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Pavement Serration Introduction

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It was determined that the friction factor of the pavement had reduced over a period of years due to the polishing effect of high traffic volumes. Heavy truck traffic tends to accentuate this action.

Pavement grooving or serration was used experimentally to increase the friction factor at some of these locations. The grooves were sawed longitudinal to the direction of travel. The saw cuts were generally 1/8 inch deep by 1/8 inch wide with center to center distance between grooves varying from 1/2 inch to 1 inch. These grooves, in addition to raising the friction factor, provide escape paths for water trapped under the tire footprints where partially worn tread patterns did not allow escape through the treads.

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STATE OF CALIFORNIA
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DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

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EVALUATION OF MINOR IMPROVEMENTS

PAVEMENT SERRATION
(Interim Report)

November 1967

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PAVEMENT SERRATION

Introduction

Several years ago the California Division of Highways became aware that some sections of older concrete freeways were having an unusual number of accidents occurring in wet or rainy weather. These accidents in general were of a ran off the road or sliding nature.

It was determined that the friction factor of the pavement had reduced over a period of years due to the polishing effect of high traffic volumes. Heavy truck traffic tends to accentuate this action.

Pavement grooving or serration was used experimentally to increase the friction factor at some of these locations. The grooves were sawed longitudinal to the direction of travel. The saw cuts were generally 1/8 inch deep by 1/8 inch wide with center to center distance between grooves varying from 1/2 inch to 1 inch. These grooves, in addition to raising the friction factor, provide escape paths for water trapped under the tire footprints where partially worn tread patterns did not allow escape through the treads.

Analysis of Data

A summary of all of the presently available data are shown in Tables 1 and 2. Six of these locations were on urban freeways in the vicinity of Los Angeles, five of

which had concrete pavements, the other an asphaltic surface. Accident data was also reviewed for comparison purposes on a mile of unserrated asphaltic surfaced freeway. The above projects had one year before and after periods. An additional project on Interstate 80 near the Nevada State Line with two year periods was also reported. This freeway is rural and required longer periods to obtain meaningful data.

At the Los Angeles area freeways, the number of wet or rainy days was determined in both the before and after periods. There were 30 wet days in the before period and approximately 15 wet days in the after period. Fifteen additional wet days were accumulated from the following year and the accidents on these days were added to the after period.

The friction factors (when available), number of wet pavement accidents, number of dry pavement accidents and the total accidents before and after the serration are recorded in Table 1.

The chi-square statistical test was used to determine if, in fact, a significant change had occurred in accidents after the serration. If the change was significant it is noted by a small "s" in the after accident columns of Table 1. A confidence level of 0.10 was used. This means that a change as great or

greater than this would not have occurred by chance more than ten times out of one hundred. In other words, there is at least a 90 percent certainty that the accident reduction observed did not occur by chance.

Table 2 shows the exposure in million vehicle miles, accident rates, type of freeway (rural or urban) and its average (statewide) accident rate for each serrated location.

Both wet and dry pavement accident rates were calculated relative to the number of wet or dry days. These rates could not be calculated at the Interstate 80 location in the Sierras since the number of wet days was not available.

All of the accident rates on wet days were much higher than the average state highway rates at both urban and rural locations. Since the number of wet days is very few in southern California, the resulting exposure is also very small. When this is divided into the relatively large number of accidents occurring on wet pavement, the result is an unusually high rate. All locations (excepting one) had higher than average total accident rates in the before period. The urban concrete surfaced freeways all had below average (<1.61) rates in the after period. The two rural locations (both concrete surfaced) still had higher than average total accident rates (>1.00) despite sizable drops in rates after the pavement serration.

1. Concrete Pavements

For concrete pavements, the 1/8" x 1/8" x 1" spacing produced an increase of 16 percent in the average friction factor, the 3/4 inch an increase of 35 percent and the 1/2 inch spacing an increase of 40 percent. The over-all average increase was 22 percent (up 0.05).

