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by
James L. Burchett
Research Engineer Chief

and

Rolands L. Rizenbergs
Assistant Director of Research

Division of Research
Bureau of Highways
DEPARTMENT OF TRANSPORTATION
Commonwealth of Kentucky

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J. L. Burchett and R. L. Rizenbergs
Kentucky Department of Transportation

ABSTRACT

Frequent measurements of skid resistance were made on 20 pavements in common use in Kentucky. Tests were conducted from November 1969 through 1973. Principal analysis involved relating changes in skid resistance to day of the year and relating skid resistance to temperature at the time of test, to average antecedent temperatures, and to average rainfall.

Seasonal variations exhibited an annual sinusoidal cycle. The changes in sand-asphalt and bituminous concrete surfaces under higher volumes of traffic were about 12 skid numbers. The changes in portland cement concrete and bituminous concrete under lower volumes of traffic were about 5 skid numbers. The lowest skid numbers (SN's) occurred in early to mid-August for portland cement concrete and sand-asphalt pavements and in late August to early September for bituminous concrete. Correlations between changes in SN and temperature were best for ambient air temperature averaged over 4- and 8-week periods prior to date of test. However, correlations between changes in SN and temperature were not as good as correlations between SN and day of the year. On the other hand, combining traffic volumes in the form of deviations from yearly average daily traffic with temperature yielded correlations with SN's which were as good as correlations between SN's and the day of the year.

It was concluded that skid resistance measurements in Kentucky should be conducted between the first of July and the middle of November to be assured of detecting significant differences in SN. However, frequent testing of reference sections is recommended to define more specifically each year the beginning and ending date of the testing season.

INTRODUCTION

Laboratory studies of wear and frictional characteristics of aggregates in Kentucky began in 1956, and field testing of pavement surfaces began in 1958. Many variables associated with testing devices, procedures, and methods of test were investigated and led eventually to standardization. From 1958 to 1969, field tests were conducted with an automobile in several modes *(1)*. Testing then was confined mostly to a 6-month period from mid-May through mid-November. Also, the greater manpower needs for testing with an automobile could best be satisfied in the summertime. However, concerns persisted with regard to the influence of weather and the seasonal changes. A limited investigation of seasonal changes was conducted during 1965, 1966, and 1967. Results then indicated significant fluctuations, but the data were insufficient to define the change *(2)*.

A two-wheeled skid-test trailer was acquired in 1969 and was adopted for routine testing *(3)*. Statewide surveys were initiated, and the data were used for a multiplicity of purposes, including the identification of hazardous locations in wet weather. The test period needed to be defined to minimize variability. Also, measurements outside the test period needed to be adjusted to a common base.

Periodic measurements were initiated in 1969 on 20 pavement sections; there were four types of surfaces. Tests were conducted from November 1969 through 1973. Changes in skid resistance were related to day of the year. Relationships were sought between skid resistance and temperature at the time of test, average temperature for 1 to 8 weeks prior to the day of test, and average rainfall. This paper presents those analyses.

DATA

Pavement Sections

A total of 20 pavement sections were selected within 48 km (30 miles) of Lexington. Fourteen were 2.4 km (1.5 miles) long and the other six were 1.6 km (1.0 mile) long. The sections were bituminous (Class I, Types A and B), sand asphalt, and portland cement concrete. The annual average daily traffic (AADT) per lane ranged from 200 to 10,300. Each section was at least 3 years old; therefore, polishing effects due to traffic had stabilized.

Weather Data

Precipitation and temperatures were obtained from monthly tabulations of "Local

Climatological Data" *(4)* for the Lexington area. Monthly and weekly average precipitation were determined both in terms of quantity and duration. Average temperatures for periods of 1, 2, 3, 4, and 8 weeks preceding tests were calculated from daily average temperatures, which were determined by averaging 3-hour readings. Monthly average temperatures were recorded. Ambient air temperature and pavement surface temperature were measured and recorded at the time of test.

Skid Resistance Measurement

Skid resistance was measured with a Surface Dynamics Pavement Friction Tester (Model 965A) manufactured by K. J. Law Engineers, Inc., Detroit, Michigan. The two-wheeled skid-test trailer was acquired in 1969. This trailer complied with ASTM E 274 *(5)*. The measurements represent the traction developed between a standard 14-inch test tire (ASTM E 249) *(6)* and a wetted pavement. The locked-wheel measurements are expressed in skid numbers (SN).

From November 1969 to December 1972, the test sections were tested on a monthly basis. Six of the sections were overlaid in June 1972. Testing continued during March and June 1973 on the 14 remaining sections. Equipment malfunctions, weather conditions, and other circumstances prevented testing during some months. In all, tests were made during two-thirds of the scheduled months.

Measurements were made in the left wheel path at 17.9 m/s (40 mph). Tests were also made at 8.9 m/s (20 mph) and at 26.8 m/s (60 mph) during one-half of the schedule.

SKID NUMBER VERSUS DAY OF YEAR

Skid numbers from the 17.9-m/s (40-mph) tests were plotted versus date of test. These plots indicated that skid numbers varied sinusoidally during the year. It was desirable to derive an equation to indicate the day of occurrence of the highest and lowest SN. Therefore, the model equation for the regression analysis was based on the cosine function; one cycle encompassed 365 days. This equation was

$$SN_p = SN_a - \Delta SN \cos [360° (D - D_1)/365]$$

where SN_p = predicted skid number,

SN_a = skid number about which SN varies,

ΔSN = largest variation of SN about SN_a,

D = day of year, and

D_1 = day of year at which SN is lowest.

The values of SN_a, ΔSN, and D_1 were determined for each test section using the method of least squares. These values along with other statistics are presented in Table 1. The variations in SN were determined for each section by subtracting SN_a from SN_p. The resulting curves were drawn as shown in Figure 1.

The variances in SN on bituminous surfaces were associated with traffic volume. For example, Section 1 with a 16-point change was the same construction project as Section 2 with only a 12-point change. Section 1, however, was the outer lane and had a higher AADT than Section 2. The same was true for pairs of Sections 5 and 6, 7 and 8, 9 and 10, and 17 and 18. All other sections were on two-lane roads, and, therefore, pairs of sections had nearly the same AADT. These pairs were Sections 3 and 4, 11 and 12, and 19 and 20. There were very little differences in the SN's in those cases.

Changes in skid numbers (measured SN minus SN_a) for each type of surface were combined, and regression equations were determined. Class I, Type A and Type B, bituminous pavements were also divided into two groups: greater or less than 3,500 vehicles per day per lane. The equations and their coefficients are tabulated in Table 2. Regression curves for the 365-day cycle are given in Figure 2. Data and curves are in Figure 3a-c.

The regression curves indicated that SN's for Class I, Type A, with the higher AADT's varied seasonally by 14 points; the lowest SN occurred in early September. The SN's for Class I, Type A, with the lower AADT's varied by 4 points; and the lowest SN occurred in mid-August. The SN for Class I, Type B, surfaces with the higher AADT's varied seasonally by 11 points; and those with the lower AADT's varied by 6. The lowest SN's for those pavements occurred in late August and early September, respectively. The SN for portland cement concrete pavements varied seasonally by 5 points. The lowest value occurred during mid-August. The SN for sand asphalts varied seasonally by 11 points (lowest in early August).

