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Investigation of Lime Slurry to Control Absorptive Aggregates Used In Asphalt Concrete

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Cechetini, James A. and Sherman, George B.

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16. ABSTRACT

Details of an investigation of the use of lime-slurry used as an additive to asphalt concrete to control excessive expansion are presented. Various tests and measurements were made both in the field and laboratory on the materials used. Tests included stability, cohesion, specific gravity, immersion compression, Abson recovery and deflection. Yearly condition surveys were also made.

It was concluded that lime-slurry treatment of expansive asphalt concrete aggregate will reduce premature pavement cracking of the type that has occurred in northeastern California.

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Asphalt concrete, expansion, construction, hydrated lime, lime slurry

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HIGHWAY RESEARCH REPORT

INVESTIGATION OF LIME SLURRY TO CONTROL ABSORPTIVE AGGREGATES USED IN ASPHALT CONCRETE

INTERIM REPORT

STATE OF CALIFORNIA

BUSINESS AND TRANSPORTATION AGENCY

DEPARTMENT OF TRANSPORTATION

DIVISION OF HIGHWAYS

TRANSPORTATION LABORATORY

RESEARCH REPORT

CA-DOT-TL-3113-3-73-28

Prepared in Cooperation with the U.S. Department of Transportation, Federal Highway Administration September, 19/

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STATE OF CALIFORNIA—BUSINESS AND TRANSPORTATION AGENCY

RONALD REAGAN, Governor

DEPARTMENT OF TRANSPORTATION

DIVISION OF HIGHWAYS
TRANSPORTATION LABORATORY
5900 FOLSOM BLVD., SACRAMENTO 95819

September 1973
CA-DOT-TL-3113-3-73-28
FHWA No. D-3-13

Mr. Robert J. Datel
State Highway Engineer

Dear Sir:

Submitted herewith is a research report titled:

INVESTIGATION OF LIME SLURRY TO
CONTROL ABSORPTIVE AGGREGATES
USED IN ASPHALT CONCRETE

By

James A. Cechetini
Co-Principal Investigator

George B. Sherman, P.E.
Principal Investigator

Very truly yours,

JOHN L. BEATON
Laboratory Director

ACKNOWLEDGMENTS

We wish to express our sincere appreciation to the many people who participated in this study.

To the many Engineers from District 02 and the California Department of Transportation who provided invaluable technical assistance.

To the maintenance crews from District 02 who did such an excellent job of controlling traffic, and

To all the other Engineers and Technicians within the Transportation Laboratory who furnished advice and assistance.

TABLE OF CONTENTS

I. INTRODUCTION

In certain areas of California there exists an acute shortage of good quality aggregates for use in bituminous paving mixtures. In these areas generally the aggregates are highly absorptive and have a history of poor pavement performance. One such location containing a preponderance of absorptive aggregates is in the northeastern part of California in Modoc County. Aggregates from this area are of volcanic origin and generally contain expansive clays such as montmorillonite and nontranite. Asphalt concrete containing these absorptive aggregates has often developed premature transverse cracking and raveling, generally associated with excessive expansion and contraction.

The results of routine tests did not reveal the reason for this asphalt concrete cracking after a relatively short period under traffic. However, results from expansion tests,[1,2] which consisted of measuring the change in length of compacted asphalt concrete bars subjected to alternate cycles of wetting and drying, did show asphalt concrete containing these absorptive aggregates to be highly expansive. Cracks appeared in the test bars after a few weathering cycles. The appearance of the test bars was similar to that of the roads in Modoc County experiencing premature failures.

Several papers[3,4,5,6] have been presented on the use of various fillers as a deterent to premature pavement raveling. One of the fillers most commonly mentioned in reducing this raveling has been hydrated lime. The Texas Highway Department constructed an experimental section in which the aggregates were treated with a lime slurry prior to being mixed with asphalt. This was done in an attempt to prevent stripping of the asphalt from the fine aggregate and thus prevent severe raveling failures of the type they had been experiencing. Their laboratory data and six years of actual road service has shown this treatment to be satisfactory[3]. In addition, a report by McDonald[4] contained data showing that the use of a lime additive reduced volume changes in aggregate mixes.

A preliminary series of laboratory asphalt concrete expansion tests was therefore conducted to evaluate the feasibility of using a lime treatement to prevent the premature distress that had been common in northereastern California. The findings showed lime treatment to be effective in reducing the expansion of these laboratory test specimens. In conjunction with District 02 of the Department of Transportation, it was agreed to incorporate a test section using a lime slurry additive in one paving contract in a troublesome area of northeastern California. A 2.9 mile long test section was selected and the pavement placed during the fall of 1965. This section of pavement has recently been covered with a seal coat. The laboratory and field data from this 6-year study is presented in this report.

II. CONCLUSIONS

From the data compiled during the six-year study, it is concluded that:

1. There is a good correlation between the results of the expansion bars and the actual pavement performance observed.

2. Lime slurry treatment of expansive asphalt concrete aggregate will reduce or delay pavement cracking of the type that has occurred in northeastern California.

3. Lime slurry will reduce expansion in asphalt concrete mixes containing expansive clays.

4. Lime slurry treatment of asphalt concrete aggregate will not significantly affect the hardening rate of the asphalt.

5. For this project the rate at which the asphalt hardened was directly related to the density of the asphalt concrete.

III. RECOMMENDATIONS

From the results of this study, it is recommended that a lime slurry treatment be used on asphalt concrete aggregates which have been found to be highly expansive in nature.

IV. IMPLEMENTATION

From the findings of this 6-year study, test methods have been developed to determine absorption and expansion (Mod. C.K.E. and A.C. expansion tests). When used with other tests (D.T.A. and X-ray) for quantitative and qualitative analysis with respect to the type of clay present, determination can be made as to the need for a lime slurry or another type of additive to control expansion. In the future, as more and more border-line aggregates are required for base and surfacing, these tests will become more widely used.

V. DISCUSSION

A. Project Description

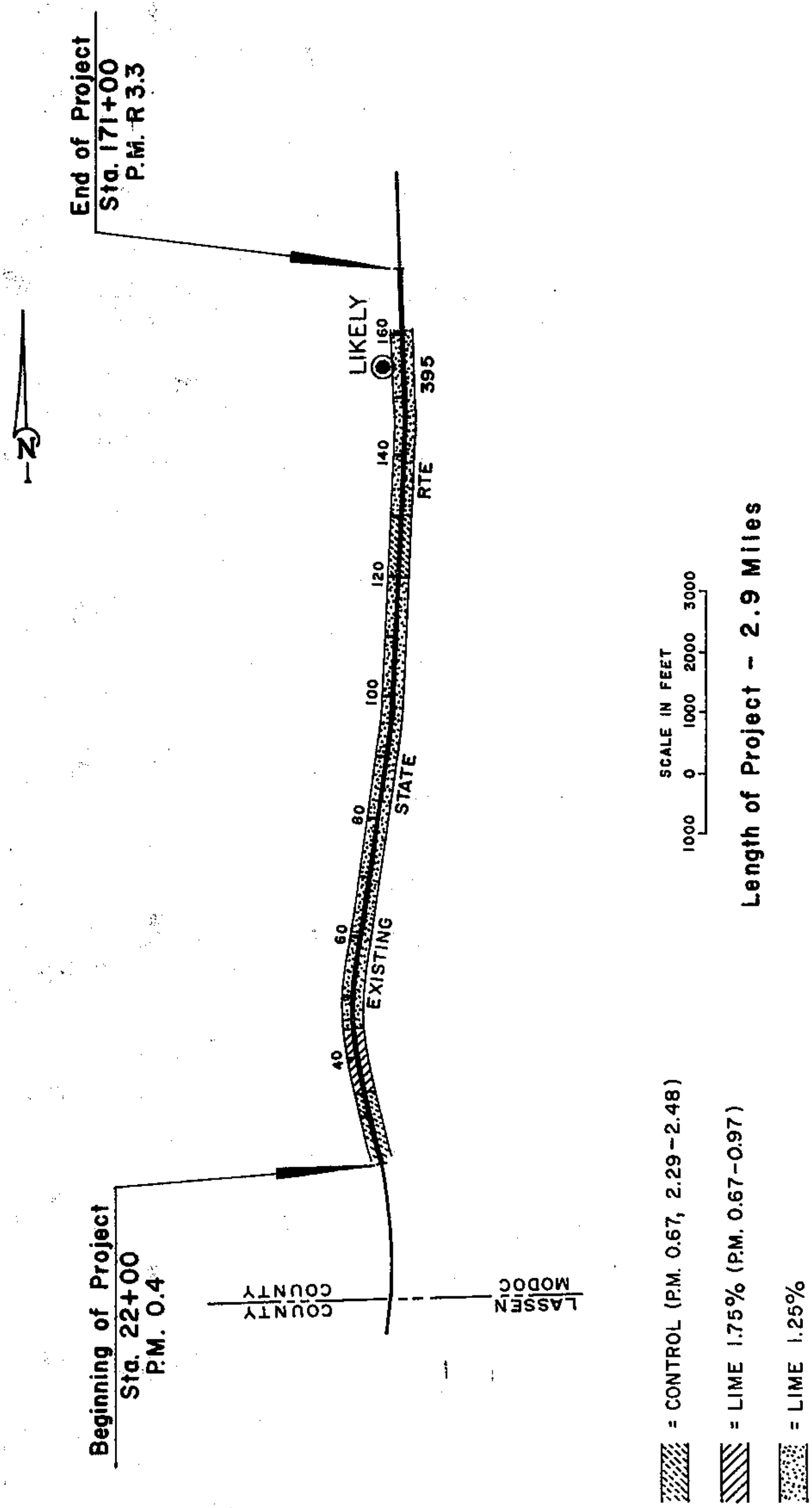
The site selected for the experimental test section is located near Likely, California (see Figure 1). The 2.9 mile long, 2 lane project included overlaying some existing roadway and constructing some highway on a new alignment. From Station 24+50 to Station 156+50 the aggregate subbase varied in thickness from 0.00' to 0.75', while the thickness of the aggregate base was 0.5'. From Station 156+50 to 169+31, a minimum of 0.35' aggregate subbase was placed over the existing roadway. Aggregate base 0.5' thick was again used (see Figure 2).

