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17. KEYWORDS
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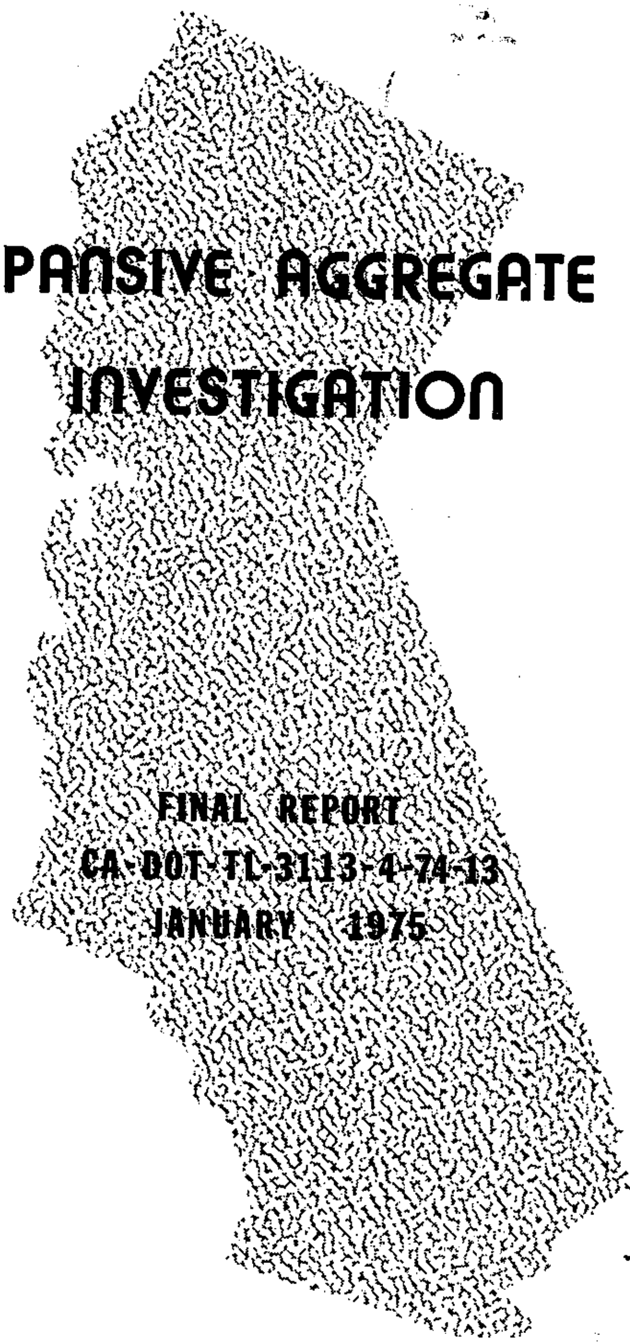
TRANSPORTATION LABORATORY

RESEARCH REPORT



EXPANSIVE AGGREGATE INVESTIGATION

FINAL REPORT

CA-DOT-TL-3113-4-74-13

JANUARY 1975

74-13

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

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

January 1975

FHWA No. D-3-13
TL No. 633113

Mr. R. J. Datel
Chief Engineer

Dear Sir:

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

EXPANSIVE AGGREGATE INVESTIGATION

Study made by . . . . Pavement Branch

Under the Supervision of . . . . G. B. Sherman

Principal Investigator . . . . R. N. Doty

Co-Investigator . . . . J. A. Cechetini

Report Prepared by . . . . J. A. Cechetini

Very truly yours,

JOHN L. BEATON
Chief Engineer, Office of Transportation Laboratory

Attachment

ACKNOWLEDGEMENTS

We wish to express our sincere appreciation to the many engineers and technicians from the various Districts who provided invaluable technical assistance during this study.

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INTRODUCTION

The original objective of this study of expansive aggregate use in asphalt concrete was to determine the effect of absorptive aggregates on the rate at which asphalt hardens. A set of asphalt concrete briquettes was fabricated using absorptive and nonabsorptive aggregates and then encapsulated in epoxy resin, while a duplicate set of specimens was not encapsulated. To our surprise, after a relatively short weathering period on the roof of the laboratory, those encapsulated briquettes fabricated using absorptive aggregate expanded to such an extent that the epoxy coating was completely ruptured (Fig. 1). Measurements of these briquettes showed that their volume had increased by approximately 19 percent, while the epoxy-encapsulated specimens containing nonabsorptive aggregate did not expand measurably and the epoxy coating remained intact. These observations indicated that moisture may have penetrated through minute holes in the epoxy coating and caused the absorptive aggregates to expand. It was theorized that if the force created by the expanding aggregates was sufficient to rupture the epoxy coating, then the same force might be sufficient to crack or fail an asphalt concrete pavement. It was also reasoned that if this expansion was due to the absorptive aggregates, then it might be possible to classify those aggregate types which were expansive by determining their absorptive tendency.

On the basis of the above-noted findings, it was decided to attempt to develop a research laboratory procedure which would permit the determination of the expansive tendencies of aggregates and to relate the results to field performance. It was expected that the research test procedure might require rather elaborate specimen fabrication and laboratory weathering processes. Since our original findings indicated that absorptive aggregates were involved, one of the first tests studied was the Modified Centrifuge Kerosene Equivalent Test (Modified CKE) (1). Also studied was the Immersion Compression Test, the Percent of Asphalt Absorption as determined by the Rice Method (Asphalt Institute M52) and the amount of aggregate clay content. This report will present our development of a research laboratory expansion test, our field correlations with it to date, and a modified expansion test that provides results in a relatively short period. Also discussed are our findings relative to other tests studied as potential indicators of expansive properties.

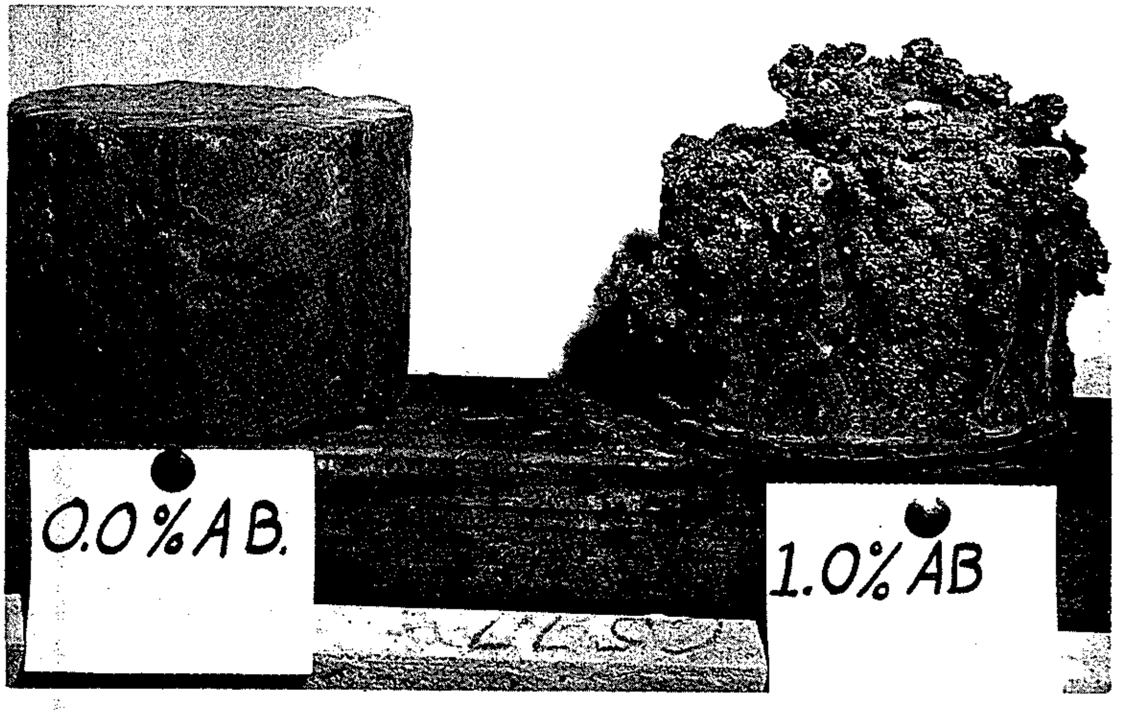


Figure 1

EPOXY ENCAPSULATED BRIQUETTES

CONCLUSIONS

1. There appears to be a useful correlation between the results of the Modified CKE and Expansion Tests and the relative field performance of asphalt concrete pavement containing treated and untreated aggregates.

