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16. ABSTRACT

Numerous reports have been published by various agencies on the advantages of adding mineral fillers to asphalt concrete paving mixtures. Some of the advantages of adding mineral fillers, as stated in these reports are:

1. Increase in tensile properties of the mixtures.
2. A greater resistance to impact loads.
3. Greater flexibility.
4. Permits the use of a higher percent of asphalt.

In July 1961, the Pavement Section of Headquarters Laboratory with the cooperation of District 10, constructed an experimental test section to evaluate the effectiveness of mineral fillers in asphalt concrete pavement. The test section located near Stockton, while not a mainline route, does however, carry a large volume of truck traffic.

Structurally, the test section consisted of 3-inches of Type "B" asphalt concrete, 8-inches of Class "B" road mixed cement treated base, and 13-inches of aggregate subbase.

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State of California
Department of Public Works
Division of Highways
Materials and Research Department

August 16, 1965

Research Authorization
Number 431188

Mr. L. R. Gillis
Asst. State Highway Engineer
Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is:

A Report Covering The

EVALUATION OF MINERAL FILLERS

IN ASPHALT CONCRETE

(10-SJ-5-C-A,C,D. Contract 60-10TC26)

Study made by .... Pavement Section
Under general direction of .... E. Zube
Work supervised by .... M. Nelson
J. Cechetini
Report prepared by .... M. Nelson
J. Cechetini

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INTRODUCTION

Numerous reports have been published by various agencies on the advantages of adding mineral fillers to asphalt concrete paving mixtures. Some of the advantages of adding mineral fillers, as stated in these reports are:

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In July 1961, the Pavement Section of Headquarters Laboratory with the cooperation of District 10, constructed an experimental test section to evaluate the effectiveness of mineral fillers in asphalt concrete pavement. The test section located near Stockton, while not a mainline route, does however, carry a large volume of truck traffic.

Structurally, the test section consisted of 3-inches of Type "B" asphalt concrete, 8-inches of Class "B" road mixed cement treated base, and 13-inches of aggregate subbase.

The test section, shown in Figure 1, is 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 comparative cost estimates per ton of mix for the above-mentioned sections are:

A.	Control Mix Section	=	$5.50 per ton	
B.	AC with Limestone Filler	=	7.22 " "	, 31% increase
C.	AC with Asbestos Fiber	=	9.64 " "	, 75% increase
D.	AC with Asbestos Powder	=	7.28 " "	, 32% increase

The above cost figures should not be considered as entirely representative for this type of construction as the tonnage involved was small and the construction of the test section was paid for as extra work as it was not a part of the contract.

Data will be presented on the preliminary mix design, placing and rolling procedure of the asphalt concrete, and results from field and laboratory tests.

SUMMARY

Since the construction of the test sections in 1961 several condition surveys have been made. The following is a brief summary on each of the four sections. A detailed condition survey is presented later in this report.

Approximately two weeks after construction, transverse hairline type cracks appeared in the medium fiber asbestos section(C). It took approximately three months for a few hairline type cracks to appear in the other three sections (A,B and D).

The size and number of cracks in the "C" section increased rapidly with each successive survey while the rate of cracking in the other sections progressed much more slowly.

The transverse cracks in the "C" section ranged from 1/16" to 1/8" in width and occurred at approximately 10 foot intervals. The cracks in the other three test sections (A,B and D) were smaller in size and occurred in a more random type pattern.

A final crack survey of all test sections made in 1965 showed the following: (Fig. 2)

A. Control Section-36 lineal feet per station.

B. Limestone Filler Section-48 lineal feet per station.

C. Medium Fiber Asbestos Section-138 lineal feet per station.

D. Powdered asbestos section-27 lineal feet per station.

CONCLUSIONS

From physical test data and periodic condition surveys over a 4½ year period of actual service performance of these test sections it is concluded that:

1. Section "C" containing the Med. asbestos fiber which showed the highest tensile strength by laboratory test exhibited the poorest service performance.

2. Results from the expansion-contraction[3] test (Fig. 3) and condition surveys indicated the asphalt concrete mix with powdered asbestos filler had increased the flexibility of the mix. The other two mineral fillers failed to show any visible signs of increasing the flexibility of the mix, as cracking appeared both in AC test sections and in the expansion-contraction specimens for these fillers.