PRECIPITATION AND TEMPERATURE VERSUS DAY OF YEAR

The mechanisms which change pavement surface characteristics are many and have been enumerated elsewhere *(7)*. Two factors investigated in this study and which may be associated with these mechanisms were precipitation and temperature.

Since changes in skid numbers correlated with day of the year, factors associated with the principal mechanisms causing variances must also correlate with day of the year. Figure 4 is a plot of monthly averages of precipitation and temperature. The amount and duration of precipitation and air temperature correlated somewhat with month of the year.

Precipitation

Precipitation, given in Figure 4, was greatest during late spring and early summer and least during late summer and early fall. This trend was most evident in weekly averages throughout the 4-year period, as shown in Figure 5. However, the amounts were highly variable, as, for example, both the largest and the least weekly averages occurred in early fall. The average duration of precipitation (number of hours per month with 0.25 mm (0.01 inch) or more), as shown in Figure 4, exhibited trends similar to the amounts of precipitation. The trend is illustrated more clearly in the weekly averages in Figure 6. The durations of precipitation were the longest during mid-winter and were uniformily shortest from late spring to early fall. Average weekly durations (trace or more) were also determined for the 4-year period. These are plotted in Figure 7 along with the best-fit cosine function. The best-fit curve indicated a good correlation between duration and day of the year. The trend was similar to that of variances in SN versus day of the year. The longest and shortest rainfalls occurred from one-half to one month before the occurrence of the highest and lowest skid resistances, respectively. However, precipitation was not specific enough, not measured often enough, to permit correlations with changes in SN.

Temperature

Monthly averages of air temperature during the period of study varied sinusoidally with month of the year (see Figure 4). Lowest temperatures occurred during January or February, and highest temperatures occurred during July or August. Temperatures each test date were evaluated for relationships between temperature and day of the year.

Air temperature and pavement surface temperature were recorded at the time of skid testing. Regression analysis was performed using these data for each type of pavement. The model equation was

$$T_p = T_a + \Delta T \cos [360° (D - D_h)/365],$$

where T_p = predicted temperature,

T_a = temperature about which T varies,

ΔT = variation of T about T_a,

D = day of year, and

D_h = day of year at which T is highest.

The results of the regression analyses are presented in Tables 3 and 4. Good correlations were obtained in all cases. The lowest air temperature of 8°C (46° F) occurred in late January, and the highest of 28° C (82° F) was observed during the last of July. The lowest pavement surface temperature of 12° C (53°F) occurred during mid-January, and the highest, 38° C (101° F), was during mid-July. When these values were compared to the values in Table 2, the highest and lowest skid numbers lagged the lowest and highest temperature periods by one-half to one and one-half months. If the principal mechanism in changing skid resistance was associated with air or pavement temperature, then the reaction of that mechanism to temperature changes must have occurred over a period of a few weeks.

Air temperatures were averaged over periods of 1, 2, 3, 4, and 8 weeks prior to the date of test. Correlation of these averages with day of test (based on a 1-year cycle) were made by regression analysis. Results are presented in Table 5. The results indicated excellent correlations between air temperature, as averaged, and day of the year. A comparison of Table 5 with Table 2 indicated that days of highest and lowest SN agreed more closely with the days of highest and lowest temperature for the 4-week and 8-week periods: the 4-week period matched the fine-textured portland cement concrete, sand asphalt, and the low volume, Class I, Type A, surface; the 8-week period matched more closely the other types of pavements.

SKID NUMBER VERSUS TEMPERATURE

The similarity between temperature cycles and skid resistance cycles indicated that temperature may be the primary factor that seasonally alters pavement surface characteristics, and, therefore, alters skid resistance of the surface. In that case, the SN's obtained should correlate with air or pavement surface temperature. A regression analysis of SN versus several measures of temperature were made for each test section. The linear model equation used was

$$SN_p = SN_i + \Delta SN_t T$$

where SN_p = predicted skid number,

SN_i = SN at 0° C or (0° F)

ΔSN_t = change of SN_i per 1° C (or 1° F), and

T = temperature.

As expected, the best correlations were found for pavements that also showed the best

correlations between SN and day of the year (see Table 1). Also, in general, the best correlations were obtained with air temperature, averaged for either a 4- or 8-week period prior to the day of testing. Additional analysis was made to determine if grouping the test sections by pavement type improved the correlation between SN and temperature. The measure of temperature used in this analysis were air temperature, averaged over 4- and 8-week periods prior to the day of testing. The SN_p's were calculated for test sections using the temperature of 21°C (70°F) for each measure of temperature. The corresponding SN_p was subtracted from the measured SN. Test sections were grouped as before. Regression analyses of these adjusted SN's versus each average of air temperature were made. The results are presented in Tables 6 and 7.

Results indicated that correlations between skid resistance and temperature were not as good as correlations between skid resistance and day of the year. For these data, therefore, prediction of the skid resistance cycle based on correlations between SN and temperature would not be as accurate as using day of the year. This may mean that other factors have confounded the relationship between changes in skid resistance and temperature.

Inasmuch as changes in SN were associated with traffic volume, deviations from yearly average daily traffic may be a significant factor. Monthly average daily traffic were determined from data presented by Agent, et. al *(8)*. These averages were converted to percent deviations from yearly average daily traffic and plotted versus day of year in Figure 8. These deviations were included as a second variable in the regression analyses of skid number and temperature. The linear model equation was

$$SN_p = SN_i + \Delta SN_t T + \Delta SN_a A$$

where SN_p = predicted skid number,

SN_i = SN at mean AADT and at 0°C (or 0°F),

ΔSN_t = change of SN_i per 1°C (or 1°F),

T = temperature,

ΔSN_a = change in SN_i per one-percent deviation from yearly average daily traffic, and

A = percent deviation from yearly average daily traffic.

Results indicated that correlations between skid resistance and the combined variables of temperature and fluctuations of traffic volumes were as good as correlations between skid resistance and day of the year. Equations for the best correlation for each pavement

section are presented in Table 8. Skid numbers were predicted using these equations and with temperature and traffic volume values determined for selected days of the year. Temperature values were determined from the equations in Table 5. Traffic deviations were determined from the curves in Figure 8. The predicted skid numbers fit the data at least as well as the equations relating skid reisstance to day of year.

SUMMARY AND CONCLUSIONS

The seasonal variations of four types of pavements in Kentucky exhibited an annual sinusoidal cycle. When test sections at the same location (shoulder and lane versus median lane) were compared, the magnitude of the annual variation in skid resistance was strongly associated with volume of traffic. Lanes having the greater traffic experienced the largest annual variation in skid resistance. Adjacent lanes with like volumes experienced about the same annual variation. When sections at different locations were compared, those with the higher AADT's did not necessarily exhibit the greatest changes in SN. Other factors apparently confounded the correlation.

The lowest skid numbers during the year for portland cement concrete and sand-asphalt pavements occurred in early to mid-August. The lower SN for Class I surfaces occurred in late August to early September. The change in skid resistance of sand-asphalt and Class I surfaces with higher volumes of traffic was about 12 points. The change in skid resistance of portland cement concrete and bituminous concrete pavements with lower volumes of traffic was about 5 points.

