Concrete Median Barrier Study During Periods of Snow Accumulation

TSD-360-77

TRAFFIC and
SAFETY
DIVISION

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
AND TRANSPORTATION

MICHIGAN DEPARTMENT
OF
STATE HIGHWAYS AND TRANSPORTATION

Concrete Median Barrier Study
During Periods of Snow Accumulation

TSD-360-77

By
William H. Opland
Traffic Engineer

May, 1977

ACKNOWLEDGMENTS

The work described in this report was conducted by the Traffic and Safety Division under the general supervision of Mr. Donald E. Orne, Engineer of Traffic and Safety. The research was performed by the division's Safety Programs Unit under the direct supervision of Mr. Richard L. Blost.

A special note of thanks goes out to Mr. Allen Lampela, Supervising Engineer, Standards Subunit, Engineering Development, for his assistance in providing data from prior concrete median barrier studies. Appreciation is expressed to Mr. Arturs Bekmanis for his helpful counsel concerning Delphi techniques. In addition, special appreciation goes out to Ms. Kim Bernson, Student Assistant, Safety Programs Unit, who assisted in the data gathering process.

Special thanks are in order for Mr. Preston Masters of the Accident Analysis Subunit and Sergeant Hayes of the Michigan Department of State Police for their cooperation in providing access to the accident record files. Finally, appreciation and thanks are expressed to all of the District Traffic and Maintenance Engineers who participated in the Delphi Survey.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The purpose of this study was to examine the effects that snow accumulation in concrete median barrier areas has on the safety of vehicles striking the concrete wall. By analyzing concrete median barrier accidents which occurred on Michigan freeways during the winter months, an improved perspective of the type of accident experience and the magnitude of the problem was obtained.

To supplement the accident analysis, a Delphi Survey was conducted of various district personnel to obtain a better understanding of the operational problems that are occurring in the field. The results of this survey not only helped to more fully define the problem, but also provided a valuable source of information in helping to arrive at operational solutions to the problem.

RECOMMENDATIONS

In summary, the problem of snow accumulation along concrete median barrier sections of freeway does not appear to create a high degree of seriousness to the motoring public. A total of 226 barrier accidents took place throughout the 5-winter study period during which no fatalities occurred. Of these, 16 critical accidents (six hurdles and 10 rollovers) occurred.

The effectiveness of concrete median barrier (CMB) during winter periods of snow accumulation seems to be closely associated with both snow removal procedures and effective wall heights. The results of this study indicate that the safety and effectiveness of concrete median barrier can be improved by positively addressing a series of items that were found to greatly affect the vehicle/CMB/environmental relationship. Based on the results of both the accident analysis and the Delphi Survey as conducted in this study, the following recommendations are presented:

1. Since the snowplowing process known as "verticalizing" has met with much success in District 6, this method should be considered for possible use on a statewide basis in concrete median barrier shoulder areas.

2. Snow removal procedures along concrete median barriers that create traffic backups for the motoring public should not be employed, i.e., "engineering judgment" should dictate the feasibility of when and where CMB shoulder areas should be addressed.

3. Since many of the district personnel strongly favor the use of concrete glare screen atop CMB in urbanized areas, strong consideration should be given to its installation along existing CMB sections currently without it. Although it would be rather difficult to determine the cost effectiveness of such projects, it is felt the added safety provided by concrete glare screen would warrant its use.

4. Where new concrete median barrier is to be installed, consideration should be given to increasing the effective height of the wall. Again, it is felt that the increased wall height will provide an added margin of safety for the motoring public.

INTRODUCTION

Overview

During the last several years, many miles of concrete median barrier (CMB) have been erected along the Michigan freeway system. The concrete barrier walls, funded mainly through safety improvement projects, have been installed primarily to prevent the cross-median head-on type collision. The CMB has replaced the traditional steel beam guardrail in narrow median sections of existing freeways, while the newly constructed freeways incorporate CMB as part of their integral design.

In addition to helping prevent the cross-median type accident, the CMB redirects errant vehicles back to the traveled throughway. As such, many would-be property damage accidents are eliminated. Since the CMB is highly maintenance-free as compared to its counterpart, the steel beam guardrail, it is especially suitable for use on the freeway system.

However, some concern has been expressed about snow related accidents that have occurred along CMB sections. More specifically, the problem of snow accumulation packed in along the CMB has presented itself.

This paper will address the CMB accident problem during periods of snow accumulation. An analysis of CMB accidents will be presented. In addition, the results of a Delphi survey which was conducted among district personnel will be revealed.

Data Collection

Accident Records:

The major thrust for CMB construction began in 1971. Since that time, the completed CMB mileage has lengthened each year. As of June, 1976, there were 89 miles of concrete median barrier in place along the Michigan freeway system. Table 1 shows the breakdown of where the barrier is located and the date by which it was completed.

In order to examine the accident experience with CMB during periods of snow accumulation it was decided to select for study those accidents that occurred between November 1 and March 15 of each winter. While it is realized that snow did not fall every day during the winter months, it was felt that snow accumulation was present along the median barrier for a large percentage of this period. It was felt that for the scope of this report, that is, obtaining a better "handle" on snow accumulation related CMB accidents, that the above mentioned dates would suffice quite adequately.

Accident reports for the winters 1971-1972 through 1975-1976 were used in the study. It was felt that five winters of accident experience would provide a sufficient data base from which to analyze.

Delphi Survey:

To supplement the analysis of accident data, the department's district traffic and safety and maintenance engineers were requested to participate

TABLE 1

CONCRETE MEDIAN BARRIER IN MICHIGAN

County	City	Route	Control Section	Mileage Points	Mileage	Date
Emmet	Mackinac	I-75	24071	0.40-1.67	1.27	
Bay		I-75	09034	4.63-5.12	0.96	01-01-76
			09035	0.00-0.47		
Genesee	Flint	I-75	25031	12.66-15.12	7.19	06-08-74
			25032	0.00-3.27		07-16-74
			25032	3.89-5.35		11-21-73
	Flint	I-475	25132	3.51-6.40	3.93	01-01-74
			25132	13.98-15.02		
Jackson		I-94	38101	0.00-12.39	13.02	01-01-76
			38101	15.09-15.72		
Kent	Wyoming	US-131	41131	10.00-13.12	4.90	04-30-75
	Grand Rapids		41131	13.38-14.17		
			41131	15.04-16.30		
Macomb	Harper Woods	I-94	50111	0.00-0.35	0.35	
Oakland	Southfield	US-10	63081	1.04-5.25	4.21	10-18-74
	Madison Heights	I-75	63174	3.59-4.03	0.44	
Saginaw		I-75	73111	0.59-6.35	5.76	01-01-76
Washtenaw	Ann Arbor	I-94	81062	0.00-7.42	10.28	08-18-75
			81062	7.85-9.13	9.13	06-04-76
			81063	0.00-0.50		06-04-76
			81104	17.21-18.29		08-18-75
Wayne	Dearborn	I-94	82022	15.38-16.6	16.9	08-16-74
	Detroit		82023	0.00- 4.84		06-18-75
	Detroit		82024	0.00- 4.02		06-18-75
	Harper Woods		82025	0.00- 6.70		06-18-75
Wayne	Detroit	I-75	82194	2.12- 4.74	2.6	X 12-13-71
Wayne	Detroit	I-96	82123	5.43-10.97	6.35	11-21-73
			82123	5.43- 6.55		
			82123	5.43- 6.84		
			82124	0.00- 0.81		X 08-27-71
Wayne	Detroit	US-10	82111	0.00- 1.50	10.92	01-01-76
			82112	0.00- 6.04		
			82112	6.13- 6.34		
			82112	6.44- 9.60		
			82112	9.50- 9.60		

in a Delphi Survey. It was felt that the district "experts" could lend some valuable insight into the particular operational problems that might be occurring along freeway sections with CMB.

The Delphi procedure employs three simple principles in obtaining group opinion. The first is that group judgment is better than individual judgment. Secondly, the participant is able to maintain anonymity throughout the process. Lastly, through a feedback process following each round, a consolidated group opinion is obtained.