3. Of the three mineral fillers used, one filler did accommodate 0.3% more asphalt than the control mix. The other two fillers, however, required less asphalt than the control mix as shown in Table 1.

4. Data from this study and previous studies have pointed out that no specific type of mineral filler can be used for all types of AC mixes with assured success.

RECOMMENDATION

It is recommended, that when a mineral filler is required, expansion-contraction test bars be made using various known fillers. From the results of the expansion-contraction tests, one would be able to evaluate the various fillers. The filler which proved to be the most effective for that particular AC mix would be selected for use.

PRELIMINARY STUDY

Aggregate samples were obtained for preliminary design from the source selected to supply material for the test section. From the preliminary test results (Table 1), the grading and the asphalt content were determined for each of the four mixes to be used in the test section.

FIELD COMPACTION PROCEDURE FOR THE ASPHALT CONCRETE

The asphalt concrete was placed by a Barber-Greene paver. The rolling was in accordance with the 1960 Standard Specifications; that is, the breakdown pass was made by a 12 ton, two-axle tandem roller, followed by a pneumatic tired roller. The final rolling was completed by an 8 ton tandem, steel wheel roller.

Tables 2 and 3 show the temperatures of the various mixes when delivered to the test section. Also included are the air and pavement temperatures during breakdown rolling.

SAMPLING OF MATERIALS

(a) Aggregates (Source: Munn & Perkins in Escalon)

Although the aggregate source was sampled prior to road construction, aggregate samples were periodically taken during operation for sieve analysis. Several sacks of raw aggregates were also obtained for future asphalt concrete research studies.

(b) Asphalt (85-100 Penetration)

Asphalt samples were taken from the circulating line, as well as the storage tank. The test results for the asphalt samples are shown in Table 4.

(c) Asphalt Concrete

As shown in Tables 2 and 3, no appreciable loss in temperature was noted even though, the haul distance from the hot plant to the job site was approximately 30 miles. The reason for the slight loss in temperature was due to the asphalt concrete being covered with tarpaulins during the trip from hot plant to the job site.

Samples of asphalt concrete were taken from the hopper of the Barber-Greene paver. Two 50 lb. sacks of the level course and two sacks of surface course were obtained from each of the four sections.

PHYSICAL TESTS PERFORMED IN FIELD AND LABORATORY

(a) Water Permeability Test

The first test to be made on the completed pavement was the Water Permeability Test. Tests were made on the various sections approximately one hour after the final rolling and again twenty-four hours later. The permeability of the different sections is shown in Table 5.

The maximum permeability for a dense graded asphalt concrete pavement has been tentatively set at an average of 150 ml/per minute approximately 24 hours after placing. As shown in Table 5, all sections met this tentative requirement with the exception of the control mix section, which was slightly above the average maximum limits.

(b) Condition Survey

Periodic surveys were made and results are as follows:

Control Section (Sta. 25+00 to 27+80)

Transverse cracks ranging from hairline to 1/16" in width were visible in October 1961 when the first condition survey was made. The lineal footage of cracks per station in October 1961 was 21.5 feet (Figure 2). Since the October 1961 survey, the increase in transverse cracking has been slight. The lineal footage of cracking recorded in the January 1965 survey was 36 feet per station.

This section is in very good condition.

Limestone Section (Sta. 28+50 to 31+25)

Twenty lineal feet per station of hairline transverse cracks were recorded in the October 1961 survey. This amount of transverse cracking increased to 32 lineal feet per station in April 1962. Moderate spalling, or loss of some of the coarse aggregates from the pavement surface, was also noticed during the April 1962 survey. The amount of cracking has steadily increased to 48 lineal feet per station as reported in the January 1965 survey. The cracks now range from hairline to 1/8" in width.

The general condition of this section is good.

Medium Fiber Asbestos Section (Sta. 33+00 to 36+00)

Hairline transverse cracks appeared 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 these cracks were at 10 foot intervals throughout this section. The amount of cracking has steadily increased with time, and in the January 1965 survey 138 lineal feet of cracking per station was recorded. The general condition of this section is fair.

