AN EVALUATION OF THE 1966-67 SKIDPROOFING PROGRAM

TSD-SS-129-70

TRAFFIC and
SAFETY
DIVISION

DEPARTMENT OF STATE HIGHWAYS
STATE OF MICHIGAN

65-6631

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

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Twenty-two locations completed under thirteen statewide contracts, let during the 1966-67 fiscal year.

Prepared By

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Abstract

This report (second in a series*) is the evaluation of the addition of a skidproofed surface at 22 locations throughout Michigan in the fiscal year 1966-67.**

The aggregate number of accidents were reduced from 807 during the year "before" to 726 in the year "after". This reduction was primarily due to a reduction of accidents occurring during wet pavement conditions (289 "before" to 217 "after").

The decreased number of accidents recorded during the "after" period was achieved despite an overall 4.3 percent increase in trunkline average daily traffic and was found to be a statistically significant reduction, resulting in a savings of $106,700 to the motoring public. The total cost of skidproofing at all locations was $806,484.

* See "Evaluation of 1965-66 Skidproofing" published by Michigan Department of State Highways in February, 1970.

** Fiscal year runs from July 1, 1966 to June 30, 1967.

General Discussion

Traffic accidents, in general, are a complex phenomena resulting from a multiplicity of factors involving both physical and mental conditions. Among the physical elements, the roadway, itself, may be a significant contributor to its relative safety (or lack thereof).

The safety of a particular section of roadway is determined by numerous individual aspects including: geometric configuration of intersections; capability of the roadway to handle an adequate flow of traffic; operational devices, such as signs and signals; and the condition of the roadway surface. It is the roadway surface which is the subject of this report.

After a period of service, roadway surfaces tend to lose their abrasiveness. This is especially true at signalized intersections where constant vehicular stopping and starting tends to polish the pavement and minimize the frictional characteristics necessary for effective braking action. The rectification of this "polishing" by applying a fine aggregate bituminous emulsion is referred to as skidproofing.*

