U.S. Department
of Transportation
Federal Highway
Administration

Memorandum

Subject: INFORMATION: Cable Barrier Considerations

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From: Jeffrey A. Lindley
Associate Administrator

In Reply Refer To: HSSD

To: Division Administrators

Cable roadside and median barriers may be the most versatile and forgiving barrier systems available for reducing the severity of run-off-road crashes. However with growing use of cable barrier systems over the last decade the increasing variations in the number of cables, cable heights, post spacing, cable pre-stretch, cable tensioning, slope placement, length between anchorages, placement on curves, soil conditions/footing design, and other factors have led to confusion. This memorandum addresses these issues and, although it does not contain all the answers, it offers points to consider when dealing with these issues. It also discusses recently completed research as well as ongoing work that will lead to objective guidance for cable barrier design and placement. An attachment to this memorandum provides links to Web sites with additional cable barrier information.

It should be noted that crash testing of any roadside features to the NCHRP Report 350 criteria and the subsequent FHWA acceptance is only a starting point when specifying hardware. Highway agencies should be selective in their choice of hardware and carefully review the FHWA acceptance letters for conditions and cautions that they should consider when designing roadside features. The AASHTO Roadside Design Guide is also a source of information that designers should use to help select and design barrier installations.

The FHWA acceptance letters on cable barrier systems may be seen on our Web site at: http://safety.fhwa.dot.gov/roadway_dept/road_hardware/longbarriers.htm. In the drop-down menu select Cable Barrier and click on "Search by Keyword."

Number of Cables and Cable Height: The original US generic three-cable system has been joined by proprietary systems with three and four cables. The additional cable on proprietary systems either enhances TL-3 performance or, if used to increase the overall height of the barrier, can allow for TL-4 performance. The Web site referenced above can be used to identify systems by test level as well as by number of cables. Four cable systems should use an end anchor which provides for a separate anchor connection for each cable, or that has been crash tested at the trailing end. Recent research by the National Crash Analysis Center (NCAC) has shown that adding a fourth cable to the generic three-cable design increases the likelihood that the cable barrier will catch a broader spectrum of vehicles (ref 1). It should be noted that there is a variety of spacings across the various cable barrier system designs. Current efforts are considering whether these spacings will be adequate to accommodate the larger pick-up truck defined in the proposed update to NCHRP Report 350 (ref 2).

Post Spacing: Cable barrier systems have been tested and accepted with post spacing ranging from 6.5 feet to 32.5 feet. In general, deflection distance is known to increase with longer spacing between posts. What is not known, but strongly suspected, is that longer post spacing may also affect the propensity for vehicles to penetrate the cable barrier, i.e., by underride or traveling between cables. The FHWA recommends that highway agencies specify the post spacing when cable barrier systems are bid. The conventional range for cable post spacing is 6.5 to 15 feet.

High Tension Cable Systems: Tensioning the cables after installation improves the performance of the system by reducing deflection and increasing the potential to capture the impacting vehicle. In high tension systems, cables are tensioned on the order of 5 times greater than in conventional cable systems. Performance problems have been noted when anchor blocks have been too small to accommodate the increased load. Sometimes this does not become apparent until cooler weather further increases the tension to the point where anchor blocks or individual post foundations are pulled out of the ground. Specifications should be included and followed that provide for anchor block masses adequate to accommodate the expected loads. The **installation temperature** is also a critical factor. Highway agencies should specify a minimum tension at a discreet installation temperature, and plan follow up inspections to ensure the desired tension is maintained. If possible, the temperature of the cable itself, rather than the ambient temperature, should be specified.

Cable Pre-Stretch: Pre-stretched cables have advantages including reduced dynamic deflection by reducing the “play” between the individual wire strands in the bundle that forms the cable prior to installation.

Slope Placement: The effectiveness of a cable barrier system is influenced by its placement on the side slope and the directions from which it can be hit. Some agencies have placed cable barriers on slopes as steep as 1V:4H if within 4 feet of the break point and others have considered it possible to place the cable barrier anywhere on *roadside* slopes 1V:6H or flatter. A NCAC study on *median* cable barrier placement on slopes completed in April 2007 found that placement 4 feet from the center of a v-shape median with 1V:6H side slopes increased the likelihood that mid-sized vehicles would underride the barrier (ref 2). This report notes that placement of the barrier one foot from the bottom of the ditch is, however, generally acceptable on slopes as steep as 1V:6H. [W-beam guardrail should be placed on slopes no steeper than 1:10 and caution should be taken on considering such installations on slopes as steep as 1:6.]