This mineral filler was also used in an experimental asphalt concrete test section in Contra Costa County[1] with similar results. That is, transverse cracks appeared shortly after the pavement had been completed. It might be added, the source of aggregates and the climatic conditions were entirely different for these two projects.

Another recent report has been published in "Evaluation of Asbestos Paving Mixes."[2] This study was made at the U. S. Naval Civil Engineering Laboratory in Port Hueneme, California. The results reported by J. A. Bishop showed that the addition of 2% asbestos fiber did not improve the strength properties of the asphalt concrete mix.

Powdered Asbestos Section (Sta. 36+50 to 40+00)

Transverse cracking increased from 3.5 feet in October 1961 to 27.5 lineal feet per station in April 1962. From April 1962 until the final survey, January 1965, no additional cracking has appeared. This section is in excellent condition.

(c) Stability Test

From the asphalt concrete samples obtained during construction, briquettes were fabricated and tested. As shown in Table 6, the stability of the normal, or control, mix and powdered asbestos filler sections was slightly below 35, while the stability of the limestone and fiber filler sections was 35 or slightly higher.

(d) Test on Asphalt Concrete Cores

Four inch cores were removed periodically from the various test sections. The first series of cores were taken in October 1961 shortly after construction, the second series in December 1962, and the final series in January 1965. Table 7 presents the test data obtained from the cores from the various test sections. The results show the normal trend; i.e., the stability has increased slightly with time. This increase in stability is due primarily to continued compaction by truck traffic. The increase in cohesion is no doubt due to the increase in hardness with age of the asphaltic binder. The average drop in asphalt penetration (Abson Recovery) for all sections was from 58 to 22 (Table 7). This is about the normal hardening rate for an 85-100 asphaltic binder after four years' exposure to normal field conditions.

Considerable difficulty was experienced in recovering the asphalt from the cores by the Abson Recovery method in the medium fiber asbestos section due to the fibers clogging the filters. However, we were able to complete this test on the 1962 cores from this section.

From the Abson Recovery results obtained, and the microviscosity test results, it appears that the asphalt concrete mixes with and without mineral fillers had little or no effect on the asphalt rate of hardening.

(e) <u>Expansion and Contraction Test</u>[3]

Along with the normal routine tests, test bars (3"x3"x11.25") were made from the asphalt concrete samples taken from the four test sections. These test bars were made to determine what effect, if any, the various mineral fillers would have on the expansion and contraction of asphalt concrete. As shown in Figure 3, test bars containing asbestos fiber filler expanded 0.075" during the first cycle (1 cycle equals 7 days in moist room and 7 days in 100°F oven). For the same period of time, the control bar expanded only 0.035". The asbestos fiber filler had increased the expansion 114% over the expansion of the control bar during the first cycle. Transverse cracks also appeared in the test bar containing the asbestos fiber during the first cycle as shown in Figure 3.

The maximum expansion of 0.057" for the control bar occurred during the fourth and final cycle. The maximum expansion for the test bar containing powdered asbestos filler was 0.029" and this also occurred during final weathering cycle. In comparing the maximum expansion of the control bar with the bar containing powdered asbestos, we find that the powdered asbestos has reduced the total expansion 51%. It might be added, transverse cracks appeared in the control test bar during the 2nd weathering cycle. The test bar with powdered asbestos showed no visible signs of cracks during the entire test.

The limestone filler did suppress expansion during the first cycle in comparison with the control bar; however, the succeeding cycles showed this filler ineffective in decreasing expansion. Cracks appeared in the test bar with limestone filler during the second cycle.

As shown, one of the asbestos fillers (powdered) proved to be beneficial to the asphalt concrete mix. However, another asbestos (fiber) has had detrimental effects on the asphalt concrete. Chemically, these two asbestos fillers are the same, the only difference between these fillers is the particle size. One filler consists of medium length strands of asbestos, while the other is powdered.

The results of the expansion-contraction test for AC mixes using the various fillers did correlate with the actual pavement condition. That is, both the expansion-contraction results and the pavement condition survey showed powdered asbestos superior to the control and the limestone section, and all test sections superior to the medium fiber asbestos section.

