Speeds of Passenger Cars on Wet and Dry Pavements

WALTER R. STOHNER, Assistant Civil Engineer
Vehicle Operation Section, Bureau of Highway Planning
New York State Department of Public Works

● WET pavements offer less skid resistance than do dry pavements. Do drivers realize this fact and govern their speed accordingly? A study of speeds on wet and dry pavements was conducted in New York, in the spring of 1954, in an attempt to obtain factual information on the subject.

STUDY PROCEDURE

All study locations were on open rural highways removed from the influence of intersections and with a minimum of interference from roadside development. Four sites on 2-lane pavements and one site on a 4-lane divided pavement were selected with horizontal curves of various degrees immediately adjacent to fairly long tangents. Curvature varied from 2½ to 9 degrees. The grades were level or nearly so on the tangent, around the curve and for a considerable distance beyond. This minimized the effect of grades on speed and provided for somewhat similar effects of the curvature on the speeds of vehicles from either direction. Two of the 2-lane sites had blacktop surfaces. The geometric characteristics of the sites studied are included in Table 1.

Observations on wet pavements were taken first. On all occasions, the surfaces were wet and rain was falling from a sprinkle to moderately heavy rain (Table 1). On no occasion did it rain so hard as to affect visibility appreciably. Observations on dry pavements were taken a few weeks later at the same time and weekday corresponding to the wet observations except, at one study location, where additional observations required for the wet pavement condition were taken after the observations for the dry pavement condition.

The number of vehicles recorded varied considerably from site to site as the wet pavement studies were dependent on continued rain. The commercial vehicles recorded were excluded from the study as they were too small in number to permit statistical analysis. Therefore, the analysis includes only passenger cars and, to insure that none was influenced by others, those following another vehicle within a time spacing of nine seconds were excluded. Table 1 shows the number of free-moving and meeting passenger cars in the sample which were used for analysis.

Analysis of Free-Moving Passenger Car Speeds

Passenger car speeds were tabulated according to the site, whether on tangent or curve location, for both wet and dry pavement conditions. Cumulative speed distribution curves were plotted for each location studied from these data (Figures 1-5).

These figures show that there is very little difference in the speed distributions of free-moving passenger cars on wet and dry pavements.

TABLE 1

DESCRIPTION OF STUDY LOCATIONS AND CONDITIONS OF STUDY

Site	Route	Location	Pavement Width	Pavement Type	Shoulder Width ft	Curvature Deg-Min	Super-Elevation ft/ft	Wet Pavement: Cars Number	Wet: Duration of Study hr	Wet: Precipitation[a] Date Mo-Day	Wet: Precipitation[a] Amt in	Dry Pavement: Cars Number	Dry: Duration of Study hr	Dry: Precipitation[a] Date Mo-Day	Dry: Precipitation[a] Amt in
1-2D-1	9	Pottersville	20'	Macadam	4	9 - 0	0 10	144	2 00	5- 3	0 11	132	1 75	6- 7	0
1-2D-2	9	N Hudson	20'	Concrete	6	5 - 30	0 04	131	3 00	5- 3 5- 4	0 11 0 50	129	2 50	6- 8	0
2-2D-2	162	Rural Grove	22'	Concrete	8	4 - 0	0 04	103	4 00	4-14 4-28 6- 2	0 0 2 65	113	3 50	4-14 5- 5	0 0
8-2D-1	9H	Valatia	24'	Blacktop	8	2 - 30	0 01	165	1 75	4-27	0 15	196	3 00	5-18	0
1-2D-7	9	Rice's Corners	48'	Divided Concrete	10	2 - 30	0 02	258	3 75	4-27 4-23	0 20 0 46	360	3 75	5-18 5- 7	0

[a] Records from US Weather Bureau for Station nearest the site Weather Bureau reports may show variations from conditions encountered at the sites because of scattered shower activity prevalent during the spring and summer

