



MARICOPA COUNTY
Department of Transportation

MEMORANDUM

Date: January 8, 2014

To: MAG Specifications and Details Committee

From: Robert Herz, MCDOT Representative

Subject: Guardrail Details and revisions to Section 415 FLEXIBLE METAL GUARDRAIL **Case 14-03**

PURPOSE: Notification of MCDOT's intention of revising its guardrail details.

REVISION: To be determined.

DISCUSSION: MCDOT will be revising the standard details for guardrail to have new guardrail installed with the top of rail height to be 31-inches, the current details have the top of rail height set at 28-inches. The revised details will be in the 2015 MCDOT Supplement to MAG Specifications and Details having a target publishing date of January 1, 2015. MAG Section 415 FLEXIBLE METAL GUARDRAIL references MCDOT guardrail details. If MAG agencies desire to keep the 28-inch guardrail height then MCDOT will provide its details to MAG for inclusion in the 2015 MAG Revisions.




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 27³/₄ 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 27³/₄ 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 (27³/₄ 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



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		

Research on Standard Guardrail Height

The following full scale crash testing research provides the basis of new policy for minimum guardrail height:

NCHRP Report 350 (Report 350): Recommended Procedures for the Safety Performance Evaluation of Highway Features, 1993: Strong Post Steel Guardrail-G4(1S):

1. A full-scale physical crash test per Report 350 for TL-3 conducted at an accredited laboratory of the modified G4(1S) guardrail with timber blockouts with height of guardrail to the center of the W-beam rail element of 550 mm (21.65") or 27-3/4 inch nominal height¹. The 2000P test vehicle was successfully contained and redirected, remaining upright and stable during and after the collision period. As a result, this test is a pass.
2. A full-scale physical crash test per Report 350 for TL-3 conducted at an accredited laboratory of the modified G4(1S) guardrail with recycled polyethylene blockouts with height of guardrail to the center of the W-beam rail element of 550 mm (21.65 inches) or 27-3/4 inch nominal height². The 2000P test vehicle was successfully contained and redirected, remaining upright and stable during and after the collision period. As a result, this test is a pass.
3. A full-scale physical crash test per Report 350 Test No 3-11 conducted at an accredited laboratory using 27 inch G4(1S) guardrail (as measured to the top of the rail)³. This guardrail was slightly different than standard G4(1S) in that it utilized a tapered block which caused the posts to be embedded slightly less than the typical 27 inch guardrail system. The 2000P test vehicle was contained, but rolled over during redirection. When this test was repeated with the barrier mounted at 27-3/4 inches⁴, the test vehicle climbed the barrier and came to rest upright on top of the guardrail. The laboratory concluded the results of both tests indicate the 27-3/4 inch height steel post guardrail is at the upper limit at which acceptable performance can be obtained and any modifications to the barrier could produce unacceptable results.
4. A full-scale physical crash test per NCHRP Report 350 for TL-3 conducted at an accredited laboratory of the modified G4(1S) guardrail with injection molded High Density Polyethylene (HDPE) blockouts with height of guardrail to the center of the W-beam rail element of 550 mm (21.65 inches)⁵. The 2000P test vehicle was successfully contained and redirected remaining upright and stable during and after the collision period. As a result, this test is a pass.
5. A full-scale physical crash test per NCHRP Report 350 for TL-3 conducted at an accredited laboratory of the modified G4(1S) guardrail with injection molded HDPE block outs with height of guardrail to the top of the W-beam rail element of 706 mm (27-3/4 inches)⁶. The 2000P test vehicle was successfully contained and redirected, remaining upright and stable during and after the collision period. As a result, this test is a pass.

6. Additional Computer Simulations:

Two (2) crash test simulations⁹ per NCHRP 350 Test No 3-11 conducted by a laboratory using a 2000P pickup truck (test vehicle) using Livermore Software or LS-DYNA finite element modeling conducted on 27-3/4 inch high metric version W-beam guardrail (metric barrier).