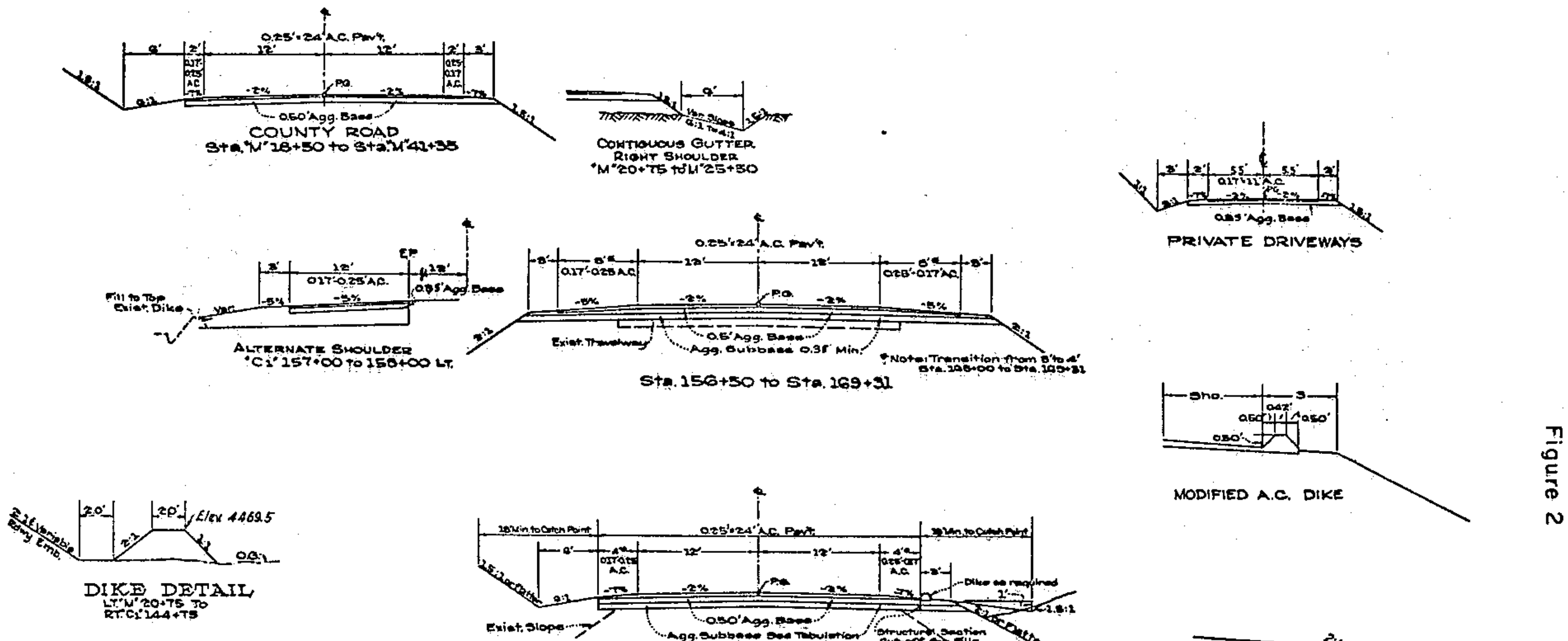
The design thickness for the AC pavement was 0.25' which was to be placed in two equal lifts.

Figure 1

IN MODOC COUNTY BETWEEN 0.4 MILE NORTH OF LASSEN COUNTY LINE & LIKELY

CONSTRUCTED 9/65





Aggregate Subbase Tabulation

Sta.	to Sta.	Depth (Ft)
24+50	58+50	0.00
58+50	125+00	0.50
125+00	135+00	0.75
135+00	145+00	0.50
145+00	169+31	0.35 Min.

Note Dimensions are subject to tolerances specified in the Standard Specifications

Superelevation as directed by the Engineer

(02-MOD-395, PM 0.4/3.3)

0.5 Mi. North of Lassen Co. Line to Jess Valley Road at Likely

TYPICAL CROSS SECTIONS

B. Mix Design

The asphalt concrete selected for this job was a Type B 3/4" maximum mix conforming to the requirements of Section 39 of the California Standard Specifications dated January, 1964. The results of laboratory tests on the aggregates and asphalt selected for use in the experimental asphalt concrete were as follows:

Aggregates

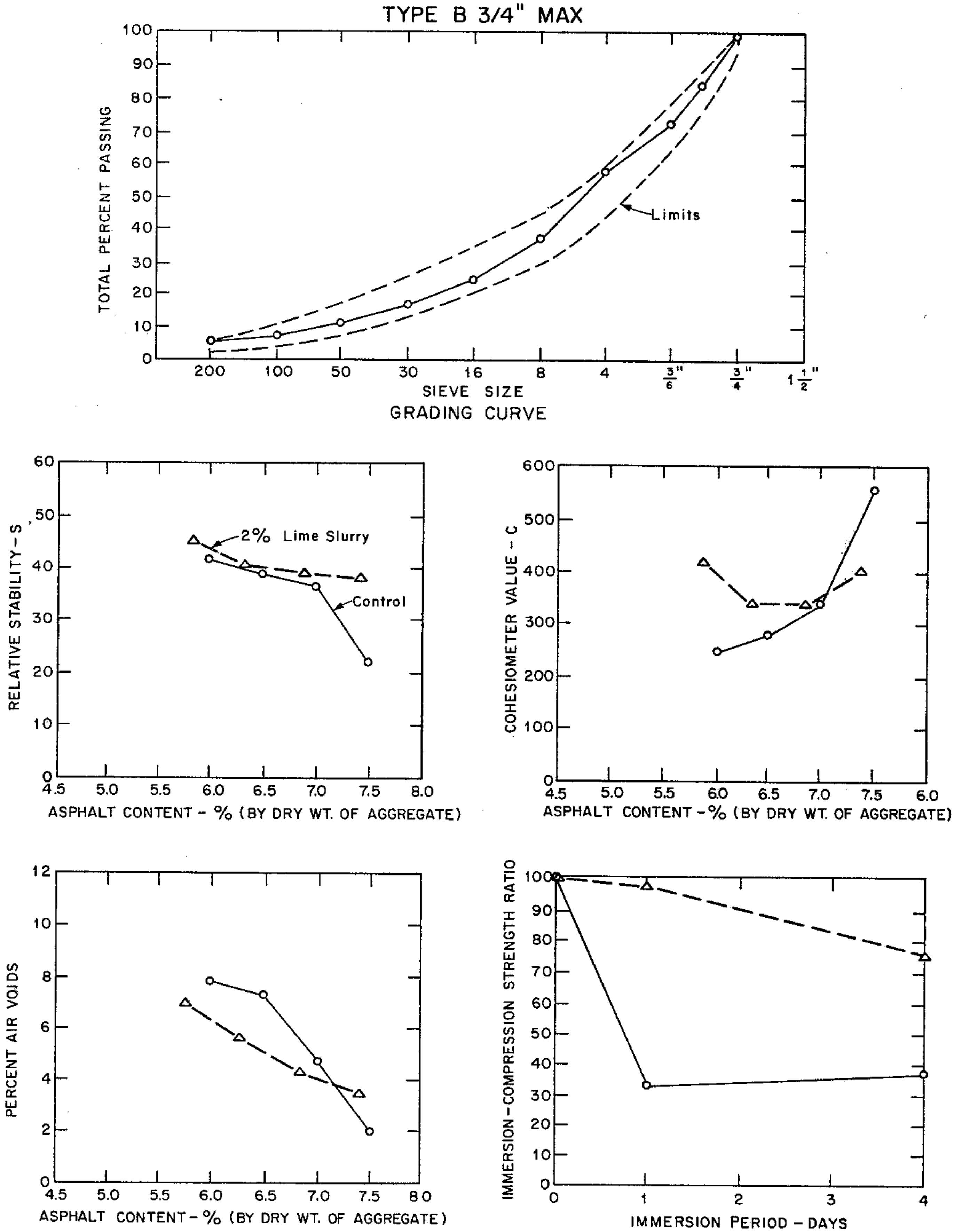
Tests	Test Method	Results
X-ray & D.T.A.	-	Feldspar, calcite, quartz, and more than 5% montmorillonite
Sand Equivalent	Calif. No. 217	50 (75 with 2% lime slurry)
CKE Test	Calif. No. 303	$K_c = 1.4$, $K_f = 1.7$, $K_m = 1.6$
Modified CKE Test	-	1.4% absorption (0.8% with 2% lime slurry)

Asphalt

Tests	Test Method	Test Results
Flash Point (T73)	AASHO T73	420°F
Penetration @77°F (T49)	AASHO T49	137
Penetration ratio	"	43
Xylene Equivalent (T102)	AASHO T102	-35%
Viscosity S.F. 275°F (T72)	AASHO T72	184 sec.
% Original penetration	AASHO T49	46%
Ductility (T51)	AASHO T51	100+
Softening Point (T53)	AASHO T53	120°F

The grading curve used as well as the results of the stability, cohesion, percent air voids, and immersion compression tests for the laboratory specimens fabricated with the lime treated and untreated aggregate are presented in Figure 3. The results

