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16. ABSTRACT
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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF FACILITIES CONSTRUCTION
OFFICE OF TRANSPORTATION LABORATORY

EVALUATION OF FRICTION REQUIREMENTS FOR CALIFORNIA STATE HIGHWAYS IN TERMS OF HIGHWAY GEOMETRICS

Study Made By .... PAVEMENT BRANCH

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NOTICE

CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quality	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2) square feet (ft^2) acres	6.432×10^{-4} .09290 .4047	square metres (m^2) square metres (m^2) hectares (ha)
Volume	gallons (gal) cubic feet (ft^3) cubic years (yd^3)	3.785 .02832 .7646	litre (l) cubic metres (m^3) cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s	28.317	litres per second l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph) feet per second (fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity (G) (ft/s^2)	9.807	metres per second squared (m/s^2)
Density	(lb/ft^3)	16.02	kilograms per cubic metre (kg/m^3)
Force	pounds (lbs) (1000 lbs) kips	4.448 4448	newtons (N) newtons (N)
Thermal Energy	British termal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds (in-lbs) foot-pounds (ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi)	6895	pascals (Pa)
	pounds per square foot (psf)	47.88	pascals (Pa)
Stress Intensity	kips per square inch square root inch ($ksi\sqrt{in}$)	1.0988	mega pascals$\sqrt{metre}$ ($MPa\sqrt{m}$)
	pounds per square inch square root inch ($psi\sqrt{in}$)	1.0988	kilo pascals$\sqrt{metre}$ ($KPa\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{+F - 32}{1.8} = +C$	degrees celsius (°C)

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A special thanks is offered to Mrs. Linette Abbott, Mr. Don Larsen, and Mr. Leon Williams for their efforts in classifying the accident locations by photolog, and then manually merging those classifications with data from the TASAS file to produce the TASAS/Photolog file for this study. Mr. Williams was also of great help in merging the data from the TASAS/Photolog file with the data from the SRI file, and then checking that data to produce the working or final version of the ACCIDENT file. A special thanks is also offered to the staff of The Skid Resistance Unit, Pavement Branch, Office Of Transportation Laboratory: Specifically, to Messrs. Don Larsen, Gene Stucky, Jim Lewis, and Burt Anderson for their meticulous preparation of the SRI file, which enabled that file to be used for statistical purposes in this study.

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INTRODUCTION

One of the many important functions of an effective highway system is to provide highway surfaces that enable motorists to perform normal driving maneuvers at reasonable speeds under wet conditions without experiencing loss of control by skidding. Except for extremely smooth pavement, which may be identified by skid number (and, in some cases, by simple visual examination), the criterion used to initiate work to improve pavement surface texture is either a wet pavement accident frequency which exceeds the average rate for the area, or a sudden increase in wet pavement accidents. While such "after the fact" procedures are cost-effective insofar as the potential for future accidents is concerned, it requires some loss in property damage (often involving injuries and sometimes fatalities) prior to initiating improvement. It is desirable, therefore, to have an index that will reliably indicate locations where a higher than normal wet pavement accident rate may be expected.

One approach toward the development of such an index is to relate ASTM E274 skid numbers to wet pavement accident frequency. (AASHTO T242 friction numbers are identical to ASTM skid numbers which will be used in this report). According to this test procedure, skid tests are performed at a constant test speed using a locked-wheel towed trailer on a water layer applied 0.022 inch thick in the center of the wheel path of the roadway. The resulting skid number is defined as the average horizontal force between the skidding tire and the wetted pavement for one second, divided by the average vertical wheel load for the same second, multiplied by 100.

Since December 1975, CALTRANS has maintained a statewide Skid Resistance Inventory (SRI) file. On a regular basis, tests have been made on curves, intersections, bridge decks, weave sections and tangent sections. The entire highway system is tested every four years with many primary routes tested yearly or every other year.

Nationwide, several studies (1, 3, 5, 6, 11, 16, 17) have been completed in an attempt to establish criteria that would minimize wet pavement accidents by establishing minimum skid numbers. In the past, when a minimum value has been proposed by another agency, an in-house investigation by CALTRANS Traffic Engineers has shown that many locations have skid numbers less than the proposed value with no record of a wet pavement accident problem. Therefore, it has been considered inappropriate to adopt minimum skid number levels because of the difficulty in establishing justifiable values and because the adoption of a value higher than necessary would require utilization of limited highway improvement funds that should be used to improve known problem areas.

However, the potential benefits of a preaccident program justify further effort to establish a procedure that would effectively incorporate skid numbers in a wet pavement safety program. One possible approach is to group the highway sections by geometric classification. Thus, the objective of this research project is to investigate the influence of bridges, curves, intersections, tangent sections and weave sections on the correlation between skid numbers and wet pavement accident rates in California.

CONCLUSIONS

Based on an evaluation of skid test data and wet pavement accidents with consideration for wet time percent and for traffic density and exposure, the following conclusions are warranted.

(1) When all geometric classification records are combined, the wet pavement accident rates are low and rather uniform for pavements having skid numbers which are greater than 26, but increase substantially as the skid numbers decrease from 25 to 17. Certain geometric alignments and driving conditions, when compared to other types of geometric alignments and driving conditions, display significantly greater wet pavement accident rates (by magnitudes which may vary from at least three times to as much as nine times) when the skid number is less than 25.

(2) Wet pavement accident rates are significantly greater on curves than on any other geometric classification or type of alignment. This applies to pavements having skid numbers in the 26 to 54 range as well as in the 17 to 25 range. However, the wet pavement accident rate for curves having SN's of 17 to 25 is 23 times that for curves having SN's of 26 to 54.

(3) Wet pavement accident rates are significantly greater on undivided highways than on divided highways.

(4) When the skid number is less than 25, wet pavement accident rates are significantly greater for both uphill and downhill slopes (steeper than 3 percent) than for flatter terrain.

(5) When the skid number is less than 25, wet pavement accident rates on undivided roadway sections are significantly greater when the ADT is greater than 15,000 vehicles a day.

RECOMMENDATIONS

It is recommended that these findings be incorporated into a program to eliminate conditions that result in the highest wet pavement accident rates (i. e. pavements with skid numbers less than 25 using the priorities listed in the implementation section of this report). It is further recommended that a follow-up investigation be conducted for roadway sections that have been improved subsequent to June 1981. Such an investigation is needed, first, to substantiate the findings of a significant rate change at a skid number of 25, and, second, to demonstrate that surface improvements will significantly lower the wet pavement accident rate on roadways having skid numbers less than 26.

IMPLEMENTATION

The research findings will be implemented by the following CALTRANS units in ongoing, coordinated, and cooperative programs:

Office of Transportation Laboratory (OTL), Pavement Branch.

Office Of Traffic Safety Program And Research (OTSPR), Traffic Safety Program Branch.

The Transportation Laboratory is responsible for the SRI program and files. Data are routinely gathered, computerized, and sent to District Traffic Engineers for implementation under the Traffic Safety Program.

The results of this research provide the basis for prioritization for improvement of the surfaces of those roadway sections having the combined parameters which have displayed the highest indices as derived in this report. To justify surface improvements based on skid resistance only, the skid number should be less than or equal to 25. The criteria which will increase the priority of these improvements are listed in the order of highest priority as follows:

1. Locations having curves, weave sections, or intersections.

2. Locations with undivided roadways. Those that have a two-way ADT greater than 15,000 vehicles per day should have priority over those with more lightly traveled roads.

3. Locations having grades which are steeper than plus or minus three percent.

Roadway sections incorporating all of the above should be given the highest priority for surface improvement. A suggested procedure is as follows:

1. Identify locations that have skid numbers less than or equal to 25.

2. Use available facilities such as the TASAS selective accident retrieval report, the highway log, the photolog and site inspection to establish priorities and project limits.

3. Schedule surface improvements accordingly. Improve the areas that have experienced accidents before improving areas that exhibit a potential for accidents.

4. Conduct an evaluation, including before and after studies, of the benefits being achieved.

5. Modify the procedure if necessary and develop an improvement program consistent with the evaluation.

It is anticipated that between 650 and 1100 lane-miles of California state highways have skid numbers less than 26. The cost of improving the skid resistance of these 2000 locations is expected to range between $4,800,000 and $8,700,000.

DISCUSSION

To pursue the objective of this study, the location for each wet pavement accident was obtained from the TASAS Selection Accident Retrieval (TSAR) program; a skid number was matched to that location using the statewide Skid Resistance Inventory file; and the location was classified according to highway geometrics using the highway photolog. Only accidents having the primary collision location in the right (or outside) lane were used, because the code for the inside lanes does not identify the specific lane. Therefore, it is impossible to match skid numbers to accidents that occur in the inside lanes. Skid numbers were obtained only from the right lane and as close to the accident location as possible. Test results that were obtained more than 2.5 miles from the accident location were not considered to be representative of the pavement surface at the accident site. Skid numbers that were obtained within one year of the accidents were used for districts 3 and 4 data. However, in order to establish a respectable number of matches to the accident locations in District 7, skid numbers obtained between one and two years of the accident were used. Then, for each classification, the relationship between wet pavement accidents and their matching skid numbers was compared.

One concern of this study was whether wet pavement accident records that do not distinguish skidding accidents from other wet pavement accidents would provide a correlation to skidding potential as identified by skid number, or whether it would be necessary to identify and code the skidding accidents on the field reports to obtain a correlation. Certainly a significant portion of the wet pavement accidents are related to factors other than a slick pavement (such as driver fatigue, inattention, driving under the influence of alcohol or drugs, smooth treaded (illegal) tires, excessive speed, vehicular failure, etc.).

The assumption was made that among the various categories of the independent variable(s), there should be a significant correlation between the dependent variable (i.e., the overall accident rate) and the independent variable(s), represented by the skid number and the related parameters. If such correlations exist, then they should be apparent in the statistical analysis.

Wet pavement accident records for the period July 1, 1980, to June 30, 1981, in districts 3, 4, and 7 were used for this study. These district offices are located in Marysville, San Francisco, and Los Angeles, respectively. These districts were selected because they have highways typical of those found throughout California.

For the three districts, skid tests were made during various times of the year, which included wet and dry seasons. About 91 percent of these tests were made at temperatures between 45 and 85 °F. Studies (8) have shown that weather and temperature conditions play a significant role in determining the value of the skid number. However, controls that might have added to this information were not incorporated into the data collection procedure that was used for this project.

District 3 has terrain that varies from mountainous to valley with somewhat more rural than urban highway mileage. These pavements are wet about five percent of the time (10).

District 4 has predominantly coastal and rolling terrain with somewhat more urban than rural highway mileage. These pavements are wet about five percent of the time.

District 7 has coastal terrain adjacent to some high desert with predominantly urban highways. District 7 pavement is wet about two percent of the time.

Statistical information pertaining to the skid resistance data and the wet pavement accident data for these three districts is presented in the figures and tables included in Appendix II.

A. Development Of The Adopted Model

Initially, sub-files were built from the ACCIDENT files so that specific highway characteristics (such as a curve -- on a freeway -- with divided lanes -- in a rural area) and traffic densities (wet pavement ADT) could be identified. A regression analysis was then performed upon each record, and the coefficients were obtained for an equation of the following form.

$$1.0 / WET\_ADT = A0 + A1*SN + A2*SPD \quad (1)$$

where WET_ADT is the wet pavement ADT (see definitions in Appendix I), SN is the skid number at 40 mph, SPD is the posted speed, and where A0, A1 and A2 are the coefficients of the equation. Of course, the numerator, 1.0, in the term on the left of the equation, represents the frequency of the single accident.

Although the initial attempt is valid for a "local" type of analysis, data evaluation and consideration of the best available data revealed that modifications had to be made because this study was concerned with a "universal" type of analysis. In other words, the initial attempt neglected to take into consideration <u>all</u> of the opportunities for an accident to occur. Specifically, the analysis should weigh the data by comparing the number of accidents in each category with the total number of opportunities for accidents to occur in that category.

For example, wet pavement accident data for curves may show 40 accidents on pavements having a skid number of 35 and only 4 accidents on pavements having a skid number of 22. The opportunities for wet pavement accidents are determined by multiplying the number of curves that have the respective skid numbers by the wet pavement average daily traffic for these curves. With a skid number of 35, eighty locations times 160,000 wet pavement passes divided into 40 accidents provides a rate of 3.125×10^{-6} accidents per wet vehicle pass. With a skid number of 22, six locations times 7800 wet pavement passes divided into 4 accidents provides a rate of 85.47×10^{-6} accidents per wet vehicle pass. This indicates that curves that have a skid number of 22 exhibit an accident rate approximately 27 times that of curves that have a skid number of 35, even though there were ten times as many accidents at locations having a skid number of 35. For this study, the total number of opportunities for accidents to occur in each category was obtained by incorporating the SRI file as a statistical INVENTORY file. (A description of the statistical nature of the SRI file is presented in Appendix II.)

The form of the adopted equation is

AC_RATEn = A0 + A1*SN + A2*SPD .... (2)

where the variable, AC_RATEn, represents the various types of universal accident rates and the totality of their opportunities to occur throughout the study area.

For each category studied, three accident rates were considered in this report. They are as follows.

AC_RATE1 = FRQ_ACC / FRQ_INV

AC_RATE2 = FRQ_ACC / TWET_ADT

AC_RATE3 = FRQ_ACC / (TWET_ADT * FRQ_INV)

where the term, FRQ_ACC, represents the frequency of the accidents as determined from the TSAR for wet pavement accidents during the study period. The term, FRQ_INV, represents the number of locations that had a specific skid number, and the term, TWET_ADT, represents the total sum of the vehicles traveling on wet pavement at these locations during this period, sum:(WET_ADT). The data showing the skid number distribution for the three accident rates are presented in Table 1 and Figures 1, 2, 3.

A fourth accident rate, accidents per vehicle-mile, may have enhanced this study, but the length of the geometric classifications was not reasonably available. Therefore, this rate was not considered.

B. Regression Analysis

B.1. Models Used In Regression Analysis

After a preliminary study of the data, three more changes were made. First, posted speed was dropped from the evaluation because it showed no correlation to wet pavement accidents. Second, the data for each category were indexed so that the sum of all accident rates equalled 100. And third, the term (SN-14) was substituted for SN to minimize the magnitude of the coefficients obtained.

A regression analysis was performed with each of these indexed accident rates as the dependent variable on the left side of the equation and the skid numbers as the independent variable on the right side of the equation. The three types of accident rates were analyzed using the following three equations.

$$AC\_RATEn = A0 + A1*(SN-14) \quad (3)$$

for n = 1, 2, and 3.

$$\log:(AC\_RATEn) = B0 + B1*(SN-14) \quad (4)$$

for n = 1, 2, and 3.

$$AC\_RATEn = C0*\exp:(C1*(SN-14)) \quad (5)$$

for n = 1, 2, and 3.

where the symbols, A0, A1, B0, B1, C0, and C1, represent the coefficients, whose values are to be determined by the regression analysis.

Equations 3 and 4 were analyzed using the SAS Procedure, PROC GLM, which is a linear analysis. Equation 5 was analyzed using the SAS Procedure, PROC NLIN, which is a nonlinear analysis (20).

The coefficients that were obtained from all the data using the above three equations and the three accidents rates are as follows:

Equation No.	Symbol	Coefficient n = 1	n = 2	n = 3
3	A0	9.1620	11.8955	31.3321
	A1	-0.2918	-0.3883	-1.2307
4	B0	2.2497	2.3570	3.6294
	B1	-0.0642	-0.0684	-0.1563
5	C0	7.3035	19.7199	175.6041
	C1	-0.0556	-0.1790	-0.5159

Plots of the results pertaining to the regression analysis are shown in Figures 4 thru 12.

After a cursory inspection of Tables 2, 5, and 8, and of Figures 4, 7, and 10, Equation 3 can be eliminated as an appropriate evaluation equation because of poor correlation using linear regression.

The values of the parameters for Equation 4 were also determined by the linear regression technique (refer to Tables 3, 6, and 9, and to Figures 5, 8, and 11). The correlations for Equation 4 were somewhat better than those for Equation 3. However, this regression technique places its entire emphasis on minimizing the sum of the squares of the residuals. It is important to take into consideration the fact that logarithmic values are being minimized. In this regard, one must be very careful when using values obtained by a linear regression technique which minimizes nonlinear type of residuals. A good general policy is to use linear regression techniques to analyze linear equations, and nonlinear regression techniques to analyze nonlinear equations (19).

Therefore, Equation 5 was adopted as the best type of equation to evaluate the data. Tables 4, 7 and 10 and Figures 6, 9, and 12 show the relationship between the measured data and the predicted "best fit" curve for the dependent variables AC_RATE 1, AC_RATE 2, and AC_RATE 3, respectively. After observing these plots it is clear that AC_RATE 3 (Total wet pavement accidents at a specified skid number divided by the product of the total number of vehicles traveling on wet pavement locations having the same specified skid number and the number of locations having the skid number) provides the best fit equation. Using Equation 5, 23 of the 37 calculated predictions coincide with the observed data. The curve on Figure 12 indicates that the accident prediction rate increases substantially as the skid number drops below 25. Subsequent studies in Section C of this report will relate to a low range of skid numbers as those between 17 and 25 and a higher range of skid numbers between 26 and 54. These groupings will provide a larger and somewhat more consistent data base for the specific geometric type.

B.2. Figures And Tables Pertaining To The Regression Analysis

Table 1. AC_RATE1, AC_RATE2, And AC_RATE3
For Skid Number From 17 Thru 54

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- REGRESSION ANALYSIS ---------------

SN	FRQ_ACC	FRQ_INV	TWET_ADT	AC_RATE1	AC_RATE2	AC_RATE3
17	20	17	16706	13.6618	18.4081	33.9155
18	5	9	8160	6.4514	9.4220	32.7897
19	1	7	8161	1.6589	1.8840	8.4301
20	2	19	15398	1.2224	1.9971	3.2923
21	2	24	22698	0.9677	1.3549	1.7682
22	17	34	44969	5.8063	5.8127	5.3547
23	14	56	54570	2.9031	3.9448	2.2063
24	26	56	64457	5.3915	6.2022	3.4690
25	31	90	120944	3.9999	3.9412	1.3716
26	32	119	211394	3.1227	2.3276	0.6126
27	47	181	356577	3.0154	2.0267	0.3507
28	65	196	382697	3.8511	2.6116	0.4173
29	65	276	591043	2.7348	1.6910	0.1919
30	71	349	688380	2.3624	1.5859	0.1423
31	105	389	825062	3.1345	1.9568	0.1576
32	170	455	1047238	4.3387	2.4960	0.1718
33	149	544	1235933	3.1806	1.8537	0.1067
34	164	562	1231040	3.3887	2.0484	0.1142
35	160	632	1324658	2.9399	1.8572	0.0920
36	109	523	1054432	2.4202	1.5895	0.0952
37	160	619	1250139	3.0016	1.9679	0.0996
38	139	547	1098354	2.9509	1.9459	0.1114
39	93	603	1065416	1.7910	1.3422	0.0697
40	90	459	913943	2.2770	1.5142	0.1033
41	86	440	768269	2.2697	1.7212	0.1225
42	57	378	667934	1.7511	1.3122	0.1087
43	31	364	537457	0.9890	0.8869	0.0763
44	22	275	423944	0.9290	0.7979	0.0909
45	22	233	302669	1.0965	1.1176	0.1502
46	23	194	219647	1.3767	1.6101	0.2599
47	15	195	194039	0.8933	1.1886	0.1909
48	15	156	135506	1.1166	1.7021	0.3417
49	7	100	65769	0.8129	1.6365	0.5126
50	4	100	59263	0.4645	1.0378	0.3251
51	5	83	40426	0.6996	1.9018	0.7177
52	3	50	22141	0.6968	2.0834	1.3051
53	.	53	16408	.	.	.
54	3	105	37742	0.3318	1.2222	0.3646

Fig. 1. AC_RATE1 Vs. Skid Number

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- REGRESSION ANALYSIS ---------------

BAR CHART OF AC_RATE1

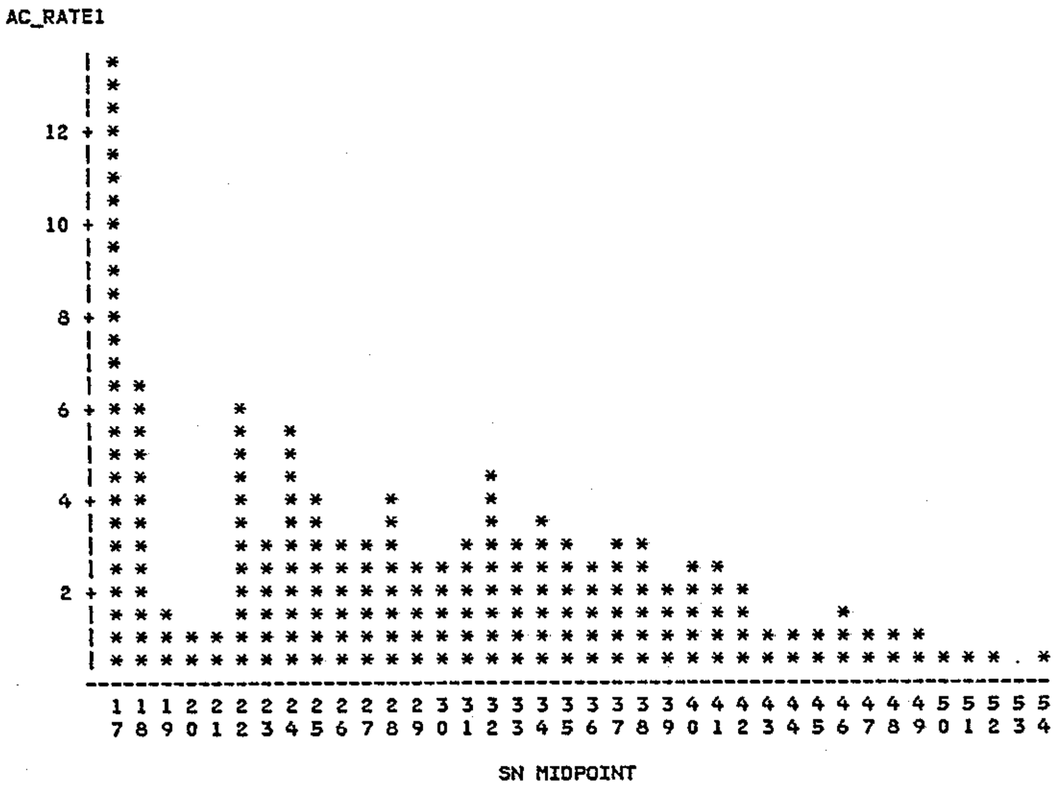


Fig. 2. AC_RATE2 Vs. Skid Number

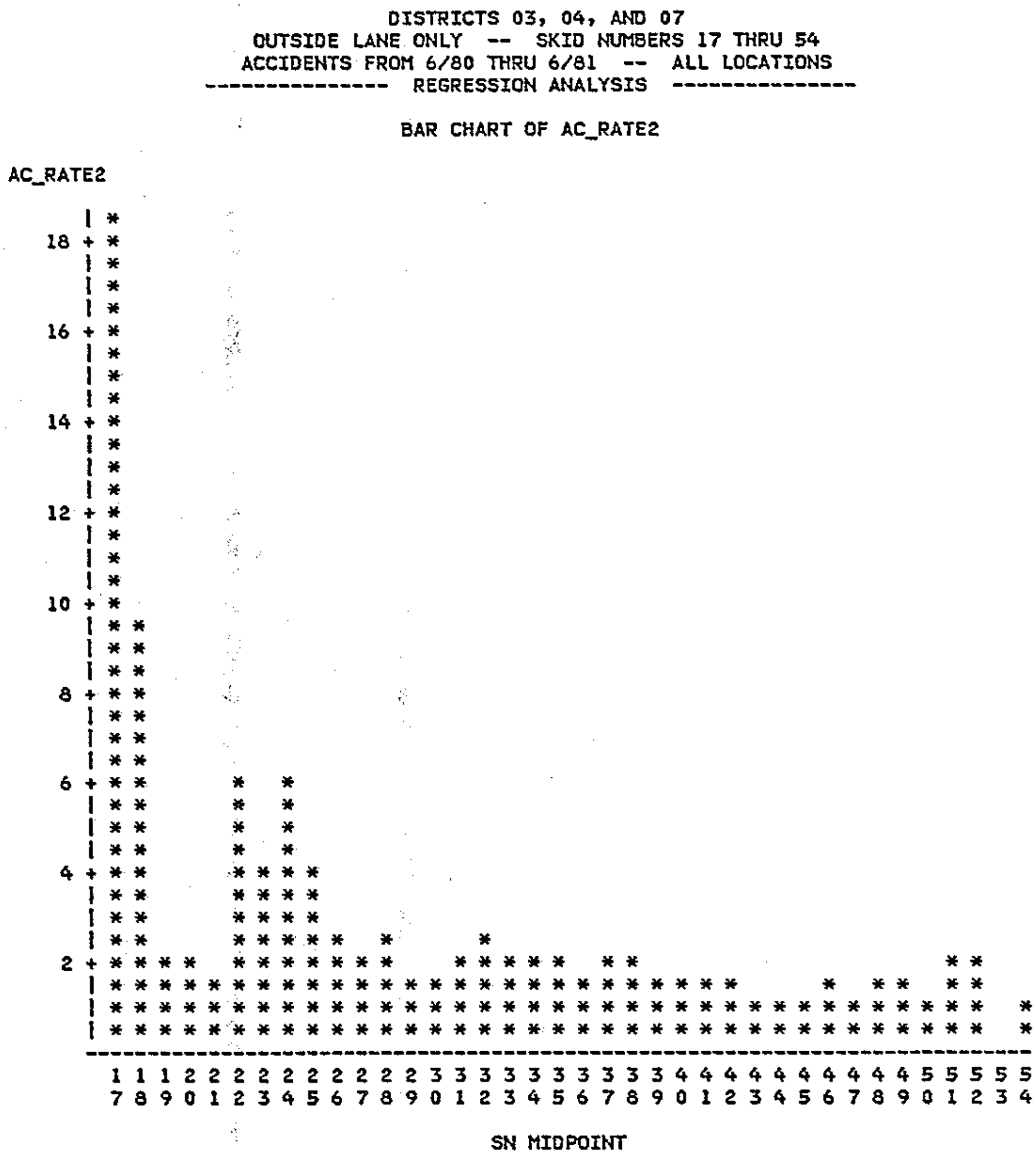


Fig. 3. AC_RATE3 Vs. Skid Number

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- REGRESSION ANALYSIS ---------------