Similarity of the annual precipitation and temperature cycle with the annual variations in skid resistance of pavements suggested that both precipitation and temperature affected skid resistance. Precipitation data were not specific enough for the location of each test section, nor skid resistance measured frequently enough, to allow for correlations with changes in skid resistance. Correlations between changes in skid number and temperature were best for ambient air temperature averaged for 4- and 8-week periods prior to date of test. This suggested that the annual changes in skid resistance resulted from a reaction of the surface to temperature over a period of a few weeks. However, correlations between changes in SN and temperature were not as high as correlations between SN and day of the year.

On the other hand, combining traffic volume in the form of deviations from yearly

average daily traffic with temperature yielded correlations with SN's which were as good as correlations between SN's and day of year. More specific traffic volumes would surely enable even better correlations.

The differences in seasonal variations amongst pavements included in this study were sufficiently large to preclude determination of factors, based on surface type and traffic volume alone, that could be routinely applied in the adjustment or correction of skid numbers whether obtained within or outside of a normal period of testing during the year. Other more specific influences must be identified and quantified. In the interim, measurements in Kentucky should be confined between the first of July and the middle of November. Measurements obtained within that period will not differ, on the average, by more than 4 SN. However, frequent testing of the reference sections is recommended to define more specifically each year the beginning and ending date of the testing season. The data from the reference sections may also serve to estimate adjustments whenever it is necessary to test at other times.

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TABLE 1. RESULTS OF REGRESSION ANALYSIS; SKID NUMBER VERSUS DAY OF YEAR; EACH PAVEMENT SECTION

SECTION	SN_a	ΔSN	D_ℓ	D_h	R^2	E_s
1	43.5	8.0	248	65	0.735	3.6
2	52.7	5.8	252	69	0.587	3.6
3	37.0	7.0	248	66	0.391	6.7
4	36.8	6.6	253	70	0.492	5.1
5	53.7	2.4	226	44	0.234	3.6
6	65.0	1.6	222	39	0.156	2.9
7	41.8	5.1	225	43	0.588	2.9
8	51.6	3.5	248	65	0.463	2.7
9	49.0	8.1	246	63	0.670	4.2
10	60.2	4.0	260	78	0.335	4.0
11	49.6	2.7	238	55	0.191	4.2
12	48.9	3.0	256	73	0.177	5.0
13	36.6	3.9	231	49	0.282	4.5
14	43.4	4.7	206	24	0.318	5.1
15	42.1	2.2	315	132	0.223	3.0
16	46.3	2.3	190	7	0.175	3.5
17	38.0	6.8	231	49	0.640	3.8
18	40.5	5.9	215	33	0.509	4.3
19	45.2	3.8	207	25	0.408	3.5
20	43.8	5.1	207	25	0.720	2.4

D_h = day of year at which SN is highest ($D_h = D_\ell - 182.5$)

TABLE 2. RESULTS OF REGRESSION ANALYSIS; DEVIATIONS FROM YEARLY AVERAGE SKID NUMBER VERSUS DAY OF YEAR; SECTIONS GROUPED BY PAVEMENT TYPE

PAVEMENT TYPE	SN_a	ΔSN	D_ℓ	D_h	R^2	E_s
CLASS I, TYPE A	-0.1	5.3	248	65	0.402	4.8
(AADT>3,500)	0.0	6.8	250	68	0.508	5.0
(AADT<3,500)	0.0	2.0	225	42	0.198	3.2
CLASS I, TYPE B	0.1	4.1	243	61	0.346	4.1
(AADT>3,500)	-0.1	5.6	239	56	0.536	3.6
(AADT<3,500)	0.1	3.1	251	68	0.215	4.3
PORTLAND CEMENT CONCRETE	0.0	2.5	223	40	0.150	4.2
SAND-ASPHALT	0.0	5.4	218	36	0.537	3.7

D_h = day of year at which SN is highest ($D_h = D_\ell - 182.5$)

TABLE 3. RESULTS OF REGRESSION ANALYSIS; AMBIENT AIR TEMPERATURE AT TIME OF SKID TESTING VERSUS DAY OF YEAR; SECTIONS GROUPED BY PAVEMENT TYPE

	T_a		ΔT					
PAVEMENT TYPE	F	C	F	C	D_h	D_ℓ	R^2	E_s
CLASS I, TYPE A	65.3	18.5	17.1	9.5	209	26	0.630	9.7
(AADT > 3,500)	66.2	19.0	16.5	9.2	206	24	0.610	9.7
(AADT < 3,500)	63.3	17.4	18.8	10.4	211	29	0.706	9.4
CLASS I, TYPE B	62.6	17.0	17.5	9.7	211	28	0.593	10.4
(AADT > 3,500)	64.1	17.8	19.8	11.0	209	26	0.670	9.7
(AADT < 3,500)	62.3	16.8	14.5	8.1	213	30	0.537	9.9
PORTLAND CEMENT CONCRETE	64.5	18.1	20.1	11.2	210	28	0.698	9.3
SAND-ASPHALT	63.7	17.6	18.2	10.1	212	29	0.636	10.1
ALL	64.2	17.8	17.8	9.9	210	28	0.633	9.8

D_ℓ = day of year at which T is lowest ($D_\ell = D_h - 182.5$)

TABLE 4. RESULTS OF REGRESSION ANALYSIS; PAVEMENT SURFACE TEMPERATURE AT TIME OF SKID TESTING VERSUS DAY OF YEAR; SECTIONS GROUPED BY PAVEMENT TYPE

	T_a		ΔT					
PAVEMENT TYPE	F	C	F	C	D_h	D_ℓ	R^2	E_s
CLASS I, TYPE A	79.8	26.5	25.1	13.9	204	22	0.681	12.5
(AADT > 3,500)	79.7	26.5	24.6	13.7	207	25	0.669	12.5
(AADT < 3,500)	79.5	26.4	26.5	14.7	198	16	0.708	12.6
CLASS I, TYPE B	75.5	24.2	21.2	11.8	197	14	0.575	12.8
(AADT > 3,500)	77.3	25.2	24.8	13.8	200	17	0.661	12.4
(AADT < 3,500)	74.4	23.6	18.5	10.3	195	13	0.510	12.9
PORTLAND CEMENT CONCRETE	74.3	23.5	26.6	14.8	194	11	0.746	10.7
SAND-ASPHALT	76.5	24.7	22.7	12.6	194	12	0.592	13.6
ALL	76.8	24.9	23.8	13.2	198	16	0.638	12.7

D_ℓ = day of year at which T is lowest ($D_\ell = D_h - 182.5$)

TABLE 5. RESULTS OF REGRESSION ANALYSIS; AMBIENT AIR TEMPERATURE AVERAGED FOR 1,2,3,4,AND 8 WEEKS PRIOR TO DATE OF SKID TESTING VERSUS DAY OF TEST; COMBINED PAVEMENT SECTIONS

PERIOD (WEEKS)	T_a F	T_a C	ΔT F	ΔT C	D_h	D_ℓ	R^2	E_s
1	55.0	12.8	22.2	12.3	212	30	0.917	4.8
2	54.5	12.5	21.6	12.0	212	30	0.944	3.8
3	53.9	12.2	22.2	12.3	215	33	0.935	4.2
4	53.8	12.1	22.4	12.4	219	37	0.958	3.7
8	54.0	12.2	21.7	12.1	233	51	0.968	2.8

D_ℓ = day of year at which T is lowest ($D_\ell = D_h - 182.5$)

SKID NUMBER VERSUS TEMPERATURE

The similarity between temperature cycles and skid resistance cycles indicated that temperature may be the primary factor that alters pavement surface characteristics, and, therefore, alters skid resistance of the surface. In that case, the SN's obtained should correlate with air or pavement surface temperature. A regression analysis of SN versus several measures of temperature were made for each test section. The linear model equation used was

$$SN_p = SN_i + \Delta SN_t T$$

where
SN_p = predicted skid number,
SN_i = SN at 0°F (or 0°C),
ΔSN_t = change of SN_i per 1°F (or 1°C), and
T = temperature.