- i. Simulation crash test of a metric barrier lowered by approximately 2-1/2 inches (25-12/2 inches above the ground) resulted in the test vehicle vaulting the barrier. As a result, this test is a failure.
- ii. Continuation of additional Finite Element Modeling simulation of the same test vehicle with a barrier height lowered by 1 inch (26-3/4 inches above the ground), projected that the test vehicle would climb atop the rail. In the absence of physical testing, this indicates a likelihood of test failure due to barrier vaulting. As a result, this test is a failure.

AASHTO MASH, 2009:

1. Strong Post W-beam Steel Guardrail - G4(1S):

Two (2) full-scale physical crash tests conducted at an accredited laboratory using metric height guardrail (27-3/4 inches) with a 5000 pound pickup truck.

- a. The first full-scale physical crash test⁷ involved a three-quarter ton 2-door pickup impacting at 98.3 km/hr and 25.6 degrees. During this test the rail ruptured and the vehicle went through the barrier (the Impact Severity [IS] value was 158 kJ compared to a target of 156.4 kJ). As a result, this test is a failure.
- b. The second full-scale physical crash test⁸ involved a one-half (1/2) ton, 4-door pickup truck. During this test the W-beam rail tore almost half way through, but the vehicle was contained and redirected. The impact conditions were 100.4 km/hr and 25.8 degrees (the IS value was 167 kJ or roughly 7 percent above the target value). The laboratory concluded that this partial tear of the W-beam was primarily due to pinch upon impact between offset block and the W-beam rail. As a result, this test is a pass.

2. Strong-Post W-beam Steel Guardrail - Midwest Guardrail System (MGS):

A full-scale physical crash test per MASH for TL-3 conducted at an accredited laboratory of the non-proprietary strong-post W-beam guardrail, named the MGS longitudinal barrier. The guardrail increased mounting height of 31 inches, blockout depth of 12 inches and specifies mid-span splices¹⁰. The 2270P test vehicle was successfully contained and redirected, remaining upright and stable during and after the collision period. As a result, this test is a pass.

¹ TTI, Research Project 405421-1, dated January 1996

² TTI, Research Project 400001-MPT1, dated February 1997

³ MwRSF Report No. TRP-03-90-99, dated November 10, 1999

⁴ MwRSF, Report No. TRP-03-104-00, dated December 13, 2000

⁵ TTI, Research Project 400001-TRB3, dated May 2001

⁶ TTI, Research Project 400001-MON1, dated February 2002

⁷ MwRSF, Report No. TRP-03-168-06, dated October 6, 2006 test no. 2214wb-1

⁸ MwRSF, Report No. TRP-03-169-06, dated October 9, 2006 test no. 2214wb-2

⁹ National Crash Test Analysis Center, Report No. NCAC2007-R-004, dated December 2007

¹⁰ MwRSF Test Nos. MGS-1 and MGS-2, dated June 2009

Crashworthy 31-inch Guardrails and Terminals

The table below lists system availability as per the date of this correspondence. Corresponding Acceptance Letters in PDF format can be accessed from the electronic version of this Appendix through the links in the table.

All Longitudinal Barriers and Miscellaneous Items can be accessed through the following link:
http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/listing.cfm?code=long.

All Barrier Terminals and Crash Cushions can be accessed through the following link:
http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/term_cush.cfm.

Name	Status	FHWA #	Date	Comments
Midwest Guardrail System	Generic	B-133	March 1, 2005	Steel or wood posts
Midwest Guardrail System	Generic	B-175	June 25, 2008	MGS with various wood species
T-31 W-beam Guardrail	Proprietary (Trinity)	B-140	November 3, 2005	NCHRP Report 350 and MASH accepted
GMS Guardrail	Proprietary (Gregory)	B-150	October 27, 2006	Gregory Mini Spacer
GMS Guardrail	Proprietary (Gregory)	B-150B	July 16, 2008	GMS with 12'6" post spacing
Nu-Guard	Proprietary (Nucor)	B-162	September 11, 2007	U-channel post with slot. No block on 31" system
Nu-Guard	Proprietary (Nucor)	B-162B	June 27, 2008	TL-4 acceptance
Terminals for 31-inch high W-beam Guardrails				
Manufacturer	Status	FHWA #	Date	Terminal Type
Road Systems, Inc.	Proprietary	CC-88	March 8, 2005	FLEAT and SKT for MGS
Trinity Industries	Proprietary	CC-94 CC-94A	September 2, 2005 August 30, 2007	ET-Plus Terminal for MGS
Texas Transportation Institute	Proprietary	CC-100	August 30, 2007	Slotted Rail Terminal at 31 inches
GMS Guardrail	Proprietary	CC-96	December 27, 2007	FLEAT and SKT-MGS for GMS guardrail