BAR CHART OF AC_RATE3

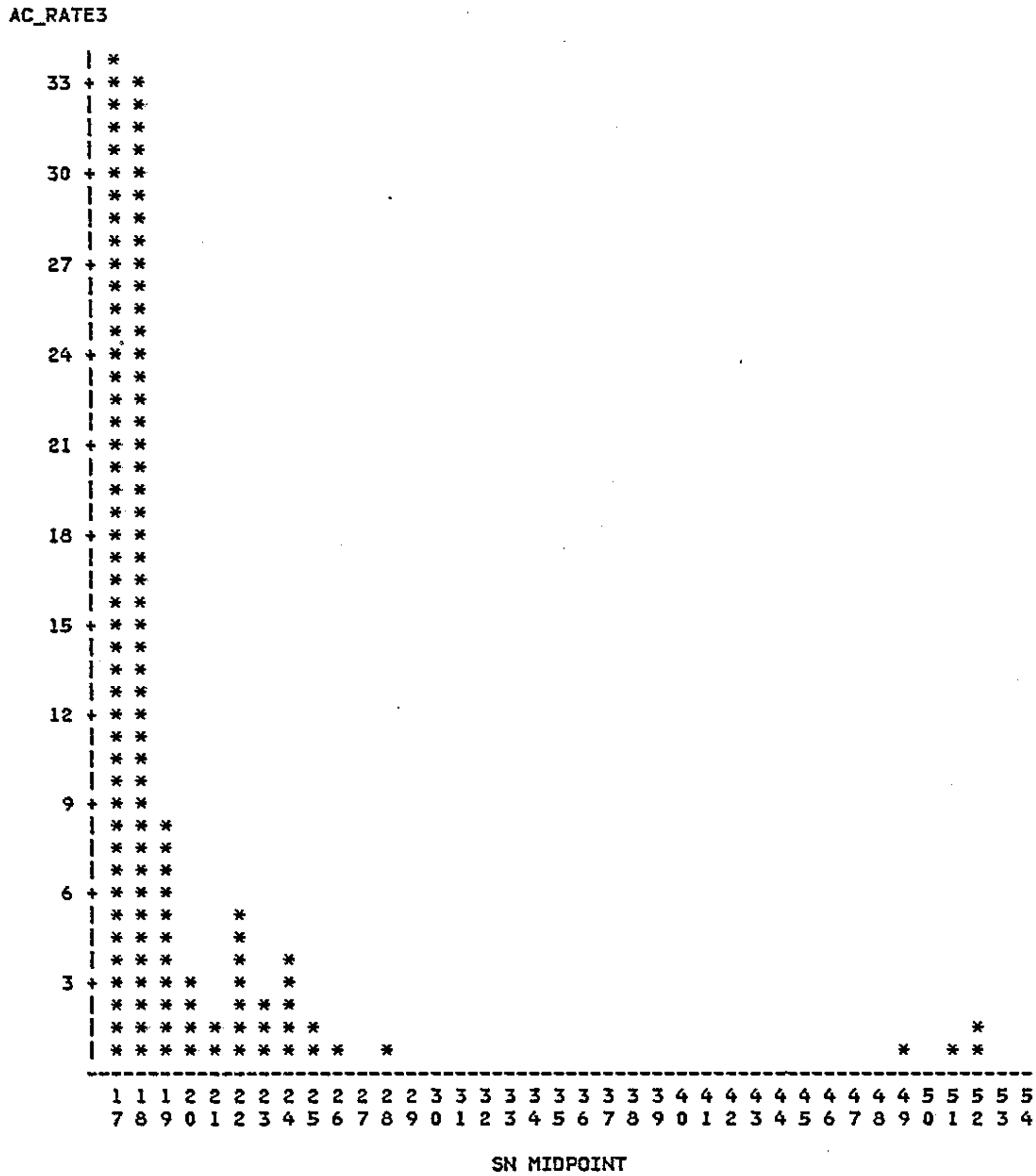


Table 2. Linear Regression Analysis
AC_RATE1 = A0 + A1*(SN-14)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE1 = ACCIDENTS PER LOCATION (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: AC_RATE1
FREQUENCY: AFREQ

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
MODEL	1	7554.40747739	7554.40747739	1044.02	0.0001
ERROR	1000	7235.86231700	7.23586232		
CORRECTED TOTAL	1001	14790.26979439			

R-SQUARE	C.V.	ROOT MSE	AC_RATE1 MEAN
0.510769	56.5756	2.68995582	4.75462054

SOURCE	DF	TYPE I SS	F VALUE	PR > F
SN	1	7554.40747739	1044.02	0.0001

SOURCE	DF	TYPE III SS	F VALUE	PR > F
SN	1	7554.40747739	1044.02	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	9.16201868	57.01	0.0001	0.16070931
SN	-0.29180738	-32.31	0.0001	0.00903111

Table 3. Linear Regression Analysis
log:(AC_RATE1) = B0 + B1*(SN-14)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE1 = ACCIDENTS PER LOCATION (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: WORK
FREQUENCY: AFREQ

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
MODEL	1	365.67857262	365.67857262	1839.18	0.0001
ERROR	1000	198.82738632	0.19882739		
CORRECTED TOTAL	1001	564.50595895			

R-SQUARE	C.V.	ROOT MSE	WORK MEAN
0.647785	34.8344	0.44590065	1.28005859

SOURCE	DF	TYPE I SS	F VALUE	PR > F
SN	1	365.67857262	1839.18	0.0001

SOURCE	DF	TYPE III SS	F VALUE	PR > F
SN	1	365.67857262	1839.18	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	2.24974618	84.45	0.0001	0.02663999
SN	-0.06420160	-42.89	0.0001	0.00149704

Table 4. Nonlinear Regression Analysis
AC_RATE1 = C0*exp:(C1*(SN-14))

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE1 = ACCIDENTS PER LOCATION (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

NON-LINEAR LEAST SQUARES SUMMARY STATISTICS   DEPENDENT VARIABLE AC_RATE1

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
REGRESSION	2	356.94805164	178.47402582
RESIDUAL	35	118.46665320	3.38476152
UNCORRECTED TOTAL	37	475.41470484	
(CORRECTED TOTAL)	36	205.14443457	

PARAMETER	ESTIMATE	ASYMPTOTIC STD. ERROR	ASYMPTOTIC 95 % CONFIDENCE INTERVAL LOWER	UPPER
A1	7.30349029	1.24318966	4.77969610	9.82728449
B1	-0.05561599	0.01283005	-0.08166222	-0.02956975

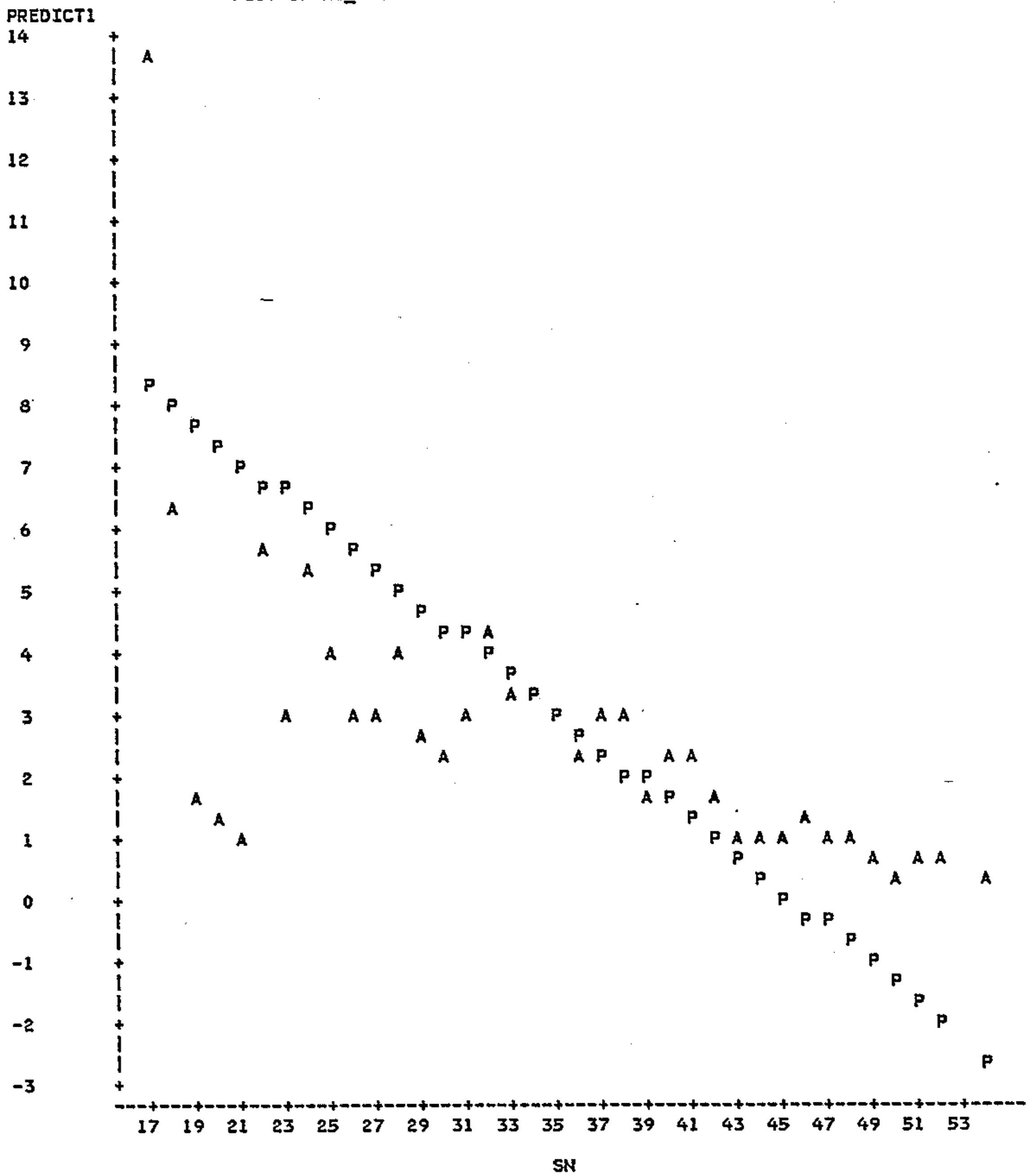
ASYMPTOTIC CORRELATION MATRIX OF THE PARAMETERS

	A1	B1
A1	1.000000	-0.820200
B1	-0.820200	1.000000

Fig. 4. Linear Regression Analysis Plot
AC_RATE1 = A0 + A1*(SN-14)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 --. ALL LOCATIONS
AC_RATE1 = ACCIDENTS PER LOCATION (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

PLOT OF PREDICT1*SN SYMBOL USED IS P
PLOT OF AC_RATE1*SN SYMBOL USED IS A

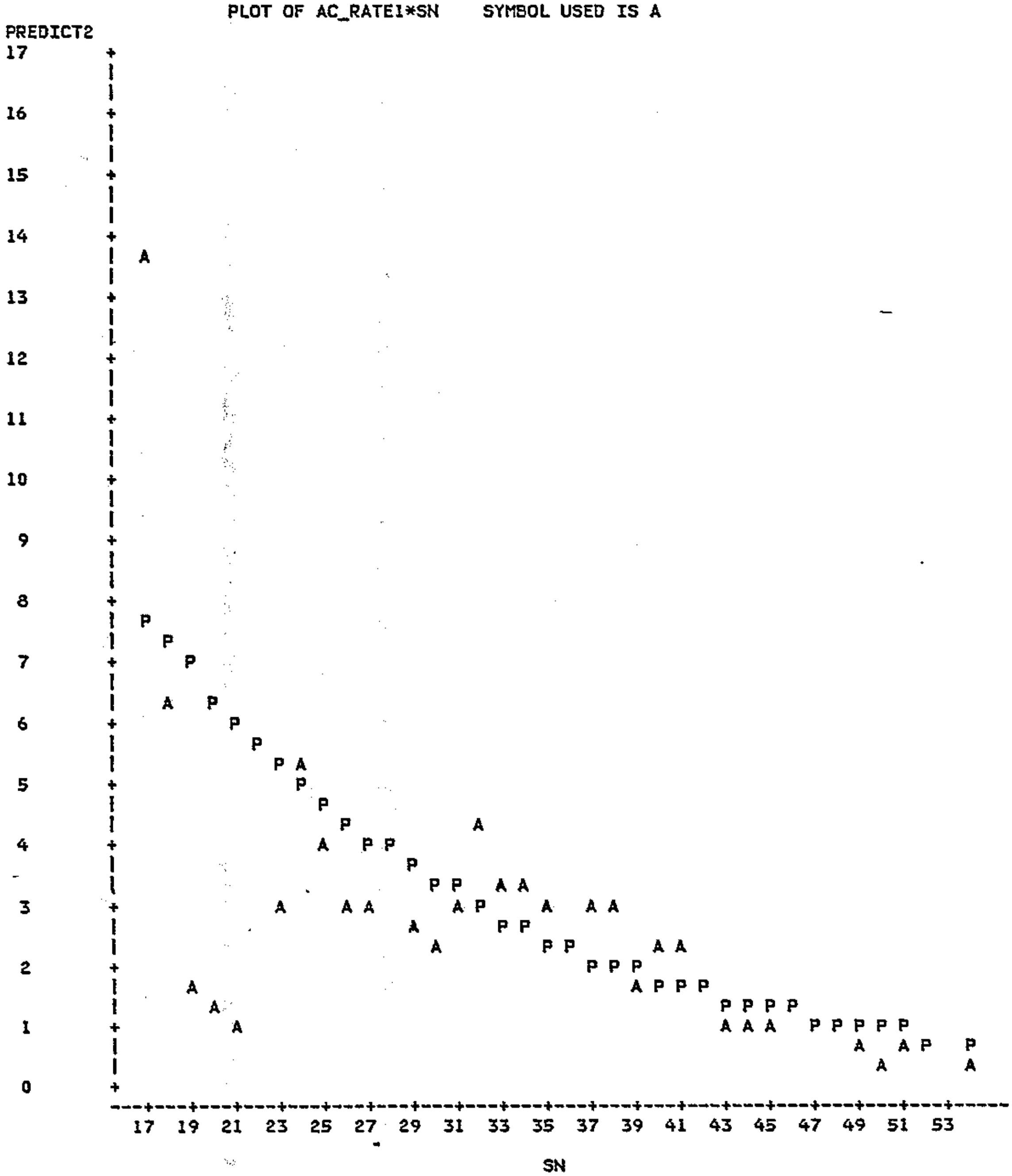


NOTE: 2 OBS HIDDEN

Fig. 5. Linear Regression Analysis Plot
log:(AC_RATE1) = B0 + B1*(SN-14)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE1 = ACCIDENTS PER LOCATION (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

PLOT OF PREDICT2*SN SYMBOL USED IS P
PLOT OF AC_RATE1*SN SYMBOL USED IS A

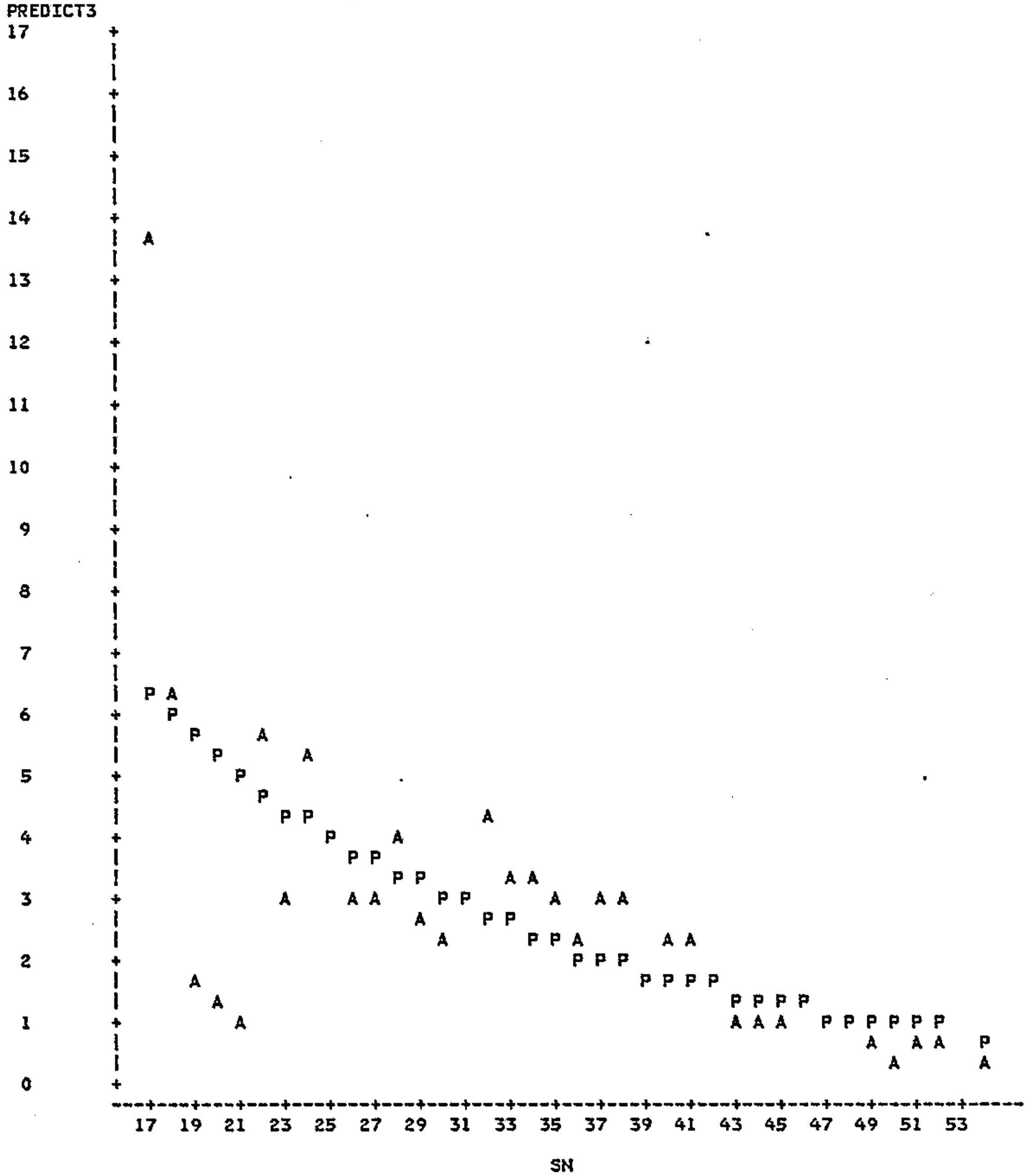


NOTE: 8 OBS HIDDEN

Fig. 6. Nonlinear Regression Analysis Plot
AC_RATE1 = C0*exp:(C1*(SN-14))

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE1 = ACCIDENTS PER LOCATION (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

PLOT OF PREDICT3*SN SYMBOL USED IS P
PLOT OF AC_RATE1*SN SYMBOL USED IS A



NOTE: 7 OBS HIDDEN

Table 5. Linear Regression Analysis
AC_RATE2 = A0 + A1*(SN-14)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE2 = ACCIDENTS PER WET-VEHICLE (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: AC_RATE2
FREQUENCY: AFREQ

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
MODEL	1	18337.97025096	18337.97025096	883.75	0.0001
ERROR	996	20667.06540578	20.75006567		
CORRECTED TOTAL	997	39005.03565674			

R-SQUARE	C.V.	ROOT MSE	AC_RATE2 MEAN
0.470144	72.8454	4.55522400	6.25327807

SOURCE	DF	TYPE I SS	F VALUE	PR > F
SN	1	18337.97025096	883.75	0.0001

SOURCE	DF	TYPE III SS	F VALUE	PR > F
SN	1	18337.97025096	883.75	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	11.89550031	49.91	0.0001	0.23835627
SN	-0.38831376	-29.73	0.0001	0.01306222

Table 6. Linear Regression Analysis
log:(AC_RATE2) = B0 + B1*(SN-14)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE2 = ACCIDENTS PER WET-VEHICLE (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: WORK
FREQUENCY: AFREQ

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
MODEL	1	569.62244645	569.62244645	1669.72	0.0001
ERROR	996	339.78411771	0.34114871		
CORRECTED TOTAL	997	909.40656416			

R-SQUARE	C.V.	ROOT MSE	WORK MEAN
0.626367	42.8647	0.58407937	1.36261088

SOURCE	DF	TYPE I SS	F VALUE	PR > F
SN	1	569.62244645	1669.72	0.0001

SOURCE	DF	TYPE III SS	F VALUE	PR > F
SN	1	569.62244645	1669.72	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	2.35702688	77.12	0.0001	0.03056249
SN	-0.06843853	-40.86	0.0001	0.00167486

Table 7. Nonlinear Regression Analysis
AC_RATE2 = C0*exp:(C1*(SN-14))

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE2 = ACCIDENTS PER WET-VEHICLE (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

NON-LINEAR LEAST SQUARES SUMMARY STATISTICS   DEPENDENT VARIABLE AC_RATE2

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
REGRESSION	2	441.41093038	220.70546519
RESIDUAL	35	183.55025488	5.24429300
UNCORRECTED TOTAL	37	624.96118527	
(CORRECTED TOTAL)	36	354.69091500	

PARAMETER	ESTIMATE	ASYMPTOTIC STD. ERROR	ASYMPTOTIC 95 % CONFIDENCE INTERVAL LOWER	UPPER
A1	19.71991117	4.64596782	10.28815105	29.15167129
B1	-0.17901571	0.03924049	-0.25867767	-0.09935375

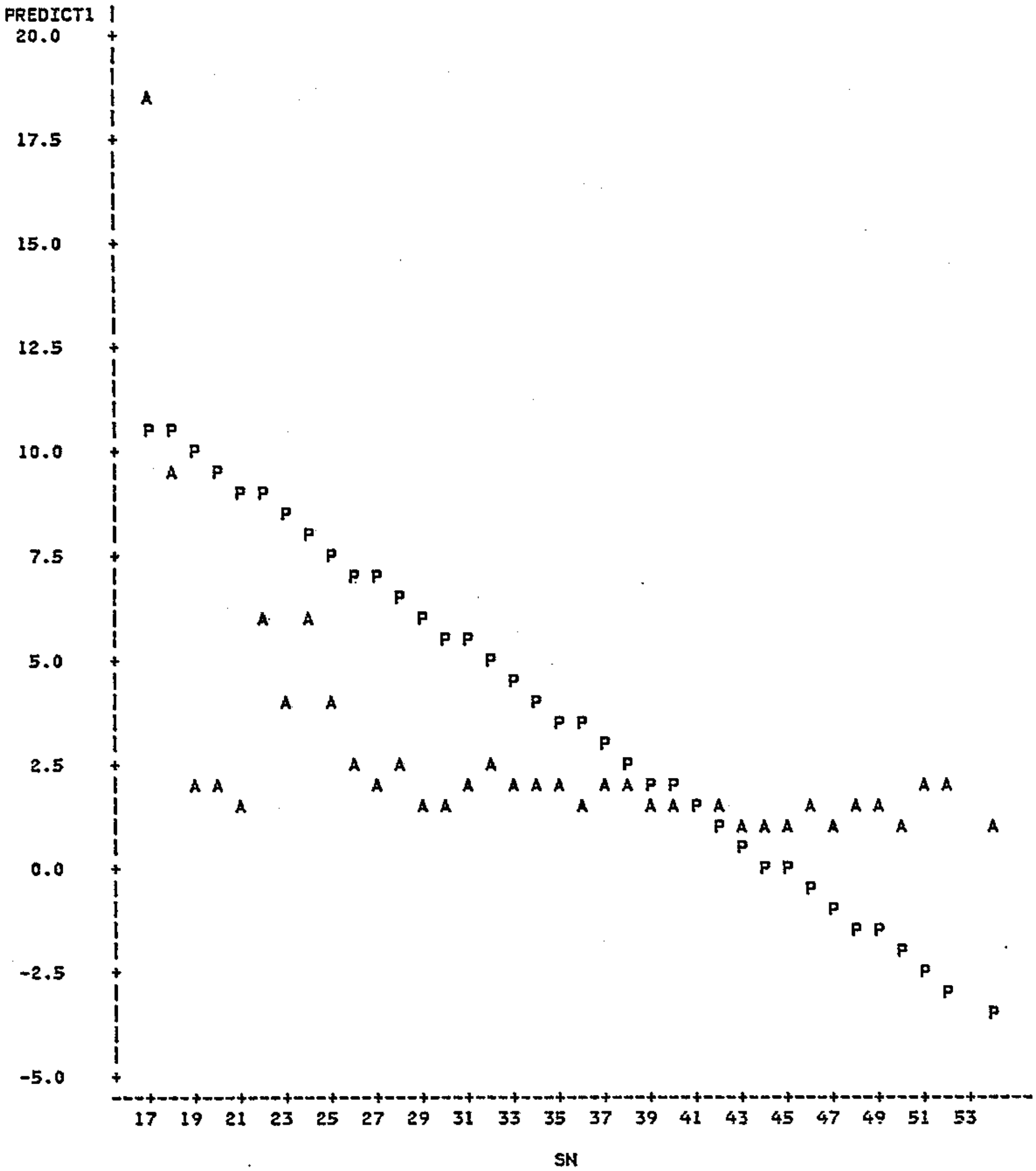
ASYMPTOTIC CORRELATION MATRIX OF THE PARAMETERS

	A1	B1
A1	1.000000	-0.886542
B1	-0.886542	1.000000

Fig. 7. Linear Regression Analysis Plot
AC_RATE2 = A0 + A1*(SN-14)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE2 = ACCIDENTS PER WET-VEHICLE (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

PLOT OF PREDICT1*SN SYMBOL USED IS P
PLOT OF AC_RATE2*SN SYMBOL USED IS A

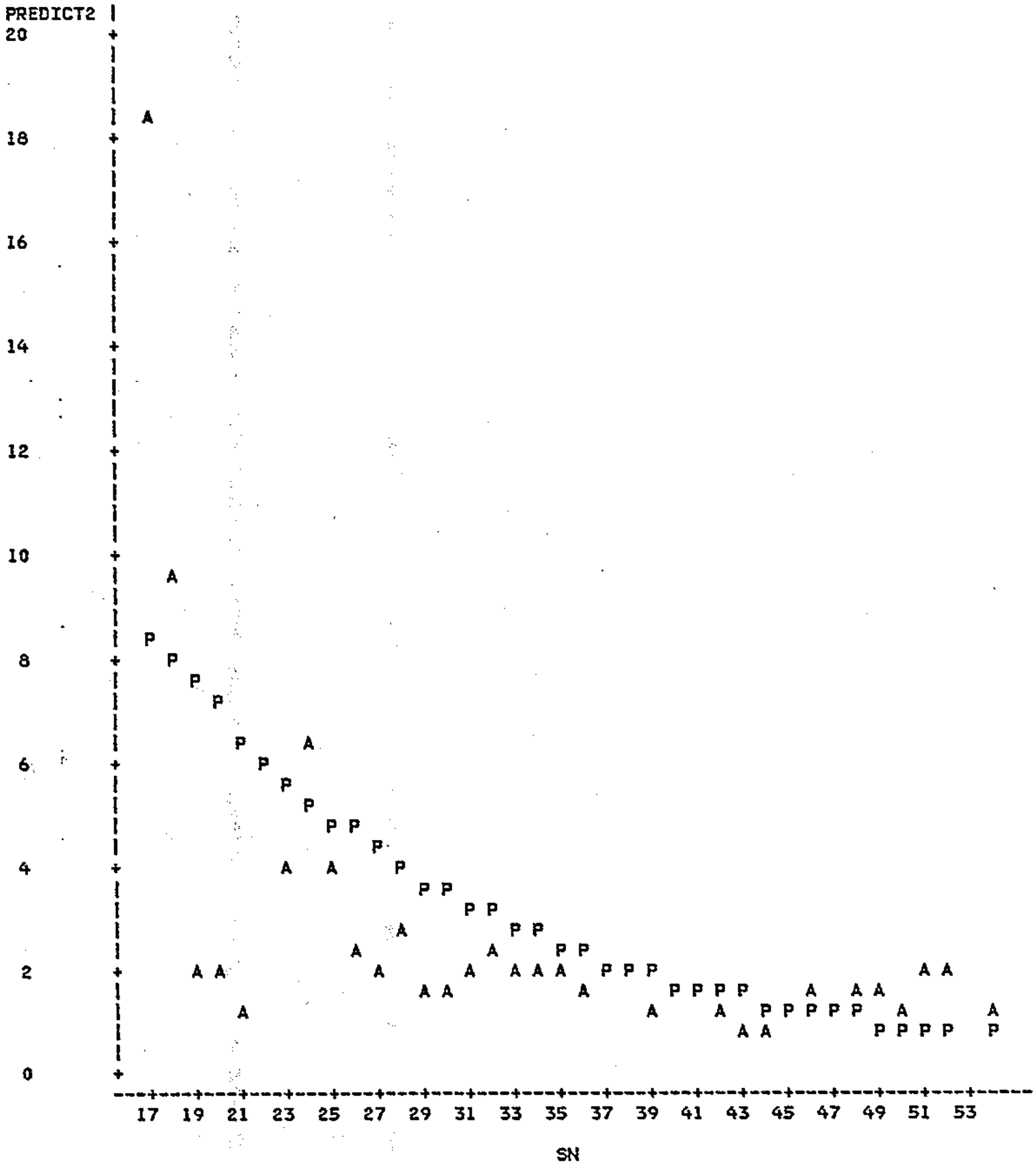


NOTE: 1 OBS HIDDEN

Fig. 8. Linear Regression Analysis Plot
log:(AC_RATE2) = B0 + B1*(SN-14)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE2 = ACCIDENTS PER WET-VEHICLE (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