The participants were given a variety of statements relating to the operational procedures, safety features, and policy guidelines concerning CMB sections of freeway during periods of snow accumulation. They were asked to express their opinion on each statement, through a multiple choice procedure, by selecting the degree to which they agreed or disagreed with the statement. In addition, a comment sheet was provided so that the respondents could express any new ideas or suggestions that were not addressed on the survey sheet.

Upon the completion of the first round survey, the results were tabulated and each statement was assigned a mean opinion rating. The first round group results were provided to the participants before the start of the second round. Upon review of the first round results, the participant was asked in the second round to reconsider the original statements, and to again answer to the best of his knowledge.

For this study, only two rounds of the Delphi procedure were applied. However, from the consolidated opinion that was obtained and the valuable information that was offered, it is felt that some valid conclusions can be drawn.

DEFINING THE PROBLEM

The majority of the concrete median barrier in place along Michigan's freeway system has what is known as the GM safety shape (see Figure 1). The acronym stems from the fact that this shape was developed at the General Motors Proving Grounds in Milford, Michigan. Since May, 1976, Michigan has been constructing the New Jersey shaped barrier (see Figure 2). The New Jersey shape, which the Southwest Research Institute in San Antonio, Texas, found to be less susceptible to rollover during actual tests, has a slightly steeper top face than does the GM shape. Since this slight difference in dimension has a significant effect on rollover experience, it is reasonable to assume that snow packed in along a barrier at various angles also effects rollover experience. In essence, the effective shape of the barrier wall is radically changed.

The snow accumulation problem on CMB areas in northern states must be viewed in a realistic manner. The first maintenance priority of a highway department during a snow storm is to get the traffic lanes cleared as soon as possible. The second priority is to clear the shoulder areas. However, where CMB exists along freeway sections, there is often little storage space for snow and more often than not the CMB gets "buried" underneath the snow. The problem is particularly prevalent along urban freeways where there is not much space to store snow.

As the snow builds up along the CMB, a ramped type platform can be created which can act as a launching pad for out-of-control vehicles. Perhaps the problem came into clear focus on February 9, 1976, when a car traveling on northbound US-10 in Southfield, Michigan vaulted right

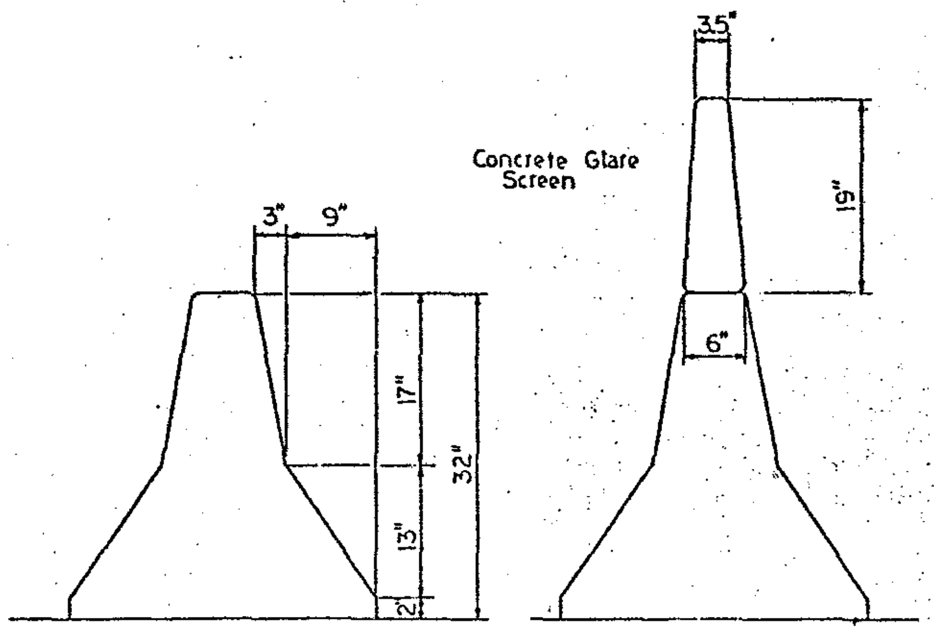

Figure 1. GM safety shape used in Michigan prior to May, 1976.

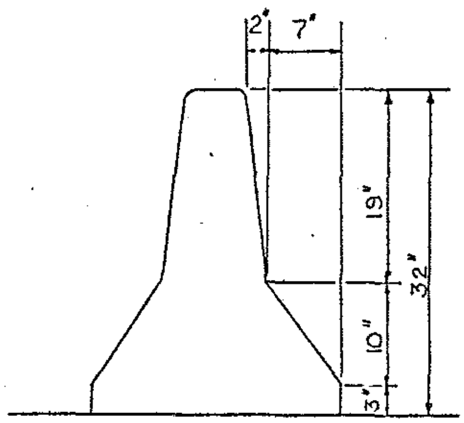

Figure 2. New Jersey safety shape now in use in Michigan.

over the CMB. Dry pavement conditions existed, but the median shoulder area was packed with accumulated snow from recent snow falls. The snow formed a triangular wedge from the edge of the traveled roadway to the top of the CMB which in turn negated the effectiveness of the barrier wall.

The situation can best be illustrated by examining the photographs that were taken at the scene of the accident. Figure 3 shows where the northbound vehicle lost control and mounted the snow wedged ramp. Figure 4 depicts the point of contact in the southbound shoulder median area. The top of the CMB is shown in Figure 5 where the vehicle scraped the wall. It can be noted how close the vehicle came to striking the light pole. It can also be noted that, at the time of the accident, concrete glare screen was not in place on the top of the wall. Concrete glare screen was installed on this freeway in the fall of 1976. Figure 5 also illustrates the relatively wide (10 feet) median shoulder areas at this location.

Figure 6 shows the northbound vehicle after it collided with a southbound vehicle and came to a halt in the inside lane of southbound US-10. The accident diagram in Figure 7 illustrates the path of the southbound vehicle after the collision. After making a 180 degree turn, the southbound vehicle mounted the median snow bank backwards and collided with a light pole atop the CMB. After hitting the pole, the vehicle flipped over (see Figure 8) and finally came to rest on the left edge of the inside lane of southbound US-10 (see Figure 9). Neither driver was injured in this 2-car collision.

Figure 3. Photo shows where vehicle mounted snow wedged ramp.

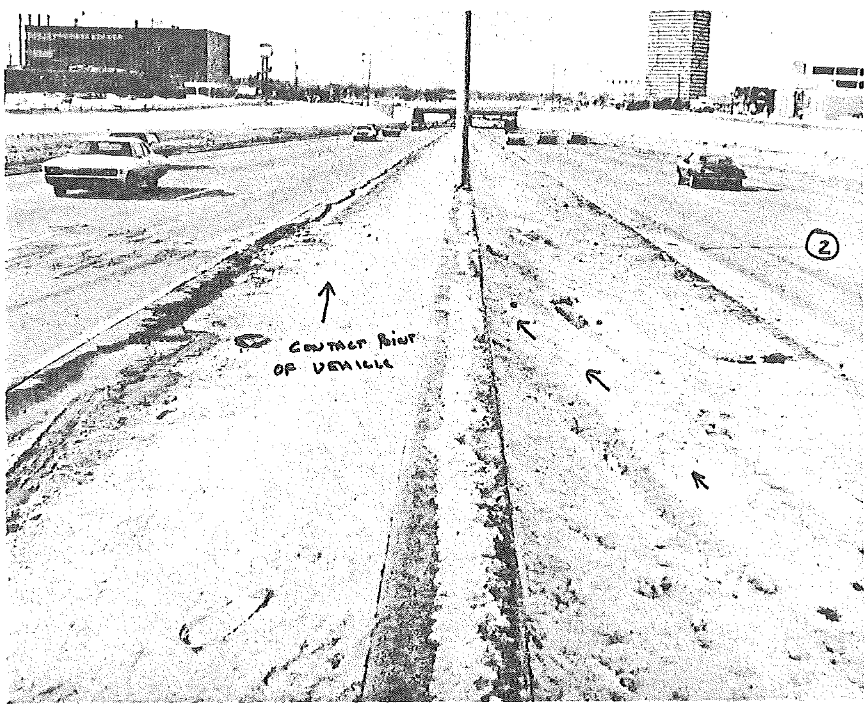

Figure 4. Photo shows contact point after vehicle hurdled barrier.

