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Median Barriers: Are They Needed When They Are Optional?

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Introduction

On February 16, 1993, the driver of a 1985 Mercury two-door sedan was driving eastbound on the Bear Mountain Parkway in Westchester County, New York. The parkway has two lanes in each direction with no median or median barrier separating opposing traffic. Driving conditions were poor because of a beginning snowstorm. Approaching a curve to the right and downward grade, the eastbound Mercury slid over the solid double yellow line and stopped in the westbound driving lane. Moments later a Cadillac, driving westbound, unable to negotiate the curve to the left, or stop, collided head on with the Mercury. As a result of the collision the driver of the Mercury, plaintiff in this case, was rendered a paraplegic. The case was presented in the Court of Claims of the State of New York in May 1997.

The basis for the plaintiff's argument was: If there had been a concrete barrier installed along the centerline of the roadway the errant Mercury would have been deflected back into the eastbound lane and would not have crossed over into oncoming traffic. The plaintiff sued the State of New York.

The case hinged upon whether the State of New York was mandated to install rigid median barriers on this roadway. The key issue became the interpretation of Figure IV-A-2, (see Fig. IV-A-2 in Appendix A) Median Barrier Warrants in the American Association of State Highway and Transportation Officials (AASHTO) publication, "Guide For Selecting, Locating, and Designing Traffic Barriers, 1977", (1977 AASHTO Guide).[1] Figure IV-A-2 uses traffic volume versus median width to determine whether a rigid barrier was warranted, optional, or not necessary. A barrier warrant is defined by AASHTO in the 1977 publication as follows:

> Barrier Warrant – A criterion that identifies an area of concern which should be shielded by a traffic barrier. The criterion may be a function of relative safety, economics, etc., or a combination of factors.

Figure IV-A-2 was not easily interpreted when the characteristics and geometry of the roadway, previously not considered in Figure IV-A-2, added to

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the probability of cross over accidents. A method to clarify the selection of rigid median barriers will be suggested and discussed further along in the paper.

Description of the Roadway

The section of the roadway where the accident occurred had traffic flow of approximately 12,400 Average Annual Daily Traffic (AADT).[2] Traffic counts were measured in 1988, 1991 and 1992, and were estimated in 1993. The length of the Bear Mountain Parkway was approximately four (4) miles in an east/west direction. Traffic volume was measured in three sections of the parkway from east to west:

From: Routes 6, 9 & 202 to Peekskill City Line – 15,300 AADT

From: Peekskill City Line to Route 6 Junction – 12,400 AADT

From: Route 6 Junction to Routes 35, 202, Taconic Parkway – 10,900 AADT

The opposing lanes were separated by a double yellow line. The topography of the roadway was generally hilly and curvy. Because there was no posted speed limit other than advisory speed, the state speed limit of 55 MPH prevailed. The advisory speed limit on the curve where the Mercury was traveling was posted at 45 MPH. The driver of the Mercury stated he was traveling at a speed of 25 MPH when he slid over the double line while he was negotiating the curve.

The plaintiff's statement of speed was verified by approximating the sliding of the Mercury off of the curve at a deflection angle between 5 and 10 degrees and utilizing a drag factor of between 0.3 and 0.4. This calculated to a sliding distance of between approximately fifty-eight (58) to one hundred and sixteen (116) feet. The result gave the Mercury an approximate speed of between 23 MPH to 37 MPH. The roadway width measured approximately 42 feet with the two driving lanes eleven (11) feet in width and the two passing lanes ten (10) feet in width. There were mountable curbs with grass shoulders adjacent to the eastbound and westbound right hand driving lanes. The downward grade was approximately five (5) percent. The radius of the curve along the centerline of the roadway was approximately six hundred and forty-five (645) feet. There was no median or median barrier dividing eastbound and westbound traffic.