PLOT OF PREDICT2*SN SYMBOL USED IS P
PLOT OF AC_RATE2*SN SYMBOL USED IS A

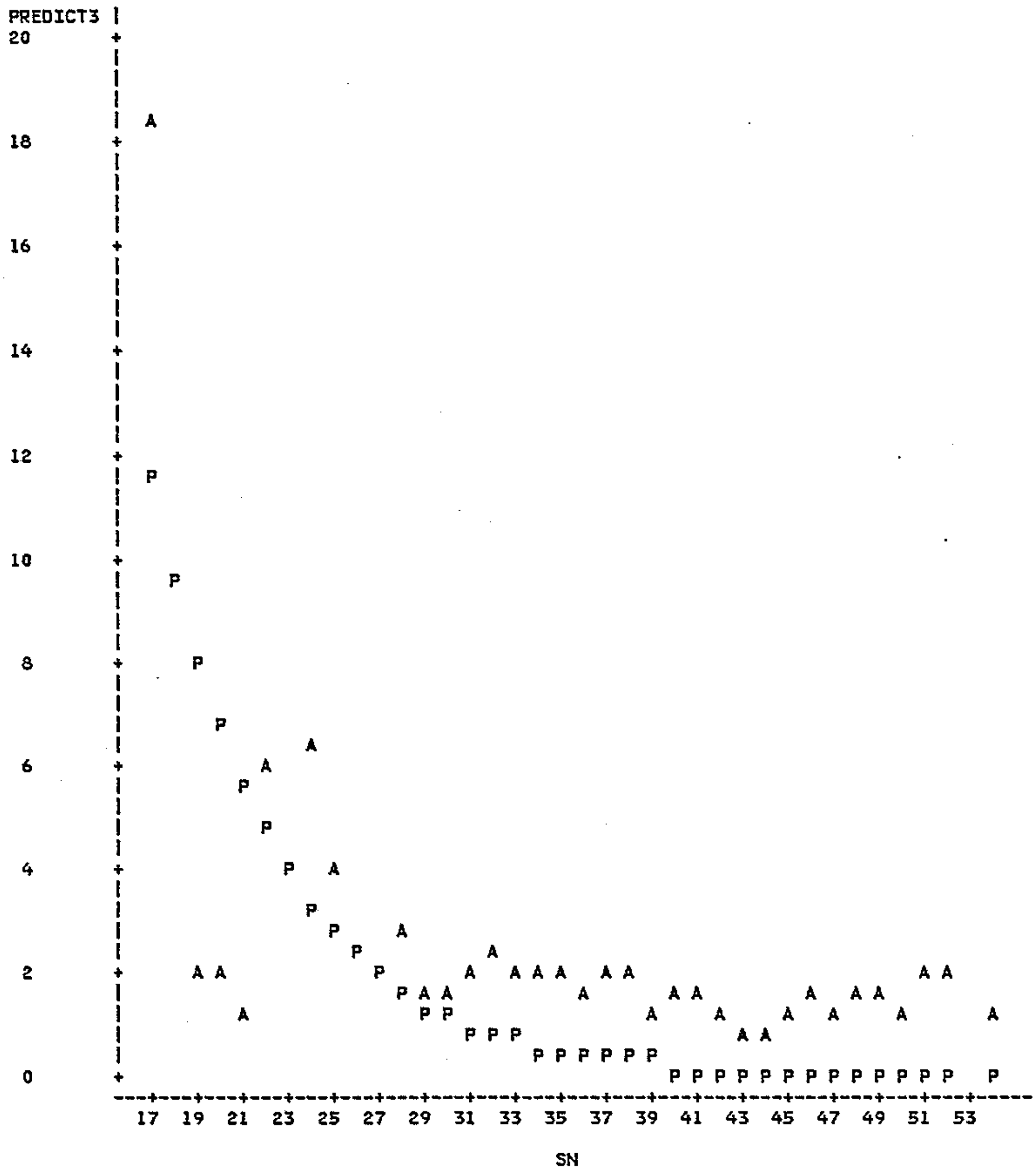


NOTE: 7 OBS HIDDEN

Fig. 9. Nonlinear Regression Analysis Plot
AC_RATE2 = C0*exp:(C1*(SN-14))

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE2 = ACCIDENTS PER WET-VEHICLE (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

PLOT OF PREDICT3*SN SYMBOL USED IS P
PLOT OF AC_RATE2*SN SYMBOL USED IS A



NOTE: 4 OBS HIDDEN

Table 8. Linear Regression Analysis
$AC\_RATE3 = A0 + A1*(SN-14)$

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE3 = ACCIDENTS PER WET-VEHICLE-LOCATION (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: AC_RATE3
FREQUENCY: AFREQ

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
MODEL	1	75825.46203266	75825.46203266	639.37	0.0001
ERROR	1000	118594.70533574	118.59470534		
CORRECTED TOTAL	1001	194420.16736840			

R-SQUARE	C.V.	ROOT MSE	AC_RATE3 MEAN
0.390008	46.2019	10.89011962	23.57073309

SOURCE	DF	TYPE I SS	F VALUE	PR > F
SN	1	75825.46203266	639.37	0.0001

SOURCE	DF	TYPE III SS	F VALUE	PR > F
SN	1	75825.46203266	639.37	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	31.33210814	67.96	0.0001	0.46105815
SN	-1.23071654	-25.29	0.0001	0.04867244

Table 9. Linear Regression Analysis
log:(AC_RATE3) = B0 + B1*(SN-14)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE3 = ACCIDENTS PER WET-VEHICLE-LOCATION (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: WORK
FREQUENCY: AFREQ

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F
MODEL	1	1222.90545628	1222.90545628	1600.70	0.0001
ERROR	1000	763.98187851	0.76398188		
CORRECTED TOTAL	1001	1986.88733479			

R-SQUARE	C.V.	ROOT MSE	WORK MEAN
0.615488	33.0614	0.87406057	2.64375324

SOURCE	DF	TYPE I SS	F VALUE	PR > F
SN	1	1222.90545628	1600.70	0.0001

SOURCE	DF	TYPE III SS	F VALUE	PR > F
SN	1	1222.90545628	1600.70	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	3.62941426	98.08	0.0001	0.03700536
SN	-0.15629567	-40.01	0.0001	0.00390654

Table 10. Nonlinear Regression Analysis
AC_RATE3 = C0*exp:(C1*(SN-14))

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE3 = ACCIDENTS PER WET-VEHICLE-LOCATION (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

NON-LINEAR LEAST SQUARES SUMMARY STATISTICS   DEPENDENT VARIABLE AC_RATE3

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
REGRESSION	2	2168.97325435	1084.48662718
RESIDUAL	35	192.80608737	5.50874535
UNCORRECTED TOTAL	37	2361.77934173	
(CORRECTED TOTAL)	36	2091.50907146	

PARAMETER	ESTIMATE	ASYMPTOTIC STD. ERROR	ASYMPTOTIC 95 % CONFIDENCE INTERVAL LOWER	UPPER
A1	175.60412266	35.04157728	104.46636106	246.74188425
B1	-0.51585477	0.05433130	-0.62615251	-0.40555702

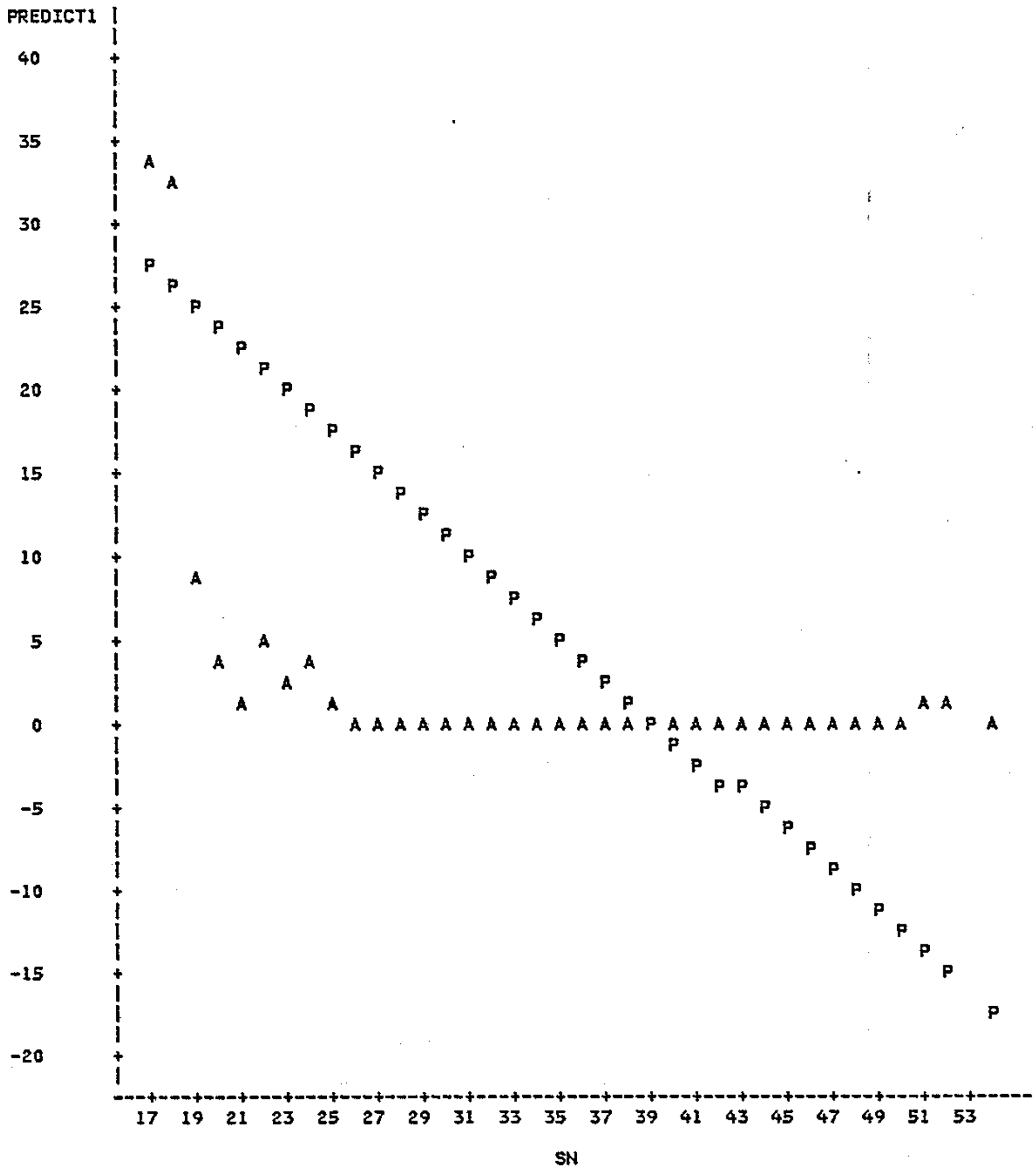
ASYMPTOTIC CORRELATION MATRIX OF THE PARAMETERS

	A1	B1
A1	1.000000	-0.967583
B1	-0.967583	1.000000

Fig. 10. Linear Regression Analysis Plot
AC_RATE3 = A0 + A1*(SN-14)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
AC_RATE3 = ACCIDENTS PER WET-VEHICLE-LOCATION (INDEXED RATE)
REGRESSION ANALYSIS OF SKID NUMBERS FOR ALL RECORDS
--------------- REGRESSION ANALYSIS ---------------

PLOT OF PREDICT1*SN SYMBOL USED IS P
PLOT OF AC_RATE3*SN SYMBOL USED IS A



NOTE: 1 OBS HIDDEN

C. Analysis Of Data

Using Three Types Of Accident Rates

SN RANGE	FRQ ACC	FRQ INV	TWET ADT	AC RATE1	AC RATE2	AC RATE3
17-25	118	312	356064	64.4	74.4	98.8
26-54	1912	9180	16767518	35.6	25.6	1.2

The above table gives the indexed rates for the three types of accident rates, when the accidents are grouped according only to a low range of skid numbers (17 thru 25) and a high range of skid numbers (26 thru 54). As one would expect with this type of grouping, the highest indexed rate (98.8) is in the lower range of skid numbers. An investigation to determine if certain roadway parameters contribute more to this accident rate than others was also conducted. The following tables show the indexed rates for different roadway parameters. The indexed rates provide a comparison within each parameter study group but are not relative between studies.

C.1. Geometric Effect

(Bridge-Tangent, Curve, Intersection, Tangent, Weave-Tangent)

SN_RANGE	CLASS	FRQ_ACC	FRQ_INV	TWET_ADT	AC_RATE1	AC_RATE2	AC_RATE3
17-25	BT	.	11	18305	.	.	.
17-25	C	8	13	6249	19.0	22.4	81.2
17-25	I	42	160	154890	8.0	4.8	1.4
17-25	T	50	70	59657	22.0	14.6	9.8
17-25	WT	13	50	106018	8.0	2.2	2.0
26-54	BT	49	878	2152077	1.8	0.4	0.0
26-54	C	318	429	117715	22.8	47.2	5.2
26-54	I	251	1938	1200454	4.0	3.6	0.0
26-54	T	796	2139	3217115	11.4	4.4	0.0
26-54	WT	379	3653	9991097	3.2	0.6	0.0

The statistics for the bridge-tangent sections having low skid numbers highlight some of the difficulty in establishing criteria. The index rate, AC_RATE 3, shows 98.8 percent to be in the low SN range, yet eleven bridge-tangents in this group have not experienced wet pavement accidents for at least 18,000 wet pavement vehicle passes. The reason for this disparity is not apparent.

The curve and the tangent data that were available for this investigation may bias the accident rates for these parameters in this study. The following evaluation will show that, although the rates may change, this bias has little effect on the resulting rank of the bridge-tangent, curve, intersection and weave-tangent classification. The variable length tangent sections on the highway system provide variable opportunities for accident occurrence. This, combined with the variable skid testing pattern that was used on the tangent sections, makes it impossible to adjust the number of tangent sections or to weigh the data to reflect accident opportunity with any confidence. Therefore, the tangent sections cannot be effectively represented in this study.

An inequity in the curve data arises from practical applications. For the skid resistance inventory, and therefore the SRI file, a curve has been defined as a roadway that generates a lateral acceleration in the test vehicle of at least 0.12G, when driven at the advisory speed. Tests on horizontal curves at the advisory speed that provide lateral acceleration less than 0.12G are recorded as tangents. The skid test operators estimate that the number of curves identified during skid inventory testing should be increased by a factor of three to approximate the number of horizontal curves that relate to the curve classification used to establish the ACCIDENT file for this study. The following table shows the results of these changes. It was assumed that the wet pavement ADT rate remains reasonably constant for curves.

SN_RANGE	CLASS	FRQ_ACC	FRQ_INV	TWET_ADT	AC_RATE1	AC_RATE2	AC_RATE3
17-25	BT	.	11	18305	.	.	.
17-25	C	8	38	18379	21.2	25.5	70.6
17-25	I	42	160	154890	19.4	15.9	10.4
17-25	WT	13	50	106018	19.3	7.2	15.1
26-54	BT	49	878	2152077	4.1	1.3	0.7
26-54	C	318	1262	522691	18.7	35.6	3.0
26-54	I	251	1938	1200454	9.6	10.2	0.7
26-54	WT	379	3653	9991097	7.7	2.2	0.1

There is a substantial change in the AC_RATE 3 values of the adjusted geometrics parameters but only one significant change in the rank. Namely, the index rate for curve classifications in the high range of skid numbers drops below those of intersections and weave-tangent classifications in the low range of skid numbers. This is a reasonable relationship which will be accepted to represent the highway geometrics.

C.2. Median Effect

SN_RANGE	DV_UNDV	FRQ_ACC	FRQ_INV	TWET_ADT	AC_RATE1	AC_RATE2	AC_RATE3
17-25	DIV	62	199	299110	26.6	12.2	10.4
17-25	UN_DIV	56	113	56954	42.4	58.0	87.6
26-54	DIV	1611	6816	16026122	20.2	6.0	0.2
26-54	UN_DIV	301	2364	741396	10.8	24.0	1.8

C.3. Grade Effect

SN_RANGE	GRADE	FRQ_ACC	FRQ_INV	TWET_ADT	AC_RATE1	AC_RATE2	AC_RATE3
17-25	+	6	30	24376	13.2	19.8	52.2
17-25	-	10	44	39327	15.0	20.4	36.8
17-25	=	102	238	292361	28.4	28.0	9.4
26-54	+	251	1268	2187362	13.0	9.2	0.6
26-54	-	343	1321	1907334	17.2	14.4	0.8
26-54	=	1318	6591	12672822	13.2	8.4	0.2

C.4. Area (Rural or Urban) Effect

SN_RANGE	RRL_URB	FRQ_ACC	FRQ_INV	TWET_ADT	AC_RATE1	AC_RATE2	AC_RATE3
17-25	RRL	10	117	53816	8.4	23.0	45.6
17-25	URB	108	195	302248	54.8	44.4	52.6
26-54	RRL	332	3332	2138820	9.8	19.2	1.4
26-54	URB	1580	5848	14628697	26.8	13.4	0.6

C.5. Access Control Effect

C.5.1. Includes One-Way

SN_RANGE	ACC_CNTL	FRQ_ACC	FRQ_INV	TWET_ADT	AC_RATE1	AC_RATE2	AC_RATE3
17-25	CONV	100	201	177014	21.4	19.6	1.2
17-25	EXPWY	.	14	8365	.	.	.
17-25	FRWY	14	92	167044	6.6	3.0	0.4
17-25	ONEWY	4	5	3641	34.4	38.2	93.0
26-54	CONV	825	3254	1695669	11.0	17.0	0.0
26-54	EXPWY	60	379	260203	6.8	8.0	0.2
26-54	FRWY	1019	5518	14788274	8.0	2.4	0.0
26-54	ONEWY	8	29	23372	11.8	12.0	5.0

Note that the index rating for one-way streets is based on only 5 SRI samples in the lower range and 29 SRI samples in the higher range. If the one-way sections are eliminated, freeways show the lowest indexed rate as noted below.

C.5.2. Excludes One-Way

SN_RANGE	ACC_CNTL	FRQ_ACC	FRQ_INV	TWET_ADT	AC_RATE1	AC_RATE2	AC_RATE3
17-25	CONV	100	201	177014	40.0	39.4	62.6
17-25	EXPWY	.	14	8365	.	.	.
17-25	FRWY	14	92	167044	12.2	5.8	20.2
26-54	CONV	825	3254	1695669	20.4	34.0	3.4
26-54	EXPWY	60	379	260203	12.8	16.0	13.6
26-54	FRWY	1019	5518	14788274	14.8	4.8	0.2

C.6. Surface Type Effect

SN_RANGE	SURFACE	FRQ_ACC	FRQ_INV	TWET_ADT	AC_RATE1	AC_RATE2	AC_RATE3
17-25	PATCH	.	2	1005	.	.	.
17-25	DNG_AC	81	188	172168	16.0	23.8	7.4
17-25	OPG_AC	19	25	37776	28.2	25.6	59.2
17-25	CHP_SL	.	8	3268	.	.	.
17-25	PCC	17	76	118235	8.2	7.2	5.6
17-25	PCC_GR	1	10	18670	3.8	2.8	15.8
17-25	SLR_SL	.	2	4552	.	.	.
17-25	OTHER	.	1	390	.	.	.
26-54	PATCH	.	5	2460	.	.	.
26-54	DNG_AC	841	3744	3505099	8.4	12.2	0.2
26-54	OPG_AC	276	681	1997480	15.0	7.0	0.6
26-54	CHP_SL	16	235	70922	2.6	11.4	2.8
26-54	PCC	390	3027	6320643	4.8	3.2	0.0
26-54	PCC_GR	387	1423	4761079	10.0	4.2	0.2
26-54	EPOXY	1	16	24977	2.4	2.0	7.4
26-54	SLR_SL	1	46	82199	0.8	0.6	0.8
26-54	OTHER	.	3	2658	.	.	.

The indexed rates for open graded asphalt concrete, OGAC, and grooved portland cement concrete, PCC-GR, appear very high for the low range of skid numbers. However, this may be reasonable. Based on previous studies, it is highly probably that OGAC surfaces that have skid numbers this low are contaminated. One example is clay tracked and compacted into the surface voids. This would create an unsatisfactory surfacing that could easily establish a high accident rate until the clay is washed away.

Since pavement grooving is justified by a high rate of wet pavement accidents, one accident per year at these locations is probably a very low rate.

C.7. Effect of Lanes In The Direction Of Travel

SN_RANGE	LANES	FRQ_ACC	FRQ_INV	TWET_ADT	AC_RATE1	AC_RATE2	AC_RATE3
17-25	1	16	70	22450	8.8	30.0	45.4
17-25	2	71	151	185082	18.0	16.2	11.4
17-25	3	26	46	99932	21.6	11.0	25.2
17-25	4	5	44	44260	4.4	4.8	11.4
17-25	5	.	1	4340	.	.	.
17-25	6	.	.	.	.	.	.
17-25	7	.	.	.	.	.	.
26-54	1	212	2056	554491	4.0	16.2	0.8
26-54	2	718	2720	3101003	10.0	9.8	0.4
26-54	3	378	1785	4709511	8.0	3.4	0.2
26-54	4	489	2002	6429288	9.4	3.2	0.2
26-54	5	95	535	1717884	6.8	2.4	0.4
26-54	6	20	81	250900	9.4	3.4	4.4
26-54	7	.	1	4440	.	.	.

Highways with only one lane in the direction of travel show high indexed rates. Normal vehicle maneuvers for these roadways, i.e. passing, stopping, or turning, place high friction demands much more frequently than for multilane roads. It is likely that the high indexed rate for six lanes in the high SN range also developed from more frequent and higher friction demands, because six-lane per direction roads exist only in weaving and merging situations justified by very high traffic densities.

C.8. Average Daily Traffic Effect For Undivided Medians

SN RANGE	ADT	FRQ ACC	FRQ INV	TWET ADT	AC RATE1	AC RATE2	AC RATE3
17-25	2500	2	38	4443	0.4	2.8	0.8
17-25	7500	5	17	5532	2.6	5.6	3.4
17-25	12500	10	19	12144	4.6	5.2	2.8
17-25	17500	10	9	4827	9.6	13.0	14.4
17-25	22500	10	7	3401	12.4	18.4	26.2
17-25	27500	7	8	7172	7.6	6.2	7.6
17-25	32500	6	5	5798	10.4	6.4	13.0
17-25	37500	8	8	9511	8.6	5.2	6.6
17-25	42500	2	2	4126	8.6	3.0	15.2
26-54	2500	37	1160	123232	0.2	1.8	0.0
26-54	7500	68	621	243800	1.0	1.8	0.0
26-54	12500	64	312	156803	1.8	2.6	0.0
26-54	17500	59	117	81827	4.4	4.6	0.4
26-54	22500	15	31	22476	4.2	4.2	1.4
26-54	27500	23	20	17962	10.0	8.0	4.0
26-54	32500	51	63	44829	7.0	7.2	1.2
26-54	37500	8	26	33615	2.6	1.4	0.6
26-54	42500	4	8	10533	4.4	2.4	3.0

The above table gives the indexed values for the three types of accident rates, when the data are grouped according to ADT for undivided medians. Note that the "breakpoint" for such ADT occurs at about 17,500, and then continues to about 42,500. Beyond this point there are few two-lane roadway sections with a greater ADT. This breakpoint probably represents one of the driving conditions for a roadway section to reach its potential for wet pavement accidents involving low skid numbers.

D. Comments And Summary

Using AC_RATE 3 for the criterion, the following information is summarized from the preceding tables and from Figure 12.

1) When all geometric classification records are combined, the accident rate is nearly constant for skid numbers greater than 26, but increases substantially as the skid number decreases below 25.

2) Curves show the highest rate of accidents followed by weaving tangents and intersections. As one would expect, these rates are substantially higher for locations having skid numbers in the low range.

3) The following roadway parameters show substantially higher rates than their counterparts:

-- Undivided over divided;

-- 3 % Grades over level;

-- One-way roadways over conventional, expressway and freeway;

-- Two-lane roads over multilane roads.

4) There is little difference in accident rates between rural and urban roads.

It is estimated that between 600 and 1100 miles (1.2 and 2.4 percent) of the state highway system would be affected by the implementation of the recommendations in this report. This estimate is subjective for the following reasons:

1) It is based upon the proportional representation of the prioritized roadway parameters in the SRI file, which incorporate function requirements into the sample selection at the expense of randomization.

2) The length of bridge decks, curves and tangent sections are variable.

3) It was assumed that 80 percent of the locations having skid numbers less than 26 are in the outside

lanes. This is probably within 5 percent of actual conditions.

The cost of increasing the skid resistance of all locations having values less than 26 is estimated to be between $4 million and $9 million. The cost of implementing the recommendations in this report will be less because other safety programs will justify improvements at some of these locations. It is predicted that the net result will be that the benefits will exceed the costs.

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APPENDICES

Appendix I contains the definitions of acronyms, terms, functions, operators, and variables.

Appendix II contains the descriptions of the data files related to this study. Section A contains the data from the INVENTORY files. Section B contains the data from the ACCIDENT files. Section C contains a description of how the files were developed.

Appendix III contains a listing of the source program, which was used to perform the statistical analysis.

APPENDIX I. DEFINITIONS.

A. Acronyms

ASTM = American Society for Testing and Materials.

B-C-I-W = Bridges, Curves, Intersections, and/or Weave sections. A nontangential roadway section (or any type of roadway section -- except a tangent section).

CALTRANS = California Department Of Transportation.

CHP = California Highway Patrol.

OTSPR = Office Of Traffic Safety Program And Research, Traffic Safety Program Branch.

OTL = Office of Transportation Laboratory, Pavement Branch.

SAS = Statistical Analysis System. The computer software which was used to perform the analysis of this study.

SRI = Skid Resistance Inventory. A highway inventory file, which is statistically semipure, and which is primarily referenced for skid number information. OTL is primarily responsible for this file.

TASAS = Traffic Accident Surveillance and Analysis System. The database which contains the information in regard to accidents on the highways in the State of California. OTSPR is primarily responsible for this system.

TRIS = Transportation Research Information Service. The software which selectively extracts and prints information from a database containing abstracts of articles related to the field of transportation.

TSAR = TASAS Selective Accident Retrieval system. The software which selectively extracts and prints information from the TASAS database.

B. Terminology

Skid number.

The ASTM manual (21) gives the following definition for "skid number".

> "The test apparatus consists of an automotive vehicle with one or more test wheels incorporated into it or forming part of a suitable trailer towed by a vehicle. The apparatus contains a transducer, instrumentation, a water supply and proper dispensing system, and actuation controls for the brake of the test wheel. The test wheel is equipped with a standard pavement test tire."
>
> "The test apparatus is brought to the desired test speed. Water is delivered ahead of the test tire and the braking system is actuated to lock the test tire. The resulting friction force acting between the test tire and the pavement surface (or some other quantity that is directly related to this force) and the speed of the test vehicle are recorded with the aid of suitable instrumentation."
>
> "The skid resistance of the paved surface is determined from the resulting force or torque record and reported as skid number (SN), which is determined from the force required to slide the locked test tire at a stated speed divided by the effective wheel load and multiplied by 100."

For this study, the "desired test speed", or the standardized test speed, was 40 mph.

