MEDIAN TREATMENT STUDY OF WASHINGTON STATE HIGHWAYS

WA-RD 516.1

March 2002

Washington State
Department of Transportation

Washington State Transportation Commission
Planning and Capital Program Management
Design Policy, Standards, & Safety Research Office

Median Treatment Study

of Washington State Highways

March 2002

Washington State Department of Transportation

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. WA-RD 516.1	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE Median Treatment Study on Washington State Highways		5. REPORT DATE March 2002
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Richard W. Glad/Richard B. Albin/Dawn M. McIntosh/David K. Olson		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Washington State Department of Transportation Transportation Building, MS 7329 Olympia, WA 98504-7329		10. WORK UNIT NO.
		11. CONTRACT OR GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Design Policy, Standards, & Safety Research Office Washington State Department of Transportation Transportation Building, MS 7329 Olympia, Washington 98504-7329		13. TYPE OF REPORT AND PERIOD COVERED Research Report
		14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

Across the median crashes are high severity, often fatal crashes occurring when errant vehicles cross the median and enter the opposing lanes of travel. Guidelines for the installation of median barriers presented in the AASHTO Roadside Design Guide were developed in the 1960's. A study of across the median crashes on Washington's multilane, divided state highways, with full access control, was conducted to evaluate median barrier guidelines and identify specific highway sections where installation of a barrier is desirable. A benefit/cost analysis was conducted to evaluate the cost effectiveness of median barrier installation. The analysis was used to develop revised guidelines for median barrier installation. In addition, the benefit/cost methodology provides a means for ranking median barrier needs based on past crash history. This ranking will allow these improvements to compete for safety improvement funds.

17. KEY WORDS Key words: Across the median crashes, median, median barrier, concrete barrier, cable barrier, guardrail		18. DISTRIBUTION STATEMENT No restrictions.	
19. SECURITY CLASSIF. (of this report) None	20. SECURITY CLASSIF. (of this page) None	21. NO. OF PAGES	22. PRICE

Abstract

Across the median crashes are high severity, often fatal crashes occurring when errant vehicles cross the median and enter the opposing lanes of travel. Guidelines for the installation of median barriers presented in the AASHTO Roadside Design Guide were developed in the 1960's. A study of across the median crashes on Washington's multilane, divided state highways, with full access control, was conducted to evaluate median barrier guidelines and identify specific highway sections where installation of a barrier is desirable. A benefit/cost analysis was conducted to evaluate the cost effectiveness of median barrier installation. The analysis was used to develop revised guidelines for median barrier installation. In addition, the benefit/cost methodology provides a means for ranking median barrier needs based on past crash history. This ranking will allow these improvements to compete for safety improvement funds.

Introduction

Across the median crashes have been identified as a national problem due to the severity of crashes that occur when errant vehicles cross the median and enter the opposing lanes of travel. The AASHTO Strategic Plan identifies across the median crashes as one of its strategies to improve safety[1]. Although the specific cause of across the median crashes may be difficult to determine, one method to reduce the severity potential for these crashes is to install a median barrier.

Guidelines for the installation of median barrier were developed in the 1960's and have remained essentially unchanged. These guidelines are contained in the American Association of State Highway and Transportation Officials' (AASHTO) Roadside Design Guide and in the Washington State Department of Transportation's (WSDOT) *Design Manual*. This paper summarizes an evaluation of across the median crashes on Washington State's divided highways.

Current Guidelines

WSDOT guidance for the installation of median barrier (Figure 700-7 in the WSDOT *Design Manual*) is essentially the same as the guidance provided in the AASHTO Roadside Design Guide. AASHTO guidance was developed using a study conducted by the California DOT in 1968 [2]. This guidance provides criteria for median barrier installation based on the average daily traffic (ADT) and width of median. The criteria

---

[1] AASHTO Strategic Highway Safety Plan, 1998.
[2] Graf, V.D. and Wingerd, N.C., "Median Barrier Warrants", Traffic Dept. of the State of California, 1968

for barrier protection indicates that the designer should "evaluate the need for barrier" on all medians up to 32.8 feet in width when ADT is 20,000, or greater. Barrier is optional for all medians between 32.8 feet and 50 feet or when the median is less than 32.8 feet and the ADT is less than 20,000. AASHTO indicates "barrier not normally considered" for median widths greater than 50 feet.

