



# FHWA FAST Act Guardrail Training Highway Barrier Installation, Inspection and Maintenance Training

## Participant Notebook

**Virtual Live Training**

**November 16 -18, 2021**



**Illinois Department  
of Transportation**

## DISCLAIMER

This material is based upon work supported by the Federal Highway Administration under Grant Agreement No. 693JJ317500085. Any opinions, findings and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the Federal Highway Administration. This document does not constitute a national standard, specification or regulation.

## INTRODUCTION

The objective of this training is to assist IDOT by providing their personnel and contractors with the appropriate information needed to enhance the probability of optimal total barrier installations. The training is divided into two segments:

- Basic highway barrier design principles for an understanding of HOW/WHY the barrier is designed and should be installed
- Highway barrier Installation, Inspection, and Maintenance training to enhance the likelihood that the installed barrier will perform its intended function

Today's program provides the State with the following deliverables:

- The Powerpoint presentations and accompanying notebook on Highway Barrier Installation, Inspection and Maintenance Training
- Highway Barrier Pocket Guide
- 4 – Technical Briefs
  - Guardrail Installations at Intersections , Side Roads, and Driveways
  - Maintenance of Damaged Guardrail
  - Selection and Grading of W-beam End Treatments
  - Midwest Guardrail System (MGS)

The deliverables are prepared by ARTBA/KLS Engineering, LLC, under direct supervision by Ms. Aimee Zhang of FHWA's Office of Safety Roadway Departure Technology Transfer Team, with review by appropriate IDOT staff. The following are responsible for providing this material:

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## ***Target Audience***

The target audience for this training includes installers, inspectors and maintenance personal having direct responsibilities for installing, inspecting, or maintaining traffic barriers (including transitions), terminals, and impact attenuators for IDOT (or local agencies).

## ***Course Goal and Outcomes***

The overall course goal is to provide installers, inspectors and maintenance personnel with the information needed to install, inspect, or maintain barriers so as to maximize the probability of optimal barrier installations and performance. Specifically, participants should have a better understanding of the following:

- The principles behind good barrier performance
- Identify possible deficiencies in a new barrier design or existing installations.
- Avoid common errors in barrier and terminal installations to optimize crash performance (and reduce liability).
- Know whether damaged hardware can still function as intended and possible remedial actions

## ***Course Contents***

This course consists of six sessions:

- Session 1:** Roadside Safety Problem, Clear Zone, and whether barrier is needed – Brief description of the run-off road (ROR) problem in Illinois, short discussion of the Clear Zone concept, and the challenge of determining when barrier should be provided
- Session 2:** Testing Requirements and Performance Characteristics of Common Barrier Systems – Identify the crash testing guidelines and performance characteristics of the various barrier systems used in Illinois.
- Session 3:** Testing Requirements and Performance Characteristics of Common Terminals and Impact Attenuators – Identify the crash testing guidelines and performance characteristics of the various systems used in Illinois.
- Session 4:** Guardrail Design, Length of Need, and Site-specific Conditions – Provides guidance concerning selecting the barrier type and creating an optimal design based on the five design principles, a quick field check of Length of Need, and some site-specific special designs.
- Session 5:** Guardrail/Terminal Installation and Common Errors – Illustrate proper barrier installation and show some common installation errors.
- Session 6:** Maintenance of Systems – Discuss various damage scenarios and their effect on barrier functionality.

## Resources

### Illinois Department of Transportation (IDOT)

- BDE Chapter 38 - <http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Split/Design-And-Environment/BDE-Manual/Chapter%2038%20Roadside%20Safety.pdf>
- IDOT Design Standard - <https://idot.illinois.gov/doing-business/procurements/engineering-architectural-professional-services/Consultants-Resources/highway-standards-and-district-specific-standards>
- IDOT Standard Specifications - <https://idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Construction/Standard-Specifications/2022%20Standard%20Specifications%20for%20Road%20and%20Bridge%20Construction.pdf>
- IDOT Qualified Products List - <http://idot.illinois.gov/doing-business/material-approvals/metals/index>.

### Federal Highway Administration (FHWA) <https://highways.dot.gov/>

- FHWA Countermeasures to Reduce Crash Severity  
[https://safety.fhwa.dot.gov/roadway\\_dept/countermeasures/reduce\\_crash\\_severity/](https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/)

### American Association of State Highway and Transportation Officials (AASHTO) <https://www.transportation.org/>

- AASHTO, Roadside Design Guide, 2011
- AASHTO, Manual for Assessing Safety Hardware, 2016 (MASH16)

### Task Force 13 website <https://www.tf13.org/>

- Guide to Standardized Highway Barrier Hardware

### Roadside Safety Pooled Fund sites:

- MwRSF: <http://mwrsf-ga.unl.edu/>
- TTI: <http://www.roadsidepooledfund.org/>

Maine Department of Transportation Guardrail Inspection Training – Google on YouTube.com



## TERMINOLOGY

Several terms will be used throughout the course; to ensure no misunderstanding, they are defined here:

**Effective barrier:** barrier that will satisfactorily perform as tested; i.e. containing and redirecting an impacting vehicle within crashworthy performance criteria

**Hazard:** an area of concern such as a terrain feature or an obstacle that should be considered for mitigation

**Warranting hazard:** a hazard that by itself would be determined to be shielded

**Secondary hazard:** a hazard that by itself would not normally be shielded (such as a typical tree or utility pole)

**Head-on versus End-on impact:** a head-on impact is essentially at zero degrees to the line of barrier; an end-on impact is hitting the end of the barrier at ANY angle.

**Upstream versus Downstream:** the upstream point is what the travelling vehicle comes to first; the downstream is as the vehicle is leaving

## GLOSSARY – Ref: AASHTO Roadside Design Guide (2011)

**Adjacent Grading**—Adjacent grading refers to the area on which the terminal is installed and the area immediately behind it.

**Advance Grading**—Advance grading refers to the area over which a vehicle may travel before any contact with a barrier terminal is made.

**Anchorage**—A device which anchors a flexible or semi-rigid barrier to the ground so as to develop the barrier's tensile strength during an impact. Anchorages differ from terminals in that they are not considered crashworthy.

**Area of Concern**—An object or roadside condition that may warrant safety treatment.

**Barricade**—A device which provides a visual indicator of a hazardous location or the desired path a motorist should take. It is not intended to contain or redirect an errant vehicle.

**Barrier**—A device which provides a physical limitation through which a vehicle would not normally pass. It is intended to contain or redirect an errant vehicle.

**Bi-directional**—For the purposes of classifying crash cushions, bi-directional describes the capability of a crash cushion to safely operate the median of a divided highway or an undivided roadway, where it will be exposed to impacts from two different directions of traffic. A bi-directional crash cushion is also a uni-directional crash cushion. A crash cushion is considered to be bi-directional when it has been qualified through a reverse-direction crash test.

**Breakaway**—A design feature which allows a device such as a sign, luminaire, or traffic signal support to yield or separate upon impact. The release mechanism may be a slip plane, plastic hinges, fracture elements, or a combination of these.

**Bridge Railing**—A longitudinal barrier whose primary function is to prevent an errant vehicle from going over the side of the bridge structure.

**Clearance**—Lateral distance from edge of traveled way to a roadside object or feature.

**Clear Runout Area**—The area at the toe of a non-recoverable slope available for safe use by an errant vehicle.

**Clear Zone**—The total roadside border area, starting at the edge of the traveled way, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. The desired width is dependent upon traffic volumes, speeds and roadside geometry.

**Conservation of Momentum Principle**—A concept of crash cushion design which involves the dissipation of the kinetic energy of an impacting vehicle by transferring the vehicle's momentum to the variable masses of materials in the crash cushion, such as sand contained in sand barrels.

**Cost-effective**—An item or action taken that is economical in terms of tangible benefits produced for the money spent.

**Crash Cushion**—Device that prevents an errant vehicle from impacting a fixed object by gradually decelerating the vehicle to a safe stop or by redirecting the vehicle away from the obstacle.

**Crash Tests**—vehicular impact tests by which the structural and safety performance of roadside barriers and other highway appearances may be determined. Three evaluation criteria are considered, namely (1) structural adequacy, (2) impact severity, and (3) vehicular post-impact trajectory.

**Crashworthy**—A feature that has been proven acceptable for use under specified conditions either through crash testing or in-service performance.

**Design Speed**—A selected speed used to determine the various geometric design features of the roadway. The assumed design speed should be a logical one with respect to the topography, anticipated operating speed, the adjacent land use, and the functional classification of the highway.

**Drainage Feature**—Roadside items whose primary purpose is to provide adequate roadway drainage such as curbs, culverts, ditches, and drop inlets.

**End Treatment**—The designed modification of the end of a roadside or median barrier.

**Flare**—The variable offset distance of a barrier to move it farther from the traveled way; generally in reference to the upstream end of the barrier.

**Frangible**—A structure quality or feature that makes the structure readily or easily broken upon impact.

**Fuse Plate**—The plate which provides structural reinforcement to the sign post hinge to resist wind loads but which will release or fracture upon impact of a vehicle with the post.

**Glare Screen**—A device used to shield a driver's eye from the headlights of an oncoming vehicle.

**Hinge**—The weakened section of a sign post designed to allow the post to rotate upward when impacted by a vehicle.

**Impact Angle**—For a longitudinal barrier, it is the angle between a tangent to the face of the barrier and tangent to the vehicle's path at impact. For a crash cushion, it is the angle between the axis of symmetry of the crash cushion and a tangent to the vehicles path of impact.

**Impact Attenuator**—See Crash Cushion.

**Length of Need**—Total length of a longitudinal barrier needed to shield an area of concern.

**Length of Need (LON) Point**—That point on the terminal or longitudinal barrier at which it will contain and redirected an impacting vehicle along the face of the terminal barrier.

**Level of Performance**—The degree to which a longitudinal barrier, including bridge railing, is designed for containment and redirection of different types of vehicles.

**Longitudinal barriers**—A barrier whose primary function is to prevent penetration and to safely redirect an errant vehicle away from a roadside or median obstacle.

**Low Maintenance/Self Restoring Crash Cushions**—Crash Cushions that either suffer very little, if any damage, upon impact and are easily pulled back into their full operating condition, or they partially rebound after an impact and may only need an inspection to ensure that no parts have been damaged, misaligned, or otherwise disabled.

**Median**—The portion of a divided highway separating the traveled ways for traffic in opposite directions.

**Multidirectional**—The capability of the fracture mechanism of a breakaway support or the plates of a split-base support to work when struck from any direction. These are also referred to as omnidirectional.