For the period January 1988 through February 1993 for the Bear Mountain Parkway the number of sideswipes and head-on collisions was 12.[3] The total number of accidents on the Bear Mountain Parkway is 201 with the following breakdown:

ACCIDENT TYPE	NUMBER
Non-reportable	94
Right angle	50
Rear end	20
Head-on/Sideswipe	12
Unknown	11
Overtake	7
Animal	7
Total	**201**

Positions of the Defendant

The attorney's for the State of New York stated the following position:

1. The Bear Mountain Parkway did not require a center median barrier either at the time of construction, circa 1932, or on the date of the accident. A median barrier was not mandatory.

2. There was no major reconstruction of the Parkway after it was built. The Parkway was designed and constructed in accordance with good standards of design and construction.

3. The criteria set forth in the American Association of State Highway and Transportation Officials (AASHTO) publication "Guide for Selecting, Locating, and Designing Traffic Barriers, 1977" suggests that a median barrier was not warranted.

4. The State of New York identifies the need for capital safety projects including the installation of median barriers using its "Priority Investigation Location"4 (PIL) process. This process screens accident experience for 0.3 mile segments of roadway for overlapping 2 year periods. The results are compared with numbers and rates for similar facilities and statistically significant high accident locations are listed. Safety needs are addressed on a priority basis. The subject accident was not on the PIL list for the years 1989, 1990, 1991, or 1992.

5. There was not a significant number of median crossing accidents at the subject location.

6. The claimant was driving improperly in the passing lane and failed to keep his vehicle under control using good, proper and reasonable standards of operating motor vehicles.

Position of the Plaintiff

The New York State Department of Transportation is a responsible, innovative and progressive agency. They have their own Manual of Uniform Traffic Control Devices,[5] and a Highway Design Manual Volumes I and II,[6] among other publications. They refer and rely on the American Association of State Highway and Transportation Officials (AASHTO) guidelines and publications. The NYSDOT Highway Design Manual states that median barriers would be required at or for medians less than 36 feet in width. The clause in the Highway Design Manual that gives the NYSDOT an opportunity not to install rigid median barriers states "...that the barrier should not cause a more severe accident than what it was designed to prevent."

In this case the primary criteria for having a rigid median barrier was that the parkway did not have a median width of 36 feet, but a solid double yellow line separating the travel lanes. This roadway qualified for a rigid median barrier according to the NYSDOT Highway Design Manual. The NYSDOT Design Manual further states that if a guide rail or median barrier was required, and if the parkway, expressway or freeway was operating with a free-flow speed of greater than 50 MPH, then a rigid barrier would be used if the clearance from the edge of the travel lane to barrier was less than 10 feet and two conditions apply that cause the roadway to operate below Level of Service D.

The NYSDOT Highway Design Manual also suggested to the design engineer that further information for determining the need of median barriers could be obtained from the 1977 AASHTO Guide.

The 1977 AASHTO Guide section IV-A, Warrants,[7] paragraph IV-A-1, Standard Section, states:

> Figure IV-A-2 presents the suggested warrants for median barriers on high speed, controlled access roadways which have relatively flat, unobstructed medians.
>
> As indicated in Figure IV-A-2, median barriers are warranted for combinations of average daily traffic (ADT) and median widths that fall within the dotted area. At low ADT's, the probability of a vehicle crossing the median is relatively low. Thus, for ADT's less than 20,000 and median widths below the warrant curve, median barrier use is shown as optional. .....

Refer to Figure IV-A-2, Median Barrier Warrants, in Appendix A. If the facts of this case are applied, 12,400 ADT, which is between 5,000 and 20,000 ADT on the x-axis, it can be seen that this falls within the "Optional" range.

