COLORADO DEPARTMENT OF TRANSPORTATION
CABLE BARRIER GUIDE

1.0 SUMMARY AND DESCRIPTION

1.1 Summary

High-tension cable barrier consists of steel wire cables mounted on weak steel posts and is used to prevent vehicles from crossing medians into opposing traffic lanes or to contain roadside departures. Cable barrier is cost effective to install compared to rigid or semi-rigid barrier systems and tends to result in less severe damage to the impacting vehicle. Cable barrier does not act as a wind break that causes snow drifting.

1.2 Description

High-tension cable barrier is the type used by CDOT and consists of pre-stretched cables mounted on light weight steel posts and tightened to several thousand pounds of tension. High tension cable barrier can be placed in long run lengths. The run length is the distance of cable barrier between end anchors. The run length may be limited by the presence of median openings or obstacles such as structures, median columns, etc.

High-tension cable barrier is installed by CDOT using concrete footings in which metal tubes are cast to form sockets for the posts. The socket allows a post to be replaced with relative ease during repairs. The damaged post is removed from the socket and replaced with a new post. This eliminates the need for specialized post driving equipment and subsurface utility location for each repair. High-tension systems can be used on slopes of 4:1 and flatter.

CDOT requires FHWA approved cable barrier meeting performance criteria in the National Cooperative Highway Research Program (NCHRP) Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, for Test Level 3 to be allowed on high speed highways.

NCHRP Report 350 crash tests are currently run on short lengths of barrier (about 328 feet), and the vehicle hitting the high-tension system causes the cable to laterally deflect approximately 8 feet. For longer runs deflection can be larger. The tension within the system allows the cable to remain close to the proper height, even when an impact removes several posts.

As of June 2009, all available high-tension systems are proprietary, and marketed by a specific manufacturer.

The NCHRP 350 tested High Tension Cable Barrier Systems currently allowed based on a Colorado Finding in Public Interest approved by the FHWA through Dec. 31, 2010 for installation on CDOT projects are:

Colorado Allowed High-Tension Systems and Manufacturers	
High-Tension System	**Manufacturer**
Brifen Wire Rope Safety Fence (WRSF)	Brifen USA
Cable Safety System (CASS)	Trinity Industries, Inc.

2.0 DESIGN AND INSTALLATION GUIDELINES

Cable barrier may be installed on any Colorado highway where appropriate. It has been used primarily in the median of divided highways to prevent cross over crashes. Cable barrier may also be installed on the outside shoulder to shield steep slopes and protect fixed hazards within the clear zone. For additional information and assistance with project development contact the CDOT Standards and Specifications Unit at 303-757-9083.

2.1 Impact Deflection

Cable Barrier which has passed NCHRP 350 tests has a maximum deflection of about 8 feet based on a 62 mph impact at a 25 degree angle on a 328 foot test section. This single series of tests is not usually performed on long runs, so it does not represent the greater deflections likely to occur in actual installations. Therefore, a minimum clear distance of 10 feet should be maintained between the cable barrier and the obstruction being protected. A 10 foot offset should be maintained from the edge of travel lane to the median cable barrier so an impacting vehicle is unlikely to deflect the barrier into opposing travel lanes. Deflection varies with the system installed, and depends on post spacing and distance between anchors.

2.2 Slopes

Most roadside barrier (guardrail, concrete barrier, etc) must be placed on slopes no steeper than 10:1, while cable barrier is intended for use on slopes that are 6:1 or flatter. This requirement is based on both computer modeling and full-scale crash testing and represents sound theory. Where existing slopes are steeper than 6:1, they should be re-graded to 6:1 or flatter. If it is not feasible to re-grade a slope to 6:1 or flatter, some cable barrier systems may be used on slopes as steep as 4:1. Their use can present a cost-effective solution for shielding those steeper slopes.

Systems have been tested for 4:1 slopes, however due to increased potential for overriding cable barrier, they should not be placed more than 4 feet horizontally from the top of the slope. For 4:1 slopes the system used must be FHWA approved for this slope.

2.3 Median Application

When a vehicle leaves the roadway and enters the median, certain predictable dynamics occur. Vehicles may enter the median at a variety of speeds and angles.

Upon departure from the travel lane and shoulder, a vehicle will initially continue along its vertical trajectory. As the slope falls away, the vehicle becomes briefly airborne. When the vehicle's inertia is overcome by gravity, it lands and its suspension is compressed. As the vehicle continues to travel through the median, the suspension rebounds and the bumper of the vehicle rises and stays at a relatively constant height throughout the remainder of the errant journey.