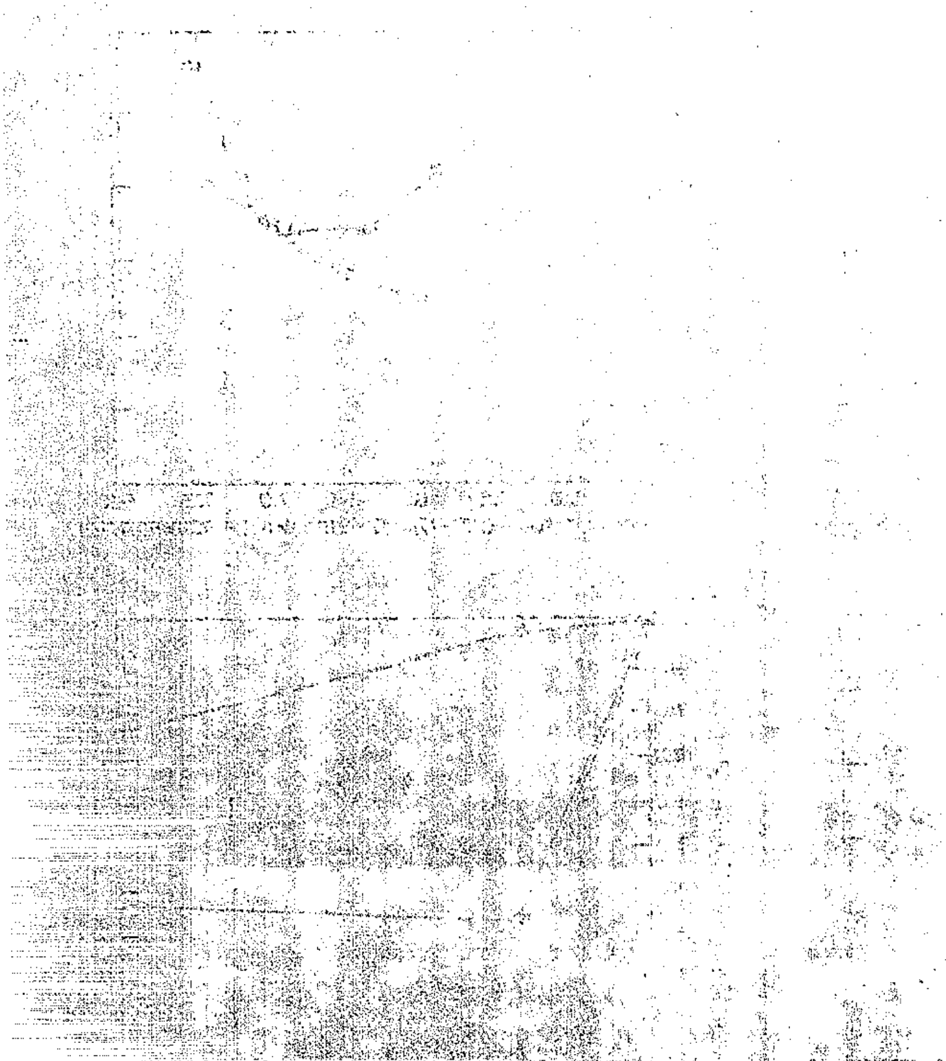
Figure 3



TYPE B 3/4" MAX
TOTAL PERCENT PASSING
Limits
SIEVE SIZE
200
100
50
30
16
8
4
3/8"
3/4"
1 1/2"
GRADING CURVE
RELATIVE STABILITY - S
2% Lime Slurry
Control
ASPHALT CONTENT - % (BY DRY WT. OF AGGREGATE)
COHESIOMETER VALUE - C
ASPHALT CONTENT - % (BY DRY WT. OF AGGREGATE)
PERCENT AIR VOIDS
ASPHALT CONTENT - % (BY DRY WT. OF AGGREGATE)
IMMERSION-COMPRESSION STRENGTH RATIO
IMMERSION PERIOD - DAYS

of the expansion contraction tests showed that the AC bars containing untreated aggregate expanded 0.082" while the bars containing aggregate treated with 2% lime (in a lime slurry) expanded 0.031" during the same testing period. These results are shown in Figure 4. Thus, the test data showed that treating the aggregate with lime slurry not only improved the strength of the asphalt concrete mix (Immersion Compression test results) but also decreased the expansion of the asphalt concrete. The lime slurry also made the AC mix less sensitive to an increase in asphalt content, up to an asphalt content of 7.5%, as shown by the stability and air void curves.

From the test data, it was recommended that the aggregates to be used for the test sections be pretreated with lime (2%) and that 6.9% 120-150 pen asphalt be used. Commercial hydrated lime conforming to the requirements of ASTM Designation: C51 was specified. The calcium hydroxide content specified at the point of delivery was 75 percent minimum, as determined by Test Method No. Calif. 414.

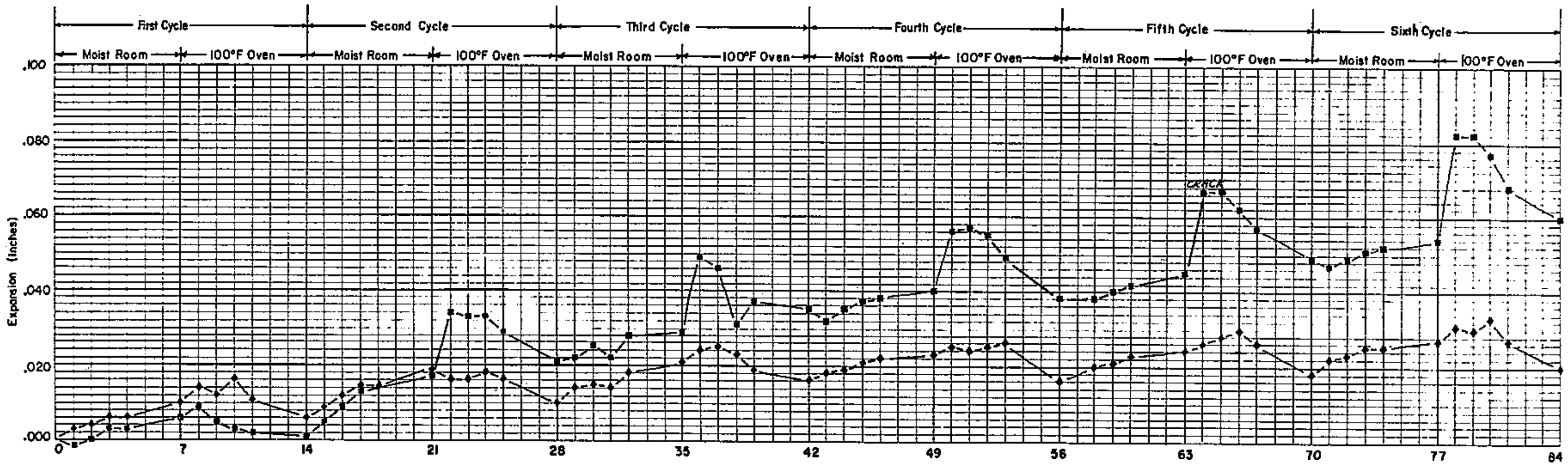


MATERIALS & RESEARCH DEPARTMENT

EXPANSION & CONTRACTION OF A-C BARS

Test No ______

Dist 02 Co MOD Rte 325 Sec ____ Cont No ______ Location of Source PAULSON PIT – LIKELY % Asphalt 6.9 Grade Asphalt 120–150 Surface Area ______ Film Thickness ______ Absorption ______



Date Began ______

Date Ended ______

FORM T-3088 (ORIG 3-64)

Figure 4

C. Plant Operations and Test Results

The aggregates specified for lime treatment, both coarse and fine, were precoated with a mixture of hydrated lime and water prior to entering the plant dryer.

The hot plant had a unique method for introducing and mixing the lime slurry with the raw aggregate (see Figures 5, 6, 7, and 8). The aggregates were discharged from the various stockpiles onto a conveyor belt, location 1. At location 2, the hydrated lime was batched with water in proper quantities, then pumped to a mixer, location 3, where the lime and water were thoroughly mixed at the approximate ratio of one part hydrated lime to three parts water, by weight. The mixing tank or storage tank was equipped with agitating paddles to keep the lime in uniform suspension until the slurry was added to the aggregate.

The lime slurry was introduced to the raw aggregate by a metering device at location 4. At location 5, a twin-screw pugmill was used for mixing the slurry and the aggregate at the rate of 3 to 5 percent of the dry weight of the aggregate. The exact proportion of lime slurry added to the aggregate was determined by the engineer. The mixing was continued until all the aggregates were thoroughly coated with the lime slurry. The lime-slurry aggregate mixture was then processed through the dryer, location 6, hot screens, and pugmill in a conventional manner. Due to the amount of moisture in the fine aggregate (caused by washing to comply with the sand equivalent requirement of the California Division of Highways) and the water in the slurry, it became necessary to decrease the rate of flow of treated aggregate into the dryer to get satisfactory temperature control of the aggregate.

A bypass was provided so that approximately 1,100 tons of asphalt concrete could be mixed with untreated aggregate.

Lime-slurry treated aggregate samples were taken at the hot plant. These samples were mixed with various amounts of 120-150 pen asphalt and laboratory fabricated specimens then tested. The results are presented in Figure 9. When comparing the aggregate grading curves in Figure 2 (untreated) and Figure 9 (lime slurry treated) it can be seen that both curves are within the specified grading envelope.

The other test results for the samples containing lime-slurry treated aggregate were approximately the same as the corresponding results from the preliminary study (Figure 2).