Figure 5. Photo shows where vehicle scraped the barrier (concrete glare screen was not present at time of accident).

Figure 6. Photo shows northbound vehicle in southbound lane.

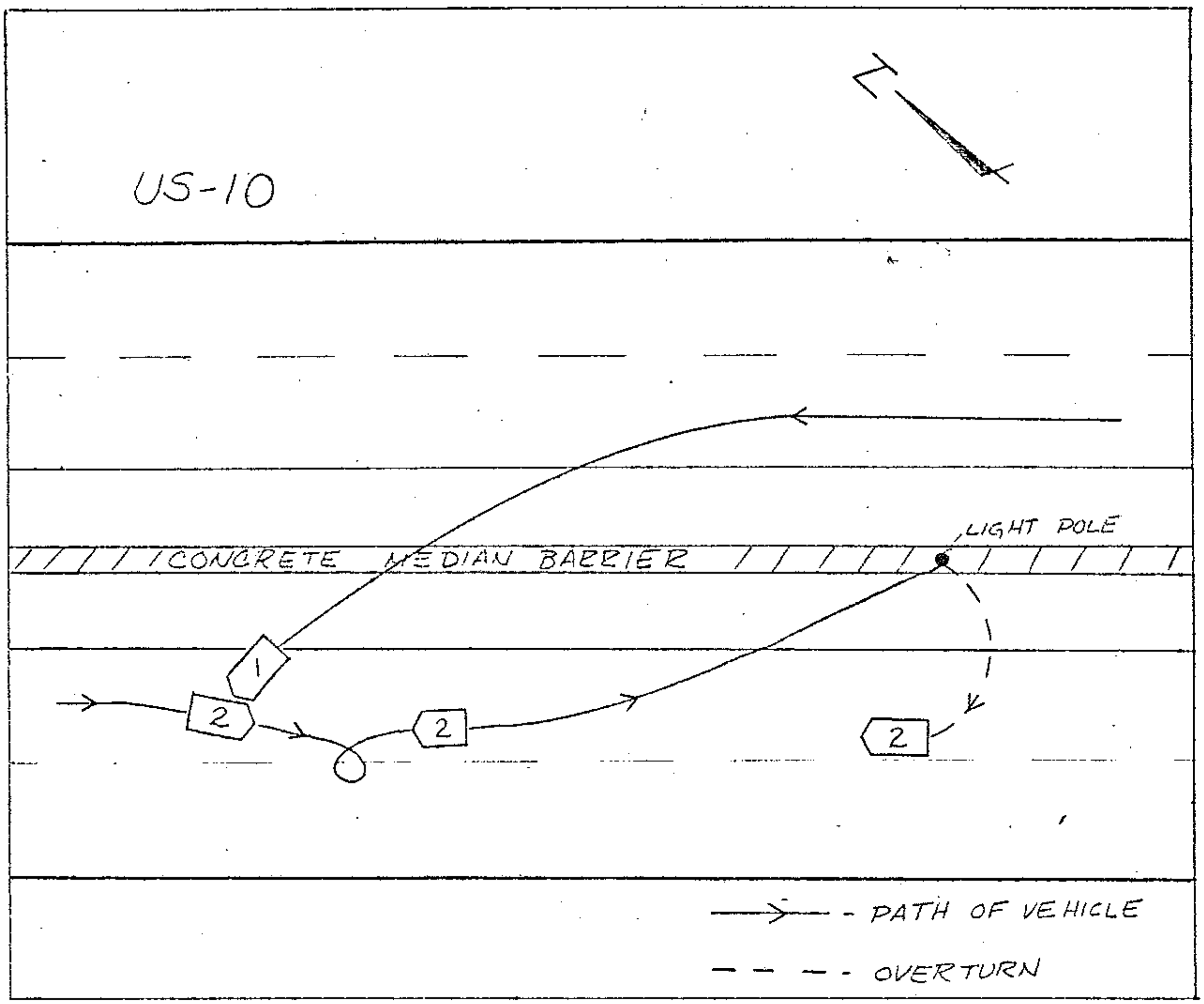

Figure 7. Accident diagram of a CMB hurdle accident.

Figure 8. Southbound vehicle struck light pole and rolled over.

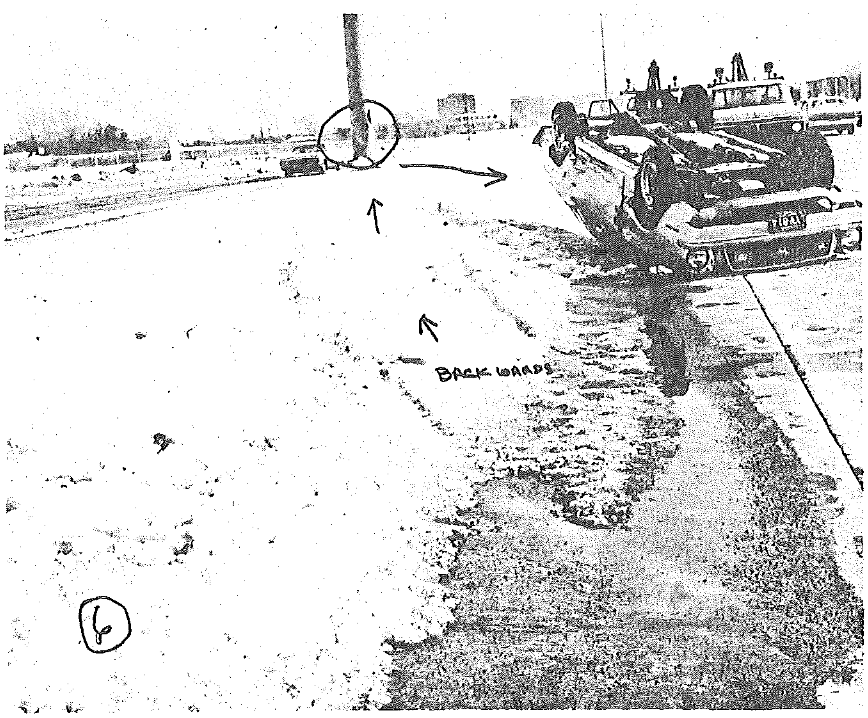

Figure 9. Photo shows path of southbound vehicle.

It should be clear from these illustrations, however, that snow accumulation and the way it is shaped in CMB areas can and does have a profound effect on the safety of out-of-control vehicles. The following photographs will also provide a clearer perspective of the various elements that are encompassed along snow/ice-encased concrete median barriers.

Figure 10 shows where a truck climbed a snowbank and knocked out several lineal feet of concrete glare screen atop the CMB. Although concrete glare screen is not designed to absorb heavy impacts, it is hypothesized that it does serve to increase the effective height of the barrier wall for most automobiles. Observations of tire marks on concrete glare screen seem to substantiate this hypothesis. The concrete glare screen in Figure 11, although fractured, may very well have prevented an errant vehicle from vaulting over the barrier and into the opposing traffic lanes.

Woven wire glare screen is found atop CMB throughout numerous horizontal curves in the state. Figures 12 and 13 show where the woven wire glare screen has been damaged by errant vehicles. The woven wire screen does not have nearly the structural strength as that of the concrete glare screen and it is also harder to maintain.

Figures 14 and 15 show some tangent segments of freeway that do not have the glare screen mounted atop the CMB. It can be observed in Figures 14 and 15 that less than 12 inches of the 32-inch high CMB is free of snow. Again, the triangular wedge of snow presents a potential problem for out of control vehicles.

Figure 10. Photo shows where truck climbed snowbank and knocked out concrete glare screen (I-94 near Ypsilanti).