C. Functions And Operators

Lower cased letters followed by a colon are used to distinguish a function or an operator from a subscripted variable.

exp:

The base value, 2.7182818, raised to a power. For example,

exp:(1.0) = 2.7182818 , and
exp:(2.0) = 7.3890561 .

log:

The natural logarithm of a number. If the number were to be transgenerated in terms of an exponent and a base, and if the base were to have a value of 2.7182818, then the natural logarithm would be the exponent. For example,

log:(2.7182818) = 1.0 , and
log:(7.3890561) = 2.0 .

sum:

A symbolic operator, which means, "The sum of all the subscripted values of a variable," such as,

sum:(A) = A(1) + A(2) + A(3) + ... + A(I-1) + A(I).

When the need for specific values of a subscript arises, (which would be very seldom), the subscript of the variable should be shown in the major equation, and then the values of the subscript should follow the major equation and be specified on a separate line, such as,

TOTAL = sum:(A(i)*B(i,j)) ,
for all i,
and j = 3, 14, 27, and 55.

D. Variables Used In Edited And Condensed Version Of SAS Program

D.1. Input Variables Used In SRI And ACCIDENT Files

ACC_CNTL = Access Control for the ROUTE.

- CONV = Conventional Highway.
- EXPWY = Expressway.
- FRWY = Freeway.
- ONEWY = One-way City Street.

ADT = Average Daily Traffic in both directions. (Note: The 30th highest annual hourly volume is equal to about 10 to 13 percent of the ADT.)

CLASS = Classification (or type of alignment) for roadway section. Except for curves, the values for this variable are obtained by a visual examination from the test vehicle.

For the purpose of the Statewide Skid Resistance Inventory, "Curves" are defined as any change in direction that will provide a lateral acceleration greater than 0.12G, when traveling at the advised speed. (Only the ACCIDENT file further classifies curves as turning either to the inside (left) or to the outside (right).)

- BC = Bridge on a Curve.
- BT = Bridge on a Tangent section.
- C = Curve.
- I = Intersection on a Tangent section.
- IC = Intersection on a Curve.
- T = Tangent section.
- WC = Weave section on a Curve.
- WT = Weave section on a Tangent section.

COUNTY = County. A listing of the abbreviations follow.

District 03	Wet Time Percent	Wet Acc. Percent	Ratio
BUT = Butte	5	18	3.6
COL = Colusa	3	14	4.7
ED = El Dorado	6	12	2.0
GLE = Glenn	4	12	3.0
NEV = Nevada	8	15	1.9
PLA = Placer	6	13	2.2
SAC = Sacramento	4	17	4.3
SIE = Sierra	7	7	1.0
SOL = Solano	4	19	4.8
SUT = Sutter	4	19	4.8
YOL = Yolo	4	13	3.3
YUB = Yuba	6	18	3.0
District 04			
ALA = Alameda	4	17	4.3
CC = Contra Costa	4	16	4.0
MRN = Marin	6	24	4.0
NAP = Napa	5	19	3.8
SCL = Santa Clara	4	14	3.5
SCR = Santa Cruz	6	18	3.0
SF = San Francisco	5	20	4.0
SM = San Mateo	5	22	4.5
SON = Sonoma	7	20	2.9
District 07			
LA = Los Angeles	2	13	6.5
ORA = Orange	2	10	5.0
VEN = Ventura	3	9	3.0

Table 11. Wet Time Percent, Wet Accident Percent, And Ratio: By County

The term, "Wet Time Percent", means the wet time expressed as a percentage of total time. It is based on an 11-year weather record (1957 - 1967), and is used to determine the variable, PCT_WET.

The term, "Wet Acc. Percent", means the wet pavement accidents expressed as a percentage of all accidents. It is based on a 5-year period (1965 - 1969).

The term, "Ratio", means the ratio of the "Wet Acc. Percent" to the "Wet Time Percent".

DIST_SN = Distance from the location of the accident to the location of the skid number in the inventory file. From the perspective of a forward moving vehicle, the distance is positive if the skid number is located towards the rear of the accident; and the distance is negative if the skid number is located towards the front of the accident. (This variable is associated only with the ACCIDENT file.)

DISTRICT = District.

DV_UNDV = Divided or Undivided median.

DV = Divided.

UNDV = Undivided.

GRADE = Approximate slope of pavement in three increments. The values for this variable are obtained by a visual examination from the test vehicle. (This variable is associated only with the SRI file.)

= means flat, or less than + or - 3 percent.

+ means steeper than +3 percent.

- means steeper than -3 percent.

LANES = Lanes in one direction.

The lane closest to the median is called the inside or Number 1 lane. The lane furthest from the median is called the outside lane. The lane(s) between the inside lane and the outside lane is referred to as the middle lane(s).

N_S_E_W = North, South, East, or West direction.

PREFIX = Prefix associated with post mile.

PST_MILE = Post Mile. Identifies a unique location on the roadway.

ROUTE = Route.

RRL_URB = Rural or Urban area location for route.
RRL = Rural.
URB = Urban.

SN = The skid number adjusted for test speed. It is the skid number which would have been obtained if the test vehicle had been traveling at a speed of 40 mph. Also, sometimes referred to as the "adjusted skid number", or "SN Sub-40", or "SN_40", or "SN(40)", or "the skid number". These are all shorter forms of the term, which is written, "skid number subscripted 40".

SN_I = Skid number unadjusted for test speed. Also, sometimes referred to as the "Initial Skid number", or "SN Sub-I". (This variable is associated only with the SRI file.)

SPD = Speed that is posted. Rounded off in increments of 5 mph (such as, 20, 25, 30, ..., 50, 55).

SURFACE = Surface type, such as concrete or asphalt.
PATCH = Patch.
DNG_AC = Dense Graded Asphalt Concrete (Usually referred to as "DGAC")
OPG_AG = Open Graded Asphalt Concrete. (Usually referred to as "OGAC")
CHP_SL = Chip Seal.
PCC = Portland Cement Concrete.
PCC_GR = Portland Cement Concrete - Grooved.
EPOXY = Epoxy.
SLR_SL = Slurry Seal.

TEMPRTR = Temperature in Fahrenheit degrees recorded at the time when the test for the skid number was made. (This variable is associated only with the SRI file.)

TERRAIN = Terrain. The values for this variable are obtained from a visual examination of the photolog. (This variable is associated only with the ACCIDENT file. It is similar to the variable, GRADE, in the SRI file, except that the variable, GRADE, is obtained from a field observation rather than from a photolog.)

F = Flat (less than + or - 3 % grade).
MU = Mountainous Up (steeper than + 3 % grade).
MD = Mountainous Down (steeper than - 3 % grade).
RU = Rolling Up (steeper than + 3 % grade).
RD = Rolling Down (steeper than - 3 % grade).

TST_SPD = Test Speed, or speed recorded at the time of the test for skid number. Rounded off in increments of 5 mph (such as, 20, 25, 30, ..., 50, 55). (This variable is associated only with the SRI file.)

WEATHER = Weather recorded at the time of the test for skid number. These values are determined by personal judgment and visual examination. (This variable is associated only with the SRI file.)

CLEAR = Clear.
CLOUDY = Cloudy.
RAINY = Rainy.
WINDY = Windy.

D.2. Transgenerated Variables Used In SRI And ACCIDENT Files

ADT = ADT rounded off in increments of 5000 (such as, 2500, 7500, 12500, ..., 37500, 42500).

LANE_ADT = Lane ADT, or LANE_ADT = 0.5 * ADT / LANES.

PCT_WET = Percent of time that pavement is wet. (Transgenerated from a table of correspondences between the County and the percent of time that the County is wet. Refer to COUNTY variable.)

SN_RANGE = A range of skid numbers, generally used only for two groups of low and high values (such as, 17-25 and 26-54).

WET_ADT = The wetted ADT. Or, WET_ADT = 0.01 * PCT_WET * ADT .

D.3. Output Variables

AC_RATE1 = Accident rate of the first kind, or

AC_RATE1 = FRQ_ACC / FRQ_INV .

AC_RATE2 = Accident rate of the second kind, or

AC_RATE2 = FRQ_ACC / TWET_ADT .

AC_RATE3 = Accident rate of the third kind, or

AC_RATE3 = FRQ_ACC / (TWET_ADT*FRQ_INV) .

FRQ_ACC = The frequency of an implied category (or of a combination of implied categories) in an ACCIDENT file. (A category is explicit when the variable, FRQ_ACC, is subscripted.) For example, suppose there were two categories, such as CLASS and SN. Suppose further that the value for CLASS was "curves"; that the value for SN was "25"; and that there were 100 curves with a skid number of 25. Then FRQ_ACC could be explicitly expressed as follows,

FRQ_ACC(CLASS,SN) = FRQ_ACC(curves,25) = 100 .

FRQ_INV = The frequency of an implied category (or of a combination of implied categories) in an INVENTORY file. (A category is explicit when the variable, FRQ_INV, is subscripted.) For example, suppose there were two categories, such as CLASS and SN. Suppose further that the value for CLASS was "curves"; that the value for SN was "25"; and that there were 100 curves with a skid number of 25. Then FRQ_INV could be explicitly expressed as follows,

FRQ_INV(CLASS,SN) = FRQ_INV(curves,25) = 100 .

FREQ = The frequency of an implied category (or of a combination of implied categories) in a SUMMARY file. (A category is explicit when the variable, _FREQ_, is subscripted.) For example, suppose there were two categories, such as CLASS and SN. Suppose further that the value for CLASS was "curves"; that the value for SN was "25"; and that there were 100 curves with a skid number of 25. Then _FREQ_ could be explicitly expressed as follows,

FREQ(CLASS,SN) = _FREQ_(curves,25) = 100 .

TWET_ADT = The total sum of the wetted ADT's, or

TWET_ADT = sum:(WET_ADT) .

TYPE = Type of summary for a given number of variables. Example: Assume that the summary includes three variables: C, B, and A. Variables are assigned values in the order of 4, 2, 1. Therefore, assign C the value of 4, assign B the the value of 2, and assign A the value of 1.

TYPE = 0, would mean that all variables are grouped together in the summary.

TYPE = 1, would mean that only variable A is being varied.

TYPE = 2, would mean that only variable B is being varied.

TYPE = 3, would mean that variable A is being varied under the varying influence of variable B.

TYPE = 4, would mean that only variable C is being varied.

TYPE = 5, would mean that variable A is being varied under the varying influence of variable C.

TYPE = 6, would mean that variable B is being varied under the varying influence of variable C.

TYPE = 7, would mean that variable A is being varied under the varying influence of both variables B and C, while variable B is being varied under the varying influence of variable C.

APPENDIX II. FILES

Data from the SRI file and the ACCIDENT file are presented in this section. The primary function of the SRI file has been to serve as a database and to identify areas that have low skid numbers for further investigation.

A. INVENTORY Files

A.1. Inventory Data

For this study the data in the SRI files are limited the outside lanes. The study period was from 6/80 thru 6/81 for Districts 03 and 04. However, for District 07, the study period was from 6/81 thru 6/82, because of the manner in which the skid testing was scheduled during the period from 6/80 thru 6/82. Generally, it takes about four years to test the entire state, with many locations reported every year or every other year.

The SRI file for District 03 originally had 3123 records of which 3116 records were found to be acceptable. District 04 had 2335 records of which 2332 records were found to be acceptable. District 07 had 4045 records of which 4044 records were found to be acceptable. This combines for a total of 9492 acceptable records. The major cause for rejection (8 out of the 11) concerned the unorthodox geometrical classification, "WTM", which involves (W)eave sections on (T)angents next to (M)edians.

The skid numbers appear to be normally distributed with a mean equal to 37.1 and a standard deviation of 6.6. This means that about 68 percent of the skid numbers are between 30.5 and 43.7. The distribution has a skew equal to 0.150224 (which means that it is slightly skewed to the right), and has a kurtosis equal to -0.0036234. (Refer to the column labeled, "FRQ_INV", in Table 1 of the discussion. Refer, also, to Figure 17 in this APPENDIX.)

The SRI file contained 2209 tangent sections and 7283 B-C-I-W sections. Of the 7283 B-C-I-W sections, 442 were curves, 897 were bridges, 2232 were intersections, and 3712 weave-sections.

The data from the SRI files for the three districts is summarized as follows.

About 72 percent of the grades in the SRI file are less than three percent; about 14 percent of the grades go up; and about 14 percent of the grades go down. Intersections are the least likely to be built on a grade, and curves are the most likely. For example, about 22.0 percent of the intersections have grades which were steeper than or equal to + or - 3 percent. About 24.1 percent of the bridges, about 25.8 percent of the weave sections, about 33.4 percent of the tangent sections, and about 58.4 percent of the curves have such steep grades. This would suggest that the accident rates on curves might be considerably affected by the their grades, because grades, themselves, demonstrated high rates for wet pavement accidents.

Approximately 22.4 percent of these highways have only one lane in each direction, 30.2 percent have 2 lanes, 19.3 percent have 3 lanes, 21.6 percent have 4 lanes, 5.6 percent have 5 lanes, and 0.7 percent have 6 lanes.

Approximately 59.1 percent of the highways are freeways, 36.4 percent are of the conventional type, and 4.1 percent are expressways. Only 0.4 percent are one-way streets.

Approximately 73.9 percent of these highways have divided medians, and 26.1 percent have undivided medians.

Approximately 36.3 percent of these highways are located in rural areas, and 63.7 percent are located in urban areas.

About 77 percent of the posted speed limits for these highways are 55 mph, 3 percent are 50 mph, 5 percent are 45 and 40 mph, 7 percent are 35 mph, one percent are 30 mph, and 2 percent are 25 mph. There are hardly any posted speed limits of 20 and 15 mph. Thus, because of such a "lopsided" amount of 55 mph posted speed limits, it would be difficult to conduct any sort of statistical analysis of accident rates involving posted speed limits.

About 41 percent of these highways are surfaced with dense graded asphalt concrete (DGAC), 33 percent with PCC, 15 percent with PCC-grooved, 7 percent with open graded asphalt concrete (OGAC), 3 percent with chip seal, one percent with slurry seal, and a few pavements have patch, epoxy, or "other" types of surfaces.

With the exception of chip seals, all pavements tended to have an average skid number of about 37. Following is table which summarizes these average values for the skid numbers of the various types of roadway surfaces in the SRI file.

SURFACE	AVERAGE SKID-NUMBER	NUMBER OF SAMPLES
DNG_AC	37.9	3932
OPG_AC	36.9	704
PCC	35.9	3103
PCC_GR	36.5	1433
CHP_SL	43.9	243
SLR_SL	38.1	48
EPOXY	34.0	16
PATCH	33.9	7
OTHER	38.0	4

The relatively small sample size of the chip seal surfaces could be misleading. There is a tendency to test good chip seal pavements less frequently because their high skid resistance tends to cause relatively great wear of the test tire. Conversely poor chip seal pavements are tested more frequently to better delineate the possible problem area.

The present policy is to test for skid resistance at, or as near as possible to, the posted or advisable speeds.

However, there are occasions when extremely sharp curves, steep grades, and heavy traffic make it impossible to follow this policy.

About 41 percent of the tests were conducted at a speed of 55 mph, 20 percent at 50 mph, 11 percent at 45 mph, 8 percent at 40 mph, 8 percent at 35 mph, 5 percent at 30 mph, 5 percent at 25 mph, 2 percent at 20 mph, with less than 1/2 percent conducted at a speed of 15 mph.

Figures and Tables that show characteristics of the Skid Resistance Inventory (SRI) data are presented on the following pages.

A.2. Figures And Tables For Inventory Data

Fig. 13. Geometric Classification Percentages
(BC, BT, C, I, IC, T, WC, WT)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

PERCENTAGE BAR CHART

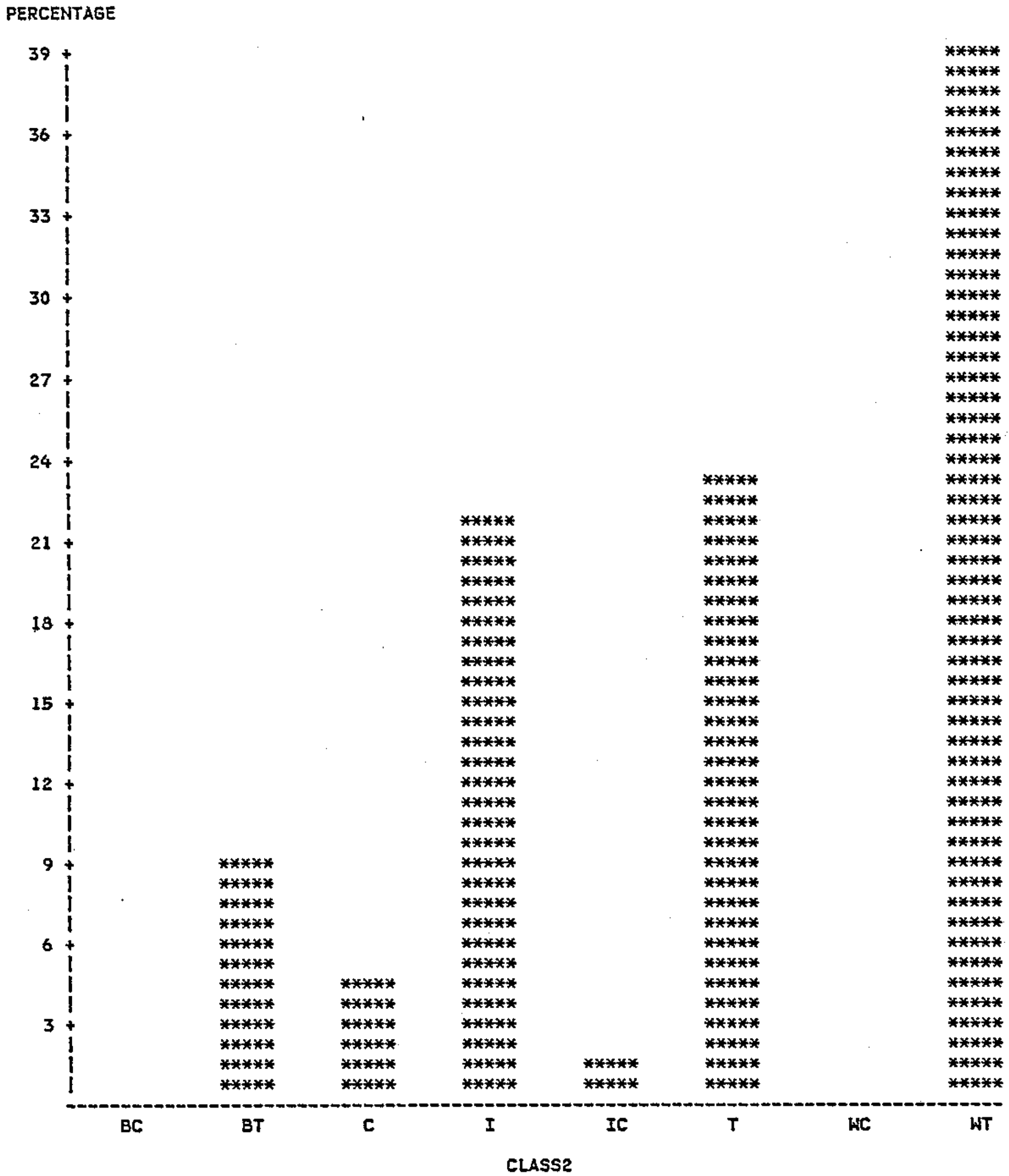

Fig. 14. Geometric Classification Percentages
(BT, C, I, T, WT)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

PERCENTAGE BAR CHART

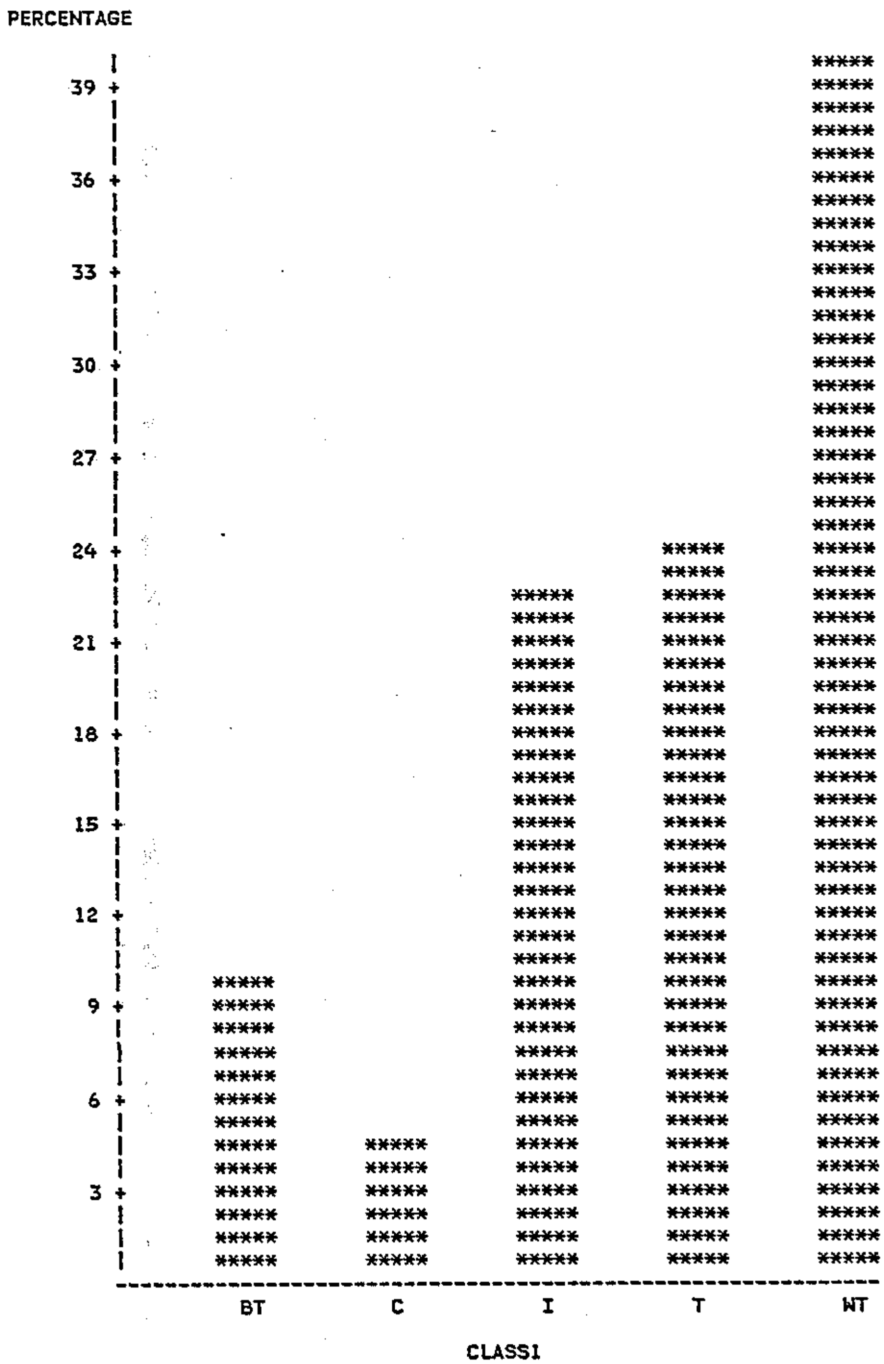

Fig. 15. GRADE Percentages
(+, -, =)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- INVENTORY FILE --------------

PERCENTAGE BAR CHART

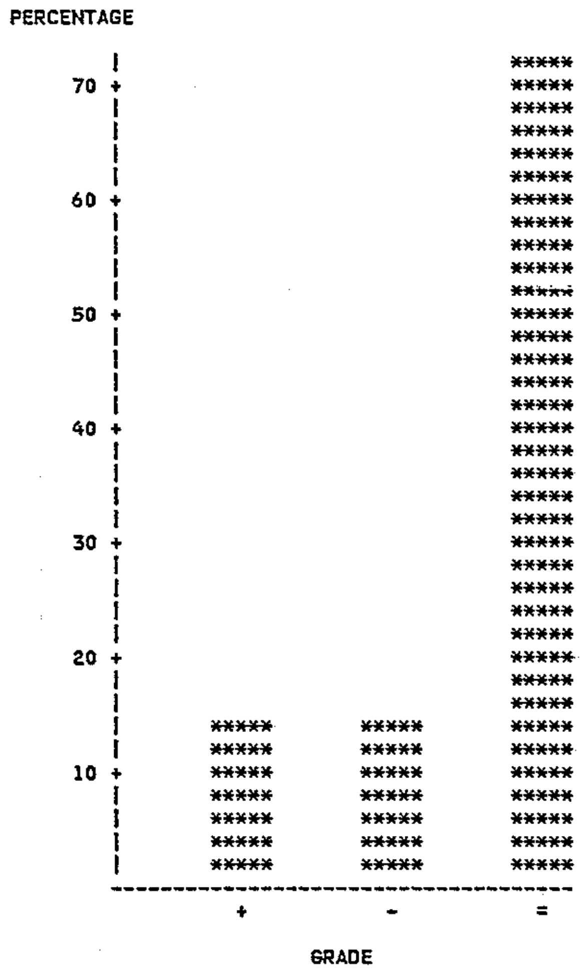

Fig. 16. GRADE Percentages By CLASS
(+, -, =)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