However, if both x and y axis's are used, and moving vertically upward from the 12,400 point to the diagonal line and across to the vertical y-intercept, the volume of 12,400 ADT also relates to a median width of approximately 10 feet. The engineer for the state took only the ADT portion of Figure IV-A-2 without regard to the width of the existing median nor to the horizontal alignment, vertical alignment, and speed limit of the roadway. In this case the defense stated that because the volume of traffic was below 20,000 ADT a rigid median barrier was optional and therefore the state did not have to install barriers on this roadway. Attention to the geometry of the roadway was ignored. In other words, it was not mandatory for the state to install rigid median barriers on the Bear Mountain Parkway. The defense relied solely on the AASHTO Guide and Figure IV-A-2 and did not apply the NYSDOT Highway Design Manual criteria, nor did they apply section IV-A, Warrants, of the 1977 AASHTO Guide that suggest that Figure IV-A-2 applies to high speed, controlled access roadways that are relatively flat with unobstructed medians. Good and acceptable engineering practice should require the design engineer to investigate and apply the geometric characteristics of the roadway.

In 1989 AASHTO published the "Roadside Design Guide",[8] (1989 Guide) that superseded the 1977 AASHTO Guide. Section 6.2, Warrants, of the 1989 Guide states;

> Figure 6.1 suggests warrants for median barriers on high speed, controlled access roadways which have relatively flat, traversable medians.

In the 1977 and the 1989 editions of the AASHTO guides, the median barrier figures (charts) for warrants have not changed.

Other Factors At Issue in the Case

The defense stated that the roadway was constructed to the proper standards and regulations in effect at the time. The roadway was constructed in the year 1931 with a speed limit of 40 MPH. The defense stated (see number 2 of the position of the defense) that there was no major reconstruction of the parkway. However, since the parkway was built the speed limit had been raised and lowered several times. In 1967 it was 50 MPH, the state speed limit, as documented in the 1967 New York State Manual of Uniform Traffic Control Devices. Prior to 1973 the speed limit was raised to 55 MPH, then lowered back to 50 MPH because of the oil embargo of 1973 and raised again to 55 MPH after the oil embargo had been lifted. Each time the speed limit was raised, an analysis of the roadway should have been performed to determine if the roadway was safe for the higher speed limit and if it conformed to the NYSDOT Highway Design Manual and AASHTO guidelines. The state did not provide any information regarding analysis performed because of the raising of the speed limit.

A member of the AASHTO Subcommittee on Design was contacted regarding the paragraph on warrants. It was explained that the Figure IV-A-2 was intended for high speed, controlled access roadways that are relatively flat with unobstructed medians. Again, the Bear Mountain Parkway was a high speed, controlled access, hilly, curvy road with no median divider. The roadway characteristics of the Bear Mountain Parkway were not applied by the state's engineer when using Figure IV-A-2 to determine if rigid median barriers were necessary.

The current Median Barrier Warrant chart published in the 1996 "Roadside Design Guide", (1996 Guide), has changed. (See Fig. 6.1 in Appendix B). The axis has been exchanged. The horizontal x-axis is the Median Width in meters and the vertical y-axis measures Average Daily Traffic (ADT). The area adjacent to 20,000 and 80,000 ADT has been changed to read "Evaluate Need For Barrier" instead of "Warranted". It would seem to the writer that "Evaluate Need For Barrier" and "Barrier Optional" is the same. The choice of words on the new version of the chart "Median barrier Warrants for Freeways and Expressways" did not make the evaluation any clearer. The change from zero (0) to 20,000 ADT reads that there is no correlation to median width as in the previous version. In the prior graph, if one would enter the graph at, 12,000 ADT, for example, it would correlate to a median width of approximately ten (10) feet. The new graph does not make the correlation between traffic volume and median width. It suggests that median barriers are always optional for traffic volume from zero (0) to 20,000 ADT without regard to highway geometry. In the prior graph, median barriers were not necessary for various combinations of traffic volume and median width.