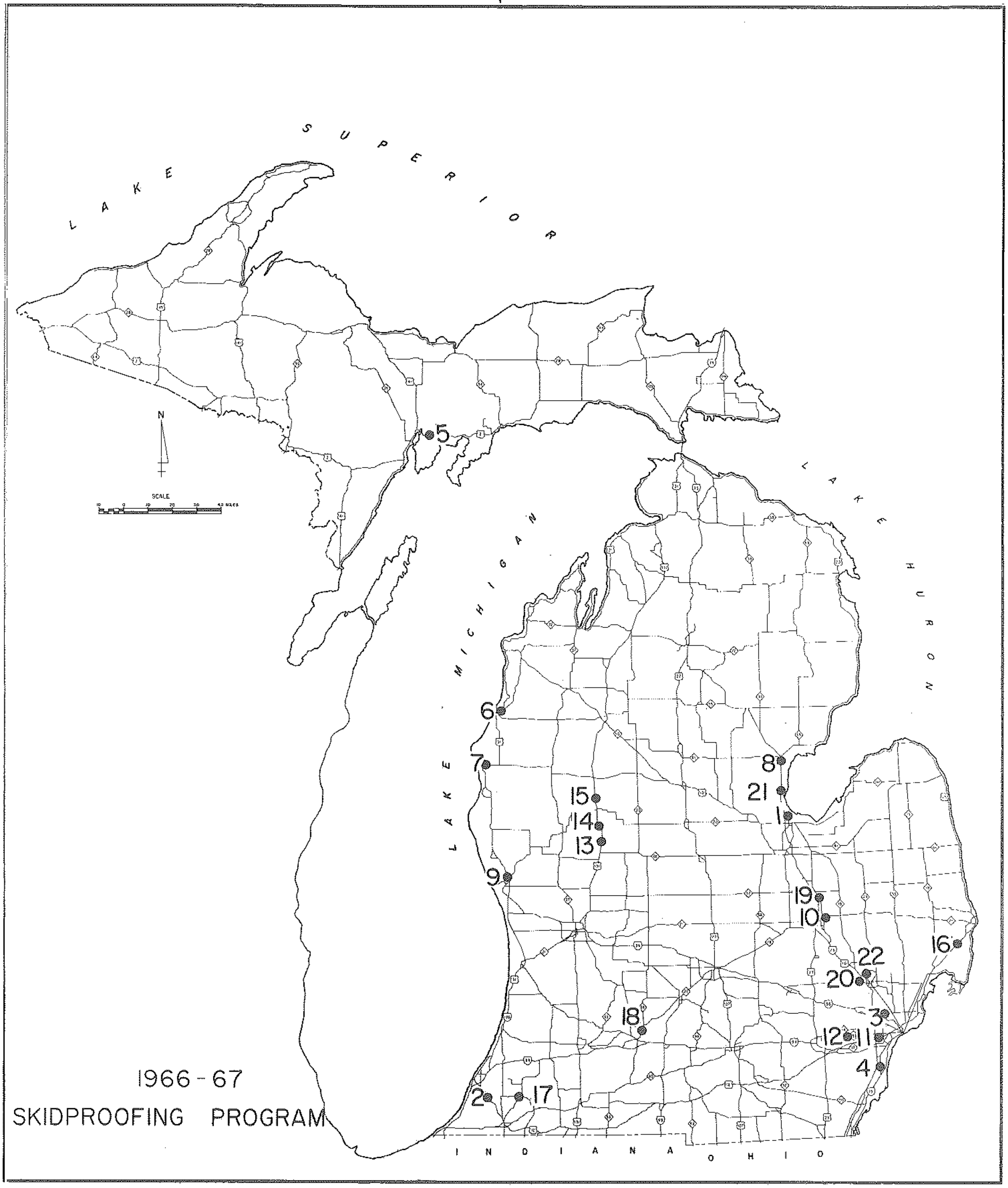
The study recognizes only the addition of skidproofing at 22 locations and takes no cognizance of other factors that might possibly affect accident potential. The majority of these locations are intersections, but some lengthy sections were also included. Because of the relatively large number of locations involved, it was deemed prohibitive, in terms of available time, to investigate the specific histories of each site as would be done with fewer

*For Skidding and Skid Test information, see Appendix A.

locations. It is reasonable to assume that the other positive and negative safety influences would tend to cancel each other in the long run.

The 22 locations covered by this report were skidproofed in 1966 and 1967 (see map). The study period in every case includes one year prior to the start of construction (the "before" period) and one year after the project completion (the "after" period).

The total cost of the thirteen contracts which covered all of the work at the 22 locations was $806,484.


LAKE SUPERIOR
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1966 - 67
SKIDPROOFING PROGRAM

Location Reference Number	INDEX OF LOCATIONS
1.	M-13 from White Street to Kiesel Avenue, Bay County (1.5 mi.)
2.	US-31 from 210' north of Red Bud Trail, northerly for 0.5 miles, Berrien County (0.5 mi.)
3.	BS-696 at Wyoming, City of Detroit, Wayne County
4.	M-85 at Sibley Road, Cities of Riverview and Trenton, Wayne County
5.	US-2, from 0.2 miles east of US-41, easterly to Ensign, Delta County (6.0 mi.)
6.	US-31 at the curve north of Memorial Bridge, City of Manistee, Manistee County (0.9 mi.)
7.	US-10 from the east limits of Ludington, to Jct. of US-31; US-31 from US-10 southerly 1 mile: US-10 from US-31, easterly 1 mile, Mason County (2.7 mi.)
8.	US-23 from Sagatoo Road to Duquite Road, Arenac County (1.1 mi.)
9.	M-20 from Muskegon River Bridge north to M-213, City of Muskegon, Muskegon County (1.4 mi.)
10.	M-21 from Dye Road to Meida Street, City of Flint, Genesee County (2.1 mi.)
11.	US-12 at Miller Road, City of Dearborn, Wayne County
12.	M-153 at Middlebelt Road, City of Garden City, Wayne County
13.	US-131 from 0.5 miles north of Morley Road northerly 0.5 miles, Mecosta County (0.5 mi.)
14.	US-131 from Fillmore Road north 0.5 miles, Mecosta County (0.5 mi.)
15.	US-131 from 0.5 miles north of Big Rapids northerly 0.9 miles, Mecosta County (0.9 mi.)
16.	US-25 from Lake Shore Pike to 0.3 miles north of Myrtle Road, St. Clair County (4.0 mi.)
17.	M-40 at M-62 west of Dowagiac, Cass County
18.	M-66, the curve at Hicks Cemetery 3.5 miles north of the City of Battle Creek, Calhoun County
19.	M-54 from south of Hill Road to north of M-54BR, Genesee County (0.5 mi.)
20.	M-59 at Elizabeth Lake Road, Oakland County (0.4 mi.)
21.	US-23 from Grove Street northerly to Old Kawkawlin Road, Bay County (1.4 mi.)
22.	US-10 from Voorheis Drive to Watkins Lake Road, City of Pontiac, Oakland County (1.1 mi.)