2. There does not appear to be any overall agreement between the Expansion Test results and results obtained by the Immersion-Compression Test (AASHTO-T-165).

3. There does not appear to be any useful correlation between the results of the Expansion Test and the percent of asphalt absorption as determined by the Rice Method (Asphalt Institute MS-2).

4. Aggregate that contains even small amounts of montmorillonite clay will expand enough to cause possible premature pavement distress.

IMPLEMENTATION

It is recommended that new aggregate sources to be used for asphalt concrete pavements on State contracts and existing sources associated with unsatisfactory pavement performance that may have been caused by expansive and/or absorptive aggregate be tested using the Modified CKE Test. If the absorption is in excess of 0.60 percent, the 24-hour Expansion Test should be used to evaluate the tendency of an asphalt concrete containing the aggregate to expand excessively. If the expansion exceeds 0.040 inches, and if the use of another less expansive aggregate is economically prohibitive, lime slurry treatment of the expansive aggregate should be seriously considered. Also, any aggregates with absorptions less than or equal to 0.60 percent that come from sources in or near deposits of montmorillonite clay should be tested using the 24-hour Expansion Test for expansive tendencies and lime slurry treatment considered if expansion greater than 0.040 inches is measured. The Expansion Test should be used to measure the effect of the lime slurry treatment.

DEVELOPMENT OF EXPANSION TEST

General

A test method was developed to measure the expansion of asphalt concrete test bars. Descriptions of this method have been previously published (2,3). Briefly, the method consists of compacting paving mixtures into 3" x 3" x 11.25" steel molds using the California kneading compactor. After cooling, the specimen is removed from the mold and epoxy applied to the ends of the compacted bar to prevent any movement of the cast in place steel pins. The bars are then cured at 100°F for approximately 60 hours before being subjected to weathering cycles. Each weathering cycle consists of seven days in a moist room followed by seven days in a 100°F oven. The specimens are generally subjected to six weathering cycles, during which length measurements and visual observations are made daily. The measurements are made with a micrometer to the nearest 0.001". The time required to complete this Expansion Test is in excess of 12 weeks.

Since the publication of this test procedure (2,3), a modified procedure has been developed in which the expansion of the asphalt concrete test bar is measured after conditioning in a 100°F water bath for 24 hours. The correlation between the expansion results obtained with the normal procedure (requiring more than 12 weeks) and the new method requiring 24 hours is shown in Figure 2. For the 12 tests completed to date, the correlation looks very promising.

Expansion vs. Absorption

The relationship between expansion and absorption (kerosene) shown in Table 1 and Figure 3, generally indicates that as absorption increases, expansion also increases. However, because of the wide range of expansion values for each range of absorption values, no distinct relationship between absorption and expansion was evident. In this study, as shown in Figure 3 and Table 1, there were mixes containing aggregates having absorptions (Mod. C.K.E.) of 0.6 to 1.0 percent, yet the expansion was quite low. Those mixes which are highly absorptive and low in expansion were placed in the moist room, as in the regular test procedure, or in the 100°F water bath, as in the modified test procedure, at the conclusion of the regular test. Eventually, most of these test bars expanded until the stresses were greater than the ultimate strength of the aggregate, at which time the aggregate began to disintegrate as shown in Figure 4. In this case, the absorption was 1.0 percent and the maximum expansion was 0.041". Other asphalt concrete test bars expanded as much as 0.080" even though the aggregates had an absorption of only 0.2 percent (Modified CKE). In this case, however, the aggregate source contained a small amount of montmorillonite clay, which is capable of exerting tremendous pressure when in the presence of water. Also, there is another reason why some asphalt concrete test bars have shown a poor correlation between absorption and expansion (Figure 3), and that is the film thickness of the asphalt. For instance, as described in a previous report(2,3), the use of a fairly

COMPARISON OF THE TWO TESTS FOR EXPANSION

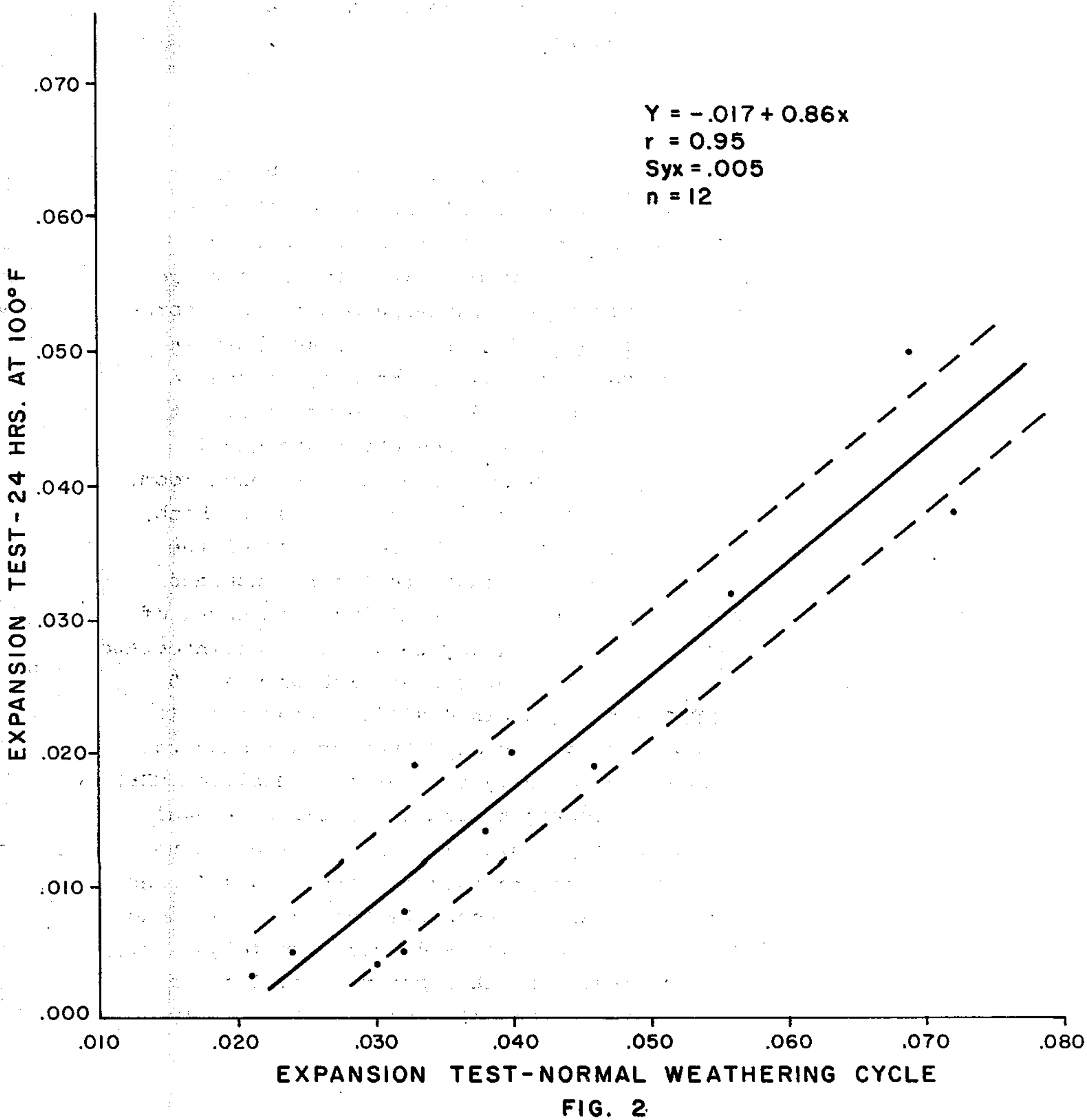


FIG. 2

Table 1

ABSORPTION VS EXPANSION

Absorption	0.0	0.1 & 0.2		0.3 & 0.4		0.5 & 0.6	0.7 & 0.8	0.9 & Greater
	.018	.010	.040	.010	.044	.005	.026	.041
		.012	.040	.010	.045	.014	.165	.071
		.015	.041	.014	.048	.016	.190	.076
		.017	.042	.017	.048	.016		.210
		.019	.042	.026	.048	.031		
		.020	.043	.027	.050	.047		
		.024	.043	.031	.052	.050		
		.025	.046	.032	.054	.052		
		.028	.048	.034	.058			
		.028	.051	.035	.062			
		.030	.053	.036	.064			
		.032	.055	.037	.065			
		.034	.063	.039	.066			
		.036	.064	.041	.070			
		.037	.074	.041	.083			
		.037	.080	.042				
		.040						