The results of the regression analysis are tabulated in APPENDIX C.

As expected, the best correlations were found for pavements that also showed the best correlations between SN and day of the year (see Table 2). Also, in general, the best correlations were obtained with air temperature, averaged for either a 4- or 8-week period prior to the day of testing. Additional analysis was made to determine if grouping the test sections by pavement type improved the correlation between SN and temperature. The measure of temperature used in this analysis were air temperature, averaged over 4- and 8-week periods prior to the day of testing. The SN_p's were calculated for test sections using the temperature of 70°F (21°C) for each measure of temperature. The corresponding SN_p was subtracted from the measured SN. Test sections were grouped as before. Regression analyses of these adjusted SN's versus each average of air temperature were made. The results are presented in Tables 7 and 8.

Results indicated that correlations between skid resistance and temperature were not as good as correlations between skid resistance and day of the year. For these data, therefore, prediction of the skid resistance cycle based on correlations between SN and temperature would not be as accurate as using day of the year. This may mean that other factors have confounded the relationship between changes in skid resistance and temperature.

Inasmuch as changes in SN were associated with traffic volume, deviations from yearly average daily traffic may be a significant factor. Monthly, average daily traffic were determined from data presented by Agent, et. al *(8)*. These averages were converted to percent deviations from yearly average daily traffic and plotted versus day of year in Figure 8. These deviations were included as a second variable in the regression analyses of skid number and temperature. The linear model equation was

$$SN_p = SN_i + \Delta SN_t T + \Delta SN_a A$$

where
SN_p = predicted skid number,
SN_i = SN at mean AADT and at 0°F (or 0°C),
ΔSN_t = change of SN_i per 1°F (or 1°C),
T = temperature,
ΔSN_a = change of SN_i per one-percent deviation from yearly average daily traffic, and
A = percent deviation from yearly, average daily traffic.

The results of the regression analyses are tabulated in APPENDIX D.

TABLE 6. RESULTS OF REGRESSION ANALYSIS; ADJUSTED SKID NUMBER VERSUS AMBIENT AIR TEMPERATURE AVERAGED FOR 4-WEEK PERIOD PRIOR TO TIME OF TEST; SECTIONS GROUPED BY PAVEMENT TYPE

	SN_i AT		ΔSN_t PER			
PAVEMENT TYPE	0 F	0 C	1 F	1 C	R^2	E_s
CLASS I, TYPE A	14.8	8.1	-0.21	-0.38	0.307	5.3
(AADT > 3,500)	17.9	9.6	-0.26	-0.47	0.358	5.7
(AADT < 3,500)	7.0	3.8	-0.10	-0.18	0.250	3.1
CLASS I, TYPE B	11.4	6.3	-0.16	-0.29	0.268	4.5
(AADT > 3,500)	14.7	8.0	-0.21	-0.38	0.417	4.1
(AADT < 3,500)	7.9	4.4	-0.11	-0.20	0.154	4.5
PORTLAND CEMENT CONCRETE	7.9	4.4	-0.11	-0.20	0.151	4.4
SAND-ASPHALT	17.8	9.8	-0.25	-0.45	0.588	3.6
ALL	12.8	7.0	-0.18	-0.32	0.296	4.7

TABLE 7. RESULTS OF REGRESSION ANALYSIS; ADJUSTED SKID NUMBER VERSUS AMBIENT AIR TEMPERATURE AVERAGED FOR 8-WEEK PERIOD PRIOR TO TIME OF TEST; SECTIONS GROUPED BY PAVEMENT TYPE

	SN_i AT		ΔSN_t PER			
PAVEMENT TYPE	0 F	0 C	1 F	1 C	R^2	E_s
CLASS I, TYPE A	16.4	9.4	-0.23	-0.41	0.337	5.2
(AADT > 3,500)	20.3	11.5	-0.29	-0.52	0.424	5.4
(AADT < 3,500)	7.4	4.7	-0.10	-0.18	0.234	3.1
CLASS I, TYPE B	12.1	7.1	-0.17	-0.31	0.274	4.5
(AADT > 3,500)	15.4	8.8	-0.22	-0.40	0.403	4.2
(AADT < 3,500)	8.6	5.2	-0.12	-0.22	0.171	4.4
PORTLAND CEMENT CONCRETE	8.0	4.6	-0.12	-0.22	0.143	4.6
SAND-ASPHALT	18.0	10.1	-0.26	-0.47	0.532	3.8
ALL	13.6	8.0	-0.19	-0.34	0.294	4.8

TABLE 8. RESULTS OF REGRESSION ANALYSIS; SKID NUMBER VERSUS PERCENT DEVIATIONS FROM YEARLY AVERAGE, DAILY TRAFFIC AND AMBIENT AIR TEMPERATURE AVERAGED FOR 1,2,3,4 OR 8 WEEKS PRIOR TO DAY OF TEST: BEST CORRELATION FOR EACH PAVEMENT SECTION

SECTION	PERIOD (WEEKS)	SN AT MEAN AADT AND AT 0 F°	0 C°	SN PER 1 F°	1 C°	SN PER 1% ADT	R	E
1	1	85.7	61.1	-0.77	-1.39	+0.54	0.743	3.6
2	1	82.6	65.3	-0.54	-0.97	+0.39	0.554	3.8
3	8	55.6	44.4	-0.35	-0.63	+0.09	0.324	7.2
4	8	55.5	44.3	-0.35	-0.63	+0.13	0.413	5.6
5	3	70.2	60.6	-0.30	-0.54	+0.24	0.417	3.2
6	3	73.5	68.4	-0.16	-0.29	+0.09	0.230	2.9
7	4	53.3	46.6	-0.21	-0.38	+0.01	0.542	3.2
8	4	67.1	57.8	-0.29	-0.52	+0.31	0.499	2.7
9	8	73.2	58.8	-0.45	-0.81	+0.15	0.599	4.7
10	8	76.0	66.4	-0.30	-0.54	+0.19	0.350	4.1
11	2	63.0	55.0	-0.25	-0.45	+0.19	0.208	4.2
12	4	62.9	54.3	-0.27	-0.49	+0.27	0.181	5.1
13	8	42.8	39.3	-0.11	-0.20	-0.08	0.285	4.6
14	1	59.3	50.0	-0.29	-0.52	+0.09	0.379	5.0
15	3	60.0	49.4	-0.33	-0.59	+0.64	0.330	2.9
16	3	48.8	47.2	-0.05	-0.09	-0.08	0.165	3.6
17	4	65.8	49.5	-0.51	-0.92	+0.40	0.713	3.5
18	3	58.9	48.0	-0.34	-0.61	+0.13	0.572	4.1
19	2	58.8	50.8	-0.25	-0.45	+0.11	0.530	3.2
20	4	52.9	47.5	-0.17	-0.31	-0.10	0.751	2.3

