LIME-TREATED MINERAL AGGREGATE REDUCES MOISTURE DAMAGE IN ASPHALTIC CONCRETE PAVEMENT

DHT-35

DEPARTMENTAL RESEARCH

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16. Abstract

This report describes an economical process for admixing lime with mineral aggregates during the production of asphaltic concrete pavement. In this process, the optimum amount of lime required is added to the field sand to treat the mineral aggregates in the asphaltic concrete pavement; the field sand, in turn, carries the lime to the other mineral aggregates during the blending, mixing, and drying process.

After being treated with the lime, the field sand is placed in a stockpile and delivered to the production plant as needed. In our tests, treated field sand stockpiled for seven months showed neither evidence of recarbonization nor signs of deterioration.

Trial tests using mineral aggregates treated by this process gave excellent results, with these same untreated mineral aggregates having shown unacceptable levels of stripping damage. Finally, our cost analysis verifies that this process of lime treatment is very competitive with other methods using liquid additives.

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LIME-TREATED MINERAL AGGREGATE REDUCES MOISTURE DAMAGES IN ASPHALTIC CONCRETE PAVEMENT

Research Report DHT-35

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November 1993

LIME-TREATED MINERAL AGGREGATES REDUCE MOISTURE DAMAGE IN ASPHALTIC CONCRETE PAVEMENT

ABSTRACT

Research has shown that lime-treated mineral aggregates are effective in reducing moisture-induced damage in asphaltic concrete pavement. This report describes a lime-treatment process that is not only less expensive than the slurry mixing process normally used, but also compatible with liquid-additive and other processes.

SUMMARY

This report describes an economical process for admixing lime with mineral aggregates during the production of asphaltic concrete pavement. In this process, the optimum amount of lime required is added to the field sand to treat the mineral aggregates in the asphaltic concrete pavement; the field sand, in turn, carries the lime to the other mineral aggregates during the blending, mixing, and drying process.

After being treated with the lime, the field sand is placed in a stockpile and delivered to the production plant as needed. In our tests, treated field sand stockpiled for seven months showed neither evidence of recarbonization nor signs of deterioration.

Trial tests using mineral aggregates treated by this process gave excellent results, with these same untreated mineral aggregates having shown unacceptable levels of stripping damage. Finally, our cost analysis verifies that this process of lime treatment is very competitive with other methods using liquid additives.

INTRODUCTION

The addition of lime to mineral aggregates used in asphaltic concrete production has proven effective in reducing moisture damage. A major drawback, however, has been the substantial expense involved in the standard (lime slurry) treatment process. This report describes an alternative lime-treatment process that is effective and economically compatible with other processes used to reduce moisture damage.

In this process, a specified quantity of lime is added to the field sand to treat all of the mineral aggregates in an asphaltic mix. If the field sand is not in a moist state, water must be added during the mixing process. The treated field sand is then stockpiled and delivered to the asphaltic concrete mixing plant as needed. During asphalt concrete production, the field sand carries the lime to the other mineral aggregates.

The optimum amount of lime required to stop moisture-induced damages for each design must be predetermined by testing laboratory mixes. During production, the predetermined lime content can be obtained by controlling the amount of treated field sand added to each design. If additional field sand is needed, it can be fed through a separate feed bin.

The actual amount of lime in the treated field sand can be determined by titrating a specified sample with a standard hydrochloric acid solution. A standard titration chart is prepared by plotting the amount of hydrochloric acid that is required to neutralize the treated field sand containing various percents of lime (see test procedure below and titration charts in Table 1 and Figure 1). This same titration procedure can be used to check the active lime concentration in any stockpile (see Figure 2 and Table 3).

The cost for treating the mineral aggregates with lime by this process is compatible with other processes commonly used to reduce moisture-induced damage in asphalt concrete. According to our results, the effectiveness of the lime-treated mineral aggregates is superior to other known processes.

