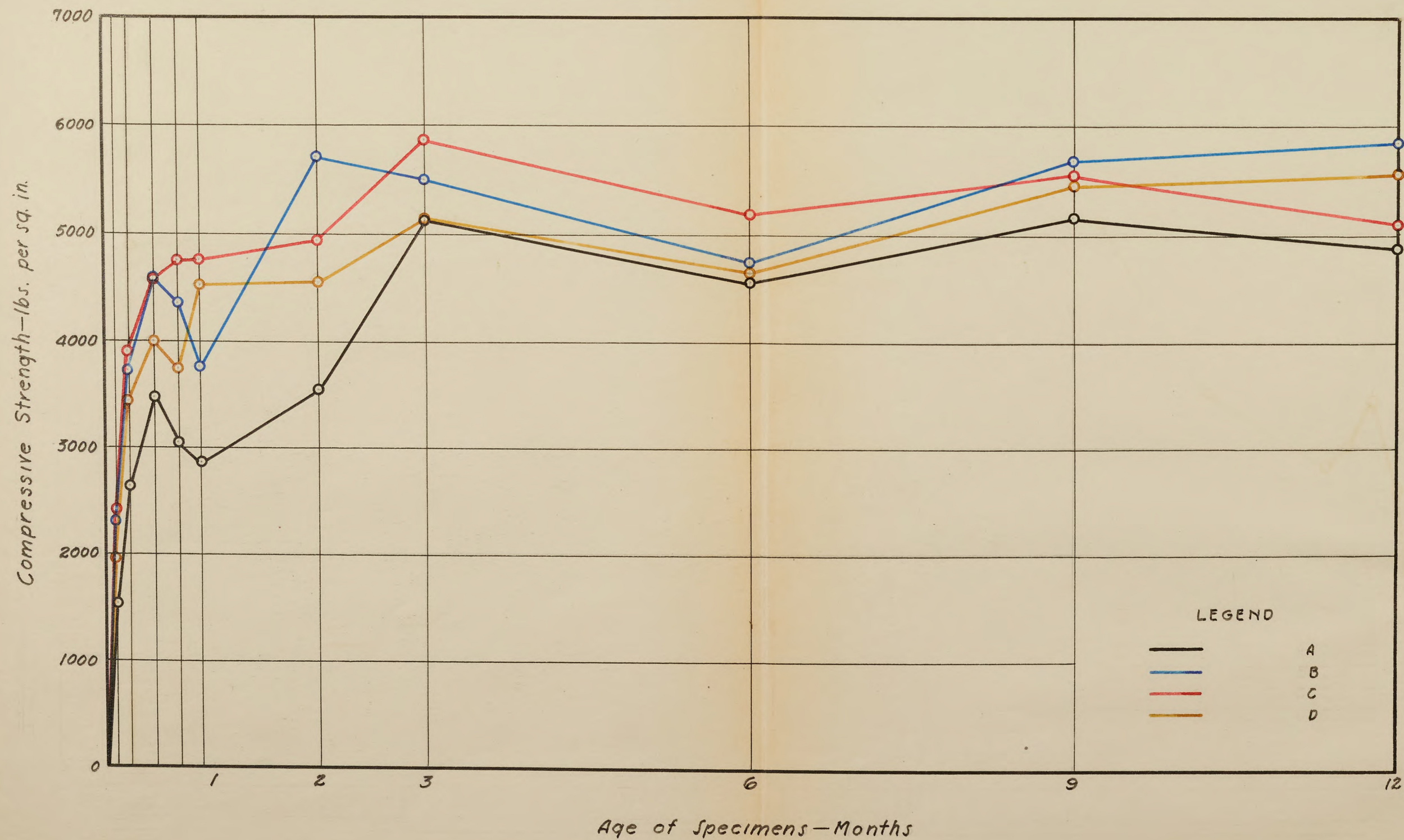