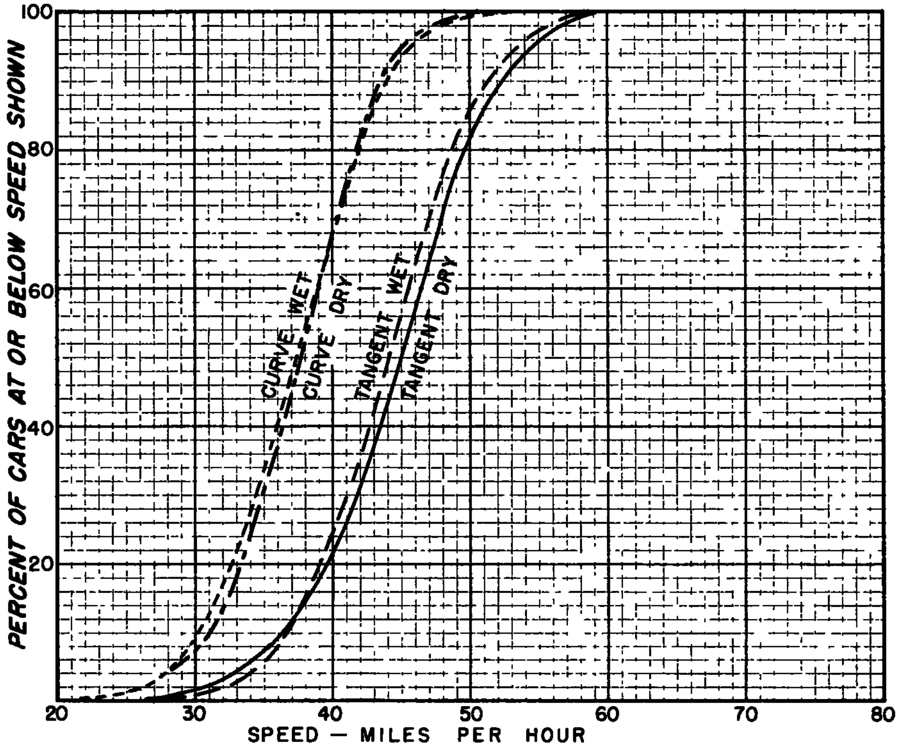

Figure 1. Distribution of speeds at Site 1-2D-1.

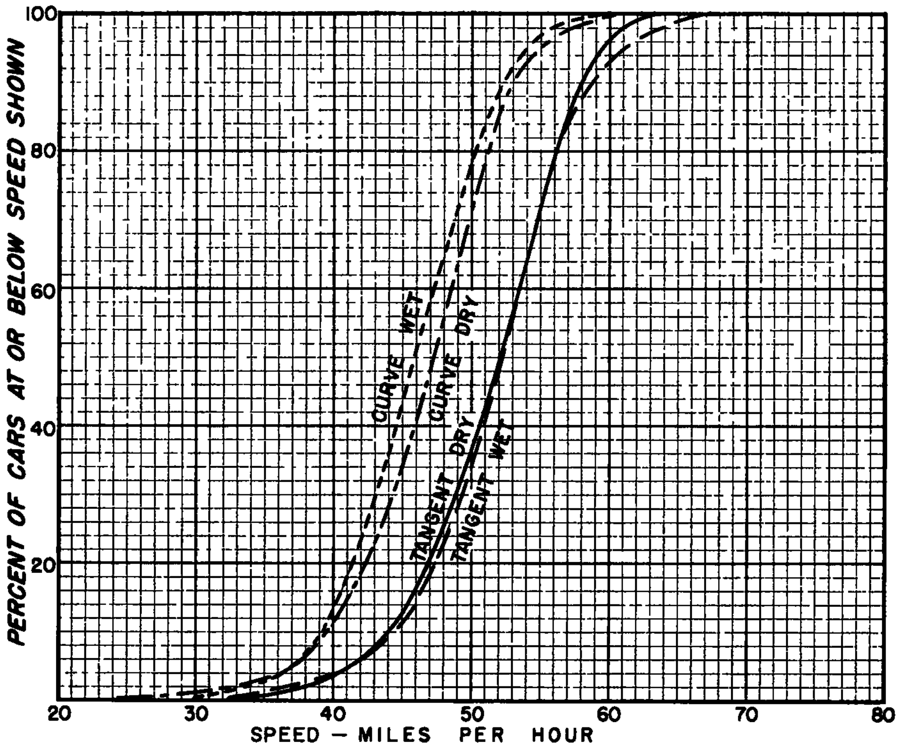

Figure 2. Distribution of speeds at Site 1-2D-2.

