Special Report

Skid Resistance of the Secondary Road System in Iowa

June, 1977

Division of Highways
Office of Materials
& Research

DEPARTMENT OF TRANSPORTATION
IOWA

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Special Report

SKID RESISTANCE OF THE SECONDARY ROAD SYSTEM IN IOWA

June 1977

by

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Testing Engineer
515-296-1237

NOTICE

The contents of this report reflect the view of the author, who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policy of the Iowa Department of Transportation. This report does not constitute a standard, specification, or regulation.

ABSTRACT

The Iowa Department of Transportation has been conducting skid resistance tests on the paved secondary system on a routine basis since 1973. This report summarizes the data obtained through 1976 on 10,101 miles in 95 of the 99 counties in Iowa.

A summary of the skid resistance on the secondary system is presented by pavement type and age.

The data indicates that the overall skid resistance on this road system is excellent.

Higher traffic roads (over 1000 vehicles per day) have a lower skid resistance than the average of the secondary roads for the same age and pavement type.

The use of non-polishing aggregates in asphaltic concrete paving surface courses and transverse grooving of portland cement concrete paving on high traffic roads is recommended.

The routine resurvey of skid resistance on the secondary road system on a 5-year interval is probably not economically justified and could be extended to a 10-year interval.

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INTRODUCTION

In June 1967, the Federal Highway Administration's National Highway Safety Bureau issued 13 Highway Safety Program Standards. These are standards which each state must implement as part of its highway safety program. Standard 12 entitled "Highway Design Construction and Maintenance" includes provisions that standards for pavement design and construction have specific provisions for high skid resistance qualities and that there is a program for resurfacing or other surface treatment for correction of locations or sections of streets and highways with low skid resistance and high or potentially high accident rates.

In April 1968, the FHWA issued Instructional Memorandum 21-3-68 entitled "Construction of Pavement Surfacing to Provide Safer Coefficient of Skid Resistance". This memorandum informed the states that there would be Federal-Aid project eligibility for work to resurface pavements with a skid number less than 35.

Subsequent IM's, policies and programs require the states to conduct skid resistance inventories on all paved roads with a posted speed limit of 40 miles per hour or higher. FHWA Instructional Memorandum 21-2-73 which supercedes IM 21-3-68 has eliminated all direct references to minimum skid numbers and asked that each state establish their own general guidelines based on their specific conditions.

The Iowa Department of Transportation became involved with skid resistance evaluation in 1965 when funds were provided by the Iowa Highway Research Board for the purpose of constructing a skid testing system conforming to ASTM E274. A limited amount of routine testing was begun in 1969 with this unit.

In 1972, a second testing system was purchased from K. J. Law Engineers Inc. when it became obvious that a complete inventory of the primary and interstate road systems could not be conducted in a timely manner. A third test system was purchased from K. J. Law Engineers Inc. in 1975 when it became the responsibility of the Office of Materials & Research to inventory the paved secondary road system for skid resistance. With the three testing systems the approximately 10,000 miles on the primary and interstate road systems and the approximately 11,000 paved miles on the secondary road system can be efficiently inventoried on a continuing basis.

INVENTORY PROCEDURE

Test Method:

All tests are conducted in conformance with ASTM E274 "Standard Method of Test for Skid Resistance of Paved Surfaces Using a Full-Scale Tire." The test apparatus consists of a two-wheel trailer towed by a truck. 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 apparatus is brought to the test speed (unless otherwise noted the speed is 40 mph). Water is delivered ahead of the test tire from a tank in the towing vehicle and the braking system is actuated to lock the test tire. The resulting friction force acting between the test tire and the pavement surface 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.

The skid test system used by the Iowa Department of Transportation is shown in Appendix A.

Test Sections:

The Office of Materials & Research has established test sections on all paved secondary roads by assigning a mileage system very similar to the milepost system used on the state primary roads. The system establishes a mileage of 0.00 at the western and southern county lines. It is a continuous mileage system from that point across the county on each county designated roadway. A test section is normally broken at county lines, corporation limits, major intersections, change in surface type, and change in surface age. Typical test section designations are shown in Appendix B.

A skid test is made every mile in each direction with a minimum of five tests in each direction on each test section.

An exception to this would be that if it becomes apparent that the SN will be above 60 the testing frequency may be reduced to one test every 2 miles in each direction. All tests are made in the center of the left wheel track of a traffic lane.

Upon completion of the testing of all paved secondary roads within a county a report is issued to the county engineer for each test section. A typical report is shown in Appendix C.

STATUS OF PROGRAM

At the end of 1976, the paved county roads had been tested in 94 of the 99 counties in Iowa. Buena Vista, Calhoun, Hamilton, and Sac counties had not been inventoried but are to be inventoried in 1977.

County roads began being tested in 1973 with 2 counties inventoried, 10 were inventoried in 1974, 47 inventoried in 1975, and 36 inventoried in 1976. It is the plan of the Office of Materials & Research to retest these roads on a five-year cycle.