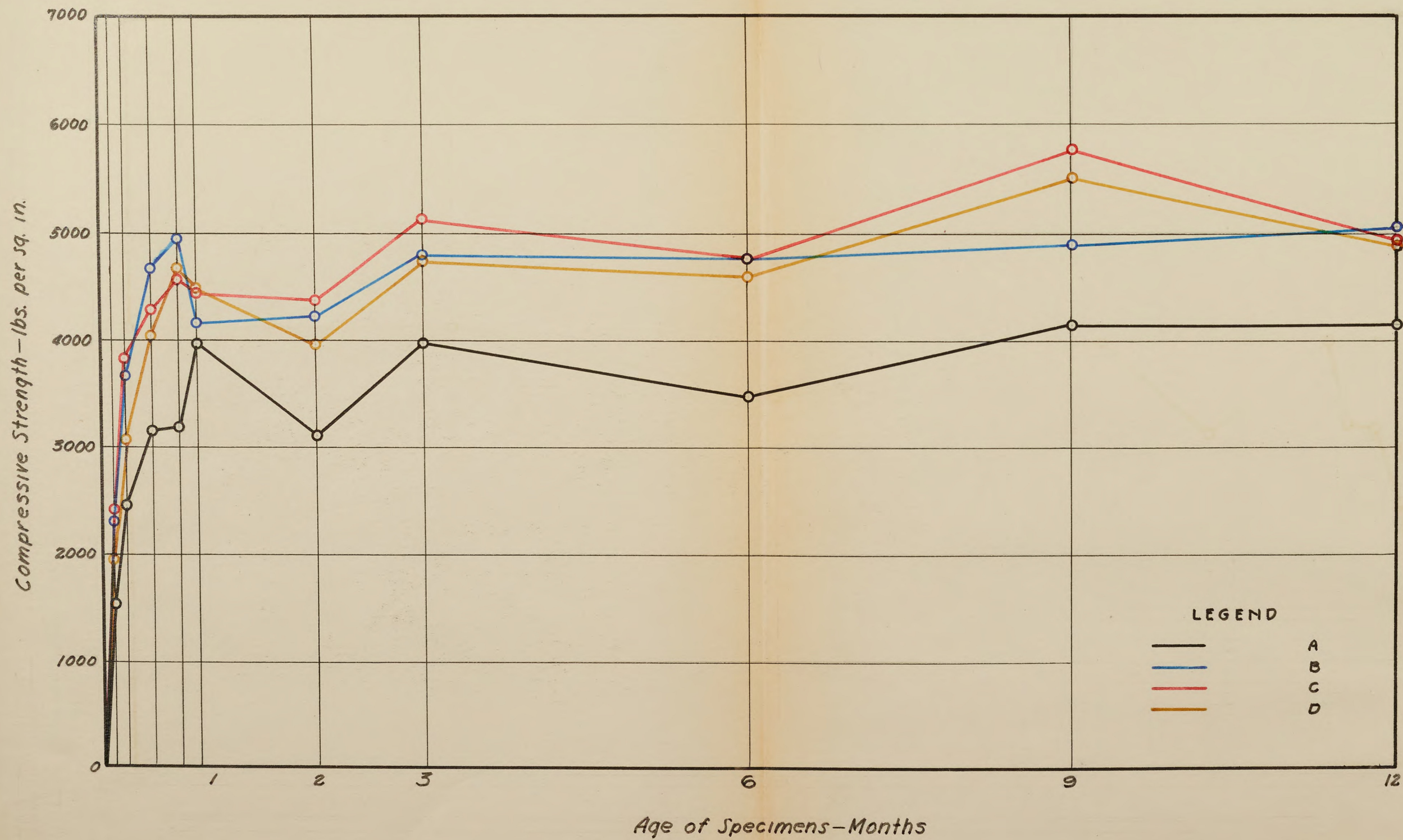


