

Research Report
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**ACCIDENTS ON RURAL INTERSTATE AND PARKWAY ROADS
AND THEIR RELATION TO PAVEMENT FRICTION**

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accepted for publication by the
Transportation Research Board

November 1974

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ABSTRACT

Friction measurements were made with a skid trailer at 70 mph (31 m/s) on 770 miles (1240 km) of rural, four-lane, controlled-access routes on the interstate and parkway systems in Kentucky. Each construction project was treated as a test section. Accident experience, friction measurements, and traffic volumes were obtained for each. Various relationships between wet-weather accidents and skid resistance were analyzed. Averaging methods were used as a means of developing trends and minimizing scatter. A moving average for progressively-ordered sets of five test sections yielded more definite results. The expression of accident occurrence which correlated best with skid and slip resistance was wet-weather accidents per 100 million vehicle miles (161 million vehicle kilometers). Accidents increased greatly as Skid Numbers (70 mph or 31 m/s) decreased from 27. Analysis of Peak Slip Numbers and accident occurrences indicated similar trends.

INTRODUCTION

To assure safe highway travel in wet weather, pavements must be designed to have sufficient and enduring skid resistance to enable drivers to perform "normal" driving tasks without risk of skidding and(or) loss of vehicle control. In emergencies, a driver may be compelled to brake hard and, with conventional braking systems, may experience skidding regardless of how skid resistant the pavement may be. Anti-locking brake systems minimize the risks of skidding and permit the driver to retain directional control of the vehicle. Without such a system, a vehicle will skid, with potential loss of control, when the demand for braking force exceeds the tractive force. As friction (traction) increases, greater deceleration is available, and a driver's chances of avoiding collision and remaining on the road are increased. Ideally, wet pavements should provide as much traction as dry pavements. In a practical and realistic sense, however, the question remains as to what minimum level of friction a pavement should provide to safeguard the public from undue hazards associated with wet-weather driving. Little satisfaction is derived from merely maintaining a friction level at or near a critical value. The critical value, however, may serve as a criterion for posting wet-weather speed restrictions and for design of surface courses providing a due margin of safety.

Investigations elsewhere (1, 2, 3, 4, 5, 6) to establish minimum friction requirements fall into two categories: (1) studies of driver behavior and, therefore, frictional demands attending driving tasks and (2) analysis of accident data and accident experience as related to pavement friction. Studies in the first category represent a logical approach but involve extensive monitoring of representative driver populations under realistic roadway conditions and situations. Interpretations as to what constitutes "normal" as opposed to "emergency" reactions or situations present a problem. Friction factors thus derived cannot easily be related to skid resistance measured with conventional testers (such as trailers) operated under prescribed procedures and conditions of test.

Accident rates have been recognized as being higher on wet than on dry surfaces; many statistics are available to support this intuitive conclusion. Furthermore, research has shown that accident rates tend to increase as wet skid resistance diminishes. This relationship is now considered to be intuitive and *a priori*. However, the interaction of many contributing factors such as roadway geometrics, traffic characteristics, driver behavior, etc., together with uncertainties concerning reliability and availability of accident data, type of friction measurements, and type of analysis have heretofore obscured relationships between accidents and pavement friction.

The primary objective of this study was to discern a relationship between accident experience and pavement friction for rural, four-lane, controlled access roads on the interstate and parkway (expressway)

systems in Kentucky. These highways were purposely chosen for this initial analysis because many of the usually confounding variables could be assumed to have minimal influence. Subsequent evaluations of such a relationship in conjunction with economical and technical considerations will surely guide the establishment of minimum levels of friction.

To define a relationship between accidents and skid resistance, the effect of all other parameters must be known or held constant insofar as possible. By limiting the study to rural, four-lane, interstate and parkway facilities, some of the parameters, such as road geometrics, access control, and speed, may be assumed to remain reasonably constant. Traffic characteristics (volume and density) and pavement surface conditions (wet or dry and skid resistance when wet) are, respectively, the regenerative and causative factors.

Annual average daily traffic volumes were obtained for 1971. Accident data were those reported during the calendar years 1970, 1971, and 1972. Pavement friction measurements were made between June and October 1971 on 770 miles (1240 km) of the interstate and parkway systems. Both locked-wheel and peak slip resistances were measured. This peak resistance is often referred to as incipient friction and exceeds the resistance measured by the locked-wheel method. In normal driving, the vehicle operates in a pre-slip and cornering mode. Therefore, both locked-wheel skid resistance and peak slip resistance at various speeds -- or some other type of measurement -- may be needed to fully characterize pavements. The measurement(s) which best correlate(s) with wet-weather accidents remains to be established.

DATA ACQUISITION AND COLLATION

Traffic Volumes

Since traffic volumes vary with time, any measurement of volume not obtained at the time and location of each accident would not precisely represent the volume associated with the accident. In studies such as this, which cover a system throughout a state, that type of volume measurement is highly impractical. The measurement of traffic volume which is generally available is an annual average daily traffic (AADT). The AADT data for 1971 were used in these analyses.

Friction Measurements

Friction measurements were obtained using a Surface Dynamics Pavement Friction Tester (Model 965A) (7) developed by the General Motors Proving Ground and manufactured by K. J. Law Engineers, Inc., Detroit, Michigan. This skid trailer complies with ASTM E 274 (8). The measurements represent friction developed between a standard test tire (ASTM E 249) (9) and a wetted pavement. The locked-wheel measurements are expressed as Skid Numbers (SN); incipient or peak friction is expressed as Peak Slip Number (PSN).

Measurements were obtained during the summer of 1971 on all rural, four-lane, interstate and parkway routes in Kentucky having a posted speed limit of 70 mph (31 m/s). Tests were made in the left wheel path only and at one-mile (1.6-km) intervals in outer lanes; no less than five tests per lane were made on each construction project. The basic test speed was 70 mph (31 m/s). Additional tests were conducted on selected pavements at 40 mph (18 m/s). Comparison between the Skid Numbers obtained at the two speeds are presented in Figure 1.

Accident Information

Accident data were obtained from State Police Records, computerized, and maintained by the Department of Public Safety. All accidents reported during the calendar years 1970, 1971, and 1972 were analyzed. A summary of accidents on rural, four-lane, interstate and parkway routes is presented in Table 1. Accidents totaled 5907 -- of which 1314 occurred during wet-surface conditions.

From these accident records, many expressions of accident occurrence may be calculated. Rates of wet-surface accidents, dry-surface accidents, fatal and injury accidents, and total accidents (including property damage accidents) are commonly calculated. Expressions used in other investigations have included (1) ratio of wet- to dry-surface accidents, (2) ratio of wet-surface to total accidents, (3) ratio of wet-surface, skidding accidents to total accidents, (4) wet-surface accidents per 100 million vehicle miles (161 million vehicle kilometers), (5) total accidents per 100 million vehicle miles (161 million vehicle kilometers), and (6) fatal and injury accidents per 100 million vehicle miles (161 million vehicle kilometers).

Test Sections

A test section is defined as "a section of pavement of uniform age and uniform composition which has been subjected to essentially uniform wear along its length" (8). Almost all construction projects fit this definition. Inasmuch as the direction of travel for a vehicle involved in an accident was not given in the accident reports, sections included both directions of travel. There were 110 test sections.