Data has been presented showing, for this particular AC mix, the powdered asbestos filler to be superior to the other mineral fillers. However, for a different AC mix, the results may show a mineral filler other than the powdered asbestos to be superior.

REFERENCES

1. W. A. Garrison, R. S. Latchaw, "Three Year Evaluation of Shell Avenue Test Road." Presented at the 44th Annual Meeting of the HRB, January 1965.

2. Highway Research Abstract, Vol. 35, No. 5, May 1965.

3. E. Zube, J. Cechetini, "Expansion and Contraction of Asphalt Concrete Mixes." Presented at the 44th Annual Meeting of the HRB, January 1965.

TABLE 1

Preliminary Test Data on
Laboratory Designed A.C. Mix

Grading: Sieve Sizes	Grading: Percent Passing	% Filler Added	% Asphalt Recom.	Stab.	Sp.Gr.	Cohes.
			Normal Mix			
3/4"	100	0	5.0	36	2.37	164
3/8"	75					
4	49					
8	37					
30	17					
200	2					
			Limestone Dust			
3/4"	100	2.0	4.5	37	2.37	220
3/8"	75					
4	49					
8	38					
30	18					
200	4					
			Med. Fiber Asbestos			
3/4"	100	2.0	5.3	37	2.36	400
3/8"	75					
4	49					
8	38					
30	16					
200	2					
			Powdered Asbestos			
3/4"	100	2.0	4.8	38	2.38	315
3/8"	75					
4	49					
8	38					
30	17					
200	2					

TABLE 2

Street Temperature Data

Level Course A. C.

Load No.	Air	Delivery	Initial Roll	Initial Roll + Air Temp.
	Temperature			
		Normal Mix		
1	95°	270°	255°	350°
2	95°	250°	235°	330°
3	96°	210°	170°	266°
		Limestone Dust		
1	95°	270°	260°	355°
2	96°	260°	230°	326°
3	95°	250°	200°	295°
		Med. Fiber Asbestos		
1	95°	310°	260°	355°
2	97°	260°	250°	340°
3	95°	300°	245°	340°
		Powdered Asbestos		
1	85°	210°	260°	345°
2	86°	275°	260°	346°
3	87°	240°	230°	317°

TABLE 3

Street Temperature Data
Surface Course A. C.

Load No.	Temperature: Air	Delivery	Initial Roll	Initial Roll + Air Temp.
			Normal Mix	
1	85°	210°	180°	265°
2	87°	230°	200°	287°
3	88°	240°	215°	303°
			Limestone Dust	
1	80°	240°	220°	300°
2	85°	240°	220°	305°
3	85°	240°	175°	260°
			Med. Fiber Asbestos	
1	75°	280°	240°	315°
2	75°	280°	255°	330°
3	78°	285°	265°	343°
			Powdered Asbestos	
1	65°	265°	250°	315°
2	70°	315°	265°	335°

TABLE 4

Identification Tests On Asphalt

Specification - Designation	AASHO Test Method	Results	Specifications (85-100)
Flash Point (°F)	T-73	450°F	440°F
Penetration of Original Sample at 77°F	T-49	98	85-100
Penetration Ratio	T-49	38	25 Min.
Heptane Xylene Equiv. % Max.	T-102	30-35	35 Max.
Furol Viscosity at 275°F	T-72	130 Sec.	85-260 Sec.
Loss on heating 5 hrs. at 325°F. % Max.(Cal.Test # 337, Thin Film Procedure)	----	0.52%	0.85% Max.
Pen. after loss at 325°F, % of orig. Pen., Min.	T-49	48%	47% Min.
Ductility at 77°F, CM. After loss at 325°F. Min.	T-49	100+CM	85-260

