Technical Report Documentation Page

1. REPORT No.
CA-DOT-TL-3132-1-75-13

2. GOVERNMENT ACCESSION No.

3. RECIPIENT'S CATALOG No.

4. TITLE AND SUBTITLE
Lime Slurry in Asphalt Concrete (District 9)

5. REPORT DATE
May 1975

6. PERFORMING ORGANIZATION
19301-762504-643132

7. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT No.
CA-DOT-TL-3132-1-75-13

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Transportation Laboratory
5900 Folsom Boulevard
Sacramento, California 95819

10. WORK UNIT No.

11. CONTRACT OR GRANT No.

13. TYPE OF REPORT & PERIOD COVERED
Final

12. SPONSORING AGENCY NAME AND ADDRESS
California Department of Transportation
Division of Construction and Research
Sacramento. California 95807

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

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It was concluded that when asphalt concrete (A.C.) specimens containing a lime slurry treated aggregate were properly mixed, beneficial effects were realized. However, the method the contractor used for introducing the hydrated lime to the fine (minus #4) material on this project was very crude, and it is doubtful that the lime treatment will have any beneficial effect on the final product.

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18. No. OF PAGES:
12

19. DRI WEBSITE LINK
http://www.dot.ca.gov/hq/research/researchreports/1974-1975/75-13.pdf

20. FILE NAME
75-13.pdf

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.

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17. KEY WORDS	18. DISTRIBUTION STATEMENT
Asphalt concrete additive, lime slurry, expansion, surface abrasion loss	Unlimited 75-13

19. SECURITY CLASSIF. (OF THIS REPORT)	20. SECURITY CLASSIF. (OF THIS PAGE)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	12	

HMRT – 1242 (ORIG. 9/72)

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION AND RESEARCH
TRANSPORTATION LABORATORY

May 1975

Final Report
643132

Mr. R. J. Datel
Chief Engineer

Dear Sir:

I have approved and now submit for your information this final research project report titled:

LIME SLURRY IN ASPHALT CONCRETE
(DISTRICT 09)

Study made by . . . . Pavement Branch

Under the Supervision of . . . . George B. Sherman
John Skog

Principal Investigator . . . . Robert N. Doty

Co-Investigator . . . . James A. Cechetini

Report Prepared By . . . . James A. Cechetini

Very truly yours,

GEORGE A. HILL
Chief, Office of Transportation Laboratory

Attachment

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ACKNOWLEDGEMENTS

We wish to express our appreciation to the personnel of District 09 for their cooperation in obtaining data for this investigation.

I. INTRODUCTION

Many aggregate sources for asphalt concrete (A.C.) in and near the town of Mojave, California (District 09) are known for their poor quality. Asphalt concrete pavements constructed using aggregate from these local sources often exhibit early pavement failures. Generally, these failures include pitting and raveling.

Laboratory test data has shown that aggregates from this area not only expand excessively when exposed to moisture, but also contain a large percentage of clay or clay-like fines as evidenced by their frequent inability to meet the sand equivalent and swell tests requirements.

The Contractor on an ongoing District 09 job proposed changing the aggregate source for the asphalt concrete on his job to decrease his aggregate haul distance. However, the results of preliminary tests by the District indicated that the material from the closer source would not comply with the Swell Test requirements (Test Method No. Calif. 305). Because the Contractor still wanted to use the new source if at all possible, the Transportation Laboratory was contacted by the District regarding treatment of the aggregate to decrease the swell of the mix. Data from a previous experimental lime slurry project[1] constructed in District 02 was submitted to District 09 engineers for their consideration. They subsequently decided to permit the Contractor to use the new source if he treated the aggregate with lime to control the swell. The aggregate source used was in a troublesome area near Mojave, California. Laboratory and field data from this study are presented in this report.

II. CONCLUSIONS

From the data compiled, we conclude that:

1. X-ray defraction tests indicate that this material contains a large percentage of a type of vermiculite which is extremely expansive.

2. Laboratory tests clearly show that a hydrated lime slurry treatment has a beneficial effect on aggregate from the source that was used on this project for asphalt concrete.

3. The procedure used by the contractor to introduce the hydrated lime to the minus #4 aggregate resulted in segregation of the lime and the minus #4 material.

4. Because of the procedure used by the contractor for blending the hydrated lime with the minus #4 material, it is doubtful that the uniformity of lime treatment was good enough to result in any beneficial effect on the final product.