$\bar{X}$ = .018 $\bar{X}$ = .038 $\bar{X}$ - .043 $\bar{X}$ - .029 $\bar{X}$ = .129 $\bar{X}$ = .100

AGGREGATE ABSORPTION VS ASPHALT CONCRETE EXPANSION

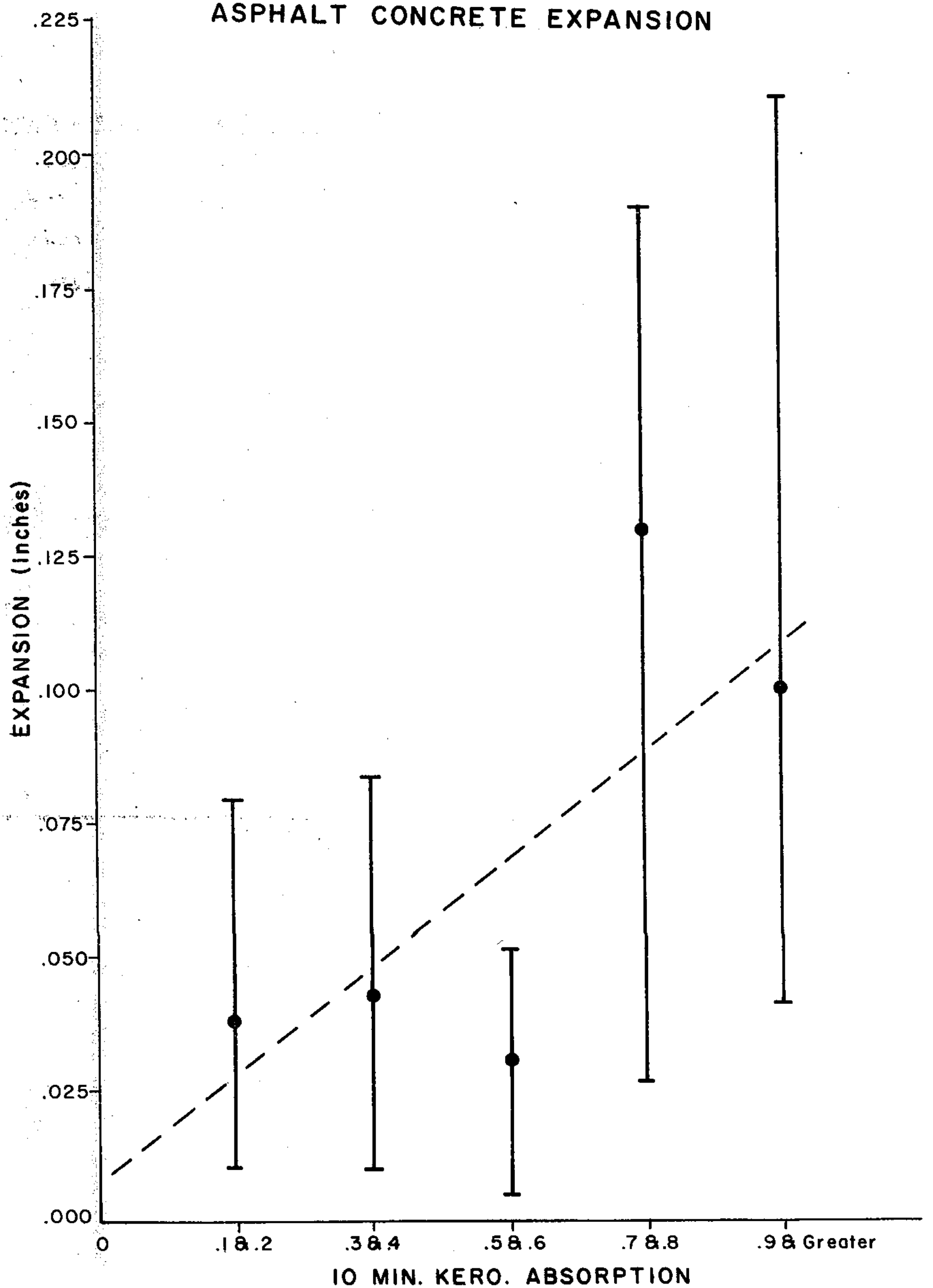
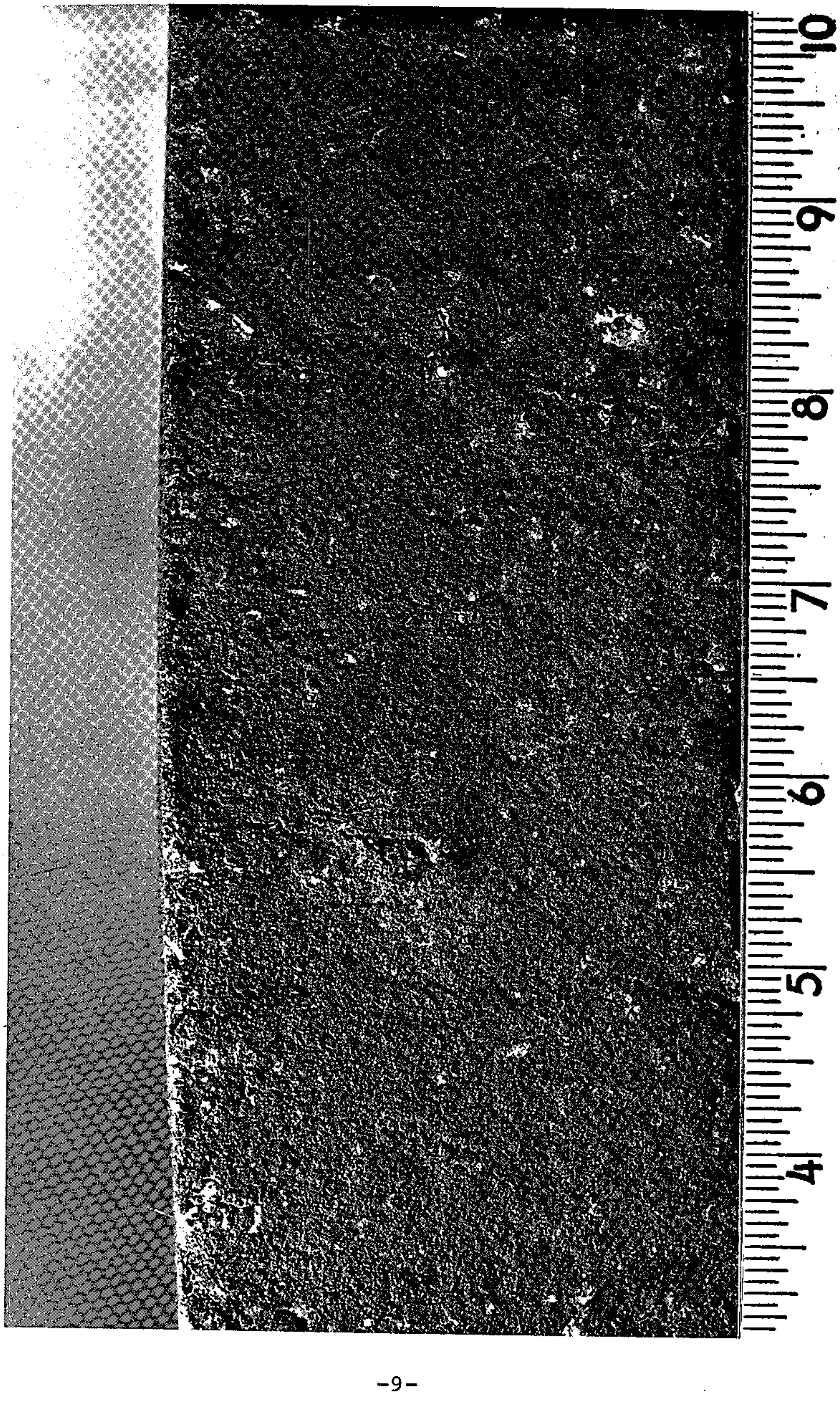


FIG. 3



AGGREGATE DISINTEGRATION

FIGURE 4

absorptive (0.6%) aggregate in a test bar resulted in an expansion of 0.049". However, by increasing the average film thickness by one micron, and thereby apparently providing a uniform, more impermeable film, the expansion was reduced to 0.008".