TABLE 5

Field Permeability Test Results

Test Section	Station	Lane	H_2O Perm. 1 Hr. After Rolling Mls/Min			H_2O Perm. 24 Hrs. After Rolling Mls/Min		
			OWT	BWT	IWT	OWT	BWT	IWT
Control Normal Mix	25+25	WBT						215
	+50	"					285	
	+75	"				280		
	26+00	"						235
	+25	"					120	
	+50	"				175		
	+75	"						115
	27+00	"					135	
	+25	"				115		
	+50	"						250
	+75	"					265	
	28+00	"				180		
	Avg.					188	201	204
	Total Avg.						198	
Limestone	30+00	WBT			175			155
	+25	"		80			75	
	+50	"	175			165		
	+75	"			175			
	31+00	"		70				
	+25	"	160					
	+50	"			375			220
	+75	"		225				
	32+00	"	275					
	+25	"			250			
	+50	"		95			60	
	32+75	"	60					
	Avg.		167	117	244	165	68	188
	Total Avg.			176			140	
Med. Fibers Asbestos	33+25	WBT			260			
	+50	"		90			75	
	+75	"	125					
	34+00	"			140			115
	+25	"		105				
	+50	"	150					
	+75	"			175			
	35+00	"		90			80	
	+25	"	80					
	+50	"			225			
	+75	"		95			70	
	36+00	"	70					
	Avg.		106	95	200		75	115
	Total Avg.			134			95	

TABLE 5 (Contd)

Test Section	Station	Lane	H_2O Perm. 1 Hr. After Rolling Mls/Min OWT	BWT	IWT	H_2O Perm. 24 Hrs. After Rolling Mls/Min OWT	BWT	IWT
Powdered Asbestos	36+75	WBT			115			115
	37+00	"		115				
	+25	"	130					
	+50	"			250			
	+75	"		160			120	
	38+00	"	220					
	+25	"			200			
	+50	"		160			150	
	+75	"	150					
	39+00	"			145			120
	+25	"		90				
	+50	"	155					
	Avg.		164	131	177		135	118
	Total Avg.			157			126	

TABLE 6

Construction Control Samples

Bottom Course

Test Section	Test Nos.	Sieve Analysis 3/4"	3/8"	4	8	30	200	Stab.	% Asph.	Sp.Gr.	Cohes.
Normal Mix	24638	100	78	53	39	16	2	33	4.5	2.36	105
	24639	100	74	52	39	16	2	34	4.4	2.36	135
2.0% Limestone Dust	24646	100	75	50	38	16	3	39	3.9	2.36	250
	24647	100	76	50	37	16	3	35	3.9	2.37	210
2.0% Asbestos Med. Fiber	24643	100	78	56	42	16	2	36	5.1	2.35	370
	24644	100	72	49	36	13	2	37	4.7	2.34	420
2.0% Asbestos, Powdered	24640	100	80	57	43	19	3	32	5.0	2.37	345
	24641	100	88	51	39	17	3	37	4.6	2.39	250