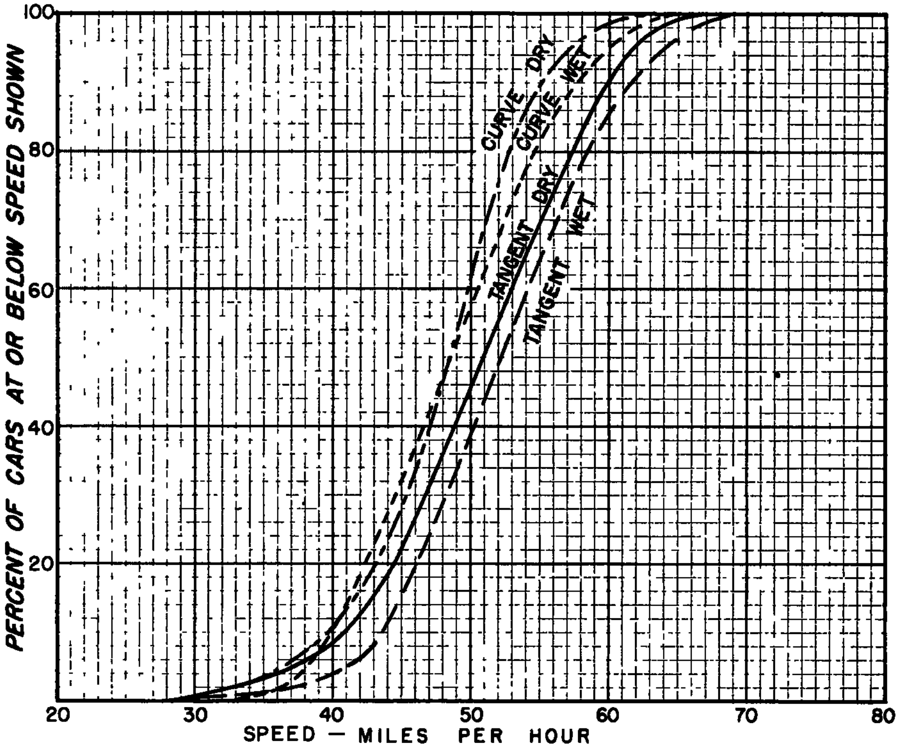

Figure 3. Distribution of speeds at Site 2-2D-2.

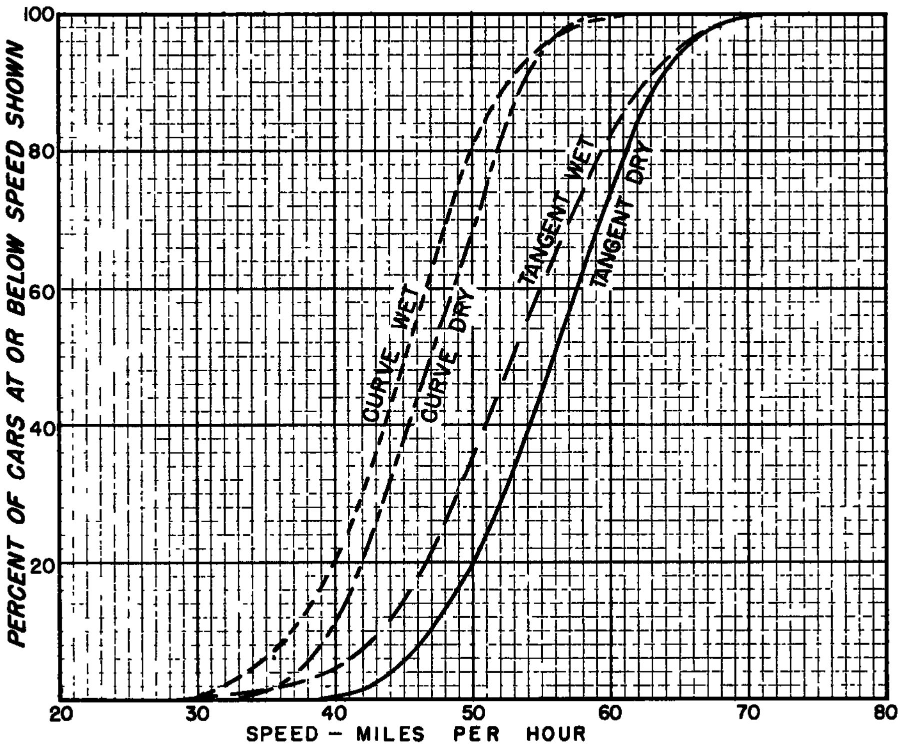

Figure 4. Distribution of speeds at Site 8-2D-1.

