THE BEHAVIOR OF ADMIXTURES OF
PORTLAND AND LUMNITE CEMENTS

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The Behavior of Admixtures of
Portland and Lumnite Cements

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OUTLINE OF THESIS

1. Characteristics of Lumnite Cement as Determined by Investigations Up to Date.

2. Compression Tests on Concrete Cylinders.

3. Compression Tests Made on 1:3 Standard Ottawa Sand Mortar.

4. Conclusions.

1. Characteristics of Lumnite Cement as Determined by Investigations Up to Date.

The Atlas Cement Co. has, during the last year, placed upon the American cement market an American made alumina cement. This cement has the trade name "Atlas Lumnite Cement". Alumina cements are a mixture of aluminous and calcareous materials which have been intimately mixed, heated to a fusion, and the resultant mixture ground to an impalpable flour. Portland cements are a mixture of argillaceous and calcareous materials which have been intimately mixed, burned and the resultant clinker ground to an impalpable flour to which gypsum is generally added to regulate the setting time.

Numerous tests have shown that the crushing strength of Lumnite cement concrete is higher in 24 hours than the crushing strength of Portland cement concrete in 28 days. (See "Concrete Age"-April, 1925) In general, Lumnite cement is used in the same way as Portland cement. It differs from Portland cement in some of its reactions such as rapidity of setting, most favorable curing temperature, most favorable method of curing and other items which up to the present time have not been investigated. The results of experiments upon the above mentioned characteristics of Lumnite cement concrete can be found in the Feb., March and April of 1925 and perhaps later issues of "Concrete Age", a monthly engineering magazine. Water affects its strength in the same manner as it affects the strength of Portland cement

Lumnite cement is slow setting, obtaining its initial set at about the same time as does the average Portland cement. When Lumnite cement begins to set it hardens rapidly. This allows ample time for mixing, transporting and placing it in the forms. Investigations in the country and abroad have indicated that the modulus of elasticity and the modulus of rupture to be double that of Portland cement. It has also been proven that alumina cements can be used at much lower temperatures without danger from action of frost than can Portland cements. These results have been confirmed in actual construction work.

There are two reasons why alumina cements can be used successfully in much colder weather. First, due to its rapid hardening qualities it reaches in a few hours a point beyond the danger of frost. Second, this rapid hardening, a chemical action, produces in Lumnite cement concrete considerable heat.

From what has been written thus far concerning alumina cements it can be seen that it is a desirable product. Its use is of great value where interruption of traffic and delay of construction is to be reduced to the minimum. The one drawback of Lumnite cement is its cost. At the present time(May 192[illegible]) it costs three times as much per barrel as does Portland cement.

The object of the experiments which are to follow, is to find a mixture of Portland and Lumnite cements (if any such mixture exists) that will produce a concrete which shall obtain its full strength more rapidly than Portland cement concrete does and which shall be economical for the strength it will develop. A series of tests were made on 6 5/8" long x 3 1/3" diam. concrete cylinders, and on standard 1:3 ottowa sand mortar molded in 2" cubes. The test on the concrete cylinders will be considered first. One brand of Portland cement was used in all tests requiring Portland cement.

2. Compression Tests on Concrete Cylinders.

The Aggregate used was bank-run, unwashed gravel obtained in the near vicinity of East Lansing, Mich. Only the aggregate which passed through a 3/4" screen was used. This was further screened through a 1/4" screen thus separating the aggregate into coarse aggregate (1/4" to 3/4") and fine aggregate (0 to 1/4").

Standard Sieve analysis tests using 1000 gram samples were made on both fine and coarse aggregate. The results obtained are shown in Tables 1 and 2.

All concrete mixtures used were designed according to "Bulletin 1., Structural Materials Research Laboratory", Lewis Institute, Chicago. A 1:5 mix was used for all tests. For a 1:5 mix using 0" to 3/4" aggregate, the above named bulletin recommends that a fineness modulus of 5 be used. It gave the following equation for finding the proportions of the mix:

$$p = \frac{A - B}{A - C}$$

where p = percentage of fine aggregate,

A = fineness modulus of coarse aggregate,

B = " " " total aggregate,

C = fine" " " fine aggregate.

