STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS DIVISION

INVESTIGATION OF SAND MORTAR CUBE STRENGTHS UTILIZING SANDS WITH DIFFERENT FINENESS MODULI FROM WATERFORD AND GUILDHALL

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GRAPHS

ABSTRACT

Sands play an important function in determining the characteristics of a concrete mix. Various compressive strengths have been noted when sand mortar cubes were tested. This investigation was conducted for the purpose of determining the properties of sands that influence the compressive strength.

Three factors which were believed to influence compressive strength of sand mortar cubes were chosen for study. These were the fineness modulus of the sands, the percent of material passing the 200 mesh sieve and the amount of water required to prepare a mix having a constant consistancy or flow characteristic.

The test chosen for the investigation was the "Compressive Strength of Hydraulic Cement Mortars AASHTO Designation T 106".

The tests conducted in this investigation indicate that all three factors studied influenced the compressive strengths of sand mortar cubes.

INTRODUCTION

Specifications for the sands used in the production of concrete allow a variance in the gradation within certain limits. These limits are usually established by specification which permits concrete of the desired quality to be produced.

As long as the sand being produced remains within the limits of the specification, the aggregate producer has performed his obligation. However, within these limits the characteristic of the mixes being produced will change as the sand varies from one end of the limits set by the specifications to the other. This change within the limits is generally compensated by slight adjustments made in the mix design.

This investigation was conducted with the hope of relating some of these variances to the compressive strength. If a producer can, by making slight adjustments in his sand production, produce a stronger concrete it would be very beneficial.

In this investigation three factors believed to influence the compressive strength of the mortar portion of concrete mixes were chosen for study. These factors are the variance of the fineness modulus of the sand, the percent of material passing the 200 mesh sieve and the amount of water required to create a constant flow.

The questions we were seeking answers to were as follows:

1. Does the fineness modulus effect the mortar strength?

2. Does the percent of 200's in each sand with the same fineness modulus have an effect on the mortar strength?

3. Is the amount of water required to produce a constant flow related to the percent of 200's or the fineness modulus of the sand"

MATERIALS

Product:	Manufacturer or Producer.
Cement:	Type II, Manufactured by the Glens Falls Portland Cement Company, Glens Falls, New York.
Sand:	Source 1 - Caledonia Sand, Produced by Caledonia, Inc., Waterford, Vermont.
	Source 2 - Guildhall Sand, Produced by Lawrence Sangravco, Inc., Guildhall, Vermont.
Admixtures:	Admixtures were not used in this investigation.

PROCEDURES

AASHTO T 106 is a test for the determination of the compressive strength of hydraulic cement mortars. The sand used in this test is specified as natural silica Ottawa sand. Our tests modified this requirement by using sands graded to obtain sands with fineness moduli ranging from 2.6 to 3.4. For each fineness moduli three gradations of sand were blended. The first gradation contained 1% passing the 200 sieve, the second contained 3% passing the 200 sieve and the third test contained 5% passing the 200 sieve. The sands used were from two different sources namely Caledonia, Inc., Waterford, Vermont and Lawrence Sangravco, Inc., Guildhall, Vermont.

The proportions of dry materials by weight were one part of cement to 2.75 parts of the particular sand tested. The amount of water used was the quantity necessary to produce the desired flow of 110 $\pm$ 5 as determined in accordance with section 7.3 of the specification. The quantity of water required to produce the desired flow was then recorded. As the mortars were being tested for flow a portion of the mortar mix was being tested with a chace air indicator to maintain an air content of 3 $\pm$ 1%.

Three cubes representing each mix were prepared, cured and tested for compressive strength at ages of three and seven days. After the mortar cubes were tested and the results compiled, the cubes prepared from Caledonia sand with fineness moduli between 2.60 and 3.10, were oven dried and weighed. This procedure was performed to determine if the weight of the two inch cubes could be related to their compressive strength. The weights of the two inch cubes were recorded and plotted against the respective fineness modulus. This graph represents the cubes relative densities and is shown in Appendix E.

RESULTS

The initial intent of this investigation was to test sands with fineness moduli between the range of 2.60 and 3.10, the limits allowed under Item 704.01, Fine Aggregate for Concrete - State of Vermont Department of Highways Standard Specifications for Highway and Bridge Construction, March 1976.