Table 1. Titration chart

Titration Standardization Data	
% Lime*	ml HCL**
0	0.0
3	11.3
6	23.0
12	45.1

*Admixed with 20 grams of sand

**1.000 Normal Hydrochloric Acid

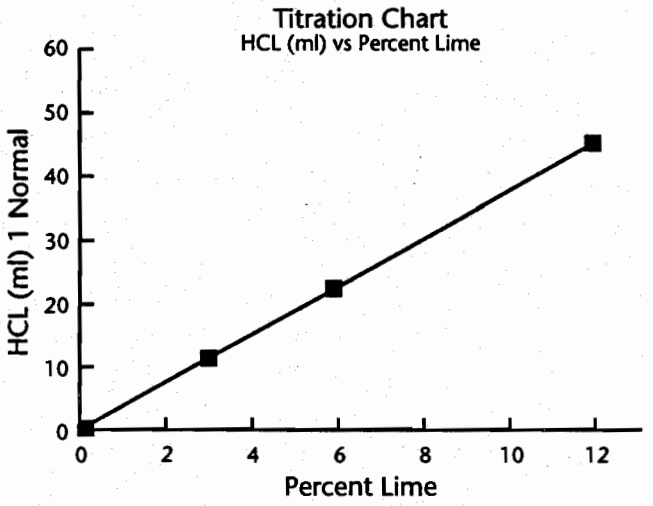


Figure 1. Titration chart showing HCL vs percent lime

DISCUSSION OF RESULTS

On November 12, 1992, four stockpiles of lime-treated field sand were prepared by pug-mixing the raw field sand with 0 percent, 1.4 percent, 5.7 percent, and 6.5 percent lime. These four stockpiles were transported to the asphalt mixing plant. Test sections of hot-mix asphaltic concrete were produced and laid on December 2, and 3, 1992, utilizing these treated field sands. The actual amount of lime used in each of these four mixes was 0 percent, 0.34 percent, 1.25 percent, and 1.43 percent of the total mineral aggregates. Another asphaltic concrete project was placed in June 1993 utilizing the treated field sand with 5.7 percent lime. This mix had a total lime content of 0.81 percent. The designs and plant mix data are seen in Table 4. As shown, Design No. 1, with the untreated field sand, failed the moisture susceptibility test. The other four designs with the treated field sand demonstrated excellent moisture susceptibility resistance.

The three stockpiles treated with lime were monitored for recarbonization and signs of deterioration for 60 days. Figure 3 shows the findings derived from test samples taken at various depths in each stockpile. After 7 months, only the surface samples show any signs of recarbonization (see Table 5).

All five HMAC designs, including the design that omitted lime-treated field sand, are performing satisfactorily. Normally, it takes 1 to 2 years before moisture damage becomes apparent with the material used in this area. Accordingly, these projects will be inspected annually for the next 5 years.

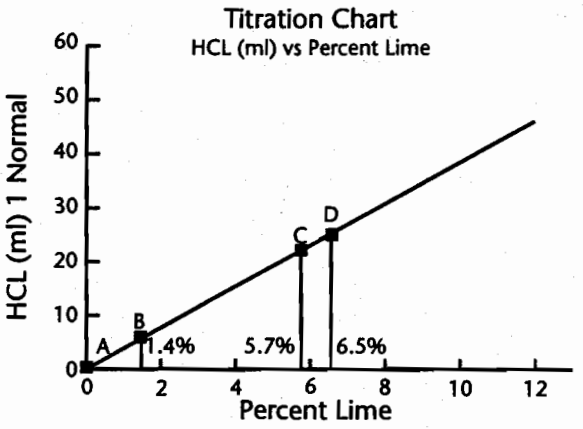


Figure 2. Active lime concentration

Table 3. Titration result

Stockpile	Design No.	HCL (ml)	Percent Lime Field Sand	Percent Lime HMAC*
A	18-92-3155	0.0	0.0	0.00
B	18-92-3174	5.0	1.4	0.34
C	18-92-3156	21.4	5.7	1.25
D	18-92-3175	24.6	6.5	1.43

*Contained 22 percent field sand

Based upon the laboratory test data, we know that 0.34 percent lime is adequate for preventing moisture-induced damages (see Table 4). The optimum amount of lime required to prevent moisture damage must be determined by laboratory tests and verified by field performance data.