The fine aggregate and coarse aggregate were mixed in the proportion of 2 1/4 : 2 3/4. This mixture, according to the formula, has a fineness modulus of 5.02 which is satisfactory.

Table 1.

Sieve Analysis of Fine Aggregate

Sieve Size		Percent of Sample by Weight Coarser Than a Given Sieve			
		Sample A	Sample B	Sample C	Sample D
100	mesh	97.2	96.4	97.0	96.5
48	"	87.8	86.9	88.9	87.9
28	"	56.0	56.1	57.7	56.5
14	"	39.6	38.7	39.4	38.7
8	"	19.1	19.5	19.0	18.9
4	"	28.0	3.1	2.0	2.6
3/8	inch	0.0	0.0	0.0	0.0
3/4	"	0.0	0.0	0.0	0.0
1 1/2	"	0.0 :	0.0	0.0	0.0
Fineness Modulus =		3.017	3.007	3.040	3.011

Average Fineness Modulus 3.018

Table 2.

Sieve Analysis of Coarse Aggregate

Sieve Size	Percent of Sample by Weight Coarser Than a Given Sieve			
	Sample A	Sample B	Sample C	Sample D
100 mesh	100.0	100.0	100.0	100.0
48 "	100.0	100.0	100.0	100.0
28 "	100.0	100.0	100.0	100.0
14 "	100.0	100.0	100.0	100.0
8 "	100.0	100.0	100.0	100.0
4 "	100.0	100.0	100.0	100.0
3/8 inch	70.0	68.0	69.0	74.0
3/4 "	0.0	1.0	1.0	1.0
1 1/2 "	0.0	0.0	0.0	0.0
Fineness Modulus =	6.70	6.69	6.70	6.75

Average Fineness Modulus 6.72

The procedure followed for making the concrete cylinders was as follows:- Enough fine and coarse aggregate were mixed together in the proper proportions to form one batch. The combined aggregate was measured and the proper amount of cement was added for a 1:5 mix. The volume of cement used in the first batch was weighed. This gave a definite basis for the proportioning of the Lumnite and Portland cements which were proportioned by weight. The cement and aggregate were then thoroughly mixed on a concrete floor. A cone was now formed with a crater in the center and water was poured into this center. The concrete was mixed thoroughly with a mason's trowel for about two minutes. A slump test was then made. All batches were required to have a slump of not less than 4 1/2" nor more than 5 1/2". If at the first trial the slump was found to be insufficient, more water was added to the mixture and it was remixed for about one minute. Usually, two trials were sufficient. If too large a slump was obtained, the sample was discarded. The concrete was then tamped thoroughly into the cardboard cylinders. These cylinders had both ends cut smooth and one end was capped. The uncapped end of the concrete cylinder was put on a glass plate, and the cap was removed so that this end could be made smooth. After recording the necessary data on the cylinder, they were stored away in moist air closets.

All cylinders were capped to insure even bearing in the testing machine. The capping was done with Plaster of Paris. The crushing strength of these cylinders is tabulated in Table 3.

Table 3.

Compressive Tests of Concrete

Method of Curing	Percent of Portland Cement in Admixture of Portland and Lumnite Cements	Compressive Strength lbs. per sq.in. (3 1/3" x 6 5/3" cyl.) 1 day	7 days	28 days
[illegible] days		[illegible]	[illegible]	[illegible]
moist air		2740	4000	4100
then	0.0	[illegible]	3000	[illegible]
dry air		2770	[illegible]	4000
		Av.-2710	[illegible]	[illegible]
		1740	2170	[illegible]
"	5.0	1650	2400	3020
		1610	2300	[illegible]
		1720	2290	[illegible]
		Av.-1700	[illegible]	[illegible]
		1400	1740	[illegible]
"	10.0	800	1800	3070
		780	1600	[illegible]
		[illegible]	1600	[illegible]
		Av. [illegible]	1700	[illegible]
		[illegible]	[illegible]	[illegible]
"	15.0	450"	2000	2520
		[illegible]	2400	[illegible]
		450		2500
		Av.- 500	[illegible]	[illegible]
			[illegible]	420
moist air	100.0		280	310
			[illegible]	450
			110	
			Av.-[illegible]	[illegible]
"	95.0		[illegible]	[illegible]
			210	410
			[illegible]	[illegible]
			Av.-200	425
"	90.0			450
				370
				400
				[illegible]
				Av.-[illegible]
"	85.0			510
				570
				600
				[illegible]
				Av.-600