Laboratory Test/Field Performance Correlation

In July 1961, an experimental test section was constructed in District 10 to evaluate the effectiveness of mineral fillers in asphalt concrete pavement. The test section was located near Stockton in the Sacramento Valley. Although not on a mainline route, the test section does, however, carry a large volume of truck traffic. Structurally, the test section consisted of 3 inches of California Type "B" asphalt concrete, 8 inches of Class "B" road mixed cement treated base, and 13 inches of aggregate subbase. The test section was divided into four sections as follows:

A. Control Section - normal asphalt concrete with no mineral filler added.

B. Limestone Section - 2% commercial limestone filler added to the mix.

C. Asbestos Fiber Section - 2% asbestos fiber added.

D. Asbestos Powder Section - 2% powdered asbestos added.

The absorption and expansion test results for the above mixes were:

a.	Control Section	0.4%	absorption	Max	Expansion		0.057"
b.	Limestone "	0.4%	"	"	"		0.060"
c.	Asbestos Fiber Section	0.7%	"	"	"		0.073"
d.	Asbestos Powder Section	0.0	"	"	"		0.029"

The above expansion data are graphically presented in Figure 5.

The expansion curve for the four AC mixes is presented in Figure 6. As shown, all the expansion test bars cracked with the exception of the bar containing the powdered asbestos. The bar containing the fiber asbestos cracked on the first day in the 100°F oven. These expansion tests were performed in 1961. At that time, the prescribed time the test bars remained in the moist room and 100°F oven had not been standardized as is now the case.

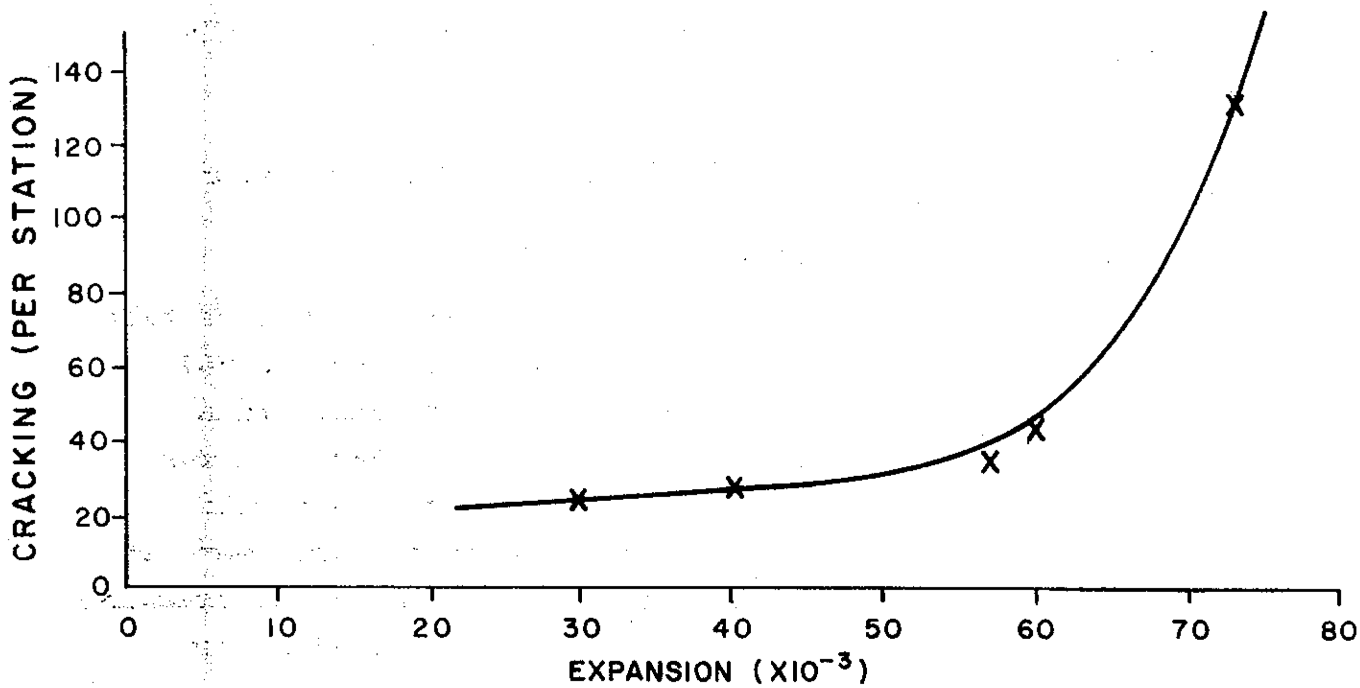
Crack surveys were made periodically. The results are shown in Figure 7.

Hairline transverse cracks appeared in the asbestos fiber section approximately two weeks after construction. The October 1961 survey recorded 76 lineal feet of cracking per station; this increased to 92 lineal feet per station in April 1962. It was also noted during the 1962 survey that the transverse cracks ranged from 1/16" to 1/8" in width and that these cracks were at 10-foot intervals throughout this section. The amount of cracking has steadily increased with time. In the January 1965 survey 138 lineal feet of cracking per station was recorded.

Photographs of the best (asbestos powder) and worst sections (asbestos fiber) are shown in Figure 8 after 5 years (1966). Since 1966, all the sections have continued to deteriorate, with the exception of the powdered asbestos section which has remained in good condition.

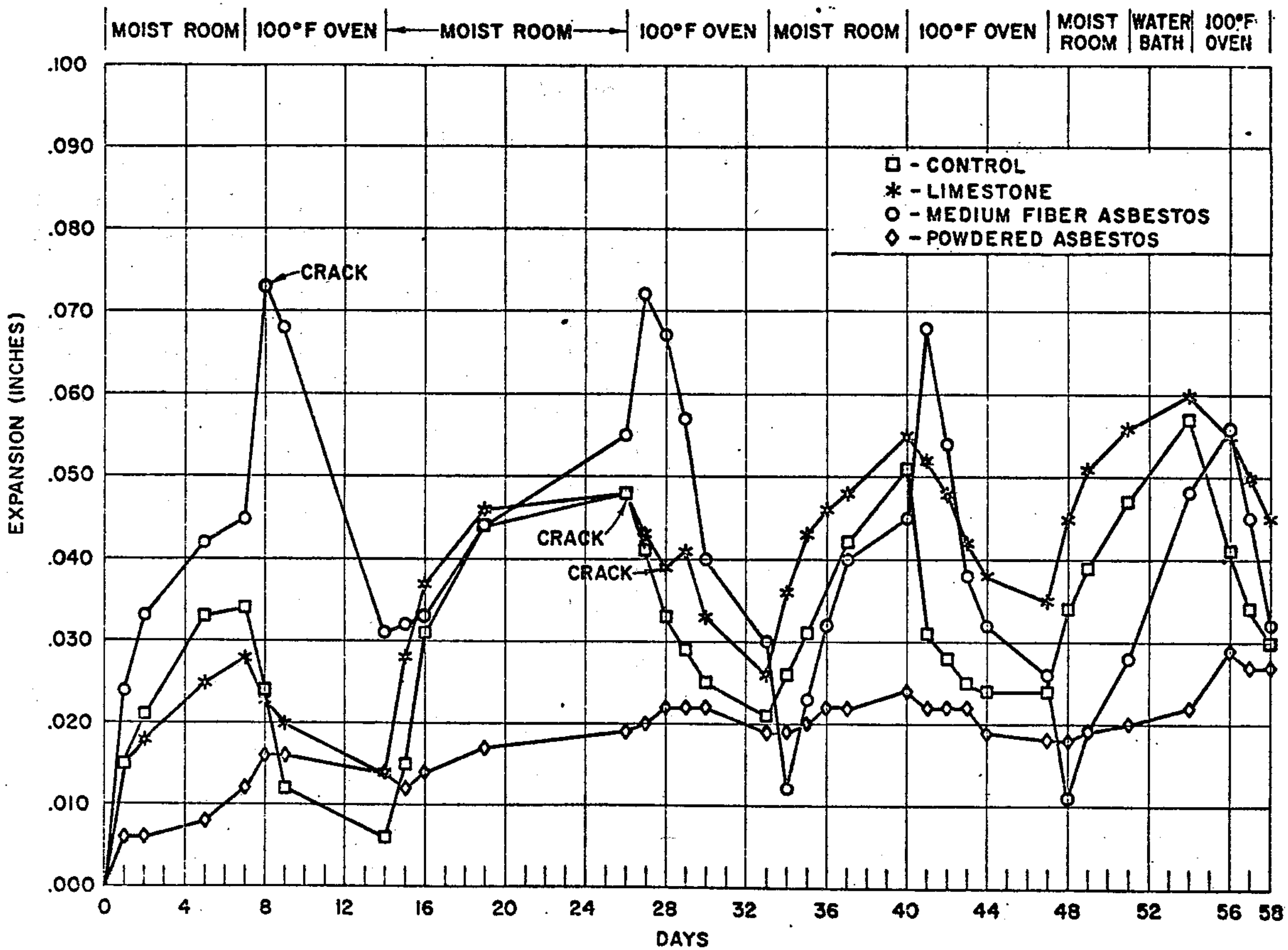
A second project (4) was constructed in 1965 in the northeastern part of California near the town of Likely. Aggregates from this area are of volcanic origin and generally contain expansive