Cable barrier should not be placed in an area where it may be impacted while the vehicle's suspension is compressed, since a penetration by under-ride is possible

Every cable barrier crash is slightly different because of site-specific factors. In general, however, the vehicle must engage at least two of the cables to be contained by the system.

Analyses of cross-median crash history and traffic volumes provide valuable information in determining the likelihood of future severe crashes on roadways. To prevent future crashes, it is important to focus safety efforts on highways that will benefit the most from safety treatments.

As traffic volume increases, the probability of a motorist crossing the median and hitting an oncoming vehicle also increases. Installing median cable barrier based on traffic volumes presents an opportunity to prevent cross median crashes.

National experience has shown that cross-median crashes occur even on highways with median widths greater than 60 feet. Roadways should not be excluded from consideration for cable barrier solely on the basis of a large median width. However, installation of cable barrier in very wide medians will increase the number of crashes involving vehicles that would have regained control or come to rest without a crash if there had been no barrier.

2.4 Location of Cable Barrier in Median

Cable barrier can be installed within 1 foot of a median ditch bottom; this is a preferred placement location for narrow medians (30 foot or less). However, drainage inlets and dikes are a frequent problem, since barrier placed near them can be either too high or too low. Also, this location can cause problems due to moisture saturation resulting in less support for end anchors and post foundations. Therefore, for wider medians, the barrier should be placed at least 8 feet and preferably 10 or more feet from the ditch bottom. Barrier placed more than 1 foot and less than 8 feet from the median ditch bottom may fail due to under-ride penetrations. Compression of a vehicle's suspension caused by passing through the ditch bottom has been shown to be a major reason for vehicles under-riding the system.

High tension cable barrier should not cross a median flow line unless the median slope is 10:1 or flatter. Cable barrier should not be placed over the top of a drop inlet.

Cable barrier should be installed at least 10 feet from the edge of the left travel lane. At this location, the errant vehicle adjacent to the barrier, while airborne, is not at a great enough altitude to override the cable during a front side encounter. This 10 foot margin from the nearby travel lane allows cable barrier to deflect errant vehicles coming from the opposite direction without encroaching into that travel lane. Cable barrier should be installed on the side of the median opposite that from which most roadway departures occur, unless the roadways are at different elevations. This allows errant vehicles more room to either regain control or dissipate part of their impact energy traversing the ditch before engaging the cable barrier. When there is an elevation difference between the roadways of a divided highway, barrier should be place on the side of the median nearest the roadway with the higher elevation. If slopes are steeper than 6:1 the barrier is generally placed no more than 4 feet from the slope break.

The designer may choose to alternate the sides of the median where the barrier is placed, so it can be placed on the inside (concave) side of curves, on the high side of separated roadways, or in a location that accommodates turnarounds for emergency and maintenance vehicles. The change should occur at natural breaks in the barrier such as at emergency turnarounds, median bridge columns, or at the ends of twin structures.

When there is an elevation difference between the roadways of a divided highway, barrier should be placed on the side of the median nearest the roadway with the higher elevation.

2.5 Outside Shoulder Barrier Placement

Cable barrier may be placed on the outside shoulder similar to other types of barrier. However due to deflection upon impact there should be a minimum 10 foot offset from fixed hazards. If the roadside slope is steep, the deflection of the cable barrier could allow a vehicle to penetrate the barrier, therefore it is desirable that the roadside slope be 4:1 or flatter for at least 10 feet behind the cable barrier.

2.6 Horizontal Curves

Cable barrier deflection is based on it being installed along a tangent or on the “concave” side (the inside) of a curve. When it is struck on the “convex” side (from the outside of the curve) the barrier must deflect enough to redevelop a concave condition. To minimize the length over which this occurs, closer post spacing through curves is recommended. Reduce post spacing to meet the manufacture’s recommendations on curves with a radius less than 2500 feet. Placement of the barrier nearest traffic on the convex side of curves is also recommended to allow maximum median availability for deflection.

2.7 Vertical Alignment

The correct vertical alignment of the system is essential since the location of the bottom cable with respect to the ground is critical to capturing smaller vehicles. Special attention should be given to sag vertical alignments. The cables and posts placed in sockets are free standing (not held down by the system); when cables in a sag curve are tightened the cable will move up in elevation exceeding the proper installation height. Sag vertical alignments with a K-Value less than 11 should be avoided.

2.8 Post Spacing

The post spacing for the system used shall be no greater than that tested in accordance with NCHRP 350 for an impact deflection not to exceed nine feet and be approved by the FHWA. The maximum post spacing shall be 20 feet. A closer spacing may be used in accordance with section 2.6.