The national focus on reducing across the median crashes was reflected in the AASHTO Strategic Plan for improving roadside safety. The need for improved guidance provided a catalyst for a research effort that is currently underway with NCHRP Project 17-14 (Improved Guidelines for Median Safety). Several states have already revised their median barrier guidelines to increase the use of median barrier. In June 1998[3], the North Carolina Department of Transportation incorporated median barrier installation for all new construction, reconstruction, and resurfacing projects with medians 70 feet or less in width, initiating a program to install approximately one thousand additional miles of median barrier on their highways. Cal-Trans has adopted more stringent warrants based on ADT for freeways with medians less than 75' in width[4].

Previous WSDOT Research

Previous research (Shankar, et al., 1999)[5] examined median crossover crashes using a statistical analysis. Using five years of crash data, the authors found that the current warrant of 30 feet over various ADT ranges needed to be reexamined, and might have

---

[3] Memorandum from State Design Engineer, June 8, 1998.
[4] Cal-Trans Traffic Manual, Chapter 7, Figure 7-7.
[5] Shankar, V., Albin, R., Milton, J., & Mannering, F., 1999. "Evaluating Median Crossover Likelihoods with Clustered Accident Counts, TRR 1635, Transportation Research Board, Washington, D.C.

significant implications for statewide infrastructure programming efforts. Shankar's research determined that median width is a significant factor in median crossover collisions.

Study Approach

The objectives of this study were twofold. The first was to develop revised guidelines for the installation of median barrier. The second was to develop a method for ranking median barrier improvements that would allow them to compete for funding. To accomplish these objectives, a benefit/cost (B/C) methodology was developed based on across the median crash histories. A detailed description of the tasks performed follows.

Identify Highway Sections

The first step was to identify the sections of Washington State's multilane, divided highways, with full access control, that contained depressed or unprotected medians. Then, because sections with this criterion are generally high volume, high-speed facilities, limited access urban sections with speeds under 45 mph and with sections with AADT under 5,000 were eliminated. The remaining sections were reviewed using the video log system as a check to identify sections without barriers for breaks at intersections and to resolve other anomalies in the locations identified. This analysis resulted in the identification of approximately 677 miles of Washington State highway segments for further study. A summary of these locations, categorized by median width groups and AADT, is shown in Table 1.

Median Width Groups	Average Annual Daily Traffic						Total Of Length
	5,000-10,000	10,000-15,000	15,000-20,000	20,000-25,000	25,000-30,000	Over 30,000	
Under 30'	0	1	0.76	3.81	0.26	0.69	6.52
30-40'	0.17	28.36	12.56	7.88	3.68	90.93	143.58
41-50'	0	13.57	4.5	1.44	3.33	44.99	67.83
51-60'	0.81	2.99	0.4	0	1.72	9.72	15.64
61-70'	0	15.85	0.05	0	4.36	9.29	29.55
71-80'	52.07	112.44	85.28	10.69	8.2	31.4	300.08
Over 80'	28.79	30.04	0.41	8.43	0.79	45.15	113.61
Totals	81.84	204.25	103.96	32.25	22.34	232.17	676.81

Table 1- Highway Miles of Depressed or Unprotected Medians

Analyze Crash History

Crash data for the identified sections was extracted from the WSDOT Transportation Information and Planning Support (TRIPS) crash database for the 5-year time period from January 1, 1996 through December 31, 2000. This database contained incomplete data for the years of 1997 and 1998 because a backlog of data entry. It was estimated that only eighty percent of the actual crash data was available in the database for these years. The majority of the missing records were for citizen reported crashes where a state trooper did not report to the scene. It is considered unlikely that these missing records contain a significant number of across the median crashes as these would generally result in a significant incident that prompted a police report.

Across the median crashes were identified in collision reports where a vehicle ended up in the opposing direction of travel. The data was reviewed to ensure that wrong-way crashes were not included. The result of this data extraction was the identification of 642 across the median crashes.

A summary of these crashes, categorized by median width and AADT, is shown in Table 2.

Median Width Groups	Average Annual Daily Traffic						Total Crashes
	5,000-10,000	10,000-15,000	15,000-20,000	20,000-25,000	25,000-30,000	Over 30,000	
Under 30'	0	0	2	1	0	0	3
30-40'	0	28	10	10	3	222	273
41-50'	0	16	6	4	1	73	100
51-60'	0	1	0	0	2	6	9
61-70'	0	4	0	0	0	12	16
71-80'	13	37	60	4	5	34	153
Over 80'	13	18	2	11	1	43	88
Totals	26	104	80	30	12	390	642

Table 2-Crash History for Median Sections

Table 3 was generated to demonstrate the crash rates of the different median width groups.

