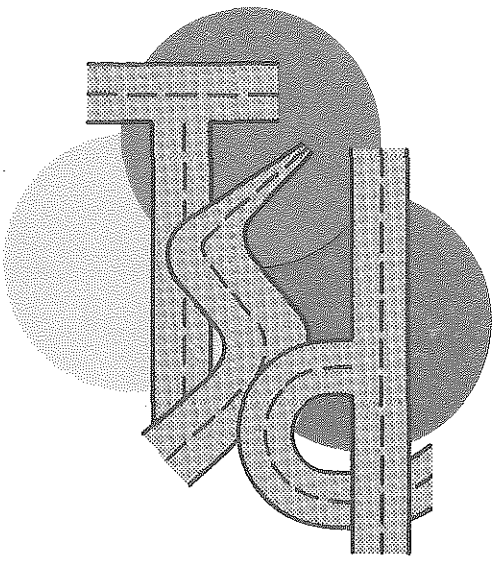
MICHIGAN DEPARTMENT OF
TRANSPORTATION LIBRARY
LANSING 48909

# AN EVALUATION OF THE 1967-68 SKIDPROOFING PROGRAM

TSD-SS-146-70



## TRAFFIC and SAFETY DIVISION

DEPARTMENT OF STATE HIGHWAYS
STATE OF MICHIGAN

MICHIGAN STATE HIGHWAY COMMISSION

Charles H. Hewitt . . . . . Chairman
Wallace D. Nunn . . . . . Vice Chairman
Louis A. Fisher . . . . . Member
Claude J. Tobin . . . . . Member

# AN EVALUATION OF THE 1967-68 SKIDPROOFING PROGRAM

TSD-SS-146-70

Nine locations completed under seven statewide contracts, let during the 1967-68 fiscal year.

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

Henrik E. Stafseth . . . . State Highway Director
J. P. Woodford . . . . . Deputy Director - Chief Engineer
G. J. McCarthy . . . . . Assistant Deputy Director - Engineering and Operations
J. G. Hautala . . . . . Chief, Bureau of Operations
H. H. Cooper . . . . . Engineer of Traffic and Safety
L. J. Doyle . . . . . Assistant Engineer of Traffic and Safety
M. R. Hoffman . . . . . Traffic Safety & Surveillance Engineer
A. A. Lampela . . . . . Supervising Engineer, Surveillance Unit
E. W. McGillivray . . . . Study Engineer

Department of State Highways
State Highways Building - P. O. Drawer K
Lansing, Michigan 48904

November, 1970

Abstract

This report (third in a series*) is the evaluation of the addition of a skidproofed surface at nine locations throughout Michigan in the fiscal year 1967-68.**

The aggregate number of accidents was reduced from 273 during the year "before" to 224 in the year "after". This reduction was primarily due to a reduction of accidents occurring during wet pavement conditions (120 "before" to 69 "after").

The decreased number of accidents recorded during the "after" period was achieved despite an overall 5.1 percent increase in trunkline average daily traffic and was found to be a statistically significant reduction, resulting in a savings of $144,500 to the motoring public. The total cost of skidproofing at all locations was $250,681.

*See "Evaluation of 1965-66 Skidproofing" published by Michigan Department of State Highways in February, 1970 and "Evaluation of 1966-67 Skidproofing" published April, 1970.

** The fiscal year is from July 1, 1967 to June 30, 1968.

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.

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 usage, 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 correction of this "polishing" by applying a fine aggregate bituminous emulsion is referred to as skidproofing.*