After the results of our tests on sands with fineness moduli between 2.60 and 3.10 were examined, this investigation was extended to include sands with fineness moduli of 3.20, 3.30 and 3.40.

The cement used to conduct the additional tests was the same type and brand used in the initial tests. However, it was believed to be from a different production lot.

The significant decrease in strengths obtained from the extended tests are believed to be the result of the change in cement and not the result of the change in fineness modulus from 3.10 to 3.20.

Our test results produced the following answers to our questions: (See Appendixes A, B, C and D)

Question No. 1 — Does the fineness modulus effect the mortar strength?

The results indicate that as the fineness modulus of the sand increased from 2.60 to 3.40, regardless of the percent of 200's contained in the sand, the compressive strength of the mortar generally increased.

Question No. 2 — Does the percent of 200's in each sand with the same fineness modulus have an effect on mortar strength?

The results indicate that as the percent of material passing the 200 sieve increased, the compressive strength of the mortars generally increased.

Question No. 3 — Is the amount of water required to produce a constant flow related to the percent of 200's or the fineness modulus of the sand?

The results indicate that the percent of 200's had little effect upon the total water requirement of a sand for any given fineness modulus. The greatest effect appeared to be a function of the fineness modulus itself. As the fineness modulus increased the amount of water required to produce the desired flow decreased.

Appendix E is a graph relating the fineness modulus to the dried mortar cube weights. This relationship indicates that as the fineness modulus and the percent of 200's increased the density of the mortar increases. Therefore, the strength of the mortar appears to increase as the density increases.

The air content of the mortar mixes was checked by the use of a Chace Air indicator. The percent of air remained within the valve of 3% $\pm$ 1. The slight variances in the percent of air in the mortar did not appear to be influenced by changes in the fineness modulus or the percent of material passing the 200 sieve. The slight variances in the percent of air did not appear to have any noticable effect upon our strength results.

CONCLUSIONS

The results obtained from this investigation indicate that the fineness modulus of a sand does influence the compressive strength of the mortar. As the fineness modulus increases, gains in the compressive strength were generally obtained.

Within any particular fineness modulus the percent of material passing the 200 sieve also influence the compressive strength. As the percent of 200 material increases from one to five percent, gains in the compressive strength were generally obtained.

The increases in compressive strength are probably related to two factors, the decreased amount of water required to obtain a given flow with sands having a high fineness modulus and the increase in density obtained with higher concentration of fines.