PERCENTAGE BAR CHART

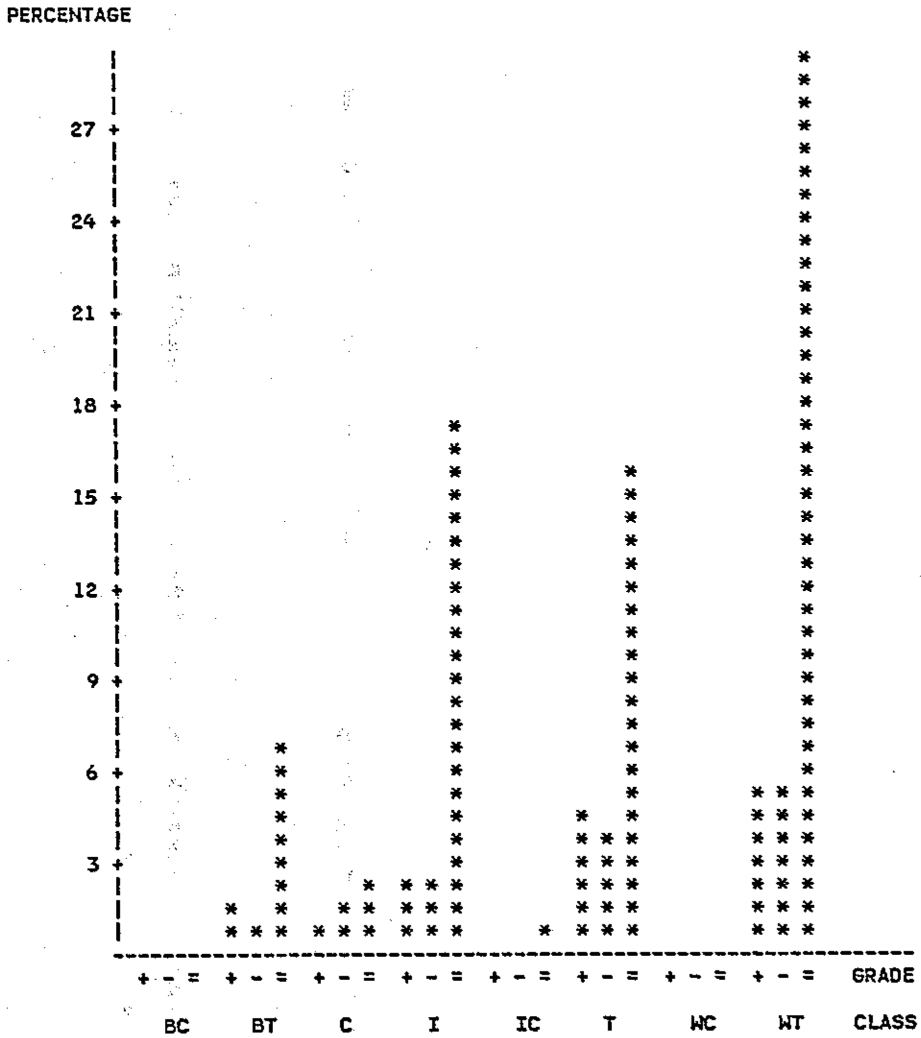

Fig. 17. Skid Number Percentages
Distribution Curve

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

PERCENTAGE BAR CHART

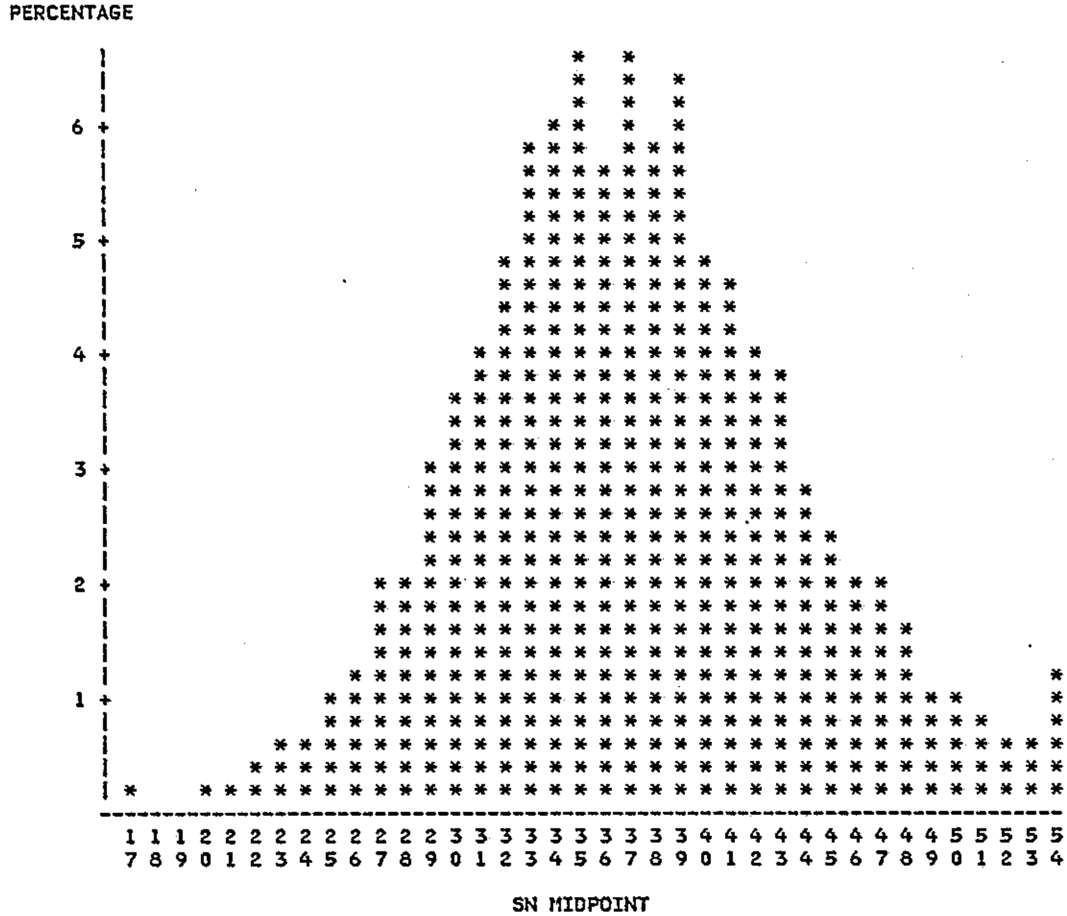

Fig. 18. WET_ADT vs Skid Number

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

BAR CHART OF MEANS

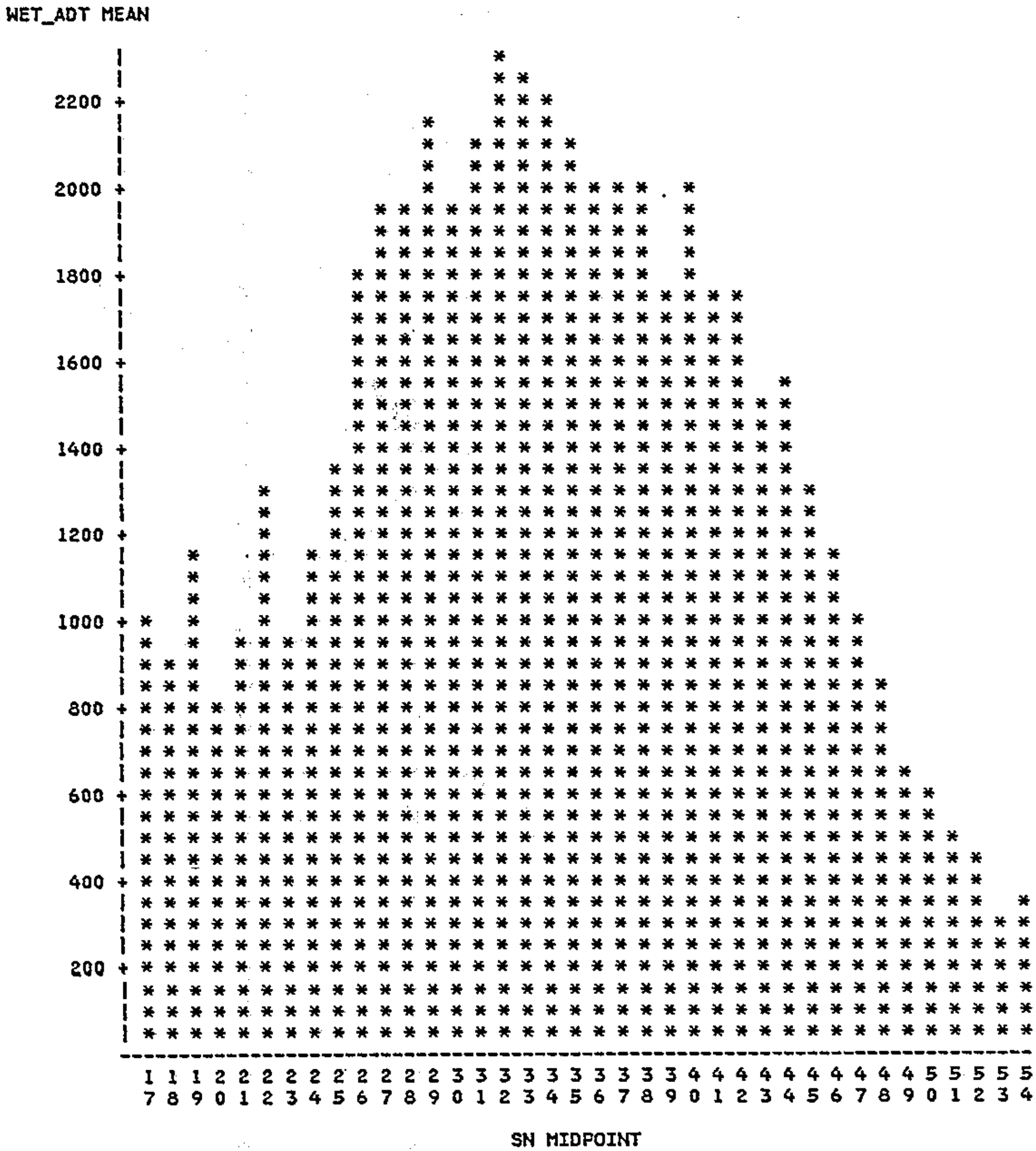

Fig. 19. ADT Percentages

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- INVENTORY FILE --------------

PERCENTAGE BAR CHART

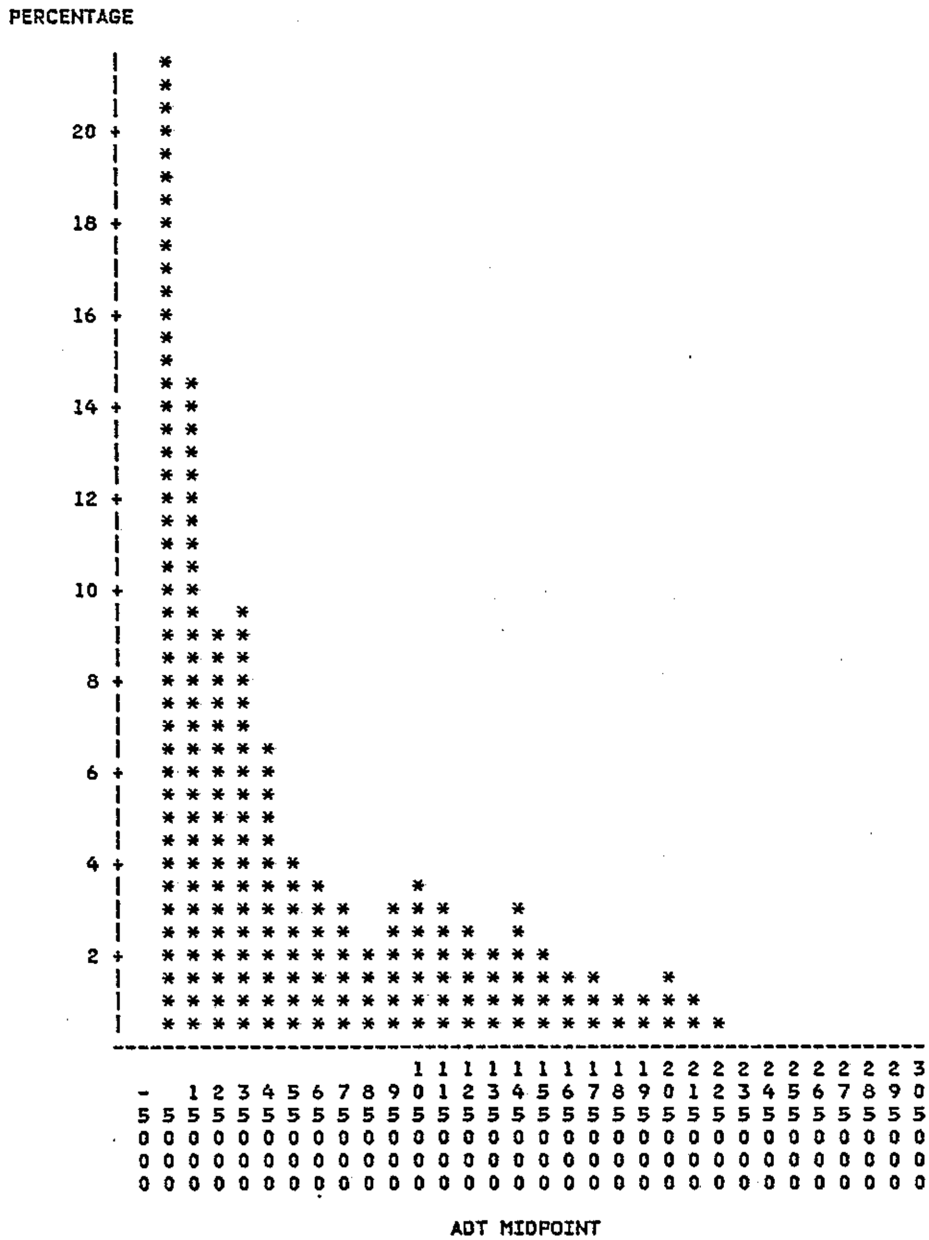

Fig. 20. WET_ADT Percentages

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- INVENTORY FILE --------------

PERCENTAGE BAR CHART

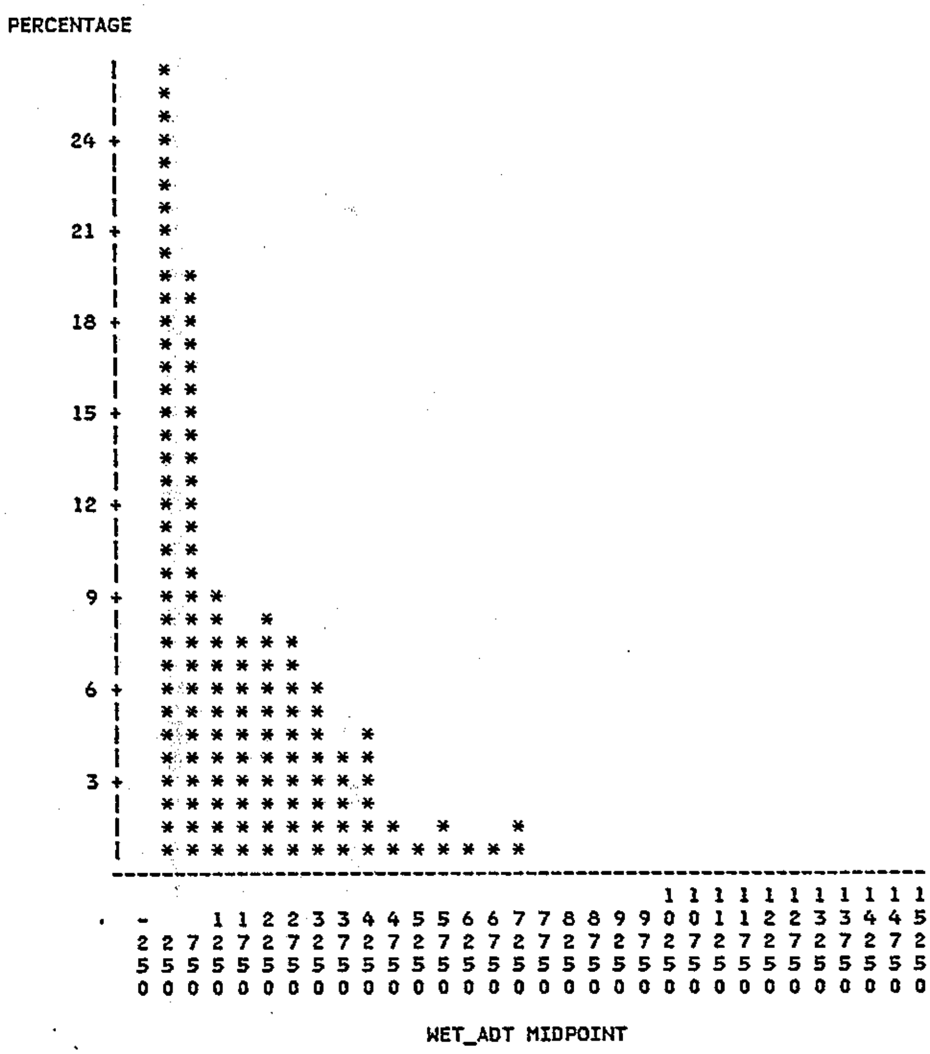

Fig. 21. LANE_ADT Percentages

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

PERCENTAGE BAR CHART

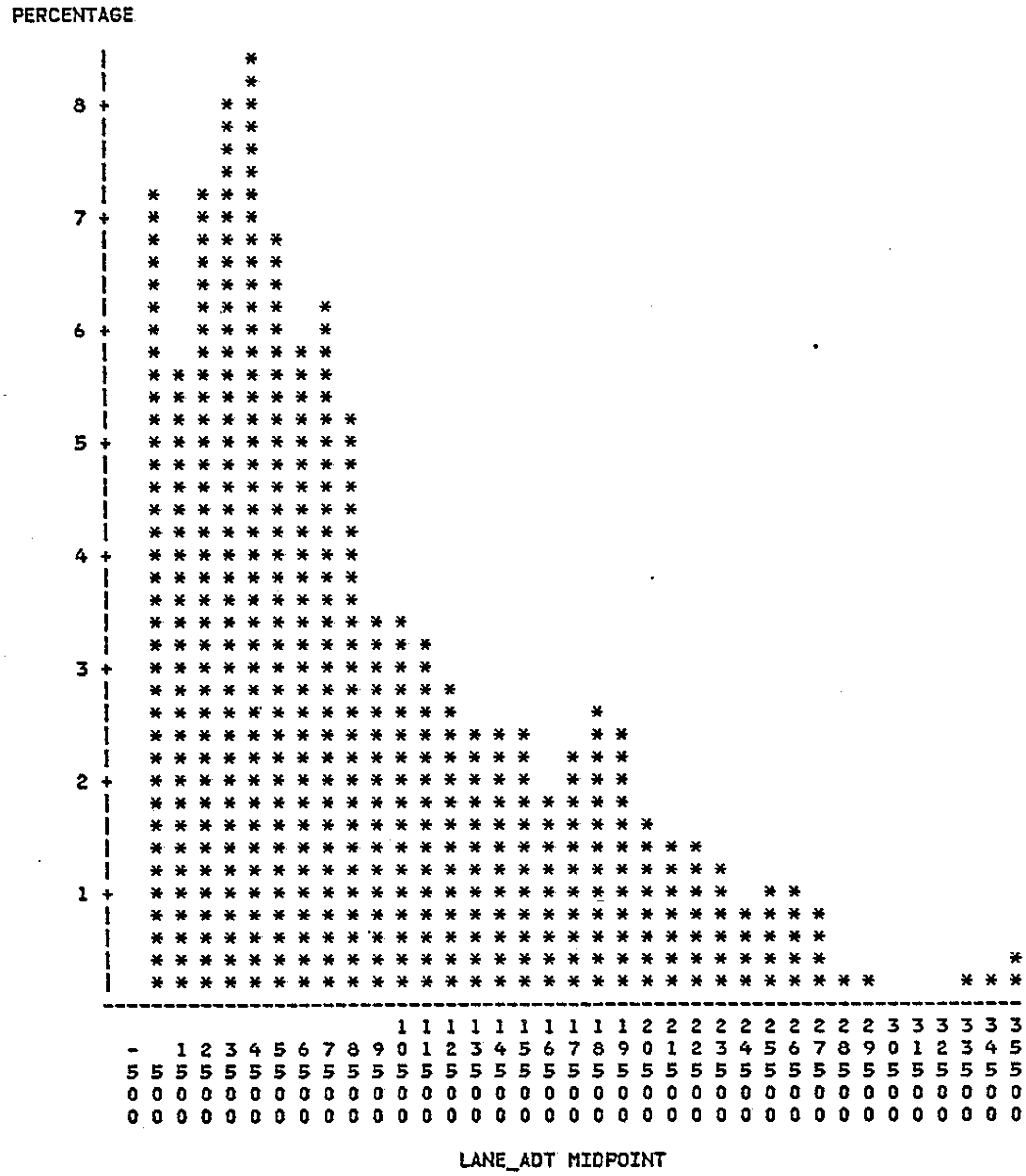

Fig. 22. SPD (Posted Speed) Percentages

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

PERCENTAGE BAR CHART

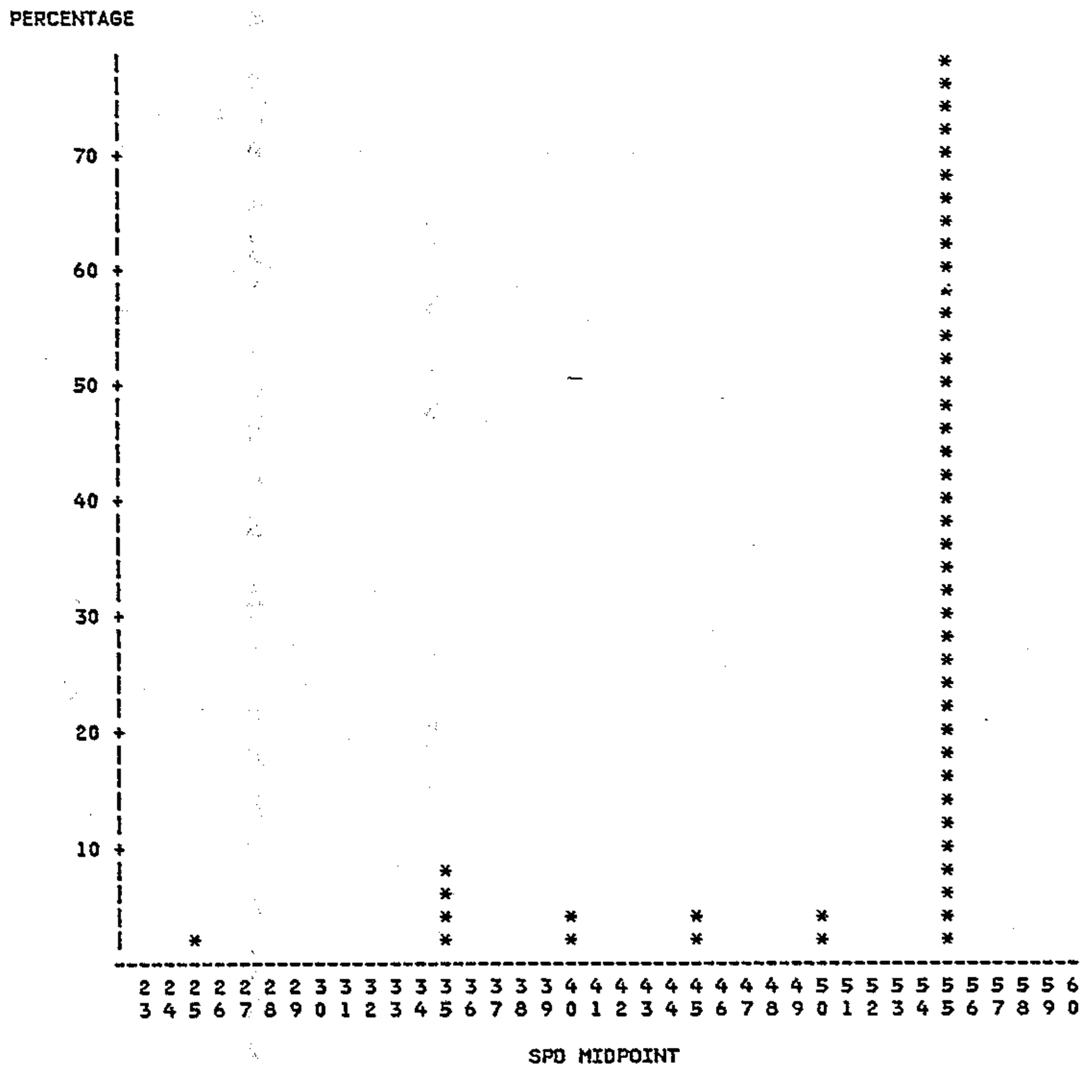

Fig. 23. Skid Number vs SPD (Posted Speed)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

BAR CHART OF MEANS

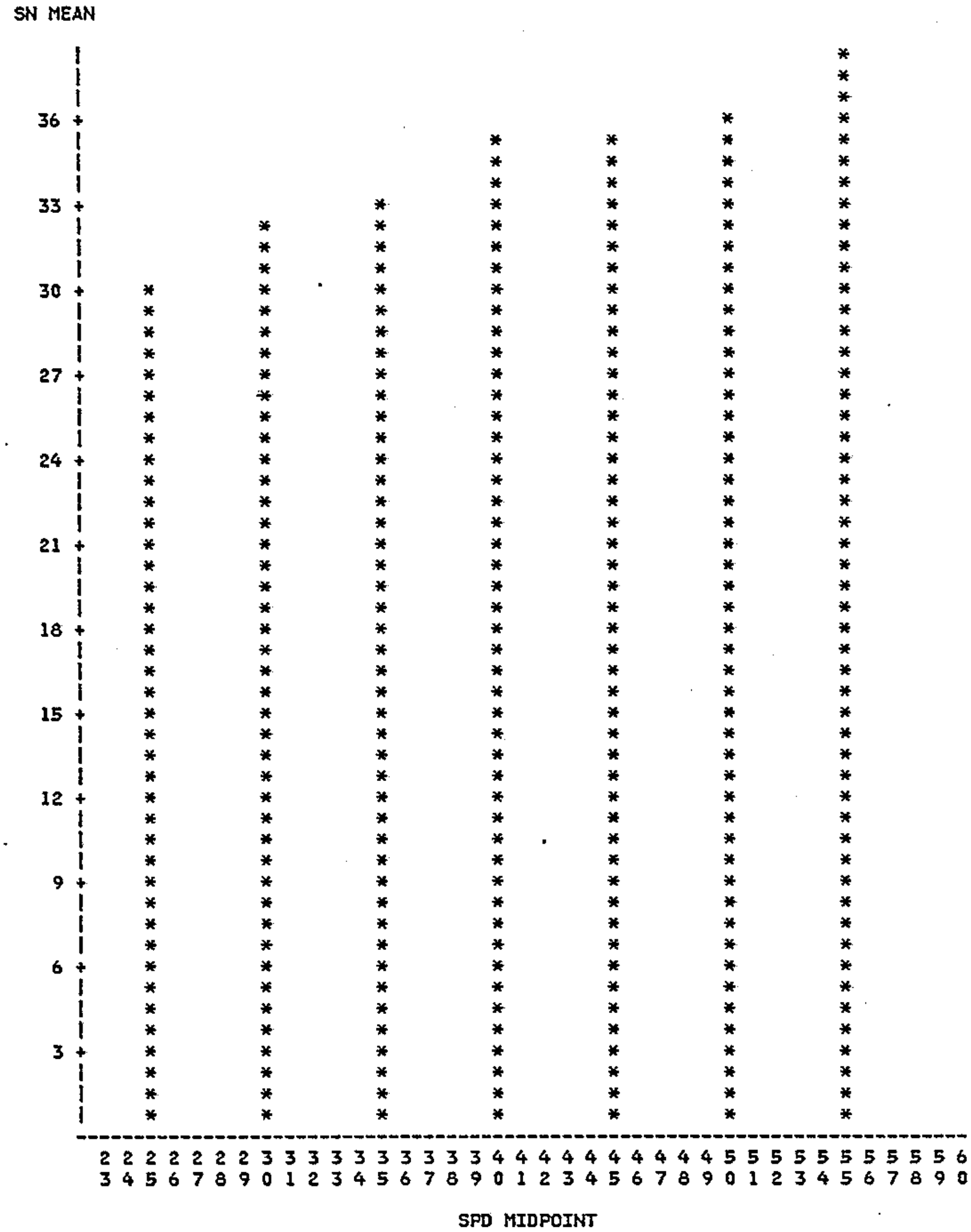

Fig. 24. SURFACE Percentages

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- INVENTORY FILE --------------

PERCENTAGE BAR CHART

```
PERCENTAGE

     |          *****
  40 +          *****
     |          *****
     |          *****
     |          *****
     |          *****
  35 +          *****
     |          *****
     |          *****                        *****
     |          *****                        *****
     |          *****                        *****
  30 +          *****                        *****
     |          *****                        *****
     |          *****                        *****
     |          *****                        *****
     |          *****                        *****
  25 +          *****                        *****
     |          *****                        *****
     |          *****                        *****
     |          *****                        *****
     |          *****                        *****
  20 +          *****                        *****
     |          *****                        *****
     |          *****                        *****
     |          *****                        *****
     |          *****                        *****
  15 +          *****                        *****    *****
     |          *****                        *****    *****
     |          *****                        *****    *****
     |          *****                        *****    *****
     |          *****                        *****    *****
  10 +          *****                        *****    *****
     |          *****                        *****    *****
     |          *****                        *****    *****
     |          *****    *****               *****    *****
     |          *****    *****               *****    *****
   5 +          *****    *****               *****    *****
     |          *****    *****               *****    *****
     |          *****    *****    *****      *****    *****
     |          *****    *****    *****      *****    *****
     |          *****    *****    *****      *****    *****             *****
      ------------------------------------------------------------------------------------
       PATCH    DNG_AC   OPG_AC   CHP_SL     PCC     PCC_GR   EPOXY    SLR_SL   OTHER

                                     SURFACE
```