FAQs:Barriers, Terminals, Transitions, Attenuators, and Bridge Railings

The FHWA barrier guidance is contained in the AASHTO Roadside Design Guide. However, numerous issues are raised by the FHWA field offices that involve interpretations, extrapolations, device selection, hardware deployment, or simply trying to fit safety devices into real world conditions.

These questions and answers offer clarification on the use of roadside hardware for issues not covered by FHWA policy or topics that simply need additional explanation. They are the considered opinions of engineers in the FHWA Office of Safety Design and FHWA Resource Center with helpful input from members of AASHTO's Guardrail Committee.

In general the questions relate to rigid and semi-rigid barrier systems. Our July 20, 2007, memorandum on Cable Barrier Considerations dealt with numerous issues of cable barrier design, selection, and placement. Additional guidance on cable barrier selection and placement on sloping terrains and adjacent to median ditches will be provided in conjunction with NCHRP 22-25 scheduled for completion in 2010. A similar project (NCHRP 20-7(257)) synthesizing information on portable concrete barrier shapes, connections, anchorages, and other considerations has recently been completed and will also be available soon.

As noted at the end of the FAQ list, we expect to develop additional guidance in this format. Please contact Mr. Nicholas Artimovich at nick.artimovich@dot.gov if you have a special need for guidance in any of those areas, or to suggest others.

Barriers:**Q. Is it OK to use Weathering Steel (sometimes called Cor-Ten, A-588, or Rusting Steel) in longitudinal barriers?**

- A. No, the use of weathering steel guardrail should be limited. Where aesthetic concerns are primary, weathering steel guardrail may be used if the owner agency adopts a frequent periodic inspection and replacement schedule.

Roadside barriers and bridge rails are usually close enough to the travelled way that they can be sprayed with water from passing traffic. In most parts of the country this water contains deicing chemicals during winter months. In seaside locations in warmer climates the salt laden air deposits corrosive chemicals on barriers. In northern climates plows can throw snow onto the rail and the abrasive action of the snow can erode the protective layer. When exposed to these environments, weathering steel never develops the 'patina' that slows corrosion as in other less aggressive environments. Within a few years significant section loss may result. The interior of box beam barriers and the lap splice of W-beams can corrode rapidly to the point where the barrier may become more hazardous than the feature it was meant to shield.

Weathering steel may continue to be used on the backside of the Steel Backed Timber rail as the steel thickness is significantly greater than the typical 12 gage W-beam section.

One accommodation that has been tried is using zinc foil at the W-beam overlap where the zinc's galvanic action slows the corrosion. Use of thicker sections (exclusive of the terminal) may also prolong the life, but maintenance should still include inspection of the sections and joints. Powder coating of *galvanized* guardrail is an acceptable aesthetic option.

Barrier terminals are also subject to section loss at rail splices, but pendulum tests have been conducted on highly weathered barrier rails using galvanized extruder-type terminals and crash-test performance has been satisfactory. Questions on aesthetic treatments of barrier terminals should be addressed to the manufacturer.

Q. Can 6 x 8 inch timber, W6 x 9 steel, and W6 x 8.5 steel posts be used interchangeably in the length-of-need section of guardrail?

- A. Yes. Crash testing under NCHRP Report 350 has shown that these posts may be substituted when not in a barrier terminal. For short stretches of damaged barrier it is probably better to use the same type posts as in the existing installation, but where longer sections must be repaired substituting posts is acceptable. Some States use 8 inch round posts for W-beam guardrail, but we do not have enough performance information to offer an opinion on whether they may be substituted for steel or rectangular wood posts. Some proprietary guardrail and cable barrier posts have also been shown to be interchangeable with the generic posts. Recent crash testing [see [NCHRP Project 22-14\(3\)](#)] under the AASHTO MASH has shown that there may be a difference in performance between steel post systems and wood post systems, especially when the top of the rail is less than 27-3/4 inches high.