RESULTS

Tables 1 thru 4 and Figures 1 thru 4 indicate the results obtained on the 10,101 miles of roads tested in the previously mentioned 95 counties. The data is grouped by pavement type (p.c. concrete, a.c. concrete, and seal coat) and pavement age (0-5 years, 6-10 years, 11-15 years, and 16+ years). Tables 1, 2, 3, and 4 catagorize the skid number levels of pavements

TABLE 1

SKID RESISTANCE INVENTORY SUMMARY
SECONDARY ROADS SYSTEM
DATA THROUGH 1976
(95 Counties)

These Values are Based on Project or Section Averages
Mileages are Roadway Miles Tested in The Inside Wheeltrack

TOTALS WITHOUT REGARD TO TRAFFIC VOLUME

0-5 YEARS OLD

SN	PC MILES	%	AC MILES	%	SC MILES	%	TOTAL MILES	%
0-20								
21-29			22.29	1.08			22.29	.75
30-34			33.23	1.61	4.75	6.15	37.98	1.27
35-39	1.01	.12	66.33	3.22	13.46	17.42	80.80	2.72
40-44	44.44	5.33	183.17	8.89	8.41	10.89	236.02	7.94
45-49	237.01	28.40	522.78	25.36	13.90	17.99	773.69	26.02
50+	552.01	66.15	1233.69	59.84	36.74	47.55	1822.44	61.30
TOTAL	834.47		2061.49		77.26		2973.22	

TABLE 2

SKID RESISTANCE INVENTORY SUMMARY
SECONDARY ROADS SYSTEM
DATA THROUGH 1976
(95 Counties)

These Values are Based on Project or Section Averages
Mileages are Roadway Miles Tested in The Inside Wheeltrack

TOTALS WITHOUT REGARD TO TRAFFIC VOLUME

6-10 YEARS OLD

SN	PC MILES	%	AC MILES	%	SC MILES	%	TOTAL MILES	%
0-20								
21-29	4.56	.35	12.92	.68	19.85	7.25	37.33	1.07
30-34	11.80	.90	64.76	3.40	17.27	6.30	93.83	2.69
35-39	51.64	3.95	100.04	5.26	24.69	9.01	176.37	5.06
40-44	122.61	9.39	150.28	7.89	30.26	11.04	303.15	8.70
45-49	489.10	37.43	335.62	17.63	41.53	15.16	866.25	24.86
50+	626.98	47.98	1240.12	65.14	140.41	51.24	2007.51	57.62
TOTAL	1306.69		1903.74		274.01		3484.44	

TABLE 3

SKID RESISTANCE INVENTORY SUMMARY
SECONDARY ROADS SYSTEM
DATA THROUGH 1976
(95 Counties)

These Values are Based on Project or Section Averages
Mileages are Roadway Miles Tested in The Inside Wheeltrack

TOTALS WITHOUT REGARD TO TRAFFIC VOLUME

11-15 YEARS OLD

SN	PC MILES	%	AC MILES	%	SC MILES	%	TOTAL MILES	%
0-20					7.60	2.10	7.60	.33
21-29			36.35	2.71	23.25	6.44	59.60	2.59
30-34	2.41	.40	22.65	1.69	18.80	5.20	43.86	1.91
35-39	9.90	1.66	44.93	3.35	55.64	15.40	110.47	4.80
40-44	47.58	7.97	145.99	10.89	57.16	15.82	250.73	10.91
45-49	236.51	39.59	272.37	20.32	35.29	9.77	544.17	23.67
50+	300.92	50.38	818.26	61.04	163.58	45.27	1282.76	55.79
TOTAL	597.32		1340.55		361.32		2299.19	

TABLE 4

SKID RESISTANCE INVENTORY SUMMARY
SECONDARY ROADS SYSTEM
DATA THROUGH 1976
(95 Counties)

These Values are Based on Project or Section Averages
Mileages are Roadway Miles Tested in The Inside Wheeltrack

TOTALS WITHOUT REGARD TO TRAFFIC VOLUME

16+ YEARS OLD

SN	PC MILES	%	AC MILES	%	SC MILES	%	TOTAL MILES	%
0-20			15.30	2.38	5.12	1.74	20.42	1.52
21-29			15.46	2.40	25.70	8.75	41.16	3.06
30-34	2.90	.71	36.34	5.64	30.10	10.25	69.34	5.16
35-39	16.58	4.08	34.76	5.40	9.19	3.13	60.53	4.50
40-44	102.22	25.14	59.21	9.19	51.09	17.40	212.52	15.81
45-49	162.19	39.90	135.07	20.98	57.92	19.72	355.18	26.43
50+	122.66	30.17	347.82	54.01	114.54	39.01	585.02	43.52
TOTAL	406.55		643.96		293.66		1344.17	

