Guardrail Committee Meeting Minutes

August 18, 2010
10:00 AM
Roadway Design Conference Room

I. Median Closures on Freeway Facilities

The Guardrail Committee discussed what steps need to be taken to address closing up the gaps between the cable median guiderail and the impact attenuator / guardrail anchor units. An Attachment (Attachment 1) was provided which was a copy of the meeting minutes letter dated December 30, 2009 to address median closures on freeway facilities. The Guardrail Committee agreed that additional steps should be taken to close up all gaps between the cable median guiderail and impact attenuators. These areas are unsightly, difficult to maintain, and are unsafe due to the lack of sight distance. Gap locations required to aid with vegetative maintenance may require the placement of flexible delineator posts.

II. Proprietary Guardrail Items

The Guardrail Committee discussed what revisions need to be made to our Roadway Special Provisions for both Guardrail Anchor Units and Impact Attenuator Units to allow the usage of 2 or more approved or equal proprietary guardrail products. Also, the Guardrail Committee discussed that the names of some of the proprietary guardrail products may need to be revised to reflect upgrades made by the manufacturers.

III. Manual for Assessing Safety Hardware (MASH)

The Federal Highway Administration has requested that we coordinate with Transportation Mobility and Safety to update our Special Provisions to reflect MASH guidelines. The Guardrail Committee watched a video presentation by Dick Albin of the FHWA Resource Center about MASH. They also were provided a copy (Attachment 2) of the November 20, 2009 letter from David A. Nicol, FHWA Director, Office of Safety Design. The letter provides information in regards to the Background and Implementation Plan for MASH and has an attachment which provides a summary of the differences between MASH and NCHRP 350.

The Guardrail Committee was provided and reviewed a copy (Attachment 3) of the letter dated May 17, 2010 also from David A. Nicol which provides guidance to the State DOTs and FHWA Division Offices on the height of guardrail for new installations on the National Highway System. This letter notes that transportation agencies should ensure the minimum height of newly installed G4 (1S) W-beam guardrail is at least 27¾" (minimum) to the top of the rail, including construction tolerance. Furthermore it notes that Division Offices should work closely with their state transportation agencies to implement a revised minimum installation height for G4 (1S) guardrail of 27¾" and consider adopting 31-inch high guardrail designs.

IV. Finite Element Evaluation of Two Retrofit Options to Enhance the Performance of Cable Median Barrier

The final report for this project has been completed for the Research and Development Unit by the University of North Carolina at Charlotte. Simulations to evaluate two cable median barrier retrofit options for back-side and front-side hits with adjustment of the cable heights were studied / validated. A brief summary of the findings was discussed with the Guardrail Committee. An attachment (Attachment 4) was provided which consisted of a copy of the Final Report cover sheet, the Technical Report Document Page and the Executive Summary.

Action Items

Discussion Topic I

- Roger Thomas and Joel Howerton will look into different alternatives that will address revising Standard Drawing 862.01 to close up the median gaps. Once the alternatives are developed, Roger Thomas will solicit information from the Division Offices to get their comments in regards to closing up all the gaps between the cable guiderail and the impact attenuators.

Discussion Topic II

- Joel Howerton will investigate if there are any approved guardrail anchor units or impact attenuators that should be added to the units currently noted in our Special Provisions. He will also look into whether or not the product names need to be revised for the guardrail anchor units and impact attenuators presently called for in the Special Provisions.

Discussion Topic III

- Jay Bennett, Roger Thomas and Joel Howerton need to meet and determine what changes need to be made to the guardrail related Special Provisions based upon the new MASH guidance.

- Jay Bennett, Roger Thomas and Joel Howerton will development an implementation plan which will address specifying the minimum guardrail placement height of 27 ¾". Also they will need to determine what height adjustment will need to be made to accommodate future resurfacing. The implementation plan will need to address both damaged guardrail and new installations. This information should be reviewed by the Guardrail Committee and Operations prior to implementation.