Compilation of Accident Data

The accident data found in the Accident Record Table was obtained from a Michigan Department of State Highways computer printout list.

The accidents recorded represent only those which occurred on the skidproofing mat or those which involved braking on the skidproofed surface.

ACCIDENT RECORD TABLE

Loc. Ref. No.	BEFORE PERIOD				AFTER PERIOD				% Change ADT
	Total Accs.	Injury Accs. (Persons Injured)	Fatal Accs. (Persons Killed)	Wet Surface Accs.	Total Accs.	Injury Accs. (Persons Injured)	Fatal Accs. (Persons Killed)	Wet Surface Accs.	
1.	55	25(42)	0(0)	20	52	15(20)	0(0)	16	+ 6.8
2.	12	6(9)	0(0)	6	5	4(6)	0(0)	3	+ 1.8
3.	57	23(38)	0(0)	20	54	20(35)	0(0)	19	0
4.	23	8(9)	0(0)	7	12	2(4)	0(0)	5	- 6.8
5.	20	5(9)	0(0)	6	16	11(22)	0(0)	4	- 3.8
6.	10	2(3)	0(0)	4	3	1(1)	0(0)	1	+ 2.2
7.	36	15(20)	0(0)	7	37	19(31)	0(0)	6	+ 5.4
8.	23	13(21)	0(0)	16	13	7(14)	0(0)	4	+ 5.5
9.	43	19(27)	0(0)	11	19	4(6)	0(0)	5	+ 8.6
10.	87	43(62)	0(0)	31	74	37(54)	0(0)	17	+13.2
11.	97	45(71)	0(0)	42	72	32(58)	0(0)	22	+10.6
12.	66	23(35)	1(1)	18	72	28(44)	0(0)	29	+12.5
13.	7	2(6)	0(0)	3	6	2(5)	0(0)	3	+ 4.7
14.	6	3(4)	0(0)	2	4	0(0)	0(0)	1	+ 4.7
15.	12	7(15)	0(0)	5	10	2(3)	0(0)	4	+ 9.1
16.	53	17(23)	0(0)	20	33	8(12)	2(3)	11	+ 8.9
17.	6	2(4)	0(0)	2	6	0(0)	0(0)	2	-11.8
18.	4	1(1)	0(0)	2	2	0(0)	0(0)	0	+ 6.2
19.	26	11(27)	0(0)	13	33	9(21)	1(1)	8	- 2.2
20.	40	12(19)	0(0)	9	37	18(33)	1(1)	8	+17.6
21.	13	3(6)	0(0)	3	9	3(6)	0(0)	0	+ 5.6
22.	111	49(86)	1(1)	42	157	66(119)	0(0)	49	+ 8.4
TOTALS	807	334(537)	2(2)	289	726	282(494)	4(5)	217	+ 4.3

RESULTS OF SKID TESTS

(40 mph coefficients of wet sliding friction)

Location Reference Number	"Before" Skid Test	"After" Skid Test
1.	0.26	0.41
2.	0.18	-
3.	-	0.36
4.	-	0.38
5.	0.20	-
6.	0.18	-
7.	0.18	-
8.	0.26	0.38
9.	0.23	0.37
10.	-	0.42
11.	-	0.35
12.	-	0.35
13.	0.23	0.41
14.	0.25	0.39
15.	0.30	0.34
16.	-	0.44
17.	0.21	-
18.	-	0.42
19.	0.26	-
20.	0.26	0.35
21.	0.23	0.46
22.	0.38	-

Results

In the one year prior to the application of skidproofed surfaces at the 22 locations, there were 807 accidents which occurred within the projects' boundaries. During the one year "after" period, 726 accidents occurred within the same limits, a decrease of 81 accidents.