Fig. 25. Skid Number vs SURFACE

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

BAR CHART OF MEANS

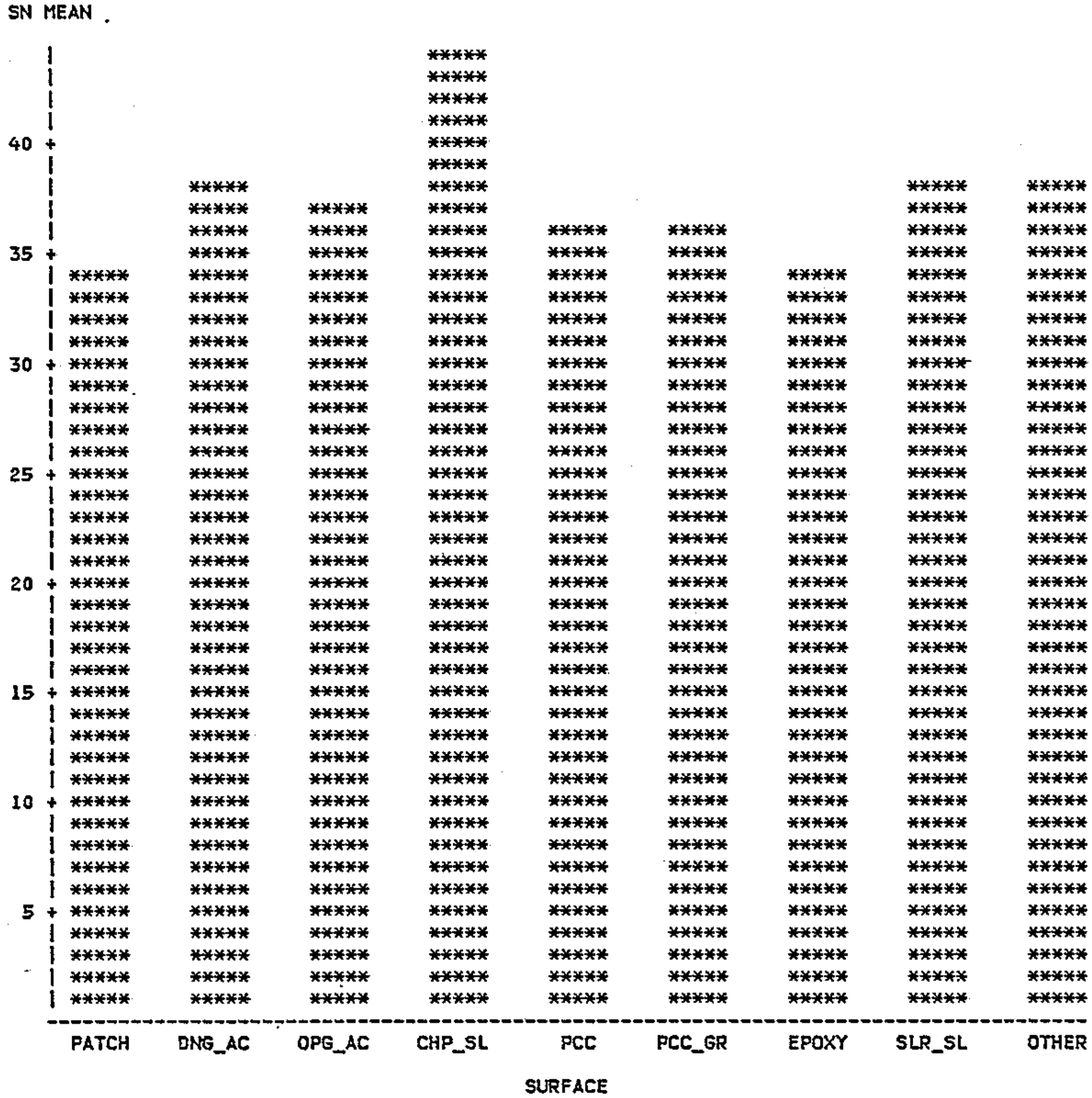

Fig. 26. TST_SPD (Test Speed) Percentages

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- INVENTORY FILE --------------

PERCENTAGE BAR CHART

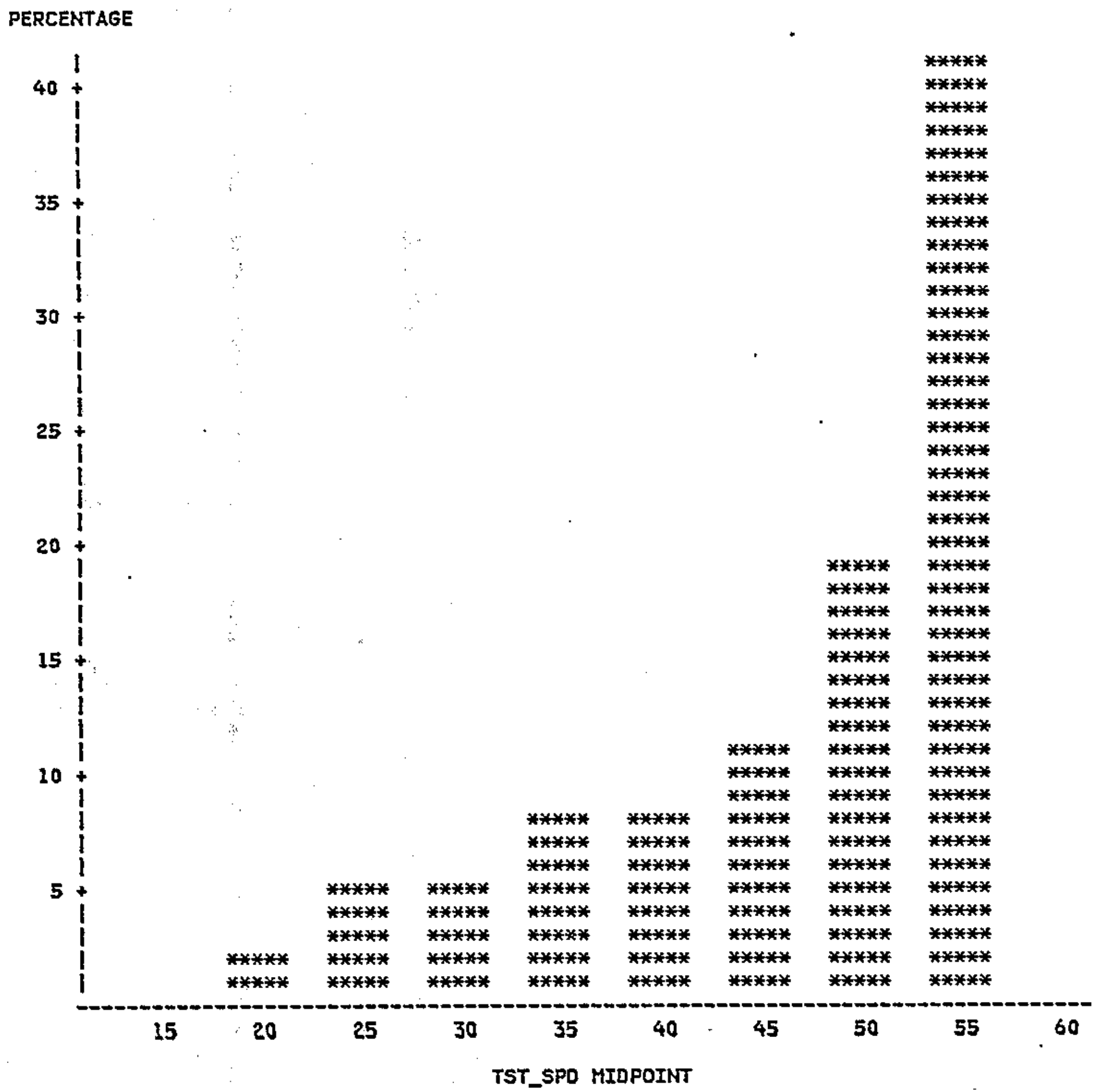

Table 12. Summary Of FRQ_INV, TWET_ADT
By CLASS, GRADE, DV_UNDV, SN_RANGE

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

TYPE	CLASS2	GRADE	DV_UNDV	SN_RANGE	_FREQ_	TWET_ADT
0					9492	17123581
1				17-25	312	356064
1				26-54	9180	16767518
2			DIV		7015	16325232
2			UN_DIV		2477	798350
3			DIV	17-25	199	299110
3			DIV	26-54	6816	16026122
3			UN_DIV	17-25	113	56954
3			UN_DIV	26-54	2364	741396
4		+			1298	2211738
4		-			1365	1946661
4		=			6829	12965182
5		+		17-25	30	24376
5		+		26-54	1268	2187362
5		-		17-25	44	39327
5		-		26-54	1321	1907334
5		=		17-25	238	292361
5		=		26-54	6591	12672822
6		+	DIV		925	2105079
6		+	UN_DIV		373	106659
6		-	DIV		818	1807328
6		-	UN_DIV		547	139333
6		=	DIV		5272	12412824
6		=	UN_DIV		1557	552358
7		+	DIV	17-25	21	17605
7		+	DIV	26-54	904	2087474
7		+	UN_DIV	17-25	9	6770
7		+	UN_DIV	26-54	364	99888
7		-	DIV	17-25	29	32858
7		-	DIV	26-54	789	1774470
7		-	UN_DIV	17-25	15	6469
7		-	UN_DIV	26-54	532	132863
7		=	DIV	17-25	149	248646
7		=	DIV	26-54	5123	12164178
7		=	UN_DIV	17-25	89	43714
7		=	UN_DIV	26-54	1468	508644
8	BC				8	19774
8	BT				889	2170382
8	C				442	123964
8	I				2098	1355344
8	IC				134	65163
8	T				2209	3276772
8	WC				9	15068
8	WT				3703	10097115
9	BC			26-54	8	19774
9	BT			17-25	11	18305
9	BT			26-54	878	2152077
9	C			17-25	13	6249
9	C			26-54	429	117715
9	I			17-25	160	154890
9	I			26-54	1938	1200454
9	IC			17-25	8	10945
9	IC			26-54	126	54218
9	T			17-25	70	59657
9	T			26-54	2139	3217115
9	WC			26-54	9	15068
9	WT			17-25	50	106018
9	WT			26-54	3653	9991097
10	BC		DIV		3	18980
10	BC		UN_DIV		5	794
10	BT		DIV		799	2138202

Table 12. Summary Of FRQ_INV, TWET_ADT
By CLASS, GRADE, DV_UNDV, SN_RANGE

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

TYPE	CLASS2	GRADE	DV_UNDV	SN_RANGE	_FREQ_	TWET_ADT
10	BT		UN_DIV		90	32180
10	C		DIV		31	38831
10	C		UN_DIV		411	85133
10	I		DIV		984	907722
10	I		UN_DIV		1114	447622
10	IC		DIV		34	39189
10	IC		UN_DIV		100	25975
10	T		DIV		1479	3081235
10	T		UN_DIV		730	195536
10	WC		DIV		8	14248
10	WC		UN_DIV		1	820
10	WT		DIV		3677	10086824
10	WT		UN_DIV		26	10291
11	BC		DIV	26-54	3	18980
11	BC		UN_DIV	26-54	5	794
11	BT		DIV	17-25	8	17186
11	BT		DIV	26-54	791	2121016
11	BT		UN_DIV	17-25	3	1119
11	BT		UN_DIV	26-54	87	31061
11	C		DIV	17-25	2	1960
11	C		DIV	26-54	29	36871
11	C		UN_DIV	17-25	11	4289
11	C		UN_DIV	26-54	400	80843
11	I		DIV	17-25	86	111530
11	I		DIV	26-54	898	796192
11	I		UN_DIV	17-25	74	43360
11	I		UN_DIV	26-54	1040	404262
11	IC		DIV	17-25	3	7772
11	IC		DIV	26-54	31	31416
11	IC		UN_DIV	17-25	5	3172
11	IC		UN_DIV	26-54	95	22802
11	T		DIV	17-25	50	54644
11	T		DIV	26-54	1429	3026591
11	T		UN_DIV	17-25	20	5013
11	T		UN_DIV	26-54	710	190523
11	WC		DIV	26-54	8	14248
11	WC		UN_DIV	26-54	1	820
11	WT		DIV	17-25	50	106018
11	WT		DIV	26-54	3627	9980806
11	WT		UN_DIV	26-54	26	10291
12	BC	-			2	5702
12	BC	=			6	14071
12	BT	+			119	329664
12	BT	-			95	215649
12	BT	=			675	1625069
12	C	+			82	22342
12	C	-			176	42290
12	C	=			184	59332
12	I	+			205	138978
12	I	-			239	139818
12	I	=			1654	1076547
12	IC	+			17	9582
12	IC	-			31	13019
12	IC	=			86	42563
12	T	+			392	511579
12	T	-			346	345127
12	T	=			1471	2420066
12	WC	-			1	1240
12	WC	=			8	13828
12	WT	+			483	1199594
12	WT	-			475	1183816

Table 12. Summary Of FRQ_INV, TWET_ADT
By CLASS, GRADE, DV_UNDV, SN_RANGE

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

TYPE	CLASS2	GRADE	DV_UNDV	SN_RANGE	_FREQ_	TWET_ADT
12	WT	=			2745	7713706
13	BC	-		26-54	2	5702
13	BC	=		26-54	6	14071
13	BT	+		26-54	119	329664
13	BT	-		17-25	2	2260
13	BT	-		26-54	93	213389
13	BT	=		17-25	9	16045
13	BT	=		26-54	666	1609024
13	C	+		17-25	2	761
13	C	+		26-54	80	21581
13	C	-		17-25	8	3441
13	C	-		26-54	168	38849
13	C	=		17-25	5	2047
13	C	=		26-54	181	57285
13	I	+		17-25	8	7021
13	I	+		26-54	197	131957
13	I	-		17-25	10	12190
13	I	-		26-54	229	127629
13	I	=		17-25	142	135678
13	I	=		26-54	1512	940869
13	IC	+		17-25	1	690
13	IC	+		26-54	16	8892
13	IC	-		17-25	1	668
13	IC	-		26-54	30	12351
13	IC	=		17-25	6	9587
13	IC	=		26-54	80	32976
13	T	+		17-25	12	8383
13	T	+		26-54	380	503195
13	T	-		17-25	11	8686
13	T	-		26-54	335	336441
13	T	=		17-25	47	42587
13	T	=		26-54	1424	2377479
13	WC	-		26-54	1	1240
13	WC	=		26-54	8	13828
13	WT	+		17-25	7	7520
13	WT	+		26-54	476	1192074
13	WT	-		17-25	12	12082
13	WT	-		26-54	463	1171734
13	WT	=		17-25	31	86416
13	WT	=		26-54	2714	7627290
14	BC	-	DIV		1	5680
14	BC	-	UN_DIV		1	22
14	BC	=	DIV		2	13300
14	BC	=	UN_DIV		4	771
14	BT	+	DIV		115	328240
14	BT	+	UN_DIV		4	1424
14	BT	-	DIV		88	214355
14	BT	-	UN_DIV		7	1294
14	BT	=	DIV		596	1595607
14	BT	=	UN_DIV		79	29462
14	C	+	DIV		5	6027
14	C	+	UN_DIV		77	16314
14	C	-	DIV		12	11167
14	C	-	UN_DIV		164	31123
14	C	=	DIV		14	21637
14	C	=	UN_DIV		170	37696
14	I	+	DIV		77	90421
14	I	+	UN_DIV		128	48557
14	I	-	DIV		70	79207
14	I	-	UN_DIV		169	60611
14	I	=	DIV		837	738094

Table 12. Summary Of FRQ_INV, TWET_ADT
By CLASS, GRADE, DV_UNDV, SN_RANGE

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

TYPE	CLASS2	GRADE	DV_UNDV	SN_RANGE	_FREQ_	TWET_ADT
14	I	=	UN_DIV		817	338453
14	IC	+	DIV		6	7427
14	IC	+	UN_DIV		11	2155
14	IC	-	DIV		8	8179
14	IC	-	UN_DIV		23	4840
14	IC	=	DIV		20	23583
14	IC	=	UN_DIV		66	18980
14	T	+	DIV		244	476317
14	T	+	UN_DIV		148	35261
14	T	-	DIV		169	306266
14	T	-	UN_DIV		177	38861
14	T	=	DIV		1066	2298652
14	T	=	UN_DIV		405	121414
14	WC	-	DIV		1	1240
14	WC	=	DIV		7	13008
14	WC	=	UN_DIV		1	820
14	WT	+	DIV		478	1196646
14	WT	+	UN_DIV		5	2947
14	WT	-	DIV		469	1181234
14	WT	-	UN_DIV		6	2581
14	WT	=	DIV		2730	7708943
14	WT	=	UN_DIV		15	4762
15	BC	-	DIV	26-54	1	5680
15	BC	-	UN_DIV	26-54	1	22
15	BC	=	DIV	26-54	2	13300
15	BC	=	UN_DIV	26-54	4	771
15	BT	+	DIV	26-54	115	328240
15	BT	+	UN_DIV	26-54	4	1424
15	BT	-	DIV	17-25	2	2260
15	BT	-	DIV	26-54	86	212095
15	BT	-	UN_DIV	26-54	7	1294
15	BT	=	DIV	17-25	6	14926
15	BT	=	DIV	26-54	590	1580681
15	BT	=	UN_DIV	17-25	3	1119
15	BT	=	UN_DIV	26-54	76	28343
15	C	+	DIV	26-54	5	6027
15	C	+	UN_DIV	17-25	2	761
15	C	+	UN_DIV	26-54	75	15553
15	C	-	DIV	26-54	12	11167
15	C	-	UN_DIV	17-25	8	3441
15	C	-	UN_DIV	26-54	156	27682
15	C	=	DIV	17-25	2	1960
15	C	=	DIV	26-54	12	19677
15	C	=	UN_DIV	17-25	1	87
15	C	=	UN_DIV	26-54	169	37609
15	I	+	DIV	17-25	3	2308
15	I	+	DIV	26-54	74	88113
15	I	+	UN_DIV	17-25	5	4713
15	I	+	UN_DIV	26-54	123	43844
15	I	-	DIV	17-25	5	9850
15	I	-	DIV	26-54	65	69357
15	I	-	UN_DIV	17-25	5	2340
15	I	-	UN_DIV	26-54	164	58272
15	I	=	DIV	17-25	78	99372
15	I	=	DIV	26-54	759	638723
15	I	=	UN_DIV	17-25	64	36307
15	I	=	UN_DIV	26-54	753	302146
15	IC	+	DIV	26-54	6	7427
15	IC	+	UN_DIV	17-25	1	690
15	IC	+	UN_DIV	26-54	10	1465
15	IC	-	DIV	26-54	8	8179

Table 12. Summary Of FRQ_INV, TWET_ADT
By CLASS, GRADE, DV_UNDV, SN_RANGE

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- INVENTORY FILE ---------------

TYPE	CLASS2	GRADE	DV_UNDV	SN_RANGE	_FREQ_	TWET_ADT
15	IC	-	UN_DIV	17-25	1	668
15	IC	-	UN_DIV	26-54	22	4172
15	IC	=	DIV	17-25	3	7772
15	IC	=	DIV	26-54	17	15810
15	IC	=	UN_DIV	17-25	3	1814
15	IC	=	UN_DIV	26-54	63	17165
15	T	+	DIV	17-25	11	7777
15	T	+	DIV	26-54	233	468540
15	T	+	UN_DIV	17-25	1	606
15	T	+	UN_DIV	26-54	147	34655
15	T	-	DIV	17-25	10	8666
15	T	-	DIV	26-54	159	297600
15	T	-	UN_DIV	17-25	1	20
15	T	-	UN_DIV	26-54	176	38840
15	T	=	DIV	17-25	29	38200
15	T	=	DIV	26-54	1037	2260451
15	T	=	UN_DIV	17-25	18	4387
15	T	=	UN_DIV	26-54	387	117027
15	WC	-	DIV	26-54	1	1240
15	WC	=	DIV	26-54	7	13008
15	WC	=	UN_DIV	26-54	1	820
15	WT	+	DIV	17-25	7	7520
15	WT	+	DIV	26-54	471	1189126
15	WT	+	UN_DIV	26-54	5	2947
15	WT	-	DIV	17-25	12	12082
15	WT	-	DIV	26-54	457	1169152
15	WT	-	UN_DIV	26-54	6	2581
15	WT	=	DIV	17-25	31	86416
15	WT	=	DIV	26-54	2699	7622527
15	WT	=	UN_DIV	26-54	15	4762

B. ACCIDENT Files

B.1. Accident Data

The original ACCIDENT files used in this study were obtained from the TASAS wet pavement accident report for the period between 06/80 and 06/81. Only accidents, which occurred in the outside lane and in Districts 03, 04, and 07, were used for this study.

The ACCIDENT file for District 03 had 436 records of which 279 were matched to skid numbers in the SRI file. District 04 had 1702 records of which 724 were matched to skid numbers in the SRI file. District 07 had 1290 records of which 1027 were matched to skid numbers in the SRI file. This combines for a grand total of 2030 usable records. The unmatched data resulted because the SRI testing did not include all of the accident locations during the specified time frame.

The skid numbers for the accident locations appear to be normally distributed with a mean equal to 34.7 and with a standard deviation equal to 5.8. This means that about 68 percent of the accidents occur on pavements that have a skid resistance between 28.9 and 40.5. The distribution has a skew equal to -0.11325 (which means that the skew is to the left), and has a kurtosis equal to 0.677289. (Refer to the column labeled, "FRQ_ACC", in Table 1. Refer, also, to the Figure 31.)

About 42 percent of the accidents occurred on tangent sections, and about 58 percent occurred on nontangential or B-C-I-W sections. As has been explained elsewhere in the text, the available data do not permit a direct comparison of the accident rates between tangent sections and any B-C-I-W section. However, the accident rate on tangent sections must be extremely low in comparison to the accident rate on any B-C-I-W section, because there would seem to be many more vehicle-miles associated with tangent sections than with any of the B-C-I-W sections.

About 13 percent of the accidents occurred on steep uphill grades, 17 percent on steep downhill grades, and 70 percent on relatively flat grades.

On steep grades, the highest proportion (54 percent) of accidents occurred on curves, 34 percent on bridges (although only about 24 percent of the bridges have steep grades), 33 percent on weave sections, 24 percent on tangent sections, and 18 percent on intersections.

About 45 percent of the accidents occurred on DGAC, 20 percent on nongrooved PCC, 19 percent on grooved PCC, 15 percent on OGAC, and only one percent on chip sealed surfaces.

Figures and Tables that show characteristics of the accident data are presented on the following pages.

B.2. Figures And Tables For Accident Data

Fig. 27. Geometric Classification
(BC, BT, C, I, IC, T, WC, WT)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
--------------- ACCIDENT FILE ---------------

PERCENTAGE BAR CHART

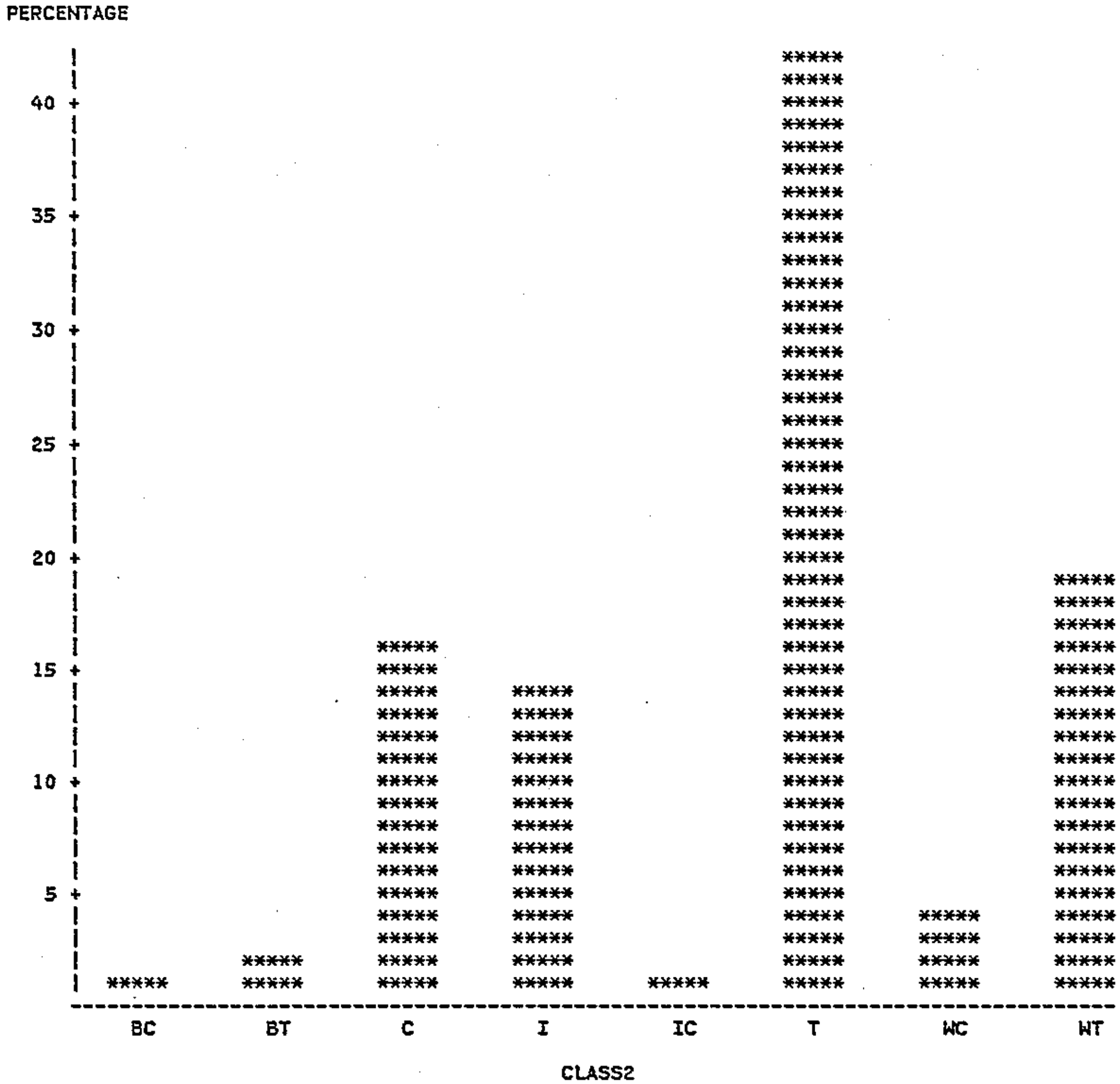

Fig. 28. Geometric Classification
(BT, C, I, T, WT)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
------------- ACCIDENT FILE --------------