Suggested Method of Barrier Graph Use

The graphs developed by AASHTO were based on the frequency or probability of median encroachments based on the volume of traffic. It was estimated that for low volumes of traffic there would be fewer encroachments, while larger volumes of traffic would result in more encroachments. The objective of this paper is to use probability to create an equivalent ADT, where necessary, taking into account the parameters of speed, horizontal alignment, vertical alignment, and median width to adjust the AASHTO charts where appropriate. These parameters can be used to enter the graph with an increased, or adjusted ADT based on roadway geometry to determine if a median barrier is warranted or optional. For example, if it is determined that the probabilities of speed, horizontal alignment, vertical alignment, and median width are equivalent factors in a crossover accident, then the probability of an accident occurring from either of these factors is:

p(S or H or V or M) = p(S) + p(H) + p(V) + p(M) where

p = probability of a crossover event occurring

S = Speed

H = Horizontal alignment

V = Vertical alignment

M = Median width

If each factor (S, H, V, and M) is given equal weight, then the probability of a crossover accident occurring when all factors are considered are:

p(S or H or V or M) = ¼ + ¼ + ¼ + ¼ = 1 or 100% greater than on a flat, level roadway.

Therefore, if, for example, on a given roadway where all four of the factors apply, and the roadway has an ADT of 10,000, the engineer would increase the ADT by 100% to 20,000 ADT and enter the graph at 20,000 where a barrier would be warranted. If the factors were not applied, a barrier would be optional for 10,000 ADT and, more likely than not, the engineer would not recommend a median barrier. Similarly, if three (3) of the factors were present then the engineer would increase the ADT by 75%; if two of the factors were present the engineer would increase the ADT by 50%; and if one factor was present the engineer would increase the ADT by 25%. Obviously this is a simplified approach. However, further studies can, and should, be performed to determine how to weigh the various factors and make the Median Barrier Warrants chart more functional.

For example, if the choice is to weight speed, horizontal curvature, vertical curvature, and median width factors from one (1) to four (4) as the chart below suggests:

SPEED MPH	WEIGHT FACTOR	HORIZ CURVE RADIUS FT.	WEIGHT FACTOR	VERT CURVE PERCENT	WEIGHT FACTOR	MEDIAN FEET	WEIGHT FACTOR
0	0	0		0%	0	0	
30	1	300	4	2%	1	10	4
40	2	500	3	4%	2	20	3
50	3	1000	2	6%	3	30	2
60	4	1500	1	8%	4	40	1

Note: The breakdown for the above chart was derived from the AASHTO A Policy on Geometric Design for Highways and Streets 1990,[9] pages 166–170.

Using the roadway characteristics in this case the weight factors can be determined. The roadway characteristics are: speed limit of 55 MPH, radius of 645 feet, vertical grade of 5%, and a median width of zero (0) feet, the following weight factors would be assigned:

Speed = 4; Horizontal Alignment = 3; Vertical Grade = 3; Median width = 4,

Then the probability of an errant vehicle crossing over into opposing traffic would be:

p(S or H or V or M) = 4/16 + 3/16 +3/16 + 4/16 = 14/16

p(S or H or V or M) = 0.875,

or add 87.5% of 12,400 AADT, = 23,250 AADT or

enter Figure IV-2-A at 23,250 ADT

This result would indicate that rigid median barriers were warranted in this case.

Conclusion

More emphasis should be placed on highway geometry and speed when applying Figure IV-A-2 of the "AASHOT Guide for Selecting, Locating, and Designing Median Barriers, 1977", and Figure 6.1 in the "Roadside Design Guide, 1989 and 1996. For example, inscribing on the charts, "For High Speed, Controlled Access and Relatively Flat Traversable Medians", would allow the design engineer to be more aware of the roadway conditions and consider the characteristics of speed, horizontal and vertical alignment, and median width of the roadway. It is suggested that a system of Equivalent AADT similar to what was suggested above be added and incorporated into the median barrier charts of the "Roadside Design Guide"

The Courts Decision

Subsequent to the writing of this paper the excerpts of the court's decision was as follows:

"..... The proof adduced at trial reflects that there had been no changes in the design of the Parkway or any "major" reconstruction since the date of construction.".