Accidents involving a personal injury or a fatality declined from the 336 recorded during the "before" period to 292 during the "after" period. The total number of persons either injured or killed, as a result of these accidents, decreased from 539 "before" to 499 "after".

It was noted also that during the "after" period 217 accidents occurred on wet pavement, a reduction of 72 from the 289 "before".

The aggregate average daily trunkline traffic recorded at these 22 locations increased by 4.3 percent during the "after" period.

Conclusions

The 10 percent reduction of total accidents (from 807 "before" to 726 "after") was found to be statistically significant at the 99 percent confidence level and attributable to the single common safety improvement, the addition of skidproofing (see Appendix "B").

It is evident that the aggregate accident reduction (of 81) is due primarily to the reduction of "wet" accidents (289 "before" - 217 "after" = 72). The reduction of wet surface accidents is the primary intent of "skidproofing" and the general improvement of "wet" surface frictional coefficients was, in fact, translated into "wet" surface accident reduction.

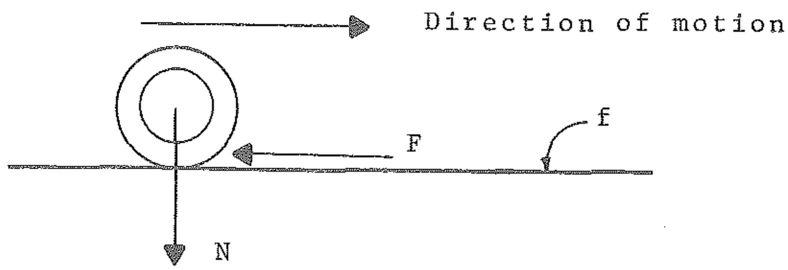
A number of skidproofing projects involved relatively lengthy stretches of roadway (the six mile section referenced by location #5, cost $95,194). Since accident patterns generally develop at specific localized locations (primarily intersections), it is evident that a considerable percentage of the cost of such "strip" projects is being used to treat non-safety needs. These costs must then be justified on the basis of other criteria (such as maintenance value). The practice of using safety-intended monies to "skidproof" long projects has now been discontinued in favor of treating localized high accident locations.

A benefit to the motoring public of $106,700 (maintenance cost saving is not included) was accrued during the composite year "after" the skidproofing projects were completed (see Appendix "C"). This is money saved by motorists having fewer accidents and is attributable to the skidproofing project.

APPENDIX "A"

Skidding and Skid Tests

The treatment of pavements to provide for safer stopping distances takes advantage of a basic principle of physics (illustrated below).



F = friction force acting to stop vehicle

N = ¼ weight of a four-wheeled vehicle

f = coefficient of friction between a rubber tire and roadway surface

where

$$F = f \times N$$

Stopping distance (once the process has been initiated) is a function of three basic variables:

(1) condition of the vehicle's braking system

(2) frictional capabilities of the vheicle's tires

(3) frictional capabilities of the roadway surface

The Michigan Department of State Highways has no control over the first two variables and must, therefore, confine its efforts to improving the frictional role contributed by the roadway surface. In essence it must increase the frictional coefficient between the road surface and the vehicle's tires.

The Department of State Highways performs thousands of skid tests each year through its Testing and Research Division. Many of the tests are performed in response to requests from other divisions, including the Traffic and Safety Division, in an attempt to pinpoint locations where an unusual number of accidents involved skidding particulary when the pavement was wet.