Table 4. Plant mix test results

	Design No.				
	1	2	3	4	5
% Lime Gradation	0.00	0.34	1.25	1.43	0.81
+7/8"	0.0	0.0	0.0	0.0	0.0
+3/8"	18.1	18.6	24.1	22.7	31.8
+#10	52.1	51.5	57.9	59.7	65.5
+#40	66.8	65.8	70.4	71.3	79.7
+#200	97.3	97.1	96.3	96.9	96.1
% Asphalt	5.4	5.6	5.0	5.2	4.6
% Density	94.5	97.6	95.8	96.9	97.9
Tensile Strength Ratio	0.34	0.99	1.03	1.01	1.09
Hveem Stability	37	41	46	41	50

Design Nos. 1, 2, 3, and 4 were mixed and placed 3 weeks after treating the field sand with lime. Those four designs were asphalt-stabilized base designs. Date laid: December 12, 1992.

Design No. 5 was mixed and placed 7 months after treating the field sand with lime. This was a surface design. Date laid: June 23, 1993.

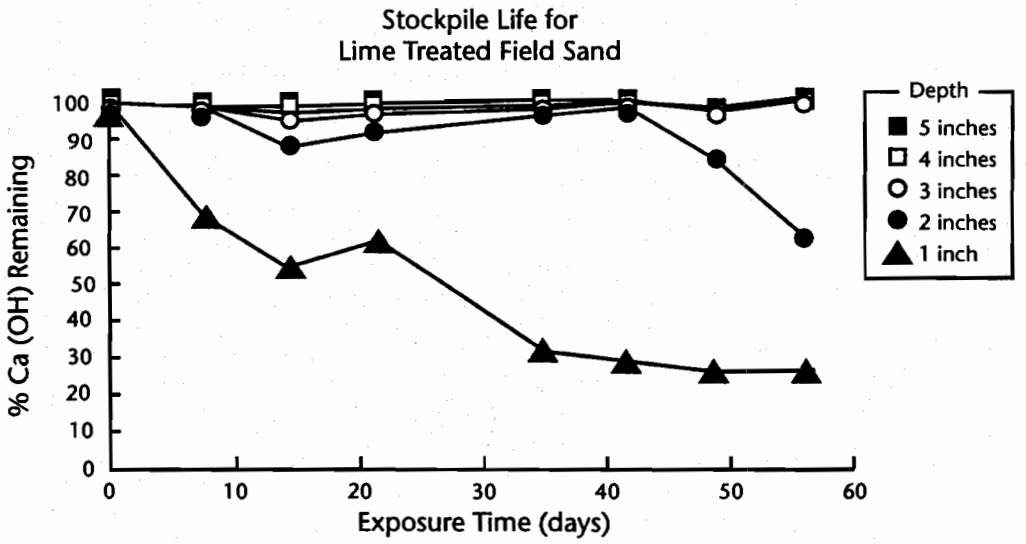


Figure 3. Stockpile life for lime-treated field sand

Table 5. Stockpile evaluation

Lime vs Acid			
Stockpile Number*	Sample Location	Hydrochloric Acid (ml)	Percent Lime
B	6 in.	5.8	1.50
B	3 ft	6.4	1.70
C	6 in.	20.0	5.20
C	3 ft	22.0	5.80
D	6 in.	27.6	7.20
D	3 ft	31.5	8.30

*Age of stockpiles: 7 months

DETERMINATION OF PERCENT LIME ADDED TO SAND

EQUIPMENT

The following equipment was used in this experiment:

(l) One 50-ml burette with stand
(2) Magnetic stirring system
(3) Four 400-ml beakers
(4) Four evaporation dishes
(5) Standard hydrochloric acid solution (approximately 1.0 normal)
(6) 1,000 grams of hydrated lime
(7) Supply of distilled or de-ionized water
(8) Standard phenolphthalein solution
(9) Stopwatch

PREPARATION OF STANDARD CALIBRATION CHART

The following describes the process used to prepare the standard calibration chart.

(1) Dry the sand to a constant weight in 140°F oven.

(2) Mix sand thoroughly.

(3) Weight out four 100 grams of sand samples. Place each sample into an evaporation dish.

(4) Add the following percents of lime to each sample: 0 percent, 3 percent, 6 percent, and 12 percent (will need more samples for higher percents of lime).

(5) Mix each sample thoroughly.

(6) Add enough distilled water to each sample to obtain a mixture near its liquid limit.