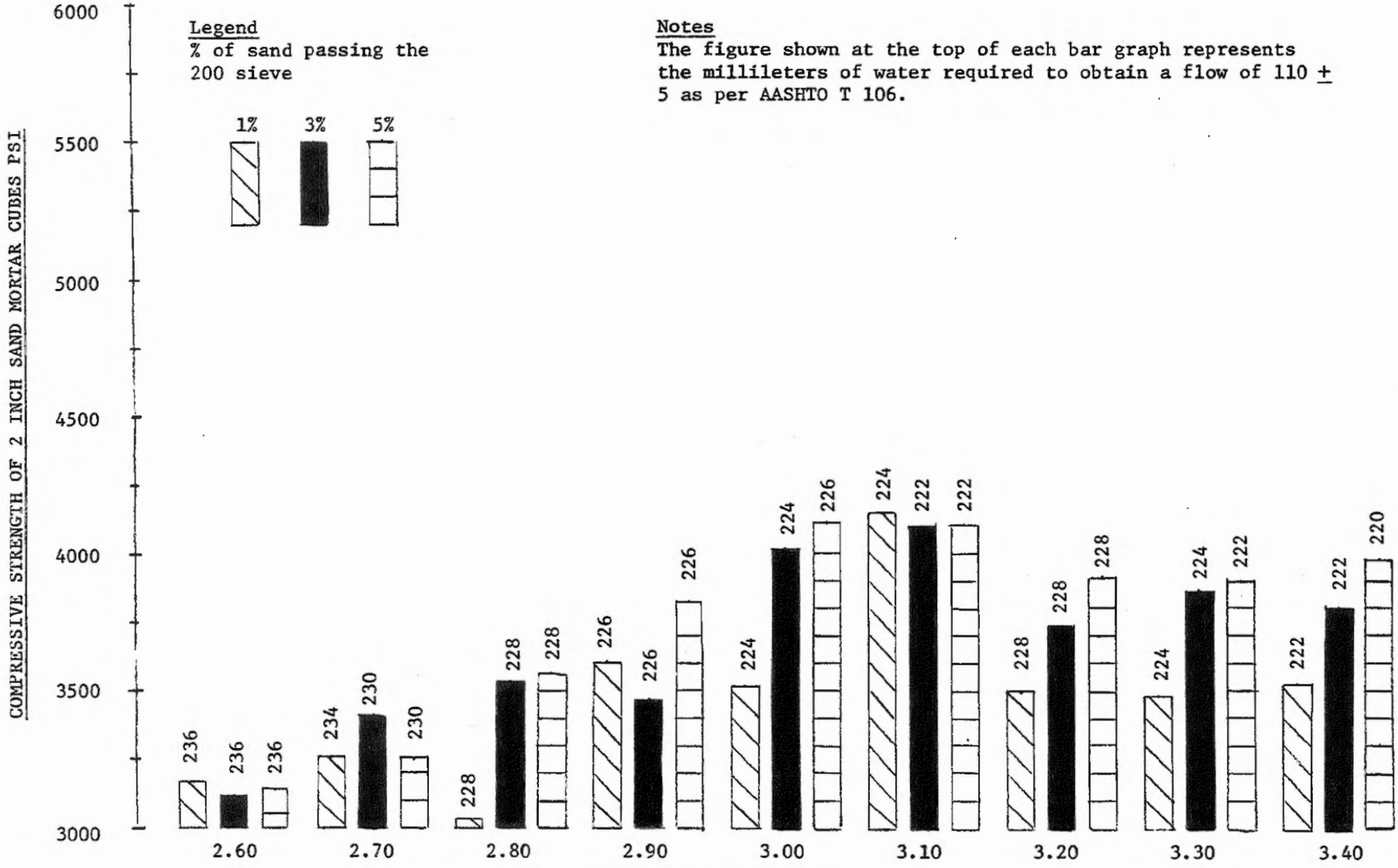
This investigation also shows that cement may play an important role in determining the compressive strength of mortar. The decrease in strengths obtained between the 3.10 sands and the 3.20 sands apparently demonstrates that the overall compressive strength dropped when cement from a different mill production sequence was used.

It is important that the conclusions obtained in this investigation be used with caution. The effects of excessive 200 material is controlled by specifications and for good reasons. AASHTO M-6 sets the maximum permissible limit at 5%. This is to limit the amount of deleterious material and control the amount of clay type particles in the 200's. Perhaps it is more important to control the type of 200 material than it is to limit the total percent passing the sieve. This would require a more detailed investigation.

Another important fact to remember in reviewing our results is that excessively high fineness modulus produce a harshness in a mix. The strength of a mix may be increased but the harshness of the mix may create problems in finishing.