Q. Can I use a water-filled barrier on my project instead of concrete barrier?

- A. Only if it includes a steel framework that has been accepted as crashworthy. To explain why, we have to agree on some definitions first:

A "**barrier**" is a device that safely redirects, slows, or stops an errant vehicle preventing a more severe crash, or prevents vehicles from entering the work area. A "**barricade**" is a lightweight channelizing device that warns motorists of a hazardous situation and offers little or no resistance when hit. For example, a barrier offers "positive protection" to shield workers in a work zone from being hit by errant motorist while a barricade does not. A "**channelizer**" is a line of traffic control devices used to delineate the traveled way.

Barriers include W-beam guardrail, jersey barriers ("K-rail" in California), steel barriers, bridge railings, weak post cable barriers, certain water-ballasted plastic units, and crash cushions. They must be crash tested at 100 km/hr using a small car and a pickup truck to assess occupant risk and barrier integrity. The test vehicle may not penetrate or vault over a barrier. When put in place each unit must be physically connected to the next unit per the state standard or per the manufacturer's instructions. If the units are merely butted end to end, or if the connection hardware gets stolen, you are maintaining a hazard that is dangerous to both the traveling public and the workers.

Barricades must have orange and white reflectorized striping in accordance with Part 6 of the Manual Uniform Traffic Control Devices, and include Type I and II "sawhorse" barricades, Type III Road Closure barricades, and some large plastic units

that accept water ballast, among others. Barricades must be crash tested at 100 km/hr with a small car to ensure that they do not cause harm to occupants of the impacting vehicle when they are struck.

A hybrid device called a "**longitudinal channelizing device**" or "**longitudinal channelizer**" consists of the large plastic units linked together, end to end, forming a wall. They are useful for controlling pedestrian traffic, guiding vehicles through confusing work zones, discouraging the use of median crossovers, and in providing more delineation when only a line of cones or drums are called for. A longitudinal channelizer is not a barrier because, upon impact by a vehicle, the plastic units rupture and the vehicle penetrates the wall. Some longitudinal channelizers can be converted into crashworthy barriers with the addition of continuous steel rails or by virtue of an internal steel framework.

Now to answer the question - Concrete "New Jersey" Barrier or "K-rail" that is properly installed and connected will redirect most impacting vehicles. Certain "water filled barriers," namely those with internal or external steel rails or frames, can also contain and redirect vehicles. Without these external steel rails or the internal steel framework, water filled longitudinal channelizers do not have the capability to redirect vehicles and may not be substituted whenever a barrier is specified. Because of the confusion over water filled barriers and channelizers that look alike, the FHWA, the AASHTO/AGC/ARTBA Task Force 13, and the American Traffic Safety Services Association support the use of clear labels on each water-filled unit that explains its purpose as a channelizing device or as a barrier unit. A discussion and a sample label are to be posted on the Task Force 13 Web site (see www.aashtotf13.org).

Please note that barrier deflection should be considered. Precast concrete barriers have lower deflection and can also be pinned in place to severely limit deflection upon impact.

Q. Which concrete barrier shape should we use – Jersey Barrier, "F-Shape," Constant-slope, Single Slope, or vertical?

- A. All these shapes are acceptable. Generally, the F-Shape or the 9.1 degree constant slope are preferred, since the "F" shape design was specifically engineered to limit the potential roll over and the 9.1 degree constant slope reasonably mimics that performance. Another consideration may be the nature of the traffic using the facility or future overlays.

An explanation of the differences in the shapes may be useful. The Jersey and F barriers are both "safety-shape" barriers that begin with a 3 inch vertical face at the pavement level. Then they break to a sloped face that goes up to 13 inches above the pavement on the Jersey barrier, but only up to a height of 10 inches in the case of the F-Shape. Both then transition to a nearly vertical face to the top of the barrier.

