U.S. Department
of Transportation
Federal Highway Administration

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Lakewood, CO 80228

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In Reply Refer To:
HDA-CO

Colorado Federal Aid Division

Mr. Tom Norton, Executive Director
Colorado Department of Transportation
4201 East Arkansas Avenue
Denver, CO 80222-3400

ATTN: Mr. Craig Siracusa, Chief Engineer

Dear Mr. Norton:

SUBJECT: Cable Barrier Systems in medians

The following informal advice and guidance was recently sent out to the FHWA Field Offices via e-mail by the FHWA Office of Safety. Please forward this information to all pertinent CDOT research, design, construction, and maintenance personnel.

> "As you are aware, several State DOTs, have begun to install significant lengths of barrier in freeway medians to minimize crossover crashes. AASHTO is currently revising Chapter 6 of its Roadside Design Guide to update warrants for median barriers. Updated warrants are likely to recommend barriers in medians up to 50 feet in width unless a crash analysis indicates such a practice would not be cost-effective for a specific State. Many DOT's have already developed more conservative warrants than those currently advocated by AASHTO in response to increased median encroachments and resultant head-on crashes.
>
> In addition to the generic 3-strand cable barrier that has been in use in some States for many years, there are now several proprietary higher-tension designs competing in the marketplace. The enclosed reports, prepared by the Ohio DOT, are an excellent example of the type of in-service performance evaluation that can yield valuable information to highway designers who are charged with selecting a specific barrier for installation. Although all of these cable barriers meet NCHRP Report 350 test and evaluation criteria, each has unique installation and maintenance characteristics. It is essential that these data be gathered for all roadside safety devices, but particularly critical when new products are introduced.
>
> Although State DOTs that have installed significant lengths of cable barrier report literally hundreds of successful impacts (where a vehicle was contained), there have been a number of instances in which a vehicle has penetrated a cable barrier - sometimes with disastrous results. Most of these penetrations have involved passenger-type vehicles with relatively low front-end profiles. Most have also

occurred when a cable barrier was offset from a ditch bottom in a median with 6:1 sideslopes. It appears that some of the vehicles left the roadway at angles greater than 25 degrees and experienced suspension compression as the vehicles "hit" the ditch bottom. These factors allowed the bumper of the vehicles to scrape along the ground as the vehicles climbed the backslope, thus getting underneath the bottom cable and continuing across the median. Computer analysis and limited testing at FHWA's FOIL (Federal Outdoor Impact Lab) facility replicated this type of penetration when the barrier was offset 4 feet from the ditch bottom. Redirection **was** obtained when the cable was offset only one foot from the ditch bottom. The proposed revision to Chapter 6 of the Roadside Design Guide recommends that cable barrier **not** be placed on a 6:1 slope beyond a ditch unless it is within one foot of the ditch bottom **or beyond** 8 feet. It is a proposed revision at this point, but the best advice currently available.

Any barrier penetrations should be thoroughly investigated and reported so we can collectively increase our body of knowledge on hardware performance and make whatever adjustments are needed to maximize that performance."

If you have any questions about the information provided herein, please contact Ms. Marcee Allen, Safety & Traffic Engineer, at (720) 963-3007.

Sincerely yours,

Marcee Allen

for David A. Nicol, P.E.
Division Administrator

Enclosures:

- Ohio ORES Field Visits report prepared 4/11/05
- Summary of Cable Products prepared 4/11/05

cc: Larry Brinck, CDOT Standards Engineer
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Mitch Kumar, CDOT Project Development Branch Manager
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File 807
Reader File
MAllen.ama
F:\SAFETY\Roadside Hardware\Cable Barrier Ltr to C. Siracusa 4-29-05.doc

BUCKLE UP AMERICA

ORES Field Visits to Cable Median Barrier Projects (Prepared 4/11/05)

This office organized several field visits during February and March 2005 to identify post-construction concerns for the first wave of cable median barriers installed in Ohio. Representatives from CO's Roadway Engineering, Production, and Safety & Mobility offices, along with district, manufacturer, contractor and FHWA personnel were invited to each meeting.