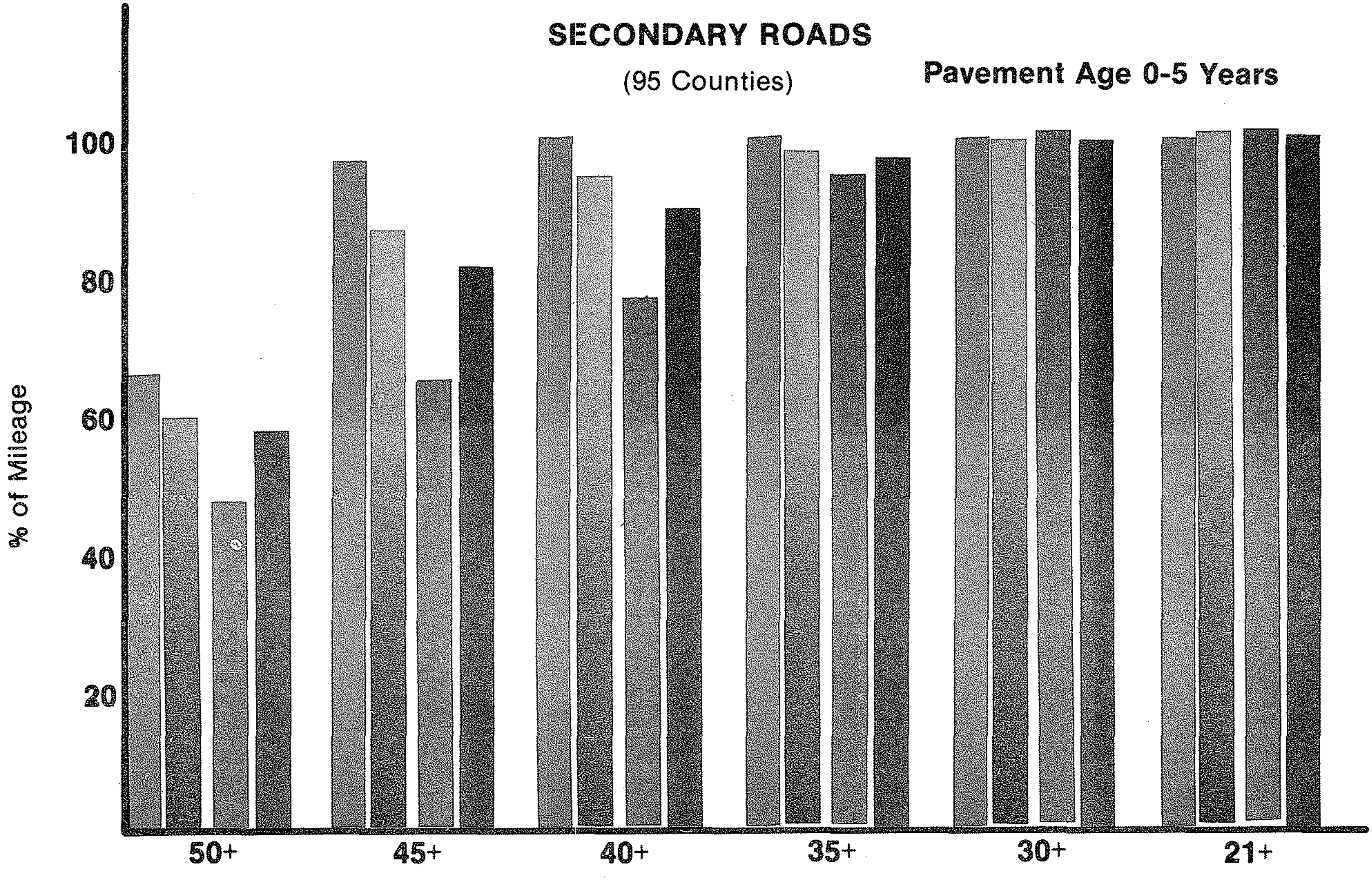

SECONDARY ROADS
(95 Counties)
Pavement Age 0-5 Years
% of Mileage
100
80
60
40
20
50+
45+
40+
35+
30+
21+
Skid Number