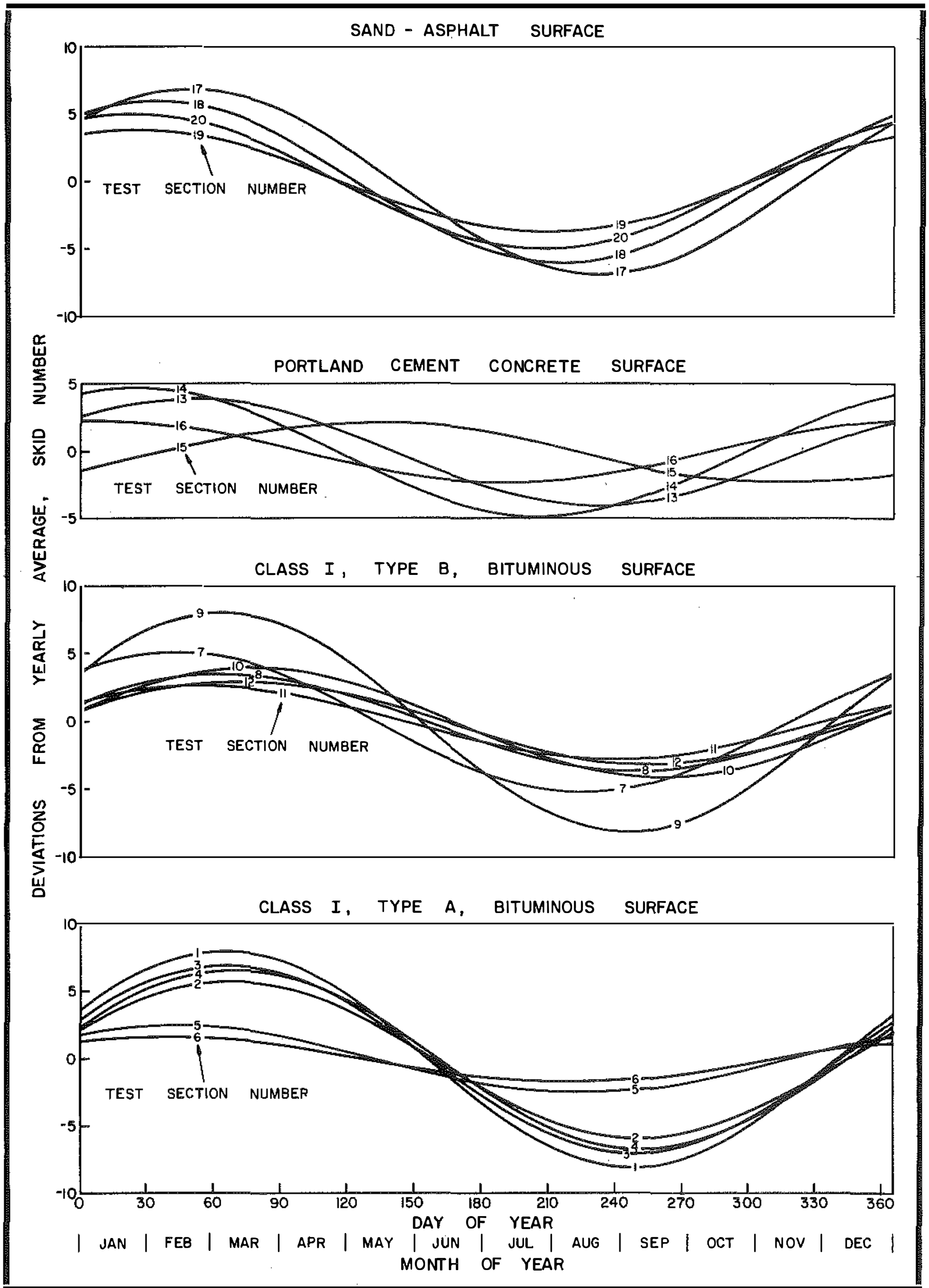
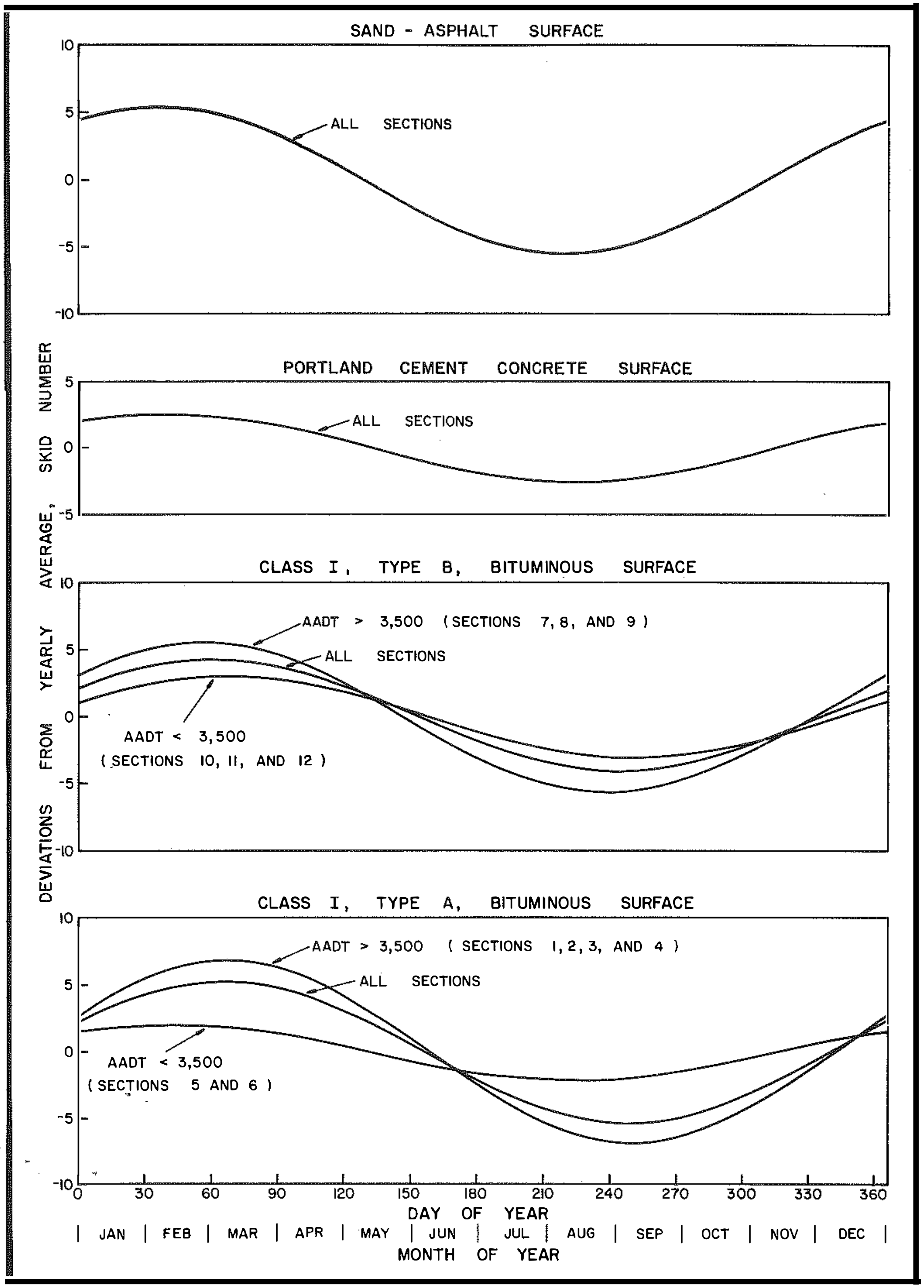


Figure 1. **Best-Fit Curves; Skid Number Variation versus Day of Year; Each Test Section; By Pavement Types.**

Figure 2. Best-Fit Curves; Skid Number Variation versus Day of Year; Test Sections Grouped by Pavement Type.