On rural, four-lane roadways, most traffic travels in the outer lanes (approximately 80-85 percent), and a large percentage of maneuvers begin or terminate there. The outer lane, left wheel-path Skid Numbers were averaged to characterize the skid resistance of the test sections. Distributions of these values, SN and PSN, for the 110 test sections are exhibited in Figures 2 and 3, respectively. The relationship between SN and PSN is shown in Figure 4.

Milepoints recorded in accident reports were used to describe the location of accidents to the nearest tenth of a mile (0.16 km). The ratios of wet- to dry-surface accidents and wet-surface to total accidents and rates of wet-surface accidents and total accidents, in terms of 100 million vehicle miles (161 million

vehicle kilometers)(total vehicle miles(kilometers) traveled under all pavement conditions), were calculated for each test section. These rates were based upon the lengths of sections and the 1971 AADT's and pertain to accidents for a 3-year period. Similar calculations were made for the accident data spanning 6-month periods (June through November).

SKID NUMBERS AND ACCIDENTS

Analysis of Test Sections by Cross Classification

To aid in determining the relationship between different combinations of traffic volume, Skid Numbers, and accidents, data for test sections were arrayed as shown in Table 2. Elements of the array are average wet-surface accident rates, total accident rates, ratios of wet-surface to total accidents, and ratios of wet- to dry-surface accidents for all test sections within Skid Number and traffic volume categories.

Analysis of the arrays led to the conclusion that the data needed to be stratified with respect to AADT to better define the relationship between accidents and pavement friction. A plot of wet-surface accident rate versus Skid Number (Figure 5) further illustrated the need for sorting and grouping the data. Stratification of data by AADT's showed improved relationship between accidents and Skid Numbers for some accident expressions but not necessarily for other expressions. Considerable variability in data remained after elimination of test sections having AADT's less than 3,000 vehicles per day. However, a trend of decreasing wet-surface accident rates with increasing Skid Numbers was unmistakable. Resulting relationships between accidents and pavement friction involving wet-surface accident rate are presented in Figure 6 and similarly for other accident expressions in Figures 7, 8, and 9.

Analysis of data for test sections with AADT's above 3,000 continued, seeking that expression of accident occurrence relating best with pavement friction. This was accomplished by taking elements in the arrays as predicted values. Actual accident occurrences for each test section were then compared to this "predicted" value to obtain deviations. This enabled computation of a coefficient of correlation for each accident expression. The correlation coefficients ranked the expressions in the following order:

1. wet-surface accidents per 100 million vehicle miles (161 million vehicle kilometers),
2. total accidents per 100 million vehicle miles (161 million vehicle kilometers),
3. ratio of wet-surface to total accidents, and
4. ratio of wet- to dry-surface accidents.

The degree of correlation was not sufficiently encouraging to enable a decisive selection of the best expression. Analyses to determine the relationship between accident occurrence and pavement friction were therefore continued using all four expressions.

Analysis of Test Sections by Averaging Techniques

Three averaging methods were used to reduce variability and, thereby, to more clearly demonstrate general relationships already apparent in the data set for test sections having AADT's above 3,000 vehicles per day. A discussion of these methods and the resulting trends follows.

Cumulative Averages. Two techniques were used to calculate cumulative averages. The first involved calculating the average of each expression for accident occurrence for all test sections having a Skid Number less than or equal to a given value. The second procedure involved calculating average accident occurrence -- for each method of expression -- of all test sections having a Skid Number greater than a given value. These average values are plotted in Figures 10, 11, 12, and 13.

In the first procedure of calculating averages, accident occurrences for low Skid Numbers had the greater influence upon the average value obtained. Extreme values of the expressions for accident occurrence for a test section at high Skid Numbers were attenuated through division by the large number of test sections with lower Skid Numbers. Thus, the second procedure, which yielded opposite weightings, was necessary to verify the trends and to insure that large deviations at high Skid Numbers were not being masked by the averaging process. The resulting trends were reasonably similar for wet-surface accident rate and total accident rate. For other expressions, the trend lines were not as similar; and the data points were quite scattered. Wet-surface accident rate decreased as the Skid Numbers increased to approximately 28; further increase in Skid Numbers resulted in only slight reduction in accidents.

Since the trends were similar, and because of the ranking of accident expressions discussed previously, subsequent analyses were restricted to wet-surface accidents per 100 million vehicle miles (161 million vehicle kilometers) as the method of expressing accident occurrences.

Average Wet-Surface Accident Rates Grouped by Skid Number. In the second method, test sections were grouped by Skid Number. The average wet-surface accident rate was calculated for each group. These averages are plotted in Figure 14. Again the trend indicated a rapidly decreasing accident rate with increasing Skid Numbers up to about 27. The variability was greater than that obtained by the first method because several groups included only one or two test sections, each having equal weighting as groups containing a larger number of test sections. Still, the trends by the two methods were very similar.

Moving Averages. The third method involved calculation of an average wet-surface accident rate and an average Skid Number for progressively-ordered sets of five test sections. The first average was of the five test sections with the lowest Skid Numbers. The test section with the lowest Skid Number was then dropped, and a test section with the next highest Skid Number added. This was repeated

until all test sections had been averaged in a group of five. In cases where more than one test section had the next highest Skid Number, one of these was randomly added each time. Test sections were dropped in the same sequence as they were added. Resulting averages are plotted in Figure 15.

The trend was similar to those developed by the previous two methods. However, this method indicated a more distinct change in the slopes of the two branches of the curve. At a Skid Number below 27, the wet-surface accident rate increased by two to three accidents per 100 million vehicle miles (161 million vehicle kilometers) per Skid Number, whereas above 27 the wet-surface accident rate decreased nominally.

The foregoing analysis here involved accident data for the entire 3 years while skid resistance was measured in the summer and fall of 1971. Pavements, of course, exhibit lower friction in the summer and fall, but the measured values may not be assumed to necessarily represent the lowest friction during the year for a particular pavement nor for the road system as a whole. The rapid change in the slope of the curve in Figure 15, for instance, may occur at some higher or lower Skid Number depending on when measurements are made. If accident data were subdivided into subsets for two periods of the year and the measured values reflected the mean Skid Number for each period, the rapid change in the slope would then be expected to occur at the same Skid Number provided driver behavior remained the same throughout the year. Since skid resistance values were not available for the winter-spring period, Figure 16 was prepared to show the relationship between wet-surface accident rate and pavement friction for summer-fall period. In contrast to Figure 15, a slightly higher Skid Number at which the accident rate increased rapidly is evident. The data, however, are more scattered, presumably due to the reduced data base (less than half of all wet-surface accidents). A shift towards a higher Skid Number would be anticipated because the accident rates associated with the 3-year period were related to friction values which were lower than the mean friction for a full year. Due to greater scatter of data in Figure 16, the trend established in Figure 15 must be accepted as the better indication of the relationship between accidents and pavement friction even though the accident data in Figure 16 more closely correspond to the measured skid resistance.