Figure 1

PC 834 MILES
AC 2062 MILES
SC 77 MILES
TOTAL 2973 MILES

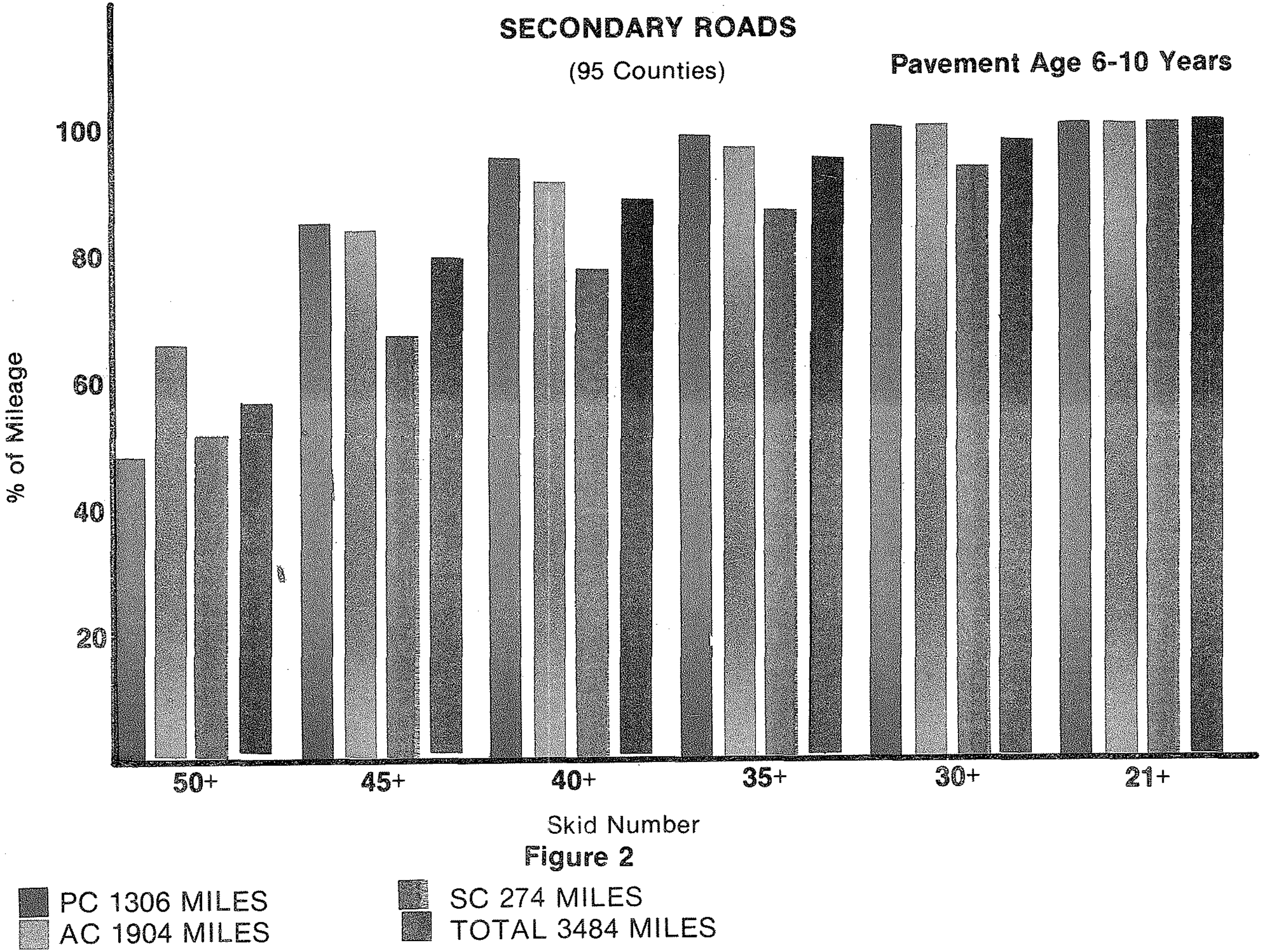

SECONDARY ROADS
(95 Counties)
Pavement Age 6-10 Years
% of Mileage
100
80
60
40
20
50+
45+
40+
35+
30+
21+
Skid Number
PC 1306 MILES
AC 1904 MILES
SC 274 MILES
TOTAL 3484 MILES