FIG. 2—SPECIMENS STORED IN LABORATORY



had no previous experience along this line, the matter was taken up with F. R. McMillan, Director of Research of the Portland Cement Association. Mr. McMillan attached no significance to the apparent retrogression inasmuch as he believed it due to a difference in moisture content and temperature at the time of the test. He stated that a difference of 20% or more may occur due to moisture content and that recently it has been observed that temperature is also a factor affecting apparent strength.

Since several tests were made shortly after a rain had fallen (a day or so), there is no question but that the roof specimens tested contained moisture. Hence the results obtained from those tests should vary, however, on the other hand, those cylinders stored in the laboratory were not subjected to the weather, and it seems strange therefore, that they should show such great variation.

It is difficult to understand just why the roof specimens should test higher than those stored in the laboratory. One might suppose that this is due to the fact that the former received a partial curing inasmuch as they were kept moist for sometime after having been placed on the roof. A glance at Table 4

FIG 3-COMPARATIVE STRENGTHS
ROOF SPECIMENS

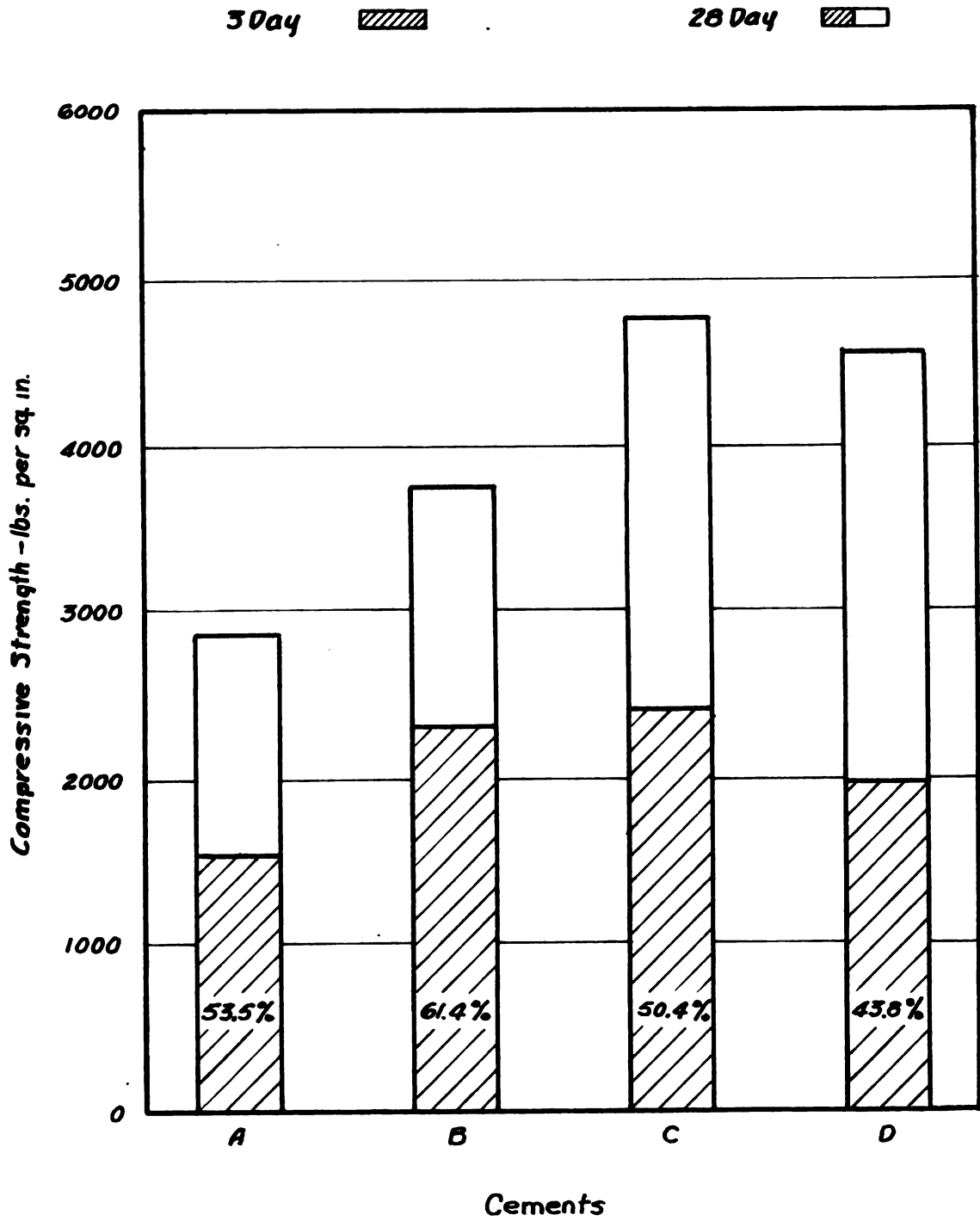


FIG 4-COMPARATIVE STRENGTHS
LABORATORY SPECIMENS

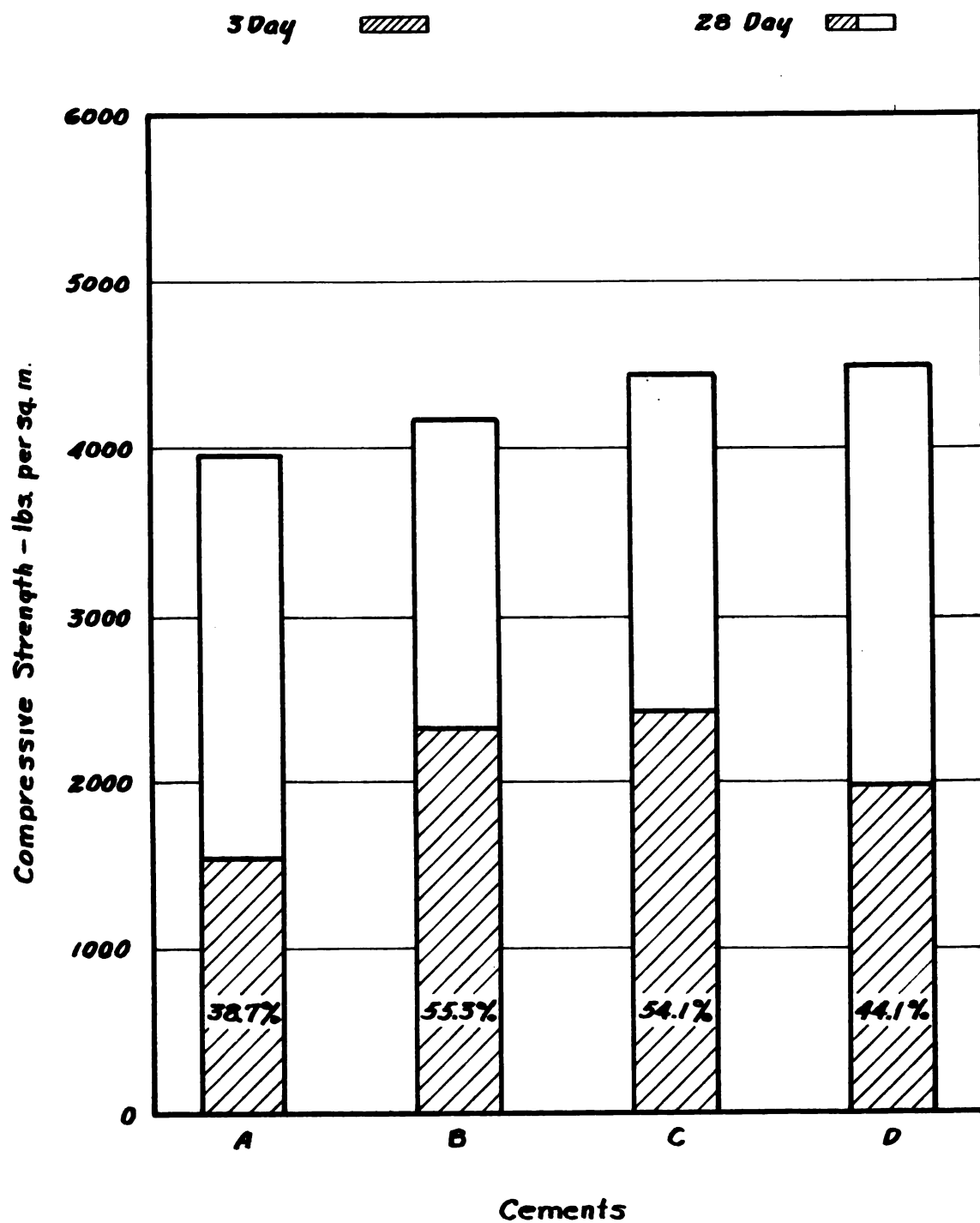


TABLE IV
AVERAGE WEEKLY TEMPERATURES AND PRECIPITATION
June 15, 1929 - June 8, 1930

<u>Week ending</u>	<u>Temperature</u>	<u>Precipitation</u>