Wet-surface accident rates were calculated for 100 million miles (161 million kilometers) of total travel under all pavement conditions rather than wet-surface travel mileage. The true accident rate for wet-surface conditions would be several times higher since pavements were wet only 13 percent of the time. Also, as shown in Table 3, precipitation during the June-to-November periods were substantially less than for the winter-spring periods. Yet, the wet-surface accident rates for 1970 and 1971 were higher during the June-to-November periods. Precipitation occurrences in 1972, especially during winter-spring, was substantially more than for the two preceding years. If precipitation for the

two 6-month periods (during 3 years) were the same, the wet-surface accident rate of 19.5 (June to November) would be 25.2 compared to 19.3 for winter-spring periods. Therefore, lower skid resistance of pavements during summer and fall obviously contributed to an increase in wet-surface accidents.

PEAK SLIP NUMBERS AND ACCIDENTS

As discussed previously, there is a need to analyse different measurements of pavement friction to determine which correlates the best with accident experience. The peak friction force was measured routinely during all tests; thus these data were available for analysis. Test section averages were arrayed as shown before but Peak Slip Numbers (PSN) were substituted for Skid Numbers. The arrays again indicated the desirability for sorting the data by AADT at 3,000 vehicles per day. Wet-surface accident rates again appeared to be the best expression for accident occurrence. Test sections were grouped by Peak Slip Number, and average wet-surface accident rates were calculated for each Peak Slip Number as shown in Figure 17. The plot indicates more scatter than was obtained with Skid Numbers (Figure 14); this may be due to each data point representing fewer test sections. The greatest change of slope occurred at a Peak Slip Number of about 57. Similar results were obtained utilizing the five-point moving average, as shown in Figure 18, and the change in slope remained at the same Peak Slip Number.

The point of greatest change in slope of the curve in Figure 18 was at Peak Slip Number of 57 and in Figure 15 at Skid Number of 27. According to Figure 4, a PSN of 57 is equivalent to SN of approximately 27. Scatter of the data in Figure 15 in comparison to Figure 18 also appear to be similar and, therefore, suggests that both measurements of friction relate equally well to accident occurrence. This was somewhat unexpected because of the inherent measurement and chart analysis errors associated with peak slip resistance (PSN) determination. Peak slip resistance occurs for a very brief period of time during wheel lock-up, and the measurement represents a much shorter length of pavement than the locked-wheel test (SN). For that reason, poor agreement between SN and PSN in Figure 4 was credited largely to inaccuracies in PSN. If such a conclusion is valid, some of the scatter of data in Figure 18 may be due to errors in PSN. In that event, Peak Slip Number may correlate best with accident experience.

SUMMARY AND CONCLUSIONS

On rural, four-lane, interstate and parkway (expressway) facilities, wet-surface accidents per 100 million vehicle miles (161 million vehicle kilometers) correlated best with skid resistance. Even using the best statistical expression of accidents, scatter and spurious variability in data seem inevitable. Stratification of the data by AADT at 3,000 vehicles per day minimized scatter. Averaging methods as a means of developing trends and minimizing scatter between variables were used in the study. Of

the averaging methods investigated, the "moving average" yielded more definitive results. Definite trends were established in regard to the relationship between wet-surface accident rates and Skid Numbers (Figure 15). Wet-surface accident rate decreased rapidly as the Skid Number (70 mph or 31 m/s) increased to 27; further increases in Skid Number beyond this point resulted in only a slight reduction in accident rate. The analysis here involved accident data throughout the year (3-year period) while skid resistances were measured in the summer and fall (1971) when pavements normally exhibit lower friction values. As expected, analysis of the accident data for 6-month periods (June to November) (Figure 16) indicated a slightly higher friction. The data, however, were more scattered due to the reduced data base.

Wet-surface accident rates for 2 of the 3 years considered in this study were higher during the summer-fall periods (Table 3) even though the roads were wet a lesser proportion of time. When adjusted to equal time of precipitation during December to May and June to November, wet-surface accident rates for the summer-fall periods were higher for all 3 years. Lower skid resistance of pavements during summer and fall obviously contributed to an increase in wet-surface accidents.

Definite trends were also evident between wet-surface accident rates and Peak Slip Numbers. The greatest change in slope of the trend lines (Figure 16) occurred at a PSN₇₀ of about 57. Scatter of data was no worse than that for Skid Numbers. This was somewhat unexpected because of the inherent measurement and chart analysis errors associated with peak slip resistance determinations. A Peak Slip Number of 57 is equivalent to a Skid Number of approximately 27; and, as shown in Figure 15, a SN₇₀ of 27 also corresponds to the greatest change in slope of trend lines. This suggests that either the correlation between the two friction measurements overshadowed any subtle differences that may exist between accidents and either measurement of friction or that both skid and slip resistance are equally valid indexes of friction requirements for pavements.

It should be reemphasized that the findings cited here pertain to rural, four-lane, limited access, expressway type highways with posted speeds of 70 mph (31 m/s) and that no consideration was given in the analysis to geometrics of roadways nor to points of traffic conflicts. High accident or repeat accident locations certainly warrant further study to determine what variables or combination of variables may contribute to wet-surface accidents. Nevertheless, it was demonstrated that there is a relationship between accident experience and pavement friction; this relationship should be utilized as a guide in establishing minimum friction requirements for pavements. The established trends, relating wet-surface accident rates with skid resistance, indicated a definite value of skid resistance below which the accident rate increased rapidly. Also, the methods described herein may be used in future analyses to establish skid resistance requirements for other types of highways.

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ACKNOWLEDGEMENTS

The work reported in this paper was done by the Kentucky Bureau of Highways in cooperation with the Federal Highway Administration. Contents of the paper reflect the views of the authors and not necessarily the official views or policies of the Kentucky Bureau of Highways or the Federal Highway Administration.

TABLE 1
SUMMARY OF YEARLY ACCIDENT OCCURRENCE
(110 TEST SECTIONS)

ROUTE	1970				1971			
	TOTAL ACCIDENTS	DRY-SURFACE ACCIDENTS	WET-SURFACE ACCIDENTS	FATALITIES	TOTAL ACCIDENTS	DRY-SURFACE ACCIDENTS	WET-SURFACE ACCIDENTS	FATALITIES
I 64	190	102	34	16	225	138	46	5
I 65	287	179	72	9	349	225	65	12
Kentucky Turnpike	233	146	64	6	222	168	29	5
I 71	229	116	59	2	254	132	68	6
I 75	643	395	110	24	597	361	140	29
Jackson Purchase Parkway	11	9	2	0	16	13	1	0
Pennyrile Parkway	45	38	4	2	51	38	3	3
Western Kentucky Parkway	89	59	22	5	76	51	15	3
Bluegrass Parkway	70	50	10	6	64	41	11	1
Mountain Parkway	47	27	10	2	32	19	11	2
Total	1844	1211	387	72	1886	1186	389	66
ROUTE	1972				TOTAL			
	TOTAL ACCIDENTS	DRY-SURFACE ACCIDENTS	WET-SURFACE ACCIDENTS	FATALITIES	TOTAL ACCIDENTS	DRY-SURFACE ACCIDENTS	WET-SURFACE ACCIDENTS	FATALITIES
I 64	267	164	59	12	682	404	139	33
I 65	400	273	101	12	1036	677	238	33
Kentucky Turnpike	332	242	82	15	787	556	175	14
I 71	259	145	57	6	742	393	184	70
I 75	611	361	167	17	1851	1117	417	26
Jackson Purchase Parkway	23	13	7	0	50	35	10	0
Pennyrile Parkway	63	47	11	0	159	123	18	5
Western Kentucky Parkway	109	75	20	4	274	185	57	12
Bluegrass Parkway	62	38	13	5	196	129	34	12
Mountain Parkway	51	22	21	2	130	68	42	6
Total	2177	1380	538	73	5907	3687	1314	211