Figure 2

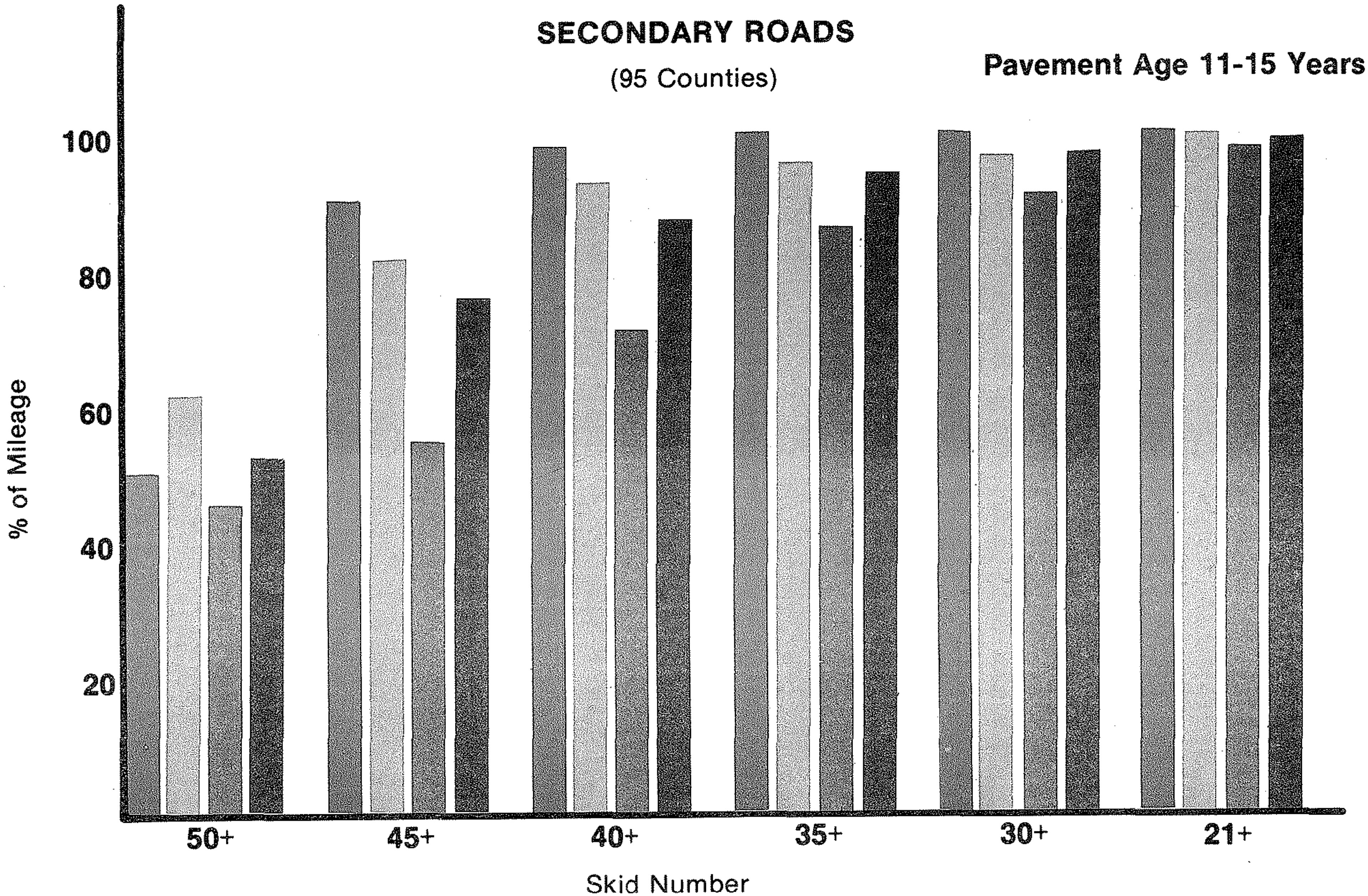


Figure 3

PC 597 MILES
AC 1341 MILES
SC 361 MILES
TOTAL 2299 MILES

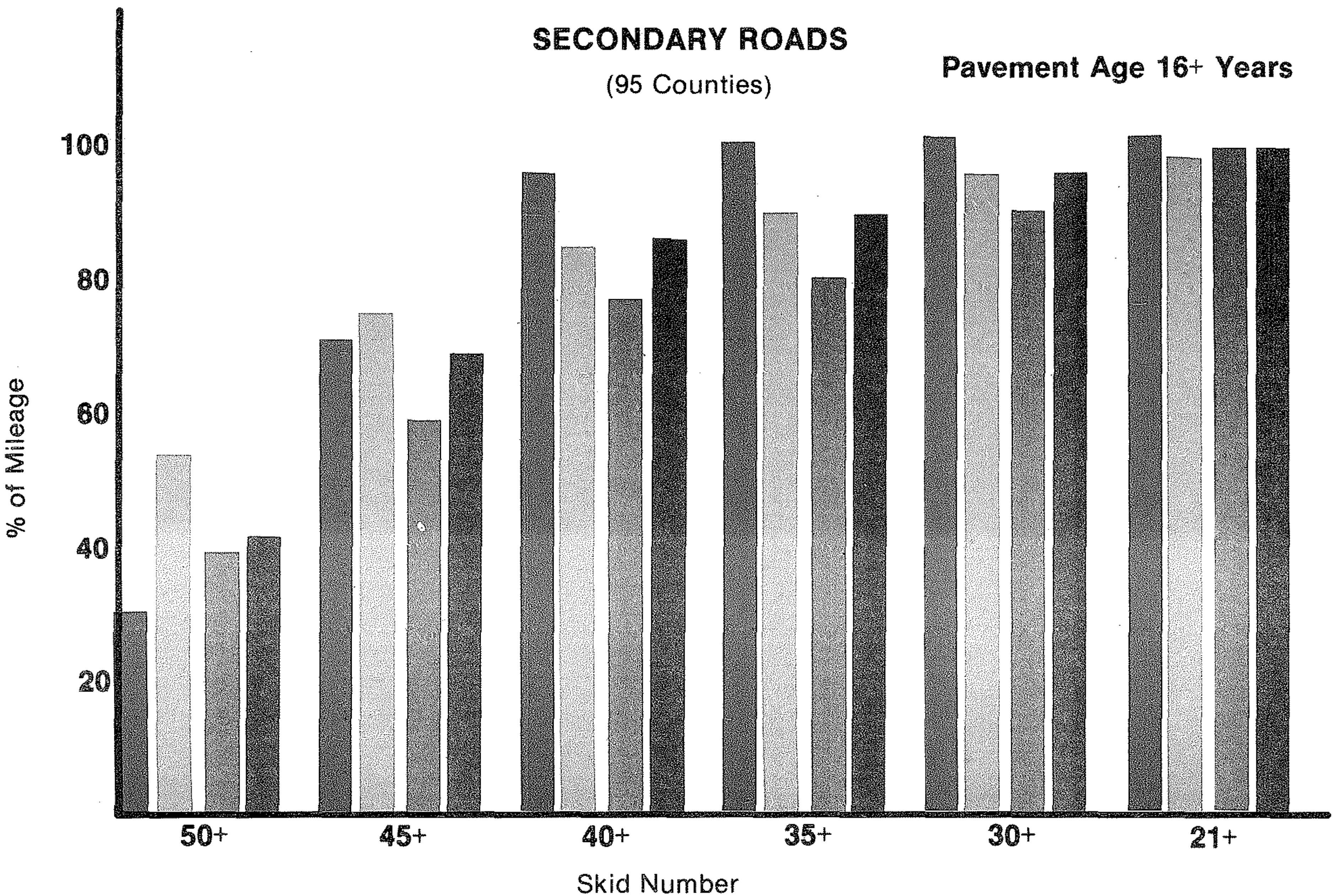

SECONDARY ROADS
(95 Counties)
Pavement Age 16+ Years
100
80
60
40
20
% of Mileage
50+
45+
40+
35+
30+
21+
Skid Number

Figure 4

PC 406 MILES
AC 644 MILES
SC 294 MILES
TOTAL 1344 MILES

0-5, 6-10, 11-15, and 16+ years of age, respectively, without regard to traffic volume. Figures 1, 2, 3, and 4 indicate the percentage of miles at or above certain stated skid numbers for pavements 0-5, 6-10, 11-15, and 16+ years of age, respectively, also without regard to traffic volume.

As an example, Table No. 1, 0-5 years old, indicates for A.C. pavement that 1.08% of the mileage has a skid number from 21-29, 1.61% from 30-34, 3.22% from 35-39, 8.89% form 40-44, 25.36% from 45-49, and 59.84% at 50 or above. Figure No. 1 shows 59.84% at 50+, 85.20% (59.84% + 25.36%) at 45+, 94.09% (59.84% + 25.36% + 8.89%) at 40+, 97.31% (59.84% + 25.36% + 8.89% + 3.22%) at 35+, 98.92% (59.84% + 25.36% + 8.89% + 3.22% + 1.61%) at 30+ and 100% (59.84% + 25.36% + 8.89% + 3.22% + 1.61% + 1.08%) at 21+.

It should be noted from Table 4 that approximately 294 miles of seal-coated surface is listed as being 16 or more years old. This age is certainly beyond the design life for this type of surface and, therefore, the data shown for this category is questionable. All data concerning age and pavement type was the latest available in the Office of Secondary Roads. It may be that some seal-coated roads are resealed as part of a normal county maintenance program and the information regarding re-sealing has not been reported as consistently as with the more permanent types of pavement resurfacing.

The average traffic count on paved secondary roads is estimated to be 250-500 vehicles per day. To make a comparison of the skid resistance of the average county paving with higher traveled sections, approximately 116 miles of paving with maximum traffic counts ranging from 900 to 2700 vehicles per day were examined in greater detail. These higher traffic roads were located in Sioux, Scott, Blackhawk, Dubuque, Linn, and Johnson counties.

A complete description of the higher traffic test sections is listed in Appendix D and summarized in Table 5. A comparison is made between the skid resistance of higher traffic secondary roads and the total mileage of paved secondary roads in the same category. As an example, the data in Table 5 shows that the average skid resistance of the 0-5 year old p.c. concrete pavements analyzed with a high traffic volume is SN=44. Ninety-five percent of the total 0-5 year old p.c. concrete mileage tested had a skid number higher than 44. This type of comparison can be made for both a.c. and p.c. pavements of various ages.

