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A Preliminary Report on Faulting of Portland Cement Concrete Pavements Constructed on Bituminous-Treated Subgrades and Cement-Treated Subgrades

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D.L. Spellman

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16. ABSTRACT

This report compares the performance of Portland cement concrete pavements as affected by the type of treated base on which it was constructed, i.e., on bituminous-treated or cement-treated subgrades. Comparisons are made in the development of faulting at weakened plane joints. Faulting is considered to be one of the best measures of performance that can be applied in the relatively early history of a pavement.

The number of pavements that have been constructed on bituminous-treated subgrades is limited. Of ten projects available for study, eight were selected. The other two were not used because profilograph records were not available for pavements constructed on cement-treated subgrade that were considered to be comparable with respect to location, age and traffic. It was desired to consider increases in faulting over a period of a few years as well as the amount of faulting now present. This consideration led to the elimination of some cement-treated subgrade projects that might otherwise have been considered for comparison purposes with certain bituminous-treated subgrade projects, because earlier profilograms were not available.

For each of the eight selected bituminous-treated subgrade projects, a companion cement-treated subgrade project was selected. These are listed in Tables 1 and 2. With one exception, the companion projects were constructed within three years of each other.

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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

A Preliminary Report

on

FAULTING OF PORTLAND CEMENT CONCRETE PAVEMENTS CONSTRUCTED ON BITUMINOUS-TREATED SUBGRADES AND CEMENT-TREATED SUBGRADES

September 1, 1960

State of California
Department of Public Works
DIVISION OF HIGHWAYS

Materials and Research Department

September 1, 1960

Mr. Lyman R. Gillis
Assistant State Highway Engineer
Division of Highways
Sacramento, California

Dear Sir

Submitted for your consideration is:

A Preliminary Report on

FAULTING OF PORTLAND CEMENT CONCRETE PAVEMENTS
CONSTRUCTED ON BITUMINOUS-TREATED SUBGRADES
AND CEMENT-TREATED SUBGRADES

Study made by	Technical Section
Under general direction of	Bailey Tremper
Report written by	D. L. Spellman

Very truly yours

F. N. Hveem
Materials & Research Engineer

cc:WLWarren

Preliminary Report

on

FAULTING OF PORTLAND CEMENT CONCRETE PAVEMENTS CONSTRUCTED ON BITUMINOUS-TREATED AND CEMENT-TREATED SUBGRADES

This report compares the performance of portland cement concrete pavements as affected by the type of treated base on which it was constructed, i.e., on bituminous-treated or cement-treated subgrades. Comparisons are made in the development of faulting at weakened plane joints. Faulting is considered to be one of the best measures of performance that can be applied in the relatively early history of a pavement.

The number of pavements that have been constructed on bituminous-treated subgrades is limited. Of ten projects available for study, eight were selected. The other two were not used because profilograph records were not available for pavements constructed on cement-treated subgrade that were considered to be comparable with respect to location, age and traffic. It was desired to consider increases in faulting over a period of a few years as well as the amount of faulting now present. This consideration led to the elimination of some cement-treated subgrade projects that might otherwise have been considered for comparison purposes with certain bituminous-treated subgrade projects, because earlier profilograms were not available.

For each of the eight selected bituminous-treated subgrade projects, a companion cement-treated subgrade project was selected. These are listed in Tables 1 and 2. With one exception, the companion projects were constructed within three years of each other.

The degree of faulting was measured from profilograms. It was not possible to measure faulting less than 0.05-inch because of uncertainty due to the presence of "hash" in the profilograph trace. Faults less than 0.05-inch therefore, were recorded as zero. The larger faults were recorded as 0.05-inch, 0.10-inch, 0.20-inch, 0.30-inch or 0.40-inch.

To obtain the value of faulting in inches per mile, the faulting for all classified joints were totaled, then divided by the total number of joints in the sections counted (including those joints not faulted). The figure thus obtained gives a value of faulting in terms of inches of faulting per joint. Multiplying this value times the number of joints per mile gives the faulting in inches per mile. This value is thought to be more representative of over-all conditions than a value of inches per joint based on faulted joints only.

Faulting can be compared in a number of different ways. Several of the ways considered are discussed below.