III. RECOMMENDATIONS

If aggregate intended for use in asphalt concrete requires lime treatment, the specifications should require that water be added to the lime to form a slurry followed by the introduction of the slurry into the aggregate. The specifications should then require that this combination of aggregate and slurry be mixed uniformly and completely prior to its introduction into the dryer. Stock-piling the treated material should be permitted but not required after this mixing operation. This procedure (without stockpiling the treated aggregate) was previously used with success in District 02 [1].

IV. DISCUSSION

A. Project Description

The project was located in Kern County on Route 58 between post miles 128.5 and 135.5. The asphalt concrete containing aggregate treated with lime slurry was used to construct a portion of the shoulders and frontage roads on contract 09-023324. Field tests, which included nuclear densities and water permeabilities, were made on the frontage road (F-13 line) from stations 38+25 to 41+25. In the same locations, cores were cut from the pavement and tests were made on the recovered asphalt from the cores. All the tests were performed on the surface course only.

B. Laboratory Test Results

Aggregate

The results of physical tests made on the aggregate used on this project are presented in the following Table 1:

TABLE 1

Aggregate Characteristics

Tests	Test Method No.	Results
X-Ray & D.T.A.	- - - - -	40-50 percent Plagroclose & Orthoclase; 20-25 percent Vermiculite*; 15-20 percent Quartz; 5 percent Pyroxine; 5 percent Olivine; less than 5 percent mixed layer Clay.
Sand Equivalent	Calif. No. 217	44 (57 with 0.5 percent Lime Slurry)
C.K.E. Test	Calif. No. 303	$K_c = 1.1$, $K_f = 1.3$, $K_m = 1.2$
Modified C.K.E. Test(2)	- - - - -	0.7 percent Absorption. (0.4 percent with 0.5 percent Lime Slurry)

*The geologist's report showed as much as 25 percent vermiculite, and it was noted that this type of vermiculite is extremely expansive. Also, it degrades into montmorillonite, an extremely expansive clay.

Asphalt Concrete

The aggregate specified for lime treatment was the minus #4 material only. The hydrated lime was introduced to the minus #4 material while the aggregate was on the conveyor belt (Figures 1 and 2). The minus #4 material containing the 0.5 percent lime was then accumulated in a stockpile, Figure 3. From this stockpile, the minus #4 material was hauled to the hot plant where it was combined with the untreated coarse aggregate.

The grading curves, stability, cohesion, specific gravity, and abrasion loss at 100°F for the laboratory mixed asphalt concrete specimens and the test results for asphalt concrete mix removed from the pavement behind the paver are presented in the following Table 2. Although the mix containing untreated aggregate complied with the swell requirements, District 09 laboratory data indicated that asphalt concrete containing the untreated aggregate from this source exceeded the specification limit of 0.030 maximum. No explanation for this inconsistency in test results is available.

TABLE 2

Asphalt Concrete Mix Characteristics

Grading Curve

	Lab	Field		Spec.
	0.5% Lime (Slurry)	No Lime	0.5% Lime (Slurry)	
3/4	100	100	100	95-100
1/2	85	85	86	
3/8	72	72	73	65-80
1/4	- -	- -	- -	- - -
4	54	56	62*	45-60
8	43	41	48*	30-45
16	28	26	33	
30	17	16	22	15-25
50	10	10	15	
100	6	6	10	
200	3	4	7	3-7
% Asph	6.0	6.0	6.0	-
Den (PCF)	142/143	140/140	141/140	-
Stab.	46/45	48/45	44/39	35
% Void	5.1/6.0	6.7/6.3	-	-
Cohes.	165/158	160/130	130/100	-
Swell	.003/.004	.003/.004	.016/.006	0.030
Surf. Abra.	37.7/24.5	81.3/59.3/60.4	47.5/44.3/60.0	-
Surf. Abra. Avg.	33.6	67.0	50.6	