TABLE 2
ACCIDENT RATES AND RATIOS

NO OF TEST SECTIONS	WET-SURFACE ACCIDENT RATES*							TOTAL ACCIDENT RATES*						
	16	24	19	25	26	110	94	16	24	19	25	26	110	94
	AADT (VEHICLES PER DAY)							AADT (VEHICLES PER DAY)						
70-MPH														
(31 m/s)														
SKID NUMBER	0	3001	4001	9001	14001	0	3001	0	3001	4001	9001	14001	0	3001
	3000	4000	9000	14000	24000	24000	24000	3000	4000	9000	14000	24000	24000	24000
1970														
16 - 20				25.4	21.3	24.6	24.6				95.1	86.3	93.5	93.5
21 - 25		24.3	8.0	16.0	18.3	16.1	16.1		113.7	46.6	66.6	87.8	75.2	75.2
26 - 30	14.9	7.2	6.4	24.3	9.7	9.3	8.8	100.1	53.7	47.4	76.8	69.5	62.9	59.3
31 - 35	15.3	16.1	11.6			15.1	14.9	51.2	77.0	58.0			65.3	72.3
36 - 40	13.0	12.9	2.8			10.4	6.8	84.7	48.0	41.5			67.8	44.1
41 - 50	0.0	22.9				15.3	22.9	0.0	82.4				54.9	82.4
1971														
16 - 20				28.3	15.9	26.0	26.0				95.8	87.1	94.3	94.3
21 - 25		27.6	9.1	13.9	20.4	26.7	16.7		78.8	41.9	86.0	85.8	77.0	77.0
26 - 30	6.3	6.5	12.5	24.3	11.6	10.3	10.7	47.3	70.9	68.5	68.7	76.6	70.2	72.4
31 - 35	8.4	6.2	0.0			5.9	4.6	82.3	60.3	31.4			62.8	53.1
36 - 40	2.0	25.9	18.4			10.0	21.4	49.0	82.1	35.3			51.1	54.0
41 - 50	0.0	5.8				3.9	5.8	0.0	76.2				50.8	76.2
1972														
16 - 20				24.8	24.2	24.7	24.7				96.1	97.0	96.3	96.3
21 - 25		42.8	19.4	20.7	26.1	24.5	24.5		109.9	58.1	91.1	104.1	91.6	91.6
26 - 30	27.6	15.3	17.7	44.5	17.7	19.0	18.2	74.2	75.9	75.5	137.5	72.1	77.0	77.3
31 - 35	9.2	18.1	6.3			13.2	15.2	61.4	88.2	82.0			78.2	86.6
36 - 40	38.7	11.8	7.7			26.5	9.4	116.0	90.5	50.9			95.5	66.7
41 - 50	0.0	11.3				7.5	11.3	474.4	64.9				201.4	64.9
1970 - 1972														
16 - 20				26.2	20.5	25.1	25.1				95.7	90.1	94.7	94.7
21 - 25		31.6	12.2	16.9	21.6	19.1	19.1		100.8	48.9	81.3	92.6	81.3	81.3
26 - 30	16.3	9.7	12.2	31.0	13.0	12.9	12.6	73.8	66.8	63.8	94.3	72.7	70.0	69.7
31 - 35	11.0	13.5	6.0			11.4	11.6	65.0	75.2	57.1			68.8	70.7
36 - 40	17.9	16.8	9.6			15.7	12.5	83.2	73.5	42.5			71.4	54.9
41 - 50	0.0	13.3				8.9	13.3	158.1	74.5				102.4	74.5

*Accidents per 100 million vehicle miles (161 million vehicle kilometers)

NO OF TEST SECTIONS	RATIO OF WET-SURFACE TO TOTAL ACCIDENTS							RATIO OF WET- TO DRY-SURFACE ACCIDENTS						
	16	24	19	25	26	110	94	16	24	19	25	26	110	94
1970														
16 - 20				0.26	0.26	0.26	0.26				0.54	0.44	0.52	0.52
21 - 25		0.14	0.18	0.24	0.19	0.20	0.20		0.69	0.40	0.50	0.44	0.48	0.48
26 - 30	0.15	0.13	0.13	0.32	0.14	0.15	0.15	0.19	0.23	0.22	0.50	0.25	0.34	0.25
31 - 35	0.45	0.15	0.17			0.24	0.15	0.56	0.33	0.37			0.40	0.34
36 - 40	0.14	0.58	0.11			0.21	0.30	0.23	0.25	0.17			0.21	0.19
41 - 50		0.25				0.25	0.25		0.49				0.49	0.49
1971														
16 - 20				0.25	0.18	0.24	0.24				0.54	0.32	0.50	0.50
21 - 25		0.33	0.24	0.15	0.23	0.21	0.21		0.55	0.32	0.27	0.45	0.41	0.41
26 - 30	0.25	0.13	0.13	0.35	0.16	0.16	0.15	0.50	0.20	0.35	0.67	0.26	0.30	0.28
31 - 35	0.16	0.10	0.0			0.10	0.07	0.55	0.24	0.0			0.31	0.18
36 - 40	0.03	0.60	0.55			0.25	0.57	0.04	0.33	2.78			0.89	2.16
41 - 50		0.07				0.07	0.07		0.08				0.08	0.08
1972														
16 - 20				0.24	0.24	0.24	0.24				0.44	0.43	0.44	0.44
21 - 25		0.39	0.35	0.22	0.25	0.27	0.27		1.47	0.90	0.40	0.43	0.61	0.61
26 - 30	0.41	0.21	0.21	0.32	0.23	0.24	0.22	0.75	0.34	0.46	0.52	0.42	0.44	0.41
31 - 35	0.15	0.18	0.08			0.15	0.16	0.21	0.32	0.50			0.31	0.37
36 - 40	0.30	0.14	0.13			0.23	0.14	0.68	0.50	0.26			0.54	0.35
41 - 50	0.0	0.18				0.12	0.18	0.0	0.29				0.19	0.29
1970 - 1972														
16 - 20				0.26	0.22	0.25	0.25				0.50	0.40	0.48	0.48
21 - 25		0.29	0.24	0.21	0.22	0.23	0.23		1.15	0.45	0.37	0.40	0.47	0.47
26 - 30	0.21	0.16	0.17	0.33	0.17	0.18	0.18	0.29	0.22	0.31	0.55	0.27	0.28	0.27
31 - 35	0.19	0.16	0.11			0.16	0.15	0.30	0.27	0.27			0.28	0.27
36 - 40	0.20	0.31	0.22			0.22	0.26	0.31	1.36	0.38			0.50	0.78
41 - 50	0.0	0.17				0.11	0.17	0.0	0.26				0.18	0.26

TABLE 3
SEMIANNUAL ACCIDENT SUMMARY

YEAR	PERIOD	NUMBER OF ACCIDENTS			RATIO OF ACCIDENTS		ACCIDENT RATES*			PRECIPITATION (PERCENT)**
		TOTAL	DRY-SURFACE	WET-SURFACE	WET/TOTAL	WET/DRY	TOTAL	DRY	WET	
1970	Jan-May, Dec	965	476	166	0.17	0.35	92.3	45.6	15.9	13
	Jun-Nov	879	645	221	0.25	0.34	66.9	49.1	16.8	10
1971	Jan-May, Dec	948	511	160	0.17	0.31	90.7	48.9	15.3	13
	Jun-Nov	938	676	229	0.24	0.34	71.4	51.5	17.4	10
1972	Jan-May, Dec	1029	542	280	0.27	0.52	98.5	51.9	26.8	18
	Jun-Nov	1148	838	278	0.24	0.33	87.4	63.8	21.2	12
1970- 1972	Jan-May, Dec	2942	1529	606	0.21	0.40	93.8	48.8	19.3	15
	Jun-Nov	2965	2159	728	0.25	0.34	75.3	54.8	18.5	11

*Accidents per 100 million vehicle miles (161 million vehicle kilometers) (all pavement conditions).