STOCKTON JOB



CORRELATION BETWEEN CRACKING AND EXPANSION OF LABORATORY TEST SPECIMENS

FIG. 5



EFFECT OF VARIOUS FILLERS

FIGURE 6

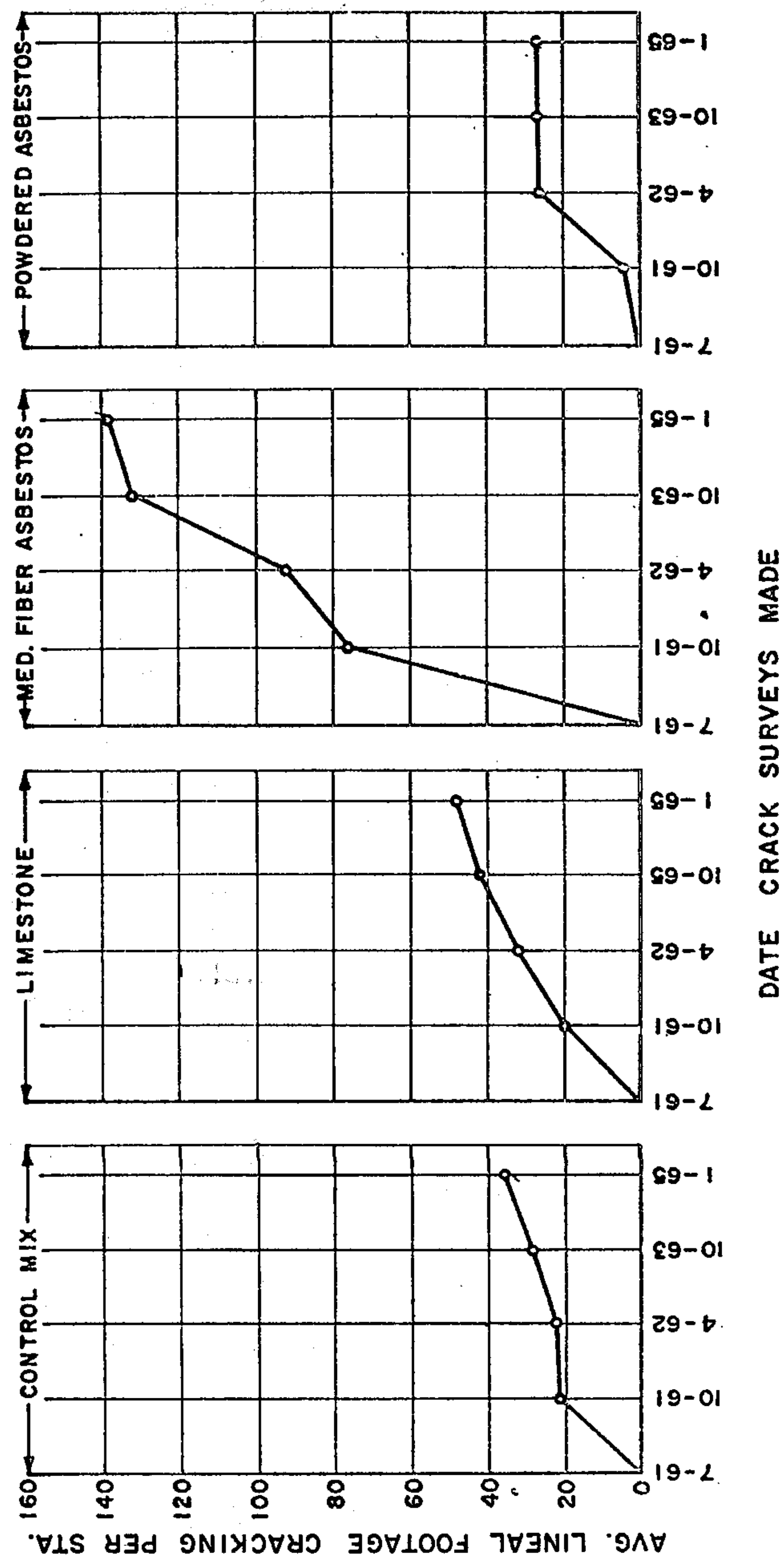
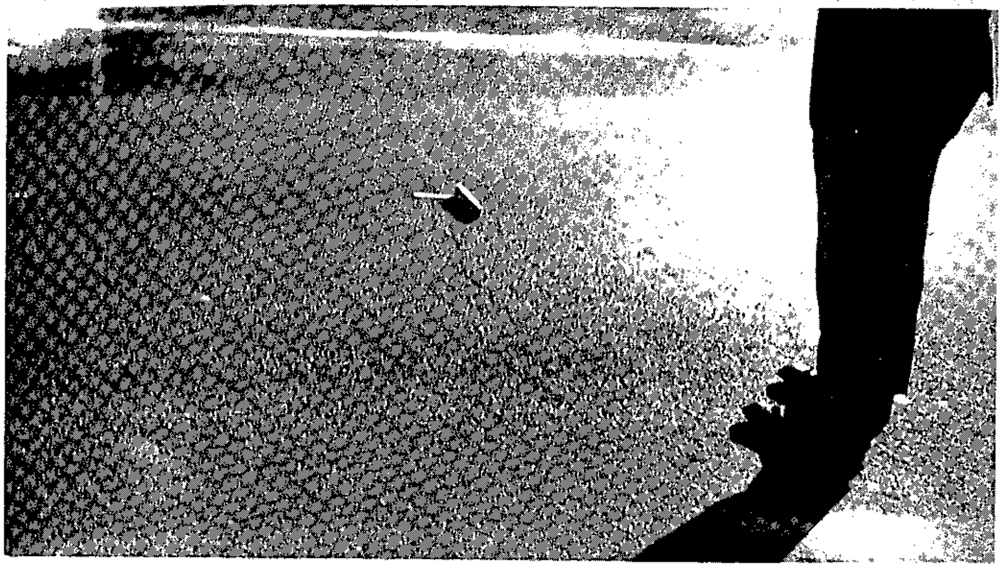
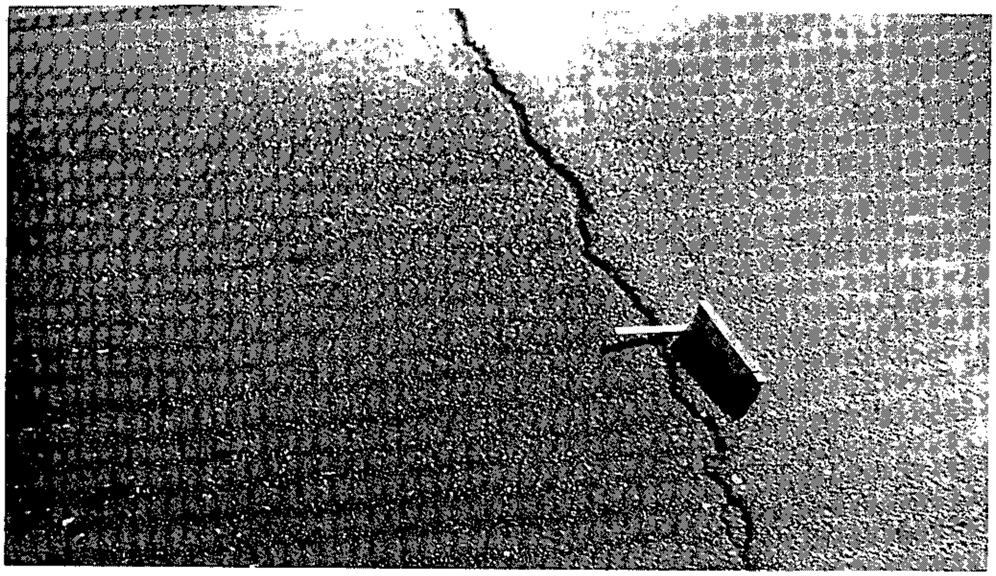

CONTROL MIX
LIMESTONE
MED. FIBER ASBESTOS
POWDERED ASBESTOS
AVG. LINEAL FOOTAGE CRACKING PER STA.
160
140
120
100
80
60
40
20
0
7-61
10-61
4-62
10-63
1-65
DATE CRACK SURVEYS MADE

FIGURE 7



Asbestos Powder Section After 5 Years



Asbestos Fiber Section After 5 Years

FIGURE 8

clays such as montmorillonite and nontranite. Asphalt concrete containing these absorptive aggregates has often developed premature raveling and transverse cracking. This had been attributed to excessive expansion and contraction of the asphalt concrete.