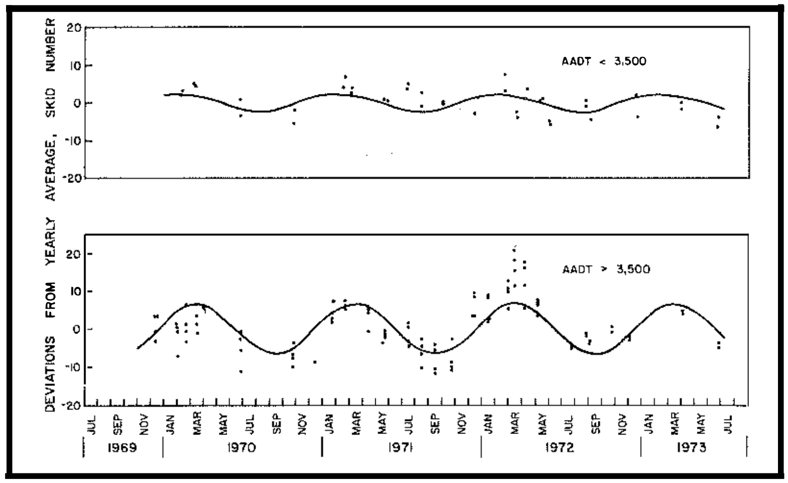


Figure 3a. Skid Number Variation versus Date of Test; Class I, Type A, Bituminous Pavement; Grouped by AADT.

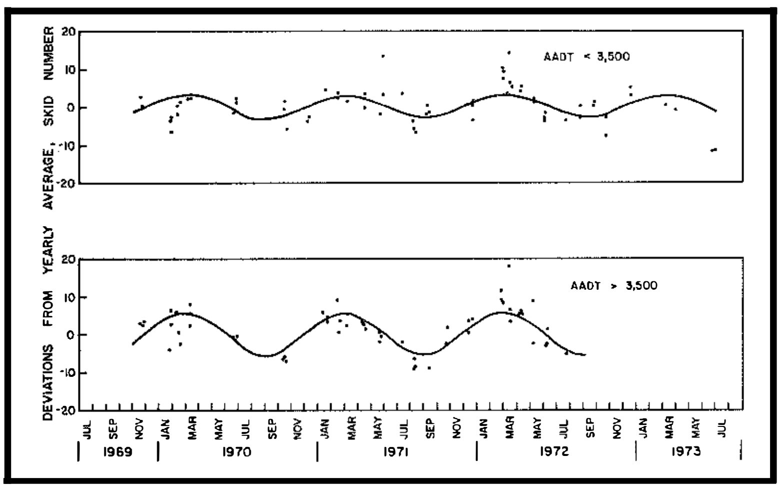


Figure 3b. Skid Number Variation versus Date of Test; Class I, Type B, Bituminous Pavement; Grouped by AADT.

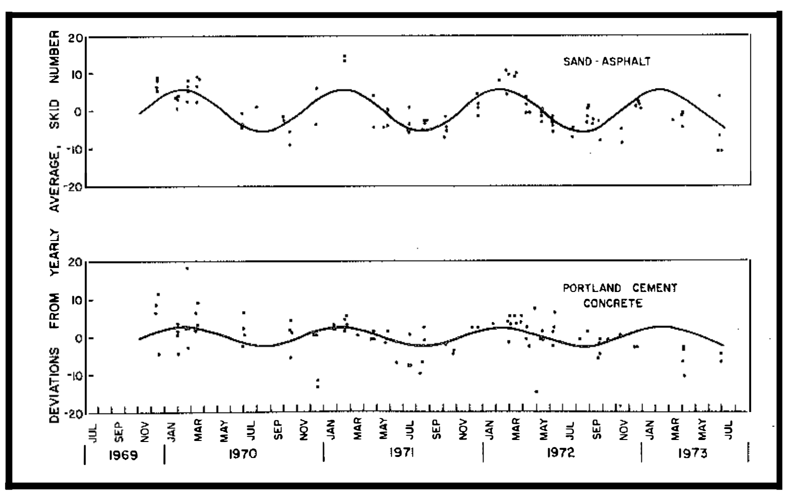
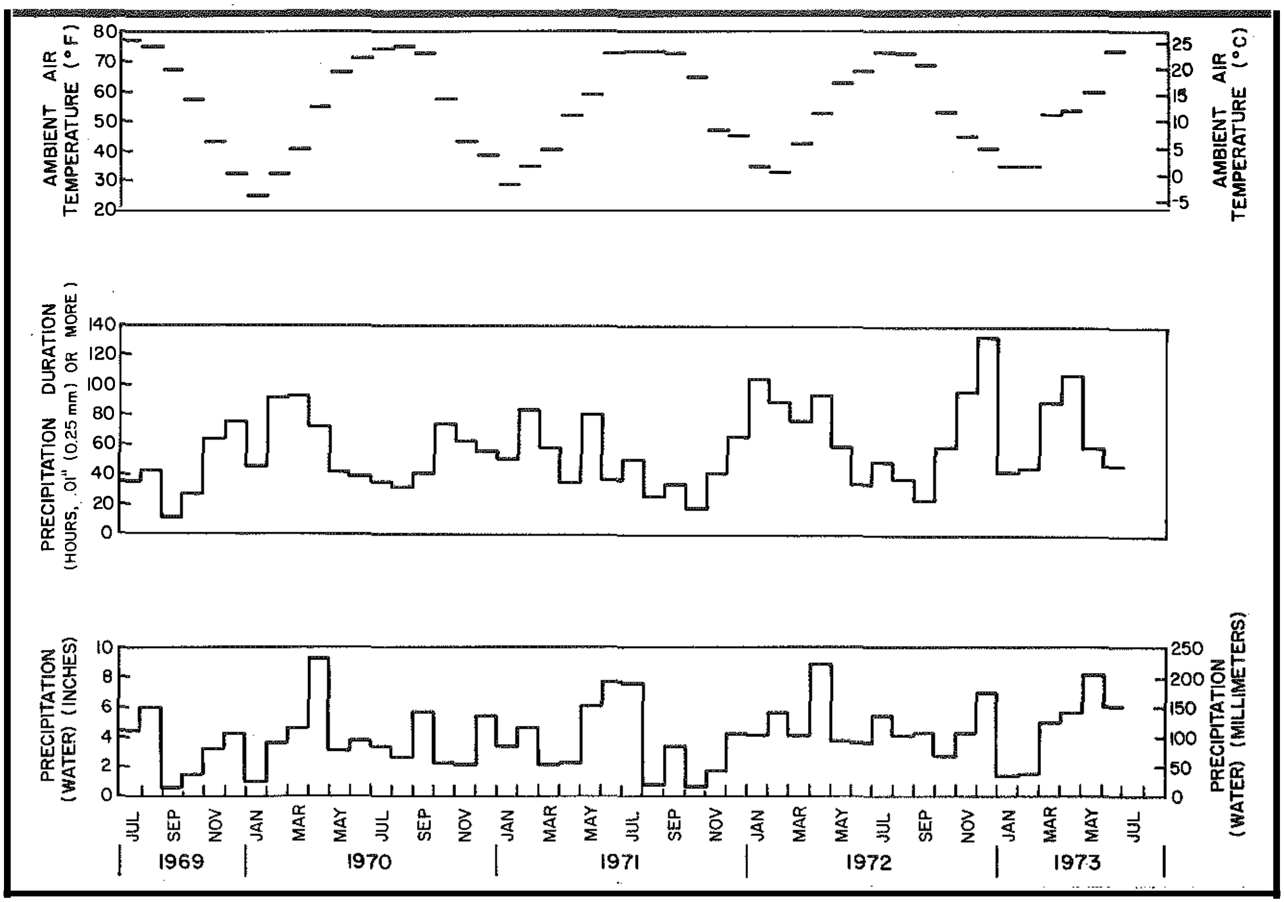