2.9 Cable Barrier Run Length

The maximum run length between end anchors should not exceed 10,000 feet. This allows for proper tensioning of the system, and will limit the length of cable subject to repair after impacts. Shorter run lengths may be more appropriate for some roadways.

2.10 Vegetation Control

Vegetation control in the area between the cable barrier and the adjacent lane must be addressed. Failure to provide some positive form of vegetation control will hinder the future maintenance of the system. Positive vegetation control measures may include installation of a geotextile-aggregate strip, or a paved strip. The designer should consider the concerns of maintenance personnel that must deal with the vegetation when determining the optimum vegetation control measure to be used.

2.11 NCHRP 350 Test Level

Cable barriers are available for both NCHRP 350 Test Level 3 and Test Level 4. Roadside safety research and testing is currently based on NCHRP Report 350 Test Level 3 (TL-3), which uses a 4,400 lb pickup traveling at 62 mph at an impact angle of 25 degrees to determine maximum deflection. Test Level 4 (TL-4) tests are done for containment of a larger (18,000 lb) truck traveling at 50 mph at a 15 degree angle impact. Cable barriers approved for Test Level 3 or 4 may be used for high speed highways. TL-4 cable barrier is taller than TL-3 cable barrier, allowing TL-4 barrier to capture large vehicles and vehicles with high centers of gravity. Barrier meeting Test Level 4 may be appropriate for areas with high truck counts, and narrower medians. TL-4 barrier may be more expensive than TL-3 barrier. The decision to use TL-4 barrier is the Region's option and should be made based on site conditions, traffic count, truck percentage and economy using engineering judgment.

2.12 Length of Need

Length of need is the length of barrier required to contain and redirect an impacting vehicle. Most end anchor systems are typically gating and should not be included in the length of need. Cable barrier should continue 50 feet downstream from the hazard before connecting to the end anchor to maintain re-directive and capture capabilities.

2.13 Termination of Cable Barrier at Rigid or Semi-rigid Guardrail

Cable barrier should never be connected to rigid barriers. Cable barrier may be connected to metal beam guardrail with caution due to the difference in deflection and rigidity. Proper tension in the cable barrier is not maintained if bolted guardrail joints slip. Cable barriers should be terminated in anchors that tie the cables to substantial ground anchors to assure that proper tension is maintained. If the guardrail is sufficiently flared beyond the cable barrier alignment, a cable barrier anchor may be placed in front of the guardrail. If the guardrail is not flared, the cable barrier should be terminated behind the guardrail using a cable ground anchor. The cable barrier should be tapered to within a few feet of the backside of guardrail to prevent vehicle from running into hazards located behind the guardrail.

2.14 Cross Culverts

Cross culverts with less than 36 inches of cover can impede placement of posts. Locations of these structures should be taken into account prior to setting posts. Post spacing can be adjusted to span small structures up to 20 feet.

Shallower post footings may be designed for structures with less than 36 inches of cover.

2.15 High Snow Areas

Cable barrier may be bent over and damaged by snow plow hits or by heavy snow loads due to piling from plowing operations. Locations prone to heavy snow loads and some mountainous areas may not be appropriate for cable barrier unless it can be placed a sufficient distance from areas to be plowed to allow room for snow piling and for proper drainage away from roadway. Damaged posts covered by snow and ice can be hard to replace due to freezing into the footing sleeve. Replacing damaged posts where conditions are often icy may be difficult.

2.16 Parallel Median Installations

A parallel median installation is a location where a run of cable barrier is installed on each side of the median. Parallel installations of cable barrier should not be used since a single run of barrier on one side of the median can protect against hits from both sides. Parallel installations can lead to unnecessary hits and higher long-term maintenance costs. Vegetation control would also be a problem in such situations. Instead, designers should rely on a single run of cable barrier designed for the situation or consider a barrier system other than cable barrier. An exception is at median openings where the cable barrier is run on one side. A short run may be added to the opposite side to help close the gap.

2.18 Soil Survey

A soil survey may be done prior to design. Soil survey information should be included in the plans to provide needed information for sizing post and anchor foundations. If anchors are undersized they may move upon tensioning or when cable is impacted. Post footings may pull out of the ground upon impact if undersized.

When the foundations are sized by the Contractor in coordination with the manufacturer, the foundation design must be sealed by a Professional Engineer licensed in the State of Colorado.

2.19 Existing Cable Barrier Installation

Where cable barrier is to be partially replaced or extended, cable barrier which is compatible with the existing type should be installed. Prior installations that do not meet current guidelines should be replaced or reset when there is an adjacent project or when included in a safety upgrade project.