Minutes prepared by Roger Thomas, PE ____________

Minutes approved by Jay Bennett, PE ____________

Attachment 1

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

BEVERLY EAVES PERDUE
GOVERNOR

EUGENE A. CONTI, JR.
SECRETARY

MEMO TO: File

FROM: Roger Thomas, PE
Project Engineer Roadway Design

DATE: December 30, 2009

SUBJECT: **Meeting to Address Median Closures on Freeway Facilities**

A meeting was held December 9, 2009, at 10:30 a.m. in the Roadway Design Conference Room to discuss a request by Kevin Lacy, State Traffic Engineer. Kevin requested that the Department re-initiate efforts to provide improved median treatments on freeway facilities at median hazards where there is a gap between the cable median guiderail and the impact attenuator/guardrail anchor unit. The following is a list of the meeting attendees:

Roger Thomas	Jay Bennett	Shawn Troy
Brad Robinson	Tony Wyatt	David Harris
Brad Hibbs	Glenn Mumford	Joel Howerton

Roger Thomas began the meeting and gave a brief overview of the letter dated January 3, 2008, from Allen Pope, Division 3 Engineer, to the Incident Management Responders. This letter addressed the median closures on 4 lane median divided freeway facilities with cable guiderail or guardrail. This letter notes that originally gaps were left between the cable guiderail and impact attenuators/guardrail anchor units for maintenance operations and emergency response. However, Division 3 has a new initiative to close up additional gaps on freeway facilities to make them safer.

Tony Wyatt noted the initial request to address this concern was originally initiated during the October 21, 2009, Traffic Engineering Roundtable Meeting in Winston Salem. During the meeting, a PowerPoint presentation was given by Pate Butler which noted how Division 3 was trying to implement a comprehensive program to close up guiderail to impact attenuator/guardrail anchor unit gaps along their freeway facilities. From this meeting, the Transportation Mobility and Safety Unit decided to investigate further what steps or measures could be taken to implement a comprehensive statewide program to close up additional median gaps.

Brad Hibbs questioned if there was any crash data information available which addressed areas where cable guiderail to impact attenuator/guardrail anchor unit gaps currently exist.
Shawn Troy provided a handout with crossover crash data for crashes that occurred between January 2004 and December 2009 (5 years). The Statewide Crossover Crash Project Methodology data was based upon specified criteria from accident reports. The data findings

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RALEIGH NC

noted 106 crashes related to crossovers. A table of routes and counties summarizing the crashes was provided. It was noted that due to these crashes there were likely a lot of secondary crashes that were not accounted for with this data.

It was the consensus of the group that for existing freeway facilities the quickest and most costs effective way to close up the gaps would be to place delineator post along the gaps. This method could be used until another solution is developed. For projects currently under design, a new detail would need to be developed to connect the cable guiderail to a steel beam guardrail anchor unit and form an envelope protecting the median hazard.

Bobby Lewis, Division 4 Maintenance Engineer, did not attend the meeting however he conveyed his comments to Roger Thomas prior to the meeting. Bobby noted that he would like to have all the gaps closed and at the legal crossovers he would recommend having Safe Hits (a flexible soil and surface mount post) posts installed.

Jay Bennett requested that Joel Howerton find out more information about Safe Hits. Everyone questioned its longer term durability and if its profile when hit would be low enough to not damage the front of a Highway Patrol Car.

David Harris noted that the number of times mowing operations occurred for each Division varies. Also, the measures they implement to reduce mowing costs varies. The Eastern Divisions are converting their turf over to centipede grass. Low growing, low maintenance, turf species that if managed correctly can cut mowing down to once or twice a year. The Western Divisions are utilizing some low growing species such as hard fescue and blue grasses. They also spray a plant growth regulator herbicide that will inhibit growth for a month or two and sometimes can reduce mowing by two to three cycles. David expressed concern with closing up all freeway gaps. He was especially concerned with how mower operators could mow each side of the median without having to increase the number of times they would be required to cross travel lanes.

Tony Wyatt noted that there may be funding available to close up additional gaps through the Maintenance of Effort projects that are currently under development. This would require a quick timeframe to develop a detail for closing the gaps and coordinating with the Division Engineers to get by in with implementing the program.

RDT

Attachments

CC: Meeting Attendees (w/att.)
Kevin Lacy (w/att.)
Bobby Lewis, PE (w/att.)

Attachment 2

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: INFORMATION: Manual for Assessing Safety Hardware (MASH)

Date: November 20, 2009

From: David A. Nicol
Director, Office of Safety Design

In Reply Refer To: HSSD

To: Directors of Field Services
Federal Lands Highway Division Engineers
Division Administrators

The American Association of State Highway and Transportation Officials (AASHTO) recently published the *Manual for Assessing Safety Hardware* (MASH). MASH is an update to and supersedes NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, for the purposes of evaluating new safety hardware devices. MASH is not a design standard and does not supersede the criteria for the design of roadside safety hardware contained within the AASHTO Roadside Design Guide.