The Texas Constant-Slope Barrier is 1070 mm (42 in) high and has a constant-slope face that makes an angle of 10.8 degrees with respect to the vertical. California developed a Single Slope profile that makes an angle of 9.1 degrees with respect to the vertical. The crash tests indicate that the performance of the Texas Constant-Slope Barrier is comparable to that of

the NJ-shape and the performance of the California Single-Slope Barrier is comparable to that of the F-shape.

A vehicle impacting one of the safety shape designs will have a significant portion of its energy absorbed in the climbing or lifting action that occurs when the tires roll up the lower sloping face. In low speed impacts this may result in the vehicle's redirection with no sheet metal contact with the face of the concrete wall. In medium impacts there will be damage to the vehicle but the occupants will experience minimum forces. In high speed impacts to safety shaped walls there will be significant vehicle damage and minor to moderate injury potential to the occupants. For the Jersey barrier there is a much greater likelihood that a small car will be rolled by the "safety shape" profile. The "F" shape design was specifically engineered to limit the potential for small cars to roll over upon impact.

Vehicles impacting the single slope barrier or vertical wall will experience little potential for roll-over. However, the barrier will absorb none of the crash energy by lifting the vehicle – there is always sheet metal damage and the occupants get the full force of hitting a concrete wall. The vertical wall has similar impact parameters, with the added potential for an occupant's head to hit the wall if it is high enough.

A benefit of the constant slope, single slope, or vertical barriers is that you can apply multiple overlays without affecting the shape, and therefore the performance, as long as the total height remains adequate. Both "safety shapes" allow for no more than three inches of overlay.

In general, for high speed highways the single slope barrier is most appropriate to limit rollovers, since much of the fleet now has side airbags to absorb the impact to the occupants. The side impact airbags will improve the safety of the occupants. For lower speed roads, the F shape would be better for the majority of impacts it would be expected to handle.

Q. Do we need to tie down our portable concrete barrier?

A. It depends. If you are placing the barrier near the edge of a bridge deck a catastrophic failure could occur if a vehicle caused the barrier to deflect enough to push it over the edge. If the barrier were placed on pavement with a work area on the other side then you can tolerate more deflection and bolting it down usually isn't necessary. Barrier deflection in this case may, indeed, push the concrete into the work area, but there appears to be little if any data relating to workers injured when the barrier is deflected causing it to slide into the work area.

Q. Can I fix a channel shape or some other device to the pavement behind portable concrete barrier to keep the barrier from sliding?

A. No. If the barrier is struck by a vehicle tall enough to push it across the deck the barrier could 'trip' over the channel shape and tip over allowing the vehicle to intrude into the work area. The only acceptable location to secure a barrier is in front so that the anchors will resist the overturning moment.

Q. Do cable barriers pose an extraordinary safety risk for motorcyclists?

A. We understand that motorcyclists worldwide have raised this concern. First, the unprotected motorcyclist is at great risk anytime he or she goes off the roadway at speed and contacts a

barrier or any other object. Second, we have yet to see a crash report where the *cables* caused the severe injury. Our reviews show the barrier *posts* cause the greatest number of

injuries (other than the cyclist going completely over the barrier and impacting the ground or some other unforgiving hazard.) Since the post spacing on cable systems is typically two to three times greater than the post spacing on steel beam systems, cable systems allow a greater potential for the rider to avoid striking the posts.

We also note that some European installations (notably in Sweden and the United Kingdom) place cable systems in the paved roadway where there had been no median (“central reserve” as the Brits call it). The cable barrier separates traffic on “two plus one” roads that have three lanes, two lanes in one direction and one in the opposite direction. This puts traffic very close to the barrier and allows very little room for error for motorcyclists or auto drivers. The proximity of the barrier to traffic also results in an increase in the number of impacts, but the motorcyclists are much more vulnerable and have more reported crashes. We don’t anticipate cable barrier installations of this sort in the United States.

The European community addressed this question in "Barriers to Change: Designing Safe Roads for Motorcyclists" where it states "The Panel concludes that, despite the amount of high profile coverage that wire rope barriers have attracted, limited research does not warrant the inference that they are more or less dangerous than other types of barrier on the market."