Figure 5

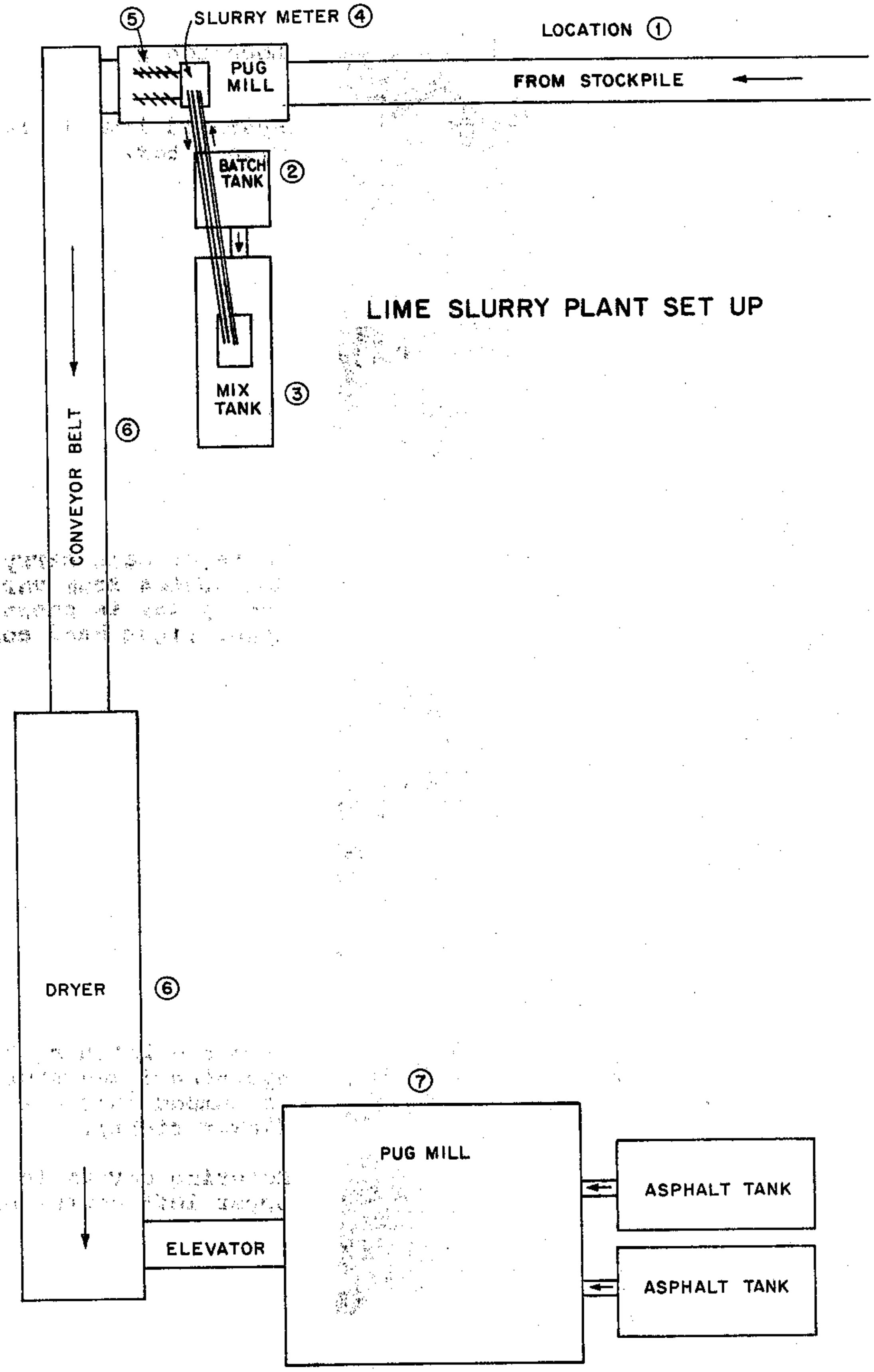
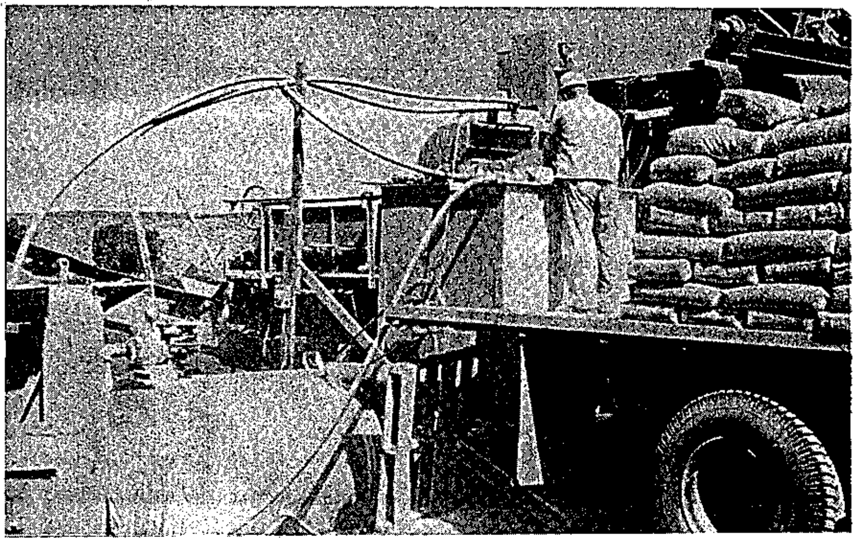
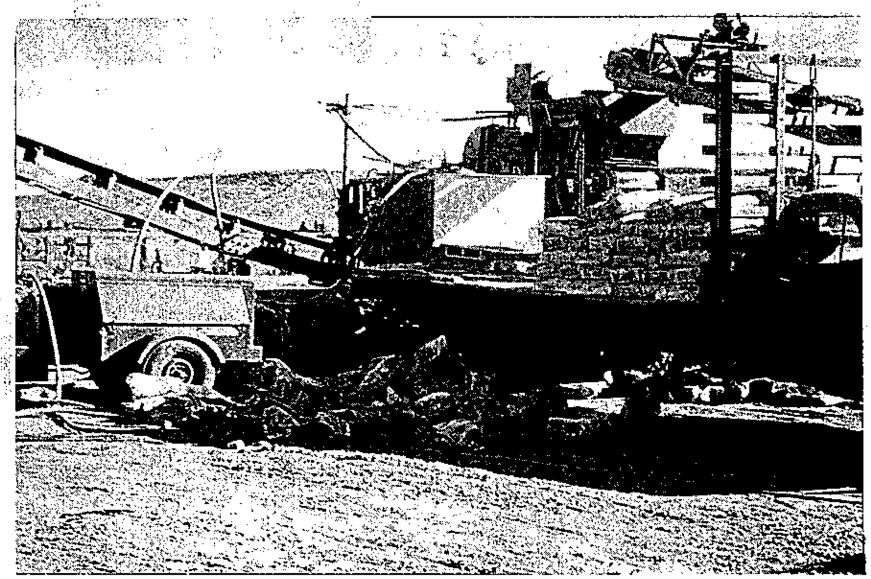

⑤
SLURRY METER ④
LOCATION ①
PUG MILL
FROM STOCKPILE
BATCH TANK ②
LIME SLURRY PLANT SET UP
MIX TANK ③
CONVEYOR BELT
⑥
DRYER
⑥
⑦
PUG MILL
ASPHALT TANK
ASPHALT TANK
ELEVATOR

Figure 6

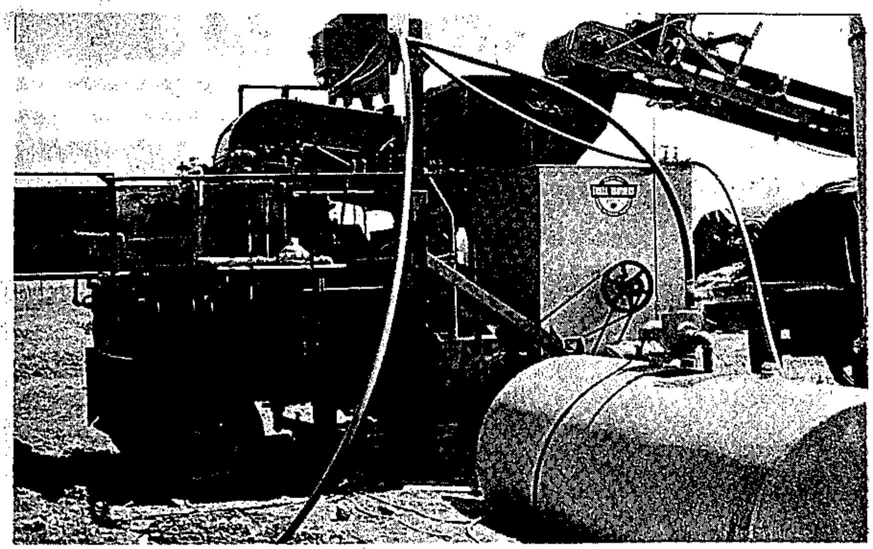


Location 2

Hydrated lime is combined with water.



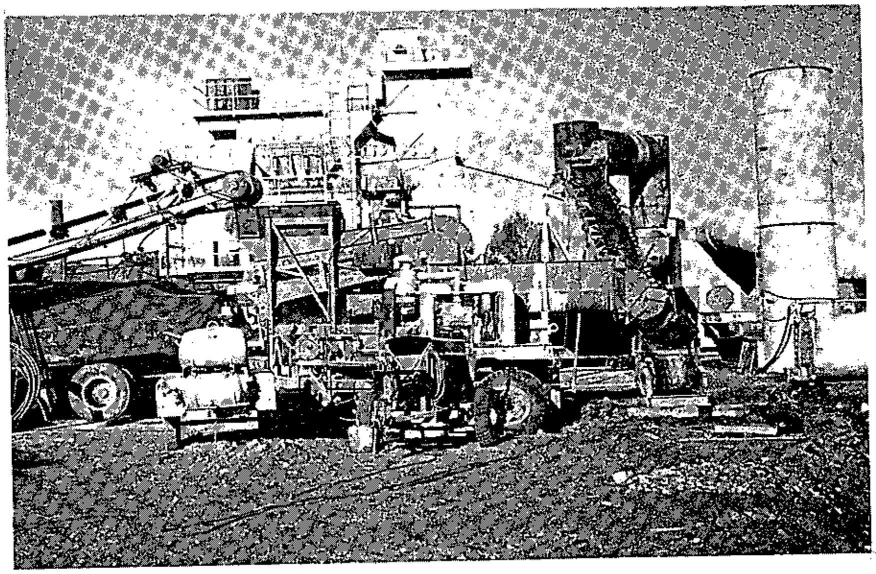
Conveyor belt carrying aggregates from various stockpiles is shown in upper right hand corner.