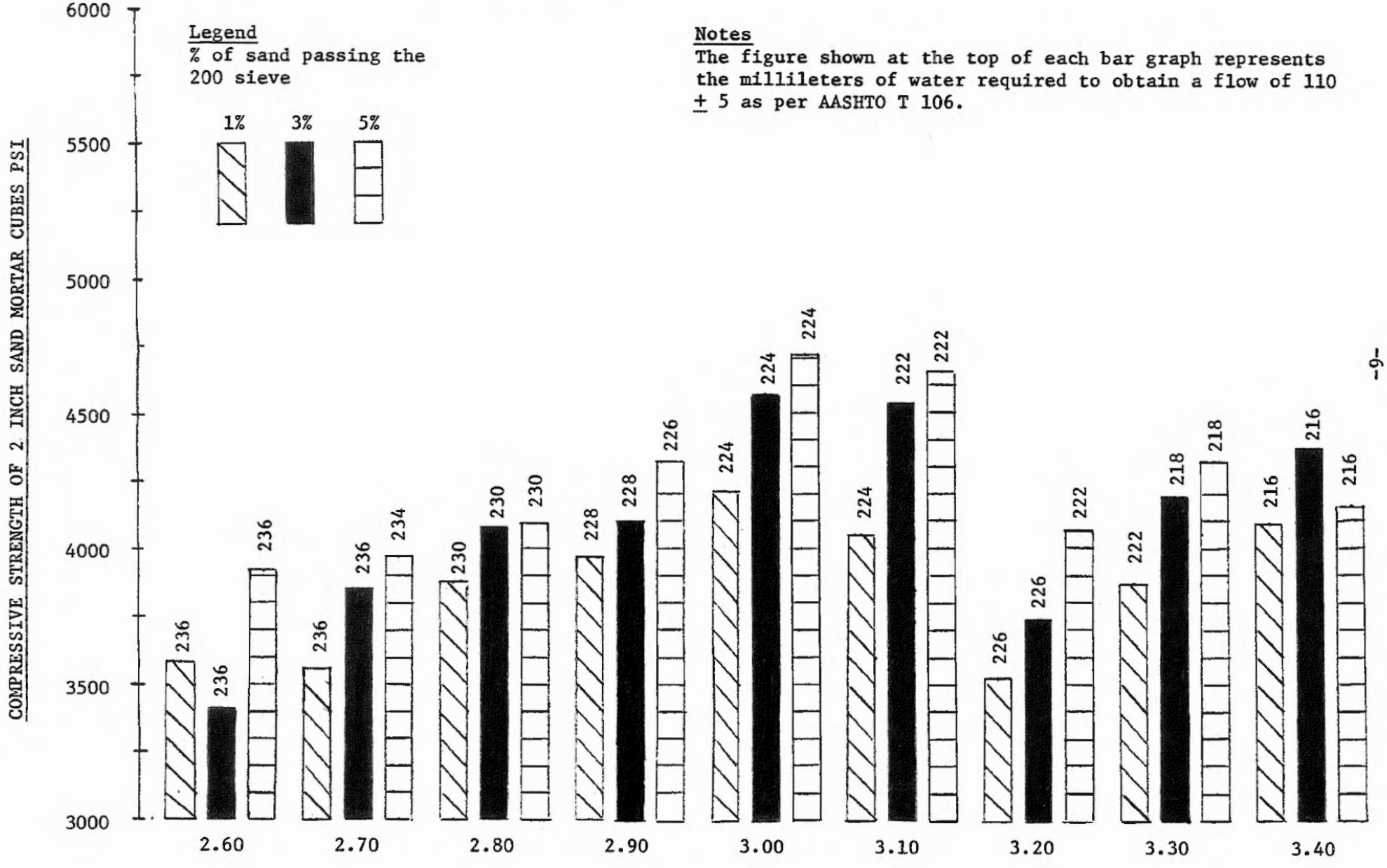
The knowledge obtained in this investigation is valuable as long as the mix being produced does not possess undesirable characteristics. The information may be used to alter sand production to obtain strength increases if the alterations do not produce other undesirable side effects.

