THESIS

TESTS OF CEMENT

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T E S T S O F C E M E N T.

By

G. N. CARDOZO and A. C. DODGE.

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TESTS OF CEMENT.

The object of this set of tests was primarily to determine the effect, if any, of the repeated application of loads -- well within the ultimate breaking limit -- on cement briquetts, and incidentally to determine the effect of saturation with water on the strength of briquetts and cubes.

The briquetts used in these tests were of the standard shape with the smallest cross sectional area equal one (1) inch. The cubes were three (3) inches on a side.

The moulds used for the briquetts were the regular cast iron moulds used by the department, each mould holding six (6) briquetts. For the cubes, a special mould was constructed. The sides and ends were of cast iron, and at intervals of three (3) inches vertical slots were cut in each side into which sheet steel squares three (3) inches on a side and three-sixteenths (3/16) inches thick were inserted, thus forming eight cubes in the mould. One side was screwed on with but one screw at one end and was held with an ordinary wooden clamp at the other, thus allowing for the easy removal of the cement blocks.

Two different brands of cement were used (Atlas and Aetna). The Aetna being a local cement manufactured at Fenton, Michigan, and the Atlas a well known standard brand. We found little or no difference in the quality

of these cements throughout the test.

There were two (2) mixtures of each cement tested, viz. a one-to-three (1 to 3) and a neat mixture. The cement in every case was sifted through a hundred (100) gauze sieve, and the proportions of water and sand were made by weight. The sand used was the standard crushed quartz testing sand, and was sifted through a number twenty (2) sieve.

The machine constructed for applying the intermittant load consisted essentially of a lever to which at one end was attached a counter weight and a clamp for holding a briquette, while on the other a load was applied by means of tension in a spring balance. This load was made intermittant through the revolution of a shaft to the end of which an arm was fastened at a right angle. A stud was screwed into this arm and the balance hooked into a groove in this stud. When the arm was in a vertical position upward, the load was due simply to the weight of the balance and the longer arm of the lever; this load was accounted for by the counter weight on the other end making the actual strain on the briquette equal to zero (0). As the shaft revolved, the load began at once to be applied, reaching a maximum after a revolution through one hundred and eighty (180) degrees, and then decreasing to zero (0) on the completion of the turn. The shaft made thirty-eight (38) revolutions per minute, thus making a corresponding number of load ap-

plications in the same time. A counter was attached to record the revolutions. For details see drawing. For other tensile tests, a regular standard Fairbanks shot machine was used.

The intermittant loads applied were determined by means of the spring balance at the point of application of the load, and as a check, readings of load at beginning and end of test were taken by means of spring balance put in place of the briquette. As the ratio of lever arms was four and seven-tenths (4.7) to one (1), multiplying the balance reading at the point of application by four and seven tenths (4.7) gave the load on the briquette. This computed load on the briquette never differed from the load as actually measured with the balance in place of the briquette by more than two (2) or three (3) pounds.

The first briquette placed in the machine was put in wet and given a load of one hundred and twenty pounds (120 lbs.), breaking on the first application. Accordingly the second briquette was given a load of fifty-eight (58) pounds, which was thought to be about half its ultimate strength. After five thousand revolutions the briquette, having apparently suffered no change, was taken out and broken on the Fairbanks machine. The breaking load was one hundred and eighty-two (182) pounds. The briquette had apparently grown stronger. Another briquette was accordingly taken from the water and tested

on the Fairbanks maching, breaking at one hundred and thirty one (131) pounds. The intermittant load was now made eighty-seven (87) pounds and fifty thousand (50,000) applications were given. During the application of this load the machine was shut down twice owing to the closing of the shop for the night. After fifty thousand (50,000) applications, the briquette being apparently uninjured, it was broken on the Fairbanks machine. Its ultimate was found to be two hundred and ninety-two (292) pounds. The apparent difference in strength between the briquettes after leaving the machine as compared with the strength on being placed in the machine led to the conclusion that either the intermittant load or the evaporation of the water which the briquette had absorbed strengthened it. As the first conclusion seems manifestly absurd, the second must account for the increase in strength. Accordingly a series of tests was undertaken to verify this conclusion, and, as far as we were able to determine with a limited number of briquettes, there is a variation of about twenty-five (25) per cent in strength between wet and dry one(1) to three (3) cement mixtures. The neat cement mixtures apparently suffered no change in strength whether wet or dry. This leads to the conclusion that for masonry work using cement mortar or for concrete work which is exposed under water, the tensile or compressive strength of the concrete and of the joints of masonry would be greatly increased if faced over with