Q. What guidance is available on the timeliness of guardrail repair?

- A. It is important that each agency develop their own guidance for when to make repairs. While severely damaged roadside barriers need to be repaired within a reasonable amount of time, FHWA cannot recommend a specific response time. Each agency must make a risk assessment about the timing of repair for each different category of damage and establish specific response times. The assessment would include, among other factors, agency resources (within its overall mission), hazard exposure (how likely is it the guardrail will be hit again), and hazard severity. Vagueness on the timeliness of repairs does not prevent liability. Timing of repairs should be dependent on providing a safe facility, not on recovering damages from insurance companies.

The performance of damaged guardrail was assessed in the NCHRP Project 22-23 “Criteria for Restoration of Longitudinal Barriers.” Information on that study may be found here: <http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=696>.

If repair work is done under contract the State should notify the contractor promptly when the damage is discovered. The time that the contractor is given to respond needs to consider utility coordination (i.e., “Miss Utility” or “One Call” to avoid damaging subsurface utilities) and the fact that additional terminal grading or lengths of barrier may be needed to bring the device up to current standards. Special events and weather factors should also be considered when establishing mandatory response times.

The FHWA has updated the publication “W-beam Guardrail Repair” (Publication

#FHWA-SA-08-002) and it is available on line at http://safety.fhwa.dot.gov/local_rural/training/fhwasa08002/fhwasa08002.pdf.

Information on the eligibility of Federal funding for replacement parts of safety features may be found at <http://www.fhwa.dot.gov/federalaid/080610.cfm>.

Q. What is “guardrail?” Our agency only uses “guiderail.”

- A. These terms are synonymous. A few States are required by judicial interpretation to refer to steel beam barriers as “guiderail” because the barriers are not seen as devices that can guard motorists from all injuries. Rather, the steel beam system can only “guide” the car and its occupants. (In Europe, “guard fence” and “road restraint systems” are the common names for roadside barriers.)

Barrier Terminals and Crash Cushions

Q. When repairing crash-damaged guardrail terminals or crash cushions, may we use “breakaway posts” or other components that fit if they are supplied by another manufacturer?

- A. Barrier terminals and crash cushions are precisely engineered devices that are subjected to a range of crash tests (up to 8 different tests) meant to show proper performance when impacted by errant vehicles. If the substitute parts do not crush, break, bend, or slide the same way as the crash-tested parts, the device’s performance will be affected, with the potential for negative performance. (Even if the device’s performance in one test may improve with the substitute part in place, it may lead to failure under another test impact condition.) If the component in question is covered by patent and unique to the system then the overall effect can only be determined by the original manufacturer and/or a crash test laboratory.

Substitutions of components are allowable if any one of these conditions is met:

- 1) The substitute components are generic items (like guardrail line posts, W-beam rail elements, some fastener hardware, etc.) that meet the same specification as the crash tested parts, or
- 2) The manufacturer of a patented device has determined that the part will not adversely affect the device’s performance and has agreed that the part may be substituted, or
- 3) The substitute component has been successfully crash tested as part of the same system, or
- 4) A critical or “smart” part that was formerly covered by a patent is manufactured to the same specification as the original part.

This guidance applies to the safety performance of barrier terminals, crash cushions, and the barriers themselves when considering the use of substitute components.

Most current guardrail terminals and impact attenuators are patented devices. Where the system, device, or components thereof are patented proprietary products, then the guidance in the January 11, 2006, FHWA memorandum, “Guidance on Patented and Proprietary

Product Approvals”,

[<http://www.fhwa.dot.gov/programadmin/contracts/011106.cfm>] should be followed. This memorandum contains a link to additional FAQs on the use of proprietary products in Federal-aid contracts.

Q. Our highways are signed for 75 mph. Shouldn't we use crash cushions that have been crash tested at speeds higher than 100 km/hr (62.5 mph)?

- A. No. The FHWA Office of Safety considers that a 100 km/hr test is representative of worst case run-off-road crashes.