*Out of Specification

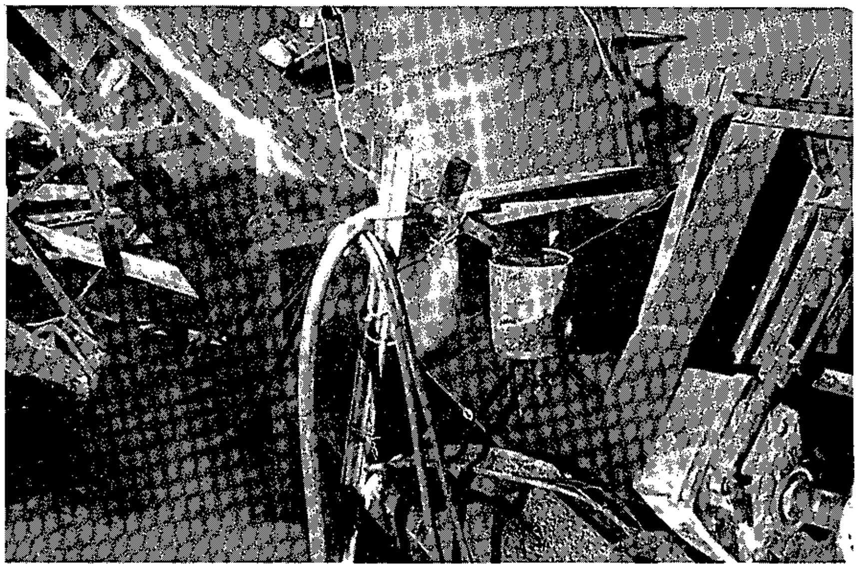

FIGURE 1
HYDRATED LIME BEING INTRODUCED

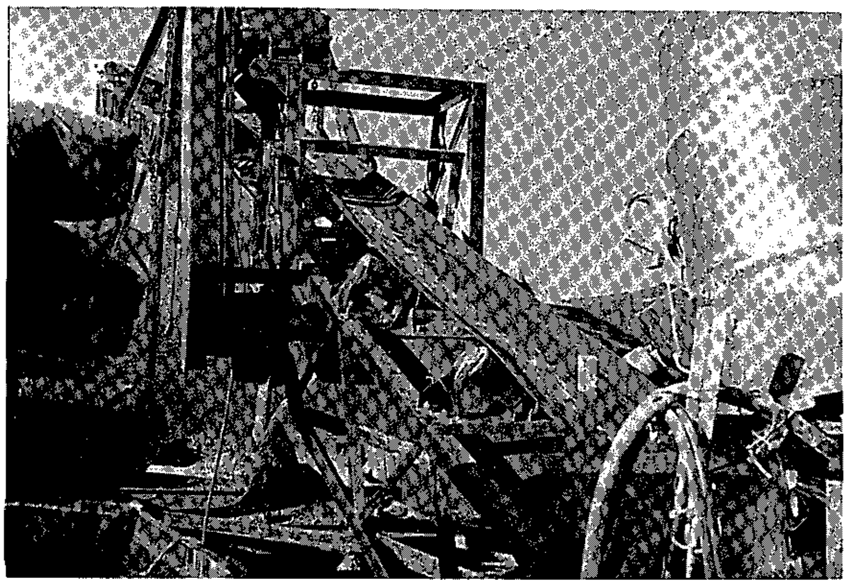

FIGURE 2
FINES WITH HYDRATED LIME ON BELT TO STOCKPILE

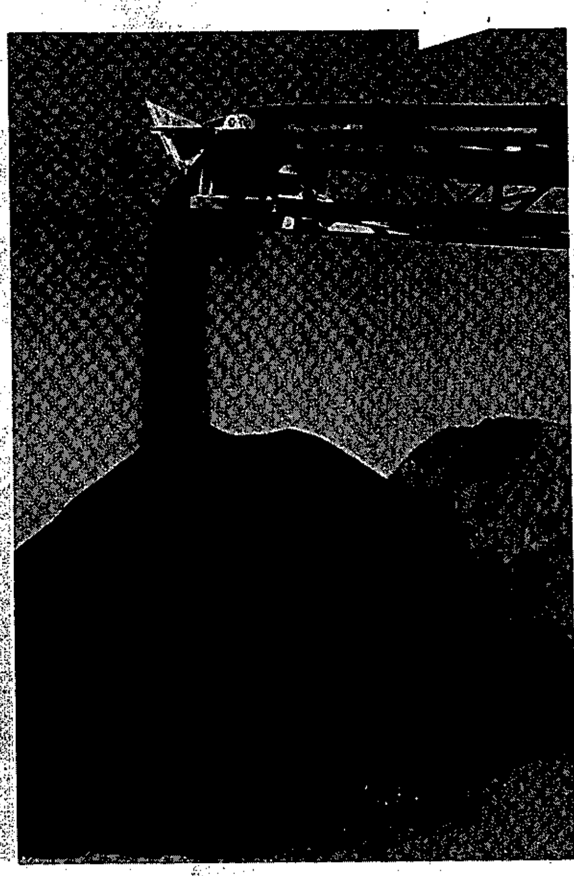

FIGURE 3

STOCKPILE SHOWING SEGREGATION

Expansion-Contraction

Expansion-contraction tests[1] were completed on A.C. bars containing untreated aggregates, aggregates treated with 0.5 percent hydrated lime in the form of a lime slurry in the laboratory, and aggregates sampled from the cold feed belt that supposedly had been treated with 0.5 percent hydrated lime in dry form by sprinkling dry lime on the fine aggregate belt only (see Figures 1 and 2). The test results are presented in Figure 4. As shown, the untreated bars expanded about 0.110" (average of 2) in 24 hours, while the expansion in 24 hours for the bars containing the lime slurry treated aggregate were 0.050" and 0.080". The lowest expansion was exhibited by the bars fabricated with "lime treated" material taken from the cold feed belt.

A second group of expansion bars consisted of A.C. test bars fabricated with asphalt concrete sampled from the A.C. immediately behind the paver. This asphalt concrete supposedly contained 0.5 percent lime by dry weight of the aggregate. Test bars were also made using aggregate sampled from the stockpile containing 0.5 percent lime, and two A.C. bars were made using aggregate from the stockpile with an additional 1.5 percent lime added for a total of 2.0 percent lime in the form of a lime slurry. The expansion results are presented in Figure 5. As shown, the bars fabricated with the asphalt concrete mix sampled from behind the paver expanded about 0.105" in 24 hours, which would make one question if these test specimens contained any lime, particularly when the previously tested bars containing untreated aggregates expanded 0.110" in 24 hours as shown in Figure 4. The expansion of the test bars containing "stockpile" aggregate and asphalt added in the laboratory correlated favorably with the corresponding results (0.5 percent lime) shown in Figure 4. As expected, the