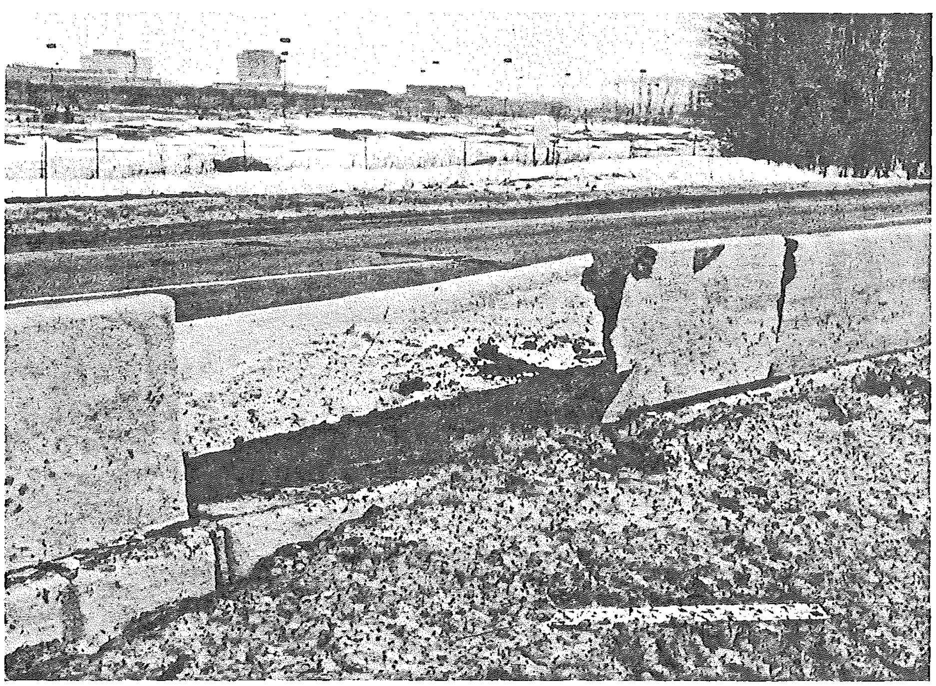

Figure 11. Concrete glare screen probably prevented vehicle from "ramping" over barrier (I-94 in Ann Arbor).

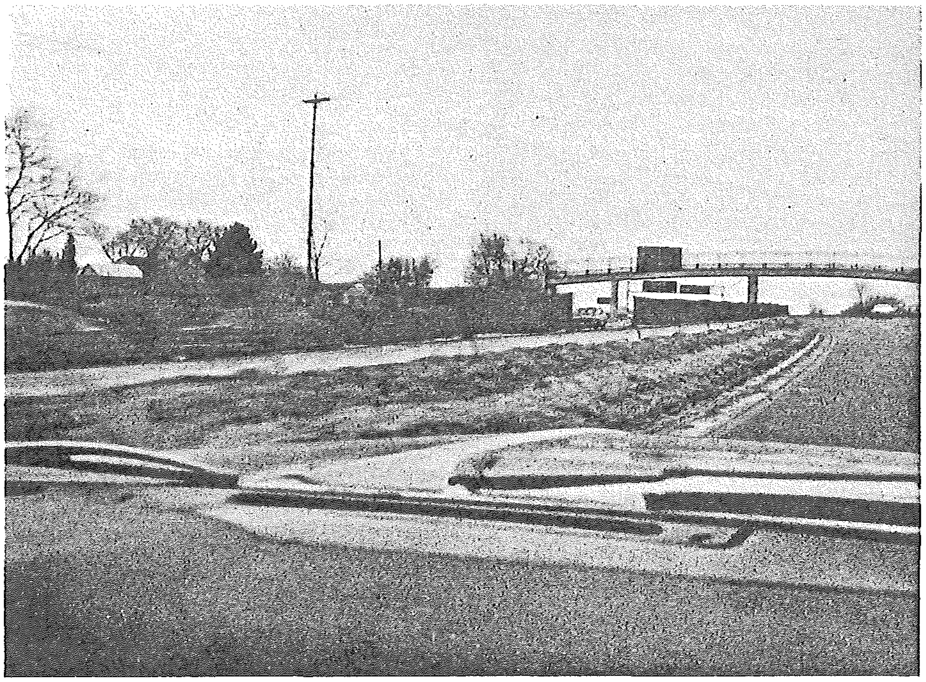

Figure 12. Photo shows where short section of woven wire glare screen was knocked out (I-75 near Flint).

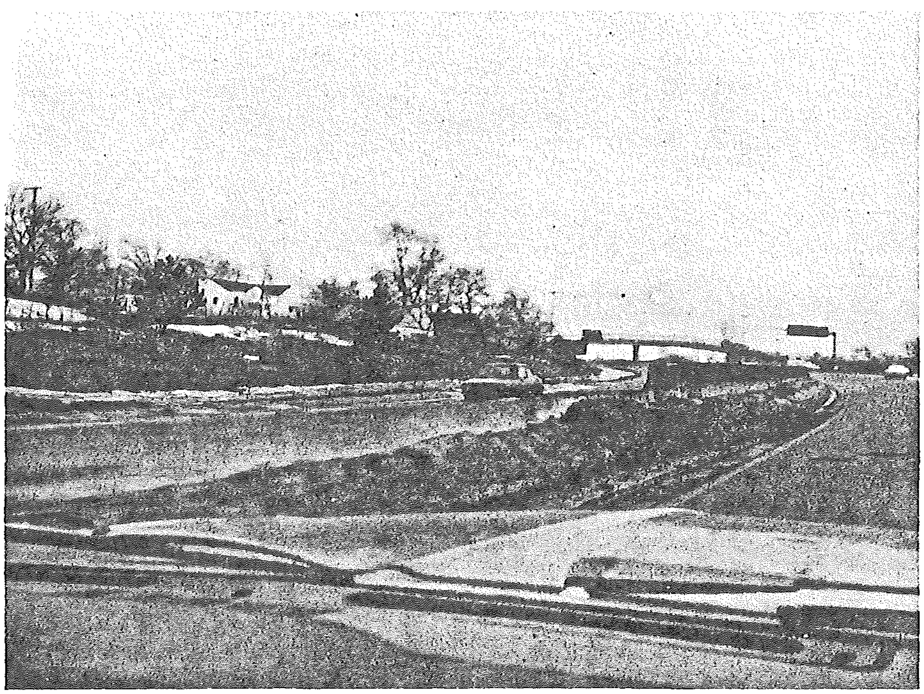

Figure 13. Photo shows where long section of woven wire glare screen was knocked out (I-75 near Flint).

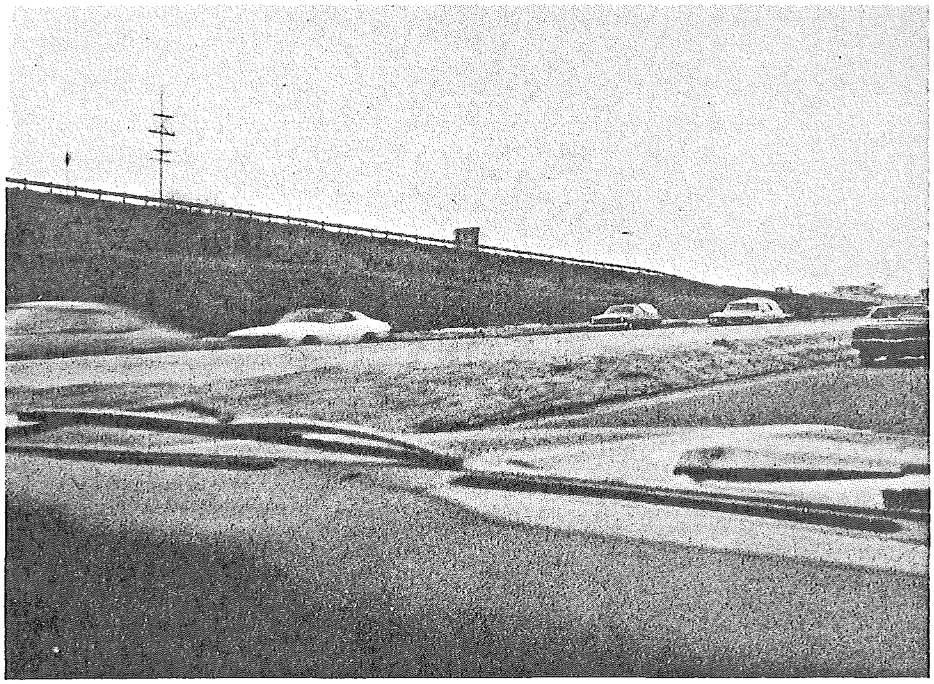

Figure 14. Tangent section of CMB that has no glare screen mounted on top (I-75 near Flint).