**Median Barrier**—A longitudinal barrier used to prevent an errant vehicle from crossing the median.

**Non-Recoverable Slope**—A slope which is considered traversable but on which an errant vehicle will continue to the bottom of the slope. Embankment slopes between 3H:1V and 4H:1V may be considered traversable but non-recoverable if they are smooth and free of fixed objects.

**Offset**—Lateral distance from the edge of traveled way to a roadside object or feature.

**Omni-directional**—See Multidirectional.

**Operating Speed**—The highest speed at which reasonably prudent drivers can be expected to operate vehicles on a section of highway under low traffic densities and good weather. This speed may be higher or lower than posted or legislated speed limits or nominal design speeds where alignment, surface, roadside development, or other features affect vehicle operations.

**Operational Barrier**—One that has performed satisfactorily in full-scale crash tests and has demonstrated satisfactory in-service performance.

**Performance Level**—See Level of Performance.

**Recoverable Slope**—A slope on which a motorist may, to a greater or lesser extent, retain, or regain control of a vehicle. Slopes flatter than 4H:1V are generally considered recoverable.

**Recovery Area**—Generally synonymous with clear zone.

**Reusable Crash Cushions**—Reusable crash cushions have some major components that may be able to survive most impacts intact and can be salvaged when the unit is being repaired.

**Roadside**—That area between the outside shoulder edge and the right-of-way limits. The area between roadways of a divided highway may also be considered roadside.

**Roadside Barrier**—A longitudinal barrier used to shield roadside obstacles or no-traversable terrain features. It may occasionally be used to protect pedestrians or “bystanders” from vehicle traffic.

**Roadside Signs**—Roadside signs can be divided into 3 main categories: overhead signs, large roadside signs, and small roadside signs. Large roadside signs may be defined as those greater than or equal to 50ft<sup>2</sup> in area. Small roadside signs may be defined as those less than 50ft<sup>2</sup> in area.

**Roadway**—The portion of a highway, including shoulders for vehicular use.

**Rounding**—The introduction of a vertical curve between two transverse slopes to minimize the abrupt slope change and to maximize vehicle stability and maneuverability.

**Runout Distance Grading**—Refers to the area into which a vehicle may travel after impacting a terminal ahead of its LON point.

**Sacrificial Crash Cushions**—Sacrificial crash cushions are crashworthy roadside safety devices designed for a single impact. These system’s major components are destroyed in impacts and must be replaced, but many of the other parts of the system can be reused.

**Severity Index**—A severity index (SI) is a number from zero to ten used to categorize crashes by the probability of their resulting in property damage, personal injury, or a fatality, or any combination of these possible outcomes. The resultant number can then be translated into an accident cost and the relative effectiveness of alternate safety treatments can be estimated.

**Shielding**—The introduction of a barrier or crash cushion between the vehicle and an obstacle or area of concern to reduce the severity of impacts of errant vehicles.

**Shy Distance**—The distance from the edge of the traveled way beyond which a roadside object will not be perceived as an obstacle by the typical driver to the extent that the driver will change the vehicle's placement or speed.

**Slip Base**—A structural element at or near the bottom of a post or pole which will allow release of the post from its base upon impact while resisting wind loads.

**Slope**—The relative steepness of the terrain expressed as a ratio or percentage. Slopes may be categorized as positive (backslopes) or negative (foreslopes) or as a parallel or cross slope (in relation to the direction of traffic).

**Staged Attenuation Device**—A crash cushion that is designed to be progressively stiffer as an impacting vehicle deforms or penetrates it.

**Temporary Barrier**—Temporary barriers are used to prevent vehicular access into construction or maintenance work zones and to redirect an impacting vehicle so as to minimize damage to the vehicle and injury to the occupants while providing worker protection.

**Terminal**—A terminal is essentially a crashworthy anchorage, a device used to anchor a flexible or semi-rigid barrier to the ground. Being crashworthy, terminals are normally used at the end of a barrier that is located within the clear zone or that is likely to be impacted by errant vehicles.

**Traffic Barrier**—A device used to prevent a vehicle from striking a more severe obstacle or feature located on the roadside or in the median or to prevent crossover median accidents. As defined herein, there are four classes of traffic barriers, namely; roadside barriers, median barriers, bridge railings, and crash cushions.

**Transition**—A section of barrier between two different barriers, or more commonly, where a roadside barrier connects to a bridge railing or to a rigid object such as a bridge pier. The transition should produce a gradual stiffening of the approach rail so vehicular pocketing, snagging, or penetration at the connection can be minimized.

**Traveled Way**—The portion of the roadway for the movement of vehicles, exclusive of shoulders.

**Through Traveled Way**—The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

**Traversable Slope**—A slope from which a motorist will be unlikely to steer back to the roadway but may be able to slow and stop safely. Slopes between 3H:1V and 4H:1V generally fall into this category.

**Uni-directional**—For the purposes of classifying crash cushions, uni-directional describes the capability of a crash cushion to operate in a location where it will be exposed to traffic impacts from only one direction. Such locations may include gore areas, or roadside locations on a divided highway. A crash

cushion is considered to be uni-directional unless it has been qualified as bi-directional through a reverse-direction crash test.

**Vehicle**—A motorized unit for use in transporting passengers or freight, ranging from an 820-kg [1,800-lb] automobile to a 36000-kg [80,000-lb] van-type tractor trailer.

**Warrants**—The criteria by which the need for a safety treatment improvement can be determined.

**Work-Energy Principle**—“A concept of crash cushion design which involves the reduction of an impacting vehicle’s kinetic energy to zero, the condition of a stopped vehicle, through the conversion of kinetic energy into other forms of energy.”

**Working Width**—The distance between the traffic face of the test article before the impact and the maximum lateral position of any major part of the system or vehicle after the impact.

**Zone of Intrusion (ZOI)**—The region measured above and behind the face of a barrier system where an impacting vehicle or any major part of the system may extend during an impact.



## Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
AADT	Average Annual Daily Traffic
BLON	Beginning Length of Need
BDEM	Illinois Bureau of Design and Development Manual
CIP	Critical Impact Point
FARS	Fatal Analysis Reporting System
FAST ACT	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
HTC	High Tension Cable
MUTCD	Manual on Uniform Traffic Control Devices
MASH	Manual for Assessing Safety Hardware
MGS	Midwest Guardrail System
NCHRP	National Cooperative Highway Research Program
RDG	Roadside Design Guide
ROR	Run-off-Road
ROW	Right-of-Way
SHSP	Strategic Highway Safety Plan
SPWB	Strong Post W-Beam
TL	Test Level
WZ	Work Zone

# Session 1: Roadside Safety Problem, Clear Zone and Warrants for Barrier



**FAST Act Guardrail Safety Training  
Highway Barrier Installer, Inspector and  
Maintenance Training**

FHWA COTR: Aimee Zhang  
FHWA, Office of Safety  
(202) 366 0087

Instructor: Bill Fitzgerald, PE and  
John Durkos  
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(703) 858 1356

**Virtual Live Training  
November 16 – 18, 2021**

Logos: U.S. Department of Transportation, ARIBA American Road & Transportation Builders Association, KLS Engineering, Illinois Department of Transportation

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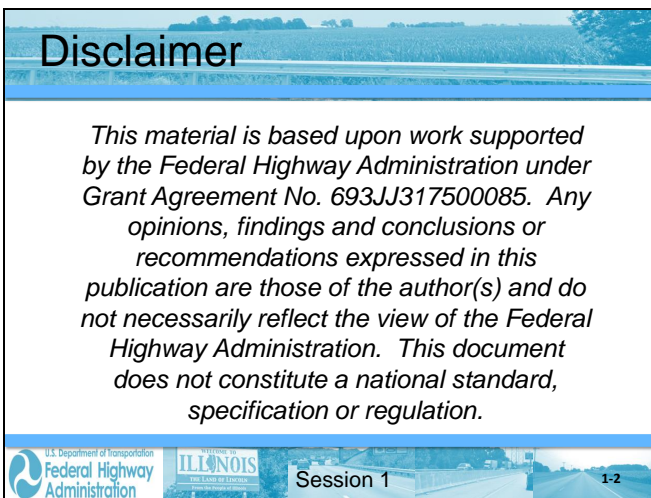
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### Disclaimer

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Logos: U.S. Department of Transportation Federal Highway Administration, ILLINOIS THE LAND OF LINCOLN, Session 1, 1-2

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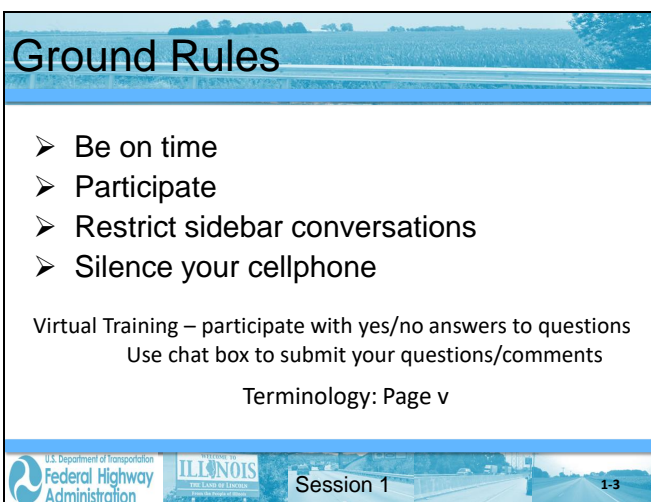
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### Ground Rules

- Be on time
- Participate
- Restrict sidebar conversations
- Silence your cellphone

Virtual Training – participate with yes/no answers to questions  
Use chat box to submit your questions/comments

Terminology: Page v

Logos: U.S. Department of Transportation Federal Highway Administration, ILLINOIS THE LAND OF LINCOLN, Session 1, 1-3

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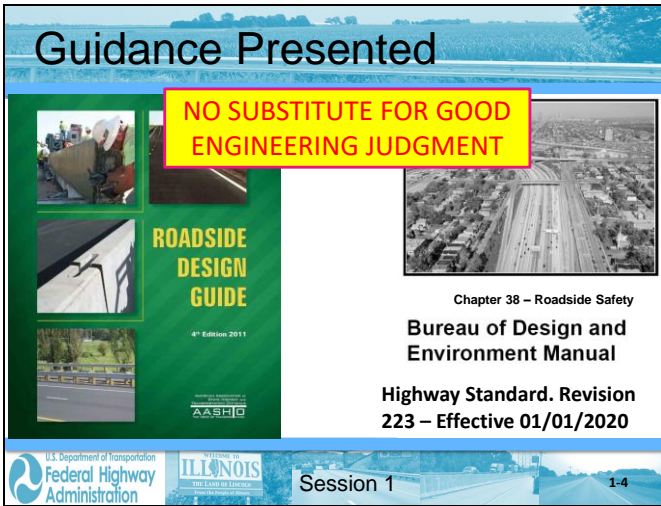
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**Guidance Presented**



**NO SUBSTITUTE FOR GOOD ENGINEERING JUDGMENT**

**ROADSIDE DESIGN GUIDE**  
4th Edition 2011  
AASHTO

Chapter 38 – Roadside Safety  
**Bureau of Design and Environment Manual**  
Highway Standard. Revision 223 – Effective 01/01/2020

U.S. Department of Transportation  
**Federal Highway Administration**

WELCOME TO **ILLINOIS**  
THE LAND OF LINCOLN  
Join in the Progress of History.