From the batching tank the hydrated lime-water slurry is pumped into mixing tank (lower right).

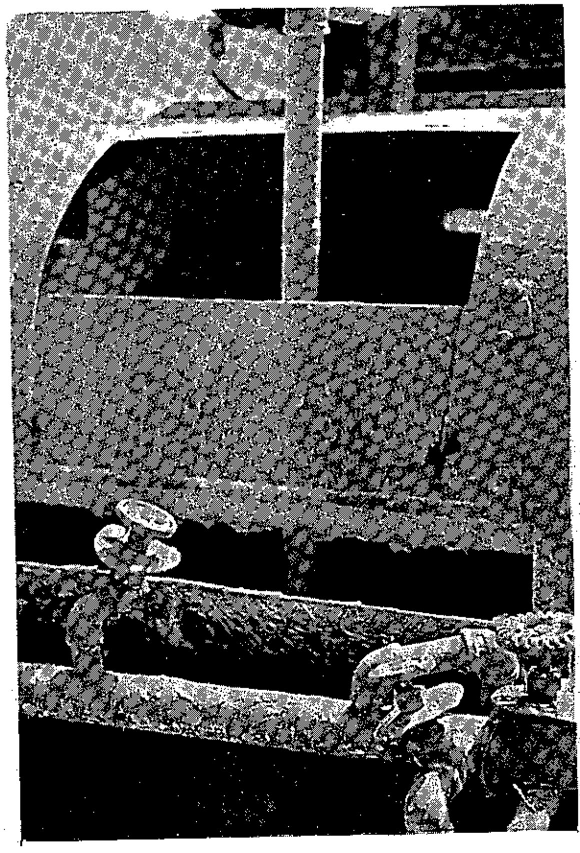
Metering device is shown in upper left center of photo.

Figure 7



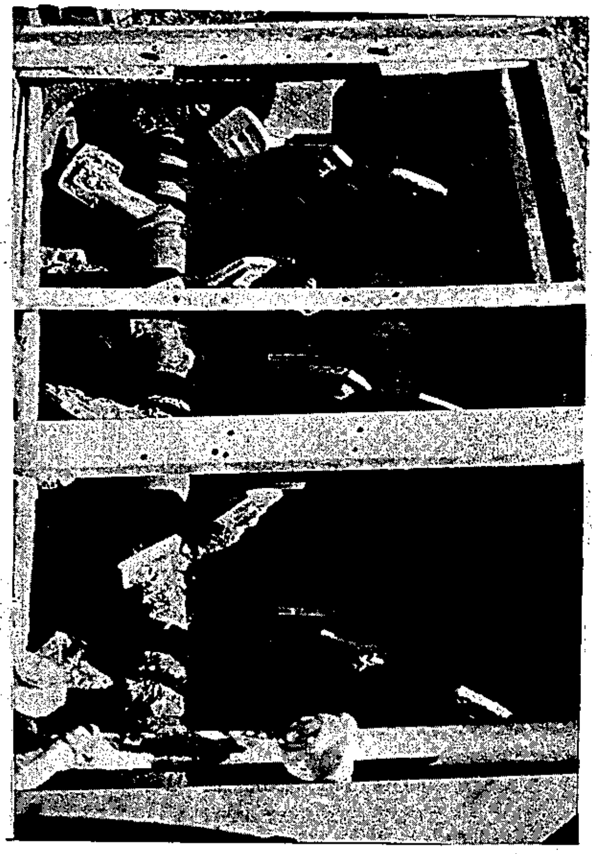
Overall view of plant-cold feed belt shown on left.

Lime slurry aggregate mix being discharged on belt to dryer shown on right.

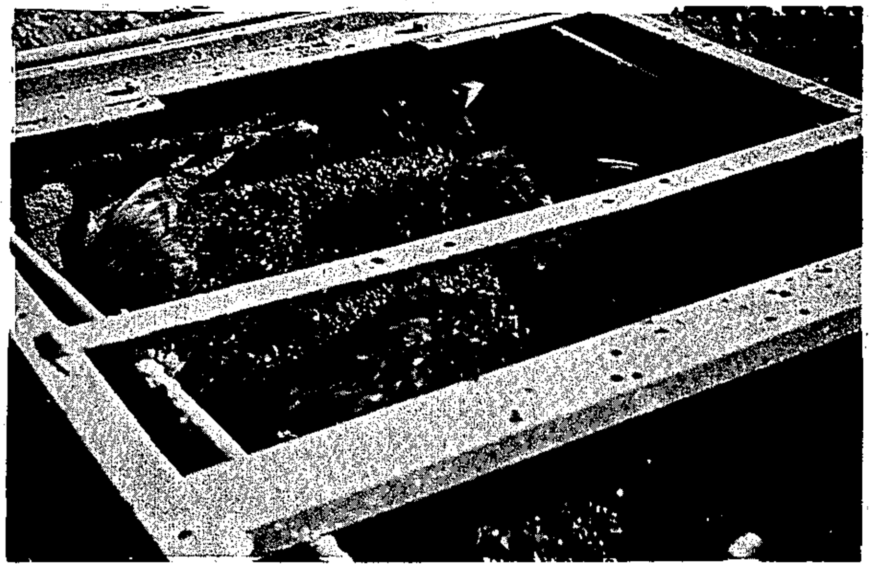


Lime slurry being added to aggregate from metering device.

Figure 8



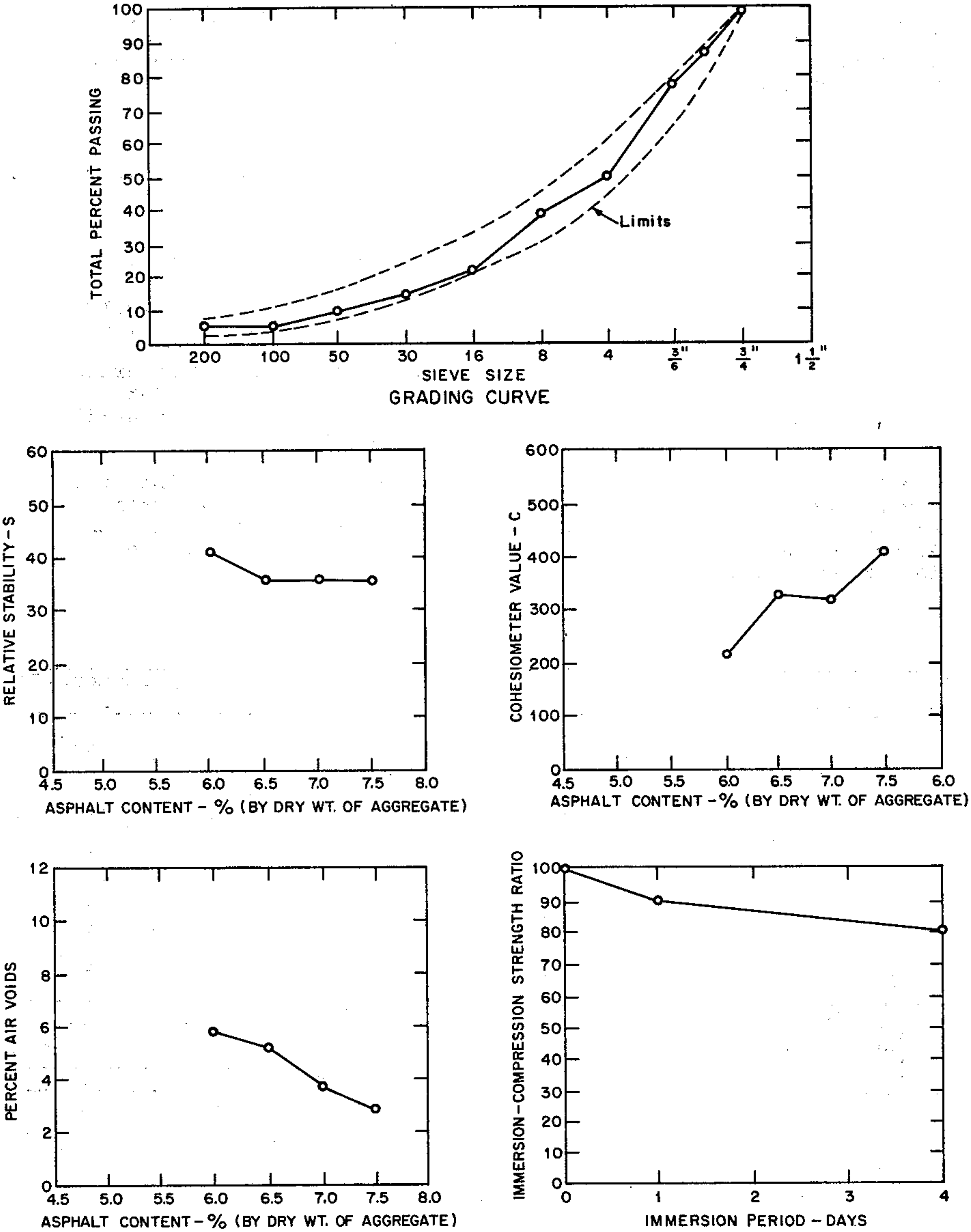
Location 5, aggregate/lime slurry mixing pugmill, showing twin-screws.