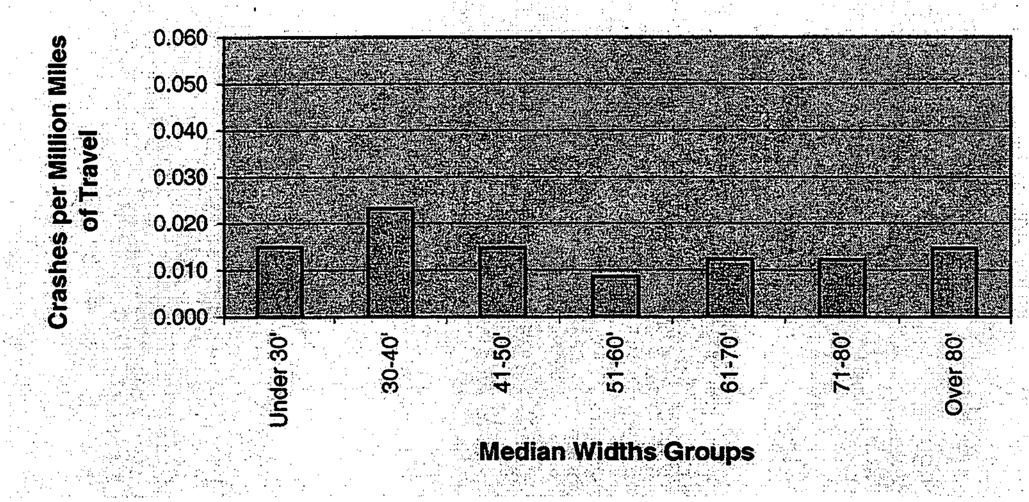

Table 3-Crash Rates of Median Groups

Perform Benefit/Cost Analysis

To perform a benefit/cost analysis, it was necessary to identify the benefits expected from the installation of a median barrier. Benefits anticipated from installation of barrier would be in the reduced societal cost of crashes. WSDOT uses the values in Table 4 for societal cost of crashes. These numbers were used for safety investment programming during the 1999-2001 budget process.

Severity	Societal Cost
Per Fatal Collision	$800,000
Per Disabling Injury Collision	$800,000
Per Evident Injury Collision	$62,000
Per Possible Injury Collision	$33,000
Per Property Damage Only Collision	$5,800

Table 4-Societal Costs of Crashes

The addition of a barrier is expected to reduce the potential for high severity, head-on collisions. However, the number of crash occurrences may increase. It is also expected that the presence of a barrier might introduce damage in incidents where a vehicle might have recovered without damage in the barrier-free median. Since the number and severity of unreported median encroachments is unknown, it was not possible to estimate this negative impact.

The number and severity of future crashes is difficult to predict. For the B/C analysis, assumptions were made that the number of "after" crashes will be equal to the number of "before" crashes and that the severity of the crashes will be "possible injury." While this approach probably underestimates the number of barrier collisions, it might also overestimate the average severity (particularly for the flexible and semirigid barriers), resulting in a reasonable balance of costs.

Using actual contract cost data, estimates of construction costs for three different types of barrier (cable barrier, beam guardrail, and concrete barrier) were developed. These costs assumed that minimal grading would be required for barrier installations. Maintenance costs for periodic inspection, adjustment, and repair were estimated by reviewing actual maintenance costs for repairs to systems in Washington State. The minimal grading assumption underestimates costs for some locations. However, the lack of site-specific cross section data prevents a more detailed analysis for individual locations, so costs for traffic control or drainage items that might be required with barrier placement were not included. For purposes of a system-wide comparison of different barrier types, this approach provides the level of detail needed to compare costs between barrier systems.

Type of Treatment	Construction Costs (per mile)	Yearly Maintenance Costs (per mile)
Cable Barrier	$95,040	$1,880
Guardrail	$168,960	$270
Concrete Barrier	$285,120	$43

Table 5-Estimated Construction and Maintenance Costs

Using an inflation rate of four percent per year over twenty years, the present worth B/C ratios were determined for each segment and then grouped by ten-foot median width increments.