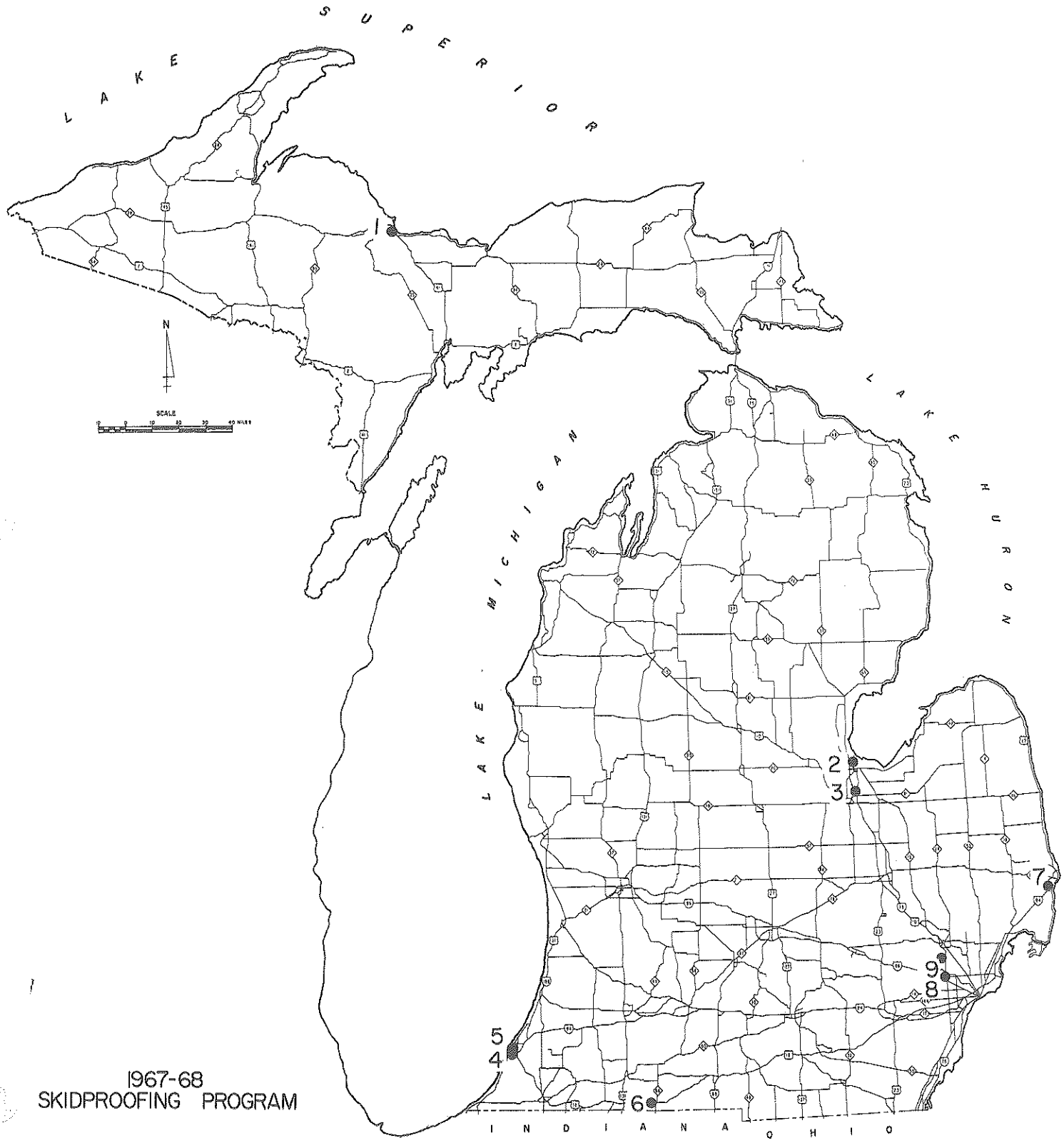
Six of the nine locations involve the approaches to an intersection while the remaining three involve lengthier sections of roadway.

The nine locations covered by the report were skidproofed in 1967 or 1968 (see map). The study period in every case is one year prior to the start of skidproofing (the "before

*For Skidding and Skid Test Information, see Appendix A

period) and one year after the project completion (the "after" period).

The total cost of the seven contracts which covered all the work at the nine locations was $250,681.




1967-68
SKIDPROOFING PROGRAM

## INDEX OF LOCATIONS

| Location Reference Number | |
|---|---|
| 1. | M-28, US-41 from Hampton Street to Genesee Street, inside lanes only, City of Marquette, Marquette County (0.15 miles) |
| 2. | BL-75 from I-75 to M-13, Monitor Township, Bay County (2.20 miles) |
| 3. | I-75 from M-13 northerly (0.15 miles), Kochville Township, Saginaw County |
| 4. | BL-94 (Main Street) from State Street-First Street to US-33, US-31, (Niles Avenue), City of St. Joseph, Berrien County (0.20 miles) |
| 5. | US-33 (Niles Avenue) from 150 feet north of BL-94 (Main Street) to BL-94 (Main Street), City of St. Joseph, Berrien County (0.30 miles) |
| 6. | US-12 from its west junction with M-66 west 1.41 miles, City of Sturgis, St. Joseph County |
| 7. | Northbound US-25BR (Military St.) from M-29 to Center Street and southbound US-25BR (Electric St.) from M-29 to Conner Street, in the Cities of Marysville and Port Huron, St. Clair County (3.37 miles). This project also included 2,000 feet of curb and gutter from 315 feet southwest of M-29 in Marysville to Dove Street in Port Huron for roadside control. |
| 8. | Northbound US-24 (Telegraph Road) from 150 feet north of Joy Road to 475 feet south of West Chicago Road, Redford Township, Wayne County (0.39 miles) |
| 9. | US-24 (Telegraph Road) at BS-96 (Grand River Avenue), City of Detroit, Wayne County (all quadrants) |

Compilation of Accident Data

The accident data found in the Accident Record Table was obtained from a Michigan Department of State Highways computer printout and checked with local police agencies.