Total accidents were reduced 76 percent with wet pavement accidents almost completely eliminated (97 percent) and dry pavement accidents dropping 28 percent. Wet pavement accidents were significantly decreased by all serration patterns used. Dry pavement accidents at 3/4 inch and the 1/4" x 1/4" x 1" location were significantly reduced also. Although the number of dry (1/2" space) pavement accidents increased slightly, the change was not significant. (Could easily have occurred by chance.)

Some spalling was observed between the cuts on 1/2" centers. When 3/4" spacing was used, this spalling no longer was a problem. At the one location that has been serrated in the mountains, snow chains have caused considerable spalling between the grooves even at one inch centers. This spalling in itself can possibly cause out of control accidents if the chips are large and frequent. It affects the controllability of a car similar to, but not as great as, street car tracks. It is possible that tire treads from specific model cars may fit into these

ruts to a greater extent than others, and that front wheel alignment imperfections could also cause this sensation. Throughout this mountain highway, considerable spalling of the pavement (due to chains) is evident regardless of whether it was serrated or not. This may be a situation reflecting the quality of the local aggregate. It is felt, however, that one inch spacing should be maximum even in mountain areas.

Since spalling was observed on the 1/2" spaced grooves and the accident reductions are approximately the same as at 3/4" spacing, It is suggested that 3/4" spacing be used on future serration projects except in snow country.

There is some evidence that after serrating, the friction factor tends to drop. Seventeen months after the pavement was serrated, the friction factors were again measured at three locations in or near Los Angeles. These more recent measurements are shown in parentheses in the table along with the percent change from the original after readings. The average readings dropped 0.037 (12 percent) at those locations measured. When converting this drop to a per year basis, it appears that the friction factor drops 0.026 per year. Further study is indicated in this area in order to determine exactly how much of a loss to expect with each grooving pattern per year of use and what remedial action can be taken after the first

serration has worn down. The wearing or rounding of the corners of the cut could cause an initial rapid drop in the friction factor which may not continue at the same rate. Another experimental system cuts V's instead of slots with 3/16 inch V's on one inch centers and smaller 1/8 inch V's in the middle. This is supposed to prevent rounding of the corners that occur at the slots.

It is possible that although the friction factor may lower below the standard of 0.25, the escape paths for water under smooth tires could remain. Thus the accident reduction would continue. All of this is of a highly speculative nature since not enough time has elapsed to determine specific characteristics of this treatment.

2. Asphalt Pavement

A one half mile section of asphalt pavement was serrated on the Hollywood Freeway at Cahuenga Pass. The 1/4" x 1/4" x 1" grooving on the asphalt pavement produced an average increase of 22 percent (+0.02) in the friction factor. However, both motorcycles and light automobiles experience steering difficulty in traversing these serrated curves. For this reason these cuts were considered too wide and deep. It should be mentioned that as a general rule, a low friction factor on asphalt pavement would not be corrected in this manner, but since this pavement was 10 years old, very dry and dense, it was decided that serration would be helpful.

The project also had a large accident reduction (-79 percent) with wet pavement accidents reduced 96 percent and dry pavement accidents decreasing 36 percent. This is surprising since there was only a small increase in the friction factor.

It has been mentioned that the present small wheeled measuring device could possibly give slightly erroneous readings when the grooves are at one inch spacing or greater.

For comparison purposes, a one mile stretch of asphaltic concrete freeway south of this serrated area was also reviewed. In the same one year periods, both wet and dry pavement accidents increased slightly with total accidents increasing 22 percent (95 to 116).

3. Cost of Grooving

The cost of pavement serration is approximately ten cents per square foot. The total accident reduction in the one year after period at the Los Angeles locations was $110 per accident reduced. If the reductions continue, of course, this cost will lower even more. As of now the serviceable life of pavement serration is not known.