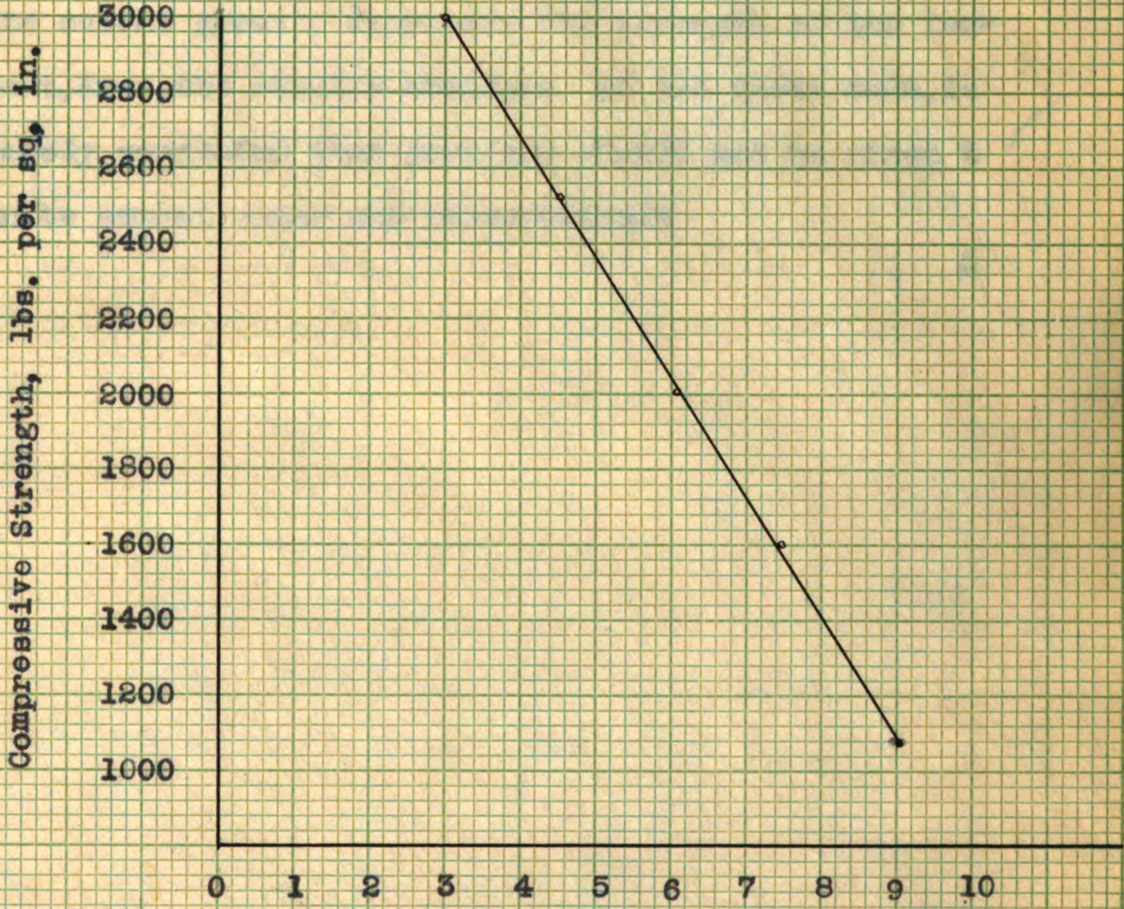
From Table 5 we note that the strength of the Portland cement is very low. At 28 days the compressive strength of the Portland cement concrete should have been not less than 2000 lbs. per sq. in. We may then safely say that the strength of the concrete is due entirely to the presence of the Lumnite cement. By means of Figure 1., we can calculate the compressive strength that the concrete would have due to the percentage of Lumnite cement only. From these values and the values in Table 5, the percent loss in strength due to a given percent of Portland cement in the admixture can be easily computed.