Surface Course

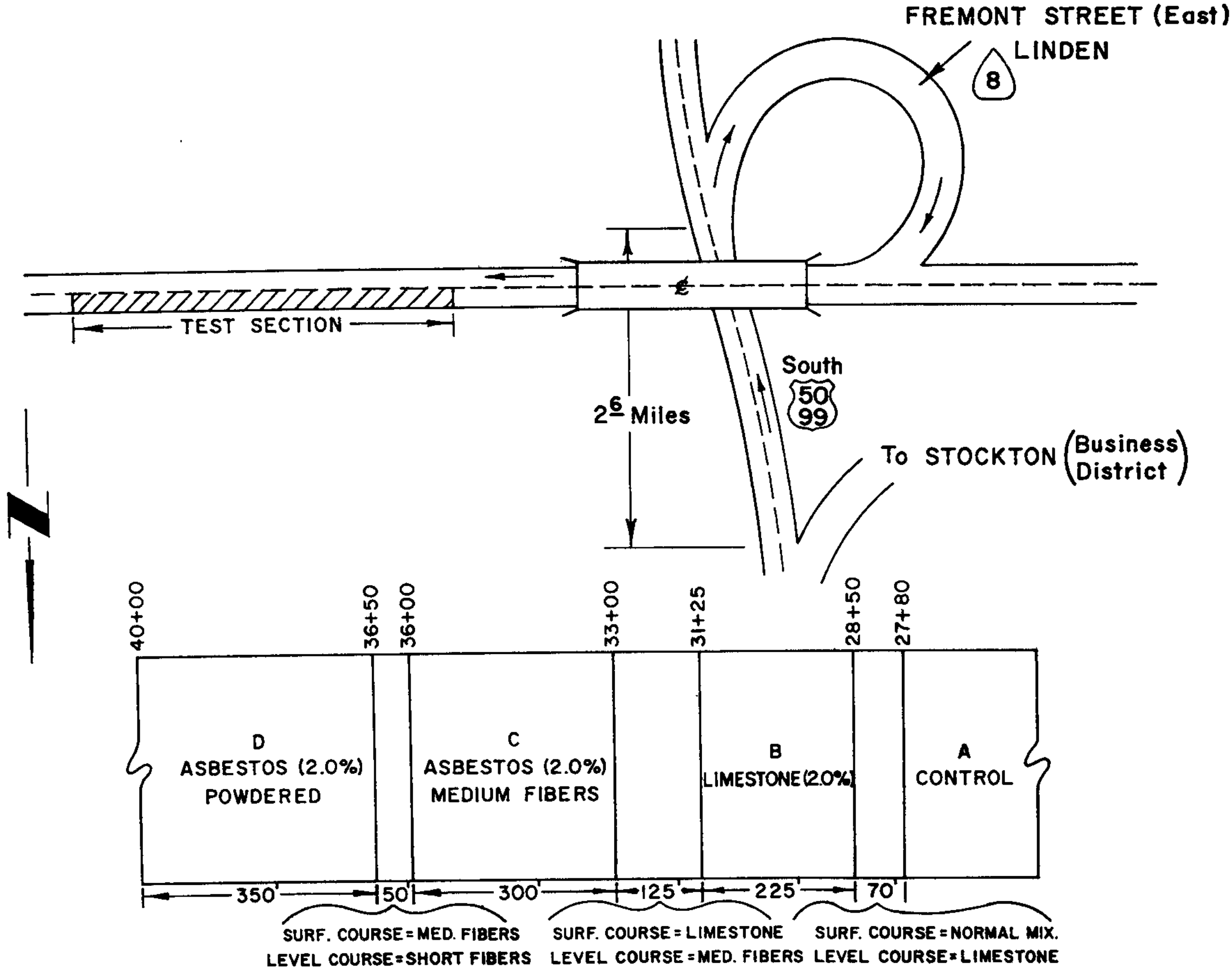
Test Section	Test Nos.	3/4"	3/8"	4	8	30	200	Stab.	% Asph.	Sp.Gr.	Cohes.
Normal Mix	24688	100	77	53	40	15	2	33	4.2	2.36	176
	24689	100	83	55	41	17	2	30	4.5	2.35	174
2.0% Limestone Dust	24687	100	78	51	40	17	3	35	4.1	2.37	260
	24686	100	75	48	37	13	3	37	4.1	2.38	345
2.0% Asbestos, Med. Fiber	24685	100	76	47	36	14	2	35	4.9	2.35	501
	24684	100	75	47	38	15	3	35	4.7	2.35	511
2.0% Asbestos, Powdered	24683	100	82	55	42	18	3	29	4.5	2.39	293
	24682	100	68	51	41	19	3	33	4.2	2.37	420

TABLE 7

Data From Cores Removed From Test Section

Test Sections	Stabilometer			Sp. Gravity			Cohesion			Abson (Pen)			Micro-Vis. (Pen)	
	1961	1962	1965	1961	1962	1965	1961	1962	1965	1961	1962	1965	1962	1965
Control	27	28	30	2.28	2.30	2.32	96	151	142	58	37	26	25	19
Limestone	28	31	33	2.30	2.30	2.31	140	175	275	57	26	21	27	16
Asbestos, Med. Fiber	22	30	29	2.24	2.28	2.29	215	147	298	*	32	*	19	19
Asbestos, Powdered	23	27	28	2.29	2.28	2.31	130	165	223	60	26	19	22	18

*Unable to perform modified Abson Recovery Test. Asbestos fibers clogged filter.