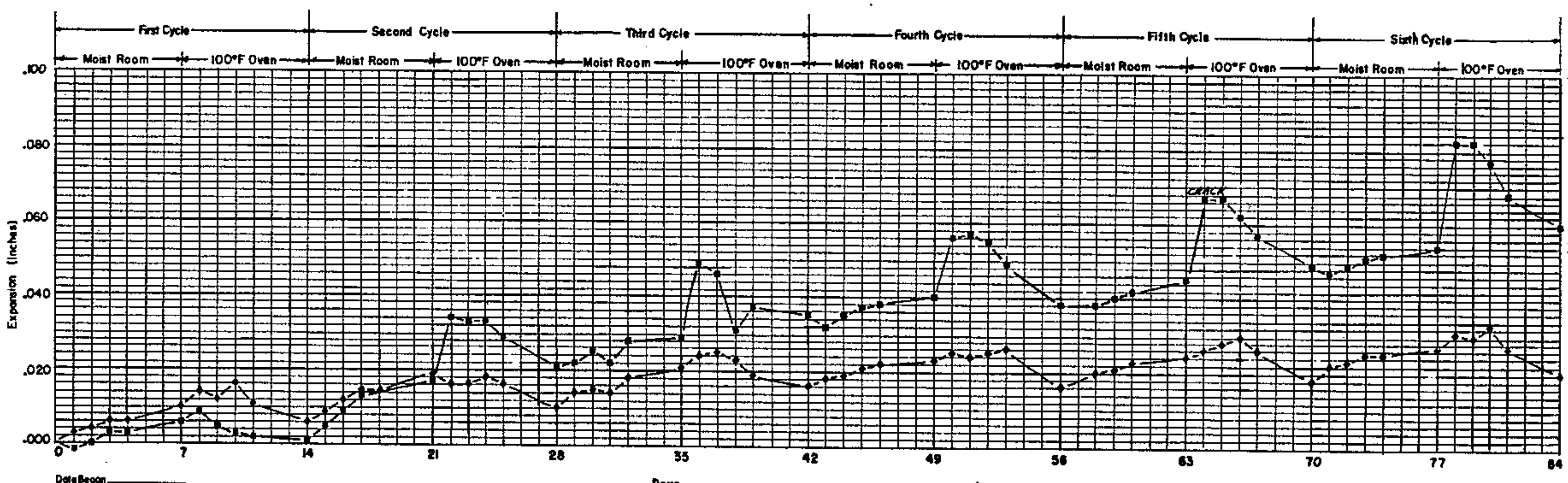
The results of routine tests did not reveal the reason for this asphalt concrete cracking after a relatively short period under traffic. However, the absorption (Modified CKE) of the aggregate used was 1.4 percent so expansion bars were fabricated and tested. The test bars expanded in excess of 0.080", indicating that the asphalt concrete containing these absorptive aggregates was 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.

A preliminary series of laboratory asphalt concrete expansion tests was therefore conducted to evaluate the feasibility of using a lime treatment to prevent the premature distress that had been common in northeastern California. The findings showed lime treatment to be effective in reducing the expansion of these laboratory test specimens from 0.082" to 0.031" (Figure 9). In conjunction with District 02 of the California Department of Transportation, it was agreed to incorporate a test section using a lime slurry additive in a 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. The major portion of the 2.9 mile long, 2-lane wide, project was constructed using aggregate treated with lime slurry; however, there were two 1000' control sections which were not treated.

Yearly condition surveys were made. The results are presented in Table 2. As shown, the lime slurry treatment reduced the

EXPANSION & CONTRACTION OF A-C BARS Test No ______

Dist 02 Co MOD Rte 395 Sec ____ Cont No ____ Location of Source PAULSON PIT - LIKELY % Asphalt 6.9 Grade Asphalt 120-150 Surface Area ____ Film Thickness ____ Absorption ____



■ UNTREATED

◆ LIME TREATED

FIGURE 9

Table 2

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.

amount of cracking considerably. Based on these two studies, there appears to be a correlation between expansion, as measured using laboratory fabricated bars, and the relative condition of the asphalt concrete pavement.

In addition to these attempts to evaluate the field performance correlation with the Expansion Test, an effort was made to correlate Modified CKE absorption with field performance. The eleven Districts of the California Department of Transportation were contacted and field performance requested for those asphalt concrete pavements containing aggregate with Modified CKE absorptions of 0.50 percent or more. Nine of the eleven Districts had pavements containing aggregates of this type. The data is presented in Table 3. It can be seen that in all cases, adjustments such as additional asphalt or wasting of the natural fines were required to obtain acceptable performance from the pavement containing these absorptive aggregates. It therefore appears as though aggregates exhibiting absorption of at least 0.60 percent should generally be tested further to ascertain their suitability for use in asphalt concrete pavement.

EXPANSION VS. IMMERSION COMPRESSION TEST (AASHTO-T-165)

The Immersion Compression Test is one of several tests involving exposure of AC test specimens to moisture. In two independent studies, one by Eager (5) and the other by O'Harra (6), data was presented showing a close correlation between Immersion Compression Test results and actual field performance of asphalt concrete pavements. Consequently, both researchers suggested a criteria for judging the quality of an aggregate based upon the results of the Immersion Compression Test. A retained strength of not less 70 percent, after the briquette is soaked in a 140°F water bath for 24 hours and then tested for compressive stength per AASHTO Test T-167, was the recommended minimum.

Table 3

Modified CKE Absorption vs. Field Performance

Percent Absorption	Performance
0.5	Borderline.
0.5	Surface dry (spalling & pitting).
0.5	Do not use this site anymore.
0.5	Have had some problems with mud drying up. Must use more asphalt than recommended by CKE test.
0.5	Problems with cracking and spalling.
0.5	Problems with pavement drying; source is no longer being used.
0.6	Poor road performance OK to use if natural fines are wasted.
0.6	Surface dry (spalling & pitting).
0.6	Poor performance; transverse cracking and spalling.
0.6	Had problems.
0.6	Have had problems with pitting and cracking.
0.7	Poor road performance
0.7	Surface dry (spalling & pitting).
0.7	Poor performance, cracking.
0.8	Pavements constructed from both sources have been overlaid. One source is no longer being used.
0.8	Same as above.
0.8	Poor performance.
0.9	Good; however, more asphalt is needed than recommended by the CKE test.
0.9	Same as above.
0.9	Some problems; not used anymore.
1.0	Have had problems with this source.
1.2	Do not use as an 14C aggregate source.
1.4	Same as above.
1.4	Poor road performance.
1.9	Poor road performance.

Because all the field expansion problems that had been encountered involved exposure of the AC to moisture, a study of this standard AASHTO test was undertaken.

A comparison was made to determine if the Immersion Compression Test could be used as a quick method for predicting expansion. The data presented in Table 4 and Figure 10 indicate that there is no useful correlation between these tests.

EXPANSION VS. ASPHALT ABSORPTION (RICE METHOD)

Another test procedure that was investigated was the Rice Method for determining asphalt absorbed by the aggregate in the asphalt concrete mix. This was investigated because it was reasoned that the tendency of asphalt concrete to fail may be associated with the film thickness of the asphalt on the aggregate. The Rice Method, as outlined in The Asphalt Institute Manual (MS-2), is based upon the maximum theoretical specific gravity of the mixture and its composition in terms of aggregate and total asphalt content. As stated in the Rice procedure, the first step involves calculating the "virtual" specific gravity for the aggregate mixture.

The volume of asphalt absorbed by an aggregate is generally less than the volume of water absorbed; therefore, the "virtual" specific gravity generally should be between its bulk and apparent specific gravities. The amount of asphalt lost by absorption is:

$$A_{ac} = \frac{Gv - Gag}{Gv \cdot Gag} 100$$

where, A_{ac} = asphalt lost by absorption into the aggregates as pounds of asphalt per 100 pounds of dry aggregate.