Summary

In summary, it appears that pavement grooving provides an excellent method for increasing the friction factor on older polished concrete pavements. However,

presently available data indicates that the vehicle polishing effect continues and the friction factor lowers approximately 0.026 per year after serrating. Only a short time has passed after these installations, consequently a great amount of information is yet to be learned about this treatment.

Both accidents and rates were reduced significantly at pavement serrated locations. Greater reductions were realized on rainy or wet days than on dry days.

Since approximately equal accident reductions were noted at both 1/2 inch and 3/4 inch spacings and no spalling was noticed at the 3/4 inch groove spacing, it is recommended that future projects use 1/8" x 1/8" x 3/4" grooves except in snow country where the one inch spacing should be used.

Despite the large reduction in accident rates at the locations studied, pavement serration should not be considered a "cure all" remedial treatment. The locations studied had extremely high accident rates, especially during wet weather, and the pavement friction factors were very low. Until additional information is available, care should be used in selecting locations for pavement serrating projects.

Table 1

EFFECTS OF PAVEMENT SERRATION

LOCATION DESCRIPTION	ACCIDENTS									FRICTION FACTORS 1/						CURVATURE		AADT/1000		SERRATION PATTERN & PAVEMENT TYPE
	BEFORE			AFTER			% CHG.			BEFORE		AFTER		% CHG.						
CO. RT. P.M.	WET	DRY	TOT.	WET	DRY	TOT.	WET	DRY	TOT.	LOW	AVG.	LOW	AVG.	LOW	AVG.	RADIUS	DIR.	BEFORE	AFTER	
ORA-5 (23.3-23.6) 1/2" on PCC	46	4	50	1 S	7	8 S	-98	+75	-84	0.17	0.25	0.30 (0.28)	0.35 (0.30)	+77 (-7)	+40 (-14)	2000'	RT.	39.0	45.0	1/8 x 1/8 x 1/2 on PCC
LA-5 (29.5-30.0)	12	6	18	2 S	2	4 S	-83	-67	-78	0.14	0.23	0.24 (0.20)	0.31 (0.27)	+72 (-17)	+35 (-13)	2000'	LT.	102.0	104.0	1/9 x 1/8 x 3/4 on PCC
LA-10 (22.6-22.8)	26	16	42	0 S	6 S	6 S	-100	-63	-86	0.17	0.27	NA	NA	NA	NA	1020'	LT.	163.0	164.0	1/8 x 1/8 x 3/4 on PCC
SUB-TOTAL 3/4" on PCC	38	22	60	2 S	8 S	10 S	-95	-64	-83	0.14	0.23	0.24	0.31	+72	+35					
LA-405 (2.1-2.6)	21	9	30	0 S	11	11 S	-100	+22	-63	0.14	0.20	0.17 (0.13)	0.24 (0.22)	+21 (-24)	+20 (-8)	TANGENT		129.0	131.0	1/8" x 1/8" x 1" on PCC
LA-405 (3.8-4.1)	4	6	10	0	4	4	-100	-33	-60	0.13	0.19	0.16	0.21	+23	+11	3000'	RT.	132.0	139.0	1/8" x 1/8" x 1" on PCC
NEV-80 (19.8-20.2) 2/	5	9	14	0 S	6	6 S	-100	-33	-57	NA	NA	NA	NA	NA	NA	1400'	LT.	7.0	9.0	1/8" x 1/8" x 1" on PCC
SUB-TOTAL 1" on PCC	30	24	54	0 S	21	21 S	-100	-14	-61	0.13	0.19	0.16	0.22	+23	+16					
TOTAL PCC	114	50	164	3 S	36	39 S	-97	-28	-76	0.13	0.23	0.16 (0.13)	0.28 (0.26)	+23 (-12)	+22 (-7)			572.0	592.0	
LA-101 (8.8-9.3) AC	139	55	194	6 S	35 S	41 S	-96	-36	-79	0.21	0.23	0.26 (0.26)	0.28 (0.29)	+24 (–)	+22 (+4)	2050' 2052'	Reversing	136.0	134.0	1/4" x 1/4" x 1" on AC
TOTAL SERRATED	253	105	358	9 S	71 S	80 S	-96	-32	-78	0.16	0.22	0.23 (0.22)	0.28 (0.27)	+43 (-12)	+26 (-8)					
LA-101 (7.8-8.8)	36	59	95	41	75	116	+14	+27	+22	NOT SERRATED						VAR.	Reversing	122.0	123.0	NOT SERRATED (AC)