Figure 1., shows that the strength of a concrete varies (within certain limits) directly with the ratio of the volume of cement to the volume of aggregate. For 67% decrease in the cement ratio the graph shows a 43% decrease in the compressive strength of concrete. That is, a decrease of 1% in cement, causes a decrease of .64 % in strength. The strength of 100 % Lumnite cement concrete is known. Using this value as a basis, the strength of the other samples due to the Lumnite cement can be calculated. The difference between calculated value obtained and the value given in Table 5, is the effect produced by the given percentage of Portland cement in the admixture. No attempt will be made to draw conclusions concerning the effect of adding Lumnite Cement to Portland cement because of the low strength which the Portland cement concrete developed.

Tests made upon the time of set of admixtures of

Curve Showing Compressive Strength of Different Mixtures of Concrete

Data for Curve Taken from "Concrete Engineer's Handbook"-Hool and Johnson, Page 845



Ratio of Combined Volume, Fine and Coarse Aggregate Measured Separately.

Lumnite and Portland cements show a flash set when the percent of Portland present varies from 40 % to 60 %. An impractical working set is obtained when the percent of Portland cement varies between 40 % and 85 %.

Table 4 shows that the addition of Portland cement to Lumnite cement greatly decreases the strength of the Lumnite cement. From the results obtained of the tests made, it can be safely concluded that Portland should not be mixed with Lumnite cement under any circumstances

Table 4.

Influence on Strength of Amounts of Portland Cement in Portland-Lumnite Cement Concrete

Percent of Portland Cement in admixture of Portland and Lumnite cement	Computed strength that would occur with given quantity of Lumnite cement only			Compressive strength (lbs. per sq. in.) Note: Values taken from Table 5.			Percent decrease caused by Portland cement in mix.		
	Days			Days			Days		
	1	7	28	1	7	28	1	7	28
0.0	2710	[illegible]	[illegible]	2710	[illegible]	[illegible]	0	0	0
5.0	[illegible]	3710	3740	1170	1340	1730	[illegible]	57	26
10.0	2340	3380	[illegible]	830	1700	[illegible]	[illegible]	[illegible]	27
15.0	2450	3470	3490	[illegible]	2400	[illegible]	77	[illegible]	20

3. Compression Tests Made on 1:3 Standard Ottawa Sand Mortar.

The normal consistencies of the Portland and Lumnite cements used were obtained according to the standard methods in use by the American Society for Testing Materials. The normal consistencies of the Portland and Lumnite cements used were found to be [illegible] % and [illegible] %, respectively. 22.5 % was used as the normal consistency of the cement admixture in all cases. For 1:3 standard Ottawa sand mortar, using a cement whose normal consistency is 22.5 %, the amount of water to be used equals 10.25 % by weight of the combined of Ottawa sand and cement. (See "Concrete Engineers' Handbook"-Hool and Johnson, page 830.)

The mortar was placed and made in 2" gang molds, according to standard methods advocated by the American Society for Testing Materials.

Table [illegible] shows that as much as 15 % of Portland cement may be substituted for Lumnite cement without effecting the strength of the concrete. The values for the compressive strength of the mortar, in table [illegible], are very erratic. The results obtained in the compression tests of the concrete cylinders should carry more weight in our conclusion because they are more consistent and logical.

Table 5.

Compressive Tests on 1:3 Standard Ottawa Sand Mortar

Percent of Portland Cement in Admixture of Lumnite and Portland Cement	Compressive Strength (lbs./sq.in.) (2" cubes) 7 Days	Percent of Portland Cement in Admixture of Lumnite and Portland Cement	Compressive strength (lbs./sq.in.) (2" cubes) 7 Days
0.0	3250 2750 2500 Av.- 2830	80.0	600 1120 1120 950 Av.- 950
5.0	2500 3250 2000 Av.- 2580	85.0	770 750 700 750 Av.- 740
10.0	3250 2500 2750 Av.- 2850	90.0	750 920 7 0 1000 Av.- 850
15.0	2750 2750 3750 Av.- 3080	95.0	800 900 1000 900 Av.- 900
20.0	2250 2000 1750 Av.- 2000	100.0	1000 1120 920 1120 Av.- 1040
25.0	1750 2250 1750 Av.- 1910		

CONCLUSIONS

As a result of the tests conducted in connection with this thesis, two conclusions were arrived at:

1. Portland cement, if mixed with Lumnite cement, acts to the detriment of the Lumnite cement.

2. The behavior of Lumnite cement in compression is not very consistent.

Bibliography

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