Figure 3c. Skid Number Variation versus Date of Test; Portland Cement Concrete and Sand-Asphalt Pavement.

Figure 4. Average Precipitation and Temperature for each Month of the Study Period.



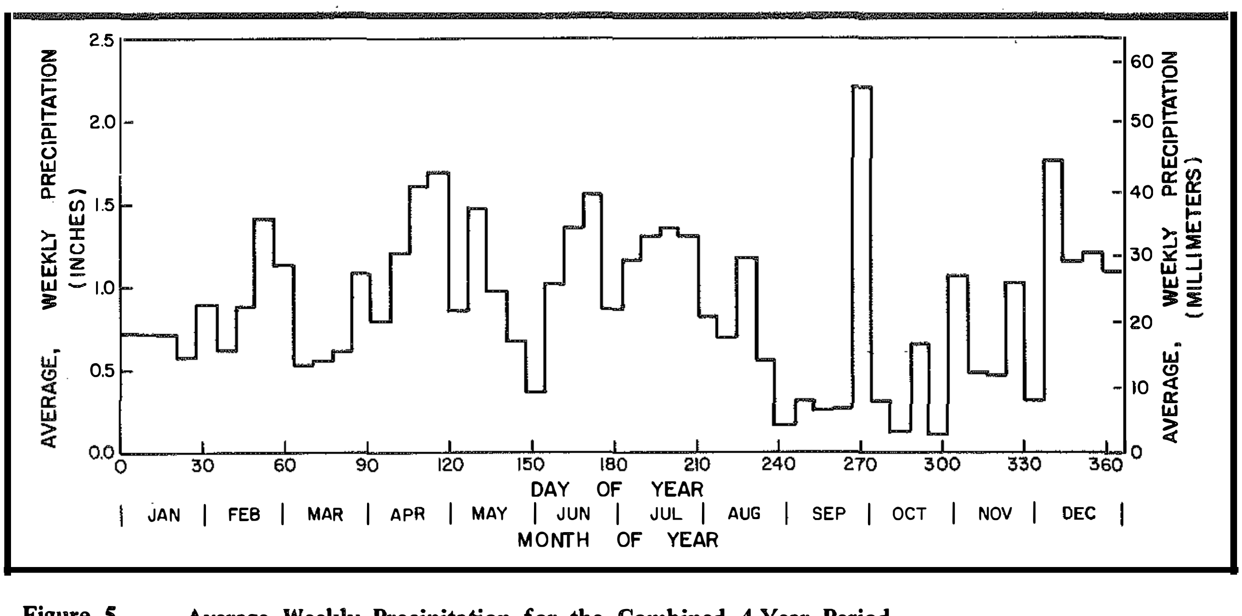
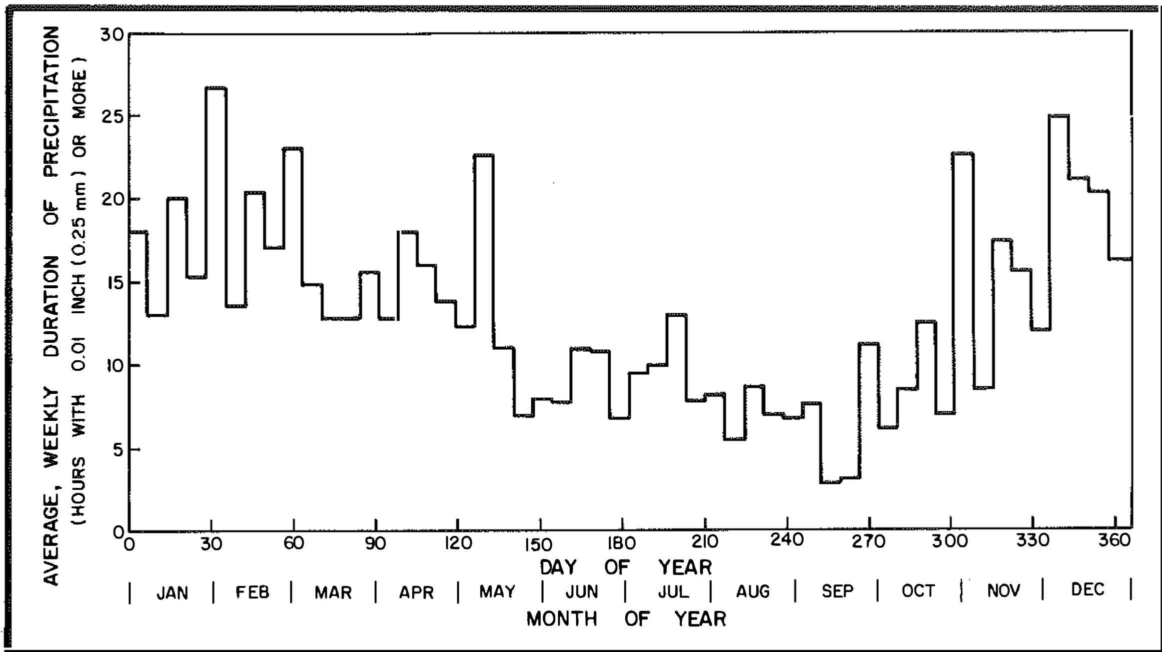


Figure 5. Average Weekly Precipitation for the Combined 4-Year Period.