The lime slurry/aggregate mix is thoroughly mixed.

Figure 9

LOW LIME (AGGREGATE FROM PLANT SITE)



D. Street Operations and Test Results

As previously mentioned, lime slurry was used at a rate of from 3 to 5 percent by dry weight of the aggregate. Thus, "high" and "low" lime slurry test sections were constructed. The length of each of the test sections was as follows:

a. Two 1,000 ft. (24' wide) control sections were constructed from Stations 24+50 to 34+50 (Control #1) and Stations 120+00 to 130+00 (Control #2). In these sections, the asphalt concrete aggregate did not receive a lime slurry treatment.

b. One 1,000 ft. (24' wide) "high" lime slurry section was constructed between Stations 34+50 and 44+50. In this section, the asphalt concrete contained aggregate treated with 5% lime slurry (1.75% hydrated lime).

c. For the remainder of the project, the asphalt concrete aggregate was treated with a 3% lime slurry (1.25% hydrated lime). This pavement was from Stations 44+50 to 120+00 and Stations 130+00 to 169+31.

The AC mix was delivered to the street, then end-dumped into the paver (Cedar-Rapids). Most of the AC samples were taken from the mat immediately behind the paver. The test data for all the AC street samples taken on this project are presented in the following table.

(Table 1)

Sieve Size	Grad. Limits	Average $\bar{X}$	Standard Dev. σ	Range	Frequency N
1	100	100	0	100	14
3/4	95-100	99	1.9	93-100	14
1/2		88	5.0	82-98	14
3/8	65-80	75	6.1	68-83	14
4	45-60	50	7.2	38-64	14
8	30-45	34	5.6	34-42	14
16		24	3.7	22-29	14
30	15-25	18	2.6	15-21	14
50		13	1.9	8-10	14
100		9	1.4	5-9	14
200	3-7	7	1.4	5-9	14
% Asphalt		5.53	0.7	5.2-6.4	14
Density PCF		140	2.0	138-142	14
Stability		37	7	15-43	14
Cohesion		465	144	191-615	14

As shown in Table 1, the amount of asphalt extracted from field AC specimens was significantly less than the recommended asphalt content of 6.9%. Since the aggregate used for the asphalt concrete was absorptive, it was felt that all the asphalt was not being recovered using the normal extraction procedure (Test Method No. Calif. 310). However, lengthening the soaking and drying periods had little or no appreciable effect on the indicated asphalt content in that the average of these additional samples was 5.8%. Therefore, this low asphalt content has been attributed to an error at the hot plant when the asphalt was being added to the aggregate. The relative performance of the asphalt concrete pavements containing treated and untreated aggregates was still considered to be of value, however.

The air temperature during construction ranged from 45 to 78°F, while the temperature of the AC mix after arrival at the street ranged from 220 to 340°F.

The following table contains a summary of temperatures, breakdown coverages and water permeability test results for the various test sections.

(Table 2)

Sections	Control (1) 24+50to34+50		High Lime 34+50to44+50		Low Lime* 44+50to120+00		Control (2) 120+00to130+00	
	Level	Surface	Level	Surface	Level	Surface	Level	Surface
Temp. Mix (°F) Breakdown	160	210	210	210	210	245	210	230 to 240
Temp. Mix Pneumatic (°F)	90	115	90	90	100	100 to 150	100	160
Number of Breakdown Coverages**	1	1	1	1	1	3	1	10+
Water Permeability (ML/MIN)	-	519 to 1070	-	557 to 1200	-	960 to 1030	-	30 to 70

*From Station 60 to 64+50 (NBL & SBL) this section received a minimum of 10 coverages during breakdown. Permeabilities ranged from 80 to 200 ML/MIN.

**Coverage = As many passes as necessary to cover the entire paving width.

Pass = One movement of the roller in either direction in a single path.

In most cases, the normal rolling sequence was one coverage by a 12-ton tandem followed by three coverages with 9-ton pneumatic and a final coverage with an 8-ton tandem. Note that in control section 2, which was given additional breakdown coverages in the surface course, the water permeability was reduced considerably.

E. Follow-up Condition Survey and Test Results

Within two weeks after the test section was completed, cores were removed from each subsection. The test results from the cores are presented in the following table.

(Table 3)

Sieve Size	Grad. Limits	Average $\bar{X}$	Standard Dev. σ	Range	Frequency N
1	100	100	0	100	9
3/4	95-100	99	2.2	93-100	9
		91	1.9	87-93	9
3/8	65-80	80	1.2	78-82	9
4	45-60	53	3.1	49-58	9
8	30-45	36	2.7	33-42	9
		25	1.9	22-29	9
30	15-25	18	1.6	15-21	9
200	3-7	7	0.9	6-9	9
% Asphalt		5.7	0.4	5.2-6.4	9
Density PCF		132	2.0	130-136	9
Stability		18	2.4	15-22	9
Cohesion		192	92.2	83-413	9

Significant differences between the results of the cores and the same AC mix compacted in the laboratory (Table 1) were found in the stabilities, cohesion, and densities. The average stability of the briquettes compacted in the laboratory was 37 while the average stability for the cores was 18, or about 49% relative stability.

The probable cause for the variance between the core densities and the same mix fabricated in this laboratory is due to lack of compaction as shown in the following table (3A) of core densities from other job sites. In this study, the cores, after testing, were broken up, and recompacted. As shown, the densities were increased as well as the stabilities.

(Table 3A)

Effect of Laboratory Recompaction

Test No.	Date Rec'd.	Contract Number	Core Sp. Gr.	Core Stability	Lab. Recompaction Core Sp. Gr.	Lab. Recompaction Core Stability
35925	9-15-69	04-275734	2.41	25	2.46	38
35884	9-2-69	04-325314	2.30	24	2.35	45
35924	9-15-69	04-275734	2.38	24	2.46	38
35862	8-25-69	10-037834	2.01	22	2.10	46
35926	9-15-69	04-040114	2.36	23	2.46	39
36008	10-3-69	09-025734	2.18	14	2.34	39
36048	10-9-69	01-046614	2.24	21	2.27	56
36049	10-9-69	01-086604	2.22	18	2.31	47

Cores were also taken approximately one year after construction of the pavement for Abson Recovery tests to determine if the lime slurry had any effect upon the asphalt with respect to the rate of hardness. The results of these tests are presented in Table 4, below:

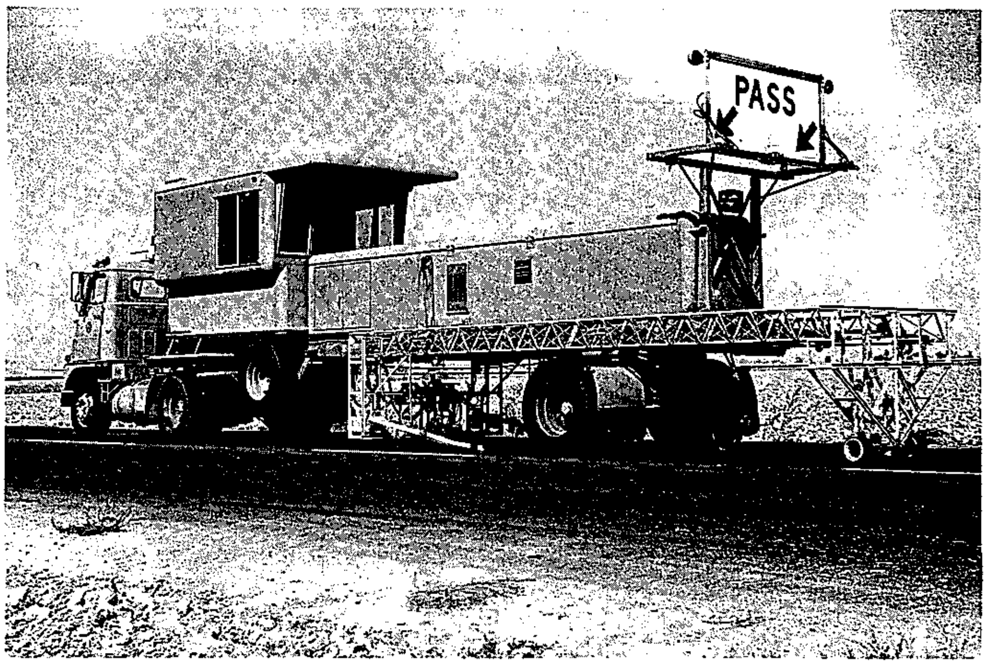
(Table 4)

	Test Made in Sept. 1965				Test Made in Aug. 1970			
	Control (1)	High Lime	Low Lime	Control (2)	Control (1)	High Lime	Low Lime	Control (2)
Penetration	103) 73) 84) Avg. 89	73) 92) 90) 100) Avg. 89	85) 92) 81) Avg. 86	53) 72) 120) Avg. 82	16	18	21	22
Soft.Point(°F)	121) 124) 123) 123	122) 123) 122) 118) 122	124) 121) 122) 123	128) 125) 116) 123	162	155	150.5	155
Ductility(CM)	100+) 100+) 100+) 100+	100+) 100+) 100+) 100+) 100+	100+) 100+) 100+) 100+	100+) 100+) 100+) 100+	8	19	57	27

From this data, it was concluded that the lime slurry did not have any significant effect on the rate of hardening of the asphalt. Control section 2 as well as a portion of the low lime slurry section (60+00 to 64+50) received more breakdown compactive effort than did the remainder of the pavement. The cores used in the determination of the above table for the low lime section were taken from Station 60+50. Therefore, it appears that the increase in compactive effort did decrease the rate of hardening of the asphalt.

Deflection measurements were made on three different dates for the various experimental sections. The California Traveling Deflectometer (see Figure 10) was used to make the deflection measurements.