Comparison on the Basis of Loads Carried

For this comparison the EWL for each section was computed from the 1956 traffic counts, then multiplied by the sum of the number of years of service for each type of road at the time the profiles were made. While traffic has increased during the years, it was thought that for a basis of comparison, the 1956 counts were as representative as any for this purpose. It actually favors the bituminous-treated jobs because they have a somewhat greater average age and the use of 1956 traffic data probably implies a greater EWL than was actually experienced. Total faulting shown in Table 3 is the sum of the faulting in inches per mile for the eight jobs of each type considered.

Table 3

Type of Subgrade	Total EWL at 1st profile $(X\ 10^{-6})$	Total Faulting at 1st profile in./mile	Faulting Inches per mile per million EWL	Total EWL at 2nd profile $(X\ 10^{-6})$	Total Faulting at 2nd profile in./mile	Faulting Inches per mile per million EWL
B.T.S.	360	208	0.58	439	289	0.66
C.T.S.	285	121	0.42	384	195	0.51

Faulting can be further compared as to increase per million EWL between the time the first and second profiles were made. Table 4 indicates that faulting rate increases with

the age of the pavement, possibly due to failure of drainage and opening of joints. This could result in greater erosive effect of water on the subgrade.

Table 4

Type of Subgrade	Total Increase in EWL Between 1st and 2nd profile (X 10-6)	Total Increase in Faulting between 1st and 2nd profile	Increase in Faulting, in. per mile per million EWL
B.T.S.	79	81 in./mile	1.02
C.T.S.	99	74 in./mile	0.75

A comparison of faulting based on years of service is shown in Table 5.

Table 5

Type of Subgrade	Total Faulting (for 8 jobs) at 1st profile	Total Yrs. of Service to 1st profile	Inches Faulting per mile per year of service	Total Faulting (for 8 (jobs) at at 2nd profile	Total Years of Service to 2nd profile	Inches Faulting per mi. per year of service
B.T.S.	208	70	2.97	289	86	3.36
C.T.S.	121	51	2.38	195	69	2.82

The above table indicates that the amount of faulting per year of service is greater for pavements over bituminous-

treated subgrades than for pavements over cement-treated subgrades.

Comparison by Projection
<u>of Data to a 10-year Level</u>

By comparing faulting of the two types of road at an age of 10 years as determined by projection of data where necessary, it is seen that total faulting per mile for eight jobs having bituminous-treated subgrades would be 283 inches, or 35.4 in./mi. as compared to a total of 240 inches, or 30 in./mi. for those with cement-treated subgrades, or about 18% more faulting for bituminous treated subgrades. To obtain values for the 10-year level for those jobs not having a profile made at the age of 10 years, the points were plotted for the age of pavement at the time the first and second profiles were made, then projected on a straight line to a 10-year level. Four of the bituminous-treated subgrade jobs were likewise projected. While there is evidence that faulting does not increase at a uniform rate from year to year, it was the only way of comparing on this basis. Later, profiles may show just how fast faulting does progress on some of the jobs in question, but since faulting depends on amount and character of traffic, and maintenance to prevent water from entering the subgrade through joints, it is not likely that

any uniform value could be reached for all pavements.

In addition to the possibility of unintentional bias in selecting pavements on the two types of subgrade for comparison, there is a possibility that the raw base materials that were treated were not of comparable quality. There is evidence that those projects that were selected for bituminous-treated subgrade involved the treatment of sands that were devoid of fine sizes. Such a design determination probably was made on the basis of economy resulting from the need of a high cement factor in clean sands. It could well be the case that had bases of the general quality used for cement-treated subgrade been treated as bituminous-treated subgrade, the results would have been unfavorable to the latter.

Cores were cut in the pavements laid on bituminous-treated subgrades and the character of the treatment was noted. In general, the treatment was found to be well bound with little evidence of stripping of asphalt from the aggregate except in the case of IV-Ala-69-Oak. On this project, the core holes revealed the presence of about 3/4-inch of untreated sand immediately below the bottom of the slab. It is difficult to determine whether the untreated sand resulted from stripping action or represents a layer placed over the bituminous-treated subgrade for purposes of

correcting subgrade elevation.