TABLE 5

Skid Resistance of Higher Traffic
Secondary Roads

Pavement Age	Pavement Type	Miles	Ave. SN	% of Total Mileage with higher SN (1)
0-5 yrs	A.C.	49.56	45	60
0-5 yrs	P.C.	14.02	44	95
6-10 yrs	A.C.	18.12	39	91
6-10 yrs	P.C.	4.44	44	85
11-15 yrs	A.C.	18.23	42	81
11-15 yrs	P.C.	5.00	40	90
16+ yrs	A.C.	8.33	31	90

(1) Similar pavement types and ages are compared; i.e., A.C. pavement 0-5 yrs. old is compared with all A.C. pavement 0-5 yrs. old without regard to traffic volume, 6-10 yrs. old A.C. pavement is compared with all A.C. pavement 6-10 yrs. old, etc.

DISCUSSION:

The inevitable question that arises when discussing the subject of skid resistance is "What level of skid resistance should be maintained?" This is a complex subject and therefore no single or direct answer can be given to this question. The skid resistance of a pavement surface must be high enough so that normal traffic maneuvers can be accomplished with a relatively high degree of safety.

Roads with poor geometry, such as sharp curves, poor sight distance, etc., would normally include more areas where braking is likely to occur, thereby, requiring better frictional properties than roads with superior geometrical features. Conversely, the road with the better geometry generally also has higher mean traffic speeds than the road with poor geometry. The higher speed vehicle requires higher frictional properties of the pavement to stop in the same distance as the lower speed vehicle.

There is presently no federal, AASHTO, ASTM, or other national standard which exists that establishes minimum skid resistance values. National Cooperative Highway Research Program Report No. 37 recommends SN=37 as the minimum permissible for standard main rural highways. This value applies to measurements at 40 mph, although it is assumed that the mean traffic speed is 50 mph. It should be re-emphasized that NCHRP Report No. 37, while a valuable guide, does not constitute a minimum standard.

The data established from the skid resistance survey shows that for pavements 0-5 years old 98% of the mileage meets or exceeds SN=35 and 95% meets or exceeds SN=40. For pavement 6-10 years of age 96% meets or exceeds SN=35 and 91% meets or exceeds SN=40. For 11-15 year old pavement, 95% meets or exceeds SN=35 and 90% meets or exceeds SN=40. For pavement 16+ years of age 90% meets or exceeds SN=35 and 86% meets or exceeds SN=40.

The overall skid resistance of seal-coat surfaces are generally lower than those of p.c. concrete or asphaltic concrete. This is probably to be expected since the life expectancy of seal-coat surfaces are generally less than of the more permanent types of paving. The skid resistance of the p.c. concrete and asphaltic concrete paving is excellent with only a small percentage of the total mileage below SN=35.

The overall skid resistance of the paved secondary road system is very good for all pavement ages. With the high level of skid resistance existing on the older paving it does not appear that polishing plays a significant role at the relatively low traffic volumes normally encountered on the secondary road system. Since there is not a critical reduction in the level of skid resistance the practice of resurveying this road system on a 5-year interval is not economically justified and the routine retesting interval should be extended to 10 years. Skid testing would be available upon request, however, if the skid resistance on any section is in question.

The lower skid resistance on some seal-coat and asphaltic-concrete sections is, in all likelihood, associated with flushing or bleeding in the wheel tracks. For the most part this phenomena can be recognized and corrected in the field without the benefit of skid tests.