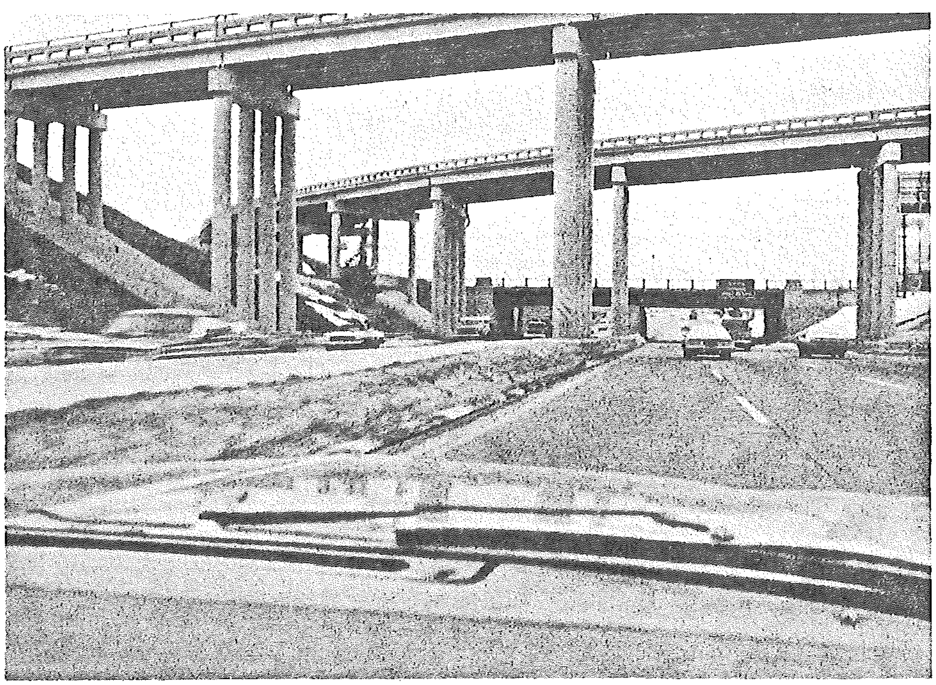

Figure 15. Snow wedged in along 32 inch high CMB (I-75 near Flint).

As can be seen in Figure 16, the concrete glare screen provides an effective wall height of 51 inches. It can be noted how much wall space is visible even with snow piled against the bottom portion of the CMB.

Figure 17 illustrates the same type of wall section as in Figure 16, but it also shows the results of a maintenance plowing procedure known as "verticalizing." It should be noted that a clear median shoulder is provided by the vertically cut snow face. In addition, the vertical face makes it difficult for a vehicle to scale the wall.

Clearly then, the effectiveness of CMB during periods of snow accumulation is closely associated with snow removal procedures. While many variables enter into the scope of the problem (such as traffic volumes, maintenance equipment and manpower, shoulder width, etc.), the ensuing analysis of data should serve to provide a clue as to the magnitude of the accident problem.

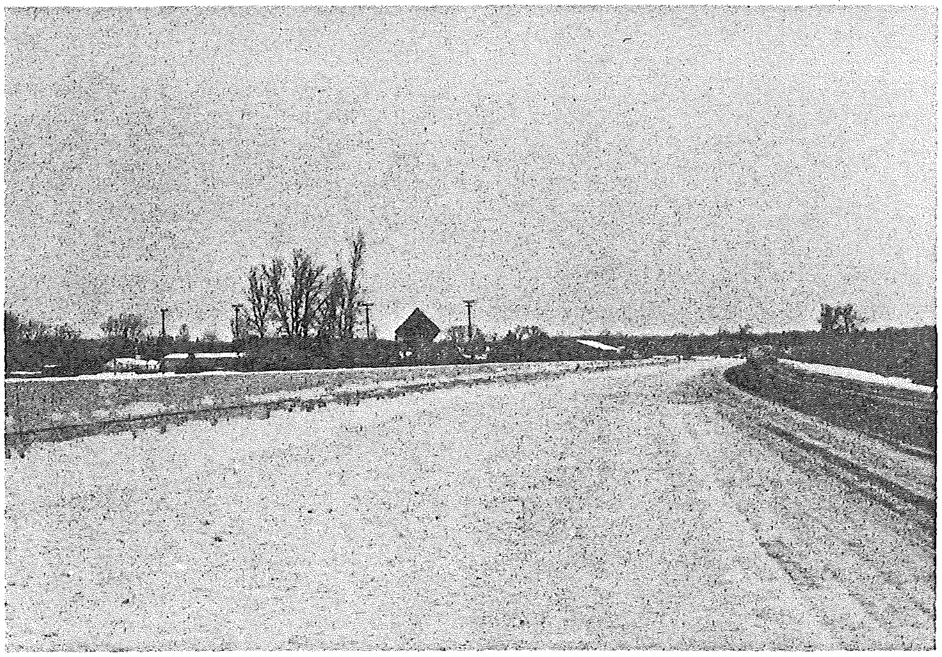

Figure 16. Concrete glare screen provides a 51 inch wall height (I-75 near Saginaw).

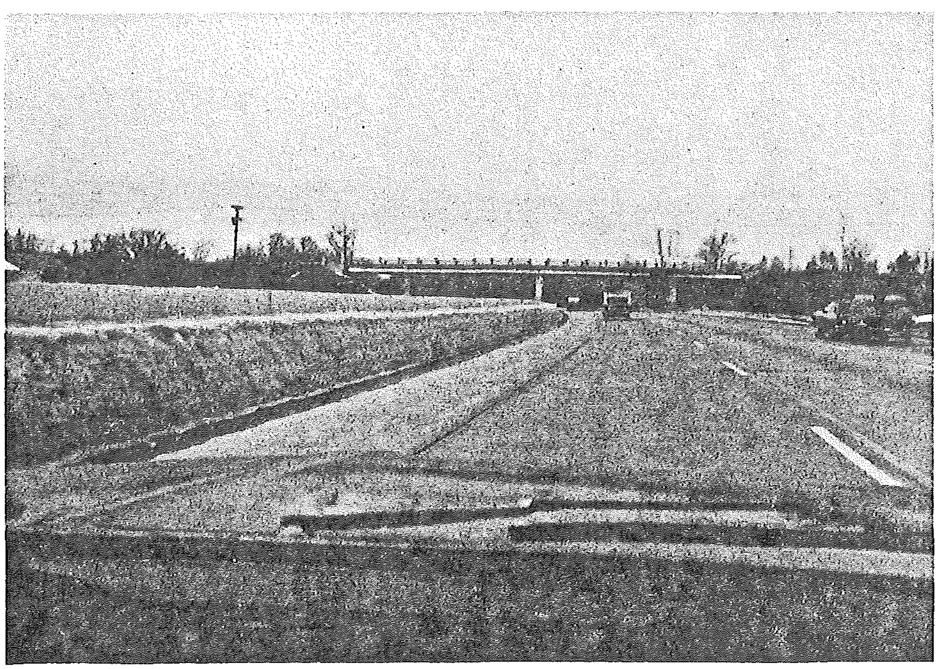

Figure 17. Results of snowplowing procedure known as "verticalizing" (I-75 near Saginaw).

ANALYSIS OF DATA

Accident Data

Concrete median barrier accidents were analyzed for the winters 1971-1972 through 1975-1976. For the purposes of this report, a winter shall be defined as the 4-1/2 month period commencing on November 1 of one year and terminating on March 15 of the following year. Since the total CMB mileage in Michigan has increased in successive years, no attempt was made to stratify the accident data by particular winters. Instead, the five-year winter CMB accidents were analyzed in a conglomerate time frame.

However, several stratifications were made on the data as can be seen in Table 2. The accidents were first classified into groups that had similar road surface conditions, i.e., dry surface, wet surface, and snow/ice surface. The combined groups are also shown at the bottom of Table 2.

Each group was stratified by vehicle type, number of accidents, number of single vehicle accidents, number of multiple vehicle accidents, number of injury accidents, and number of people injured. In addition, where the vehicles either hurdled over the barrier or hit the barrier and rolled over, the corresponding indication is also noted in the "accidents" columns in parentheses.