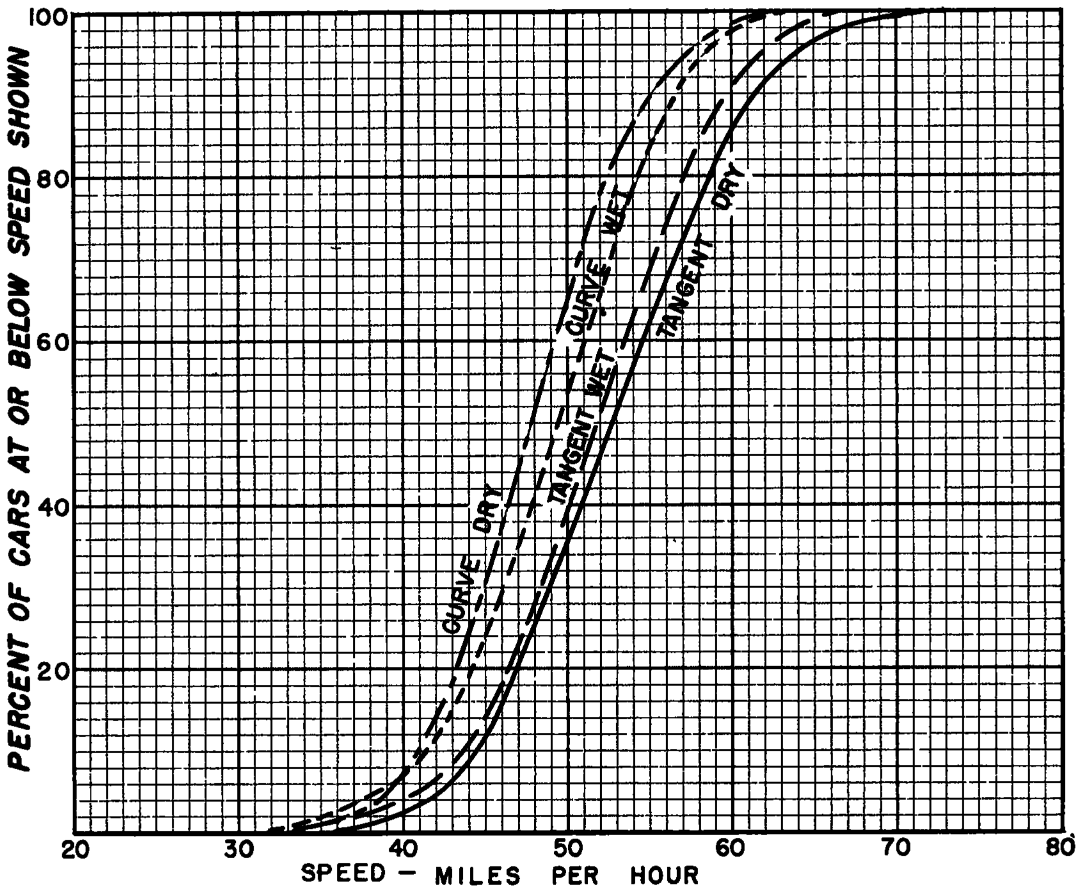

Figure 5. Distribution of speeds at Site 1-2D-7.

Data in Table 2 shows the average speeds, various percentile speeds and maximum speeds observed on the tangent locations at the five sites studied. At these locations, the maximum difference between the average speeds on wet and dry pavements was 2. 8 mph. The average difference was 1. 4 mph. At two of the five tangent locations, the average speeds were higher on wet pavements than on dry pavements. Also, at three of the five tangent locations, the maximum speeds were higher on wet pavements than on dry pavements. It is to be noted that the various percentile speeds show the same general relations as the average speeds.

Data in Table 3 shows the average speeds, various percentile speeds and maximum speeds observed on the curve locations at the five sites studied. At these locations, the maximum difference between the average speeds on wet and dry pavements was 1. 8 mph. The average difference was about 1 mph. At two of the five curve locations, the average speeds were higher on wet pavements than on dry pavements. Also, at three of the five curve locations, the maximum speeds were higher on wet pavements than on dry pavements. Again it is noted that the various percentile speeds show the same general relations as the average speeds.