Background

The purpose of MASH is to present uniform guidelines for the crash testing of both permanent and temporary highway safety features and evaluation criteria to assess test results. It also includes guidelines for the in-service evaluation of safety features. These guidelines and criteria, which have evolved over the past 40 years, incorporate current technology and the collective judgment and expertise of professionals in the field of roadside safety design. They provide: (1) a basis on which researchers and user agencies can compare the impact performance merits of candidate safety features, (2) guidance for developers of new safety features, and (3) a basis on which user agencies can formulate performance specifications for safety features.

The need for updated crash test criteria was based primarily on changes in the vehicle fleet. A summary of the differences between NCHRP Report 350 and MASH is attached for your information. The summary includes a brief synopsis of the expected effects on crash tested roadside hardware. A video presentation about this publication, developed by Mr. Dick Albin of the FHWA Resource Center, is online at: https://admin.na3.acrobat.com/_a55098539/mashfinal

Implementation Plan
Requirements in Section 1408 of SAFETEA-LU stated that "The Secretary, in cooperation with the Association [i.e., AASHTO], shall publish updated guidance regarding the conditions under which States, when choosing to improve or replace highway features on the NHS, should improve or replace such features...". The AASHTO/FHWA Implementation Plan was developed to satisfy that requirement.

Implementation of MASH on the NHS will be as follows:

- The AASHTO Technical Committee on Roadside Safety is responsible for developing and maintaining the evaluation criteria as adopted by AASHTO. FHWA shall continue its role in the review and acceptance of highway safety hardware.
- All highway safety hardware accepted prior to adoption of MASH using criteria contained in NCHRP Report 350 may remain in place and may continue to be manufactured and installed.
- Highway safety hardware accepted using NCHRP Report 350 criteria is not required to be retested using MASH criteria.
- If highway safety hardware that has been accepted by FHWA using criteria contained in NCHRP Report 350 fails testing using MASH criteria, AASHTO and FHWA will jointly review the test results and determine a course of action.
- Upon adoption of MASH by AASHTO, any new highway safety hardware not previously evaluated shall utilize MASH for evaluation and testing.
- Any new or revised highway safety hardware under development at the time the MASH is adopted may continue to be tested using the criteria in NCHRP Report 350. However, FHWA will not issue acceptance letters for new or revised highway safety hardware tested using NCHRP Report 350 criteria after January 1, 2011.
- Highway safety hardware installed on new construction and reconstruction projects shall be those accepted under NCHRP Report 350 or MASH.
- Agencies are encouraged to upgrade existing highway safety hardware that has not been accepted under NCHRP Report 350 or MASH:
  - during reconstruction projects,
  - during 3R projects, or
  - when the system is damaged beyond repair.
- Highway safety hardware not accepted under NCHRP Report 350 or MASH with no suitable alternatives available may remain in place and may continue to be installed.

Policy Implications
As noted in the Implementation Plan, hardware that has been tested and accepted under NCHRP Report 350 does not have to be re-tested under MASH. States may leave that existing hardware in place and they may continue to install it in new projects. When Report 350 hardware fails crash testing under MASH criteria we will confer with AASHTO and determine whether the device may continue in use, decide to study it further, or recommend that other hardware be used.

We recommend that you advise your States NOT to immediately convert their specifications to require MASH-tested devices; there are not enough devices available that have been crash tested under the new guidelines. States should be open to allowing and/or adopting MASH-tested hardware as it becomes available, but most NHCRP Report 350 devices will continue to be acceptable for the near future.

Availability of MASH
The Office of Safety is purchasing one copy for each FHWA Division Office, including the Federal Lands Highway Division Offices, and these will be sent separately. MASH can be purchased from the AASHTO online bookstore: https://bookstore.transportation.org/item_details.aspx?ID=1539. We also intend to purchase copies of the revised Roadside Design Guide for the Division Offices, the Resource Center, and FLHD, when it is issued in 2010.

Attachment

cc:
Associate Administrator for Infrastructure
Associate Administrator for Operations
Associate Administrator for Research, Development and Technology
Resource Center
SAFETYFIELD

Summary of Differences between MASH and NCHRP 350

The AASHTO *Manual for Assessing Safety Hardware* (MASH) presents uniform guidelines for crash testing permanent and temporary highway safety features and recommends evaluation criteria to assess test results. This manual is recommended for highway design engineers, bridge engineers, safety engineers, maintenance engineers, researchers, hardware developers, and others concerned with safety features used in the highway environment.

