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FINAL REPORT

LIME BENEFACTION OF AGGREGATES

Max L. Alexander

73-55

February 1973

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State of California

Business and Transportation Agency

Memorandum

To : Mr. John L. Beaton

Date: March 6, 1973

File : 762504-643122

From : Mr. George B. Sherman - Pavement
Department of Public Works—Division of Highways

Subject:

Attached is a copy of the final report for our study titled "Lime Benefaction of Aggregates." We found that the addition of as little as 1/2% lime by dry weight of the aggregate substantially improved the R-values and sand equivalent values of the ten aggregates tested. Consequently, we recommend that the Division continue to permit lime benefaction of base and subbase aggregates to comply with R-value and sand equivalent specifications. It was found, however, that the durability index test required for aggregate base material should be run on the material prior to lime treatment. We are recommending to the specifications committee that the specifications for aggregate base include the provision that the durability index test be performed on an aggregate prior to the addition of any additive.

Although the addition of lime is shown to improve the R-values and sand equivalent values of aggregates, it is important to note that previous studies have also shown that lime should not be used with aggregates which are to be cement treated. Our report on the "Effects of Hydrated Lime on Cement Treated Base From the Edgewood Quarry, San Carlos" which was attached to my letter to Allan S. Hart, November 23, 1970, indicated that lime may be detrimental to the compressive strength of cement treated base. M. Hatano's work in 1963 also shows a reduction in compressive strength when lime is added to cement treated base mixes. Not only is there the possibility of the lime having an adverse effect on compressive strength, it can also interfere with the titration test used to determine cement content.

On one recent project in District 04 (Contract No. 04-419254), the supplier for the cement treated base aggregates elected to add a small amount of lime to the aggregate in order to meet the sand equivalent requirements. Because of the difficulties noted above, a contract change order was approved to lower the sand equivalent requirement on the aggregate, provided an additional 0.5% of cement was included in the mix at the contractors expense.

Beaton 3/12

OHS 3-15

FORM H-AD 37A

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This study was completed under the general direction of Mr. Robert E. Smith, Senior Materials and Research Engineer. Mr. Randall J. Springer, Highway Engineering Technician I, performed all the tests under the supervision of Mr. Max L. Alexander, Materials and Research Engineering Associate. The estimated cost of this research is $3,500.

George B. Sherman

George B. Sherman
Assistant Materials and
Research Engineer - Pavement

RND:lb

Attachment

cc: GAHill
CCPeterson (3)
RESmith
MLAlexander
RJSpringer
M&R Library (10)
Research Coordination (Orig.)
JRCropper

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Final Report
Lime Benefaction of Aggregates
19303-762504-643122

February 1973

Introduction:

The purpose of this research project was to evaluate the effect of lime pre-treatment or benefaction on the sand equivalent and R-value tests for aggregates which are of marginal quality for use as aggregate base and subbase. Because the durability index test is a specification requirement, it was included in this program. Variations in the amount of lime, moisture content, and curing time were also studied for their effect on these tests.

Materials:

Ten aggregates, having sand equivalent and/or R-values equal to or less than current specification minimums were selected from different areas of California. Finely ground, hydrated lime conforming to the 1971 California Standard Specifications was used for treating the aggregates.

Testing:

Following routine sample preparation procedures, the materials were tested according to the following schedule:

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Testing Schedule

(1 Replica)

SAMPLE NO. (In Ascending S.E.)	Tests (As Rec'd)					R-value, SE and Durability Tests (After Lime Treatment)					
						% Lime Added		Curing Moist. Content		Loose Cure Period	
	Fine Grade	Coarse Grd.	Durability (Df)	SE	R-Value	½	1	3 %	8	1 day	7 day
1	x	x	x	x	x	x	x	x	x	x	x
2	x	x	x	x	x	x	x		x	x	
3	x	x	x	x	x	x	x	x		x	
4	x	x	x	x	x	x	x		x		x
5	x	x	x	x	x	x	x	x	x		x
6	x	x	x	x	x	x	x		x	x	
7	x	x	x	x	x	x	x	x		x	
8	x	x	x	x	x	x	x		x		x
9	x	x	x	x	x	x	x	x			x
10	x	x	x	x	x	x	x	x	x	x	x

The results of these tests are recorded in Table I.