Session 1 1-4

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# Objectives of Course

This training will help you to:


- Evaluate when a traffic barrier may be the best treatment to use at a specific site.
- Understand the principles of good barrier system design
- Identify installations that may not adequately shield all the significant hazards or secondary hazards.
- Recognize common installations errors for barriers and terminals and know how to avoid them.
- Understand when damaged barrier and/or end treatment may no longer be functional.

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Session 1 1-5

Session 1:  
Roadside Safety Problem, Clear  
Zone and Warrants for Barrier



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From the People of Illinois

Session 1

1-6

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# Session 1 Learning Outcomes

At the end of this session, you will be able to:

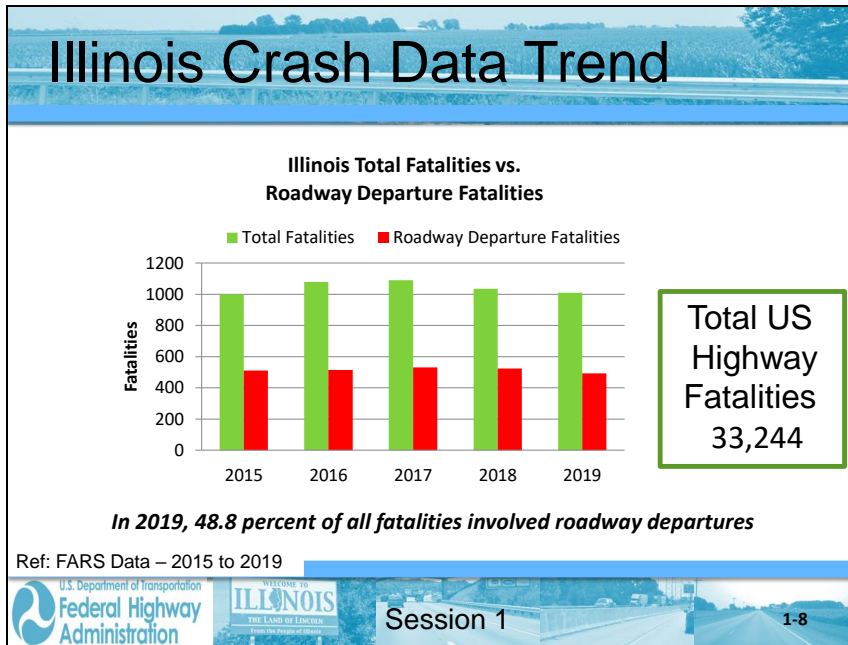
- Identify the primary Roadside Safety Concerns in Illinois.
- Identify the need for training.
- Define clear zone and barrier warrants.

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From the People of Illinois

Session 1

1-7



### Illinois Crash Data

	5-Yr. Total
Impact Attenuator	6
Concrete Traffic Barrier	69
Guardrail Face/End	118
Ditch	264
Cable Barrier	5

Ref: FARS Data – 2014 to 2018

Session 1
1-9



**Real World Crashes**



Video Clip

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THE LAND OF LINCOLN  
From the People of Illinois

Session 1

1-10

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# Need for Training

Potential consequences of poorly designed barrier systems include:

- Systems may not function as designed.
- Crash severities may be increased.

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THE LAND OF LINCOLN  
From the People of Illinois

Session 1

1-11

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# Need for Training

Must have a strong connection between systems



Session 1

1-12

## Need for Training

Examples of improper installation of systems:



**Fatal Flaw**

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THE LAND OF LINCOLN  
The Great State of Illinois

Session 1

1-13

## Need for Training

Examples of improper installation of systems:



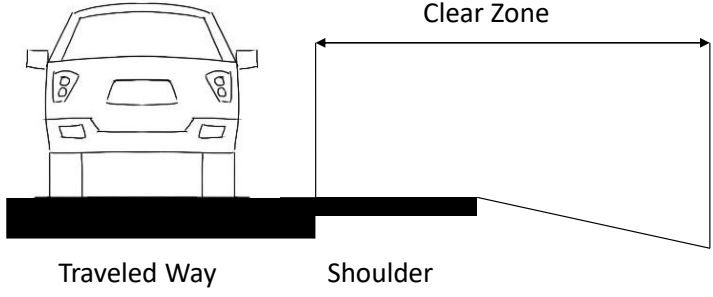
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THE LAND OF LINCOLN  
The Great State of Illinois

Session 1

1-14

# Clear Zone: A Definition




The diagram shows a top-down view of a car on a road. The road is divided into a 'Traveled Way' (black bar) and a 'Shoulder' (white bar). A double-headed arrow labeled 'Clear Zone' spans from the right edge of the traveled way to the right edge of the shoulder.

The unobstructed, traversable area provided beyond the edge of the through traveled way for the recovery of errant vehicles. The clear zone includes shoulders, bike lanes, and auxiliary lanes, except those auxiliary lanes that function like through lanes.

Ref: AASHTO Roadside Design Guide, 4<sup>th</sup> Edition, Glossary

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Session 1 1-15

## Clear Zone Principle



Get  
**MAXIMUM,**  
**COST-EFFECTIVE**  
width

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Session 1 1-16

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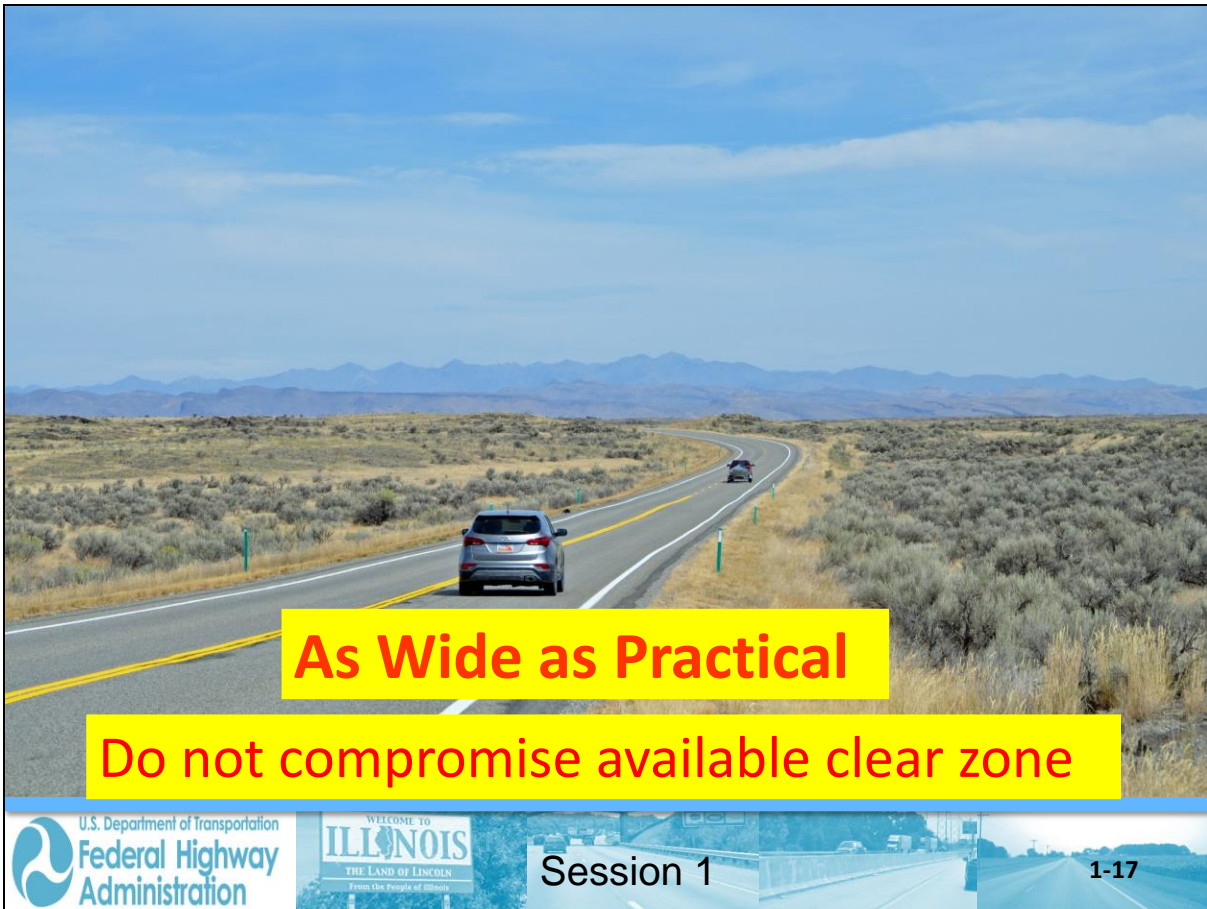
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### Clear Zone Factors

- Slope Type and Steepness
- Design Speed
- Traffic Volume
- Horizontal Curvature

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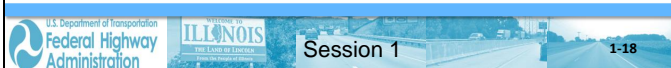
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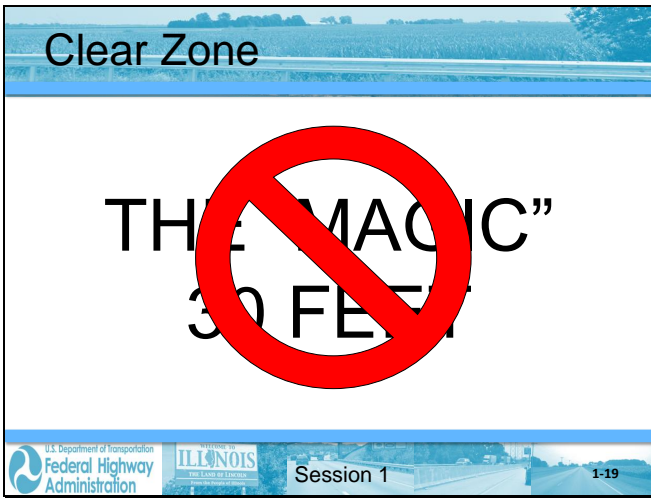
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## IDOT Clear Zone Table