PERCENTAGE BAR CHART

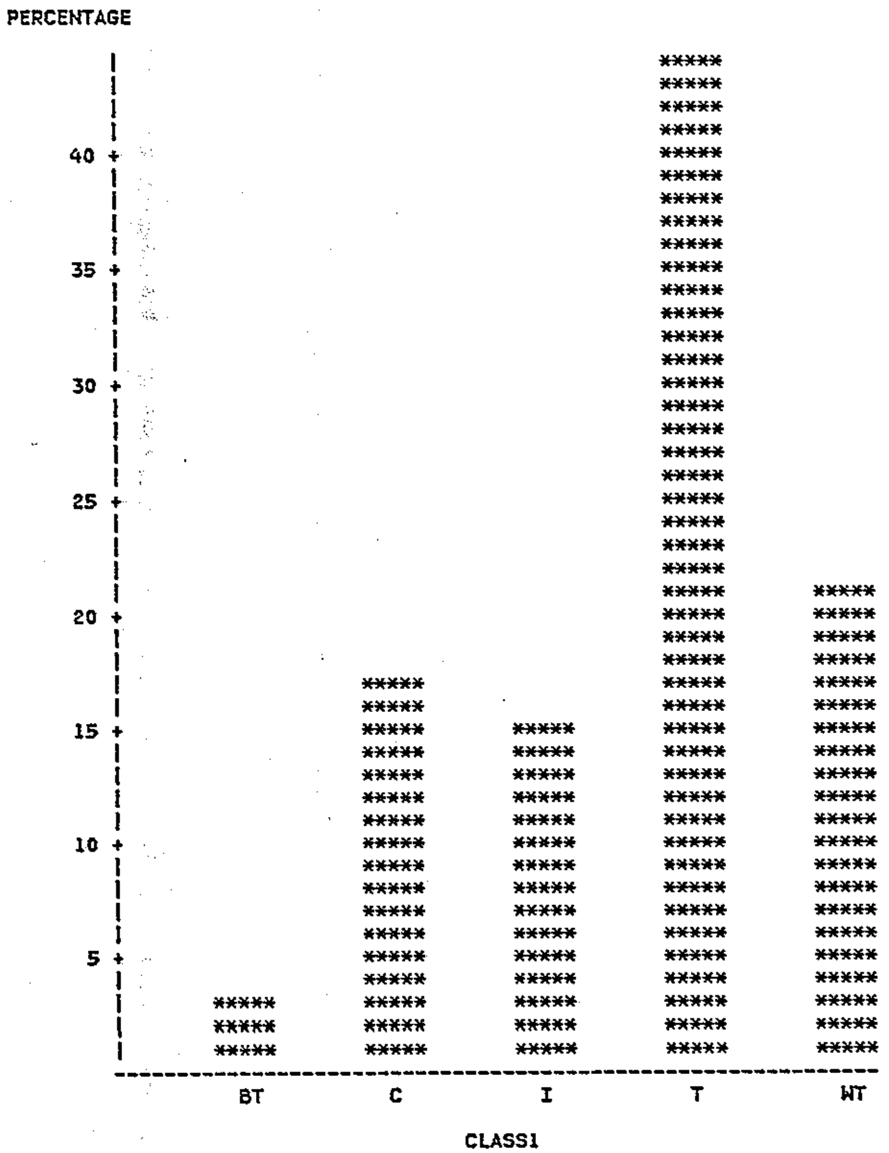

Fig. 29. GRADE Percentages
(+, -, =)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- ACCIDENT FILE ---------------

PERCENTAGE BAR CHART

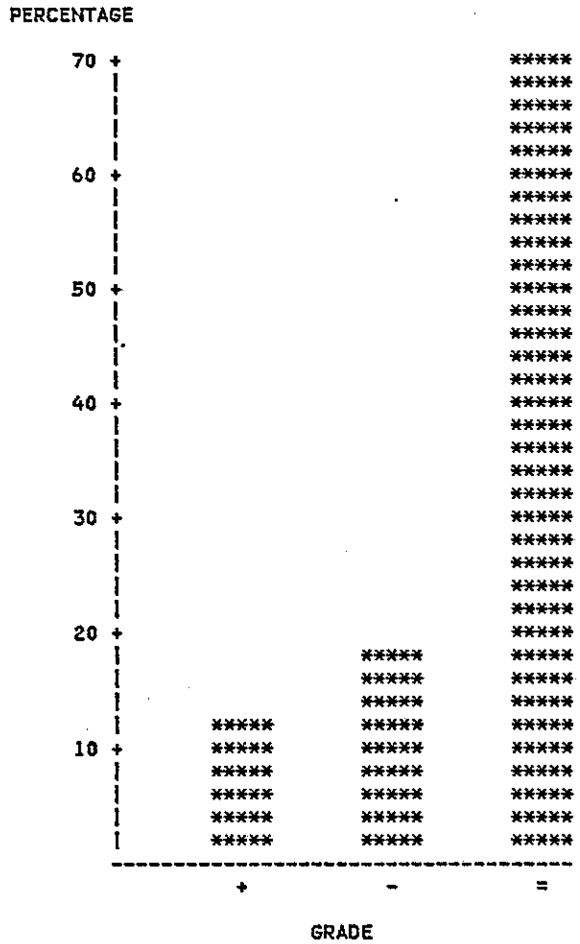

Fig. 30. GRADE Percentages By CLASS
(+, -, =)

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- ACCIDENT FILE ---------------

PERCENTAGE BAR CHART

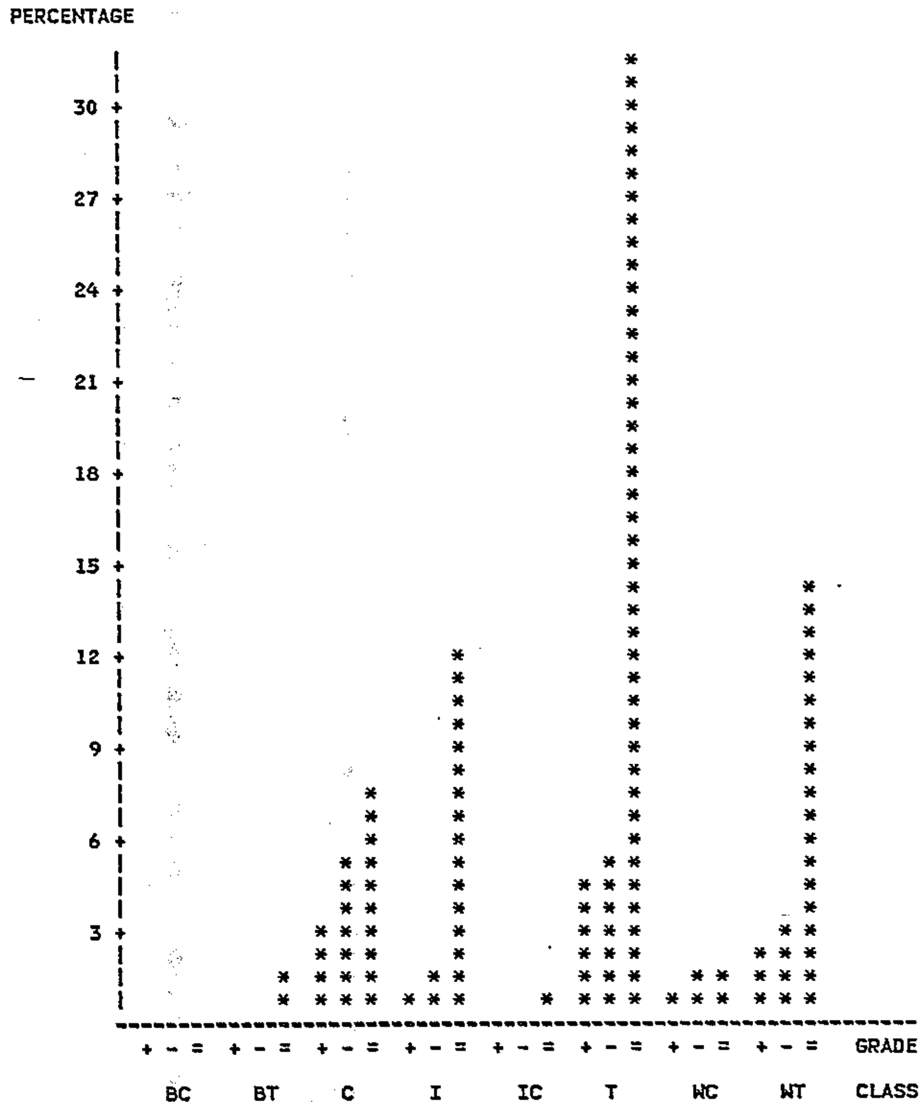

Fig. 31. Skid Number Percentages
Distribution Curve

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- ACCIDENT FILE ---------------

PERCENTAGE BAR CHART

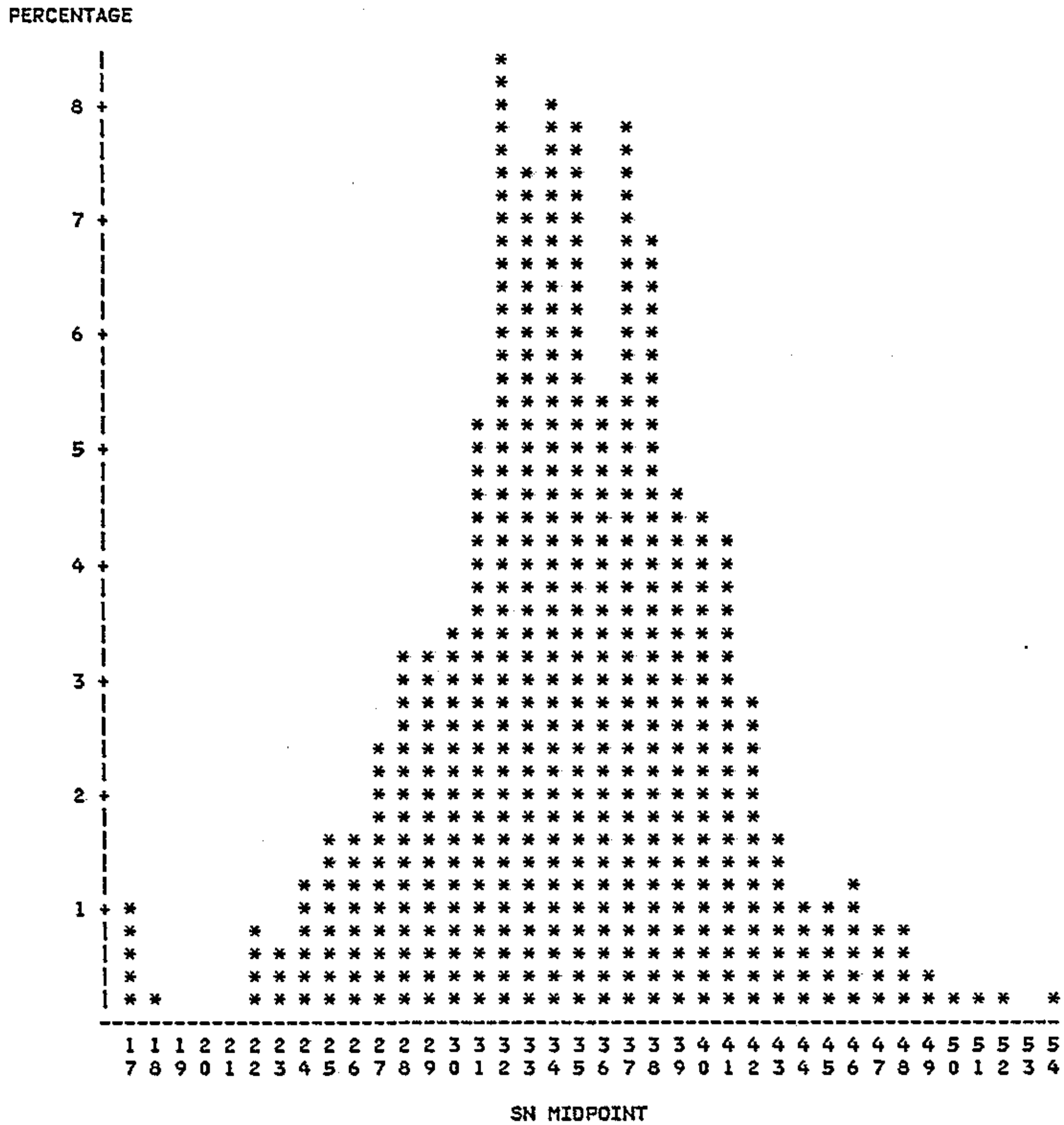

Fig. 32. SPD (Posted Speed) Percentages

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- ACCIDENT FILE --------------

PERCENTAGE BAR CHART

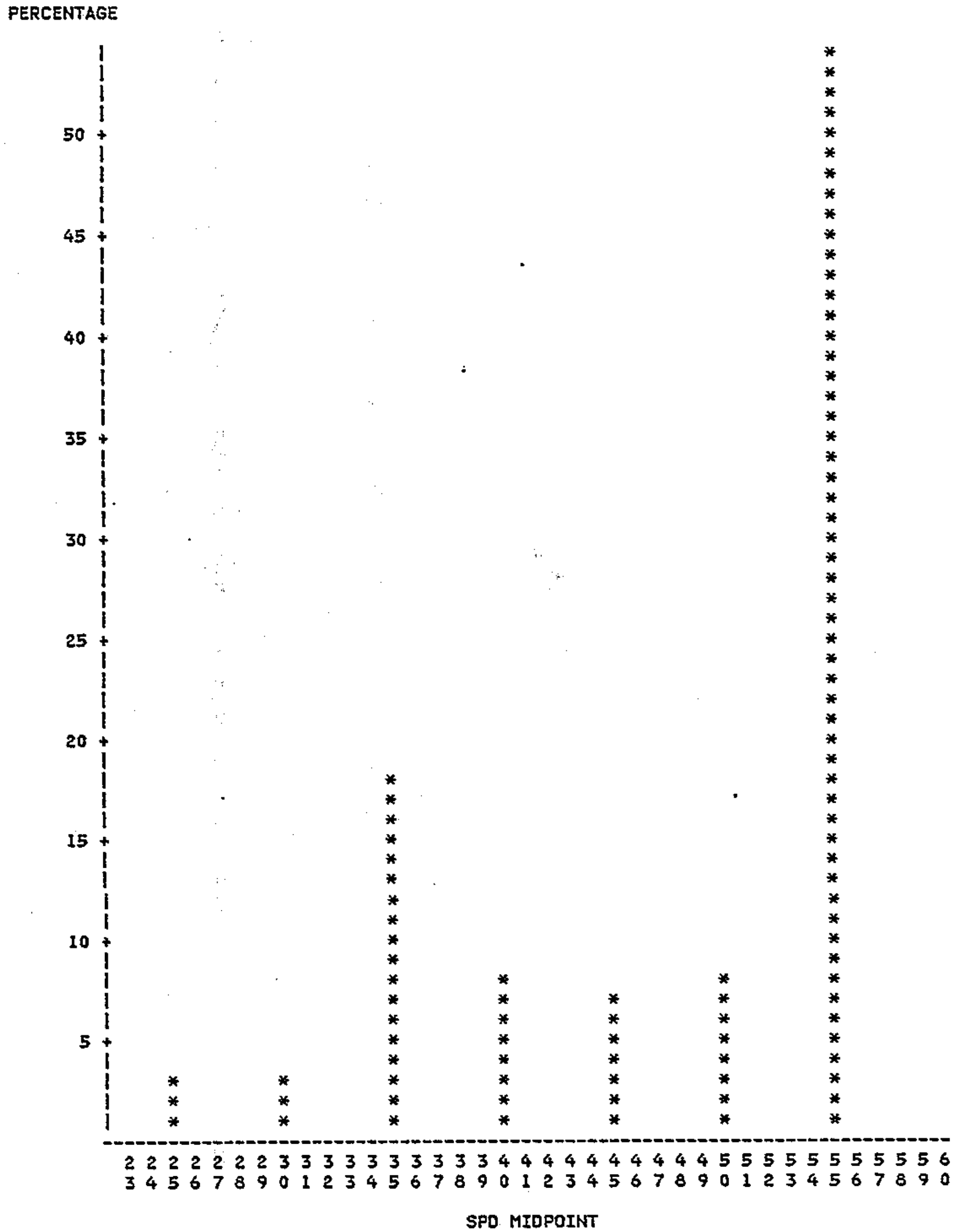

Fig. 33. SURFACE Percentages

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- ACCIDENT FILE ---------------

PERCENTAGE BAR CHART

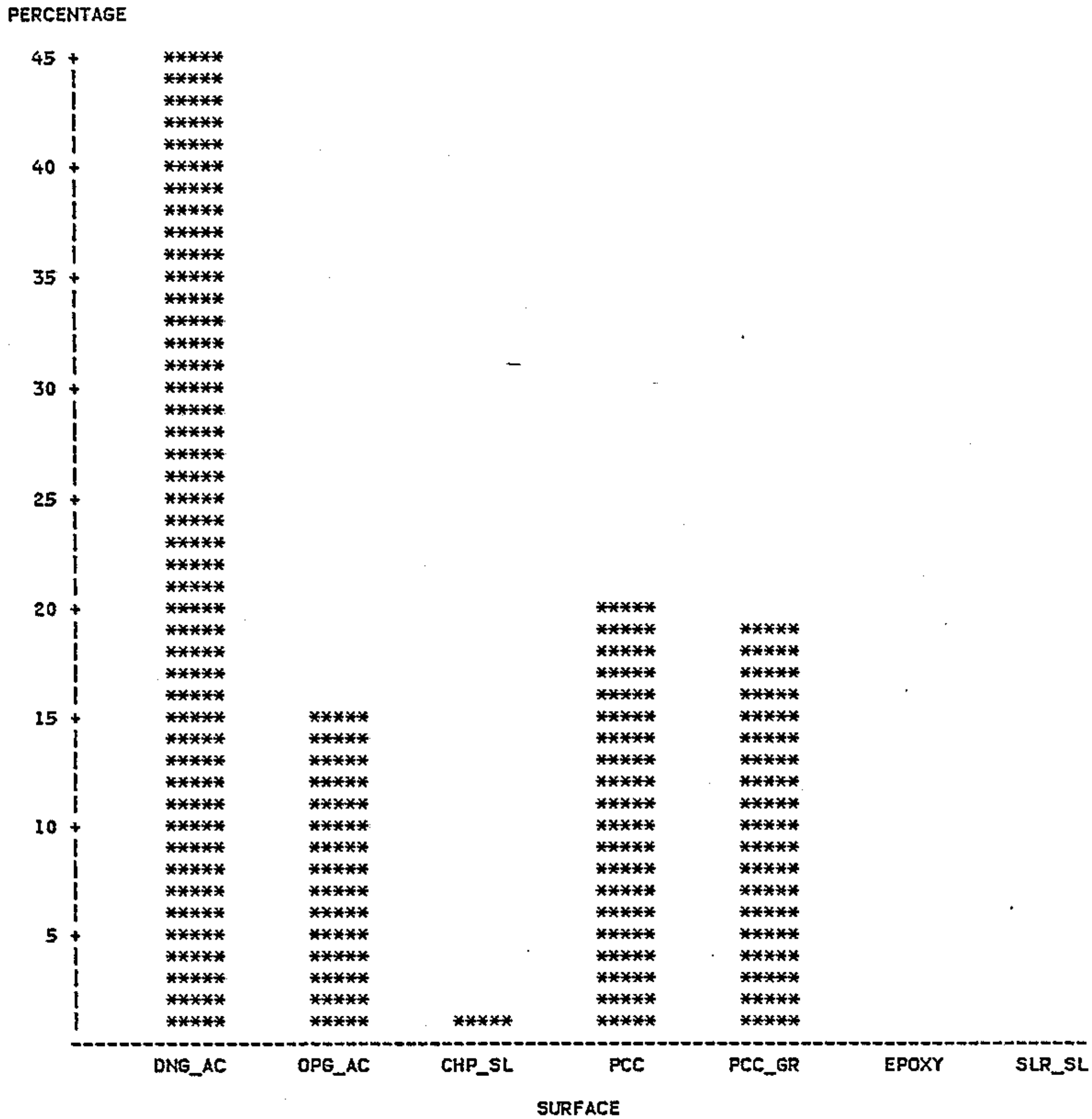

Table 13. Summary Of FRQ_ACC, TWET_ADT
By CLASS, GRADE, DV_UNDV, SN_RANGE

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- ACCIDENT FILE ---------------

TYPE	CLASS2	GRADE	DV_UNDV	SN_RANGE	_FREQ_	TWET_ADT
0					2030	4757681
1				17-25	118	148792
1				26-54	1912	4608890
2			DIV		1673	4522668
2			UN_DIV		357	235014
3			DIV	17-25	62	104623
3			DIV	26-54	1611	4418044
3			UN_DIV	17-25	56	44168
3			UN_DIV	26-54	301	190845
4		+			257	665291
4		-			353	706929
4		=			1420	3385461
5		+		17-25	6	10337
5		+		26-54	251	654954
5		-		17-25	10	14260
5		-		26-54	343	692669
5		=		17-25	102	124194
5		=		26-54	1318	3261266
6		+	DIV		204	634067
6		+	UN_DIV		53	31224
6		-	DIV		267	663591
6		-	UN_DIV		86	43338
6		=	DIV		1202	3225009
6		=	UN_DIV		218	160451
7		+	DIV	17-25	5	9750
7		+	DIV	26-54	199	624317
7		+	UN_DIV	17-25	1	587
7		+	UN_DIV	26-54	52	30637
7		-	DIV	17-25	4	8797
7		-	DIV	26-54	263	654794
7		-	UN_DIV	17-25	6	5463
7		-	UN_DIV	26-54	80	37875
7		=	DIV	17-25	53	86077
7		=	DIV	26-54	1149	3138933
7		=	UN_DIV	17-25	49	38118
7		=	UN_DIV	26-54	169	122334
8	BC				16	80508
8	BT				49	263018
8	C				326	802994
8	I				293	252731
8	IC				27	28868
8	T				846	2090339
8	WC				81	165947
8	WT				392	1073276
9	BC			26-54	16	80508
9	BT			26-54	49	263018
9	C			17-25	8	12566
9	C			26-54	318	790427
9	I			17-25	42	38910
9	I			26-54	251	213821
9	IC			17-25	3	5902
9	IC			26-54	24	22966
9	T			17-25	50	70891
9	T			26-54	796	2019448
9	WC			17-25	2	779
9	WC			26-54	79	165168
9	WT			17-25	13	19743
9	WT			26-54	379	1053533
10	BC		DIV		16	80508
10	BT		DIV		48	262441
10	BT		UN_DIV		1	577

Table 13. Summary Of FRQ_ACC, TWET_ADT
By CLASS, GRADE, DV_UNDV, SN_RANGE

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- ACCIDENT FILE ---------------

TYPE	CLASS2	GRADE	DV_UNDV	SN_RANGE	_FREQ_	TWET_ADT
10	C		DIV		265	769750
10	C		UN_DIV		61	33244
10	I		DIV		196	180884
10	I		UN_DIV		97	71847
10	IC		DIV		15	16081
10	IC		UN_DIV		12	12787
10	T		DIV		724	2004275
10	T		UN_DIV		122	86065
10	WC		DIV		51	153075
10	WC		UN_DIV		30	12872
10	WT		DIV		358	1055653
10	WT		UN_DIV		34	17623
11	BC		DIV	26-54	16	80508
11	BT		DIV	26-54	48	262441
11	BT		UN_DIV	26-54	1	577
11	C		DIV	17-25	4	7402
11	C		DIV	26-54	261	762348
11	C		UN_DIV	17-25	4	5164
11	C		UN_DIV	26-54	57	28080
11	I		DIV	17-25	19	24588
11	I		DIV	26-54	177	156296
11	I		UN_DIV	17-25	23	14322
11	I		UN_DIV	26-54	74	57524
11	IC		DIV	17-25	1	3022
11	IC		DIV	26-54	14	13059
11	IC		UN_DIV	17-25	2	2879
11	IC		UN_DIV	26-54	10	9907
11	T		DIV	17-25	28	51691
11	T		DIV	26-54	696	1952583
11	T		UN_DIV	17-25	22	19200
11	T		UN_DIV	26-54	100	66865
11	WC		DIV	26-54	51	153075
11	WC		UN_DIV	17-25	2	779
11	WC		UN_DIV	26-54	28	12093
11	WT		DIV	17-25	10	17919
11	WT		DIV	26-54	348	1037733
11	WT		UN_DIV	17-25	3	1823
11	WT		UN_DIV	26-54	31	15800
12	BC	+			6	28720
12	BC	-			4	14338
12	BC	=			6	37450
12	BT	+			6	42064
12	BT	-			6	22652
12	BT	=			37	198302
12	C	+			66	178920
12	C	-			109	219355
12	C	=			151	404718
12	I	+			19	17532
12	I	-			27	25538
12	I	=			247	209661
12	IC	+			4	3046
12	IC	-			7	6506
12	IC	=			16	19315
12	T	+			96	268604
12	T	-			105	263602
12	T	=			645	1558133
12	WC	+			15	14467
12	WC	-			37	40769
12	WC	=			29	110711
12	WT	+			45	111938
12	WT	-			58	114168

Table 13. Summary Of FRQ_ACC, TWET_ADT
By CLASS, GRADE, DV_UNDV, SN_RANGE

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- ACCIDENT FILE ---------------

TYPE	CLASS2	GRADE	DV_UNDV	SN_RANGE	_FREQ_	TWET_ADT
12	WT	=			289	847170
13	BC	+		26-54	6	28720
13	BC	-		26-54	4	14338
13	BC	=		26-54	6	37450
13	BT	+		26-54	6	42064
13	BT	-		26-54	6	22652
13	BT	=		26-54	37	198302
13	C	+		26-54	66	178920
13	C	-		17-25	1	1997
13	C	-		26-54	108	217358
13	C	=		17-25	7	10569
13	C	=		26-54	144	394149
13	I	+		17-25	2	2550
13	I	+		26-54	17	14982
13	I	-		26-54	27	25538
13	I	=		17-25	40	36361
13	I	=		26-54	207	173300
13	IC	+		26-54	4	3046
13	IC	-		17-25	1	1997
13	IC	-		26-54	6	4509
13	IC	=		17-25	2	3905
13	IC	=		26-54	14	15410
13	T	+		17-25	3	7200
13	T	+		26-54	93	261404
13	T	-		17-25	6	9487
13	T	-		26-54	99	254115
13	T	=		17-25	41	54204
13	T	=		26-54	604	1503929
13	WC	+		17-25	1	587
13	WC	+		26-54	14	13880
13	WC	-		17-25	1	192
13	WC	-		26-54	36	40577
13	WC	=		26-54	29	110711
13	WT	+		26-54	45	111938
13	WT	-		17-25	1	587
13	WT	-		26-54	57	113581
13	WT	=		17-25	12	19155
13	WT	=		26-54	277	828015
14	BC	+	DIV		6	28720
14	BC	-	DIV		4	14338
14	BC	=	DIV		6	37450
14	BT	+	DIV		6	42064
14	BT	-	DIV		6	22652
14	BT	=	DIV		36	197725
14	BT	=	UN_DIV		1	577
14	C	+	DIV		51	172095
14	C	+	UN_DIV		15	6825
14	C	-	DIV		90	208708
14	C	-	UN_DIV		19	10647
14	C	=	DIV		124	388946
14	C	=	UN_DIV		27	15772
14	I	+	DIV		13	13646
14	I	+	UN_DIV		6	3886
14	I	-	DIV		15	18307
14	I	-	UN_DIV		12	7231
14	I	=	DIV		168	148931
14	I	=	UN_DIV		79	60730
14	IC	+	DIV		2	1094
14	IC	+	UN_DIV		2	1952
14	IC	-	DIV		3	2623
14	IC	-	UN_DIV		4	3883

Table 13. Summary Of FRQ_ACC, TWET_ADT
By CLASS, GRADE, DV_UNDV, SN_RANGE

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- ACCIDENT FILE ---------------

TYPE	CLASS2	GRADE	DV_UNDV	SN_RANGE	_FREQ_	TWET_ADT
14	IC	=	DIV		10	12364
14	IC	=	UN_DIV		6	6951
14	T	+	DIV		82	261116
14	T	+	UN_DIV		14	7488
14	T	-	DIV		87	254468
14	T	-	UN_DIV		18	9134
14	T	=	DIV		555	1488690
14	T	=	UN_DIV		90	69443
14	WC	+	DIV		4	7020
14	WC	+	UN_DIV		11	7447
14	WC	-	DIV		19	35842
14	WC	-	UN_DIV		18	4927
14	WC	=	DIV		28	110213
14	WC	=	UN_DIV		1	498
14	WT	+	DIV		40	108312
14	WT	+	UN_DIV		5	3626
14	WT	-	DIV		43	106652
14	WT	-	UN_DIV		15	7516
14	WT	=	DIV		275	840689
14	WT	=	UN_DIV		14	6481
15	BC	+	DIV	26-54	6	28720
15	BC	-	DIV	26-54	4	14338
15	BC	=	DIV	26-54	6	37450
15	BT	+	DIV	26-54	6	42064
15	BT	-	DIV	26-54	6	22652
15	BT	=	DIV	26-54	36	197725
15	BT	=	UN_DIV	26-54	1	577
15	C	+	DIV	26-54	51	172095
15	C	+	UN_DIV	26-54	15	6825
15	C	-	DIV	26-54	90	208708
15	C	-	UN_DIV	17-25	1	1997
15	C	-	UN_DIV	26-54	18	8650
15	C	=	DIV	17-25	4	7402
15	C	=	DIV	26-54	120	381544
15	C	=	UN_DIV	17-25	3	3167
15	C	=	UN_DIV	26-54	24	12605
15	I	+	DIV	17-25	2	2550
15	I	+	DIV	26-54	11	11096
15	I	+	UN_DIV	26-54	6	3886
15	I	-	DIV	26-54	15	18307
15	I	-	UN_DIV	26-54	12	7231
15	I	=	DIV	17-25	17	22038
15	I	=	DIV	26-54	151	126893
15	I	=	UN_DIV	17-25	23	14322
15	I	=	UN_DIV	26-54	56	46407
15	IC	+	DIV	26-54	2	1094
15	IC	+	UN_DIV	26-54	2	1952
15	IC	-	DIV	26-54	3	2623
15	IC	-	UN_DIV	17-25	1	1997
15	IC	-	UN_DIV	26-54	3	1886
15	IC	=	DIV	17-25	1	3022
15	IC	=	DIV	26-54	9	9341
15	IC	=	UN_DIV	17-25	1	882
15	IC	=	UN_DIV	26-54	5	6069
15	T	+	DIV	17-25	3	7200
15	T	+	DIV	26-54	79	253916
15	T	+	UN_DIV	26-54	14	7488
15	T	-	DIV	17-25	4	8797
15	T	-	DIV	26-54	83	245671
15	T	-	UN_DIV	17-25	2	690
15	T	-	UN_DIV	26-54	16	8444

Table 13. Summary Of FRQ_ACC, TWET_ADT
By CLASS, GRADE, DV_UNDV, SN_RANGE

DISTRICTS 03, 04, AND 07
OUTSIDE LANE ONLY -- SKID NUMBERS 17 THRU 54
ACCIDENTS FROM 6/80 THRU 6/81 -- ALL LOCATIONS
-------------- ACCIDENT FILE ---------------

TYPE	CLASS2	GRADE	DV_UNDV	SN_RANGE	_FREQ_	TWET_ADT
15	T	=	DIV	17-25	21	35694
15	T	=	DIV	26-54	534	1452996
15	T	=	UN_DIV	17-25	20	18510
15	T	=	UN_DIV	26-54	70	50933
15	WC	+	DIV	26-54	4	7020
15	WC	+	UN_DIV	17-25	1	587
15	WC	+	UN_DIV	26-54	10	6860
15	WC	-	DIV	26-54	19	35842
15	WC	-	UN_DIV	17-25	1	192
15	WC	-	UN_DIV	26-54	17	4735
15	WC	=	DIV	26-54	28	110213
15	WC	=	UN_DIV	26-54	1	498
15	WT	+	DIV	26-54	40	108312
15	WT	+	UN_DIV	26-54	5	3626
15	WT	-	DIV	26-54	43	106652
15	WT	-	UN_DIV	17-25	1	587
15	WT	-	UN_DIV	26-54	14	6929
15	WT	=	DIV	17-25	10	17919
15	WT	=	DIV	26-54	265	822769
15	WT	=	UN_DIV	17-25	2	1236
15	WT	=	UN_DIV	26-54	12	5245

C. Development Of Files

This research project was concerned with four types of files. The SRI file and the TASAS file supplied this research project with about 95 percent of its information.

