Engineering Policy Group

Technical Bulletin

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Guard Cable

The primary purpose of all roadside barriers is to prevent a vehicle from leaving the traveled way and striking a fixed object or terrain feature that is less forgiving than the barrier itself. Containing and redirecting the impacting vehicle using a barrier system accomplishes this. Cable barrier is one such system.

It consists of steel cables mounted on weak posts. It is relatively inexpensive to install and very effective at capturing errant vehicles. There are two types of guard cable systems in use today, low tension and high tension.

Each system has its advantages and disadvantages. In general, a high-tension system has a higher initial cost with lower long-term maintenance costs and concerns. MoDOT is allowing high-tension cable as a no-cost change order whenever a sub-contractor is able to provide it at the same cost as low tension.

Low-Tension

Until very recently, MoDOT has specified the use of low-tension guard cable system exclusively. This system is also commonly called the "U.S. generic" system; referring to the fact that it is not exclusively manufactured by any single producer. Low tension simply means the cables themselves are tensed only enough to eliminate sag between posts. Large springs at either end of the cable run are compressed (according to temperature) to achieve the low tension in the system.

When a vehicle impacts the low-tension system under normal conditions, the cable moves as much as 12 feet from its original location. This movement is known as the dynamic deflection.

Given the lack of tension in the system, individual installations, or "runs", of cable are limited to 2,000 ft. with an anchor assembly at each end.

High-Tension

In appearance, high-tension cable is very similar to low-tension. In most other aspects, the two systems are very different.

High-tension cable consists of three or four pre-stressed cables supported by weak posts. Currently, all high-tension systems are proprietary, that is, marketed under exclusive right of a specific manufacturer. There are five systems currently being marketed in the United States.

During installation, the cables are placed on the posts, and then tightened to a specific tension according to temperature. The tensions values range between approximately 2,000 and 9,000 pounds. Due to this tightening, the cable installations can be of indefinite

Pros & Cons

Low-Tension

Advantages

- low initial cost
- employs readily available materials

Disadvantages

- individual "runs" are limited to 2,000 ft.
- entire run is ineffective after a single strike
- large deflections

High-Tension

Advantages

- lower maintenance costs
- unlimited length of runs
- cable stays strung after impact allowing the rest of the system to function
- lower deflections

Disadvantages

- can have higher initial cost
- all systems are proprietary
- unfamiliarity in most states

length, in fact, the runs are usually only limited by the presence of obstacles such as median openings or bridge columns.

When a vehicle impacts the high-tension system under normal conditions, the cable deflects as little as 8 ft. from its original location. The inherent tension within the system also allows the cable to remain strung, even after an impact that removes several posts, thus allowing the remainder of the run to funciton normally.

Testing Criteria

A roadside safety hardware feature must undergo rigorous safety tasting before it can be used on the National Highway System (NHS). Most state have adopted the same testing criteria for highways that are not on the NHS. The standard by which all roadside safety features are measured is contained within the National Cooperative Highway Research Program Report No. 350 (NCHRP 350).

NCHRP 350 evaluates safety hardware according to three general factors:

- Structural Adequacy: the system must contain and redirect the vehicle with no under-riding, overriding, or penetration.
- Occupant Risk: fragments of the system cannot penetrate the passenger compartment, the vehicle must remain upright during and after the collision, and the passenger must not undergo excessive impact or deceleration.
- Vehicle Trajectory: after the impact, the vehicle should not intrude into adjacent traffic lanes nor should it exit the system at an angle greater than 60% of the entry angle.

What is "TL-3"?

Within NCHRP 350 are six separate test levels (TL) representing different vehicles, impact angles and speeds.

Test level three (TL-3) is probably the most common as it establishes safety criteria for both small cars and pickups at 60 mph. This category of traffic accounts for nearly 90% of all vehicle traffic in MIssouri.

Data for the six test levels is summarized in the following table.

Test Level	Vehicle	Angle	Speed
1	1800 lb Car 4400 lb Pickup	20° 25°	30 mph 30 mph
2	1800 lb Car 4400 lb Pickup	20° 25°	45 mph 45 mph
3	1800 lb Car 4400 lb Pickup	20° 25°	60 mph 60 mph
4	1800 lb Car 4400 lb Pickup 17,600 lb Single-Unit Truck	20° 25° 15°	60 mph 60 mph 50 mph
5	1800 lb Car 4400 lb Pickup 80,000 lb Semi Truck (Cargo)	20° 25° 15°	60 mph 60 mph 50 mph
6	1800 lb Car 4400 lb Pickup 80,000 lb Semi Truck (Tanker)	20° 25° 15°	60 mph 60 mph 50 mph

Currently Approved
High Tension Systems and Manufacturers

- **Brifen**: Brifen USA
- **CASS**: Trinity Industries, Inc.
- **Gibraltar**: Gibraltar
- **Safence**: Safence, Inc.
- **U.S. High Tension**: Marion Steel Company

Installation

Missouri Standard Plan for Highway Construction No. 606.41 gives the installation criteria for three-strand, low-tension guard cable. High-tension guard cable systems are to be installed according to the individual manufacturer's specifications, most of which are available on line.