3 DAY BREAKS OF 2 INCH MORTAR CUBES USING CALEDONIA SAND



Appendix A

3 DAY BREAKS OF 2 INCH MORTAR CUBES USING GUILDHALL SAND

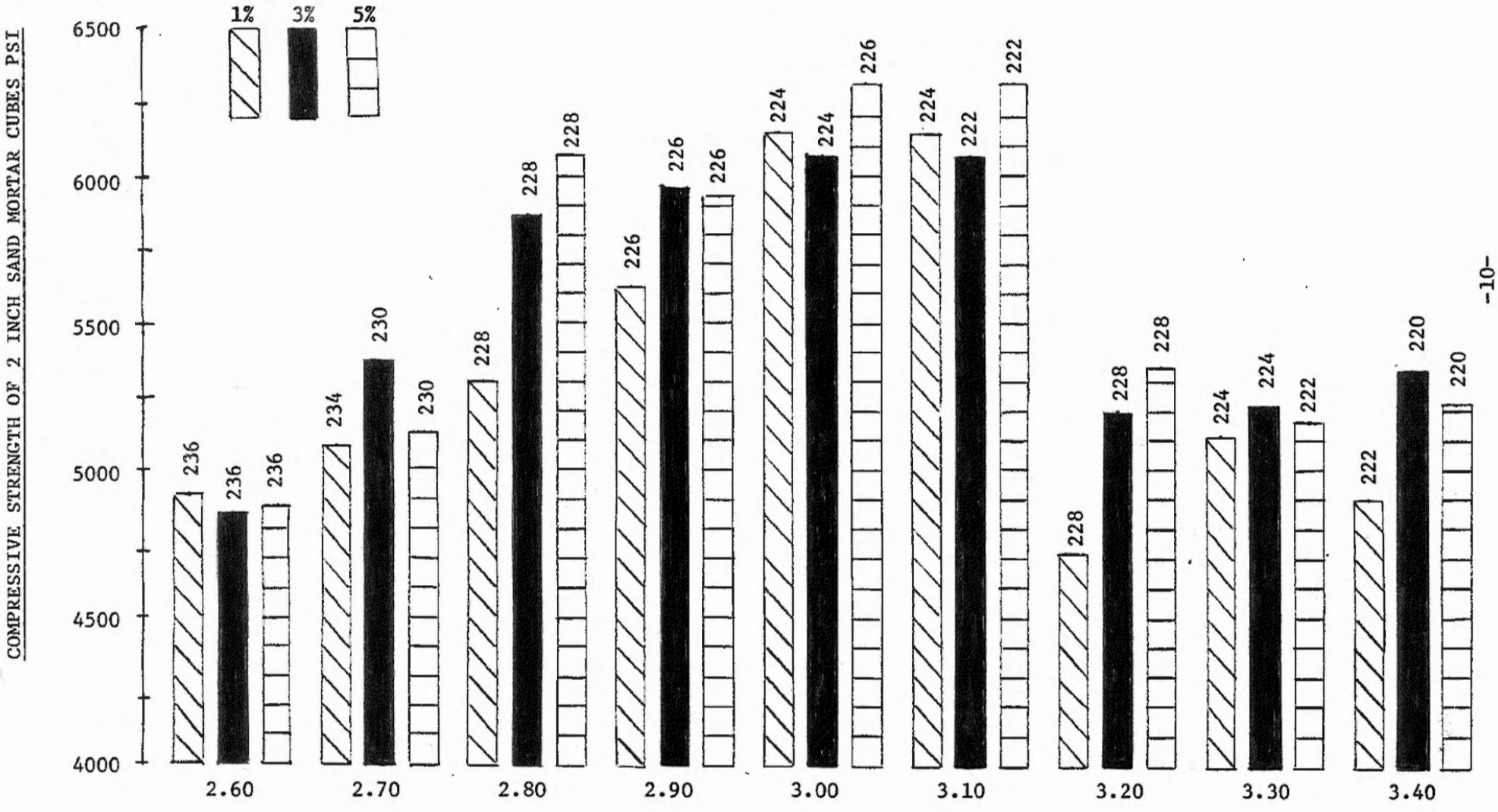


Appendix B

7 DAY BREAKS OF 2 INCH MORTAR CUBES USING CALEDONIA SAND

Legend
% of sand passing the 200 sieve

Notes
The figure shown at the top of each bar graph represents the millileters of water required to obtain a flow of 110 ± 5 as per AASHTO T 106.