ACCIDENT RECORD TABLE

| | BEFORE PERIOD | | | | AFTER PERIOD | | | |
|---|---|---|---|---|---|---|---|---|
| Loc. Ref. No. | Total Accs. | Injury Accs. | Fatal Accs. | Wet Surface Accs. | Total Accs. | Injury Accs. | Fatal Accs. | Wet Surface Accs. |
| | | Persons Injured | Persons Killed | | | Persons Injured | Persons Killed | |
| 1 | 20 | 6(7) | 0(0) | 14 | 16 | 4(8) | 0(0) | 5 |
| 2 | 26 | 14(23) | 0(0) | 10 | 25 | 14(20) | 0(0) | 6 |
| 3 | 12 | 3(7) | 0(0) | 8 | 2 | 1(1) | 0(0) | 1 |
| 4 | 45 | 13(20) | 0(0) | 22 | 14 | 1(1) | 0(0) | 8 |
| 5 | 2 | 0(0) | 0(0) | 1 | 1 | 0(0) | 0(0) | 0 |
| 6 | 31 | 10(20) | 1(1) | 16 | 21 | 7(9) | 0(0) | 9 |
| 7 | 53 | 18(36) | 0(0) | 23 | 43 | 8(12) | 1(1) | 17 |
| 8 | 30 | 7(8) | 0(0) | 8 | 39 | 9(18) | 0(0) | 3 |
| 9 | 54 | 15(28) | 0(0) | 18 | 63 | 26(43) | 0(0) | 20 |
| TOTALS | 273 | 86(149) | 1(1) | 120 | 224 | 70(112) | 1(1) | 69 |

## RESULTS OF SKID TESTS

40 m.p.h. coefficients of wet sliding friction

| Location Reference Number | "Before" Skid Test | "After" Skid Test |
|---|---|---|
| 1 | 0.25 | 0.53 |
| 2 | 0.26 | —— |
| 3 | 0.21 | —— |
| 4 | 0.21 | —— |
| 5 | 0.21 | —— |
| 6 | 0.24 | —— |
| 7 | NB 0.27<br>SB 0.24 | —— |
| 8 | 0.25 | 0.59 |
| 9 | — | —— |

Results

In the one year prior to the application of skidproofed surfaces at the 9 locations, there were 273 accidents which occurred within the projects' boundaries. During the one year "after" period, 224 accidents occurred within the same limits, a decrease of 49 accidents. The aggregate average daily trunkline traffic recorded at these 9 locations increased by 5.1 percent during the "after" period, which adds significance to the accident reductions.

Accidents involving personal injury and fatalities decreased from the 87 recorded during the "before" period to 71 during the "after" period (18.4 percent). The total number of persons either injured or killed, as a result of these accidents, decreased from 150 "before" to 113 "after" (24.7 percent).

Accidents that occurred on a wet surface pavement decreased from the 120 "before" to 69 "after" (42.5 percent).

Conclusions

The 17.9 percent reduction of total accidents (from 273 "before" to 224 "after") was found to be statistically significant at the 99 percent confidence level and attributable to the single common safety improvement, the application of skidproofing material (see Appendix "B").

It is evident that the aggregate accident reduction of 49 is due primarily to the reduction of wet surface accidents (120 "before" - 69 "after" = 51).

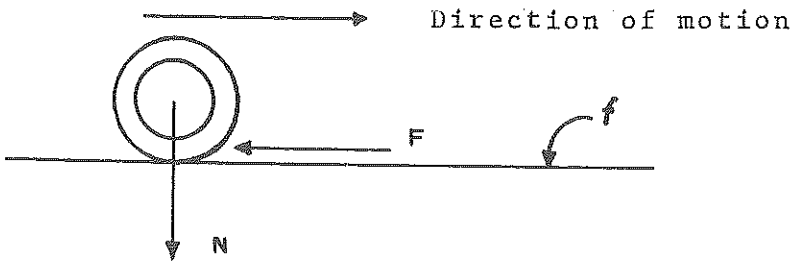
Three of the skidproofing projects involved relatively long sections of roadway (for example, the 3.37 mile section referenced by location #7 at a cost of $99,673.76). Since accident patterns generally develop at specific localized locations (primarily intersections), it is evident that a considerable 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 $144,500 (maintenance cost savings is not included) was accrued during the composite year "after" the skidproofing projects were completed (see Appendix "C"). This is money saved by motorists as a result of fewer accidents and is attributable to the skidproofing projects.

# 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 vehicle'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, particularly 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. Coefficients 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

### Statistical Theory

Let $X_{bi}$ = number of accidents at location i before the skid-proofing

$X_{ai}$ = number of accidents at location i after the skidproofing

Suppose: $X_{bi}$ is binomial distribution with parameters $P_{bi}$ and $N_{bi}$, and

$X_{ai}$ is binomial distribution with parameters $P_{ai}$ and $N_{ai}$

Let $P_{bi}$ and $P_{ai}$ denote respectively the probabilities of the occurrence of accidents before and after the skidproofing for location i.