(7) Mix the water-sand mixture thoroughly.

(8) Cover each dish and allow to set undisturbed for 48 hours.

(9) Dry the sample.

(10) Thoroughly mix sample and screen over the #40 sieve. Discard the material retained on the #40 sieve.

(11) Place 20 grams of each sample into a 400-ml beaker.

(12) Add 100 ml of distilled water to each sample.

(13) Add 5 drops of phenolphthalein to each sample.

(14) Titrate each sample separately as explained in steps (14) through (17).

(15) Place sample on a mechanical magnetic stirring stand.

(16) After thoroughly mixing, titrate the purple colored solution with the standard hydrochloric acid solution until the solution remains clear for 20 seconds.

(17) Record the number of ml of hydrochloric acid required to obtain a clear solution.

(18) Prepare a standard chart by plotting the percent lime versus the ml of hydrochloric acid.

DETERMINATION OF PERCENT LIME IN SAND

(1) Obtain a lime-treated sand sample and follow steps (9) through (16).

(2) Read the percent lime corresponding to the number of ml of acid required as shown on the standard chart.

APPENDIX

DESIGN # 1

Texas Department of Transportation
District 18 Laboratory

Control:	2374-07-025	Project:	IR635-6(307)466
Item:	292 Ty B	Material:	Asph. Stab. Bas.
Highway:	IH 635	Producer:	Austin Paving
Engineer:	Jimmy Barnes	Date Sampled	12-02-92
Sampled By:	Carl D Eudy	Date Received:	12-02-92
Lab. No.:	18-92-3153	Date Reported:	12-08-92
Remarks:	Plant mix with 0% lime.		

Sieve Size	Extraction Gradation (Tex-210F)	Design Gradation	Specification
1 1/2"	0.0	0.0	0
+ 7/8"	0.0	0.0	0 - 10
+ 3/8"	18.1	26.5	15 - 45
+ #10	52.1	60.2	50 - 70
+ #40	66.8	71.0	60 - 80
#40 - #200	30.5		
- #200	2.7	2.4	0 - 8
Asphalt:	5.4 *	4.8	3.5 - 6.5

* out of the Tolerance.

Molded Sp Gr:		2.337
Theo Sp Gr(Tex-227-F):		2.473
Percent Density:		94.5
Specification:	min.	94.0
Stripping(Tex-530-C):		15 %
Specification:		N/A
Flush Point(% asphalt):		+1.0
Specification:		N/A
Hveem Stability(Tex-208-F):		37
Specification:	min.	30
TSR(Tex-531-C):		0.34
Specification:	min.	0.70

DESIGN # 2

Texas Department of Transportation
District 18 Laboratory

Control:	2374-07-025	Project:	IR635-6(307)466
Item:	292 Ty B	Material:	Asph. Stab. Bas.
Highway:	IH 635	Producer:	Austin Paving
Engineer:	Jimmy Barnes	Date Sampled	12-03-92
Sampled By:	Carl D Eudy	Date Received:	12-03-92
Lab. No.:	18-92-3172	Date Reported:	12-08-92
Remarks:	Plant mix with 0.34% lime.		

Sieve Size	Extraction Gradation (Tex-210F)	Design Gradation	Specification
1 1/2"	0.0	0.0	0
+ 7/8"	0.0	0.0	0 - 10
+ 3/8"	18.6	26.5	15 - 45
+ #10	51.5	60.2	50 - 70
+ #40	65.7	71.0	60 - 80
#40 - #200	31.5		
- #200	2.9	2.4	0 - 8
Asphalt:	5.6 *	4.8	3.5 - 6.5

* out of the Tolerance.

Molded Sp Gr:		2.368
Theo Sp Gr(Tex-227-F):		2.427
Percent Density:		97.6
Specification:	min.	94.0
Stripping(Tex-530-C):		30 %
Specification:		N/A
Flush Point(% asphalt):		+0.5
Specification:		N/A
Hveem Stability(Tex-208-F):		41
Specification:	min.	30
TSR(Tex-531-C):		0.99
Specification:	min.	0.70

DESIGN # 3

Texas Department of Transportation
District 18 Laboratory

Control:	2374-07-025	Project:	IR635-6(307)466
Item:	292 Ty B	Material:	Asph. Stab. Bas.
Highway:	IH 635	Producer:	Austin Paving
Engineer:	Jimmy Barnes	Date Sampled	12-02-92
Sampled By:	Carl D Eudy	Date Received:	12-02-92
Lab. No.:	18-92-3154	Date Reported:	12-08-92
Remarks:	Plant mix with 1.25% lime.		