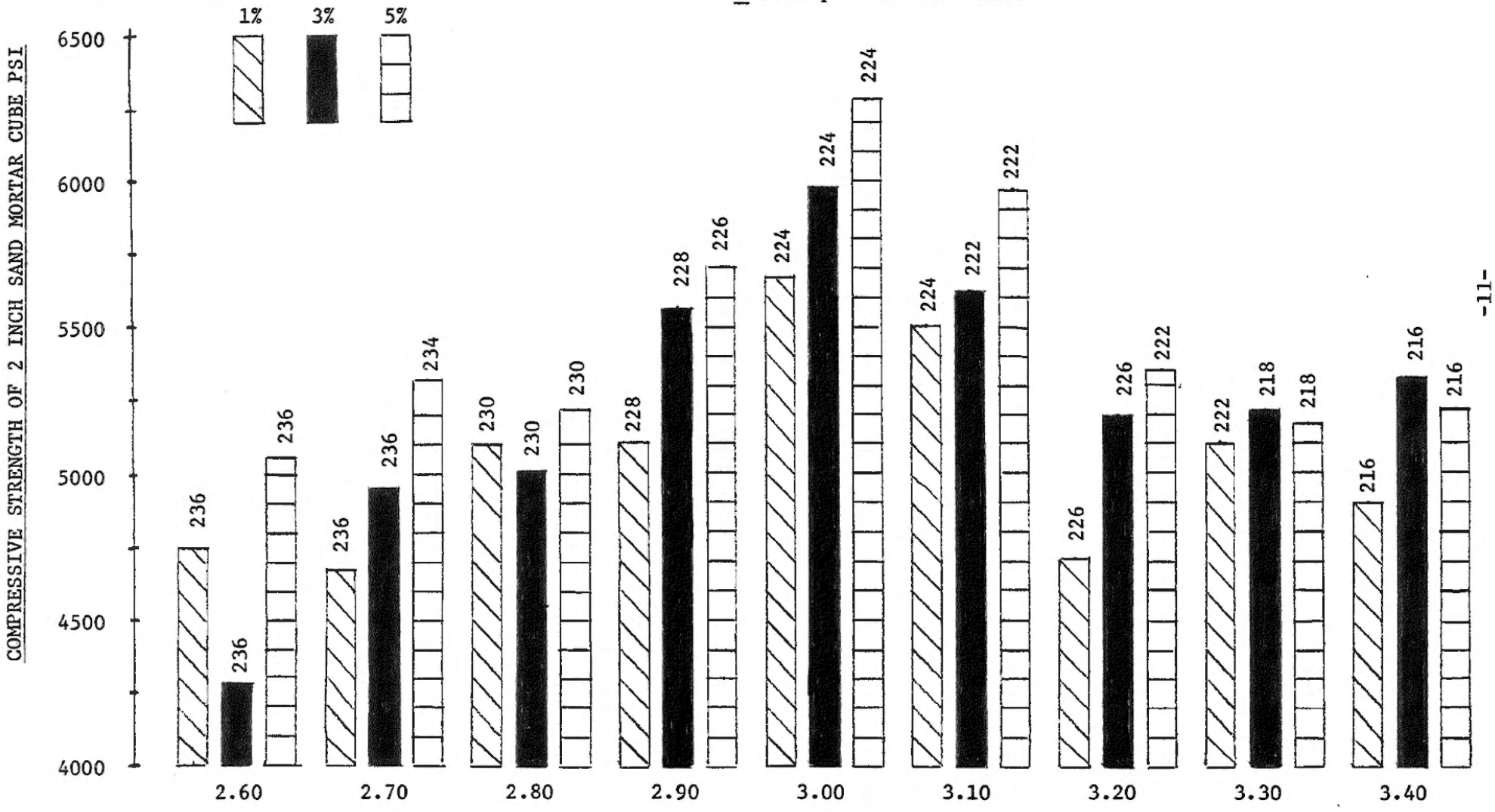


Appendix C

7 DAY BREAKS OF 2 INCH MORTAR CUBES USING GUILDHALL SAND

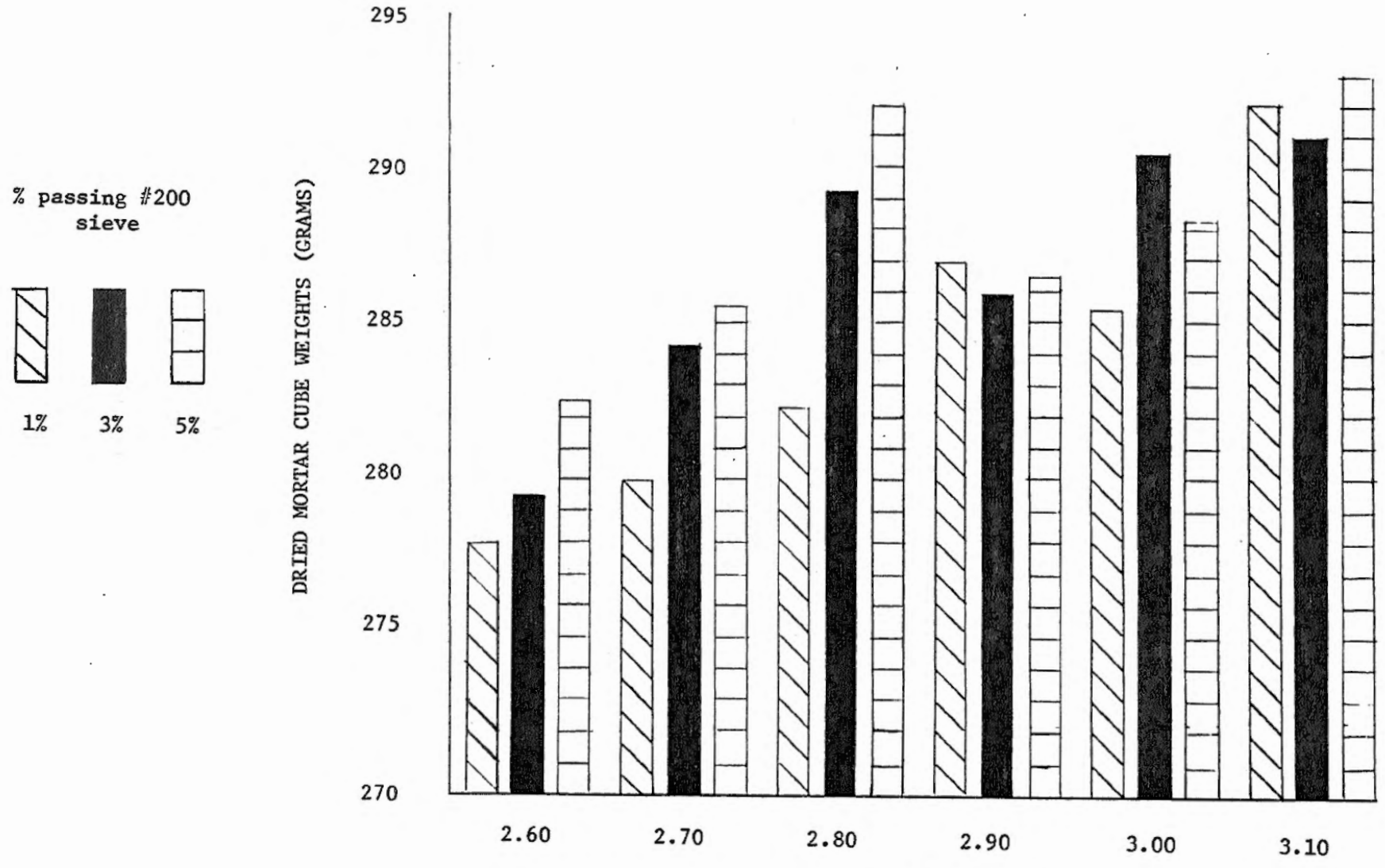
Legend
% of sand passing the 200 sieve

Notes
The figure shown at the top of each bar graph represents the millileters of water required to obtain a flow of 110 ± 5 as per AASHTO T 106.



FINENESS MODULUS OF SAND

Appendix D



CALEDONIA SAND RELATIVE DENSITY

Appendix E

#8		9		11		13		15		17		19
#16		31		33		35		37		39		41
#30		54		56		58		60		62		64
#50		76		78		80		82		84		86
#100		90		92		94		96		98		100
#200		2.60		2.70		2.80		2.90		3.00		3.10

2.60

8	5	6	7	8	9
16	28	29	29	30	31
30	53	53	54	54	54
50	76	76	76	76	76
100	98	96	94	92	90
	2.60	2.60	2.60	2.60	2.60

2.80

8	11	12	13	14	15
16	33	34	35	36	37
30	58	58	58	58	58
50	80	80	80	80	80
100	98	96	94	92	90