MASH is an update to and supersedes NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features,* for the purposes of evaluating new safety hardware devices. MASH does not supersede any guidelines for the design of roadside safety hardware, which are contained within the AASHTO *Roadside Design Guide*. An implementation plan for MASH that was adopted jointly by AASHTO and FHWA states that all highway safety hardware accepted prior to the adoption of MASH – using criteria contained in NCHRP Report 350 – may remain in place and may continue to be manufactured and installed. In addition, highway safety hardware accepted using NCHRP Report 350 criteria is not required to be retested using MASH criteria. However, new highway safety hardware not previously evaluated must utilize MASH for testing and evaluation.

MASH was developed through National Cooperative Highway Research Program (NCHRP) Project 22-14(02), "Improvement of Procedures for the Safety-Performance Evaluation of Roadside Features," and contains revised criteria for impact performance evaluation of virtually all highway safety features, based primarily on changes in the vehicle fleet. Some of the major differences between MASH and NCHRP Report 350 include:

Changes in Test Matrices

- The small car impact angle is increased from 20 to 25 degrees to match the impact angle used with light truck testing
- The impact speed for the single-unit truck test is increased from 80 km/h to 90 km/h to better distinguish the TL-4 test from TL-3
- The impact angle for length-of-need testing of terminals and crash cushions is increased from 20 to 25 degrees to match that for longitudinal barriers
- The impact angle for oblique end impacts for gating terminals and crash cushions is reduced from 15 to 5 degrees
- For small vehicle tests on cable barrier, the target impact point must be at mid-span to evaluate the potential for under-ride, while the target impact point for all other test vehicles shall be limited to 1 foot upstream of the post for all test conditions
- Length-of-need tests with the pickup truck are required to meet occupant risk criteria
- A head-on test with the mid-size car is added for staged impact attenuation systems
- The barrier mounting height is recommended to be set at the maximum for small car tests and at the minimum for pickup truck tests
- The critical impact point for the small car terminal test is defined as the point where the terminal behavior changes from redirection to gating
- The critical impact point for reverse direction impacts requires testing at the transition from backup structure to crash cushion
- Two previously optional TMA tests are now mandatory
- Variable message signs and arrow board trailers are added to the TMA crash test matrix
- A pickup truck test is added to tests of support structures and work zone traffic control devices

- Longitudinal channelizers are added as a category and a test matrix is recommended
- Event data recorded and airbag deployment data to be collected on test vehicles

Changes in Test Installations

- Performance-based specifications for soil are added to the existing material-based specifications to help ensure consistency in soil strength
- The lateral width requirement for fill material is eliminated
- Any rail element splices that are used in the field are required to be installed in the impact region during testing
- Cable tension is required to be set to the value recommended for 100 degrees Fahrenheit
- More detailed documentation of components used in the test installation is required
- Minimum installation length requirements are specified more clearly

Changes in Test Vehicles

- The size and weight of test vehicles is increased to reflect the increase in vehicle fleet size:
    - the 820C test vehicle is replaced by the 1100C
    - the 2000P test vehicle is replaced by the 2270P
    - the single unit truck mass is increased from 8000 kg to 10,000 kg
    - the light truck test vehicle must have a minimum center of gravity height of 28 inches
- The option for using passenger car test vehicles older than 6 years is removed
- Truck box attachments on test vehicles are required to meet published guidelines
- External vehicle crush must be documented using National Automotive Sampling System (NASS) procedures
- A new crushable nose needs to be developed for use on surrogate test vehicles
- TMA designers are required to select maximum and minimum support truck weight ratings

Changes in Evaluation Criteria

- Windshield damage evaluation uses quantitative, instead of qualitative, criteria
- Windshield damage criteria is applied to permanent support structures in addition to work zone traffic control devices
- The occupant compartment damage evaluation uses quantitative, instead of qualitative, criteria
- All evaluation criteria will be pass/fail, eliminating the "marginal pass"
- All longitudinal barrier tests are required to meet flail space criteria
- Maximum roll and pitch angles are set at 75 degrees
- The subjective criteria for evaluating exit conditions are eliminated; reporting the exit box evaluation criterion is required
- Documentation on vehicle rebound in crash cushion tests is required

Changes in Test Documentation

- CAD drawings of the test device and test installation are required
- Additional documentation of the test and evaluation results is required

Changes in Performance Evaluation

- Language emphasizing the importance of in-service evaluation is added

U.S. Department of Transportation
Federal Highway Administration

Memorandum

SENT VIA ELECTRONIC MAIL

Subject: ACTION: Roadside Design: Steel Strong Post W-beam Guardrail

Date: May 17, 2010

From: David A. Nicol, P.E.
Director, Office of Safety Design

In Reply Refer To: HSSD

To: Division Administrators

This memorandum provides guidance to all State DOTs and FHWA Division Offices on the height of guardrail for new installations on the National Highway System (NHS). It details the minimum mounting heights of systems successfully crash tested per the NCHRP Report 350 "Recommended Procedures for the Safety Performance Evaluation of Highway Features" and the AASHTO Manual for Assessing Safety Hardware (MASH).