Figure 10



Deflection measurements were recorded for both wheel tracks. The results are presented in Table 5. As shown, the maximum deflections were recorded during the 1970 survey; however, these deflections were not excessive. It is interesting to note that the low lime slurry section which was constructed over an old existing AC pavement had the least deflection, as well as the least amount of failed area.

Condition surveys have been made yearly since this project was constructed. The survey consisted of recording the amount of cracking and spalling that had occurred and the amount of patching that had been required. Photographs taken during the 1969 survey are shown in Figures 11 and 12.

The results from all the condition surveys are presented in Table 6. As shown, no visible signs of cracking were noticed in any of the sections during the 1966 and 1967 surveys. This was probably due to the below normal rainfall in this area during 1966 and 1967.

Cracks were recorded in all the sections during the 1968 survey; however, more cracks appeared in the control #1 than control #2, and both sections had more cracks than either of the lime slurry treated sections.

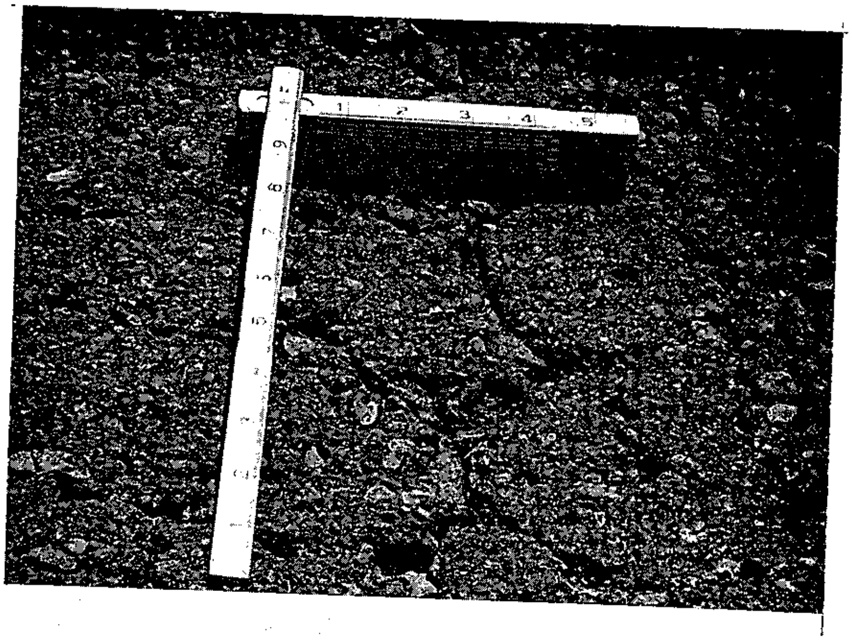
Table 5

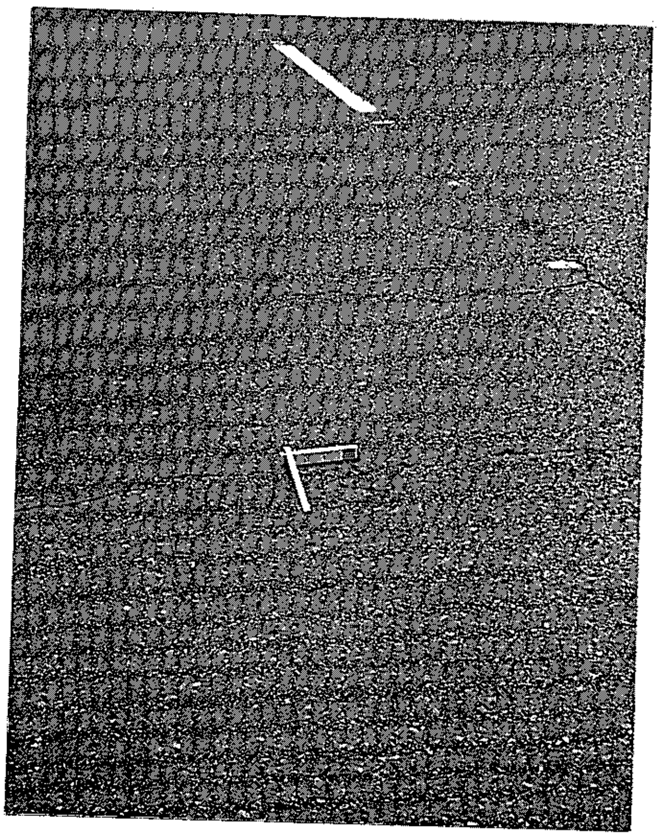
DEFLECTION (IN)

Test Sections & Stations	Oct. 1965						June 1970						May 1971					
	IWT			OWT			IWT			OWT			IWT			OWT		
	$\overline{X}$	σ	N	$\overline{X}$	σ	N	$\overline{X}$	σ	N	$\overline{X}$	σ	N	$\overline{X}$	σ	N	$\overline{X}$	σ	N
Control (1) 24+50 to 34+50	0.010	1.5	50	0.008	1.2	50	0.020	3.2	48	0.021	4.0	49	0.016	2.7	49	0.018	3.4	48
Control (2) 120+00 to 130+00	0.015	1.2	77	0.012	1.5	79	0.021	3.3	54	0.026	4.0	54	0.018	2.9	56	0.018	2.7	56
High Lime 34+50 to 44+50	0.014	4.5	65	0.012	4.1	65	0.019	3.1	42	0.024	6.9	42	0.017	3.9	48	0.016	2.6	48
Low Lime 44+50 to 120+00	0.016	1.9	79	0.013	1.6	79	0.016	2.9	53	0.020	3.9	51	0.015	3.2	55	0.014	2.7	55
Low Lime* 156+50 to 169+31	-	-	-	-	-	-	-	-	-	-	-	-	0.009	1.7	42	0.011	1.3	42

*Lime Slurry AC constructed over old existing pavement.

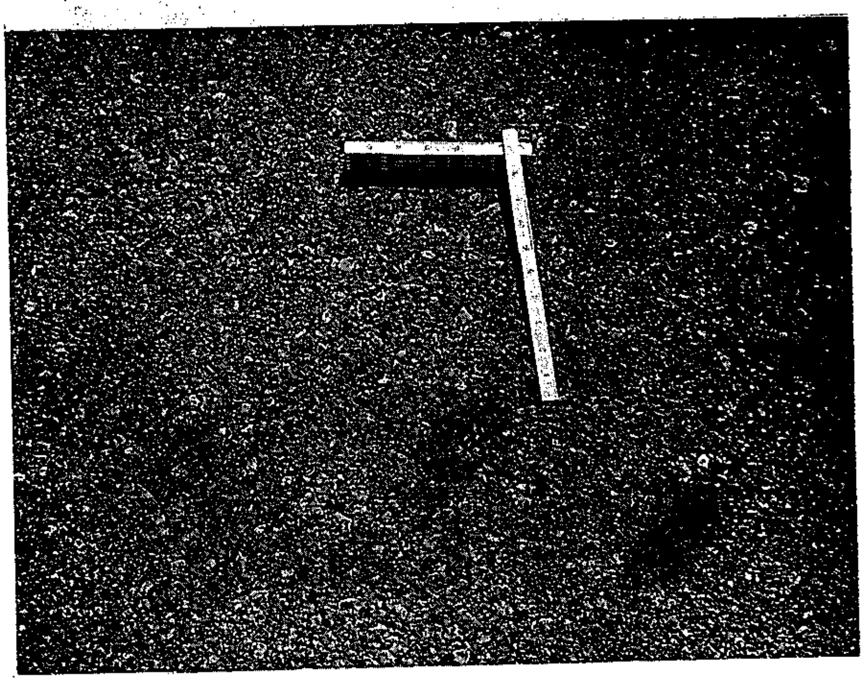
Figure 11





Top photo shows Control Section #1: Bottom photo shows Control Section #2. 1969 Photos

Figure 12



High Lime Section - 1970 Photo

Table 6

Test Sections	Stations	Amount of Cracking per Station														
		1966		1967		1968		1969		1970			1971		
		B.C.*	CR.**	B.C.	CR.	B.C.	CR.	B.C.	CR.	B.C.	CR.	Patch	B.C.	CR.	Patch***
Control #1	24+50 to 34+50	0	0	0	0	18	35	375	55	776	72	113	960	72	113
Control #2	120+00 to 130+00	0	0	0	0	6	8	20	44	199	103	113	439	176	113
High Lime	34+50 to 44+50	0	0	0	0	2	0	12	17	70	74	0	290	115	0
Low Lime	44+50 to 120+00	0	0	0	0	0	1	4	19	20	55	19	125	100	19
Low Lime	160+00 to 169+31	-	-	-	-	-	-	-	-	-	-	-	0	74	0

*Block Cracking in Ft^2 per station (100'x12' wide)

**Cracking both longitudinal and transverse in Ft. per station(100'x12' wide)

***Patching in Ft^2 per station (100'x12' wide)

Note: Center line cracks are not included in above data. There is no cracking data between Stations 130+00 to 160+00, as this area is in the town of Likely, making a crack survey impractical.