Sieve Size	Extraction Gradation (Tex-210F)	Design Gradation	Specification
1 1/2"	0.0	0.0	0
+ 7/8"	0.0	0.0	0 - 10
+ 3/8"	24.1	26.5	15 - 45
+ #10	57.9	60.2	50 - 70
+ #40	70.4	71.0	60 - 80
#40 - #200	25.9		
- #200	3.7	2.4	0 - 8
Asphalt:	5.0	4.8	3.5 - 6.5

Molded Sp Gr:		2.355
Theo Sp Gr(Tex-227-F):		2.457
Percent Density:		95.8
Specification:	min.	94.0
Stripping(Tex-530-C):		25 %
Specification:		N/A
Flush Point(% asphalt):		+0.5
Specification:		N/A
Hveem Stability(Tex-208-F):		46
Specification:	min.	30
TSR(Tex-531-C):		1.03
Specification:	min.	0.70

DESIGN # 4

Texas Department of Transportation
District 18 Laboratory

Control:	2374-07-025	Project:	IR635-6(307)466
Item:	292 Ty B	Material:	Asph. Stab. Bas.
Highway:	IH 635	Producer:	Austin Paving
Engineer:	Jimmy Barnes	Date Sampled	12-03-92
Sampled By:	Carl D Eudy	Date Received:	12-03-92
Lab. No.:	18-92-3173	Date Reported:	12-08-92
Remarks:	Plant mix with 1.34% lime.		

Sieve Size	Extraction Gradation (Tex-210F)	Design Gradation	Specification
1 1/2"	0.0	0.0	0
+ 7/8"	0.0	0.0	0 - 10
+ 3/8"	22.7	26.5	15 - 45
+ #10	59.7	60.2	50 - 70
+ #40	71.3	71.0	60 - 80
#40 - #200	25.5		
- #200	3.1	2.4	0 - 8
Asphalt:	5.2	4.8	3.5 - 6.5

Molded Sp Gr:		2.401
Theo Sp Gr(Tex-227-F):		2.478
Percent Density:		96.9
Specification:	min.	94.0
Stripping(Tex-530-C):		15 %
Specification:		N/A
Flush Point(% asphalt):		+0.5
Specification:		N/A
Hveem Stability(Tex-208-F):		42
Specification:	min.	30
TSR(Tex-531-C):		1.01
Specification:	min.	0.70