The purpose of the field visits were an effort to ascertain and monitor any design, construction, maintenance and performance issues so that these lessons could be applied to future projects.

For background information, cable barrier is being considered as standard median protection for ODOT. This is due to the apparent increase in cross median accidents throughout the state.

Even on the national level, AASHTO and NCHRP have been working to develop new Median Barrier Warrants to replace AASHTO's Roadside Design Guide Figure 6.1 (published in ODOT's Location and Design Manual, Volume 1, as Figure 601-2). Because national guidance in providing states with updated guidelines is lagging, several states have implemented their own warrants. Within ODOT, the offices of Safety & Mobility and Roadway Engineering are working together to develop guidelines for Ohio. According to one analysis approximately 500 miles of ODOT Interstate system is a candidate for cable installation.

Several states have had a median protection program in place for at least a few years. The states that have been leading the way on median protection have used generic cable (known as US Customary) because of a lack of other suitable products. This generic cable has been in use by the state DOT's for several decades for roadside applications. Since this product has some major drawbacks, it never really gained favor over standard w-beam guardrail in Ohio. However, ODOT itself has installed the product once, in the median of LAK-90 in the early 1990's.

ODOT accepted existing national guidance on Median Barrier Warrants until a rash of accidents on Interstate north of Cincinnati. Within a 14 month period starting in October 2001 there were 11 fatal cross median accidents. Investigation of each accident report shown no single factor was involved; all of them seemed to be unique. ODOT responded by installing a new and revolutionary type of cable system in this stretch of interstate. It is a tensioned cable system an the product is attractive because it seems to have overcome the biggest concern of the generic system: tensioned cables hold their height after an impact and were poised for a second impact without immediate repair.

The system chosen was Brifen Wire Safety Fence. It is a product that has been in use for 15 years exclusively outside of the United States (except for it's first US installation, in Oklahoma). Since some of the steel components were only available from the Great Britain, ODOT obtained FHWA approval to install it here. Brifen components are now made in the USA.

Three other proprietary cable system have now been accepted by FHWA as having met NCHRP Report 350 crash testing criteria. They are the Trinity CASS, Marion Steel SafeRoads and the Safence system. (Safence is not yet made from American materials and will not be considered.)

ODOT is currently of the position that each of these products perform in a similar manner during impacts and therefore the three products should be bid as equals. However, this position does not account for any installation, repair or maintenance concerns. The field visits were an effort to determine if it is a valid assumption, or if one product stands out a being better and should be recommended.

Ohio is the only state which has each of the three proprietary cable systems installed, allowing us an unique position to compare the products. During the visits, the groups looked at the design, construction, maintenance and performance issues with each barrier.

The three locations visited are Brifen (BUT/WAR 75), Marion Steel (FRA 270/315) and Trinity CASS (LOR 90). Each system is described below, followed by a summary table.

Brifen WRSF

CO staff met with District 8's Planning, Construction and Maintenance, FHWA's Joe Glinski, and Brifen's Richard Butler on March 7 at District 8. Brifen's 14 mile system was installed in 2003 and it's performance had actively been tracked as part of FHWA's approval of the foreign product in 2002. In fact, this office submitted the first of three yearly In-service Performance Evaluation reports to FHWA just prior to the visit. The report concludes the system is working as expected, although it is prudent to continue to gather data for two more years.

The biggest issue raised was that of a recorded accident occurring on January 4, 2005 which destroyed 14 posts, a significant accident on a tensioned system. The accident was caused by a passenger car spinning on wet pavement (a witness said 80 mph), hitting the cable on the near side of the ditch. Somehow the vehicle penetrated the cable, and wound up on the other traffic lanes, causing a second accident. One non-incapacitating injury was reported. In the field visit no one could say for sure if the cable was the cause of the penetration or a fluke of the accident.