The third and fourth types of files are referred to as the TASAS/Photolog file, and the ACCIDENT file. The TASAS/Photolog file contains merged information from the TASAS file and from a visual examination of the Photolog to obtain the geometric classification for the accident location. The ACCIDENT file contains merged information from the TASAS/Photolog file and the SRI file.

The following is an outlined description of the procedure, which was used in this research project to build the ACCIDENT file.

C.1. The TASAS Selective Accident Retrieval (TSAR) Program

From the TSAR report, extract the location and the highway geometric classifications of wet pavement accidents.

1. District
2. County
3. Route
4. Post mile (with Prefix and/or Suffix)
5. Direction of Travel
    a. North and South
    b. East and West

6. Time and Date
    a. Hour
    b. Day, Month, Year
    c. Weekday or Weekend
7. Area
    a. Rural
    b. Urban
8. Access Control
    a. Conventional
    b. Expressway
    c. Freeway
    d. One-way
9. Median
    a. Divided
    b. Undivided
10. Number of Lanes (For each direction, 1 thru 8)
11. Lane In Which Accident Occurred. (For this particular study, select only the outside lane.)
12. Percent of wet time.

<u>C.2. The Highway Photolog</u>

Review the Highway Photolog and establish the terrain (mountainous or rolling) and the type of highway or bridge alignment (curve, intersection, tangent section, or weave section) for each accident from the selected districts. Then manually code and merge the TASAS data, from Section C.1 above, with the pertinent Photolog data, from this section, to produce the TASAS/Photolog file.

1. Type of Geometric Classifications
   a. Highways
      i. Curves (CI and CO)
      ii. Intersections (ICI, ICO and I)
      iii. Tangent sections (T)
      iv. Weave sections (WCI, WCO and WT)
   b. Bridges
      i. Curves (BCI and BCO)
      ii. Tangent sections (BT)
2. Type of Terrain
   a. Flat (F) (Less than + or - 3%)
   b. Mountainous Up (MU) (Steeper than +3%)
   c. Mountainous Down (MD) (Steeper than -3%)
   d. Rolling Up (RU) (Steeper than +3%)
   e. Rolling Down (RD) (Steeper than -3%)

C.3. The SRI file

Review the SRI file, and obtain the skid number which existed nearest the location and nearest the date of the reported accidents. Distance limitations are necessary to ascertain that the skid number represents the location of the accident. Therefore, select skid numbers from locations prior to the accident location up to 2.5 miles. If tests were not taken in this prior section, then obtain skid numbers from a section beyond the accident location up to a limit of 0.25 miles.

(Note: The average distance from the accident site to the recorded skid number was 0.40 miles for skid numbers ranging from 40 to 54, and 0.20 miles for skid numbers ranging from 17 to 39. Also, with few exceptions (e.g., Route 580), routes with north and east directions will have their skid numbers taken from post miles which are lower than those of the accidents; and routes with south and west directions will have their skid numbers taken from post miles which are higher than those of the accidents.)

In no case shall data be used if a bridge exists between the location of an accident and the location of the data extracted from the SRI file. Care must be used to insure that the data, which are extracted from the SRI file for a bridge, are from the same bridge upon which the accident occurred or was located.

Data obtained from the SRI file are as follows.

1. Skid number. (For this particular study, examine only the lane furthest from the median (or the outside lane).)
2. Average Daily Traffic (or ADT).
3. Posted Speed.
4. Surface Type.
5. Distance from the location of the accident to the nearest acceptable test site or location of the skid number.

Merge this data obtained from the SRI files with the TASAS/Photolog data to produce the working or final version of the ACCIDENT file.

APPENDIX III. SAS PROGRAM

A. Flowchart For SAS Program

SAS (20) is a programming language of the "structured" variety. With a structured approach to programming, a programmer must make an extra effort to avoid the use of any branching instructions, such as a "GO TO" instruction. However, and this is very important, it is much easier to debug and to document or flowchart a structured program. This is because, with a structured program, practically all of the instructions follow each other in ordered sequence -- one after the other. Thus, the flowchart, which follows, is simply an orderly sequential explanation of those orderly sequential instructions. Those sequential instructions are listed in Section B, which immediately follows this section.

Read-In And Analyze SRI File.

1. Read SRI File. Read the following variables: District; County; Route; Prefix; Post mile; Direction; Lanes; Class; ADT; Speed; Grade; Surface; Test speed; Skid number_I; Weather; Temperature; Divided or undivided median; Access control; Rural or urban area; and Skid number_40. Test and accept only clean records. PCT_WET transgenerated from COUNTY using table of correspondences. SN_RANGE transgenerated from SN. LANE_ADT transgenerated when dividing ADT by LANES.

2. Print charts for various variables of the SRI file.

3. Summarize FRQ_INV, and TWET_ADT for all combinations of CLASS, GRADE, DV_UNDV, and SN_RANGE. Print results.

Read-In And Analyze ACCIDENT File.

4. Read ACCIDENT file. Read the following variables: District; Route; County; Rural or urban status; Prefix; Post mile; Divided or undivided median; Access control; Lanes; Direction; Class; Terrain; ADT; Posted speed; Surface; Skid number_40; and Distance from the location of the accident to the location of the inventoried Skid number_40. Test and accept only clean records. PCT_WET transgenerated from COUNTY using table of correspondences. GRADE transgenerated from TERRAIN. SN_RANGE transgenerated from SN. LANE_ADT transgenerated when dividing ADT by LANES.

5. Print Charts for various variables of the ACCIDENT file.

6. Summarize FRQ_ACC, and TWET_ADT for all combinations of CLASS, GRADE, DV_UNDV, and SN_RANGE. Print results.

Perform A Regression Analysis For All Records Of The ACCIDENT File.

7. Perform a regression analysis for all records of the ACCIDENT file, using as a dependent variable the relative indexed accident rates, AC_RATE1, AC_RATE2, and AC_RATE3, and using as an independent variable the skid numbers, SN.

First, perform a linear regression using the SAS Procedure, PROC GLM, in the following manner.

AC_RATEn = A0 + A1*(SN-14) ,
for n = 1, 2, 3.

Second, perform a linear regression using the SAS Procedure, PROC GLM, in the following manner.

log:(AC_RATEn) = B0 + B1*(SN-14) ,
for n = 1, 2, 3.

Third, perform a nonlinear regression using the SAS Procedure, PROC NLIN, in the following manner.

AC_RATEn = C0*exp:(C1*(SN-14)) ,
for n = 1, 2, 3.

8. Print, chart, and plot results.

Examine AC_RATE1, AC_RATE2, and AC_RATE3 Over A Low And A High Range Of Skid Numbers For Major Variables.

9. For each major variable, calculate the relative indexed accident rates, AC_RATE1, AC_RATE2, and AC_RATE3, over a low range of skid numbers (17-25) and a high range of skid numbers (26-54). Print results.

B. Source Listing Of SAS Program

The following source listing is an edited and condensed version of the original SAS program. Editing was required, because the original program used 14" x 11" (width x length) paper with 10-pitch columns for printout, while the following source program uses 8.5" x 11" paper with 15-pitch columns for printout. Output of the SAS program has also been condensed from some 260 pages to some 60 pages of the most pertinent information.

```
OPTIONS ERRORABEND   ERRORS=5      S=72
        LINESIZE=90  PAGESIZE=68  NOOVP
        NONUMBER     NODATE;

CMS FILEDEF ACC03 DISK WORKBB03 ACC80-81 A;
CMS FILEDEF ACC04 DISK WORKBB04 ACC80-81 A;
CMS FILEDEF ACC07 DISK WORKBB07 ACC80-81 A;
CMS FILEDEF INV03 DISK   DIST03 SRI80-81 A;
CMS FILEDEF INV04 DISK   DIST04 SRI80-81 A;
CMS FILEDEF INV07 DISK   DIST07 SRI81-82 A;
CMS FILEDEF  TERM TERM;

TITLE1 DISTRICTS 03, 04, AND 07;
TITLE2 OUTSIDE LANE ONLY  --  SKID-NUMBERS 17 THRU 54;
TITLE3 ACCIDENTS FROM 6/80 THRU 6/81  --  ALL LOCATIONS;

MACRO MACSLCT
     CLASS2 = SUBSTR(CLASS,1,2);
     IF  CLASS2 EQ 'BC'  OR  CLASS2 EQ 'IC'  OR
         CLASS2 EQ 'WC'  THEN  CLASS1 = '  ';
                         ELSE  CLASS1 = CLASS2;

     IF SN EQ .  OR  SN LE 0  THEN GO TO REJECT;
     IF SN LE 17 THEN SN = 17;
     IF SN GE 54 THEN SN = 54;
     IF SN LE 25 THEN SN_RANGE = '17-25';
                 ELSE SN_RANGE = '26-54';
     _SN_ = PUT(SN,FRMNSKNM5.);

     LANE_ADT = 0.5*ADT/LANES;
     IF  LANE_ADT LE 0  THEN LANE_ADT = .;
     EACH_ONE = 1;

     DO J = 3 TO 70 BY 5;
     IF SPD GE J  AND  SPD LE J+4  THEN GO TO NEXTA;
     END;
     ABORT 331;
     NEXTA:  SPD = J+2;

     DO J = 0 TO 40000 BY 5000;
     IF  DV_UNDV EQ 'D'  THEN GO TO NEXTBB;
     IF ADT GE J  AND  ADT LE J+4999  THEN GO TO NEXTB;
     END;
     _ADT_ = .;
     GO TO NEXTBB;
     NEXTB:  _ADT_ = J+2500;
     NEXTBB:
%

PROC FORMAT;
     VALUE FRMNSKNM
     17-19 = '17-19'
     20-22 = '20-22'
     23-25 = '23-25'
     26-54 = '26-54';

     VALUE FRMNSESN
     1-2   = COLD_SEASON
     3-5   = MILD_SEASON
     6-9   = HOT_SEASON
     10    = MILD_SEASON
     11-12 = COLD_SEASON;

*****************************************************************:

PROC PRINTTO;
TITLE4 ---------------  INVENTORY FILE  ---------------;

DATA _NULL_;  FILE TERM NOPRINT NOTITLES;
     PUT ' AT INVENTORY FILE STAGE';
```

APPENDIX III: SAS PROGRAM

```
DATA INVNTRY (DROP=J ERR AWORK);
FORMAT SURFACE FRMNSURF.
       WEATHER FRMNWTHR.
       ACC_CNTL $FRMAACC.
       DV_UNDV $FRMADU.
       RRL_URB $FRMARU.;

     INFILE INV03 END=EOF03;
     IF EOF03 THEN INFILE INV04 END=EOF04;
     IF EOF04 THEN INFILE INV07;

     INPUT DISTRICT 2-3
           COUNTY $ 65-67
           ROUTE 6-8
           MONTH 12-13
           PREFIX $ 14
           PST_MILE 15-19 2
           N_S_E_W $ 20
           LANES 23
           CLASS $ 24-26
           ADT 27-33
           SPD 34-35
           GRADE $ 36
           SURFACE 38
           TST_SPD 39-40
           SN_I 41-42
           WEATHER 43
           TEMPRTR 44-46
           DV_UNDV $ 58
           ACC_CNTL $ 59
           RRL_URB $ 62
           SN 63-64;

     IF  CLASS EQ 'WTM'  THEN GO TO REJECT;

     MACSLCT

     DO J = -34 TO 144 BY 10;
     IF TEMPRTR GE J  AND  TEMPRTR LE J+9  THEN GO TO NEXT1;
     END;
     ABORT 221;
     NEXT1:  _TMPRTR_ = J+4;

     DO J = 3 TO 70 BY 5;
     IF TST_SPD GE J  AND  TST_SPD LE J+4  THEN GO TO NEXT2;
     END;
     ABORT 222;
     NEXT2:  TST_SPD = J+2;

     IF GRADE EQ ' '  THEN GRADE = '=';

     AWORK = PUT(COUNTY,$FRMAPWET2.);
     PCT_WET = INPUT(AWORK,2.0);
     WET_ADT = 0.01*PCT_WET*ADT;
     SEASON = PUT(MONTH,FRMNSESN11.);
     TST__SPD = TST_SPD;

         OUTPUT;  RETURN;
REJECT:  DELETE;

PROC CHART;
     VBAR CLASS2 / TYPE=PERCENT;
     VBAR CLASS1 / TYPE=PERCENT;
     VBAR GRADE / TYPE=PERCENT;
     VBAR GRADE / TYPE=PERCENT GROUP=CLASS;
     VBAR SN / TYPE=PERCENT MIDPOINTS=17 TO 54;
     VBAR SN / TYPE=MEAN SUMVAR=WET_ADT MIDPOINTS=17 TO 54;
     VBAR ADT / TYPE=PERCENT MIDPOINTS=-5000 TO 305000 BY 10000;
     VBAR WET_ADT / TYPE=PERCENT MIDPOINTS=-250 TO 15250 BY 500;
     VBAR LANE_ADT / TYPE=PERCENT MIDPOINTS=-500 TO 35500 BY 1000;
```

```
     VBAR SPD / TYPE=PERCENT MIDPOINTS=23 TO 60;
     VBAR SPD / TYPE=MEAN SUMVAR=SN MIDPOINTS=23 TO 60;
     VBAR SURFACE / TYPE=PERCENT DISCRETE;
     VBAR SURFACE / TYPE=MEAN SUMVAR=SN DISCRETE;
     VBAR TST_SPD / TYPE=PERCENT MIDPOINTS=15 TO 60 BY 5;


MACRO MC_SMMRY
PROC SUMMARY DATA=DATASET;
     CLASS CLASS2 GRADE DV_UNDV SN_RANGE;
     VAR WET_ADT;
     OUTPUT OUT=TEMP
     SUM = TWET_ADT;

PROC PRINT;  ID _TYPE_;
     VAR CLASS2 GRADE DV_UNDV SN_RANGE _FREQ_ TWET_ADT;
%

MACRO DATASET INVNTRY %
MC_SMMRY

*************************************************************;

PROC PRINTTO;
TITLE4 -------------- ACCIDENT FILE ---------------;

DATA _NULL_;  FILE TERM NOPRINT NOTITLES;
     PUT ' AT ACCIDENT FILE STAGE';

DATA ACCDNT (DROP=J ERR AWORK);
FORMAT SURFACE FRMNSURF.
       ACC_CNTL $FRMAACC.
       DV_UNDV $FRMADU.
       RRL_URB $FRMARU.;

     INFILE ACC03 END=EOF03;
     IF EOF03 THEN INFILE ACC04 END=EOF04;
     IF EOF04 THEN INFILE ACC07;

     INPUT DISTRICT 1-2
           ROUTE 4-6
           COUNTY $ 8-10
           RRL_URB $ 12
           PREFIX $ 15
           PST_MILE 17-22 2
           DV_UNDV $ 24
           ACC_CNTL $ 26
           LANES 28
           N_S_E_W $ 34
           CLASS $ 38-40
           TERRAIN $ 42-43
           PCT_WET 45
           ADT 47-53
           SPD 55-56
           SURFACE 58
           SN 60-61
           DIST_SN 63-66 2;

     CLASS = SUBSTR(CLASS,1,2);
     IF  CLASS EQ 'B'  THEN CLASS = 'BT';
     IF  CLASS EQ 'CI'  OR  CLASS EQ 'CO'  THEN CLASS = 'C';
     IF  CLASS EQ 'W'  THEN CLASS = 'WT';
     AWORK = PUT(CLASS,$FRMACLSS2.);
     IF  AWORK NE 'OK'  THEN GO TO REJECT;

     MACSLCT

     GRADE = PUT(TERRAIN,$FRMATRRN.);
     WET_ADT = 0.01*PCT_WET*ADT;
     IF DV_UNDV EQ 'L' OR
        DV_UNDV EQ 'R' THEN DV_UNDV = 'D';
```

```
     OUTPUT;  RETURN;

REJECT:  ERR+1;
         DELETE;

PROC CHART;
     VBAR CLASS2 / TYPE=PERCENT;
     VBAR CLASS1 / TYPE=PERCENT;
     VBAR GRADE / TYPE=PERCENT;
     VBAR GRADE / TYPE=PERCENT GROUP=CLASS;
     VBAR SN / TYPE=PERCENT MIDPOINTS=17 TO 54;
     VBAR SPD / TYPE=PERCENT MIDPOINTS=23 TO 60;
     VBAR SURFACE / TYPE=PERCENT DISCRETE;

MACRO DATASET ACCDNT %
MC_SMMRY

*******************************************************************;

PROC PRINTTO;
TITLE4 ---------------  REGRESSION ANALYSIS  ---------------;

DATA _NULL_;  FILE TERM NOPRINT NOTITLES;
     PUT ' AT FIRST EXAMINATION STAGE';

PROC SUMMARY DATA=INVNTRY;
     CLASS SN;
     VAR WET_ADT;
     OUTPUT OUT=TEMPINV
     N        = FRQ_INV
     SUM      = TWET_ADT;

DATA TEMPINV;  SET TEMPINV;  IF _TYPE_ NE 1 THEN DELETE;

PROC SUMMARY DATA=ACCDNT;
     CLASS SN;
     VAR ADT;
     OUTPUT OUT=TEMPACC
     N        = FRQ_ACC;

DATA TEMPACC;  SET TEMPACC;  IF _TYPE_ NE 1 THEN DELETE;

DATA TEMP1;
     MERGE TEMPINV (IN=INV)
           TEMPACC (IN=ACC);
     BY SN;

     RECNO = 1;
     IF  INV=0  OR  ACC=0  THEN RETURN;

     AC_RATE1 = FRQ_ACC / FRQ_INV;
     AC_RATE2 = 1000*FRQ_ACC / (TWET_ADT);
     AC_RATE3 = 1000*FRQ_ACC / (TWET_ADT*FRQ_INV);

DATA TEMP2 (KEEP=RECNO SUM001 SUM002 SUM012);  SET TEMP1;
     BY RECNO;
     SUM001 + AC_RATE1;
     SUM002 + AC_RATE2;
     SUM012 + AC_RATE3;
     IF LAST.RECNO THEN OUTPUT;

DATA COMBINED;  MERGE TEMP1 (IN=IN1) TEMP2 (IN=IN2);
     BY RECNO;
     IF IN1 AND IN2;
     AC_RATE1 = 100*AC_RATE1/SUM001;
     AC_RATE2 = 100*AC_RATE2/SUM002;
     AC_RATE3 = 100*AC_RATE3/SUM012;

PROC PRINT;  ID SN;
     VAR FRQ_ACC FRQ_INV TWET_ADT
```

```
          AC_RATE1 AC_RATE2 AC_RATE3;

DATA COMBINED;  SET COMBINED;
     IF  AC_RATE1 EQ .  THEN DELETE;

PROC CHART;
     VBAR SN / SUMVAR=AC_RATE1 MIDPOINTS=17 TO 54;
     VBAR SN / SUMVAR=AC_RATE2 MIDPOINTS=17 TO 54;
     VBAR SN / SUMVAR=AC_RATE3 MIDPOINTS=17 TO 54;

MACRO MCNLIN
DATA TEMP;  SET COMBINED;
     WORK = LOG(MCVAR01);
     SN = SN-14;
     AFREQ = INT(10*MCVAR01+0.5);

PROC GLM;
     FREQ AFREQ;
     MODEL MCVAR01 WORK = SN;
     OUTPUT OUT=TEMP  P = PREDICT1 PREDICT2;

PROC NLIN
     METHOD=MARQUARDT BEST=1 ITERATIONS=200;

     PARMS A1 = 10
           B1 = -0.05;

     VARSN = SN;
     EXPSN = EXP(B1*VARSN);
     DERSN = VARSN*EXPSN;

     MODEL MCVAR01 = A1*EXPSN;
     DER.A1 = EXPSN;
     DER.B1 = A1*DERSN;

     OUTPUT OUT=TEMP P=PREDICT3;

DATA TEMP;  SET TEMP;
     PREDICT2 = EXP(PREDICT2);
     SN = SN+14;

PROC PLOT;
     PLOT PREDICT1*SN='P'   MCVAR01*SN='A'  /  OVERLAY;
     PLOT PREDICT2*SN='P'   MCVAR01*SN='A'  /  OVERLAY;
     PLOT PREDICT3*SN='P'   MCVAR01*SN='A'  /  OVERLAY;
     %

PROC PRINTTO;
TITLE4  AC_RATE1 = ACCIDENTS PER LOCATION (INDEXED RATE);
TITLE5  REGRESSION-ANALYSIS OF SKID-NUMBERS FOR ALL RECORDS;
TITLE6  ---------------  REGRESSION ANALYSIS  ---------------;

MACRO MCVAR01 AC_RATE1 %
MCNLIN

PROC PRINTTO;
TITLE4  AC_RATE2 = ACCIDENTS PER WET-VEHICLE (INDEXED RATE);
TITLE5  REGRESSION-ANALYSIS OF SKID-NUMBERS FOR ALL RECORDS;
TITLE6  ---------------  REGRESSION ANALYSIS  ---------------;

MACRO MCVAR01 AC_RATE2 %
MCNLIN

PROC PRINTTO;
TITLE4  AC_RATE3 = ACCIDENTS PER WET-VEHICLE-LOCATION (INDEXED RATE);
TITLE5  REGRESSION-ANALYSIS OF SKID-NUMBERS FOR ALL RECORDS;
TITLE6  ---------------  REGRESSION ANALYSIS  ---------------;

MACRO MCVAR01 AC_RATE3 %
MCNLIN
```

```
*****************************************************************;

PROC PRINTTO;
TITLE4 ---------------  SN_RANGE EXAMINATION  ---------------;

DATA _NULL_;  FILE TERM NOPRINT NOTITLES;
     PUT ' AT SECOND (FINAL) EXAMINATION STAGE';

MACRO MAC_CMPR
PROC SUMMARY DATA=INVNTRY;
     CLASS SN_RANGE MAC_VAR;
     VAR WET_ADT;
     OUTPUT OUT=TEMPINV
     N         = FRQ_INV
     SUM       = TWET_ADT;

DATA TEMPINV;  SET TEMPINV;  IF _TYPE_ NE 3 THEN DELETE;

PROC SUMMARY DATA=ACCDNT;
     CLASS SN_RANGE MAC_VAR;
     VAR ADT;
     OUTPUT OUT=TEMPACC
     N         = FRQ_ACC;

DATA TEMPACC;  SET TEMPACC;  IF _TYPE_ NE 3 THEN DELETE;

DATA TEMP1;
     MERGE TEMPINV (IN=INV)
           TEMPACC (IN=ACC);
     BY SN_RANGE MAC_VAR;

     RECNO = 1;
     IF  INV=0  OR  ACC=0  THEN RETURN;

     AC_RATE1 = FRQ_ACC / FRQ_INV;
     AC_RATE2 = 1000*FRQ_ACC / (TWET_ADT);
     AC_RATE3 = 1000*FRQ_ACC / (TWET_ADT*FRQ_INV);

     FILL = '   ';

DATA TEMP2 (KEEP=RECNO SUM001 SUM002 SUM012);  SET TEMP1;
     BY RECNO;
     SUM001 + AC_RATE1;
     SUM002 + AC_RATE2;
     SUM012 + AC_RATE3;
     IF LAST.RECNO THEN OUTPUT;

DATA TEMP1;  MERGE TEMP1 (IN=IN1) TEMP2 (IN=IN2);
     BY RECNO;
     IF IN1 AND IN2;
     AC_RATE1 = 100*AC_RATE1/SUM001;
     AC_RATE2 = 100*AC_RATE2/SUM002;
     AC_RATE3 = 100*AC_RATE3/SUM012;

     AC_RATE1 = ROUND(AC_RATE1,0.2);
     AC_RATE2 = ROUND(AC_RATE2,0.2);
     AC_RATE3 = ROUND(AC_RATE3,0.2);

PROC PRINT;  ID SN_RANGE;
     VAR MAC_VAR FRQ_ACC FRQ_INV TWET_ADT
         AC_RATE1 AC_RATE2 AC_RATE3 FILL;
%

MACRO MAC_VAR EACH_ONE %
MAC_CMPR

MACRO MAC_VAR CLASS1 %
MAC_CMPR

MACRO MAC_VAR CLASS2 %
MAC_CMPR
```

```
MACRO MAC_VAR DV_UNDV %
MAC_CMPR

MACRO MAC_VAR GRADE %
MAC_CMPR

MACRO MAC_VAR RRL_URB %
MAC_CMPR

MACRO MAC_VAR ACC_CNTL %
MAC_CMPR

MACRO MAC_VAR SURFACE %
MAC_CMPR

MACRO MAC_VAR LANES %
MAC_CMPR

MACRO MAC_VAR SPD %
MAC_CMPR

MACRO MAC_VAR _ADT_ %
MAC_CMPR

*************************  END OF PROGRAM  *************************;
```