Design Speed (mph)	Design ADT	Front Slopes			Back Slopes		
		1V:6H or flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or flatter
≤40	UNDER 750	7-10	7-10	**	7-10	7-10	7-10
	750-1500	10-12	12-14	**	10-12	10-12	10-12
	1500-6000	12-14	14-16	**	12-14	12-14	12-14
	OVER 6000	14-16	16-18	**	14-16	14-16	14-16
45-50	UNDER 750	10-12	12-14	**	8-10	8-10	10-12
	750-1500	14-16	16-20	**	10-12	12-14	14-16
	1500-6000	16-18	20-26	**	12-14	14-16	16-18
	OVER 6000	<b>18-20</b>	24-28	**	14-16	18-20	20-22
55	UNDER 750	12-14	14-18	**	8-10	10-12	10-12
	750-1500	16-18	20-24	**	10-12	14-16	16-18
	1500-6000	20-22	24-30	**	14-16	16-18	20-22
	OVER 6000	22-24	26-32*	**	16-18	20-22	22-24
60	UNDER 750	16-18	20-24	**	10-12	12-14	14-16
	750-1500	20-24	26-32*	**	12-14	16-18	20-22
	1500-6000	26-30	32-40*	**	14-18	18-22	24-26
	OVER 6000	30-32 <sup>a</sup>	36-44*	**	20-22	24-26	26-28
65-70 <sup>b</sup>	UNDER 750	18-20	20-26	**	10-12	14-16	14-16
	750-1500	24-26	28-36*	**	12-16	18-20	20-22
	1500-6000	28-32*	34-42*	**	16-20	22-24	26-28
	OVER 6000	30-34*	38-46*	**	22-24	26-30	28-30

Ref: BDE Manual Ch. 38-3 Roadside Clear Zones

3. The values for “backslope” only apply to a section where the toe of the back slope is adjacent to the shoulder. See Figure 38-3B(d). For sections with roadside ditches, see Section 38-3.04.



# Important Distinction

Available Clear Zone = Area Existing for recovery

Design Clear Zone = A selected value used for design to provide recovery area for a majority of errant drivers



**Do not compromise available clear zone**



Session 1

1-21

# Clear Zone and Curbs - IDOT

## 38-3.02(f) Curbed Sections

Because curbs do not have re-directional capabilities, except at speeds below 25 mph, the presence of curbs does not affect determination or application of the calculated clear zone value. See Section 38-9 for more discussion of roadside safety for urban cross sections.

## 38-4.06(a) Curbs

3. Redirection. Curbs offer no safety benefits on high-speed roadways and will not redirect errant vehicles.

Ref: BDE Manual Ch. 38-3 Roadside Clear Zones. 38-4.06 (a) Curbs



Session 1

1-22

# IDOT Guidance

## 38-4.02 Range of Treatments

If a roadside hazard is within the clear zone, the designer should select the treatment that is judged to be the most practical and cost-effective for the site conditions. The range of treatments, in order of preference, includes:

- Eliminate the hazard (flatten embankment, remove rock outcroppings, etc.);
- Redesign the hazard so it can be safely traversed (e.g., culvert grating);
- Relocate the hazard to a point where it is less likely to be struck;
- Where applicable, make the hazard breakaway (sign posts, luminaire supports);
- Shield the hazard with a roadside barrier;
- Delineate the hazard; or
- Do nothing

Ref: BDE Manual, Ch. 38-4.02. Range of Treatments.



Session 1

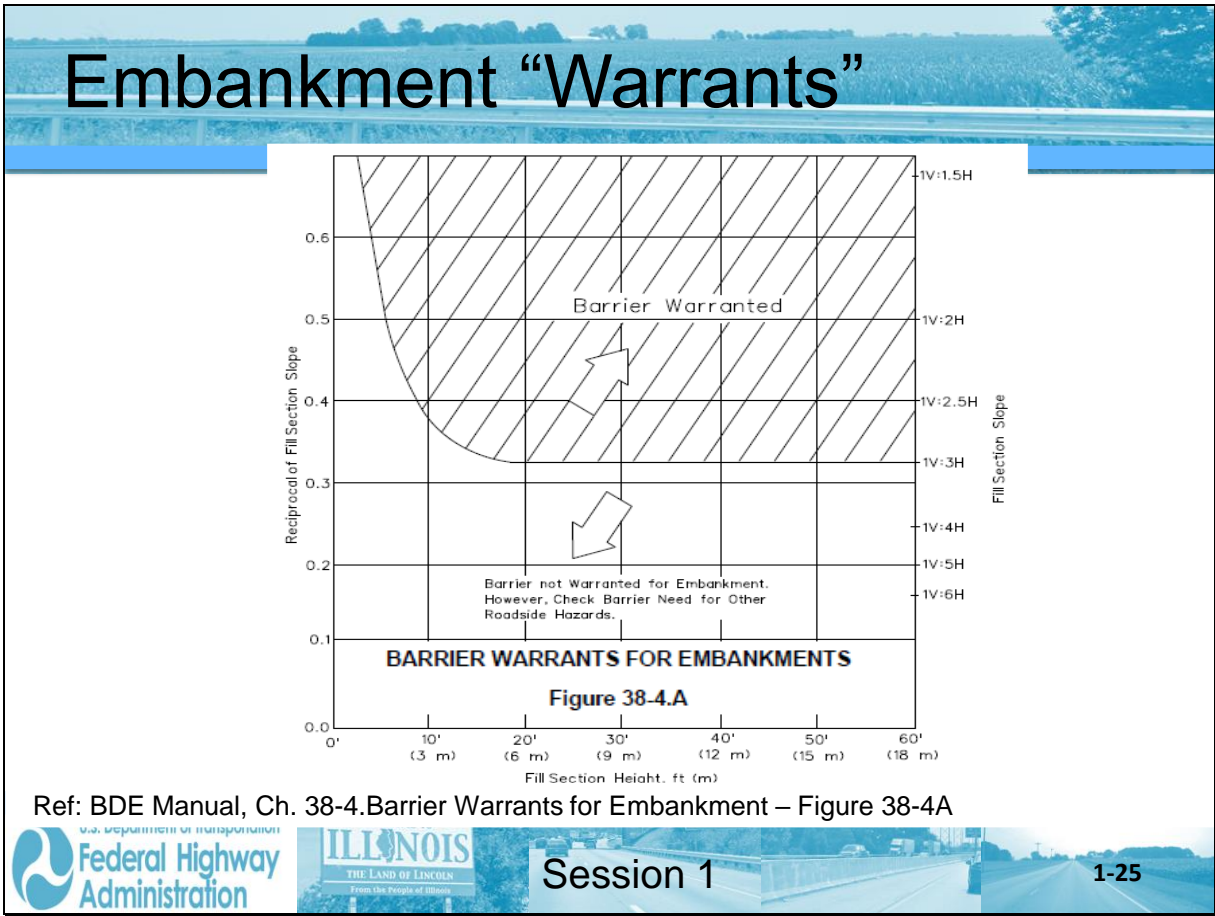
1-23



The major premise should remain that a traffic barrier should be installed only if it is expected to reduce the likelihood of severe crashes.

**38-9.05 Barrier Warrants**





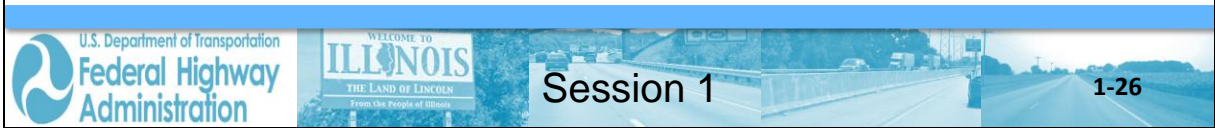


# Medians – Object

## **38-8.02 Warrants**

For median widths of 84 ft (26 m) or less, all piers, sign foundations, and similar hazards in medians of divided highways warrant shielding. For median widths greater than 84 ft (26 m), the need should be considered on a case-by-case basis.

Ref: BDE Manual, Ch. 38-8.02 Warrants



## Review Learning Outcomes

- Identify the primary Roadside Safety Concerns in Illinois.
- Identify the need for training.
- Define clear zone and barrier warrants.

A horizontal banner image with a blue-tinted background. On the left is the U.S. Department of Transportation Federal Highway Administration logo. In the center is a 'WELCOME TO ILLINOIS' sign with the text 'THE LAND OF LINCOLN' and 'From the People of Illinois'. To the right of the sign is the text 'Session 1'. On the far right is the number '1-27'.

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Session 2: Testing Requirements and  
Performance Characteristics of Common  
Barrier Systems

FAST Act Guardrail Training  
Highway Barrier Installer, Inspector and  
Maintenance Training

**Session 2:  
Testing Requirements and  
Performance Characteristics  
of Common Barrier Systems**

U.S. Department of Transportation  
Federal Highway  
Administration

ILLINOIS  
THE LAND OF LINCOLN

Session 2 2-1

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**Session 2 Learning Outcomes**

At the end of this session, you will be able to:

- Understand how barriers are tested for crashworthiness
- Identify common barrier systems
- Explain how these barrier systems function
- Define the key components of a transition design

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Session 2 2-2

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## Crash Testing Guidelines

- In 1993, crash testing and evaluation criteria were published as NCHRP Report 350
- In 2009, the Manual for Assessing Safety Hardware (MASH) was published by AASHTO. It was used by FHWA as the testing standard for all new products
- In 2016, an update to MASH was adopted and a timetable for implementation of new installations complying with this edition was signed between FHWA and AASHTO



Session 2

2-3

## MASH Test Conditions

Selection of a performance level is based on speed and traffic mix.

- **TL-1, TL-2, and TL-3:** crash tests with small car and pickup truck with a 25° impact angle at 31, 44, and 62 mph, respectively.



2,420 lbs.  
1100C



5,000 lbs.  
2270P



Session 2

2-4

### NCHRP 350 comparison with MASH Crew Cab Truck



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U.S. Department of Transportation

Session 2

2-5

### MASH Test Conditions (cont'd)

- **TL- 4:** TL-3 + 15° impact angle, 56 mph Single-Unit Truck
- **TL- 5:** TL-3 + 15° impact angle, 50 mph Tractor-Van Trailer
- **TL- 6:** TL-3 + 15° impact angle, 50 mph Tractor-Tank Trailer



22,000 lbs.