The Brifen cables weave through every post, providing additional tension. However, in an accident taking out so many posts the weave is removed allowing slack in the cable to the point where the cables sagged. The cables sagged to approximately one-half of the correct height. For any cable system the most important key is for the cables to remain at the correct height. A tensioned system can loose its tension and still perform satisfactory (it becomes a defacto generic system at that point) but if the cables are not at the correct height the system may not engage, or capture, the impacting vehicle.

At this particular accident site, the posts were still missing and the cable still sagged a full two months after the accident. The time between repairs was disconcerting.

District 8 forces perform repairs on this system, and the process they use to repair may contribute to the delay. During design most posts were driving into the ground but as an experiment 2 miles of the 14 mile system were installed with concrete foundations for socketed posts. Socketed posts were offered by the manufacturer as a easier way to repair a damaged post and a segment was installed to test this suggestion. After installation, the District immediately saw the benefits of the socketed posts in accidents because of the ease of repair. The District made the decision to upgrade all impacted posts with a concrete socketed foundation. These types of repairs necessitate extra work because of the concrete involved. Due to winter weather the median was not able to support the equipment needed and the District was not able to repair the affected site. If the District had just driven in new posts to replace the damaged ones the repairs may have been able to be done sooner.

A complicating factor was that this system had preciously been repaired at this very location using one of these concrete foundations. In the January accident one of these foundations was pulled completely out of the ground. On inspection it did not appear to have any influence on the subject accident. But this particular foundation did not appear to be constructed as to manufacturers specification (12" diameter, 36" reinforced foundation).

Marion Steel SAFEROADS

ORES, Production, and Safety & Mobility staff met with FWHA's Joe Glinski and Marion's Kevin Mally and Rick Mauer, at the site on February 8, 2005.

Marion's 12 mile system was installed in during several months in the last half of 2003. The contractor had difficulties developing a process for installation, and once that was done construction went at a smoother pace except for problems encountered by the presence of rock near the surface.

Random stops at various locations showed no obvious problems. At unrepaired accident locations it was evident that for the most part the posts sheared at the ground line and slid down the cable to a final resting point, as designed. At accidents sites, the cable seemed to remain in tension and the cables did not visually sag.

However, on March 4 this section was called to an emergency meeting at the I-270 construction office in Grove City. District 6's Construction and Maintenance had called Marion Steel's Steve Conway and Rick Mauer along with the contractor MP Dory's Tom Kuhn to discuss the Construction Engineer's belief that the TTI anchor foundations on the Marion Steel cable project were poorly designed and were moving, with the result of the terminal anchor being pulled out of the ground and a subsequent loss in cable tension in about 5 individual posts of the 35 anchors sets (3 posts each). The TTI anchor is a third-party product and is also used with the Trinity CASS cable. Each anchor foundation is a 2' by 5' deep reinforced concrete dead man weight. To their credit, Marion Steel did agree to redesign the anchor and to offer ODOT a retrofit design for the majority of anchors that did not exhibit problems. This problem is independent of the cable and is being handled separately.

Marion Steel brought out a prototype portable tension meter for the contractor. While running the tension tests on the system, it was observed several cables were rather loose, not up to the ideal 5,600 pounds of tension at 70 degrees F. Some locations were under 3,000 pounds of force. There may be many explanations for this as in method of taking the force, an uncalibrated meter, and the residual slack of a non-pretensioned system.

On March 18, this office was again called to the field by reports of line post foundations being pulled out of the ground during accidents. Upon inspection of two accident sites that the 3 foundations were damages in a 9 post hit, and 2 were damaged in a 5 post hits. The posts did not shear as designed but were bent over from the force of the impact. The channel design may have provided too much resistance and forced the socket tube to shatter the reinforced concrete foundation. This problem has occurred yet again and is actively being investigated by ODOT.