NCHRP Report 350 Accepted Systems:
Recent research on standard 27-inch guardrail shows that it does not meet NCHRP Report 350 Test Level 3 (TL-3) criteria. This requires a revision of current policy with regard to new G4(1S) guardrail installation height.

Transportation agencies should ensure the minimum height of newly-installed G4(1S) W-beam guardrail is at least 27¾ inches (minimum) to the top of the rail, including construction tolerance. A nominal installation height of 29 inches, plus or minus one inch, may be specified and is acceptable for use on the NHS. For your reference, a sampling of States that currently specify G4(1S) W-beam guardrail at 27¾ inches or higher is included in Appendix A. A summary of standard height guardrail testing is included as Appendix B.

MASH Accepted Systems:
Recent research on metric height G4(1S) guardrail (27¾ inches to the top) to meet AASHTO MASH TL-3 criteria has revealed performance issues that require the following recommendation with regard to modified G4(1S) guardrail installation height. Transportation agencies should consider adopting generic or proprietary 31-inch high guardrail designs (instead of the G4(1S) system) as standard for all new installations. The

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installation height of 31 inches to the top of the rail is the nominal height and a construction tolerance of plus or minus one inch applies. These systems meet MASH test and evaluation criteria and have improved crash-test performance and increased capacity to safely contain and redirect higher center-of-gravity vehicles such as pickup trucks and SUVs. Existing crash testing of 27¾ inch high guardrail per MASH criteria can be found in Appendix B. Examples of 31-inch guardrail and end terminals are included in Appendix C. Experience in several States that have used the generic Midwest Guardrail System has shown that there is little or no increase in cost. Numerous guardrail terminals successfully tested under NCHRP Report 350 that are compatible with 31-inch high W-beam systems are also referenced in Appendix B.

Action Needed

Division Offices should work closely with their State transportation agencies to implement the revised minimum installation height for G4(1S) guardrail of 27¾ inches, and also request that States consider adopting the 31-inch high guardrail designs.

In my November 20, 2009, memorandum, "Manual for Assessing Safety Hardware," I noted the AASHTO/FHWA Implementation Plan provided that all highway safety hardware accepted prior to the adoption of MASH using criteria contained in NCHRP Report 350 may remain in place and continue to be manufactured and installed. The G4(1S) strong steel post W-beam guardrail system installed at a minimum of 27¾ inches is consistent with this statement and may, indeed, be used on the NHS for the foreseeable future. However, we believe that States should consider adopting 31-inch guardrail as their standard because these systems exhibit superior performance at little or no additional cost.

Attached to this memorandum as Appendix D is a series of Frequently Asked Questions (FAQs) regarding guardrail, guardrail terminals, transitions, and bridge rails. A future memorandum, which will be coordinated with the AASHTO Technical Committee on Roadside Safety, will provide guidance on addressing the height of existing guardrail. If you have any questions or comments on this guidance, please contact Mr. Nicholas Artimovich at nick.artimovich@dot.gov or Mr. William Longstreet at will.longstreet@dot.gov, Office of Safety Design.

5 Attachments

cc: Mr. John R. Baxter, Associate Administrator for Federal Lands Highway
Mr. King W. Gee, Associate Administrator for Infrastructure
Mr. Jeffrey A. Lindley, Associate Administrator for Operation
Directors of Field Services
Federal Land Highway Division Engineers
Safetyfield

Sampling of States that Specify G4(1S) W-beam guardrail at 27-3/4 inches (minimum) Height

The table below lists the Division Office contacts for State DOT's that specify 27-3/4 inch (minimum) guardrail height and their corresponding contact information.