LIME SLURRY PROJECT
09-Ker-58

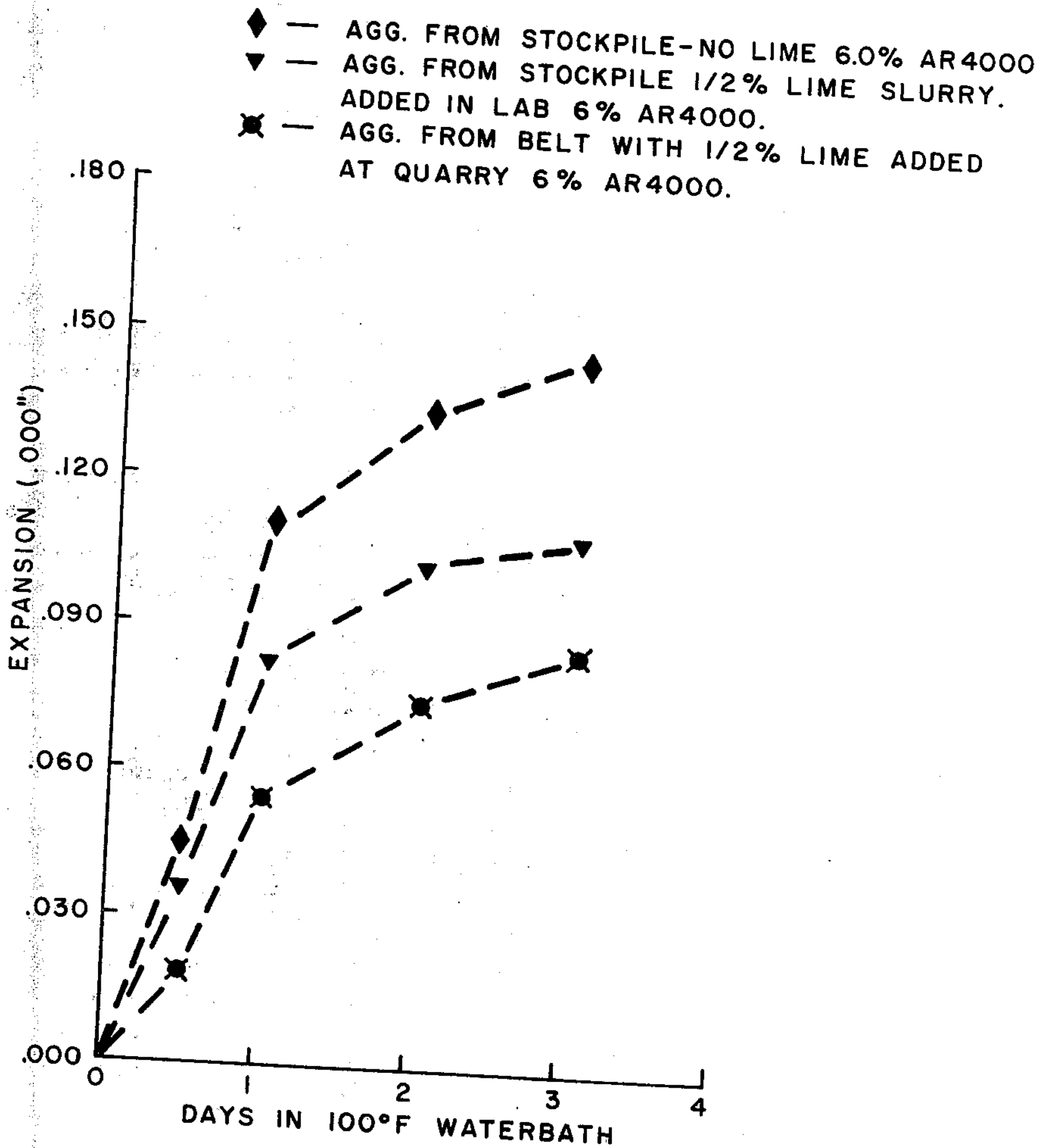

FIG. 4

LIME SLURRY PROJECT
09-Ker-58

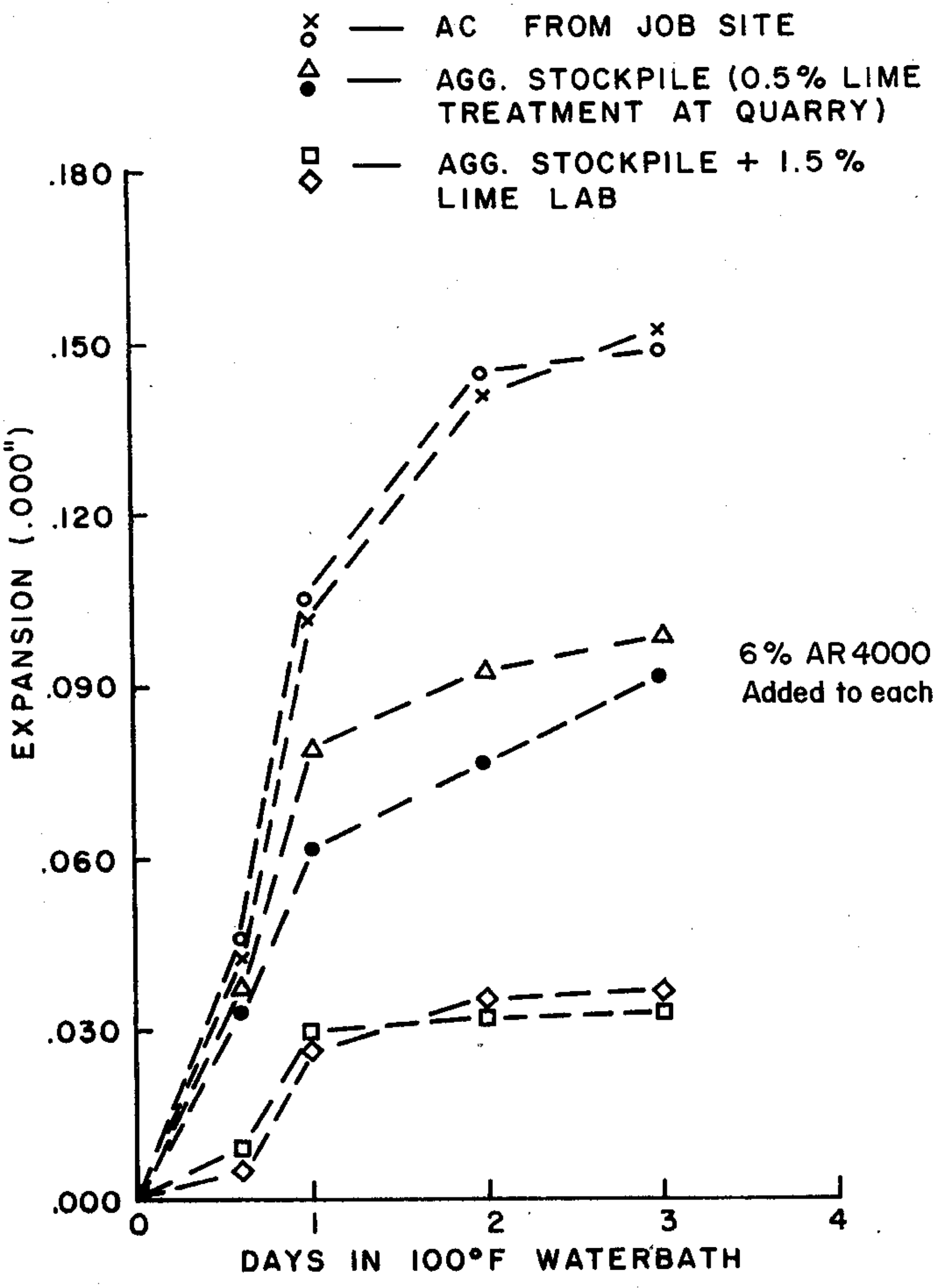

FIG. 5

test bars containing 2 percent lime in a lime slurry expanded considerably less than the untreated or 0.5 percent treated material after 24 hours in the 100°F water bath.

The test results for the asphalt recovered from the A.C. samples removed from the mat behind the paver are presented in Table 3, below.

TABLE 3

Characteristics of Recovered Asphalt

Test	Test Method	Results
Penetration @ 77°F	AASHTO T-49	66
Ductility	AASHTO T-51	150+
Viscosity @ 140°F	AASHTO T-202	1724 Poise
Viscosity @ 275°F	AASHTO T-201	258 Cs

The viscosity at 140°F is less than expected for an AR-4000 grade asphalt in that normally the viscosity is about 3000 poise. Generally, when the viscosity is low the temperature of the mix when discharged from the pugmill is also low (below 275°F). However, in this case the temperature of the mix when discharged was 300°F. Therefore we have no assignable cause as to the low viscosity. It is, however, unlikely that the presence of the lime influenced the viscosity of the asphalt.

C. Field Test Results