"..... The posted speed limit on the date of the accident was 55 miles per hour. Testimony adduced at trial, while not entirely clear, reflected that sometime after the "oil crisis" the posted speed limit on the Parkway was increased from 50 miles per hour to 55 miles per hour".

"According to him (State's expert), the graph (Figure IV-A-2) clearly indicates that placement of a median barrier is optional where, as here, the median width is less than 20 feet and the average daily traffic volume is less than 20,000 vehicles. He explained that in situations such as this, i.e., where installation is optional, the determination as to whether or not to install a median barrier requires an analysis of, among other factors, the accident history of the roadway. State's expert conducted such an analysis utilizing records maintained by the Department of Transportation and found that in the three-year period prior to this accident, the accident rates were "low to moderate" in comparison with other "similar" State roadways."

"Through his expert, Claimant asserts that placement of a median barrier was mandated under the standards set forth in the Highway Design Manual and the 1977 AASHTO Guide. ...."

"The graph clearly and unequivocally reflects that installation of a median barrier is, under the circumstances presented here, optional or a function of reasoned discretionary engineering judgment. I find on the record before me that Claimant has failed to demonstrate that the State deviated from applicable engineering standards."

"..... upon the proof before me, I am unable to find that those injuries are attributable to any negligence of the State."

Appendix A

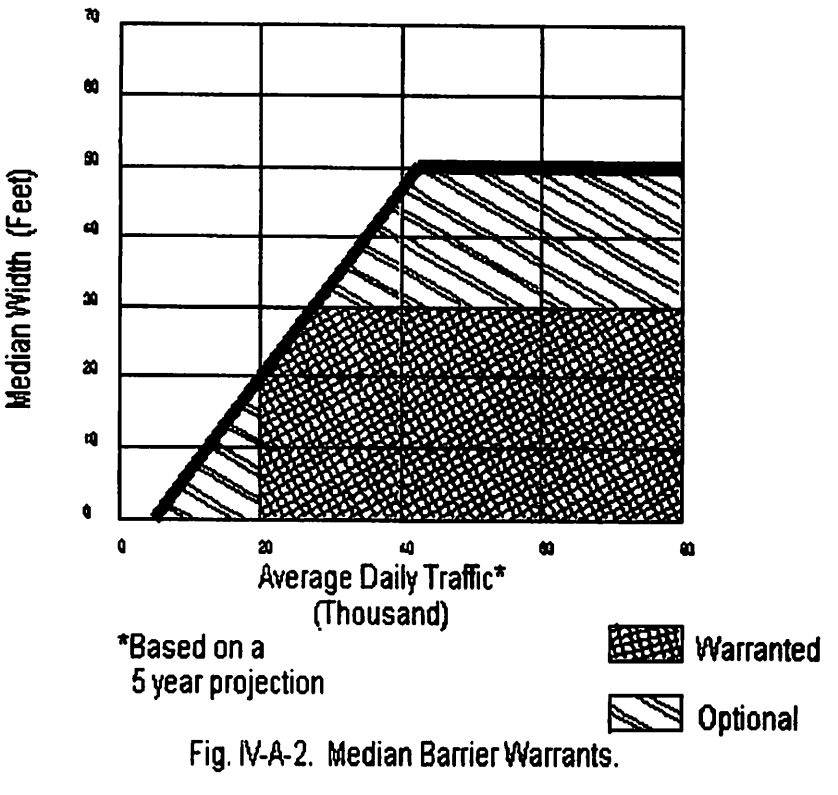

Fig. IV-A-2. Median Barrier Warrants.

From *Guide For Selection Locating and Designing Traffic Barrier,* Copyright, 1977, by the American Association of State Highway and Transportation Officials, Washington, D.C. Used by permission.