For a description of the actual skid testing procedure (see photo of skid testing device below) reference is made to Research Report No. R-585 ("Summaries of Michigan Pavement Skid Resistance: 1965 Test Program").

The skid test is initiated by actuating an electrically controlled test cycle. The cycle of events which occur is as follows:

1. Solenoids open water valves, spilling approximately 3.5 gallons of water directly into the wheel path of the skid trailer.
2. Trailer brakes are automatically locked. At this point the operator of the towing vehicle must exercise care in maintaining the specified test speed (40 mph).
3. A reading is taken which indicates the force required to pull the trailer.
4. After dragging the skidometer trailer for approximately 60 feet, the water solenoids are closed and the brakes are released simultaneously.

Skid test values are expressed as 40 miles per hour, wet, sliding coefficients of friction. Coefficient of friction of 0.40 is generally considered the dividing point between "satisfactory" and "unsatisfactory". Surfaces below 0.35 could be dangerous under wet conditions, depending on vehicle speeds and road alignment. Surfaces with coefficients of 0.20 or less are in the category of packed snow or ice.

APPENDIX "B"

The Significance of Accident Reduction

To test the aggregate accident reduction for statistical "significance" reference is made to the "Null Hypothesis" (H_0)* stating that there is no change in "before" and "after" accident numbers.

Where

	"Before"	"After"
Traffic Volume	A	B
Number of Accidents	C	D

Assume

$$A/B = C/D \qquad (H_0)$$

using Chi-square statistics

$$\chi^2 = \frac{(AD - BC)^2 N}{(A + B)\ (C + D)\ (A + C)\ (B + D)}$$

Where $N = A + B + C + D$

From Chi-square "2 x 2" Table

$\chi^2_{.99,1}$ (read Chi-square at the 99 percent confidence level, with 1 degree of freedom) = 6.63

and using

A = 383,365
B = 399,885
C = 807
D = 726

then

$$\chi^2 = 8.36 > 6.63$$

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* Reference is made to "Statistical Inference" by Helen M. Walker, page 100.

Therefore, the original hypothesis, H_0, (stating that the number of accidents during the "after" period could have been equal to the number of accidents in the "before" period) is rejected within a 99 percent level of confidence and the reduction is shown to be statistically significant.

APPENDIX "C"

Computed Benefits Derived Through Accident Reduction

Cost Analysis

The method of evaluating accident costs, used below, is given on page 67 of Roy Jorgensen's report of Highway Safety Improvement Criteria, 1966 edition. This same method is given in the Bureau of Public Roads IM21-3-67.

In the following analysis the costs provided by the National Safety Council are:

Death - $34,400

Non-fatal Injury - $1,800

Property Damage Accident - $310

$$B = \frac{ADT_a}{ADT_b} x\ (Q\ R_1{}^* + 310\ R_2{}^*)$$

where

B = annual benefit in dollars

ADT_a = average traffic volume after the improvement (399,885)**

ADT_b = average traffic volume before the improvement (383,365)**

R_1 = reduction in fatalities and injuries combined (539-499=40)

R_2 = reduction in property damage accidents (471-434=37)

and $$Q = \frac{34{,}400 + (I/F \times 1{,}800)}{1 + I/F}$$

where

I/F = ratio of injuries to fatalities that occurred statewide during the year 1966.

$$= \frac{156{,}694}{2{,}296}$$
$$= 68.4$$

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* In the above noted reference, R_1 is listed as $A_{fi} \times P_{fi}$. It is evident upon inspection that $P_{fi} = \frac{R_1}{A_{fi}}$ (see definition above)

so that $A_{fi} \times P_{fi} = A_{fi} \times \frac{R_1}{A_{fi}} = R_1$

Similarly R_2 replaces $A_{pd} \times P_{pd}$

** Aggregate trunkline ADT for all 22 locations.

Therefore,

$$Q = \frac{34,400 + (68.4 \times 1,800)}{1 + 68.4}$$

$$= 2,270$$

The computed benefits to the motoring public accrued during the year "after" period is then:

$$B = \frac{399,885}{383,365} (2,270 \times 40 + 310 \times 37) = \$106,700$$