Of the 226 total CMB accidents that occurred during the five winters, 135 (59.7 percent) occurred on snowy or icy road surfaces. There were 54 accidents (23.9 percent) that occurred on dry surfaces, while only 37

TABLE 2
Five Winter CMB Accident Numbers By
Road Surface Conditions and Vehicle Type

Vehicle Type	Dry Accidents	Single Veh. Accidents	Multi-Veh. Accidents	Injury Acc.	(No. Injured)
Full Size	15 (2H,2R)	11 (2H,2R)	4	8	(12)
Intermediate	13 (2H)	10 (1H)	3 (1H)	8	(9)
Compact	16 (5R)	14 (5R)	2	10	(12)
Trucks	8	7	1	5	(6)
Unknown	2	1	1	1	(1)
Total	54	43	11	32	(40)

Vehicle Type	Wet Accidents	Single Veh. Accidents	Multi-Veh. Accidents	Injury Acc.	(No. Injured)
Full Size	17 (2H)	12 (2H)	5	7	(7)
Intermediate	11 (1R)	9 (1R)	2	5	(6)
Compact	1	1	0	0	(0)
Trucks	7	5	2	5	(5)
Unknown	1	0	1	0	(0)
Total	37	27	10	17	(18)

Vehicle Type	Snow/Ice Accidents	Single Veh. Accidents	Multi-Veh. Accidents	Injury Acc.	(No. Injured)
Full Size	51	41	10	15	(20)
Intermediate	32 (1R)	26	6 (1R)	12	(13)
Compact	28 (1R)	23 (1R)	5	13	(24)
Trucks	24	19	5	8	(10)
Unknown	0	0	0	0	
Total	135	109	26	48	(67)

Vehicle Type	Total Accidents	Single Veh. Accidents	Multi-Veh. Accidents	Injury Acc.	(No. Injured)
Full Size	83 (4H,2R)	64 (4H,2R)	19	30	(39)
Intermediate	56 (2H,2R)	45 (1H,1R)	11 (1H,1R)	25	(28)
Compact	45 (6R)	38 (6R)	7	23	(36)
Trucks	39	31	8	18	(21)
Unknown	3	1	2	1	(1)
Total	226 (6H,10R)	179 (5H,9R)	47 (1H,1R)	97	(125)

(H) indicates a hurdle accident
(R) indicates a rollover accident

accidents (16.4 percent) occurred on wet road surfaces. It should be pointed out, however, that many of the wet and dry road surface accidents probably occurred with snow stockpiled in the median area. This would seem reasonable since the predominant sub-freezing temperatures of the winter months tend to prevent accumulated snow and ice from melting at a very rapid rate.

Almost 80 percent, or 179 out of 226, of the CMB accidents were of the single vehicle variety. Only 47, or roughly 20 percent, of the accidents involved two or more vehicles. Where a multi-vehicle accident occurred, the vehicle type designation assigned to the accident was determined by the vehicle type which first came in contact with the CMB. Of the 226 reported accidents, 97 (42.9 percent) were of the injury type. In these 97 accidents, a total of 125 people received injuries. No reported fatalities occurred as a result of the 226 CMB accidents! The remaining 129 accidents were of the property damage type. It is interesting to note that full size vehicle types comprised 36.7 percent (83 of 226) of the total accidents and only 31.2 percent (39 of 125) of the total injuries, while the compact vehicle types constituted only 19.9 percent (45 of 226) of the total accidents and yet accounted for 28.8 percent (36 of 125) of the total injuries.

During the analyzation process, it was felt that some criteria should be used to differentiate between a so called "critical" CMB accident and a "noncritical" accident. It was decided that only those accidents where vehicles completely hurdled over the barrier or struck the barrier and rolled over would be classified as "critical." These "critical" accidents would be classified as "hurdles" and "rollovers." If the vehicle hurdled the barrier and then rolled over, it would still be classified as a hurdle accident.

As mentioned earlier, Table 2 also indicates the stratification of hurdle and rollover accidents. A total of 16 critical CMB accidents occurred during the study period. These consisted of 6 hurdles and 10 rollovers. Fourteen of the 16 critical accidents were of the single-vehicle variety with the other two accidents involving other vehicles. The 14 single-vehicle accidents consisted of 5 hurdles and 9 rollovers while the two multi-vehicle accidents consisted of one hurdle and one rollover. Twelve of the 16 accidents were of the injury type with a total of 17 people being injured. Again, there were no reported fatalities experienced in all of the CMB accidents during the winter months.

Table 3 shows the frequency of hurdles and rollover accidents by vehicle type. Of particular note is the frequency rate of the compact rollovers. 13.3 percent (6 of 45) of the compact accidents were rollovers. This was almost 4 times the rollover frequency rate for intermediates (3.6 percent), and almost 5 times the frequency rate for full size vehicles (2.8 percent). Not one compact hurdled the barrier during the winter months.

TABLE 3
Frequency of Critical CMB Accidents by Vehicle Type

Vehicle Type	Acc.-% of total		Hurdles-% of Type		Rollovers-% of Type	
Full Size	83	36.7	4	4.8	2	2.8
Intermediate	56	24.8	2	3.6	2	3.6
Compact	45	19.9	0	0	6	13.3
Trucks	39	17.3	0	0	0	0
Unknown	3	1.3	0	0	0	0
Total	226	100.0	6	2.7	10	4.4

The full size vehicles showed the greatest tendency to hurdle the barrier (see Table 3). Four of the hurdles were by full sized vehicles and two were by intermediate vehicles. The full size hurdle frequency rate was slightly higher than that of the intermediate type (4.8 percent vs 3.6 percent).

In all, only 7.1 percent (16 of 226) of the CMB accidents were of the critical nature. A cursory review of each of these 16 critical accidents may be found in Appendix A of this report.

Delphi Survey

For the first two rounds of the Delphi Survey, a series of statements relating to concrete median barrier were sent to the district traffic and maintenance engineers. Generally, the statements dealt with operational problems and policies concerning CMB areas during periods of snow accumulation. A copy of the survey statements and the results of the two rounds may be found in Appendix B.

While the results of the Delphi Survey are subjective in nature, they do serve as a valuable indicator in helping to evaluate the various elements in the vehicle/CMB/environment relationship. On many items a consolidated group opinion was obtained. The following discussion will summarize the opinions of the district personnel.

Safety to the Motoring Public:

The seriousness of accumulated snow along CMB sections does not rank very high on the priority list of most district personnel. The seriousness of the problem seems to be most acute in the metropolitan district, perhaps because of its numerous miles of CMB and high vehicle exposure. In addition to requiring extensive time and manpower to clean-up CMB shoulder areas after a storm, the concensus is that work crews and equipment could create more of a hazard to the public than the snow itself. This would be particularly true in large metro areas where traffic volumes would create long backups.

Snowplowing Policies:

District personnel seemed to concur that the current snow removal policy in CMB areas is quite satisfactory. The "verticalizing" plowing technique works quite effectively and minimizes the ramping phenomenon that can occur in tapered snow sections. It was generally agreed that a contingent of plows clearing laterally from left (CMB) to right would tend to cause traffic backups. However, this method has met with success in one district in order to create storage room for additional snow. In metro areas, narrow CMB shoulder widths (two feet to three feet) present no real problems since "salt splash" from the adjacent traffic lane causes rapid melting of accumulated snow.

Alternate Snow Removal Methods:

Several ideas were brought up regarding alternate methods for snow removal from CMB areas. These ideas ranged from installing electric heating coils in the CMB to spraying a brine solution on snow covered CMB walls. The general concensus was that these alternate methods would be either ineffective or too costly. The salt brine solution has been tried in some districts and has met with limited success.

Concrete Glare Screen:

A strong consolidated opinion was expressed to install concrete glare screen on top of all existing CMB. This would tend to increase the effective height of the wall and hence reduce the cross-median accident potential. However, some concern was expressed about installing the concrete glare screen on rural north-south routes due to the drifting snow phenomenon that can occur on the downwind side of the wall.