The temperature of the asphalt concrete mix when delivered to the street ranged from 280 to 300°F, and the breakdown roller (12-ton static) made its initial coverage when the temperature of the material was between 270 and 280°F. Upon completion of the compaction sequence, thirty locations were randomly selected and nuclear density measurements were made. The following day, water permeability tests were made at the same locations selected for nuclear density measurements. The results of this testing are presented in the following Table 4.

TABLE 4

Results of Field Tests

	Sta. 38+25 to 39+25		Sta. 29+25 to 40+25		Sta. 40+25 to 41+25	
	Den(PCF)	Perm(ML/Min)	Den(PCF)	Perm(ML/Min)	Den(PCF)	Perm(ML/Min)
1	135	45	133	35	135	30
2	134	50	134	155	135	25
3	135	45	134	30	135	30
4	135	35	135*	35	135	30
5	137	35	134	40	134	20
6	135*	35	134	25	133	20
7	134	25	137	25	134	25
8	136	25	136	20	134*	25
9	136	25	135	20	135	20
10	135	85	135	25	135	20
$\overline{X}$	135.2(96%)	40.5	134.7(96%)	41	134.5(96%)	24.5
σ	0.942		1.202		0.882	

*Cores taken at these locations

Note: The laboratory test density was 140 PCF (Calif. 304)

Cores were taken from three of these locations as shown in the above table. The waxed densities of these cores are presented with the "nuclear" in-place densities for the same locations in Table 5.

TABLE 5

Core vs. In-Place (Nuclear) Density

Section	Density (PCF) Nuclear	Core
1	135	135
2	135	136
3	134	136

V. SUMMARY

In summary, the test results have shown that when A.C. specimens containing a lime slurry-treated aggregate were fabricated and tested, beneficial effects were realized. In the laboratory, the specimens were prepared under ideal conditions in that the percentage of hydrated lime was added to individual samples and was carefully controlled. However, it is questionable, even under ideal conditions, whether a small percentage (0.5 percent) of hydrated lime can be added <u>uniformly</u> to an aggregate using typical field operations. The method that was used to introduce the hydrated lime to the minus #4 material on this project was very crude. The test results for specimens containing mix from the job indicate that a significant portion of the fine aggregate in the mix may not have been lime-treated. Thus, it is anticipated that the field performance of this pavement will be erratic. The lack of uniformity of the lime treatment renders any further study of the performance of this pavement of little value.

VI. REFERENCES

1. Cechetini, J. and Sherman, G., "Investigation of Lime Slurry to Control Absorptive Aggregates Used in Asphalt Concrete", September 1973.

2. Cechetini, J., "Modified CKE Test". The Association of Asphalt Paving Technologists, Vol. 40, p. 509, 1971.