**Percent of total time of precipitation (trace or more) in the Lexington area.
Periods of snow or ice not included.

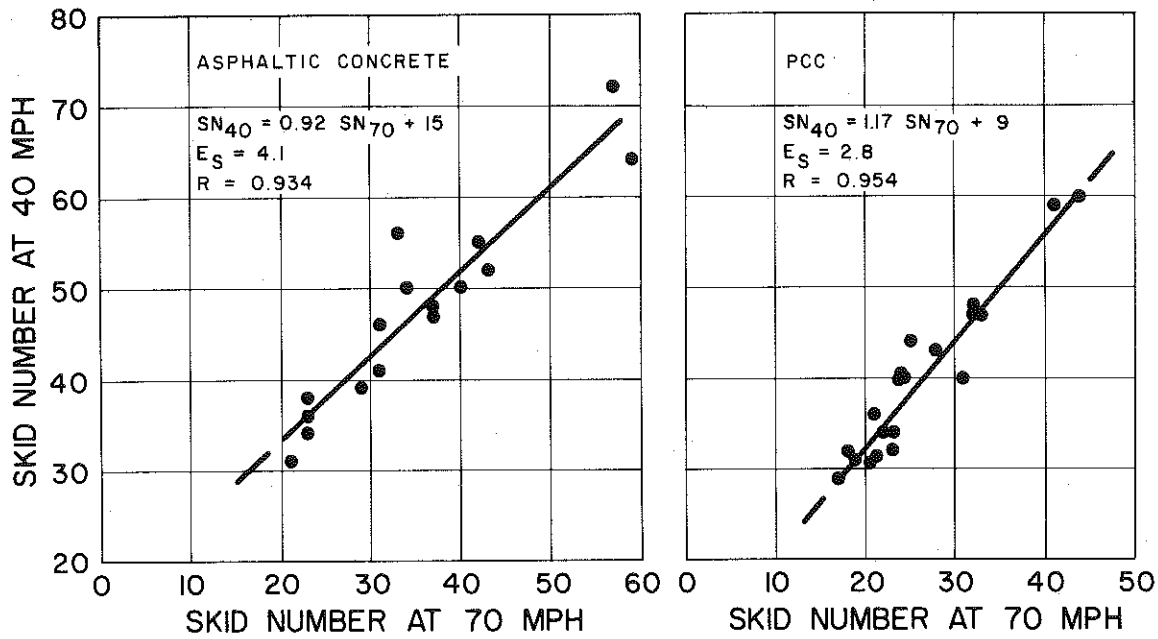


Figure 1. Correlation of Trailer Tests Conducted at 40 and 70 mph (18 and 31 m/s) on Bituminous and Portland Cement Concrete Pavements on Interstate and Parkway Routes.

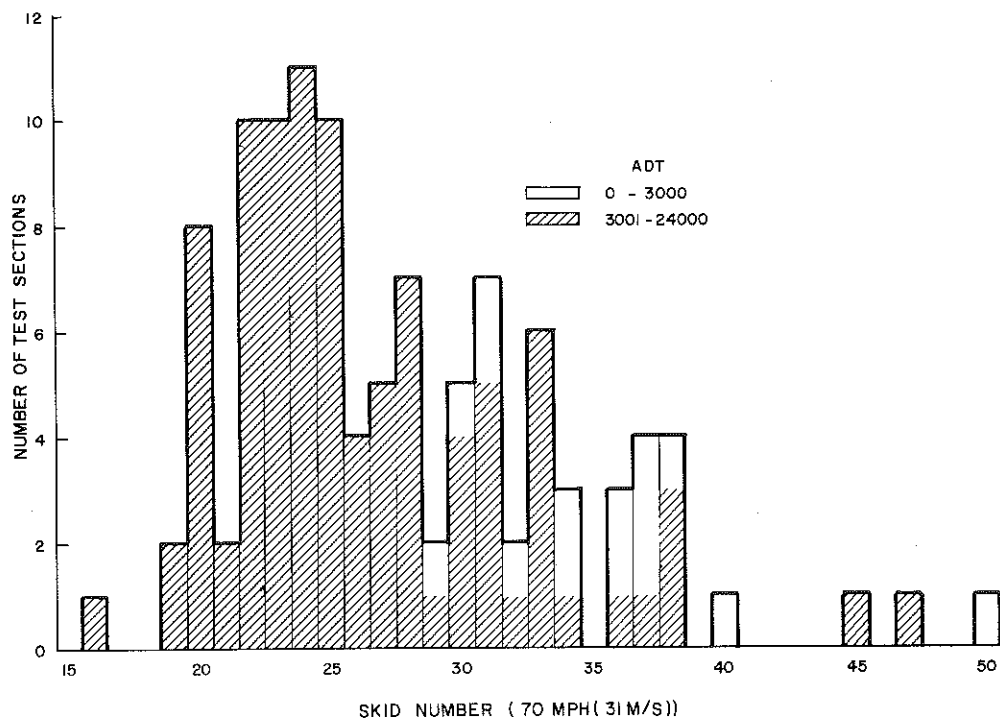


Figure 2. Skid Number Distribution for 110 Test Sections of Rural Interstate and Parkway Routes.