Appendix B

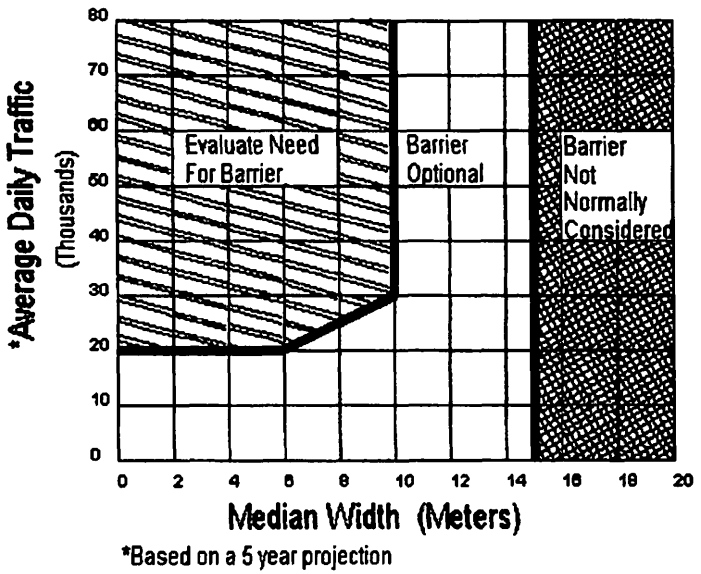

Figure 6.1 Median Barrier Warrants for Freeways and Expressways

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Appendix C

New York State Highway Design Manual Volume I, Section 10.

10.02 MEDIAN BARRIERS

10.02.01 PURPOSES

To reduce accident severity by:
A. Eliminating head-on collisions.
B. Redirection errant vehicles.

10.02.02 WARRANTS

Median1 barrier will be required at or for:
A. Medians less than 36 feet in width.
B. Interchange locations where:
   1. Adjacent opposite direction ramps exist.
   2. Exit and entrance ramp terminals at crossroads will permit wrong-way movements.

The requirement of installing median barrier in medians less than 36 feet in width will apply to all Rural and Urban Expressways and to Urban Arterials with medians where mid-block access is not allowed. .....

[1] The word median as used in this Manual means the full width between edges of pavement.

Keep in mind that median barrier should be provided only when running into the item being protected would cause a more severe accident than running into the median barrier.

CRITERIA FOR USING RIGID MEDIAN BARRIER

Although our flexible, energy absorbing barriers are superior to the concrete median barriers under most conditions, from the standpoint of cost and safety to passengers, we feel the use of rigid barriers is warranted where only very flat angle impacts are anticipated; and the advantages of the flexible system are outweighed by the problems associated with a high frequency of impacts such as;

1. Loss of protection during "down time."
2. High maintenance costs.
3. Increased accident potential created by maintenance vehicles occupying travel lanes.

Therefore, the policy for the use of concrete median barriers will be as follows:

Whenever guide rail or median barrier is required on a Parkway, Expressway of Freeway with a free-flow operating speed in excess of 50 MPH, a rigid barrier of approved type will be used if the available horizontal clearance from edge of travel lane to barrier is less than 10 feet and either of the following conditions prevail:

1. The highway operates or is expected to operate below Level of Service D during average daily peak hours.
2. The highway will operate below Level of Service D during daylight barrier maintenance operations under average daily traffic conditions.

For further information on methods for determining the need for the installation of median barrier, refer to the AASHTO Guide for Selection, Locating and Designing Traffic Barriers, 1977.

References

1. New American Association of State Highway and Transportation Officials (AASHTO) publication "Guide for Selecting, Locating and Designing Traffic Barriers".
2. New York State Department of Transportation 1993 Traffic Volume Report, page 327.
3. New York State Accident Description Report.
4. New York State Department of Transportation Priority Investigation Location.
5. New York State Department of Transportation Manual of Uniform Traffic Control Devices, 1983.
6. New York State Department of Transportation Highway Design Manual Volumes I and II.
7. AASHTO Guide for Selecting, Locating and Designing Traffic Barriers, 1977, section IV-A. Warrants, page 76.
8. AASHTO, "Roadside Design Guide", 1989
9. AASHTO, A Policy on Geometric Design for Highways and Streets, 1990, pages 166 - 170.