Gv = the "virtual" specific gravity of the aggregate

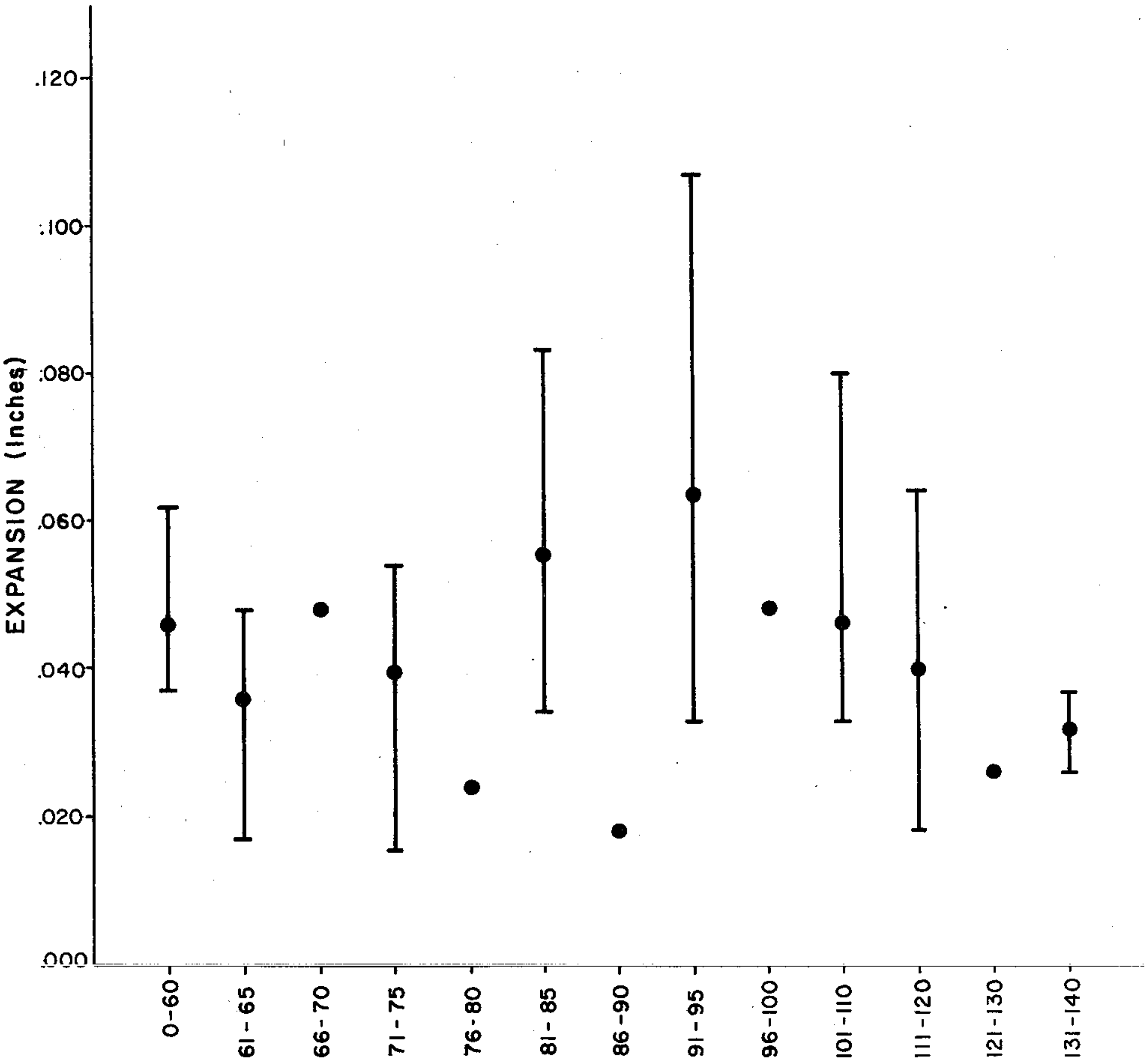
Gag = bulk specific gravity of the aggregate

Table 4

Immersion Compression Test Results
vs. Expansive Test Results
(85-100 Pen Asph only)

I-C Test Retained Strength	Expansion Results (Inches)	$\bar{X}$
0-10		
11-20		
21-30	.40	0.40
31-40	.46, .62	0.54
41-50	.37	0.37
51-60	-	-
61-65	.48, .39, .41, .17	0.36
66-70	.48	0.48
71-75	.41, .51, .54, .42, .27, .15, .41	0.39
76-80	.24	0.24
81-85	.83, .52, .34, .50	0.55
86-90	.18	0.18
91-95	.40, .32, .71, .107	0.63
96-100	.48	0.48
101-110	.37, .34, .31, .80	0.46
111-120	.39, .64, .16, .42	0.40
121-130	.26	0.26
131-140	.37, .26	0.32

EXPANSION VS IMMERSION
COMPRESSION TEST



IMMERSION COMPRESSION TEST

RETAINED STRENGTH (%)

24 HR. SOAK IN 140°F WATERBATH (85-100 ASPHALT)

85-100 PEN ASPH ONLY

FIG. 10

The Rice Method, as outlined in The Asphalt Institute Manual (MS-2) for determining the amount of asphalt absorbed by the aggregates, was used to generate the data presented in Figure 11. As shown, several specific gravity methods were used for the aggregates; however, there does not appear to be any correlation, regardless of the specific gravity method used, between expansion and percent asphalt absorbed as measured by this method.

EXPANSION VS. MONTMORILLONITE

Studies have shown that the X-ray Diffraction and D.T.A. (Differential Thermal Analysis) Tests can be used to detect the presence of expansive material, such as montmorillonite, in soil samples. It is a known fact that montmorillonite is a highly expansive clay and that the presence of this clay in AC aggregates, even in small amounts, will be detrimental when the AC is exposed to moisture. It has been reported that calcium-saturated montmorillonite, on free swell, can increase in volume 1-1/2 times, to 150 percent of its original volume while sodium saturated montmorillonite can increase in volume 15 to 20 times. Aggregate containing this clay, when exposed to water, has been known to fracture under the pressure exerted by the wet, expanding montmorillonite clay. Pressures in excess of 500 psi have been recorded when this clay has access to moisture. Testing to determine the relationship between expansion and montmorillonite clay content was therefore considered worthwhile.

The results are illustrated in Figure 12. All the AC test bars that contained montmorillonite expanded more than 0.030". The average expansion of all the test bars containing montmorillonite was 0.055". From this information, it is apparent that the X-ray Defraction and D.T.A. Tests could be used to detect the presence of montmorillonite in a sample so as to avoid the use