June 15	63	.11
22	71	.01
29	63	.11
July 6	69	.08
13	71	.12
20	63	.10
28	76	.03
Aug. 3	69	.01
10	66	.01
17	66	.00
24	66	.02
31	66	.00
Sept. 7	72	.01
14	60	.04
21	51	.07
28	65	.01

TABLE IV (Continued)

<u>Week ending</u>	<u>Temperatures</u>	<u>Precipitation</u>
Oct. 5	48	.04
12	49	.05
19	51	.00
26	45	.44
Nov. 2	47	.07
9	38	.01
16	42	.09
23	27	.06
30	23	.02
Dec. 7	24	.05
14	27	.09
21	19	.26
28	24	.04
Jan. 4	29	.05
11	25	.20
18	19	.06
25	8	.03
Feb. 1	17	.02
8	25	.05
15	24	.02
22	39	.02
Mar. 1	38	.10
8	29	.01

TABLE IV (Continued)

<u>Week ending</u>	<u>Temperature</u>	<u>Precipitation</u>
Mar. 15	35	.01
22	34	.05
29	28	.13
April 5	39	.01
12	49	.03
19	46	.20
26	38	.02
May 3	57	.05
10	65	.03
17	58	.15
24	56	.19
31	46	.03
June 7	60	.01

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will show that considerable rain fell during May and June of 1929. This is evident in the case of "A", which barely reached a strength of 4000 lbs. in the laboratory series and passed that point by 1000 lbs. in the roof specimens.

In order to compare the strength at 3 days and 28 days, Figures 3 and 4 have been drawn and illustrate quite clearly the difference existing between the standard portland and the high early strength cements. Again the effects of storage are in evidence. With regard to the 3 day strength, Figure 3 shows considerable variation between all cements. However, the most significant fact is that the 3 day strengths of the high early strength cements are far in advance of the same strength for the standard portland.