80,000 lbs.

80,000 lbs.

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Session 2

2-6


# Functional Requirement of Barrier

1. Contain Vehicle
  - No Penetration
  - No Vaulting/Under-riding
2. Redirect Vehicle Smoothly (low exit angle) with no snagging/overturning, and no excessive rotation (75 degree max)
3. Tolerable Occupant Impact Forces
4. Minimum Occupant Compartment Deformation and no Debris Intrusion



## Standard Barrier Systems

- Rigid Systems
- Semi-Rigid Systems
- Flexible Systems
- Median Barrier Systems
- Work Zone Barriers



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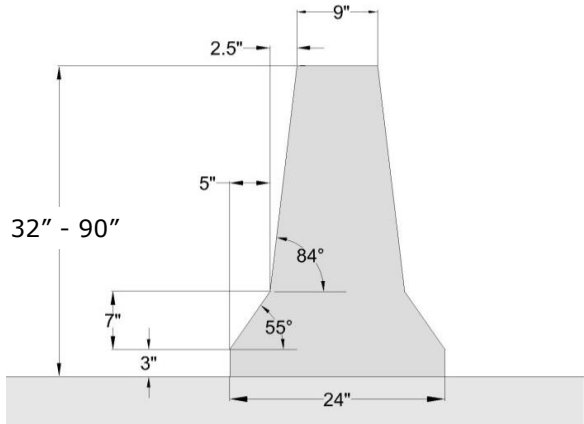
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# Rigid Barrier - Historical

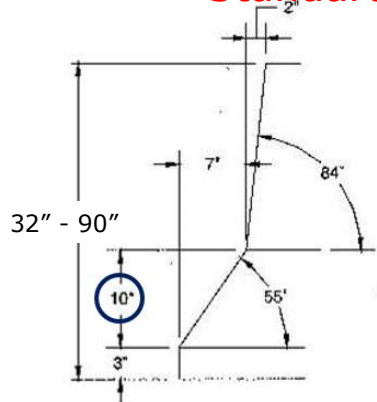
**Previous Standard**



32" - 90"  
2.5"  
9"  
5"  
84°  
7"  
3"  
24"

**F-Shape**

**Really Previous Standard**



32" - 90"  
2"  
7"  
84°  
10°  
3"  
55°

**NJ Shape**

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**Federal Highway Administration**

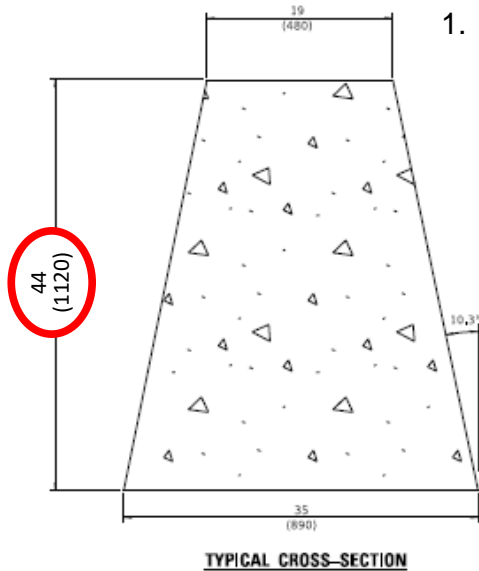
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Session 2

2-9



# Rigid Barrier – Current



1. Rigid Median Barriers. As noted earlier, the IDOT 44 in. (1120 mm) Double Face Concrete Barriers has been certified as meeting MASH criteria (Test Level 5).

38-7.9

**CONCRETE BARRIER,  
DOUBLE FACE,  
44 In. (1120 mm) HEIGHT**  
(Sheet 1 of 2)  
STANDARD 637006-04

Ref: IDOT Standard 637006-04. Concrete Barrier, Double Face



Session 2

2-10

MASH Testing  
of 32" New  
Jersey Shaped  
Concrete  
Barrier

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Rigid Barrier: TL-5 Test video



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## Barrier Systems: Semi-Rigid

- Steel Plate Beam Guardrail – **Previous**
  - 12" wide W-beam rail section (12-gauge thickness).
  - Posts are spaced at 6'-3" centers, and the nominal rail height is 27 3/4"
  - Rail splice at the post.
  - Typically one post:
    - Steel, W6 x 9 x 6'- 0" long.
  - Blockouts: 6" x 8" wood or plastic.



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27" with Wood Post & Wood Block-Out  
27 5/8" Height



Video Clip

Failed Test!!!

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2-14

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27" with Steel Post & Wood Block-Out  
27 5/8" Height



Video Clip

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2-15

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## Barrier Systems: Semi-Rigid

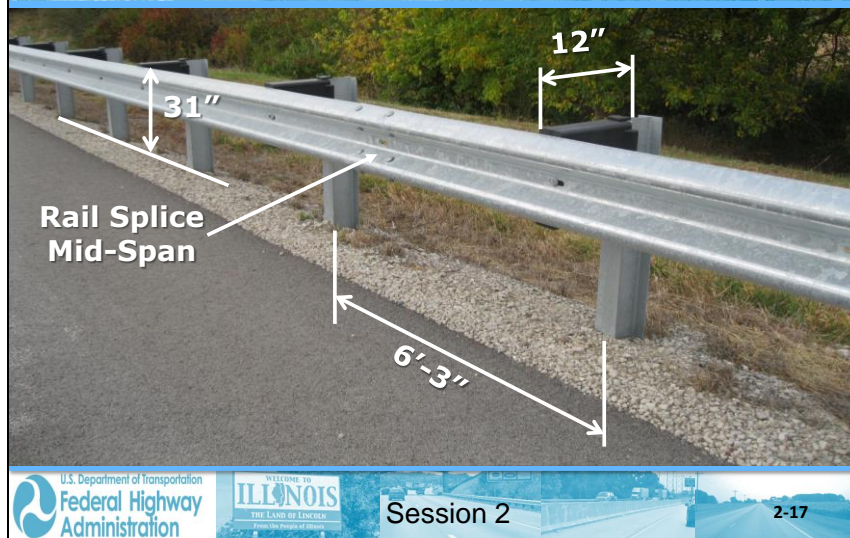
- Steel Plate Beam Guardrail (MGS) – 31”
  - 31” Height
  - Rail Splice mid-span.
  - Post spacing 6’-3”
  - Two post options:
    - Steel posts, W6 x 8.5/9.0 x 6’
    - Wood posts, 6” x 8” x 6’
    - Blockouts: 12” wood or composite



Session 2

2-16

## Steel Plate Beam Guardrail – 31”



Session 2

2-17



31" - MASH Test 3-11



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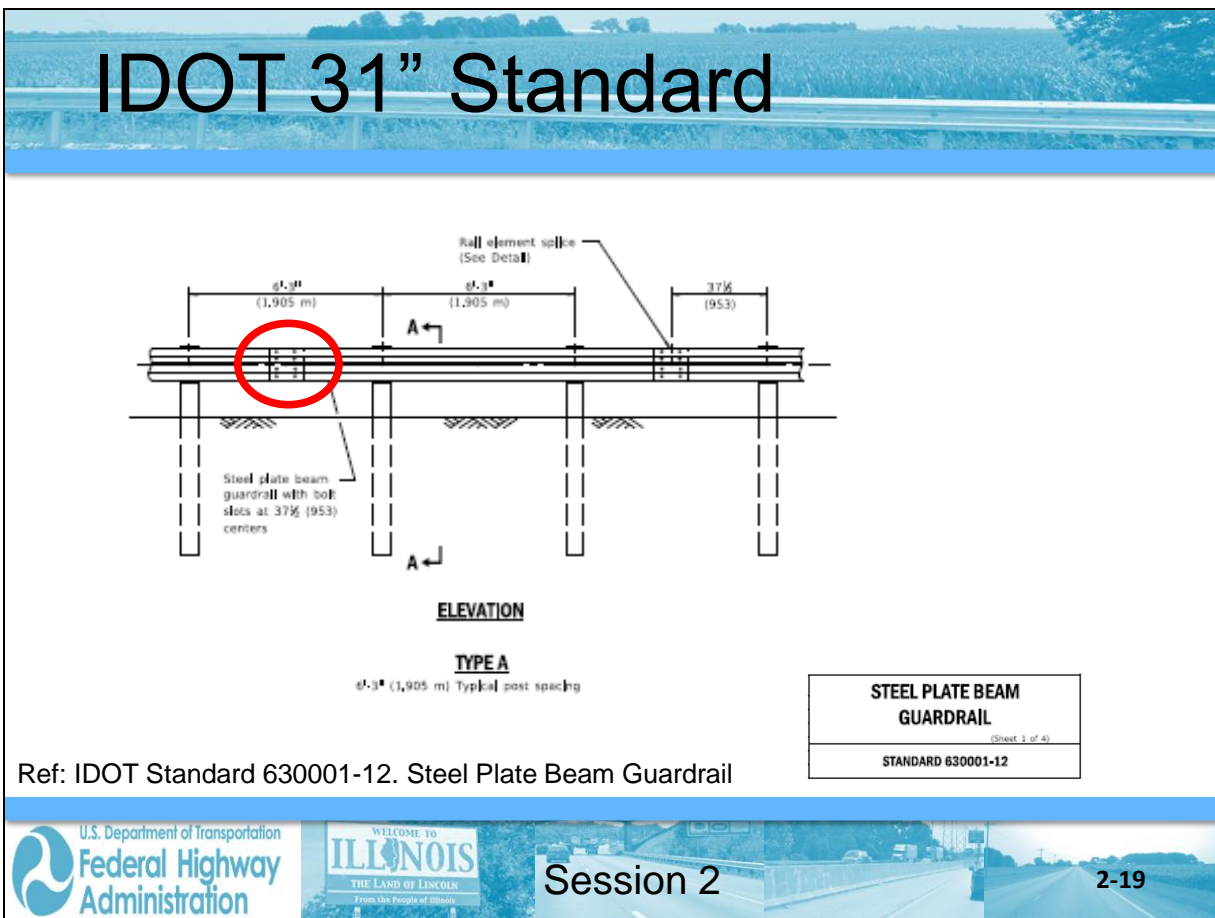
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# IDOT 31" Standard



Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail

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## Existing Guardrail Height



Must be  $\geq 27$ " to remain in place

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From the Heart of America

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2-20

## Barrier Systems: Flexible Barriers

Flexible Barrier Systems typically have relatively large deflections

Examples of Flexible Barriers include:

- Weak post W-beam **Not presented**
- Low tension cable **Not presented**
- High tension cable (HTC)