$N_{bi}$ = traffic volume at location i before the skidproofing

$N_{ai}$ = traffic volume at location i after the skidproofing

Hypothesis $H_o$: $P_{bi} = P_{ai}$ for all i
The skidproofing is ineffective

Assume: $P_{bi} = P_b$ for all i

$P_{ai} = P_a$ for all i

Then $\hat{P}_b = \frac{T_b}{N_b}$ where $\sum_{i=1}^{N} N_{bi} = N_b$ = total traffic volume before skidproofing

$T_b = \sum_{i=1}^{N} X_{bi}$ = total number of accidents before the skidproofing

$\hat{P}_b = \frac{\text{total number of accidents before skidproofing}}{\text{total traffic volume before skidproofing}}$

$\hat{P}_a = \frac{T_a}{N_a}$ where $\sum_{i=1}^{N} N_{ai} = N_a$ = total traffic volume after skid-proofing

$T_a = \sum_{i=1}^{N} X_{ai}$ = total number of accidents after the skidproofing

$\hat{P}_a = \frac{\text{total number of accidents after skidproofing}}{\text{total traffic volume after skidproofing}}$

$\hat{P}_b$ is approximately normally distributed with mean $P_b$ and variance $\frac{P_b (1 - P_b)}{N_b}$

$\hat{P}_a$ is approximately normally distributed with mean $P_a$ and variance $\frac{P_a\ (1 - P_a)}{N_a}$

Using $Z = \dfrac{\hat{P}_b - \hat{P}_a}{\sqrt{\dfrac{\hat{P}_b\ (1 - \hat{P}_b)}{N_b} + \dfrac{\hat{P}_a\ (1 - \hat{P}_a)}{N_a}}}$

Reject $H_o$ at $\alpha = .01$ level if $Z > 2.33$

Application of Accident Data

$T_b = 273$ $\qquad$ $T_a = 224$

$N_b = 254{,}600 \times 365$ $\qquad$ $N_a = 267{,}500 \times 365$

$N_b = 92{,}929{,}000$ $\qquad$ $N_a = 97{,}637{,}500$

$$\hat{P}_b = \frac{T_b}{N_b} = \frac{273}{92{,}929{,}000} = 2.93 \times 10^{-6}$$

$$\hat{P}_a = \frac{T_a}{N_a} = \frac{224}{97{,}637{,}500} = 2.29 \times 10^{-6}$$

$$Z = \frac{\hat{P}_b - \hat{P}_a}{\sqrt{\dfrac{\hat{P}_b\ (1 - \hat{P}_b)}{N_b} + \dfrac{\hat{P}_a\ (1 - \hat{P}_a)}{N_a}}} = 2.74$$

Let $\alpha = .01$

We reject $H_o$ since $Z = 2.74 > 2.33$

Hence we conclude that the skidproofing program does reduce accidents significantly.

# 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 IM 21-3-67.

In the following analysis the costs provided by the National Safety Council for year 1969 are:

Death - $41,700

Non-fatal - $2,500

Property Damage Accident - $380

$$B = \frac{ADT_a}{ADT_b} \times (Q\ R_1^* + 380\ R_2^*)$$

where

B = benefit in dollars

$ADT_a$ = average traffic volume after the improvement (267,500)**

$ADT_b$ = average traffic volume before the improvement (254,600)**

$R_1$ = reduction in fatalities and injuries combined (150-113) = 37

$R_2$ = reduction in property damage accidents (186-153) = 33

and $Q = \frac{\$41,700 + (I/F \times 2,500)}{1 + I/F}$

where

I/F = ratio of injuries to fatalities that occurred statewide, on all U.S. and Interstate routes in the state during the year 1969.

$= \frac{26,166}{602} = 43.5$

---

*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 $A_{fi} \times P_{fi} = A_{fi} \times \frac{R_1}{A_{fi}} = R_1$. Similiarly $R_2$ replaces $A_{pd} \times P_{pd}$.

**$ADT_a$ and $ADT_b$ have been computed as average figures covering the entire project for the study period.

Therefore,

$$Q = \frac{41,700 + (43.5 \times 2,500)}{1 + 43.5} = 3380.9$$

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

$$B = \frac{267,500}{254,600} \times (3380.9\ R_1 + 380\ R_2)$$

$$B = \frac{267,500}{254,600} \left[3380.9\ (37) + 380\ (33)\right]$$

$$B = 1.05 \left[125,093.3 + 12,540\right]$$

$$B = 1.05 \left[137,633.3\right]$$

$$B = \$144,500$$