The figures within the graph indicate what per cent the 3 day is of the 28 day strength. Figures 3 and 4 must again be taken separately. In the former "A" and "D" lag behind, but in Figure 3 "A" is above both "C" and "D". Both the roof and laboratory specimens show that "B" and "C" have attained 50% of their maximum strength at 3 days.

Table 5 shows the average results of all three high early strength cements as taken from Tables 2 and 3. No attempt has been made to compare these

TABLE V

AVERAGE RESULTS OF COMPRESSION TESTS
OF THREE HIGH EARLY STRENGTH CEMENTS

B - C - D

Compressive Strength # per sq. in.

Age at Test	STORAGE	
	ROOF	LABORATORY
3 days	2,227	2,227
7 "	3,677	3,497
14 "	4,390	4,323
21 "	4,283	4,723
28 "	4,343	4,363
2 months	5,067	4,147
3 "	5,503	4,870
6 "	4,857	4,687
9 "	5,555	5,335
12 "	5,493	4,947
Average	4,540	4,317
High	5,555	5,335
Low	2,227	2,227

figures with the standard portland since but one standard cement has been used, and in order that the results might be more comparable, an average of as many standard portland cements should be used.

The concrete as designed for these tests was for a strength of 3000 lbs. With the exception of the standard portland cement, this mark was passed by all cements at the end of 7 days.

It might be well to note here that of the cements used B (New Wyandotte Brand) gave the highest and most consistent results.

SPECIFICATIONS

Because of the fact that there has been no set standard for the manufacture of these special cements their quality has differed to a great extent. Therefore, the user of these cements has had no way of knowing just what results he would obtain in using them in his concrete. With no tests available and using a cement not manufactured according to any standard specifications, he has been as much at a loss as the proverbial "ship without a rudder". He has had no means of assuring himself by accepted standards that the results would be as he had anticipated.

Finally, and not without a little agitation, the long-looked-for specifications have arrived. The American Society for Testing Materials has issued its new tentative specifications for high early strength portland cement. The date of approval of these was February 18th, 1930.

The March issue of "Concrete" points out that this tentative specification makes but one change in the chemical content of the two cements, namely; high early strength and portland. They permit a maximum sulfuric anhydride (SO_3) content of 2.50 per cent in the former as compared with 2.00 per cent in standard portland cement.

The 1:3 mortar test requirements for high early strength cement are 275 lbs. per square inch in 24 hours, and 375 lbs. in 72 hours, and the 28 day strength must be at least equal to the strength at 72 hours.

These new specifications also contain the following definition for high early strength cement. High early strength portland cement is the product obtained by finely pulverizing clinker produced by calcining to incipient infusibility an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum. These specifications have been issued in printed form under serial designation

of C 74-30T.

3 Day and 7 Day Tests

Due no doubt, to the advent of high early strength cement there has been suggested a proposal to combine the 3 day mortar strength test with the 7 day test to replace the 7 day and 28 day tests now required in construction. This suggestion has come from the engineers associated with construction companies. The proposal was submitted to Committee C-1 of the American Society for Testing Materials and voted down due to the fact that such action might be a handicap to the high-silica cements which might increase more rapidly after 3 days than before. An editorial in the March issue of "Concrete" points out however, that after a few years it may be advisable to make the 3 day test a standard one and place full dependence on the 3 day and 7 day tests. It is true, of course, that much valuable time could be saved by eliminating the 28 day test, and undoubtedly 3 and 7 day tests may closely succeed the new specifications.

DISCUSSION

The writer hesitates to draw any conclusions due to two reasons; first, it does not seem that so few a number as five cylinders can be relied upon to give an accurate average; and second, the comparison of compression tests of high early strength cements with those of standard portland cement would be of more value if an average of several of the latter were used rather than just one as was done in this case.

It was necessary in many cases to discard one or two results from several tests and the averages therefore, were based on but three compression tests rather than five. Hence the result obtained was not nearly as accurate as was possible, and it seems that in order to obtain a true average, at least 8 or 10 cylinders should be tested each time.

Cements vary greatly as has been pointed out by P. H. Bates (4). He has drawn attention to the fact that in most studies of concrete, cement is not considered as a variable. However, all cements are not of the same quality since some manufacturers in endeavoring to meet the requirements of the standards of the American Society for Testing Materials, may exceed such

necessary requirements. The question arises as to whether or not there really is a standard portland cement.