Figure 6. **Average Weekly Duration of Precipitation (0.25 mm (0.01 inch) or more) for the Combined 4-year Period.**



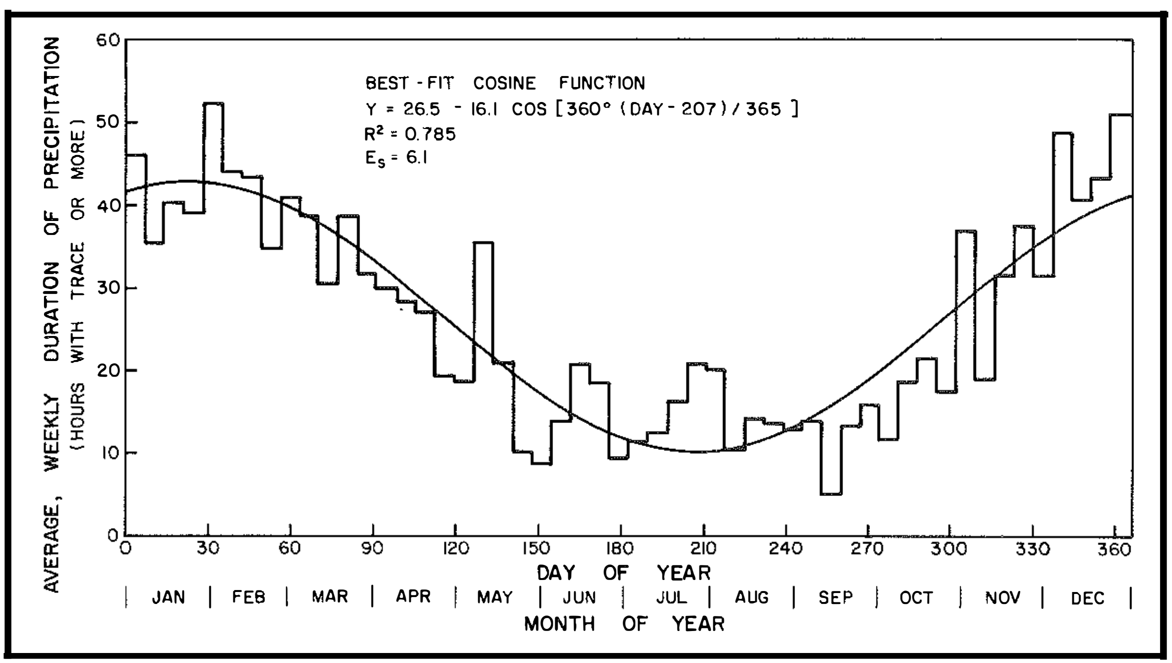
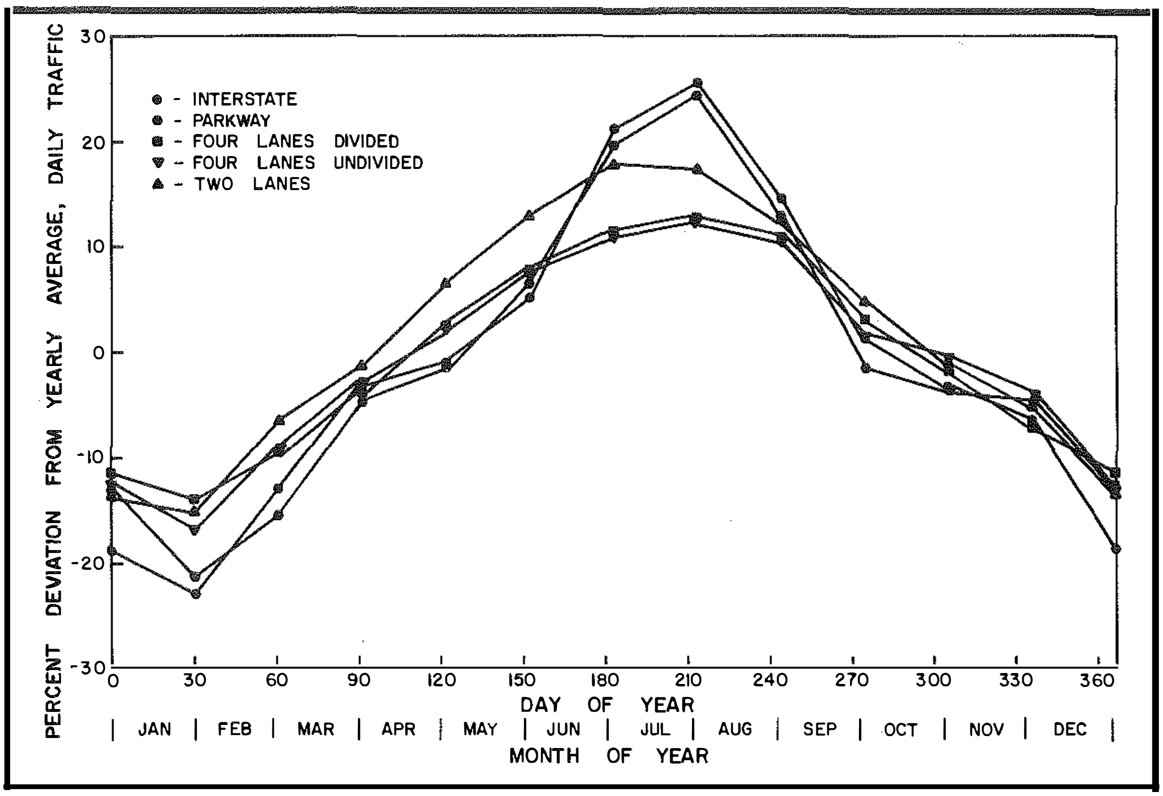


Figure 7. **Average Weekly Duration of Precipitation (Trace or more) for the Combined 4-Year Period.**

Figure 8. Percent Deviations from Yearly Average Daily Traffic versus Day of Year.



Results indicated that correlations between skid resistance and the combined variables of temperature and fluctuations of traffic volumes were as good as correlations between skid resistance and day of the year. Skid numbers were predicted using these equations and with temperature and traffic volume values determined for selected days of the year. Temperature values were determined from the equations in Table 6. Traffic deviations were determined from the curves in Figure 8.

The skid numbers predicted using the best equation for each section were plotted versus day of the year and are represented by the dashed lines in the plots of APPENDIX B. The dashed lines fit the data at least as well as the cosine curves (solid line); and, for several of the sections, the equations represented by the dashed lines are better predictors of SN's.

SEASONAL VARIATION IN SKID RESISTANCE OF REFERENCE SECTIONS AND OPEN-GRADED FRICTION COURSE

Since 1975, skid resistance of Class I Type A (Modified) bituminous pavement (Red Mile Road in Fayette County) has been measured frequently for the purpose of monitoring the performance of the test devices. (The second tester was acquired in 1976.) In 1976, another Class I, Type A (Modified), bituminous concrete (KY 4 in Fayette County) and a portland cement concrete pavement (US 60 in Fayette County) were added. Skid numbers from tests, since 1976, on the three reference sections are tabulated in APPENDIX E and are plotted in Figures 9a and 9b. Monthly averages of ambient air temperature for the Lexington area are also plotted in Figure 9a.

Each of the sections exhibited an annual cycle in skid resistance. However, the data were more variable from week to week than anticipated. No attempt was made here to deal with the short-term changes exhibited by these data. The data were analyzed to determine the best-fit curve for the 365-day cycle. Data for the portland cement concrete pavement, from tests using the device acquired in 1969, were not sufficient for these analyses. The statistical data are presented in Table 9, and the resulting curves are shown in Figures 9a and 9b.