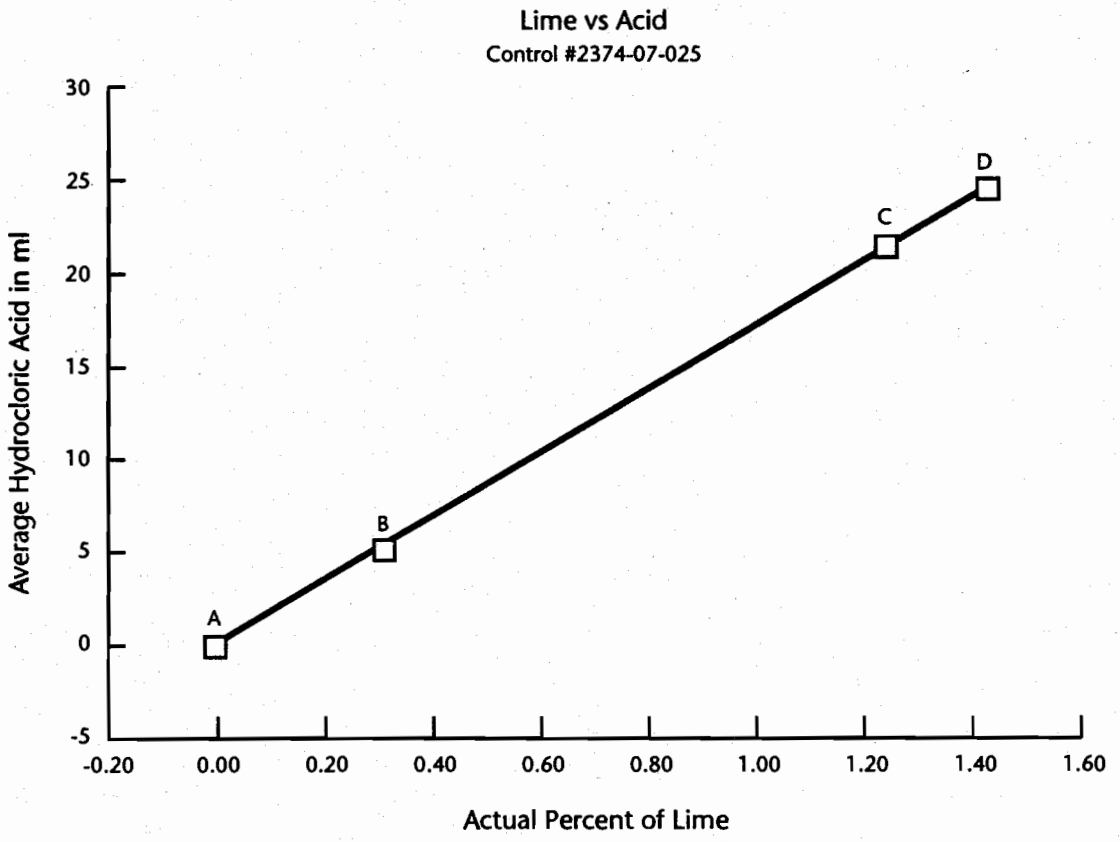
DESIGN # 5

Texas Department of Transportation
District 18 Laboratory

Control:	0009-11-136	Project:	BH93(5)
Item:	3778 Ty C	Material:	Asph Concrete
Highway:	IH 30	Producer:	Austin Bridge & Road
Engineer:	William Hale	Date Sampled	06-23-93
Sampled By:	C. Eudy\B. Bovee	Date Received:	06-23-93
Lab. No.:	18-93-1323	Date Reported:	06-28-93
Remarks:	Plant mix with 0.81% lime.		

Sieve Size	Extraction Gradation (Tex-210F)	Specification
+ 7/8"	0.0	0
+ 5/8"	3.8	0 - 5
+ 3/8"	31.8	15 - 30
+ #4	55.7	37 - 57
+ #10	65.5	60 - 70
+ #40	79.7	75 - 90
+ #80	90.3	87 - 97
+ #200	96.1	94 - 99
- #200	3.9	N/A
Asphalt:	4.6	N/A

Molded Sp Gr:	2.498
Theo Sp Gr(Tex-227-F):	2.552
Percent Density:	97.9
Specification:	94.5-97.5
Stripping(Tex-530-C):	5 %
Specification:	max. 10 %
Flush Point(% asphalt):	1.5
Specification:	N/A
Hveem Stability(Tex-208-F):	50
Specification:	min. 35
TSR(Tex-531-C):	1.09
Specification:	min. 0.70



Material: Premixed Field Sand			
Sample Number	HCL (ml)	*Lime (%)	Lab Number
A	0.0	0.00	18-92-3155
B	5.1	0.34	18-92-3174
C	21.4	1.25	18-92-3156
D	24.6	1.43	18-92-3175

* % of total mineral aggregate (22% field sand)

Titration Data Sheet for Lime Treated Field Sand Stockpile

Field Sand Stockpile Number	Design Lab Number (18-92)	* Desired Percent Lime HMAC	Titration HCL (ml)	Percent Lime Field Sand	* Actual Percent Lime HMAC
A	3155	0.0	0.0	0.0	0.00
B	3174	0.5	5.1	1.4	0.34
C	3156	1.0	21.4	5.7	1.25
D	3175	1.5	24.6	6.5	1.43

* Total mineral aggregate (22% field sand in HMAC)

Test Procedure: 20 grams field sand placed in 100 ml distilled water with 5 drops of phenolphthalein and titrated with 1.0 normal hydrochloric acid. Reading taken when solution remained clear for 20 seconds.