Division	Contact	Post	Blockout
AZ	Jennifer Brown Karen King	Steel & Wood	Wood & Plastic
DE	Patrick Kennedy		
MA	Timothy White		
MI	David Morena		
MS	Teresa Bridges		
MT	Marcee Allen	Wood	Wood
NH	Martin Calawa		
ND	Steven Busek	Wood	Wood
OH	Joseph Glinski	Steel & Wood	Wood
OK	Huy Nguyen		
PA	Michael Castellano	Steel	Wood & Plastic
UT	Roland Stanger	Steel	Composite
VT	Roger Thompson		
VA	Ivan Rucker Josue Yambo	Steel	Wood Composite
WV	Hamilton Duncan		
WI	William Bremer		

Attachment 4

NCDOT

Final Report

Finite Element Evaluation of Two Retrofit Options to Enhance the Performance of Cable Median Barriers

Prepared By

Howie Fang
David C. Weggel
Jing Bi
Michael E. Martin

University of North Carolina at Charlotte
Department of Mechanical Engineering & Engineering Science
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Charlotte, NC 28223-0001

June 30, 2009

Technical Report Documentation Page

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June 30, 2009

6. Performing Organization Code

7. Author(s)
Howie Fang, David C. Weggel, Jing Bi, Michael E. Martin

8. Performing Organization Report No.

9. Performing Organization Name and Address
The University of North Carolina at Charlotte
9201 University City Boulevard
Charlotte, NC 28223-0001

10. Work Unit No. (TRAIS)

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
North Carolina Department of Transportation
Research and Analysis Group
1 South Wilmington Street
Raleigh, North Carolina 27601

13. Type of Report and Period Covered
Final Report
July 1, 2007 – June 30, 2009

14. Sponsoring Agency Code
NCDOT 2008-10

Supplementary Notes:

16. Abstract

This report summarizes the finite element modeling and simulation efforts on evaluating the performance of cable median barriers including the current and several proposed retrofit designs. It also synthesizes a literature review of the performance evaluation of cable median barriers, existing finite element modeling and simulation work on roadside safety, and an analysis of crash data collected by the North Carolina Department of Transportation.

Two retrofit options were proposed for this project, and several designs for each option were evaluated using the full-scale finite element simulations of a vehicle crashing into a cable median barrier. The simulation results showed that the potential of vehicle under-riding in back-side impacts was higher than that for front-side impacts, because the vehicle's suspension was compressed and there was less median traversal width for back-side impacts. The evaluation of different retrofit options indicated that lowering the middle and bottom cables and changing the sides of all cables on the posts could increase the likelihood of redirecting small vehicles for back-side impacts without sacrificing the CMB's performance for front-side impacts and for large vehicle impacts. For each of the two retrofit options, a new design was developed and evaluated. The simulation results showed that the newly developed three-cable and four-cable retrofit designs could improve the performance relative to the current design in back-side impacts without sacrificing its performance in front-side impacts.

The simulation results of this project should only be used to investigate performance trends for evaluating the CMBs; they should not be used to draw definitive conclusions about CMB performance for a specific crash event, because many factors affecting CMB performance were not considered in the simulations. Finite element analysis was shown to be a useful tool in crash analysis and could be used in future research to investigate these remaining issues.

17. Key Words
Cable systems; Median barriers; Roadside structures; Highway safety; Retrofitting; Finite element method

18. Distribution Statement

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Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

EXECUTIVE SUMMARY

This report summarizes the finite element (FE) modeling and simulation efforts on evaluating the performance of cable median barriers (CMBs) including the current and several proposed retrofit designs. A literature review is provided on the performance evaluation of CMBs and FE modeling in roadside safety research. An analysis is conducted on CMB crash data collected by the North Carolina Department of Transportation (NCDOT). Based on the literature review and crash data analysis, two retrofit options are selected and evaluated using FE simulations.

In the first retrofit option, the current design was modified by lowering the middle and bottom cables (25.25 and 20.5 in., respectively, above grade in the current design) to provide better retention of small vehicles. Five different designs are first evaluated for front- and back-side impacts at different vehicle speeds and impact angles. The simulation results are analyzed and a new retrofit design is proposed. Evaluation of the new design shows that it has the same performance as the current NCDOT design for front-side impacts, but a reduced likelihood of vehicle under-riding for back-side impacts. In the second retrofit option, the current design was modified by adding a fourth cable below the current bottom cable. The best height (17 in. above grade for the fourth cable) was determined and this four-cable design was found to have similar performance to that of the new design of the first retrofit option.

The FE simulation results show that cable-vehicle engagements are related to the cable heights, impact location, impact speed, and impact angle. The use of FE simulations in the exploration of new designs has been shown to be both effective and efficient. FE modeling and simulation are recommended in future investigations of remaining research issues such as the effects of impact locations, post spacing, and soil-foundation interactions.