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2-21



## Barrier Systems: Flexible Barriers

Advantages of cable systems include:

- Low initial cost
- Lower deceleration forces
- Effective vehicle containment and redirection
- Installation conditions flexibility
- SNOW



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2-22

## Barrier Systems: Flexible Barriers

- High Tensioned Cable (HTC) Barrier
  - Five different proprietary designs available
  - Each requires a unique proprietary terminal
  - Somewhat reduced deflections
  - Generally easier maintenance
  - **Can retain effectiveness after most impacts**

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2-23

## High Tension Cable (HTC) Systems

- ★ • Brifen                      ★ = On IDOT QPL
- Safence
- ★ • CASS (Trinity Steel)
- ★ • Nucor
- ★ • Gibraltar

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## IDOT - High-Tension Cable (HTC) Systems

Illinois Department of Transportation  
Bureau of Materials

**QUALIFIED PRODUCT LIST OF HIGH TENSION CABLE MEDIAN BARRIER  
and  
HIGH TENSION CABLE MEDIAN BARRIER TERMINALS**

**April 10, 2020**

**This list supersedes the December 13, 2019 list.**

Standards Specification for Road and Bridge Construction Section 644 (Adopted April 1, 2016)  
Material Codes 55603 and 55604

The following four systems may only be used where median slopes are 1:6 or flatter as shown in the plans:

**HIGH TENSION CABLE MEDIAN BARRIER**

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## IDOT – HTC Requirements



**Specified in the QPL**

Dictate the post spacing  
Dictate the number of cables

“**644.05 Line Posts.** Line posts for the HTC median barrier shall consist of driving posts directly into the soil or setting posts in driven sockets or concrete socket foundations. Posts shall be placed at the spacing and depth recommended by the manufacturer.”



## Example HTC



### Four Cable System



Video Clip

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2-28

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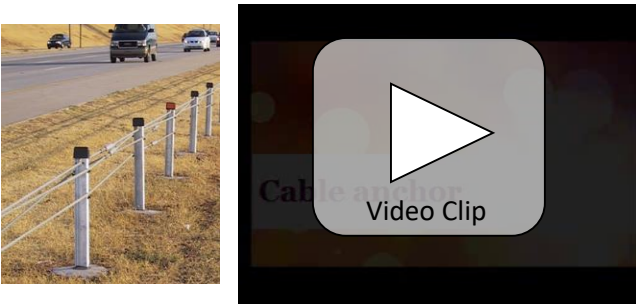
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### Post Foundation and Typical Terminal



Video Clip

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2-29

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### HTC On 4:1 Slope



Video Clip

Maximum Offset 4'

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Federal Highway Administration

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# Barriers in the Median

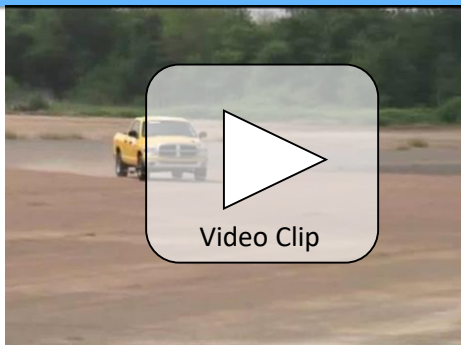
- Used to separate opposing traffic on a divided highway or to separate through traffic from local traffic.
- Many barriers approved for roadside applications can be modified for use in the median.
- Width of the median is an important consideration.
- Also must consider the dynamic deflection of the barrier to avoid intrusion into opposing traffic.
- There are terminals designed specifically to shield the ends of median barriers.



Session 2

2-31

## MASH 31" Median Barrier Test



Session 2

2-32

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# 31" Median Guardrail

The drawing consists of two main views: a side elevation on the left and a plan view on the right. The side elevation shows a cross-section of the guardrail with a top rail height of 7 inches (178 mm) and a post height of 24 1/2 inches (632 mm). The posts are labeled as 6-inch (153 mm) steel or wood posts. The ground is shown with a slope of 1:10 or flatter. The plan view shows two parallel rails with a 6-foot 3-inch (1.905 m) typical post spacing. It includes labels for 'Rail element splice (See Detail)', 'Steel plate beam guardrail', and 'Block-outs'. Traffic flow is indicated by arrows. The drawing is titled 'TYPE D Double steel plate beam guardrail 6'3" (1,905 m) typical post spacing'. A title block at the bottom right contains the text: 'STEEL PLATE BEAM GUARDRAIL (Sheet 1 of 4) STANDARD 630001-12'.


Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail





## Flexible Median Barriers

Advantage of high tension cable is it may remain effective after impact.



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## Flexible Median Barriers



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# Work Zone Concrete Barriers

Portable reinforced concrete safety shape barrier

Dynamic deflection of the barrier is an important




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## Work Zone Barrier Performance



Video Clip



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2-37

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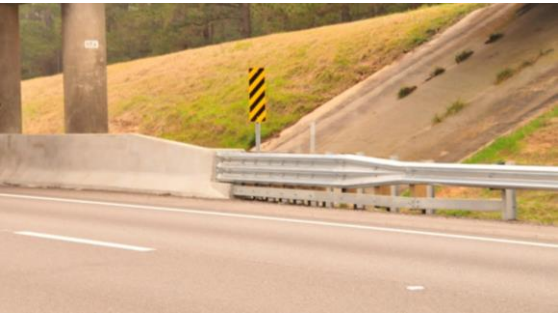
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# Transition Sections

- When a softer (more flexible) barrier precedes a stiffer barrier, a gradual stiffening must occur between the two systems.
- An effective transition must provide the following:
  - Adequate connection (TENSION continuity)
  - Adequate length to gradually increase stiffness.



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2-38

## Inadequate Transition



Video Clip

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# Transition Sections

Successfully crash-tested transitions include the following essential elements (in addition to a structural connection):

- Additional and/or Larger Posts
- Nested rail (w-beam or Thrie-beam)
- Curbs (only as crash-tested transition unit), Rub Rails, and/or Flared Parapet Wall to Prevent Snagging



Session 2

2-40



# 31" Transition Standard

**PLAN**

Formed or drilled 1 (25) hole  
Concrete constant-slope parapet or wingwall  
Steel bearing plate  
Steel connector plate for constant-slope  
K (M20) bolts  
17'-5" (5.31 m) Two sections of tie beam one set inside the other  
4'-5" (1.51 m) Single section of tie beam  
6'-5" (1.91 m) Single transition section of tie beam  
12'-4" (3.81 m) Single section of w-beam when no curb is present within this limit. Two sections of w-beam, one set inside the other, when curb is present within this limit.  
Pay limits of other type

**ELEVATION**

15'-2 1/2" (4.76 m) 10 spaces at 1'-6 1/2" (476)  
26 (184)  
21'-10 1/2" (6.67 m) 7 spaces at 3'-1 1/2" (953)  
no beighting or ending of curb within this limit.  
Pay limits of other type  
31" (787)  
24" (610)  
6 - 7/8" (21.3 mm) W6x9 (W150x13.5) Steel posts  
11 - 4" (101.6 mm) W6x9 (W150x13.5) Steel posts

**SECTION A-A**

24 (610) mbs. all posts  
Wood blockout  
7/8" (21.3 mm)  
W6x9 (W150x13.5) Steel post, typ.  
bridge approach slab

**GENERAL NOTES**

See Standard 63001 for details of guardrail not shown.  
Tie-beam rail shall be bolted to blockout at all posts.  
All slope ratios are expressed as units of vertical displacement to units of horizontal displacement (V:H).  
All dimensions are in inches (millimeters) unless otherwise shown.

DATE	REVISIONS
5-1-21	Added Detail A and revised plate dimensions on sheet 4.
1-12-20	Revised R-shape to constant slope parapet and added steel connector plate. Added two posts and revised post length.

**TRAFFIC BARRIER TERMINAL, TYPE 6**  
(Sheet 1 of 4)  
**STANDARD 631031-17**

**Steel connector plate for constant-slope**

Ref: IDOT Standard 631031-17. Traffic Barrier Terminal, Type 6

**Federal Highway Administration**

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**Session 2**

**2-41**



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## Connections to Low Parapets or Combination Rails

If the concrete parapet or portion of a combination rail is less than the transition height (31”), a steel plate may be applicable to adjust the height.



Contact BSPE



### Review Learning Outcomes

- Understand how barriers are tested for crashworthiness
- Identify common barrier systems
- Explain how these barrier systems function
- Define the key components of a transition design

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Session 3: Testing Requirements and  
Performance Characteristics of Terminals and  
Impact Attenuators

FAST Act Guardrail Training  
Highway Barrier Installer, Inspector and  
Maintenance Training

**Session 3:  
Testing Requirements and  
Performance Characteristics  
of Terminals and Impact  
Attenuators**

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Session 3 3-1

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**Session 3 Learning Outcomes**

At the end of this session, you will be able to:

- Understand how terminals and impact attenuators are tested for crashworthiness
- Identify common terminals and impact attenuators
- Understand how these systems function
- Choose the appropriate system for a specific site

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Session 3 3-2

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**Barrier Terminals**

A barrier terminal must serve two functions:

- Provide the necessary TENSION of the barrier system for downstream impacts
- Be crashworthy when impacted end-on.