	2.80	2.80	2.80	2.80	2.80

2.70

8	8	9	10	11	12
16	31	31	32	33	34
30	55	56	56	56	56
50	78	78	78	78	78
100	98	96	94	92	90
	2.70	2.70	2.70	2.70	2.70

3.00

8	17	18	19	20	21
16	39	40	41	41	42
30	62	62	62	63	63
50	84	84	84	84	84
100	98	96	94	92	90
	3.00	3.00	3.00	3.00	3.00

2.90

8	14	15	16	17	18
16	36	37	38	38	39
30	60	60	60	61	61
50	82	82	82	82	82
100	98	96	94	92	90
	2.90	2.90	2.90	2.90	2.90

3.10

	1%		3%		5%
8	20	21	22	23	23
16	42	43	43	44	44
30	64	64	65	65	66
50	86	86	86	86	87
100	98	96	94	92	90
	3.10	3.10	3.10	3.10	3.10

3.20

8	21	22	22	23	24
16	46	47	48	48	48
30	67	67	68	69	70
50	88	88	88	88	88
100	98	96	94	92	90

3.30

8	24	25	26	27	29
16	48	48	48	49	49
30	71	72	73	73	74
50	89	89	89	89	88
100	98	96	94	92	90

3.40

	↓		↑		↓
8	27	29	31	33	37
16	50	50	50	50	50
30	75	75	75	75	75
50	90	90	90	90	88
100	98	96	94	92	90