Benefits

Five Year Actual Accident Costs = (# of PDO and not stated injury) **x** (societal cost)* + (# of possible injury) **x** (societal cost)* + (# of evident injury) **x** (societal cost)* + (# of disabling and fatal injury) **x** (societal cost)*

After Barrier Five Year Crash Cost Estimate = (# of total injury) **x** (societal cost of possible injury)

Benefits = (Five year Actual Accident Costs) – (After Barrier Five Year Crash Cost Estimate) ÷ 5 [convert to yearly benefit]

*Figures from Table 4

Installation Costs

$Cost_I$ = (Section Length in miles) **x** (Average WSDOT Cost per mile)**

**Figures from Table 5

Maintenance Costs

$Cost_M$ = (Yearly Average Maintenance Cost)** **x** (Section Length)

**Figures from Table 5

Benefit Cost Calculation

$$B/C = \frac{(\text{Benefits} \times 13.59)\ [\text{Present Worth Factor}]}{Cost_I + (Cost_M \times 13.59)\ [\text{Present Worth Factor}]}$$

The B/C ratio summaries for the incremental median widths are shown in Table 6. A ranked listing of the individual locations was developed for each region, with the expectation that this list can be used for developing candidate projects when funds are available.

While the maintenance costs per mile for cable barrier are considerably higher than guardrail or concrete barrier, the low construction costs resulted in cable barrier having the lowest annualized total costs and the higher B/C ratios. It is expected that site-specific cost analysis with the inclusion of traffic control and drainage items will have the most impact on concrete barrier costs. Traffic control and drainage costs are expected to be the lowest for cable barrier. These additional cost factors further support the finding that cable barrier is the most cost effective of the barrier systems analyzed.

The B/C ratio for sections with median widths over 60 feet dropped significantly. A review of the mileage in each width category showed that medians in the 50 to 60 feet width range were a relatively small portion of the data set, increasing the possibility for an unrepresentative sample. B/C ratios for medians 50 to 60 feet wide are generally comparable to other safety program improvements, whereas B/C ratios for median widths between 30 and 50 feet generally exceed the ratio for other safety program improvements. In the final analysis, it was determined that medians of 50 feet or less presented a logical break for establishing new median barrier guidelines. This analysis resulted in B/C ratios ranging from 2.7 to 5.5 statewide for installation of a cable median barrier on highways with medians of 50 feet or less. The aggregate value for medians of 50 feet or less resulted in a B/C ratio of 5.2. Consideration was given to inclusion of average annual daily traffic (AADT) criteria, but it was determined that the type of facilities being analyzed (multilane, divided, and controlled access) would generally have high traffic volumes. Therefore, simple guidelines based on the width of the median are proposed.

Median Width Groups	Cable	Guardrail	Concrete
Under 30'	2.7	1.9	1.1
30-40'	5.5	3.9	2.3
41-50'	4.7	3.3	2.0
51-60'	3.2	2.3	1.4
61-70'	0.6	0.4	0.3
71-80'	0.8	0.6	0.4
Over 80'	2.3	1.6	1.0

Table 6 - B/C ratios for median width groups for barrier types

The B/C ratios shown are based on a system-wide analysis of typical sections. For locations where the assumptions about typical section costs do not apply, it is anticipated that the B/C will be lower due to increased site preparation costs. Site-specific analysis may result in B/C ratios that are not cost effective.

Recommendations

This study was presented to the WSDOT Highway Safety Issues Group (HSIG) on May 17, 2001. HSIG is a statewide committee chartered to coordinate the development of policy, plans, and programs for highway safety. The HSIG recommendations are:

- The WSDOT Headquarters Design Office is to revise the *Design Manual* guidance for median barrier installation to recommend placement on all medians on full access control, multilane highways with posted speeds of 45 mph or greater where the medians widths are 50 feet wide or less. The type of barrier to use is to be determined on a project basis. Medians with lower speeds or widths greater than 50 feet are to be considered based on crash history.
- The B/C analysis list developed during the study is to be distributed to the regions. Projects may be developed from the list and compete for safety improvement funding based on the B/C ratio. Site-specific analysis might change the B/C ratios and ranking shown in the list.
- Additional funding sources, such as the Washington State Traffic Commission's Target Zero funds, will be pursued to fund high B/C ratio projects identified in the study.

Conclusions

A B/C methodology was developed to evaluate traffic barrier solutions for across the median crashes on multilane, divided highways with full access control in Washington State. It was found that barrier placed in median sections up to fifty feet wide is cost effective. The B/C ratios indicate that cable barrier is the most cost effective system, based on the assumptions of this study.

A ranked list was distributed to the regions for consideration in their program development process. Projects can be developed from the list and compete for safety improvement funding based on the B/C ratio. Additional funding sources will be pursued to fund high B/C ratio projects identified in the study.