Early on in the panel discussions related to the NCHRP project for the updating of the NCHRP Report 350, there was much discussion involving the need to increase test speeds over the 100 km/h (62.2 mph) maximum speed now used. Based on data available to the research team, it was concluded that regardless of posted speeds, most impacts with fixed objects occurred at somewhat reduced speeds, probably because most drivers are braking hard as they are about to run off the road or into some fixed object. Historically (from FARS data), crash cushions have been directly responsible for very few fatalities and even fewer of these can be attributed directly to inadequate cushion capacity. Granted, a longer cushion will perform better in some head-on full-speed crashes, but the cost-effectiveness of a 70 mph cushion over a 62 mph design is far from clear. FHWA's "official" position is that highway features tested to Report 350 TL-3 (i.e., 100 km/h) are sufficient, but if any DOT wishes to use longer designs, they are most certainly free to do so. The best question to ask is whether or not there has been a "capacity" problem with existing installations.

Q. What is the difference between energy absorbing terminals and those that allow the vehicle to break through?

- A: All terminals dissipate energy during an impact, some more than others depending on impact conditions. It is agreed that in an end-on impact by a vehicle aligned with the terminal, “energy absorbing” terminals will dissipate more energy than “non-energy absorbing” terminals. However, there are also certain impact conditions in which both types of terminals dissipate essentially the same amount of energy. For these conditions the vehicle can be expected to travel a considerable distance after impact for both terminal types. Additionally, a vehicle that inadvertently leaves the road in advance of a terminal may be just as likely to miss the end as to impact it. Therefore, it seems prudent to require similar run out distances for both energy-absorbing and non-energy-absorbing terminals.

The FHWA memoranda entitled, "Guidelines for the Selection of W-beam Barrier Terminals," (October 26, 2004) and “Supplementary Guidance for the Selection of W-beam Barrier Terminals” (November 17, 2005) issued by the FHWA contain additional considerations beyond those in the Roadside Design Guide. As a point of clarification, guardrail run out distances and length of need requirements for terminals should follow recommendations in the RDG. They are dependent on traffic conditions, guardrail layout, and the characteristics of the hazard to be shielded. They are independent of the terminal type, assuming the point at which the length of need begins is the same for each terminal (normally 12.5 ft from the terminal's beginning).

Where narrow right-of-way restricts the width of the clear roadside an energy absorbing terminal may be preferred. Energy absorbing terminals can be installed parallel to the traveled way and can capture a vehicle that impacts it on the nose. However, with narrow rights-of-way come numerous unaddressed hazards including fixed objects and improper grading. It is not uncommon to see barriers used only to shield built hazards like the

approach end of a bridge railing or a culvert headwall, but terrain and other natural obstructions such as ditches and trees, are not addressed. When these hazards remain within the clear zone the guardrail designer should at least try to see that she/he has not made the situation worse when locating a guardrail terminal.

Transitions

Q. Are “lead anchors” acceptable when connecting the guardrail end shoe to the concrete parapet or end block?

- A. No. Lead anchors can work loose over time due to vibration from traffic. The only sure method of attachment is to continue the bolt through the concrete and place the nut on the outside of the structure. A good quality epoxy anchor is acceptable if properly installed according to the manufacturer’s instructions.

Bridge Railings

Q. Do bridge railings on reconstructed bridges off the NHS need to meet NCHRP Report 350 criteria?

- A. In general, FHWA standards apply to projects on the NHS. State transportation agencies may establish different standards for non-NHS projects if desired and may elect to use roadside hardware that has not been successfully tested to NCHRP Report 350 guidelines. Nonetheless, the FHWA strongly recommends the use of crash-worthy devices on all public facilities where run-off-the-road crashes may occur.

Regarding the design of new railing standards for both “on and off” NHS routes, LRFD Section 13 should apply to all new bridges and rehabilitated bridge projects where railing replacement is required. However, repair or retrofit to the existing railing system that have been found acceptable under the previous crash testing and acceptance criteria (such as NCHRP Report 230, the 1989 AASHTO Guide Specifications for Bridge Railings or equivalent) do not require further testing to the NCHRP 350 requirements at the owner’s discretion. Further support for this position can be referenced to the FHWA memorandum dated May 30, 1997. Please also be reminded that a new railing detail solely designed to the LRFD geometric and resistance requirements does not necessarily warrant “passing” of a full scale NCHRP 350 crash test at the specified performance level.

Information on crashworthy bridge railings may be found on the Task Force 13 Web site www.aashtotf13.org.