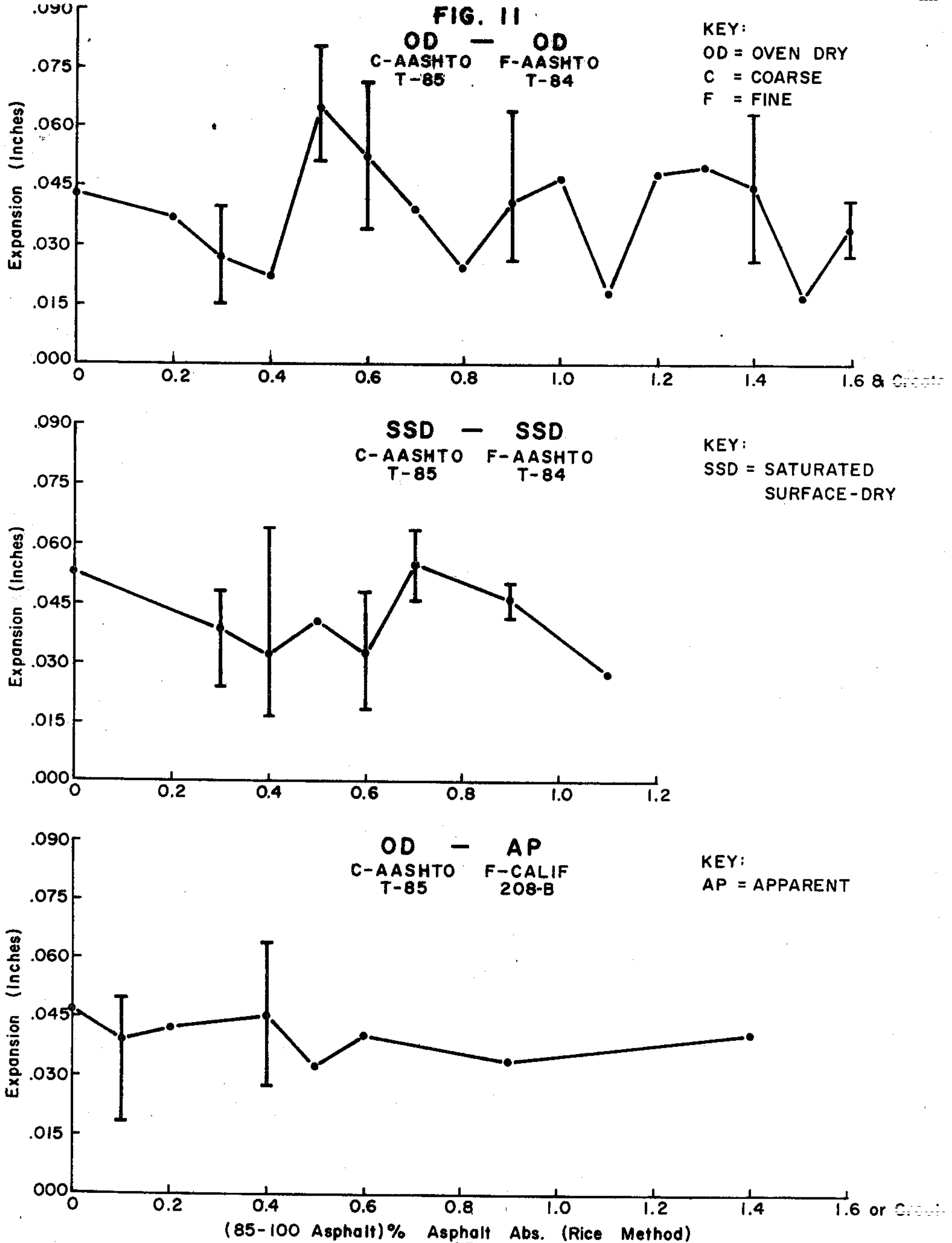

OD — OD
C-AASHTO T-85
F-AASHTO T-84
KEY:
OD = OVEN DRY
C = COARSE
F = FINE
Expansion (Inches)
.000
.015
.030
.045
.060
.075
.090
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6 &
SSD — SSD
C-AASHTO T-85
F-AASHTO T-84
KEY:
SSD = SATURATED SURFACE-DRY
OD — AP
C-AASHTO T-85
F-CALIF 208-B
KEY:
AP = APPARENT
1.6 or
(85-100 Asphalt) % Asphalt Abs. (Rice Method)

FIG. 11

ASPHALT CONCRETE EXPANSION
VS
MONTMORILLONITE CONTENT

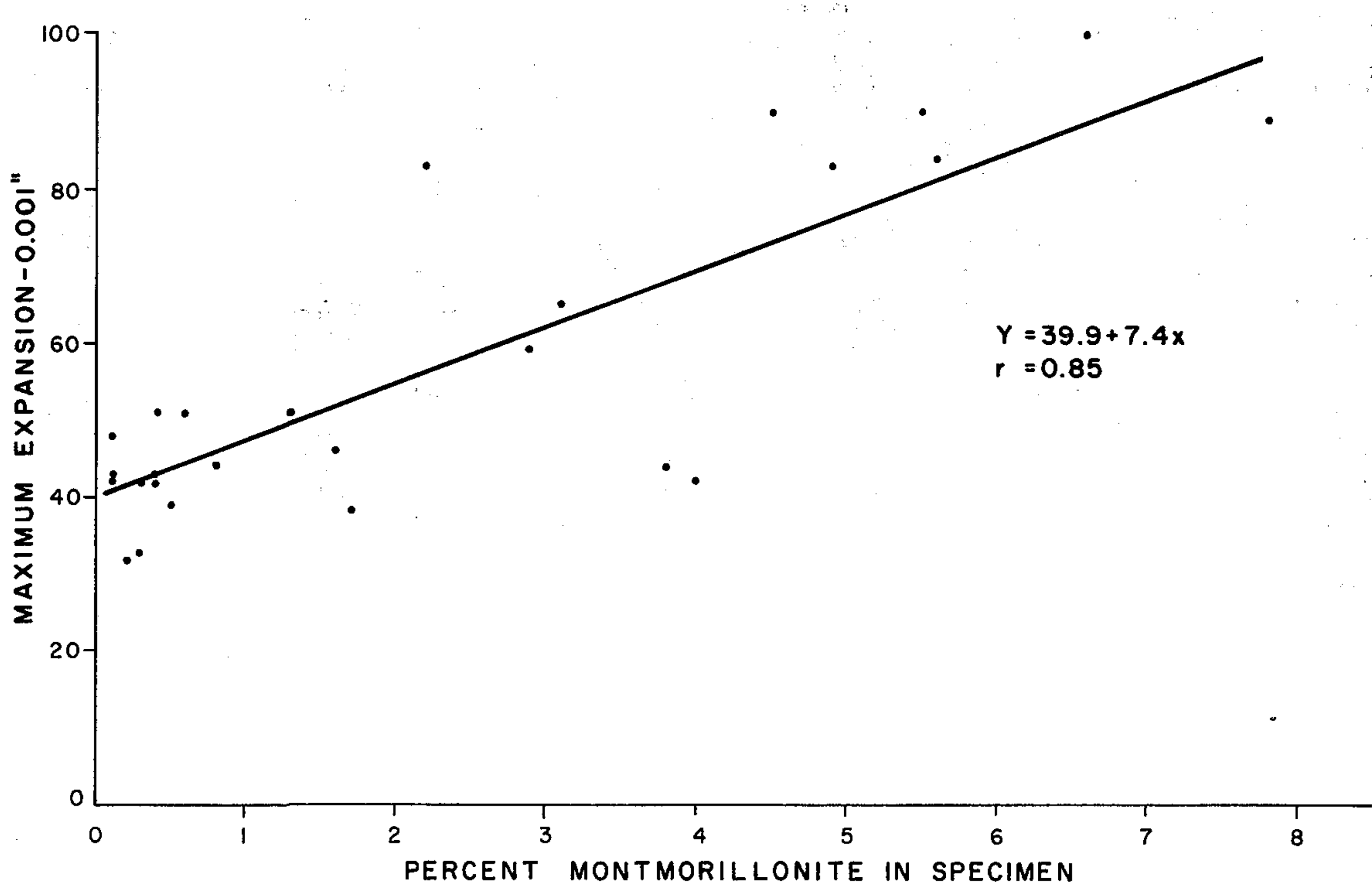


FIG. 12

of this material wherever possible. Due to their complexity, however, these tests would not be suitable for routine contract control specification compliance testing.

SUMMARY

The results of the Stockton and Likely test sections indicated that there may be a useful correlation between asphalt concrete aggregate absorption, as measured using the Modified CKE Test, asphalt concrete expansion, as measured by the Expansion Test, and the relative performance of asphalt concrete pavement containing treated versus untreated expansive aggregate. However, the limited amount of data acquired for this study (only two field projects) and the absence of a well-defined, uniform relationship between the magnitude of the aggregate absorption, asphalt concrete bar expansion, and subsequent field performance indicated that the adoption of an aggregate qualification specification based upon the Modified CKE Test and/or the Expansion Test would be premature at this time. Also, of all the test methods examined in an effort to find or develop a test that could be used in lieu of the time-consuming Expansion Test, only the 24-hour modified Expansion Test appears to have promise.

REFERENCES

1. Cechetini, James A., "Modified Centrifuge Kerosene Equivalent Test," presented at the 46th Annual Meeting of the Association of Asphalt Paving Technologists, February 1971.

2. Zube, E. and Cechetini, J., "Expansion and Contraction of Asphalt Concrete Mixes," Proceedings, Highway Research Board, Publication 1321, 44th Annual Meeting, January 1965, pp 141-163.

3. Zube, E., "Cracking of Asphalt Concrete Pavements Associated with Absorptive Aggregates," Association of Asphalt Paving Technologists, Vol. 35, p 270, 1966.

4. Sherman, G. B. and Cechetini, J., "Investigation of Lime Slurry to Control Expansive Aggregates," State of California, Department of Public Works, Division of Highways, Materials and Research Department, Research Report 633113-2, September, 1973.

5. Eager, William L., "Effect of Moisture on Bituminous Pavements in Rocky Mountain Areas," Public Roads, Vol. 33, No. 3, August 1964, pp 48-54.

6. O"Harra, W. G., "Benefication of Hydrophylic Aggregates: An Evaluation of Proposed Treatments of Arizona Aggregates," presented to HRB Committee MC-A2, Annual Meeting of the Highway Research Board, January 1967.