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Session 3 3-3

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## Anchor System - Tension



Video Clip




Session 3

3-4

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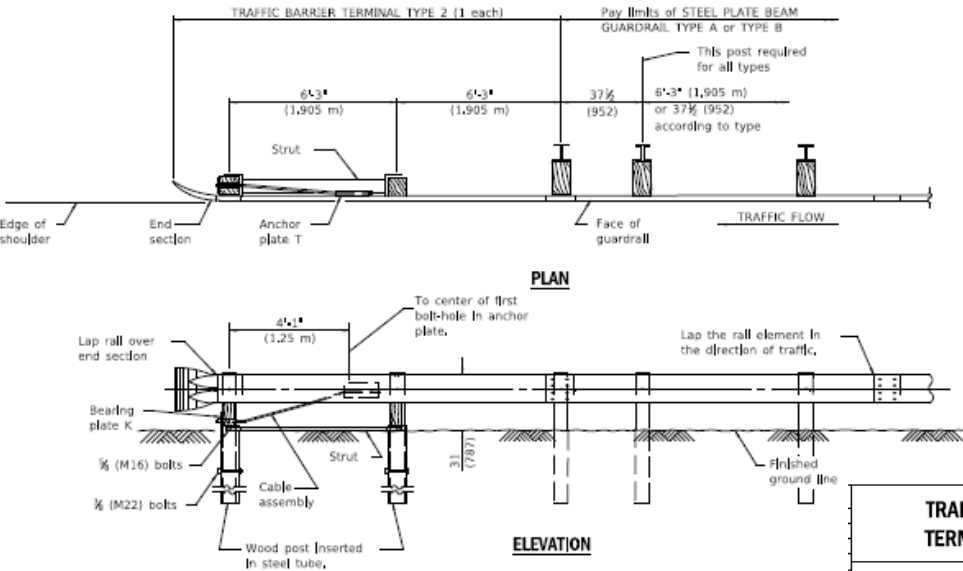
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## TBT Type 2





**PLAN**

**ELEVATION**

**TRAFFIC BARRIER TERMINAL, TYPE 2**

STANDARD 631011-10

Ref: IDOT Standard 631011-10. Traffic Barrier Terminal, Type 2

Session 3

3-5

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## HTC Terminal – Placement










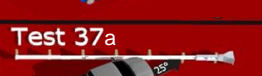
Re-emphasize hiding it so it won't release




Session 3



3-6

## Guardrail Terminals MASH Test Matrix

<p><b>Test 30</b></p> 	<p><b>Test 34</b></p> 
<p><b>Test 31</b></p> 	<p><b>Test 35</b></p> 
<p><b>Test 32</b></p> 	<p><b>Test 37b</b></p> 
<p><b>Test 33</b></p> 	<p><b>Test 37a</b></p> 

- \* Significant Change
- \* Small Car 1100C (2420 #)
- \* Pickup Truck 2270P (5000 #)

**BLON – Beginning Length of Need**

Session 3

3-7



# Guardrail Terminals

## Types of Approved Terminals available in IDOT

- TBT Type 1B – AKA: Buried-in-Backslope
- TBT Type 1 (Tangent) – is parallel to the roadway (as tested) or has a slight ( $\leq 2'$ ), but straight offset; all are Energy-absorbing
- TBT Type 1 (Flared) – post 1 is offset 3-4 feet from the parallel run of guardrail



Session 3

3-8

## TBT Type 1B – Buried-in-Backslope

- Key design considerations:
  - For slopes steeper than 10:1, keep the height of the w-beam rail constant relative to the roadway grade until the barrier crosses the ditch flow line (but a max height of 47")
  - Use a flare rate, either 14:1 or appropriate for the design speed,
  - Add a w-beam rubrail when the distance between the bottom of the w-beam rail and the ground exceeds ~19" and increasing,
  - Use an anchor of steel posts capable of developing the full tensile strength of the w-beam rail and buried 1' below ground



Don't SUBSTITUTE with Type 1 unless absolutely required

**BEARING PLATE K**

**WOOD POST**

**YOKES**

**STEEL TUBE**

**GENERAL NOTES**

See Standard 631006 for details of guardrail not shown.

The bearing plate K shall be held in position by two slight entry nails driven into the post and bent over the top of the plate.

All dimensions are in inches (millimeters) unless otherwise shown.

DATE	REVISIONS
10/11	Revised steel tube length to 45" (1,130 mm)
	Increased steel tube height, corrected hole locations in tube.

**TRAFFIC BARRIER TERMINAL, TYPE 1B**

**STANDARD 631006-08**

Ref: IDOT Standard 631006-08. Traffic Barrier Terminal, Type 1B



Session 3

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**MASH Tests**  
**Buried in Backslope – Double Rail**

Video Clip

Session 3

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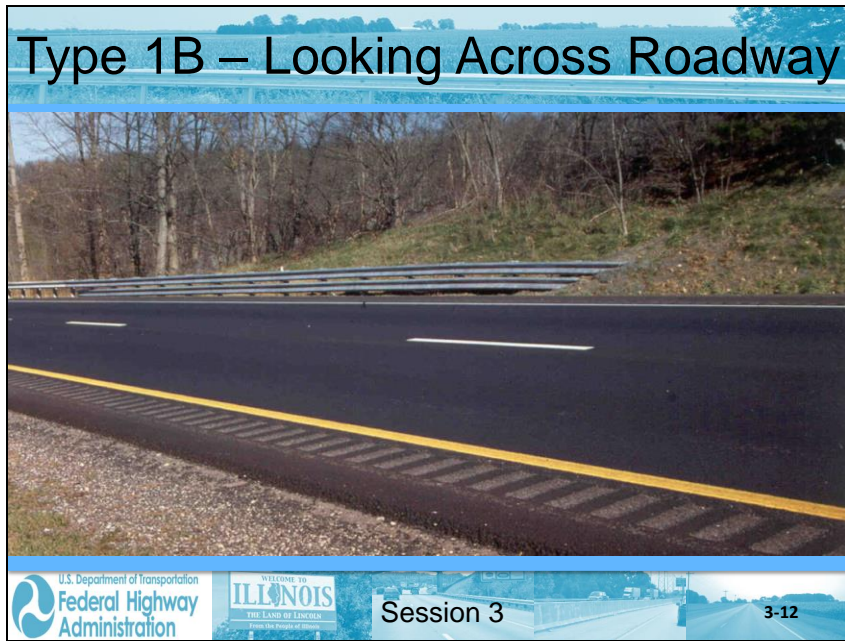
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Type 1B Single rail Considerations



Video Clip

U.S. Department of Transportation  
Federal Highway Administration

ILLINOIS  
THE LAND OF LINCOLN

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3-14

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# Type 1B – Considerations



Any concerns with this installation?

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THE LAND OF LINCOLN  
From the People of Illinois

Session 3

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## Guardrail Terminals

**Energy Absorbing Terminal**  
(vehicle is brought to a controlled stop in a short distance)

**Non-Energy Absorbing Terminal**  
Controlled Buckling Terminal  
(vehicle may travel hundreds of feet before stopping)

U.S. Department of Transportation  
**Federal Highway Administration**

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## TBT Type 1 (Flared)

Illinois Department of Transportation  
Bureau of Materials

**QUALIFIED PRODUCTS LIST OF TRAFFIC BARRIER TERMINAL, TYPE 1 SPECIAL**  
**Effective June 18, 2021**

This list supersedes the December 22, 2017 list  
Standard Specifications for Road and Bridge Construction Section 631 (Adopted April 1, 2016)  
Supplemental Specification and Recurring Special Provisions Section 631 (Adopted January 1, 2018)

**Traffic Barrier Terminal, Type 1 Special (Flared)**

**“X-Tension” – NCHRP 350**  
[FHWA acceptance memorandum HSSD-1/CC-102A dated August 19, 2011.](#)  
Drawing: [X-Tension](#)

**“SRT-31” – NCHRP 350**  
[FHWA acceptance memorandum HSSD/CC-100 dated August 30, 2007](#)  
Drawing: [SRT-31](#)

U.S. Department of Transportation  
**Federal Highway Administration**

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# TBT Type 1 (Flared) - continued

Illinois Department of Transportation  
Bureau of Materials  
(Maintained by Bureau of Safety Programs and Engineering)

Qualified Product List  
**TRAFFIC BARRIER TERMINAL, TYPE 1 SPECIAL**  
Effective June 18, 2021  
This list supersedes the April 10, 2020 list.  
Standard Specifications for Road and Bridge Construction Section 631 (Adopted April 1, 2016)  
Supplemental Specification and Recurring Special Provisions Section 631 (Adopted January 1, 2021)


Material Code 55601, 55602 & 55611

**Traffic Barrier Terminal, Type 1 Special (Flared)**  
continued

- *Road Systems, Inc.*  
3616 Old Howard County Airport  
Big Spring, Texas 79720  
Phone: (915) 263 - 2435

“MFLEAT” – MASH  
[FHWA acceptance memorandum HSST-1/CC-143 dated April 10, 2019](#)  
Drawings: [MFLEAT](#)

**\*Note:**  
Traffic Barrier Terminal Type 1 Special Flared - NCHRP 350 can continue to be used until two MASH products are available for flared end terminals on the QPL.



# Guardrail Terminals Flared, Non-Energy Absorbing

- SRT (Slotted Rail Terminal) – NCHRP 350
  - Modified w-beam panels containing horizontal slots; installed in a straight line flare.
  - Many different post configurations throughout system
  - System is 37'-6" long and connects to 31" high guardrail.



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3-19

NCHRP 350 - Test 3-31:  
SRT



Video Clip

Because of the non-energy absorption,  
no hazard should exist within 150'  
downstream of post #1



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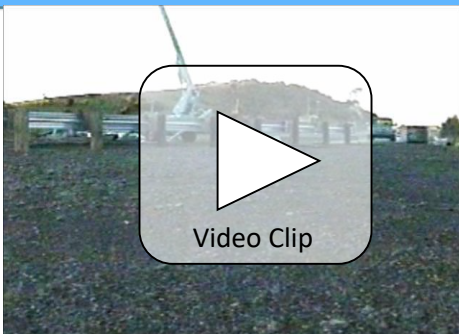
## Flared Guardrail Terminals: Energy Absorbing

### ➤ X-Tension – NCHRP 350

- Utilizes two cables passing through a friction plate in the impact head (and telescoping panels) to absorb the kinetic energy and safely contain or redirect impacting – **works in tension**
- TL-3 at ~50' long; BLON at post 1



### NCHRP 350 X-Tension - Tests 3-31, 33, & 30:





## Flared Guardrail Terminals: Energy Absorbing

- **MFLEAT – MASH** (similar to NCHRP 350 FLEAT)
  - Curls the rail (by kinking) tightly towards the roadway.
  - Steel post system; BLON at 4<sup>th</sup> Post
  - TL-3 at 39' 7" straight flared length. 3-ft. offset.
  - Cable-anchored, compression system



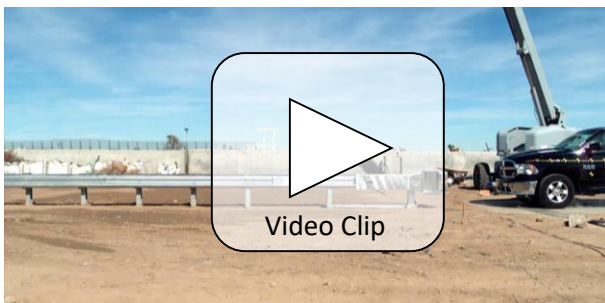
Ref: FHWA Eligibility Letter CC-143 dated 04/10/19



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### MASH MFLEAT – Test 3-31



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# TBT Type 1 (Tangent)

Illinois Department of Transportation  
Bureau of Materials

## QUALIFIED PRODUCTS LIST OF TRAFFIC BARRIER TERMINAL, TYPE 1 SPECIAL Effective June 18, 2021

This list supersedes the [December 22, 2017](#) list

Standard Specifications for Road and Bridge Construction Section 631 (Adopted April 1, 2016)  
Supplemental Specification and Recurring Special Provisions Section 631 (Adopted January 1, 2018)