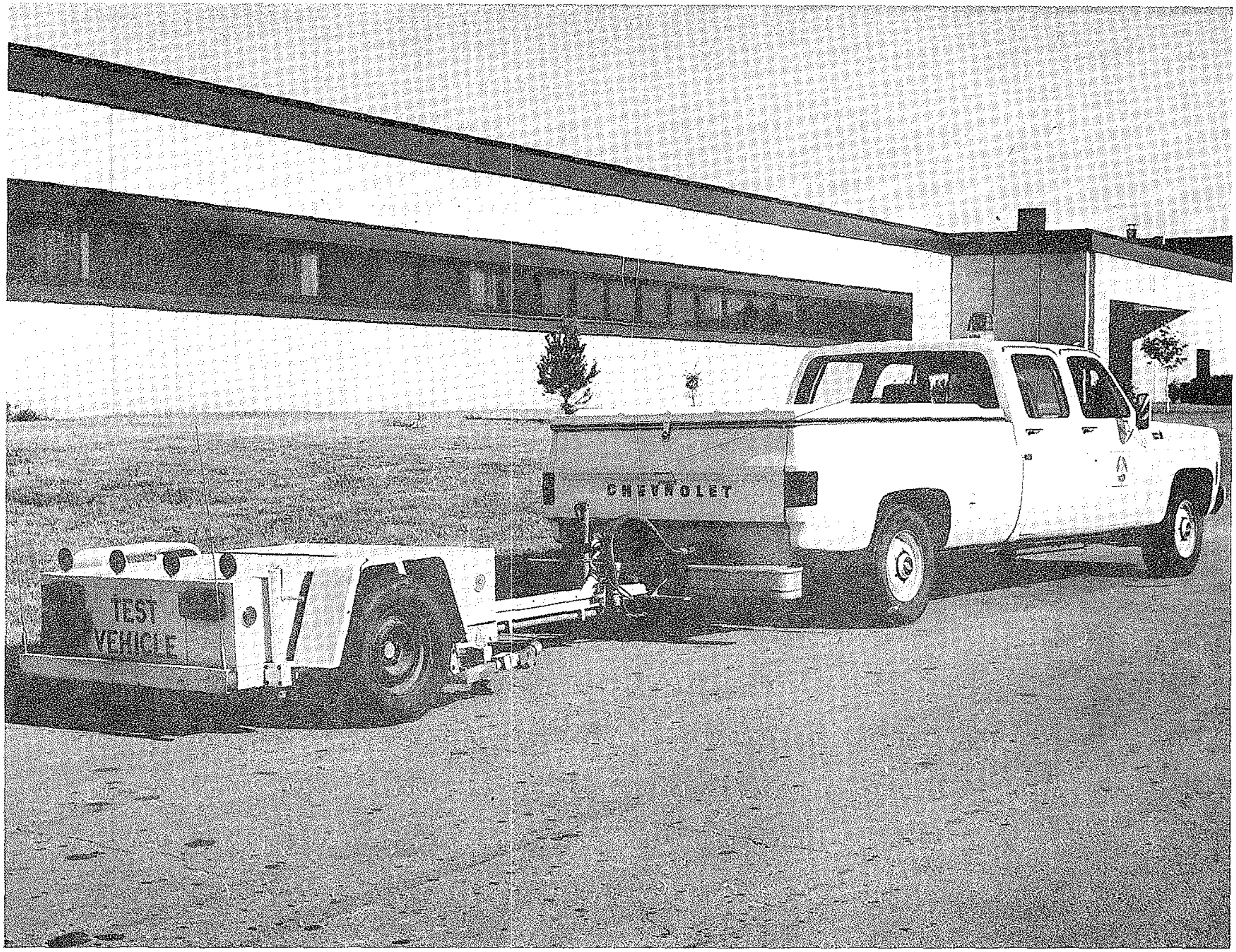
The lower skid resistance of the higher traffic volume roads indicate that polishing and subsequent loss of skid resistance is occurring and should be a matter of concern. For asphaltic concrete paving on the primary road system aggregates susceptible to a high degree of polishing under traffic are excluded from use in the surface course. This same exclusion should be seriously considered for the higher traffic volume (over 1000 vpd) roads on the secondary system. Transverse grooving of concrete paving to improve surface drainage properties for high traffic volume secondary roads should also be seriously considered.

CONCLUSIONS & RECOMMENDATIONS

The following conclusions or recommendations are derived as a result of this study:

1. The overall skid resistance of the paved secondary road system in Iowa is excellent.
2. The routine resurvey of skid resistance on the secondary road system on a 5-year interval is probably not economically justified and could be extended to a 10-year interval.

3. The higher traffic volume roads on the secondary system have a lower skid resistance than lower traffic volume roads for the same age and type of paving.
4. Serious consideration should be given to excluding polish susceptible aggregates in the surface course of asphaltic concrete paving and the incorporation of transverse grooving of portland cement concrete paving on the higher traffic volume roads on the secondary road system.



SKID TEST SYSTEM

APPENDIX B

IDA COUNTY | COUNTY NO. 47

Road No.	Beginning Mileage	Ending Mileage	Length
L-51	1.98	8.04	6.06
L-51	8.71	20.87	12.16
From N.W. 1/4 Cor. Section 6-88-41 East to Jct. Highway 20			
	0.00	3.23	3.23
L-67	0.00	10.12	10.12
M-15	2.01	9.81	7.80
D-54	7.91	9.92	2.01
D-54	16.80	17.80	1.00
M-31	1.79	9.32	7.53
M-31	9.32	19.11	9.79
D-59	21.29	22.30	1.01
M-25	0.00	9.77	9.77
M-25	12.32	16.24	3.92
From N.W. 1/4 Cor. Section 13-87-40 East to Jct. County Road M-25			
	0.45	2.63	2.18
D-15	0.00	10.39	10.39
D-15	11.39	17.41	6.02