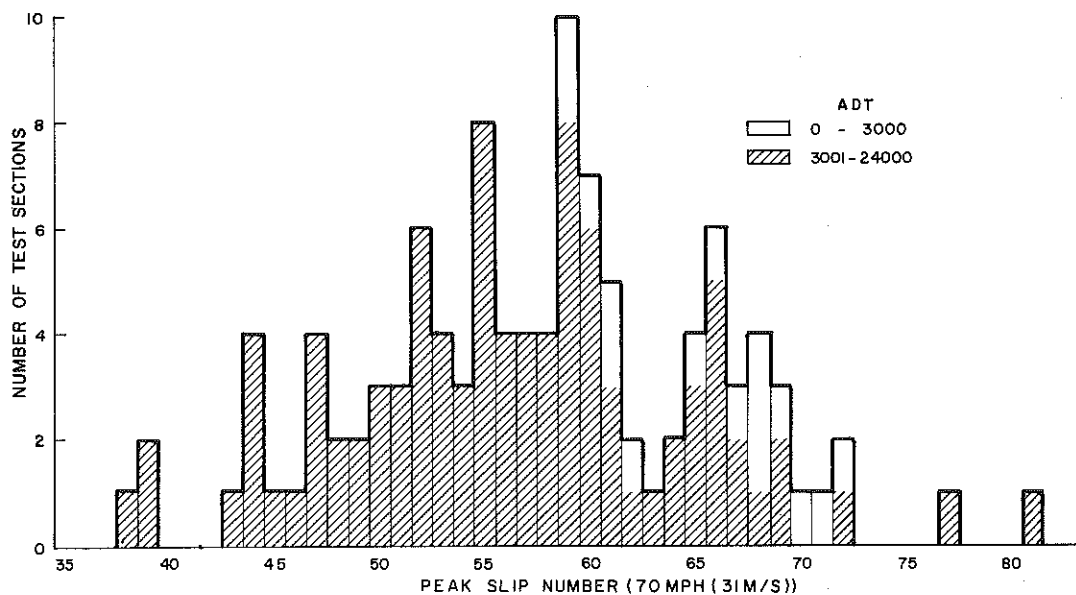


Figure 3. Peak Slip Number Distribution for 110 Test Sections on Rural Interstate and Parkway Routes.

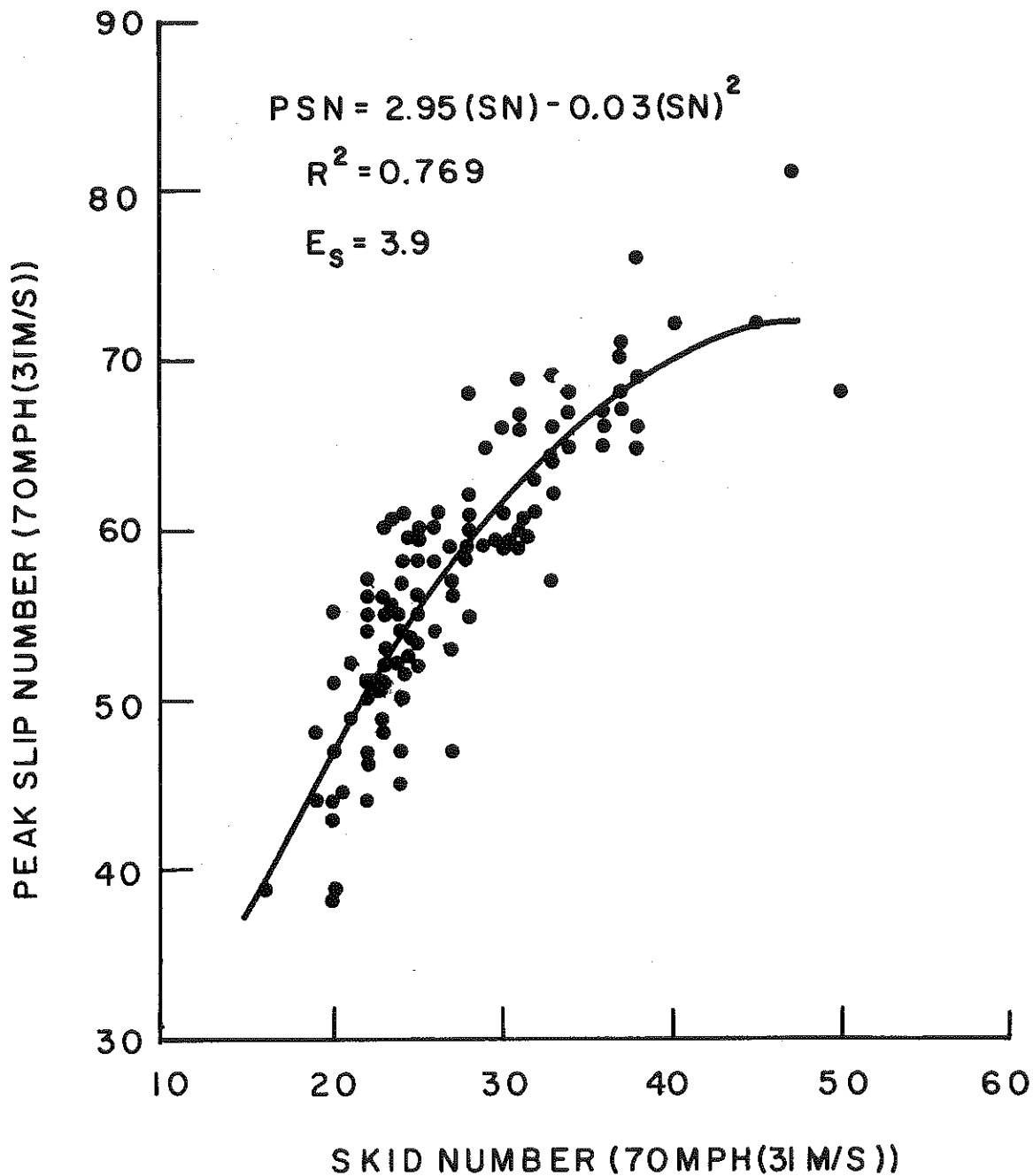


Figure 4. Relationship between Skid Number and Peak Slip Number at 70 mph (31 m/s) on Interstate and Parkway Routes.

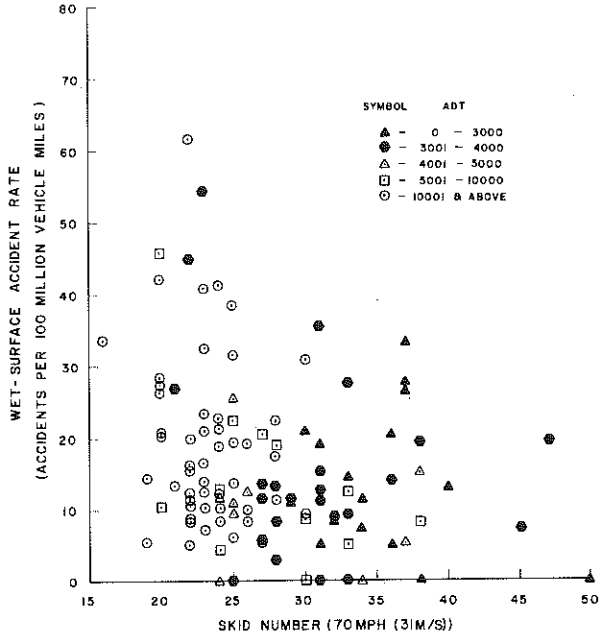


Figure 6. Comparison of Wet-Surface Accident Rate to Skid Number with Volume Stratification at AADT of 3,000.

Figure 5. Test Section Averages: Wet-Surface Accident Rate for 1970 through 1972 Versus Skid Number with AADT Stratification.