Trinity CASS

ORES, Production, and Safety & Mobility staff met with District 3's Production and Maintenance, FHWA's Joe Glinski, Trinity's Gwen Samuels, Robin Cera, and Robert Takach, and Lake Erie Construction's Ray Chapin on March 17 at ODOT's Avon Outpost. Trinity's 3 mile system was completed in October 2004, so its short time and length of exposure to traffic has not given us much data to observe. The system had never been repaired since its installation and there were two locations where 4 posts were missing. The cable remained in tension and the slack was minimal. And the asphalt mow strip led the system to have clean lines and little of the debris noticed at the other cable sites.

The group went to a location where only one post was damaged and replaced it with a new socketed post and reset the cable. Total repair time was under 5 minutes.

The group saw the effects of a cross median hit where the vehicle crossed the ditch line and struck the backside of the cable, damaging another 4 posts. The vehicle apparently had hit the cable at a relatively high angle. The CASS cables remained in tension and was ready for another impact without being repaired.

The TTI anchors on this project seemed to be solid and not moving.

SUMMARY OF CABLE PRODUCTS (Prepared 4/11/05)				
System	**Brifen**	**Marion**	**Trinity**	**Base (generic)**
--------- **PRODUCTS** ---------				
Description	4 cable woven, tensioned and prestretched	3 cable tensioned but not prestretched	3 cable tensioned and prestretched	3 cable un-tensioned and not prestretched
Product History	3000 km of use 20 foreign countries	new system, based on well used frangible sign posts.	new system to USA, but modified from an existing European system	generic cable has been in use in US since 1960's but not an ODOT standard
ODOT Installation	BUT/WAR 75 June 2003 (second in USA)	FRA 270/315 Oct. 2004 (first in USA)	LOR 90 Oct. 2004 (sixth in USA)	LAK 2 1991 (standard used throughout US)
Length of Ohio's Installation	14 miles	12 miles	3 miles	12 miles
Post spacing and crash tested deflection (at that post spacing)	10' 6" spacing 7.9' deflection	6' 6" spacing 6.5' deflection	10' 0" spacing 7.9' deflection	16' 0" spacing 11.2' deflection
Application	on one side of median slope	at edge of wide paved shoulder on one side	at edge of wide paved shoulder on one side	on one side of median slope
Approx. # of hits recorded	160 (6.5 hits/mile/year)	30 (5.0 hits/mile/year)	10 (6.7 hits/mile/year)	n/a
--------- **ISSUES TO MONITOR** ---------				
Issues	1) A penetration of unknown reason has been recorded. **Two additional years of ISPE will watch this.** 2) Cable sagging in severe hits. **District will begin to include information on ISPE.** 3) District decision to replace driven posts with concrete socketed foundation affects timeliness of repair. **Topic is being discussed by CO and District Maintenance.**	1) Replacing of problem anchor foundations. 2) Retrofitting of the remaining anchor foundation to the Project Engineer's satisfaction. 3) Redesign of damaged line post foundations. 4) Keeping watch on the cable tension. **Mfg. has not yet offered fix for anchor or line posts.**	1) Anchor system is the same as on the Marion Steel system and may be vulnerable to movement as well. **District will alert CO if problem arises.**	1) D-12 Maintenance wrote in 2000 of the problems in maintaining the cable and keeping parts. D-12 then recommended replacing the cable with Type 5 guardrail. **No project has coincided with work, although widening project is programed.**
--------- **CONCLUSIONS FROM FIELD VISITS** ---------				
Performance Conclusions	System performing to NCHRP Report 350 standards	System performing to NCHRP Report 350 standards	System performing to NCHRP Report 350 standards	System conforms to previous crash test criteria, NCHRP Report 230
Summary	Best accident data, longest evaluation time, proven system elsewhere, extra cable, woven. System seems to be proving itself beneficial.	Construction issues, first substantial installation for product, so mfg's. installation and repair manual being written after the fact from our experiences.	Construction went smoothly and observed repair was very easy. Looks to be a good system, but the length, and thus exposure to accidents, is limited.	District says cable needs immediate attention after an accident and parts are difficult to obtain.