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SAMPLE I.D.	AS REC'D GRADING		FINE DURABILITY					SAND EQUIVALENT									R VALUE								
	SIEVE		AS REC'D	1 DAY CURE		7 DAY CURE		AS REC'D	1/2 % LIME ADDED				1 % LIME ADDED				AS REC'D	1/2 % LIME ADDED				1 % LIME ADDED			
									1 DAY CURE		7 DAY CURE		1 DAY CURE		7 DAY CURE			1 DAY CURE		7 DAY CURE		1 DAY CURE		7 DAY CURE	
	#4	#200		3% SOAK	8% SOAK	3% SOAK	8% SOAK		3% SOAK	8% SOAK	3% SOAK	8% SOAK	3% SOAK	8% SOAK	3% SOAK	8% SOAK		3% SOAK	8% SOAK	3% SOAK	8% SOAK	3% SOAK	8% SOAK	3% SOAK	8% SOAK
1	52	18	25	23 1% LIME				19	22	16	19	21	22	18	22	21	28	63	54	63	51	74	67	71	68
2	100	32	25					18		19				22			44		73				81		
3	99	17	84					25	31				57				28	79				80			
4	97	16	57				35 1/2% LIME	26				33				50	65				78				78
5	49	9	33			30 1% LIME		28			41				40		62			78				83	
6	74	12	38		28 1% LIME			30		38				56			67		77				81		
7	32	4	46	30 1% LIME				31	45				69				79	84				84			
8	43	6	28				31 1% LIME	35				43				63	77				80				81
9	71	11	37			32 1% LIME		35			55				61		80			82				81	
10	40	7	55		44 1% LIME			50	62	59	62	60	63	61	63	60	82	82	81	81	81	82	81	82	81

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Conclusions:

1. Based on R-value and sand equivalent test results, the test indices of each of the ten materials studied were improved subtantially after the materials had been treated with hydrated lime. As little as 1/2% lime, by weight of the dry aggregate, substantially improved the quality of the aggregate. Increasing the amount of lime resulted in further apparent improvement within the limitations of the study.

2. The amount of water present during the loose curing period may have some affect on the reaction between the lime and the material being treated. The limited data available on Material #1 indicates that the benefaction is reduced to some degree when the treated material is cured at a high moisture content. The effect of the moisture content is decreased, however, as the amount of lime is increased. This should not be construed to imply that a further reduction in moisture content would result in additional quality improvement. The presence of water is required in the lime-soil reaction.

3. The length of loose curing time, up to 7 days, does not affect the results of either the R-value test or the sand equivalent test.

4. In each instance where the sand equivalent value was more than 5 points above the spcified minimum for a particular use, the R-value also exceeded the minimum requirements for that use. The amount of data is too limited, however, to make any broad conclusions.

5. No difficulties were encountered while performing either the R-value or sand equivalent tests. There appears to be no reason to consider procedure modifications when testing lime treated materials.

6. The durability index test should be performed only on untreated aggregates, as lime treatment results in lower test values.

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Recommendations:

1. It is recommended that lime benefaction of base and subbase aggregates to meet R-value and sand equivalent specifications be permitted. Waiving of R-value requirements for lime treated aggregates on the basis of sand equivalent test results should be verified by initial testing.

2. Due to the small percentages of lime added and the possibility of inadequate mixing, care must be exercised in sampling treated aggregates for testing. Composite sampling procedures are recommended.

3. This research indicates that lime improves aggregate quality (R-value), however, prior work has shown an adverse effect on compressive strength of cement treated bases. Lime also affects the titration test for cement content. It is, therefore, recommended that lime benefaction not be permitted for aggregates which are to be cement treated.

   In lieu of adding lime to improve borderline sand equivalent values for CTB aggregates, it is recommended that an additional 0.5 percent cement be included at the time of mixing. This provision, however, should apply only to those aggregates which meet grading and compressive strength requirements (750 psi with 5% cement) and which have sand equivalent values of not less than 15 for individual results and 17 for a moving average.

4. Further research on the effects of lime/cement combinations on the compressive strength, sand equivalent, and titration tests for CTB is recommended.

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