From an examination of the speed data in Tables 2 and 3 and Figures 1 to 5, it will be found that drivers of free-moving passenger cars operated at about the same

TABLE 2

SPEED DATA RECORDED AT THE TANGENT LOCATIONS

Site	Pavement Type	Surface Condition	Tangent Speed Average mph	70% mph	85% mph	90% mph	95% mph	Maximum mph
1-2D-1	Macadam	Dry	45 27	48 0	50 8	52 5	54 7	59
		Wet	44 64	47 2	49 9	51.4	53 5	61
1-2D-2	Concrete	Dry	52 11	54 8	57 2	58 3	59 8	64
		Wet	52 45	54 9	57 7	59 0	61 5	71
2-2D-2	Concrete	Dry	51 01	55 0	58 4	59 7	61 5	66
		Wet	52 78	56 3	59 7	61 5	64 2	70
8-2D-1	Blacktop	Dry	56 13	59 5	62 4	63 7	65 6	82
		Wet	53 37	57 1	60 9	62 5	65 2	75
1-2D-7	Divided Concrete	Dry	53 36	56 7	59 8	61 5	64 0	77
		Wet	52 08	55 4	58 3	59 7	61 8	66

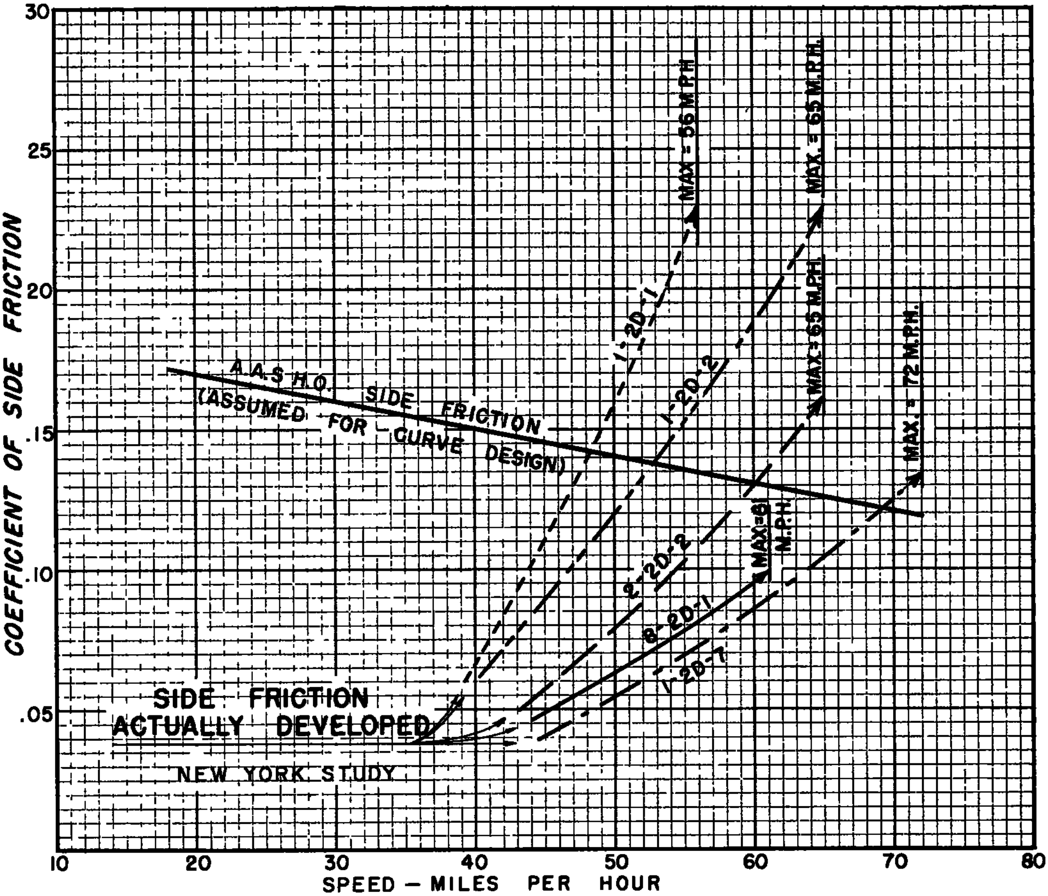

Figure 6. AASHO maximum side friction factors assumed for curve design and coefficients of side friction actually developed at various speeds on curves.

speed on wet pavements as on dry pavements. If the above data, obtained at the five study sites, are typical of operation on the majority of our open rural highways, design speed for wet pavements should be the same as that for dry pavements.