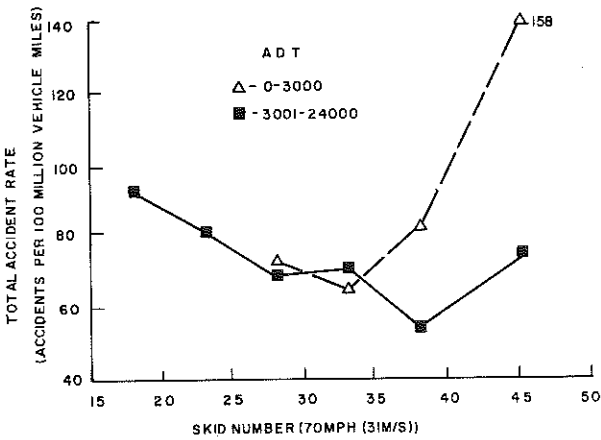
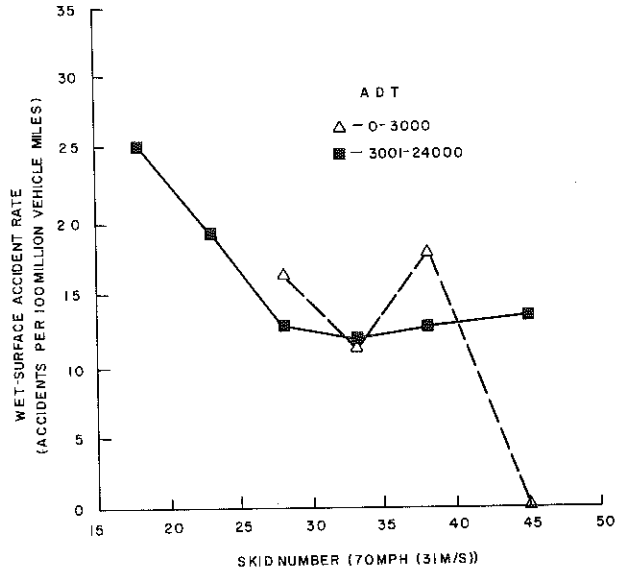
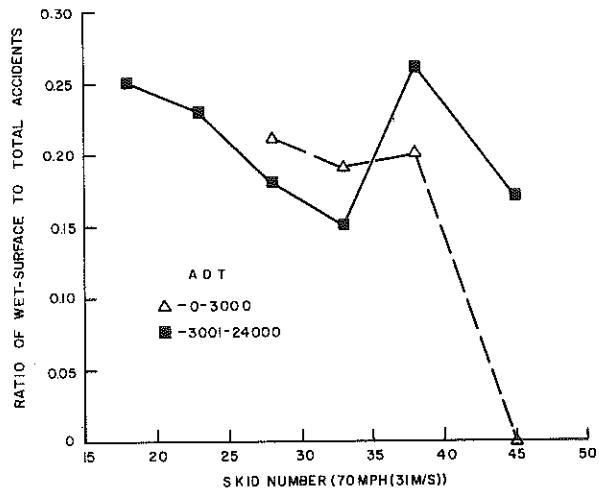


Figure 8. Comparison of Wet-Surface Accidents / Total Accidents Ratio to Skid Number with Volume Stratification at AADT of 3,000.

Figure 7. Comparison of Total Accident Rate to Skid Number with Volume Stratification at AADT of 3,000.



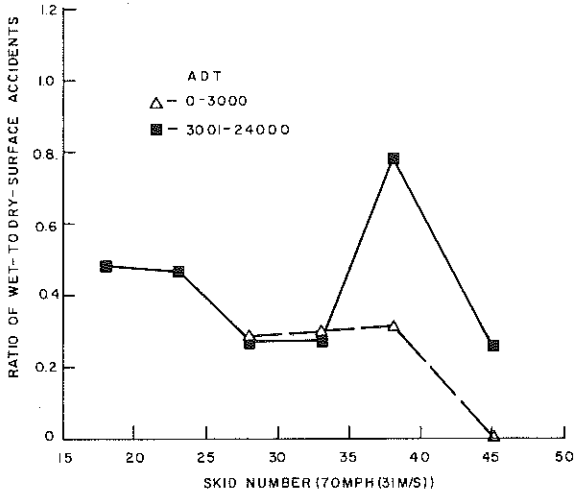


Figure 9. Comparison of Wet-Surface Accidents Dry-Surface Accidents Ratio to Skid Number with Volume Stratification at AADT of 3,000.

Figure 10. Cumulative Averages of Wet-Surface Accident Rate Versus Skid Number with Volume Stratification at AADT of 3,000.

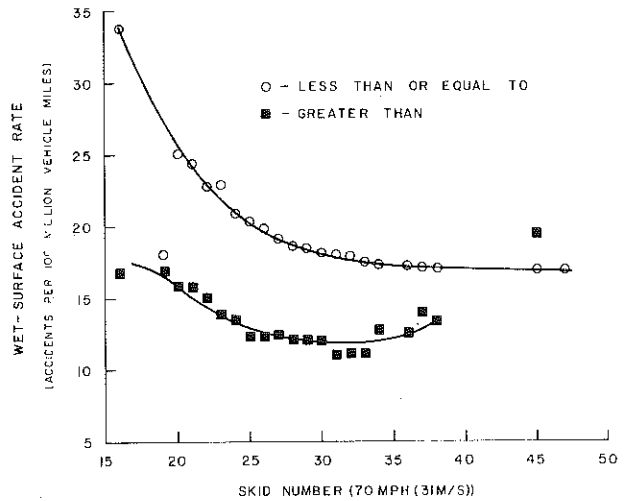
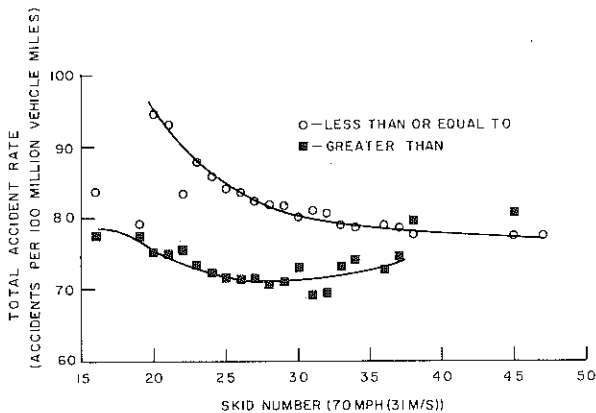


Figure 11. Cumulative Averages of Total Accident Rate Versus Skid Number with Volume Stratification at AADT of 3,000.



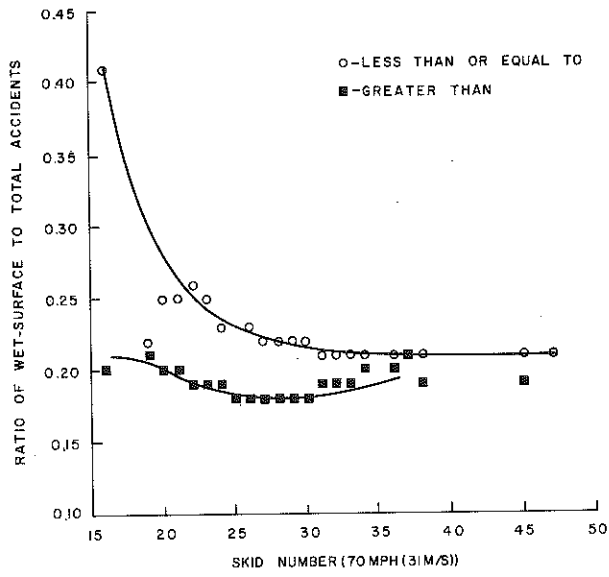


Figure 13. Cumulative Averages of Wet-Surface Accidents / Dry-Surface Accidents Ratio Versus Skid Number with Volume Stratification at AADT of 3,000.