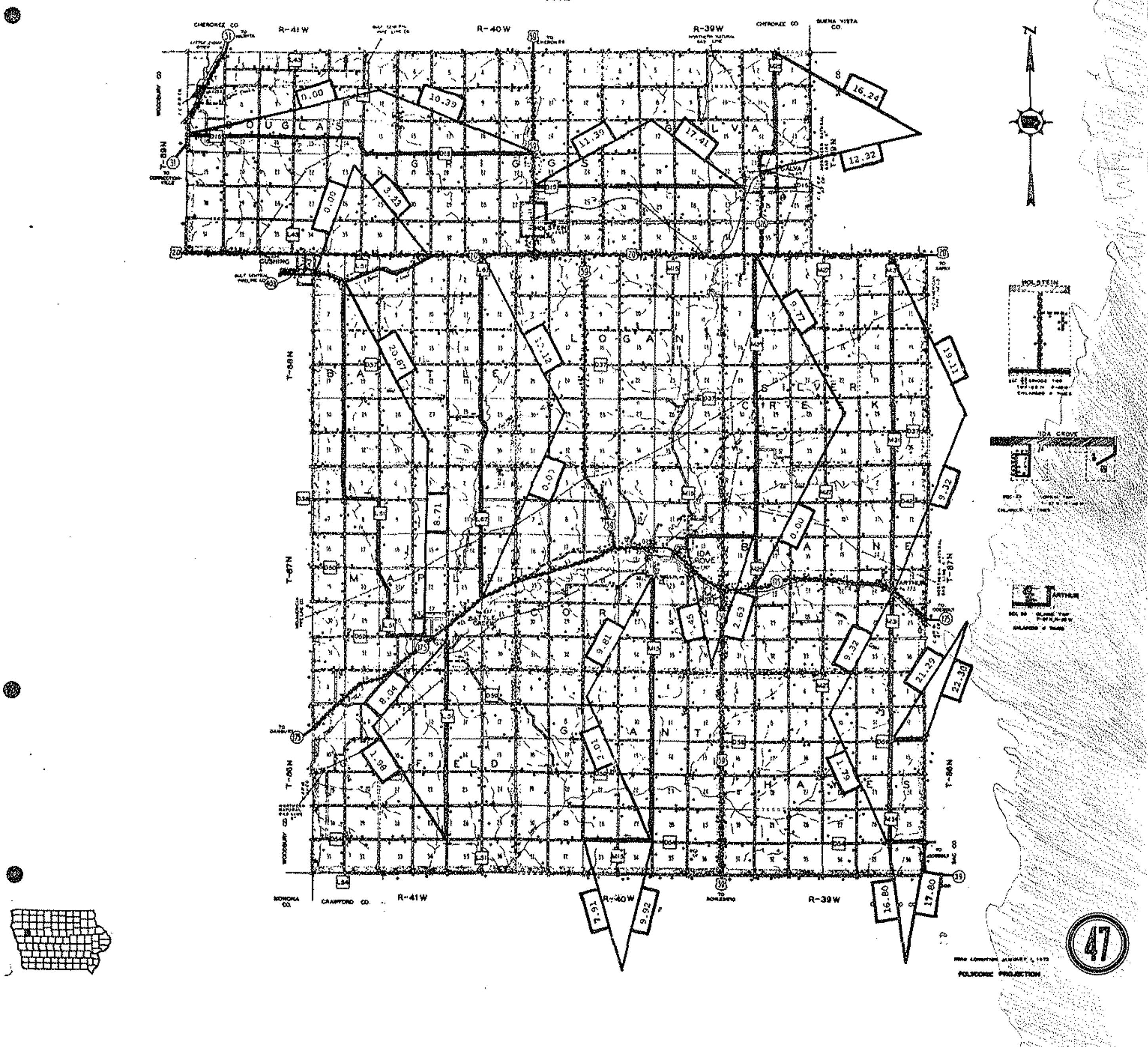
GENERAL HIGHWAY AND TRANSPORTATION MAP

IDA COUNTY

IOWA

PREPARED BY THE
IOWA STATE HIGHWAY COMMISSION
IN COOPERATION WITH THE
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
DATA OBTAINED FROM
HIGHWAY PLANNING SURVEYS DEPARTMENT

1972



APPENDIX C

COMPUTER RUN DATE - P222004
02-11-77

MATERIALS DEPARTMENT
SKID RESISTANCE TESTS

SEC. COUNTY FILE
SEC. SKID RESIST
GEOLOGY DEPT.
DIST. 3 ENGR.
COUNTY 47 CONTROL SEC. HIGHWAY COUNTY L67 BEGIN MILEPOST 0.00 END MILEPOST 10.12 IDA
COUNTY ENGR.

LANE 1 PAVT. TYPE PC DATE TESTED 11-04-76 SKID TRAILER D LAB NO. SR6-766
YEAR BUILT 19 COMPUTED MILES 10.12 PROJECT NO.

		40 M.P.H. SKID NO.					40 M.P.H. SKID NO.		
M-P	WT	REM	NB	SB	M-P	WT	REM	NB	SB
.5	I		45	49					
1.5	I		46	52					
2.5	I		49	41					
3.5	I		44	49					
4.5	I		46	46					
5.5	I		48	49					
6.5	I		41	46					
7.5	I		47	52					
8.5	I		44	49					
9.5	I		46	45					

* * * * * * SUMMARY OF DATA * * * * * *

MPH	DIRECTION	< 30	30-34	35-39	40-45	> 45	STD. DEV.	MAX.	MIN.	AVE.
40	NORTH	0	0	0	4	6	2.2	49	41	46
40	SOUTH	0	0	0	2	8	3.3	52	41	48

APPENDIX D

Skid Resistance on Highly Traveled County Roads

County	Rd. No.	Length	Surface	Year Built	Ave. SN	Date SN Tested	Max. Traffic V.P.D.
Sioux	K-64	4.55	AC	1965	42	10-11-76	1039
Sioux	K-64	3.65	AC	1973	49	10-13-76	1700
Sioux	B-40	12.60	AC	1972	50	10-11-76	1150
Scott	Y-40	5.00	PC	1963	40	8-04-75	1933
Scott	F-65	4.43	PC	1972	41	8-04-75	2720
Scott	Y-40	4.43	AC	1969	39	8-04-75	1277
Scott	F-45	3.26	AC	1973	45	8-05-75	1423
Black Hawk	D-19	3.58	PC	1972	43	8-08-74	1001
Black Hawk	T-75	3.93	AC	1973	44	8-08-74	1353
Black Hawk	C-57	6.01	PC	1972	47	8-08-74	1061
Black Hawk	V-49	4.65	AC	1969	39	8-07-74	1575
Black Hawk	V-49	3.25	AC	1969	48	8-07-74	1457
Dubuque	Y-21	3.03	AC	1972	53	7-22-75	944
Dubuque	C-9Y	4.83	AC	1952	34	7-22-75	1444
Linn	W-6E	5.13	AC	1964	51	7-30-75	1782
Linn	W-54	3.50	AC	1951	28	7-30-75	2196
Linn	E-70	4.24	AC	1971	51	7-30-75	2059
Linn	E-34	3.45	AC	1971	43	7-30-75	1494
Linn	E-34	5.40	AC	1967	41	7-30-75	1018
Linn	E-16	4.44	PC	1967	44	7-30-75	1098
Johnson	X-14	4.08	AC	1971	33	10-02-75	1388
Johnson	X-14	3.55	AC	1964	30	10-02-75	1363
Johnson	F-46	3.18	AC	1968	37	10-02-75	1405
Johnson	W-6E	3.42	AC	1971	32	9-25-75	1823