Considering the 16 projects as a whole, the cement-treated subgrades have performed better with respect to retarding faulting in the pavement. There are two exceptions to the average trend. On projects V-S.B-2-SB and X-Sol-7-B,C, both on cement-treated subgrade, the faulting exceeded that on the companion sections on bituminous-treated subgrade.

Although this study indicates better average performance on cement-treated subgrade, the difference is not very great and possibly could be attributed to unknown variables that were not considered. Subsequent surveys may provide firmer conclusions.

Conclusions

Present evidence is to the effect that, on the average, pavements constructed on bituminous-treated subgrades have developed somewhat more faulting at joints than have supposedly comparable pavements constructed on cement-treated subgrades.

Table 1

Job No.	Dist.Co.Rte. & Sec. Job Location	Type of Subgrade	Year Paved	1st Profile Age Yrs.	1st Profile Faulting in./mile	1st Profile Faulting in./Jt.	1st Profile % Jts. Faulted	2nd Profile Age Yrs.	2nd Profile Faulting in./mile	2nd Profile Faulting in./Jt.	2nd Profile % Jts. Faulted
1	VI-Ker-4-E	BTS	1947	10	23	.063	87	12	32	.091	100
2	VI-Ker-4-D	CTS	1948	9	19	.053	72	11	19	.054	72
3	V-S.B-2-F,E	BTS	1956	1	12	.062	55	3	25	.071	91
4	V-S.B-2-M,L	CTS	1956	1	7	.020	30	3	12	.034	53
5	VI-Fre-4-B	BTS	1946	11	19	.055	69	13	26	.074	84
6	VI-Fre-4-A	CTS	1948	8	7	.019	39	11	33	.094	91
7	VII-Ven-2-C	BTS	1947	10	20	.058	67	12	24	.067	71
8	V-S.B-2-SB	CTS	1948	9	29	.081	60	11	29	.084	80
9	VIII-SBd-26-D	BTS	1947	10	29	.082	89	12	37	.105	98
10	VIII-SBd-26-C,Upl, Ont,D	CTS	1954	2	2	.003	12	5	12	.013	51
11	X-Sta,S.J-4-B,A	BTS	1947	10	48	.136	99	12	59	.168	100
12	VI-Ker-4-C	CTS	1949	8	14	.040	62	10	16	.046	68
13	IV-Ala-69-Oak	BTS	1950	7	48	.135	91	9	77	.218	98
14	IV-Ala-69-C,Snl	CTS	1951	6	29	.083	86	8	51	.146	98
15	III-Sac-3-B	BTS	1947	11	9	.025	38	13	9	.025	41
16	X-Sol-7-B,C	CTS	1949	8	14	.040	52	10	23	.066	69

Table 2

VI-Ker-4-E	Cawelo to Famoso OH
VI-Ker-4-D	Kern River to Snow Road
V-S.B-2-F,E	Arroyo Hondo to Gaviota
V-S.B-2-M,L	Los Alamos to S. of Santa Maria
VI-Fre-4-B	Calwa OH to Fresno
VI-Fre-4-A	Kingsburg to Selma
VII-Ven-2-C	Montalvo to Ventura
V-S.B-2-S.B	Park Place to Rancheria St.
VIII-SBd-26-D	Vineyard Ave. to Etiwanda Ave.
VIII-SBd-26-C	LA County Line to Archibald Avenue
X-Sta-S.J-4-B;A	Salida to Ripon
VI-Ker-4-C	Brundage Lane to Hoskins Road
IV-Ala-69-Oak	Oakland City Limits to High St.
IV-Ala-69-C,Snl	Lewelling Blvd. to Oakland City Limits
III-Sac-3-B	North Sacramento Viaduct to Ben Ali
X-Sol-7-B,C	Fairfield Bypass

[illegible]

Ontario to Parado [illegible]
Cuyama River to [illegible] Road

Arroyo Hondo to Gaviota
[illegible] to S. of [illegible]
North

Calvo [illegible] Avenue
Kingsburg [illegible]

Montalvo to Ventura
Park Place to Petroleum St.

Vineyard Ave. to Archibald Ave.
L.A. County Line to Archibald
Avenue

Sullivan to Alpha [illegible]
Brundage Lane to [illegible] Road

Oakland [illegible] Limits to [illegible]
Leweling Blvd. to Oakland
City Limits

North [illegible] Viaduct to
[illegible]
Fairfield [illegible]