WEST BOUND LANE
(LINDEN ROAD)
FIGURE 1

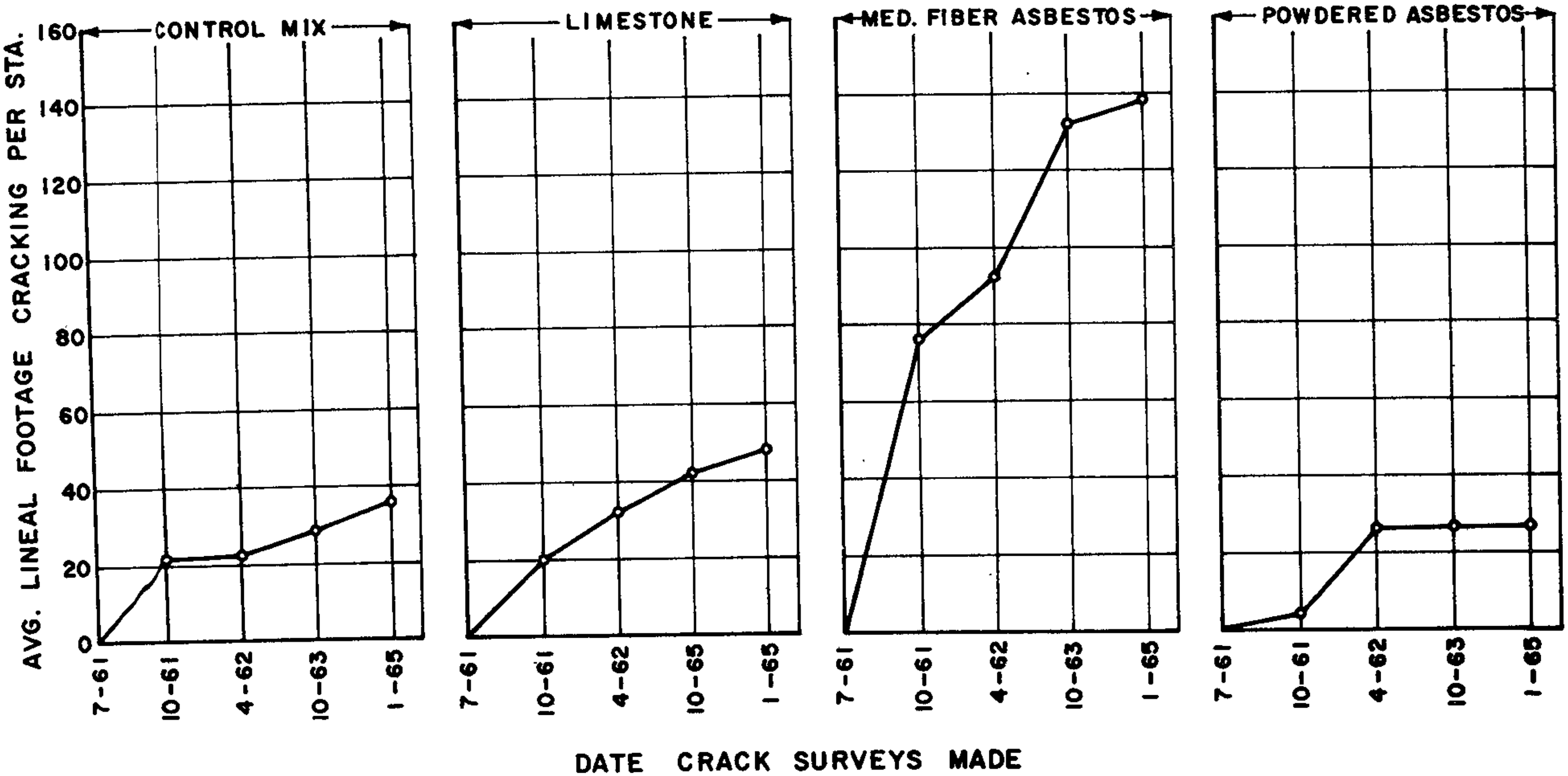
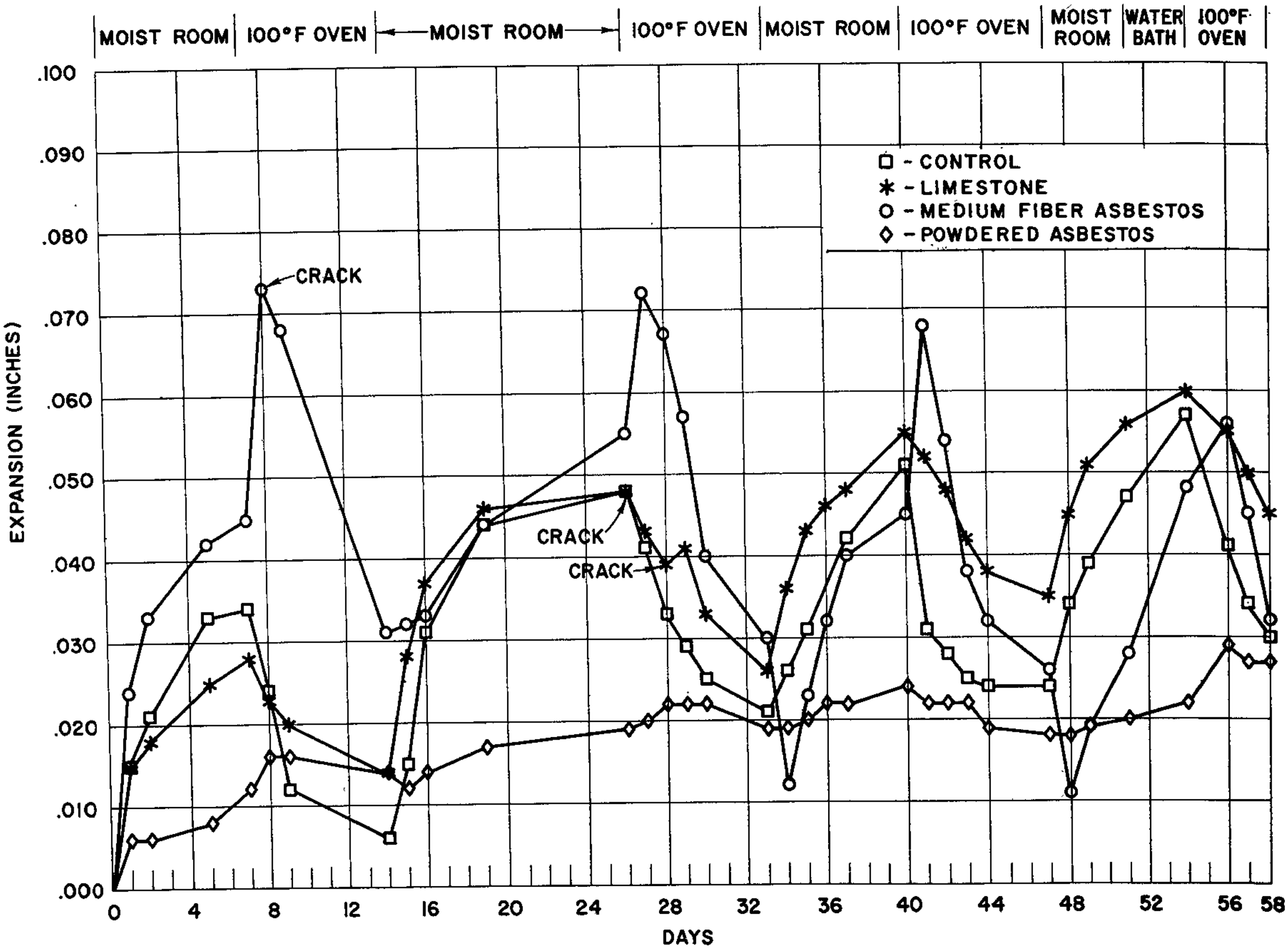

CONTROL MIX
LIMESTONE
MED. FIBER ASBESTOS
POWDERED ASBESTOS
AVG. LINEAL FOOTAGE CRACKING PER STA.
160
140
120
100
80
60
40
20
0
7-61
10-61
4-62
10-63
1-65
DATE CRACK SURVEYS MADE

FIGURE 2



EFFECT OF VARIOUS FILLERS

FIGURE 3