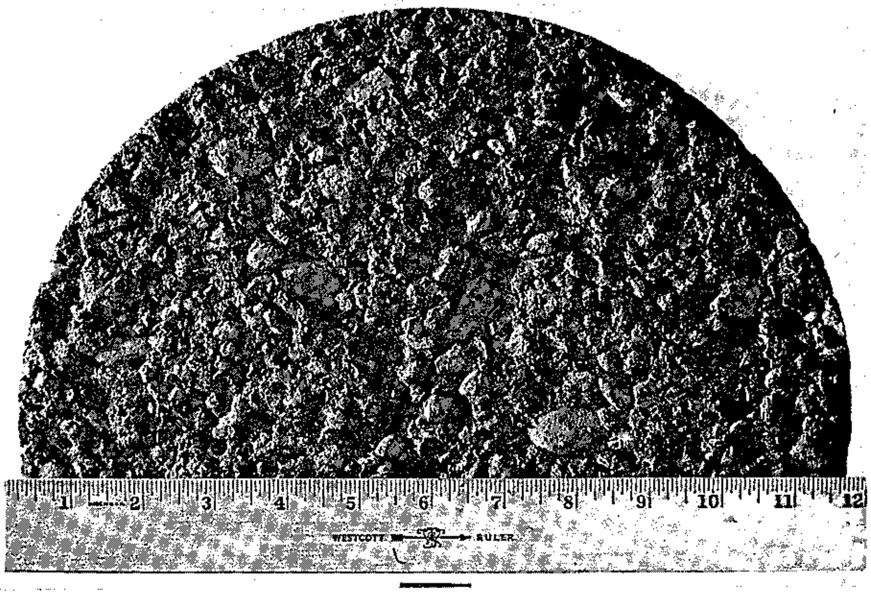
The reason for the wide variance between the two control sections, with respect to cracking, is probably the difference in compaction procedure used in these two sections during construction. In control section #1, one coverage by a 12-ton tandem was used for the breakdown. This was followed by one to three coverages by a 9-ton pneumatic. The final rolling consisted of a coverage by an 8-ton tandem. In control section #2, the initial rolling consisted of a minimum of 10 coverages by a 12-ton tandem, while the intermediate and final rolling procedures were the same as those used for control section #1.

As shown in Table 6 the amount of block cracking, as well as transverse and longitudinal cracking, has been increasing in all sections at a rapid rate since 1970. However, the sections with the lime slurry additive have block cracked much less than the control sections. This tends to confirm the results of the expansion test (Figure 3), in which the AC test bars with the lime slurry expanded much less than the control bars. Photographs of cores removed from representative areas from the various sections are shown in Figures 13 and 14. Notice that the cores with heavy compaction are denser than those with light compaction. It can also be seen that the cores without the lime slurry have more asphalt stripping, and more exposed aggregate.

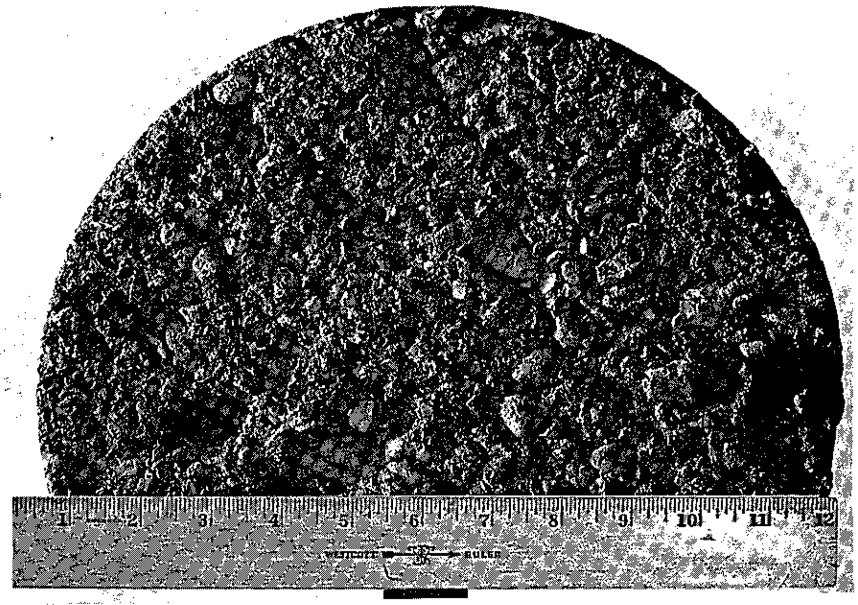
As mentioned previously, cross sections within the project consisted of aggregate subbase varying in thickness from 0.00' to 0.75', an aggregate base of 0.5', and 0.25' of asphalt concrete. From Station 156+50 to Station 169+31, the cross section was similar with one major exception - the aggregate subbase, base, and asphalt concrete pavement (low lime slurry) were all placed over an old existing AC. This section of new pavement constructed over the old existing pavement has remained in excellent condition for six years. There was no block cracking or patching in this area at the time of the 1971 survey and the amount of cracking, both longitudinal and transverse, was equal to 74 feet per station.

Examination of Tables 5 and 6 shows that the lime slurry additive did significantly reduce the amount of pavement failure for five years. However, from April 1970 to April 1971, all sections have shown an accelerated rate of pavement failure with the exception of Stations 156+50 to 169+31. This general increase in failed areas can be attributed, at least in part, to the higher than normal rainfall during 1970. However, these failures can also be attributed to the design thickness of the structural section and also to the lack of compaction for most of the asphalt concrete pavement. This is demonstrated by two observations. First, the section of pavement from Stations 156+50 to 169+31, which was constructed over an old existing pavement, was in excellent condition after 6 years even though

Figure 13

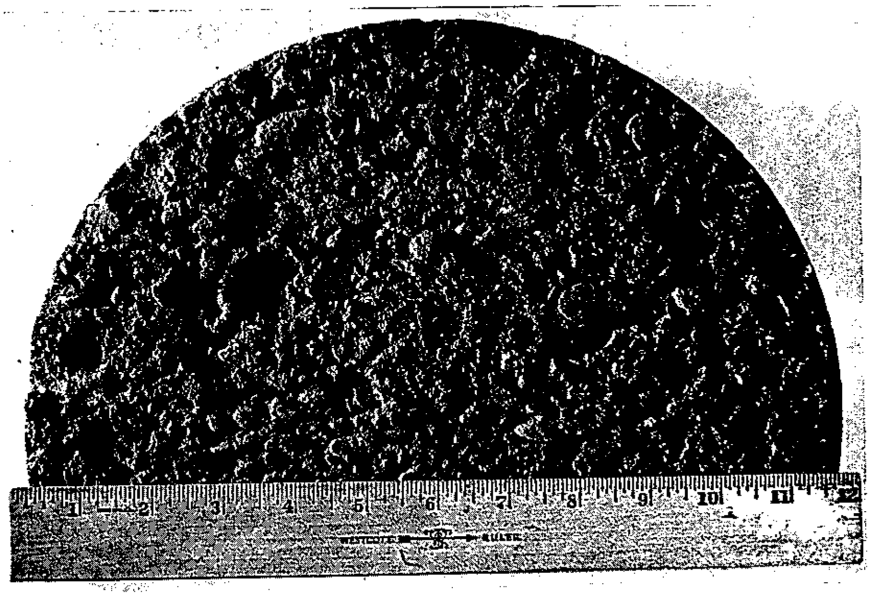


Taken from Control (1) Section - with light compaction.
Core Removed in 1970.

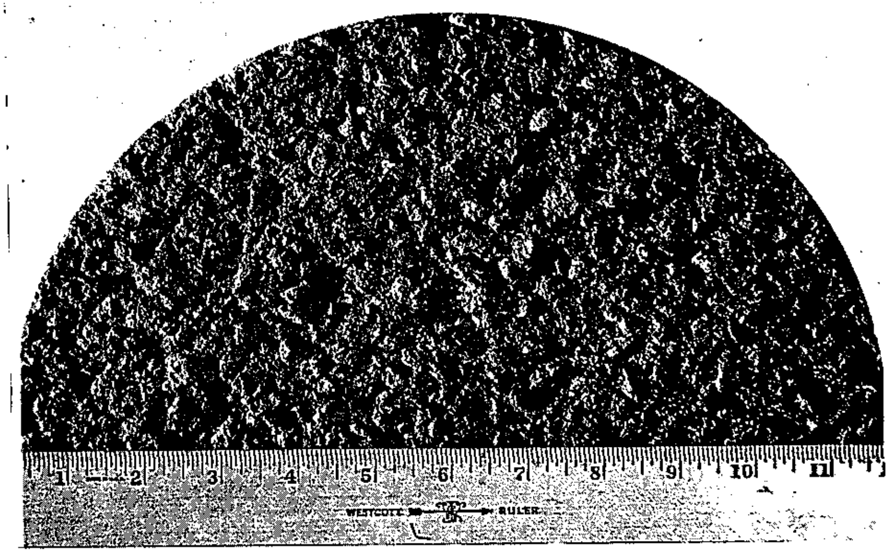


Taken from Control (2) Section - with heavy compaction.
Core Removed in 1970.

Figure 14



Taken from "high" lime section - with light compaction.
Core Removed in 1970.



Taken from "low" lime section - with heavy compaction.
Core Removed in 1970.

most of the adjacent pavement (not constructed over this existing pavement) is in fair to poor condition. This indicates that most of the test sections were not adequately designed. This could also possibly explain why the high lime area cracked more than the low lime area. Secondly, the section in the low lime area from Stations 60+00 to 64+50 which received a minimum of 10 breakdown coverages was also in excellent condition at the time of the 1971 survey while the remainder of the low lime section, which did not receive as many coverages during the breakdown rolling, was in fair to poor condition. Comparing the areas subjected to high compaction effort, one can see from Table 6 that the low lime area of high compactive effort is included in the entire area from Stations 44+50 to 120+00. Yet this total area has cracked much less than control section #2, which also received 10 coverages during the initial rolling phase. Also, as stated before, the noticeable difference between the two control sections with respect to the amount of cracking can be attributed, at least in part, to the difference in the amount of compaction the two sections received.

VI. SUMMARY

In summary, it has been shown that a lime slurry treatment will retard the amount of cracking in an AC pavement constructed with absorptive aggregates. However, the effect of a lime content in excess of approximately 1.75% was not determined. Additional investigation is needed in this area to determine the effect of larger amounts of lime in the asphalt concrete.

VII. REFERENCES

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6. O'Hara, W. G., "Effects of Natural Elements and Chemicals on Bitumen-Aggregate Combinations and Methods for Their Evaluation," Proceedings, Highway Research Board, Annual Meeting, January 1967.