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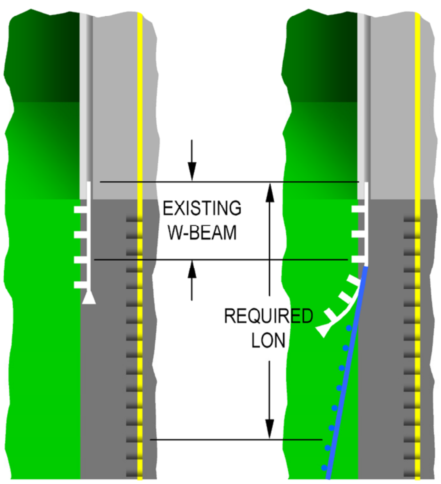
Length of Need

Like guardrail, all guard cable systems approved for use in Missouri have passed NCHRP 350 TL-3 testing. They therefore represent a legitimate roadside safety device.

As such, guard cable may be used as a substitute for the W-beam guardrail length of need (LON) absent from many median bridge ends. This practice is only financially expedient if there is already median guard cable present or if guard cable is being designed for the median.



Barrier Length of Need at Median Bridge Ends

In areas where no cable is present and safety concerns warrant a LON correction to the W-beam rail, the correction should be made with rail.

Missouri Standard Plan for Highway Construction No. 606.41 gives the details for transitioning guard cable to W-beam guardrail. While this transition detail is effective for both high and low-tension systems, most high-tension manufacturers have a much simpler, proprietary, transition approved for use.

Slopes

Guard cable, like most roadside safety hardware, is intended for use on a 1V:6H slope. The AASHTO Roadside Design Guide (RDG) says "The cable barrier remains effective when mounted on a moderate slope (up to 1V:6H)."

The 1V:6H requirement is based in both computer modeling and full-scale crash testing and represents sound theory. In practice, however, slopes as flat as 1V:6H are often the exception.

In the interest of practicality, MoDOT installed 80 miles of cable in the median of Interstate 70 on slopes as steep as 1V:5H. Virtually no difference between the success rate of this installation and 1V:6H installations has been observed. An official study of this section, as well as a section of steeper slopes on Interstate 44, was commissioned and is currently underway.

Other states that have experience with placing guard cable on slopes slightly steeper than 1V:6H have experienced similar success rates. The RDG states, "… a barrier may be considered operational if it has been used for an extended period and has demonstrated satisfactory field performance in terms of construction, maintenance, and crash experience."

In the absence of official study results, however, the Missouri Division Office of the Federal Highway Administration (FHWA) will allow no conventional guard cable to be installed on medians steeper than 1V:6H.

Steeper Slope Systems

Three high-tension systems are now NCHRP 350 TL-3 approved for use on slopes with gradients between 1V:6H and 1V:4H. The FHWA has also approved the use of these systems. Their use, while more expensive than a single run of low-tension cable, represents the most cost-effective way to treat median inslopes steeper than 1V:6H.

Further, since three equivalent sources exist, there is no need to obtain a Public Interest Finding for the use of these systems.

Parallel Installations

The preferred method of treating slopes between 1V:4H and 1V:6H is the use of high tension systems approved for those slopes. However, in certain situations, such as areas of differential profile grades or narrower medians, these systems may not function well. In these cases, parallel installations of guard cable should be specified.

The ideal location for each of the parallel runs is 2 ft. from the edge of shoulder. This location maximizes the

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distance from the through traffic while still taking into account the bumper height of the errant vehicle. As a general rule, guard cable should be located as far from the traveled way as possible in order to avoid non-critical or "nuisance" impacts.

In the double or parallel configuration, all three cables must be placed on the traffic face of the posts.

Cross-sectional Details

Nationwide, the use of median guard cable on such a large scale is a relatively recent occurrence. For this reason, specific placement geometrics are currently being developed and tested; there is very little written guidance in existence today. Certain conclusions can be drawn, however, from the AASHTO and FHWA research, other states' experience, and MoDOT's own in-service performance.

The bumper height of the impacting vehicle is critical to the function of the system. If the vehicle is slightly airborne after leaving the roadway, it may vault over the entire system. If the suspension is completely compressed at impact, the vehicle may go under the bottom cable and pass through the system. In general, the barrier should not be placed in a zone located from 1 to 10 ft. from the vertex of a V-ditch.

In a flat-bottomed ditch, MoDOT has traditionally placed the cable at the centerline of the median with good results. At this time, this practice should neither be discontinued nor changed by retrofit. However, ongoing research may yield results that recommend placement at either vertex of the ditch.

Cable placed at these points should be oriented with the two-cable side facing the nearest traffic.