A second NCAC report nearing completion analyzed the effectiveness of various placement positions across medians from 16-42 feet wide, side slope ranging from 1V:10H to 1V:4H, for v-shaped and flat bottom cross sections across impact angles from 5 to 25 degrees, speeds of 50 to 100 k/hr, and small and mid-sized passenger cars and pick-up trucks (ref 3). The results of the vehicle dynamics analyses documented in this report suggest that there may be limited placement options for many 3 and 4 cable barrier designs that will provide the likelihood of capturing a broad range of vehicles.

Placement on Horizontal Curves: Cable barriers on the inside of horizontal curves can be expected to have increased deflection. Reducing the post spacing may be an effective countermeasure, but objective criteria have not yet been established. High tensioned cable systems should be considered for severe curvilinear alignments.

Soil Conditions/Footing Design: For those cable systems that use a concrete footing for their posts, quality control of the footing concrete and reinforcement can be critical. Although the barrier performance may only be slightly affected if the footings pull out of the soil upon impact, the benefit of the extra cost of footings is lost if they have to be replaced after an impact.

Cable Splices: It is important to ensure that splice hardware provides for connections that are superior in strength to the cable itself. Obviously, if the splice fails the benefit of the full cable tension may be compromised. Manufacturer's recommendations from the maker of the *splice hardware* should be followed.

Dynamic Deflection: The "design deflection" noted in each FHWA acceptance letter is the *minimum* deflection distance that should be provided to fixed object hazards and is based on the test using the 2000P (4400 pound) pickup truck. The deflection distance recorded in FHWA letters is also related to the length of the test installation. For example, if a 300-foot long barrier system is tested and the "design deflection" recorded, the actual deflection under similar impact conditions will be greater if the barrier length between tiedowns exceeds 300 feet. Future crash test criteria will specify a minimum installation length for test sections on the order of 600 feet to better determine the deflection that can normally be expected.

For additional information on cable barrier design and testing, please contact Mr. Nicholas Artimovich of the Headquarters Office of Safety Design at nick.artimovich@dot.gov or Mr. Frank Julian of the Resource Center (Atlanta) Safety and Design Team at frank.julian@dot.gov. Please also note the broad range of information available on the Web sites referenced in the attachment.

Attachment

USEFUL LINKS

As noted in the memo, research is underway to provide additional guidance on a number of cable barrier topics. Until that work is done, designers may want to review the details found in the report "A Review of Cable/Wire Rope Barrier Design Considerations" by Dr. Dean Alberson, et al, of Texas Transportation Institute. That 2003 report is available on the internet at http://www.ltrc.lsu.edu/TRB_82/TRB2003-002025.pdf .

The AASHTO Technology Implementation Group, or TIG Web site (http://tig.transportation.org/?siteid=57&pageid=1031) includes useful links to numerous current design, construction, and maintenance issues, as well as in-service performance evaluations from six States.

The FHWA Corporate and Research Technology Web site on Cable Barriers
http://www.fhwa.dot.gov/crt/lifecycle/cable.cfm

The TRB 2007 paper "Performance Evaluation of Low-Tension Three-Strand Cable Median Barriers." Summary of the National Crash Analysis Center study using finite element modeling and full scale crash testing to investigate the problem of median cable barrier underride. Report to be distributed by the FHWA this summer.
http://pubsindex.trb.org/document/view/default.asp?lbid=802649

Commercial site that includes over 40 links to cable barrier research and policy.
http://www.gsihighway.com/research.htm

The following reports will be completed in the near future:

Ref 1: "Performance Evaluation of Low-Tension, Three-Strand Cable Median Barriers on Sloped Terrains," prepared by NCAC under FHWA contract DTFH61-02-X-00076, April 2007.

Ref 2: NCHRP Project 22-14(2) report – Proposed Update to NCHRP Report 350.

Ref 3: "Analyses of Placement Effects on Cable Barrier Systems for Varying Median Cross Sections," prepared by NCAC under FHWA contract DTFH61-02-X-00076, June 2007.