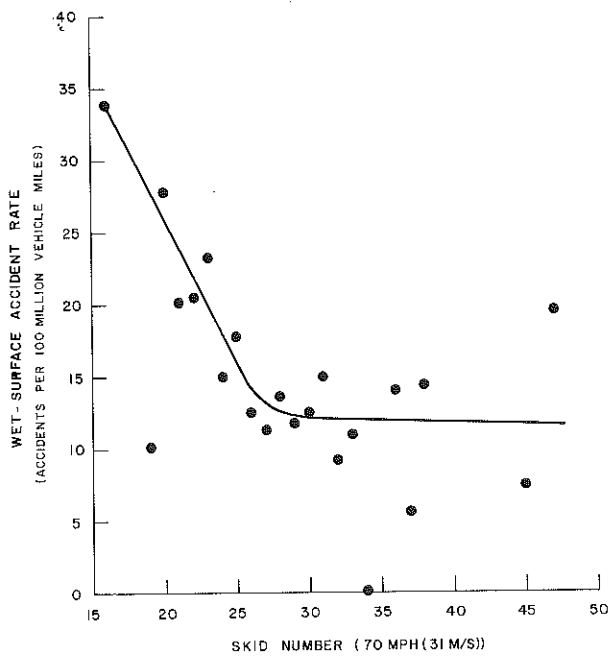


Figure 12. Cumulative Averages of Wet-Surface Accident / Total Accidents Ratio Versus Skid Number with Volume Stratification at AADT of 3,000.

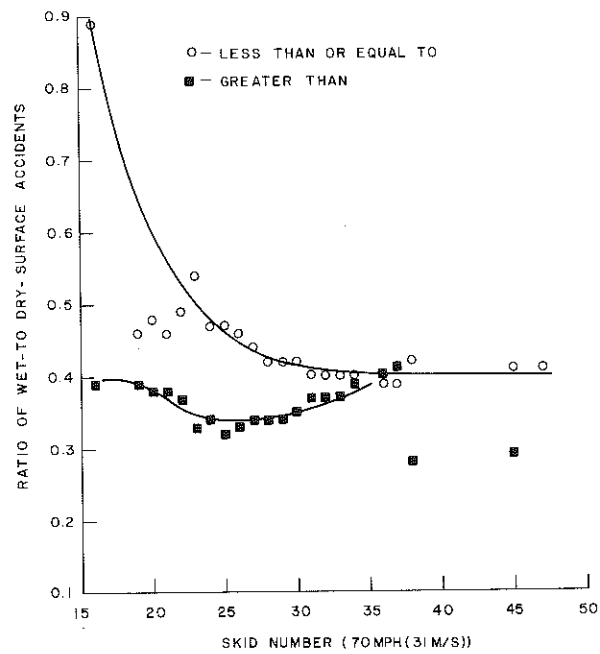


Figure 14. Average Wet-Surface Accident Rate of 94 Test Sections -- Grouped by Skid Number -- Versus Skid Number with Volume Stratifications at AADT of 3,000.

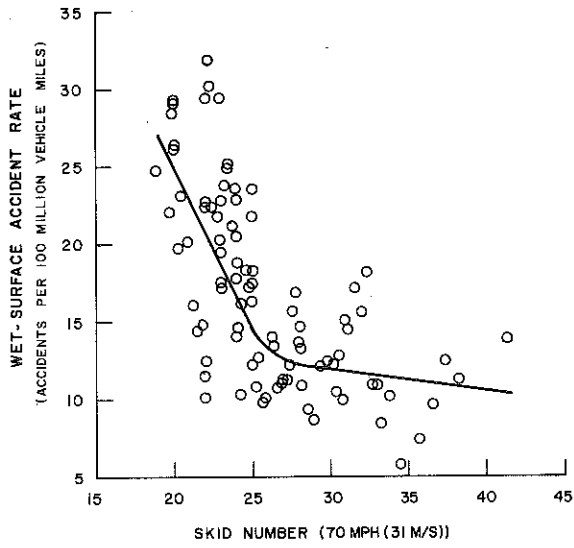
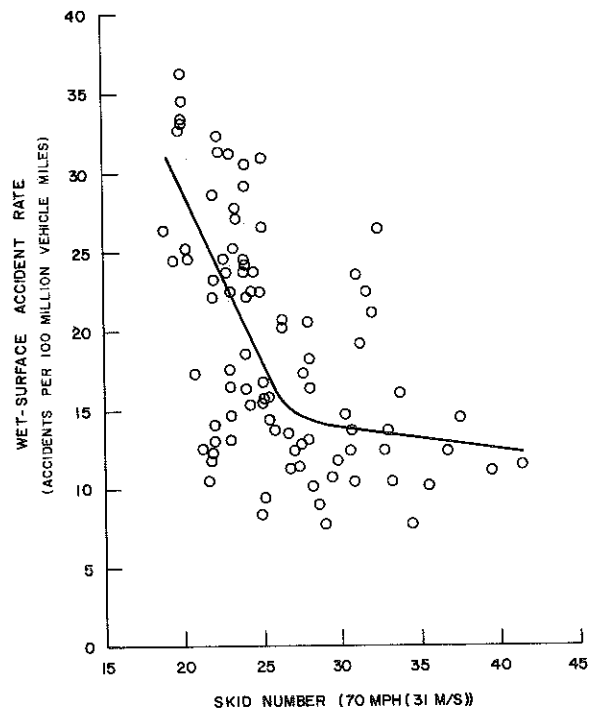


Figure 15. Five-Point Moving Averages: Wet-Surface Accident Rate Versus Skid Number with Volume Stratification at AADT of 3,000.

Figure 16. Five-Point Moving Averages: Wet-Surface Accident Rate for Summer-Fall Periods Versus Skid Number with Volume Stratification at AADT of 3,000.



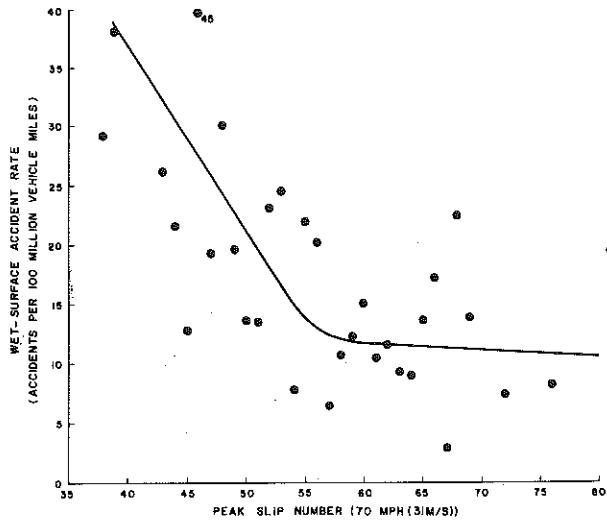


Figure 17. Average Wet-Surface Accident Rate of 94 Test Sections -- Grouped by Peak Slip Number -- Versus Peak Slip Number with Volume Stratification at AADT of 3,000.

Figure 18. Five-Point Moving Averages: Wet-Surface Accident Rate Versus Peak Slip Number with Volume Stratification at AADT of 3,000.