Mr. Bate's report contains a table giving the compressive strengths for 3 - 7 - 28 days and 1 year of 32 brands of portland cement. It is interesting to note that the average strength of these cements at one year is 5,000 lbs., with a high of 6,190 lbs. and a low of 4,070 lbs. This variation in cements is significant as brought out in this problem.

CONCLUSION

With the above facts in mind, the following general conclusion may be drawn from the results obtained in this research:

1. The high early strength cements had a greater compressive strength at all ages than standard portland cement.
2. 3 day compressive strengths of high early strength cement were far in advance of the same strength for standard portland.
3. The compressive strength for which the concrete was designed was reached by the high early strength cements prior to 7 days.

4. Results obtained showed that storage has an effect on the strength of concrete.

DESIGN DATA

and

COMPRESSIVE STRENGTHS
of
INDIVIDUAL CYLINDERS

	SAND	C.A.
Wt. of Damp Sample	10.80	48.97
" " Dried "	10.76	48.72
" " Water in Damp Sample	.04	.25
% Moisture	.37%	.51%
Wt. of 1 cu.ft. Damp Loose	108.00	97.94
" " 1 " " Dry Rodded	113.42	108.92
" " Dry Material cu.ft. Damp Loose	107.60	97.44
" " Water	.40	.50
Bulking Factor	1.05	1.11
Fineness Modulus	2.53	6.33
Maximum Size	#8	3/4"

Strength 3000#

Slump 3"-4"

M 4.79

Real Mix - 1:3.55

Nominal - 1:409

Field Mix- 1:1.66:2.42

Bulked 1:1.74:2.69

Moisture content

Sand $1.74 \times .40 = .696\# = .083$ gal.

Stone $2.69 \times .50 = 1.345\# = .161$ "
 $\underline{.244}$ gal.

Absorption

Sand $1.74 \times 107.60 \times .01 = 1.87\# = .224$ gal.

Stone $2.69 \times 97.44 \times .01 = 2.62\# = .314$ "
 $\underline{.538}$ gal.

$$\text{Water 1 cu. ft.} = 6.00 + .538 - .244 = 6.294 \text{ gal.} = 52.55$$

$$r = \frac{M_o - M}{M_o - M_f} = \frac{6.33 - 4.79}{6.33 - 2.53} = .406 \quad \text{Mix} = 1:3.55$$

40.6% Sand

59.4% C. A.

$$.406 \times 113.42 = 46.05$$

$$.594 \times 108.92 = \frac{64.70}{110.75\#}$$

$$\text{True weight} = 127.92\#$$

$$\frac{110.75}{127.92} = .867$$

$$\frac{3.55}{.867} = .409$$

$$\text{Nominal mix.} = 1:4.09$$

$$\frac{\text{Cement}}{10} = \frac{94}{10} = 9.4\#$$

$$\text{Sand} = \frac{1.74 \times 107.60}{10} = 18.72\#$$

$$\text{C.A.} = \frac{2.69 \times 97.44}{10} = 26.21\#$$

$$\text{Water} = \frac{52.55}{10} = 5.25\#$$

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1:1.74:2.69

6 gal. H₂O

$$1 \text{ cu. ft. } @ \frac{94}{3.1 \times 62.5} = .49 \text{ cu. ft. abs. vol. cement}$$

$$1.74 \text{ cu. ft. } @ \frac{113.42}{2.65 \times 62.5} = 1.18 \text{ cu. ft. sand}$$

$$2.69 \text{ cu. ft. } @ \frac{108.92}{2.65 \times 62.5} = 1.78 \text{ cu. ft. gravel}$$

$$\frac{6.0}{7.5} = .80 \text{ cu. ft. water}$$

Total volume produced 4.25 cu. ft. per sack cement

$$\text{Cement required} - \frac{5.31}{4.25} = 1.25 \text{ cu. ft.}$$

$$\text{Sand} \quad " \quad - \quad 1.25 \times 1.74 = 2.18 \text{ cu. ft.}$$

$$\text{C. A.} \quad " \quad - \quad 1.25 \times 2.69 = 3.36 \quad " \quad "$$

$$\text{Water} \quad " \quad - \quad 1.25 \times 6 = 7.50 \text{ gal.}$$

$$\frac{1.25 \times 94}{3} = 39.17\#$$

$$\frac{2.18 \times 113.42}{3} = 82.42\#$$

$$2\frac{1}{2} \text{ gal. H}_2\text{O} = 20.87\# \quad \frac{3.36 \times 108.92}{3} = 122.00\#$$

SIEVE ANALYSIS

For Fineness Modulus

[illegible]

JUNE 11, 1929

3 Days

LAB
TOTAL LBS.

A 11,720
 11,160
 9,550
 9,440
 12,150

Avg. 10,804 1,530#/sq.in.