CONCLUSIONS

The problem of accumulated snow along concrete median barrier sections of freeway does not appear to create a high degree of seriousness to the motoring public. This viewpoint is substantiated by both a factual analysis of winter month accident data and the consolidated group opinion obtained by the Delphi survey of district traffic and maintenance engineers.

A total of 16 "critical" accidents were reported during the 5-winter study period. These critical accidents, either hurdles or rollovers, accounted for only 7.1 percent of the total reported CMB accidents. Of the 226 total CMB accidents, not one fatality resulted. Almost 80 percent of the accidents were of the single-vehicle variety. Of particular note was the rollover frequency rate (13.3 percent) of compact vehicle-type accidents. When it is considered that the accident figures are statewide 5-year totals, a proper perspective of the magnitude of the problem is realized. It should be noted that there were probably many more CMB "contacts" that were not reported.

The opinions of district personnel indicated a fairly strong consensus in certain areas. They felt the seriousness of the snow accumulation problem was not overly acute. Perhaps because of higher vehicle exposure, the problem is more obvious in the metropolitan district. The district personnel felt the existing snow removal policies now in effect are quite satisfactory, with the "verticalizing" plowing procedure being a favorite method of minimizing the vaulting phenomenon along snow encased CMB walls. Unconventional methods of snow removal from CMB areas were felt to either be ineffective or too costly for implementation. The majority felt that the effective height of CMB walls should be increased for safety purposes. This could be accomplished by installing concrete glare screen on top of those walls without it.

This report has attempted to provide a better understanding of the effects that snow accumulation in CMB areas has on the safety of vehicles. It should be pointed out that some operational aspects of the problem are more unique to some districts than to others. In this light, the operational solutions to the problem may vary somewhat from district to district. It is clear, however, that while the magnitude of the problem may not be extremely large, the attention allotted to CMB areas during the winter months should not be minimal.

Appendix A

Hurdle and Rollover Accident Descriptions

APPENDIX A

Hurdle and Rollover Accidents Descriptions

The following is a description of each of the six hurdle accidents:

1. The first vehicle to hurdle was a 1965 full size Plymouth. The accident occurred at 5:10 p.m. on November 22, 1973, on southbound I-96 just north of Roosevelt in Detroit. At the time of the accident it was dark and the pavement surface was dry. The driver stated that while traveling on southbound I-96 a car cut in front of him and forced him off the road. The vehicle jumped the barrier and ended up facing south in the northbound lanes. In this single vehicle accident, the driver was not injured. It is not known if snow was along the barrier. Concrete glare screen was not in place atop the CMB.

2. The second vehicle to hurdle was a 1974 full size Dodge. The accident occurred at 6:45 p.m. on February 14, 1975, on the entrance ramp from Schaefer Road to I-94. In this single vehicle accident, the driver was injured and taken to the hospital. He suffered a type A injury. At the time of the accident it was dark and the pavement surface was dry. It is not known if snow was along the barrier. The driver stated he did not know how the accident happened.

3. The third vehicle to hurdle was a 1969 full size Cadillac. The accident occurred at 2:45 a.m. on January 7, 1976, on southbound I-75 just north of Miller Road near Flint. At the time of the accident it was dark and the pavement surface was wet. The driver advised that he was forced sharply to the side of the road by another vehicle before hurdling the barrier. The vehicle stopped upside down facing south in the middle lane of northbound I-75. In this single vehicle accident the driver suffered a type C injury. It is not known if snow was along the barrier. Woven wire fence was damaged during the accident.

4. The fourth vehicle to hurdle was a 1973 full size Chrysler. The accident occurred at 11:50 p.m. on January 24, 1976, on eastbound I-94 0.3 miles east of M-60 in Jackson County. At the time of the accident it was dark and the pavement surface was wet. A witness to the accident said the vehicle was traveling a high rate of speed, lost control, hurdled, crossed the westbound lanes, went through a fence, and struck a clump of trees. In this single vehicle accident the driver suffered a type B injury. It is not known if snow was along the barrier. Concrete glare screen was not present.

5. The fifth vehicle to hurdle was a 1972 intermediate Ford. The accident occurred at 11:45 p.m. on January 30, 1976, on northbound US-10 near the Lahser off ramp in Southfield. It was dark and the pavement surface was dry. The driver stated he didn't know what happened but that he went over the wall. The vehicle stopped in the left lane on southbound US-10. In this single vehicle accident the driver was not injured. It is not known if snow was along the barrier. Concrete glare screen was not present.

6. The sixth vehicle to hurdle was a 1973 intermediate Dodge. The accident occurred at 1:45 p.m. on February 9, 1976, on US-10 just east of Evergreen in Southfield. This vehicle was on northbound US-10 when it lost control, scaled the snowbank, and vaulted onto southbound US-10 colliding with another vehicle. The southbound vehicle was a 1975 Mustang. The Mustang spun around, went up the median snowbank striking a light pole, and finally flipped upside down. Neither driver was injured. The pavement surface was dry during this daytime accident. Glare screen was not present.

The following is a description of the ten rollover accidents:

1. The first rollover was a 1965 full size Oldsmobile. The accident occurred at 1:20 p.m. on January 17, 1972, on the Dubois exit ramp from eastbound I-94 in Detroit. The pavement surface was dry. The vehicle struck the curved section of barrier and rolled over on its top. In this single vehicle accident, the driver suffered a type A injury. It is not known if snow was present along the barrier. Concrete glare screen was not present.

2. The second rollover was a 1970 Dodge compact. The accident occurred at 1:25 p.m. on February 26, 1972, on eastbound I-94 west of Elm Road in Jackson County. She said she turned to avoid hitting some trash in the roadway, lost control, struck the barrier, and turned over. The pavement surface was dry. In this single vehicle accident the driver received a type B injury. It is not known if snow was along the barrier. Glare screen was not present.

3. The third rollover was a 1968 Buick compact. The accident occurred at 10:40 p.m. on November 8, 1973, on northbound I-75 just south of Maple Road in Genesee County. The vehicle hit the barrier, coasted along the top, and rolled over on its top with part of the vehicle being balanced on the barrier. It was dark and the pavement surface was dry. In this single vehicle accident the driver suffered a type C injury. It is not known if snow was present along the barrier. Glare screen was not present.

4. The fourth rollover was a 1963 Corvair compact. The accident occurred at 11:45 p.m. on November 6, 1974, on southbound US-131 just south of the southbound entrance ramp of Market Street in Grand Rapids. The car hit the barrier, flipped over on its top, and stopped in the right lane. In this single vehicle accident, the driver suffered a type B injury while the passenger received a type C injury. The accident occurred on a left deflecting horizontal curve. It was dark and the pavement surface was dry. It is not known if snow was along the barrier. Glare screen was not present.

5. The fifth rollover was a 1972 full size Ford. The accident occurred at 11:00 a.m. on January 13, 1975, on eastbound I-96 near Joy Road in Detroit. The driver lost control of the vehicle and struck the barrier and turned over. All four occupants received type C injuries. The pavement surface was dry during this single vehicle accident. It is not known if snow was present along the barrier. Glare screen was not present.

6. The sixth rollover was a 1975 Dodge compact. The accident occurred at 10 p.m. on January 14, 1975, on northbound I-75 near Corunna Road in Genesee County. The officer felt the driver may have fallen asleep since he was quite sleepy. The car hit the barrier in a right deflecting horizontal curve and rolled over. In this single vehicle accident both occupants received type A injuries. The pavement surface was dry. It is not known if snow was present along the barrier. Woven wire glare screen was present.

7. The seventh rollover was a 1972 compact. The accident occurred at 11:40 p.m. on November 19, 1975, on southbound US-131 south of Burton Street in Grand Rapids. He stated he was tired and apparently fell asleep and struck the barrier. The vehicle overturned and then slid some 200 feet on its top before coming to a halt. The driver was wearing a shoulder harness and was not injured. In this single vehicle accident it is not known if snow was present along the barrier. Glare screen was not present.

8. The eighth rollover was a 1971 intermediate Ford. The accident occurred at 10:30 p.m. on December 19, 1975, on northbound US-10 near Highland in Detroit. The vehicle was struck by another vehicle and forced into the barrier and rolled over. In this two car accident, the driver of the overturned vehicle suffered a type B injury. It was dark and the pavement surface was snowy. It is not known if snow was present along the barrier.