1/ Numbers in ( ) indicate results after 17 months of service.
2/ Two year before and after period. All others one year.
"S" Indicates change is significant at 0.10 level using the Chi-Square Test.
NA Indicates figures not available.

Table 2

EFFECTS OF PAVEMENT SERRATION
(ACCIDENT RATES)

LOCATION DESCRIPTION (CO. RTE. P.M.)	BEFORE WET MVM	BEFORE WET RATE	BEFORE DRY MVM	BEFORE DRY RATE	BEFORE TOTAL MVM	BEFORE TOTAL RATE	AFTER WET MVM	AFTER WET RATE	AFTER DRY MVM	AFTER DRY RATE	AFTER TOTAL MVM	AFTER TOTAL RATE	U - URBAN R - RURAL	STATE AVG. ACC. RATE	SERRATION PATTERN & PAVEMENT TYPE	Code
ORA-5 (23.3–23.6) 1/2" on PCC	0.18	255.56	1.96	2.04	2.14	23.36	0.20	5.00	2.26	3.10	2.46	3.25	R	1.00	1/8" x 1/8 x 1/2 on PCC	D
LA-5 (29.5–30.0)	0.77	15.58	8.54	0.70	9.31	1.93	0.78	2.56	8.71	0.23	9.49	0.42	U	1.61	1/8" x 1/4 x 3/4 on PCC	E
LA-10 (22.6–22.8)	0.49	53.06	5.46	2.93	5.95	7.06	0.49	0.00	5.50	1.09	5.99	1.00	U	1.61	1/8 x 1/8 x 3/4 on PCC	L
SUB-TOTAL 3/4" PCC	1.26	30.16	14.00	1.57	15.26	3.93	1.27	1.57	14.21	0.56	15.48	0.65		1.61		—
LA-405 (1.1–2.6)	0.97	21.65	10.80	0.83	11.77	2.55	0.98	0.00	10.97	1.00	11.95	0.92	U	1.61	1/8" x 1/8" x 1" on PCC	F
LA-405 (2.8–4.1)	0.59	6.78	6.64	0.90	7.23	1.38	0.63	0.00	6.98	0.57	7.61	0.53	U	1.61	1/8" x 1/8" x 1" on PCC	G
NEV-80 (19.8–20.2)	NA	NA	NA	NA	1.02	13.73	NA	NA	NA	NA	1.31	4.58	R	1.00	1/8" x 1/8" x 1" on PCC	M
SUB-TOTAL 1" on PCC	1.56	16.03	17.44	0.86	20.02	2.70	1.61	0.00	17.95	0.84	20.87	1.01		1.48		—
TOTAL PCC	3.00	36.33	33.40	1.23	37.42	4.38	3.08	0.97	34.42	0.87	38.81	1.00		1.48		—
LA-101 (8.8–9.3) A.C.	2.04	68.14	22.78	2.41	24.82	7.82	2.01	2.99	22.45	1.56	24.46	1.68	U	1.61	1/4" x 1/4" x 1" on A.C.	N
TOTAL SERRATED	5.04	49.21	56.18	1.71	62.24	5.75	5.09	1.77	56.87	1.14	63.27	1.26		1.48		—
LA-101 (7.8–8.8)	3.66	9.84	40.87	1.44	44.53	2.13	3.69	11.11	41.21	1.82	44.90	2.58	U	1.61	NOT SERRATED (A.C.)	—

NA Indicates Figures Not Available