B 18,750
 13,250
 15,890
 17,090
 16,450

Avg. 16,286 2,300#/sq.in.

C 13,600
 18,900
 14,140
 19,560
 18,560

Avg. 16,952 2,400#/sq.in.

D 12,630
 11,890
 14,690
 15,520
 15,430

Avg. 14,032 1,980#/sq.in.

JUNE 15, 1929

7 Days

	<u>LAB</u> <u>TOTAL LBS.</u>		<u>ROOF</u> <u>TOTAL LBS.</u>
A	19,690		17,280
	17,660		17,120
	15,650		20,330
	16,180		15,990
	17,510		22,300
Avg.	17,338	2,450#/sq.in.	18,604
			2,630#/sq.in.
B	29,620		27,810
	22,420		27,605
	25,580		29,500
	29,410		24,000
	22,080		25,380
Avg.	25,822	3,650#/sq.in.	26,199
			3,710#/sq.in.
Q	26,910		29,460
	28,040		26,220
	24,370		30,000
	28,810		27,000
	26,670		24,860
Avg.	26,960	3,810#/sq.in.	27,508
			3,890#/sq.in.
D	20,790		27,000
	23,440		23,560
	21,100		21,640
	21,000		22,000
	20,640		27,140
Avg.	21,394	3,030#/sq.in.	24,268
			3,430#/sq.in.

JUNE 22, 1929

14 Days

	<u>LAB</u> <u>TOTAL LBS.</u>		<u>ROOF</u> <u>TOTAL LBS.</u>
A	16,440 23,310 19,360 23,700 26,500		25,350 24,470 23,750 26,000 23,008
Avg.	22,123 3,130#/sq.in.		24,516 3,470#/sq.in.
B	32,610 25,007 34,340 30,000 35,350		33,310 31,510 33,750 29,970 33,890
Avg.	33,075 4,680#/sq.in.		32,486 4,600#/sq.in.
C	30,000 20,850 31,190 37,690 31,570		29,000 37,810 32,000 33,810 34,410
Avg.	30,260 4,280#/sq.in.		32,305 4,570#/sq.in.
D	28,050 28,813 28,300 28,130 21,790		27,230 30,000 27,200 25,150 28,770
Avg.	28,323 4,010#/sq.in.		28,300 4,000#/sq.in.

JUNE 29, 1929

21 Days

	<u>LAB</u> <u>TOTAL LBS.</u>		<u>ROOF</u> <u>TOTAL LBS.</u>
A	20,790		22,350
	15,450		21,190
	22,840		20,000
	23,550		22,620
	14,030		21,500
Avg.	22,393	3,170#/sq.in.	21,532
			3,040#/sq.in.
B	36,330		31,860
	31,700		31,460
	34,270		28,760
	34,800		31,560
	37,080		28,880
Avg.	34,836	4,940#/sq.in.	30,910
			4,370#/sq.in.
C	35,820		34,000
	30,840		27,820
	35,000		36,340
	31,650		35,730
	27,820		28,300
Avg.	32,226	4,560#/sq.in.	33,592
			4,750#/sq.in.
D	29,900		27,560
	34,440		34,030
	35,830		27,070
	31,270		24,800
	33,810		26,110
Avg.	33,050	4,670#/sq.in.	26,385
			3,730#/sq.in.

JULY 6, 1929

28 Days

	<u>LAB</u> <u>TOTAL LBS.</u>		<u>ROOF</u> <u>TOTAL LBS.</u>
A	24,810		20,600
	28,950		21,070
	28,550		15,410
	31,890		17,250
	27,330		21,910
Avg.	28,245	3,950#/sq.in.	20,208 2,860#/sq.in.
B	34,070		32,790
	31,110		24,600
	28,180		24,480
	29,680		22,760
	28,630		27,990
Avg.	29,400	4,160#/sq.in.	26,524 3,750#/sq.in.
C	32,290		32,990
	37,890		33,040
	32,340		35,270
	29,610		34,990
	31,400		32,210
Avg.	31,410	4,440#/sq.in.	33,700 4,760#/sq. in.
D	34,660		34,370
	29,310		33,040
	30,760		28,250
	32,370		30,730
	30,030		33,050
Avg.	31,775	4,490#/sq.in.	31,888 4,520#/sq.in.