9. The ninth rollover was a 1969 Pontiac compact. The accident occurred at 10:50 a.m. on December 26, 1975, on southbound I-75, 0.5 miles north of King Road in Saginaw County. The car hit a patch of ice and went out of control and hit the barrier and flipped over on its top. It was snowing at the time and the pavement surface was icy. In this single vehicle accident the driver received a type C injury. It is not known how much snow was along the barrier. Glare screen was not present.

10. The tenth rollover was a 1971 Plymouth intermediate. The accident occurred at 3:14 a.m. on March 2, 1976, on the southbound I-75 exit ramp to I-696 in Royal Oak. The driver stated that she was going too fast in the left deflecting curve and lost control, striking the left barrier and rolling over. It was dark and the pavement surface was wet. In this single vehicle accident the driver suffered a type C injury. It is not known if any snow was along the barrier.

Appendix B

Delphi Survey Statements and Results

OFFICE MEMORANDUM

DATE: April 4, 1977

TO: All District Traffic and Safety Engineers
All District Maintenance Engineers

FROM: William H. Opland, Traffic Engineer
Safety Programs Unit
Traffic and Safety Division

SUBJECT: Delphi Survey for Concrete Median Barrier Study

A statewide study of concrete median barrier accidents occurring during periods of snow accumulation is being conducted by the Traffic and Safety Division. To supplement our analysis of accident data we are soliciting the opinions of our district "experts" so that we may obtain a better grasp of the operational problems that may exist.

The Delphi procedure employs three simple principles in obtaining group opinion. The first is that group judgment is better than an individual judgment. Secondly, the participant is able to maintain anonymity throughout the process. Lastly, through a feedback process following each round, a consolidated group opinion is obtained.

The attached Delphi survey sheet should serve to stimulate your thoughts on snow-related accidents occurring at concrete median barriers. You are requested to respond to each statement by circling one of the five choices. If you wish to qualify any of your choices or add any other comments relating to the subject, you may do so on the last sheet.

The results of the first Delphi round will be made known prior to the second round. Additional statements may be added to the second round survey sheet if the first round comment sheet indicates that a particular item should be addressed.

Your added expertise in this study will be greatly appreciated. Some of you have already contributed valuable information (photographs, observations, diagrams, etc.). So that the first round results may be tabulated in a timely fashion, it is requested that the survey sheet be returned to the Safety Programs Unit by April 11, 1977. If you have any questions regarding this matter, please contact me.

William H. Opland
Traffic Engineer

WHO(324885-37)

cc R. A. Rigotti
Safety Programs Unit

OFFICE MEMORANDUM

DATE: April 14, 1977 File: 35-36

TO: All District Traffic and Safety Engineers
All District Maintenance Engineers

FROM: Donald E. Orne
Engineer of Traffic and Safety

SUBJECT: Delphi Survey for Concrete Median Barrier Study - Round 2

The results of the first round of the Delphi Survey are attached for your review. Additional comments and observations that many of you offered are greatly appreciated.

For the second round, you are requested to reconsider your answers to the original statements and make any revisions which, on second thought, you feel are called for. It is realized that some of the items addressed on the survey sheet will be more unique to some districts than to others. However, keep in mind that you are still being asked only for your best answer, based on your present knowledge.

Two additional statements have been included on the Round 2 survey sheet. This will be the final round of the Delphi Survey for this study. It is requested that the survey sheet and any additional comments that you wish to make be returned to Mr. William Opland of the Safety Programs Unit by April 22, 1977.

Thank you for your cooperation and participation in this survey.

Engineer of Traffic and Safety

DEO:WHO(137714-311)

cc: R. A. Rigotti
Safety Programs Unit

Delphi Survey for Concrete
Median Barrier Study

Please circle one of the five choices for each statement.

A. Snow accumulation packed in along concrete median barriers (CMB) creates a serious hazard to the motoring public.

1. Strongly disagree
2. Mildly disagree
3. Neutral
4. Mildly agree
5. Strongly agree

B. The department's snowplowing policy should be altered somewhat so that more attention is given to shoulder areas along concrete median barriers.

1. Strongly disagree
2. Mildly disagree
3. Neutral
4. Mildly agree
5. Strongly agree

C. Since it would require extensive time and manpower to "clean up" CMB shoulder areas after a snow storm, it would not be economically feasible to attempt such an operation.

1. Strongly disagree
2. Mildly disagree
3. Neutral
4. Mildly agree
5. Strongly agree

D. It would not be wise to devote a lot of effort to clean up CMB areas inasmuch as this could create a hazard (due to lane closures, extra trucks) to the motoring public on the through lanes.

1. Strongly disagree
2. Mildly disagree
3. Neutral
4. Mildly agree
5. Strongly agree

E. Some states employ a plowing technique whereby a contingent of plows will clear the snow from the median (left) shoulder area laterally to the outside (right) shoulder area in one continuous operation. It would be a good idea for the department to try this technique on an experimental basis next winter on a short segment of highway where CMB exists.

1. Strongly disagree
2. Mildly disagree
3. Neutral
4. Mildly agree
5. Strongly agree

F. Concrete glare screen is being used on much of our concrete median barrier. This tends to increase the effective height of the wall in addition to preventing headlight glare. It would therefore be a good idea to install a concrete glare screen on top of <u>all</u> our CMB.

1. Strongly disagree
2. Mildly disagree
3. Neutral
4. Mildly agree
5. Strongly agree

G. The idea of installing electric heating coils in the CMB has been suggested as a method of increasing the melting rate of snow and ice along barrier walls. Therefore it would be a good idea to implement this concept on an experimental basis for a short segment of new CMB.

1. Strongly disagree
2. Mildly disagree
3. Neutral
4. Mildly agree
5. Strongly agree

H. The idea of spraying a brine solution on snow covered CMB walls has also been suggested as a way of increasing the melting rate. Therefore the department should seriously consider using this method at spot locations where CMB accidents are occurring.

1. Strongly disagree
2. Mildly disagree
3. Neutral
4. Mildly agree
5. Strongly agree

I. The median width in CMB areas often affects plowing operations. Wider medians allow more snow storage space, but at the same time they can create longer snow "ramps" for errant vehicles out of control. Therefore wider median areas should be given more attention than narrower median areas after snow storms.

1. Strongly disagree
2. Mildly disagree
3. Neutral
4. Mildly agree
5. Strongly agree

J. The current snow removal policy we now have in CMB areas is adequate and no new strategies should be developed at this time.

1. Strongly disagree
2. Mildly disagree
3. Neutral
4. Mildly agree
5. Strongly agree

Additional Items

K. A process called "verticalizing" is used in some districts to establish a vertical snowbank along the concrete median barrier. The vertical snow wall tends to prevent out-of-control vehicles from vaulting over the barrier. Therefore the "verticalizing" process should be given high maintenance priority after heavy storms.

1. Strongly disagree
2. Mildly disagree
3. Neutral
4. Mildly agree
5. Strongly agree

L. Impact attenuators are often "buried" in snowbanks after plowing operations and lose their effectiveness. Therefore a high priority should be given to cleaning up the areas adjacent to impact attenuators after snow storms.

1. Strongly disagree
2. Mildly disagree
3. Neutral
4. Mildly agree
5. Strongly agree

This page may be used for any comments that you may wish to make regarding snow accumulation problems that occur along CMB sections. Any new ideas or suggestions are welcome.

Delphi Results from Round 1
(9 Respondents)

Statement	Opinion* 1	2	3	4	5	Mean Opinion
A	1	5	1	1	1	2.56
B	1	4	1	3	0	2.67
C	0	1	1	3	4	4.11
D	0	1	0	3	5	4.33
E	3	0	4	2	0	2.56
F	1	1	1	2	4	3.78
G	6	1	1	1	0	1.67
H	4	0	4	1	0	2.22
I	3	4	0	1	1	2.22
J	0	1	3	4	1	3.56

* 1 Strongly disagree

2 Mildly disagree

3 Neutral

4 Mildly agree

5 Strongly agree

MICHIGAN DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

Department of State Highways and Transportation
State Highways Building
P.O. Box 30050
Lansing, Michigan 48904