a thin coat of neat cement. After this investigation, all briquettes were dried before placing them in the intermittant load machine. For results of these tests see table II.

Owing to the high tensile stress shown by the neat cement and to the weakness of the springs used in the construction of the spring balance, it was impossible to make tests for fatigue with neat cement briquettes. The tests for fatigue show that for loads that are less than eighty (80) or ninety (90) per cent of the ultimate strength the number of applications required for breaking is comparatively large. At about ninety (90) per cent of the final stress, there is a rather sudden weakening of the briquettes and only a few applications of the load are required. For results of the fatigue tests see table I.

The compression test was conducted on the large Tinius Olsen machine. The cubes were placed between two cast iron surface plates in order that they might have a perfectly smooth bearing. Owing to the fact that the breaking strength of most of the neat cement cubes was greater than the capacity of the machine, we were able to break but one neat cube, this breaking at a pressure of fifty-one thousand, four hundred (51,400) pounds. The one (1) to three (3) cubes were broken both saturated and dry. For results of these tests see table III.

Briefly, the conclusions arrived at by these tests were, 1st, that cement suffers little from repeated applications of load until about ninety (90) per cent of its breaking load is reached, and that the saturation of one (1) to three (3) cement mixtures with water weakens them about twenty-five (25) to thirty (30) per cent, while saturation of neat cement has no effect after setting.

TABLE I.

No.	Max. Stress.	Min. Stress.	No. of applications of load.	Ultimate Strength.	Age.	Character of Briquette.
1	58#	0	5,000	132#	28 da.	1 to 3 Aetna.
2	87#	0	50,000	292#	30 "	1 to 3 "
3	110#	0	25,000	210"	31 "	1 to 3 "
4	160#	0	10,000	214#	28 "	1 to 3 Atlas.
5	175#	2	10,000	222#	28 "	1 to 3 "
6	185#	4	141		30 "	1 to 3 Aetna.
+7	188#	0	6,000		30 "	1 to 3 Atlas.
8	185#	0	152		32 "	1 to 3 "
9	190#	0	130		31 "	1 to 3 "
10	195#	0	75		31 "	1 to 3 Aetna.

+ Counter stopped on this one and consequently the number of applications was computed from time. This seems also to be an exception to the general run of results.

TABLE II.

Average age 32 days.

1 to 3.			Neat.		
No.	dry.	wet.	No.	dry.	wet.
1	310#	194#	1	650#	533#
2	253#	214#	2	545#	550#
3	222#	192#	3	578#	536#
4	265#	194#	4	510#	620#
5	187#	145#	5	412#	490#
6	200#	154#	6	651	
7	238#	153#	Average	557.5#	545#
8	240#	153#			
Av.	239⅜#	166⅝#			

The wet is equal to 71% of the dry in strength for 1 to 3 mixtures.

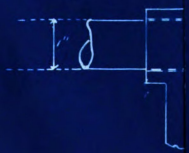
The wet is equal to the dry for neat mixtures.

TABLE III.

3" cubes, average age 36 days.

	1 to 3.		Neat.
No.	Wet.	Dry.	
1	8,000#	11,800#	51,400#
2	8,250#	9,150#	
3	7,000#	11,150#	
Av.	7,750	10,700.	

The wet is equal to 72% of the dry in strength for 1 to 3 mixtures.



INTERMITTANT LOAD MACHINE for TESTING CEMENT

ved by G.N.CARDOZO & A.C. DODGE