AUGUST 8, 1929

2 Months

	<u>LAB</u> <u>TOTAL LBS.</u>		<u>ROOF</u> <u>TOTAL LBS.</u>
A	21,640 58,590 20,000 20,150 23,690		27,140 20,470 22,100 54,060 25,520
Avg.	21,827	3,090#/sq.in.	24,920 3,530#/sq.in.
B	58,070 28,370 28,620 32,280 39,700		42,360 58,000 41,490 51,660 37,190
Avg.	29,757	4,210#/sq.in.	40,347 5,700#/sq.in.
C	33,890 33,620 28,770 36,590 27,490		25,140 41,860 34,300 40,370 32,770
Avg.	30,942	4,380#/sq.in.	34,868 4,940#/sq.in.
D	28,850 29,600 27,510 25,720 24,100		26,150 32,200 30,410 38,400 34,000
Avg.	27,920	3,950#/sq.in.	32,232 4,560#/sq.in.

SEPTEMBER 8, 1929

3 Months

	<u>LAB</u> <u>TOTAL LBS.</u>		<u>ROOF</u> <u>TOTAL LBS.</u>
A	14,380 29,540 25,000 21,570 29,800		27,000 34,335 36,000 17,655 38,125
Avg.	28,113	3,975#/sq.in.	36,153 5,110#/sq.in.
B	34,630 28,685 33,280 33,700 33,980		37,120 40,330 37,175 25,800 41,000
Avg.	33,898	4,790#/sq.in.	38,906 5,500#/sq.in.
C	35,470 38,000 37,220 34,940 35,050		44,000 43,130 39,300 41,500 40,000
Avg.	36,136	5,110#/sq.in.	41,586 5,880#/sq.in.
D	44,295 33,700 35,770 33,130 30,510		37,900 33,935 37,950 35,250 36,000
Avg.	33,278	4,710#/sq.in.	36,207 5,130#/sq.in.

DECEMBER 4, 1929

6 Months

	<u>LAB</u> <u>TOTAL LBS.</u>		<u>ROOF</u> <u>TOTAL LBS.</u>
A	26,040		29,430
	26,580		33,520
	24,440		33,370
	22,010		34,840
	25,040		31,600
Avg.	24,382	3,460#/sq.in.	32,347 4,570#/sq.in.
B	34,400		32,230
	30,810		36,110
	40,060		32,380
	32,630		33,230
	36,260		32,280
Avg.	33,525	4,740#/sq.in.	33,446 4,740#/sq.in.
C	31,340		38,000
	35,180		37,200
	32,190		35,000
	35,260		42,510
	42,350		31,020
Avg.	33,492	4,740#/sq.in.	36,746 5,190#/sq.in.
D	29,490		30,140
	35,680		34,000
	32,500		35,000
	36,730		33,220
	27,810		31,500
Avg.	32,442	4,580#/sq.in.	32,772 4,640#/sq.in.

MARCH 8, 1930

9 Months

	<u>LAB</u>		<u>ROOF</u>	
	<u>TOTAL LBS.</u>		<u>TOTAL LBS.</u>	
A	29,460		38,000	
	40,000		26,340	
	25,580		37,140	
	21,000		37,220	
	30,000		33,620	
Avg.	29,208	4,140#/sq.in.	36,495	5,160#/sq.in.
B	35,000		41,000	
	35,000		43,000	
	33,740		36,260	
	35,120		31,070	
	34,260		40,510	
Avg.	34,624	4,895#/sq.in.	40,192	5,685#/sq.in.
C	42,790		37,420	
	41,260		40,000	
	36,390		42,160	
	42,380		36,660	
	34,870		47,350	
Avg.	40,705	5,760#/sq.in.	39,060	5,530#/sq.in.
D	30,480		38,710	
	40,150		37,000	
	34,000		38,540	
	40,730		40,000	
	35,740		31,810	
Avg.	38,873	5,500#/sq.in.	38,562	5,450#/sq.in.

JUNE 8, 1930

12 Months

	<u>LAB</u> <u>TOTAL LBS.</u>		<u>ROOF</u> <u>TOTAL LBS.</u>
A	29,000		36,000
	27,600		33,640
	32,000		34,500
	30,440		30,770
	27,110		37,740
Avg.	29,230	4,140#/sq.in.	34,538
			4,880#/sq.in.
B	36,400		42,250
	32,000		40,470
	37,120		36,690
	37,350		37,660
	35,000		44,190
Avg.	35,574	5,040#/sq.in.	41,142
			5,830#/sq.in.
C	32,460		29,570
	42,280		42,130
	37,060		32,000
	35,080		34,290
	27,000		41,840
Avg.	34,776	4,925#/sq.in.	35,966
			5,090#/sq.in.
D	37,240		33,440
	35,310		39,600
	30,680		39,340
	35,000		44,770
	34,200		39,370
Avg.	34,486	4,875#/sq.in.	39,304
			5,560#/sq.in.

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