Percent Overdriving AASHO Recommended Maximum Side Friction Factors Assumed for Curve Design

From the data recorded for this study and by using the following basic formula, the coefficients of side friction developed on the horizontal curves included in this study were determined:

$$F = \frac{0.067V^2}{R} - S$$

in which
F = Coefficient of side friction;
V = Speed, mph;
R = Radius of curve, feet; and
S = Superelevation, feet per foot.

These calculated coefficients of side friction for the various speeds on each of the five curve locations studied are shown in Table 3 and have been plotted in Figure 6 with the AASHO recommended maximum side friction factors assumed for curve design.[1]

[1]A Policy on Geometric Design of Rural Highways, American Association of State Highway Officials, 1954, p. 439, Figure III-4.

TABLE 3

SPEED DATA AND COEFFICIENTS OF SIDE FRICTION DEVELOPED ON CURVES

Site	Pavement Type	Surface Condition	Curvature deg-min	Curve Speed Average mph	70% mph	85% mph	90% mph	95% mph	Maximum mph	Coefficient of side friction developed at indicated speed Average mph	70% mph	85% mph	90% mph	95% mph	Maximum mph	Percent of all cars overdriving design coefficient of side friction[a]
		Dry		38 18	40 5	42 7	43 7	45 3	53	0 05	0 07	0 09	0 10	0 11	0 20	1 5
1-2D-1	Macadam	Wet	9 - 0	37 94	40 5	43 0	44 1	45 7	56	0 05	0 07	0 09	0 10	0 12	0 23	2 1
		Dry		47 43	50 1	52 2	53 3	55 3	65	0 10	0 12	0 13	0 14	0 16	0 23	14 0
1-2D-2	Concrete	Wet	5 - 30	46 45	48 8	51 5	52 6	54 5	64	0 10	0 11	0 13	0 14	0 15	0 22	12 2
		Dry		48 44	51 2	53 6	55 0	57 2	63	0 07	0 09	0 10	0 11	0 12	0 15	3 5
2-2D-2	Concrete	Wet	4 - 0	49 03	52 5	55 8	57 5	60 0	65	0 08	0 09	0 11	0 12	0 13	0 16	8 7
		Dry		47 29	50 4	52 8	53 8	55 2	59	0 06	0 06	0 07	0 07	0 08	0 09	0
8-2D-1	Blacktop	Wet	2 - 30	45 45	48 3	51 2	52 8	55 1	61	0 05	0 06	0 07	0 07	0 08	0 10	0
	Divided	Dry		48 50	50 8	53 8	55 3	57 4	72	0 05	0 06	0 07	0 07	0 08	0 13	0 3
1-2D-7	Concrete	Wet	2 - 30	49 77	52 7	55 5	56 8	58 5	67	0 05	0 06	0 07	0 08	0 08	0 11	0

[a] AASHO recommended maximum side friction factors assumed for curve design

Referring to Figure 6, the point of intersection of each curve for the plottings of the coefficients of side friction actually developed, with the straight line representing the AASHO maximum side friction factors assumed for curve design, indicate the speeds beyond which cars were overdriving the AASHO recommended design coefficient of side friction for each curve location. To determine the percentage of the cars overdriving the AASHO recommended design coefficient of side friction, these speeds were applied to the appropriate cumulative distribution of speed curve, shown in Figures 1 to 5. These values are shown in the last column of Table 3.

The percentage of passenger cars shown overdriving the AASHO recommended design coefficient of side friction appears to be higher for the concrete pavements than the blacktop surfaces. Drivers apparently realize that the side friction on blacktop surfaces, whether they be wet or dry, is lower than it is on concrete pavements. However, the lack of any significant variation in speed indicates that they recognize no difference in friction factor between wet and dry pavements whether the pavement be blacktop or concrete.

CONCLUSIONS

1. The speeds of free-moving passenger cars on wet pavements are not appreciably lower than those on dry pavements. This was found to be true on macadam and blacktop surfaces as well as on the portland cement concrete surfaces.
2. Even though the speed of free-moving passenger cars is not generally reduced on wet pavements, an analysis of speed and the coefficients of side friction actually developed shows that most drivers of passenger cars do not exceed the design coefficient of side friction recommended by the AASHO.

ACKNOWLEDGMENTS

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