### Traffic Barrier Terminal, Type 1 Special (Tangent)\*

#### “Max-Tension Guardrail Terminal System” – MASH

[FHWA acceptance memorandum HSST-1/CC-133 dated June 15, 2017](#)

Drawing: [MAX-Tension](#)

#### “MSKT-SP-MGS” – MASH

[FHWA eligibility memorandum HSSD-1/CC-126 dated June 10, 2016](#)

Drawing: [MSKT](#)

#### “SoftStop MASH End Terminal” - MASH

[FHWA acceptance memorandum HSST/CC-115 dated November 12, 2015](#)

Drawing: [SoftStop](#)



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# TBT Type 1 (Tangent) - continued

Illinois Department of Transportation  
Bureau of Materials  
(Maintained by Bureau of Safety Programs and Engineering)

Qualified Product List  
**TRAFFIC BARRIER TERMINAL, TYPE 1 SPECIAL**  
Effective June 18, 2021

This list supersedes the April 10, 2020 list.  
Standard Specifications for Road and Bridge Construction Section 631 (Adopted April 1, 2016)  
Supplemental Specification and Recurring Special Provisions Section 631 (Adopted January 1, 2021)

Material Code 55601, 55602 & 55611

**Traffic Barrier Terminal, Type 1 Special (Tangent)\***  
continued

- SPIG Industry LLC  
14675 Industrial Park Rd  
Bristol, VA 24202  
Phone: (276) 644-9510

“SGET End Terminal” – MASH  
Drawing: [SGET](#)

**\*Note:**  
Traffic Barrier Terminal Type 1 Special Tangent - NCHRP 350 devices listed on this QPL are only allowed on contracts let before July 1, 2018. MASH devices listed on this QPL are required for contracts let on or after July 1, 2018.



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# TBT Type 1 (Tangent)

- MAX-Tension (MASH 16 version of X-Tension, Tangent)
  - Utilizes two cables passing through a friction plate in the impact head (and telescoping panels) and a cutting tooth to absorb the kinetic energy and safely contain or redirect impacting – **works in tension and compression**
  - TL-3 at ~50' long; BLON at 9'-4 1/2"; 31" only



**MUST BE STRAIGHT**

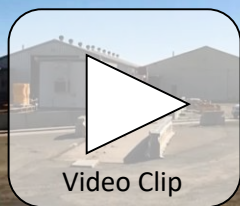


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## MASH MAX-Tension – Tests 3-30 & 31

MASH Test 3-30



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3-30

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# TBT Type 1 (Tangent)

- **MSKT** – MASH (Similar to NCHRP 350 SKT)
  - Kinks Guardrail when hit head-on or at a shallow angle
  - Steel post system; BLON at 3<sup>rd</sup> Post
  - TL-3 at 47' long; attachment to 31" MGS Barrier
  - Cable-anchored system, Compression system



## MASH MSKT – Tests 3-30 & 31



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# TBT Type 1 (Tangent)

- Soft Stop - MASH
  - Impact head slides along panels, crushing them vertically, absorbing the energy of the vehicle in shallow angle impacts – **works in tension**
  - TL-3 at 51' long; BLON at 16'-6"; 31" only



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## MASH Soft Stop – Tests 3-30 & 31



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# TBT Type 1 (Tangent)

➤ **SGET - MASH**

- Flattens guardrail when hit head-on or at a shallow angle
- Steel and wood post system; BLON at 3<sup>rd</sup> Post
- TL-3 at 47' long; attachment to 31" MGS Barrier
- Cable-anchored system, Compression system



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## MASH SGET – Test 3-31



Video Clip

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Federal Highway Administration

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# Terminal Grading

- Special grading requirements for guardrail terminals:
  - Flat terrain (10:1 or flatter) is required *in ADVANCE* of all terminals so that vehicles are relatively stable on approach
  - Flat grading must extend *behind* post 1 (**ADJACENT**) so vehicle is stable at impact *and* stub height criteria is satisfied

Ref: AASHTO Roadside Design Guide, 4<sup>th</sup> Edition, Section 8.3.3.



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# Stub Height Criteria – IDOT

Top of rail

31 (787)

Edge of paved shoulder




Top of tube

2 (50)

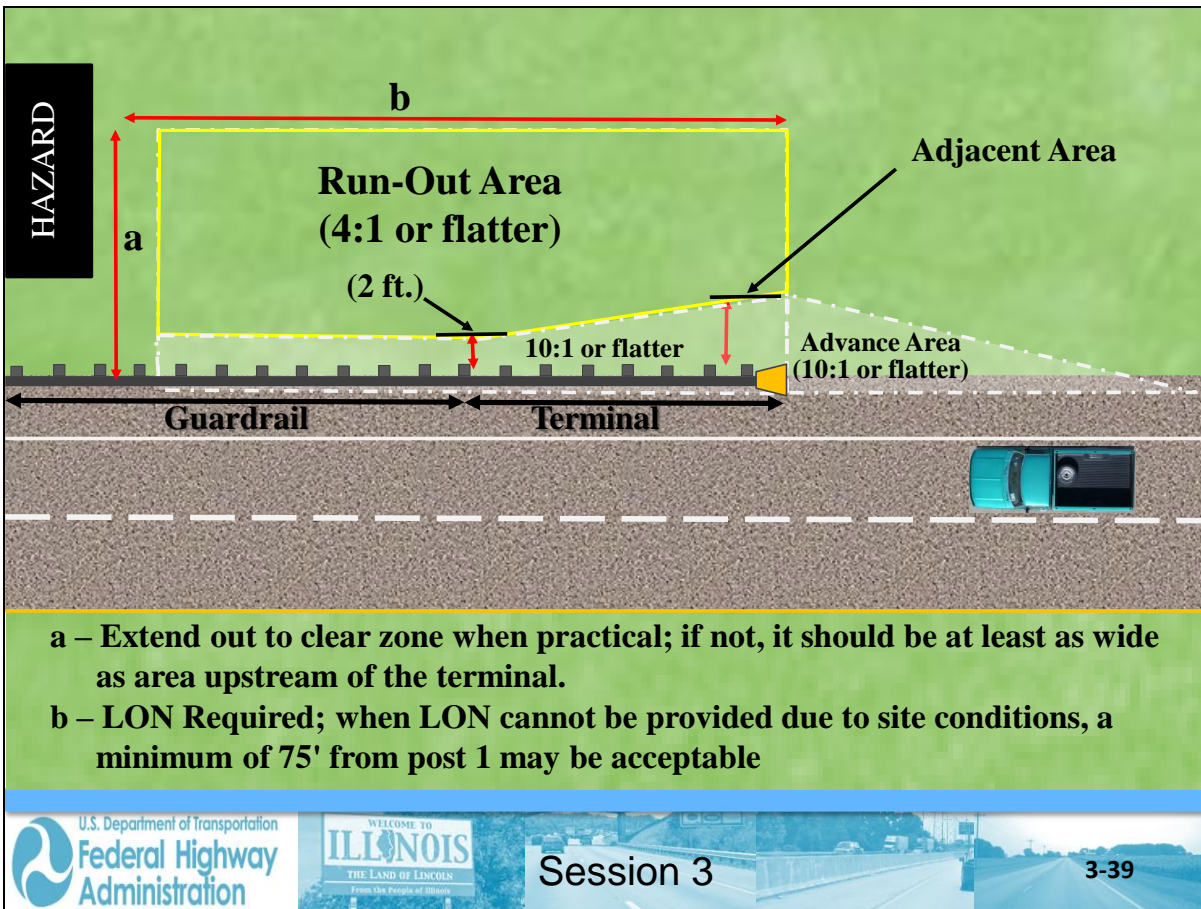
Ground line, slope 1:10 or flatter

SHOULDER WIDENING FOR TYPE 1 (SPECIAL) GUARDRAIL TERMINALS (Sheet 1 of 2) STANDARD 630301-09

Ref: IDOT Standard 630301-09. Shoulder Widening for Type 1 (Special) Guardrail Terminals

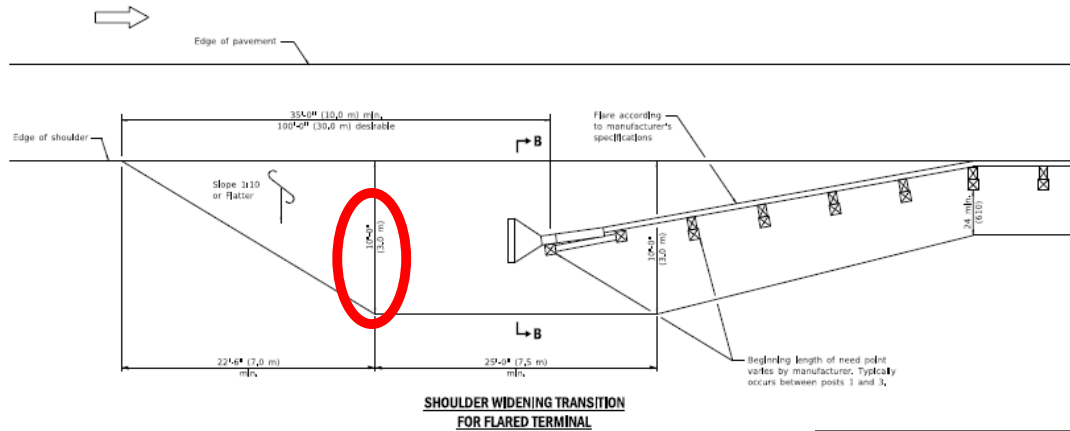
  **Session 3**  **3-38**







# TBT Type 1 (Flared) Grading



**Need special Borrow bid item for 3R projects and Density Spec**

**SHOULDER WIDENING FOR TYPE 1 (SPECIAL) GUARDRAIL TERMINALS**  
(Sheet 1 of 2)  
**STANDARD 630301-09**

Ref: IDOT Standard 630301-09. Shoulder Widening for Type 1 (Special) Guardrail Terminals



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# TBT Type 1 (Tangent) Grading

Need special Borrow bid item for 3R projects and Density Spec

<b>SHOULDER WIDENING FOR TYPE 1 (SPECIAL) GUARDRAIL TERMINALS</b> <small>(Sheet 1 of 2)</small>
<b>STANDARD 630301-09</b>

Ref: IDOT Standard 630301-09. Shoulder Widening for Type 1 (Special) Guardrail Terminals

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**Federal Highway Administration**

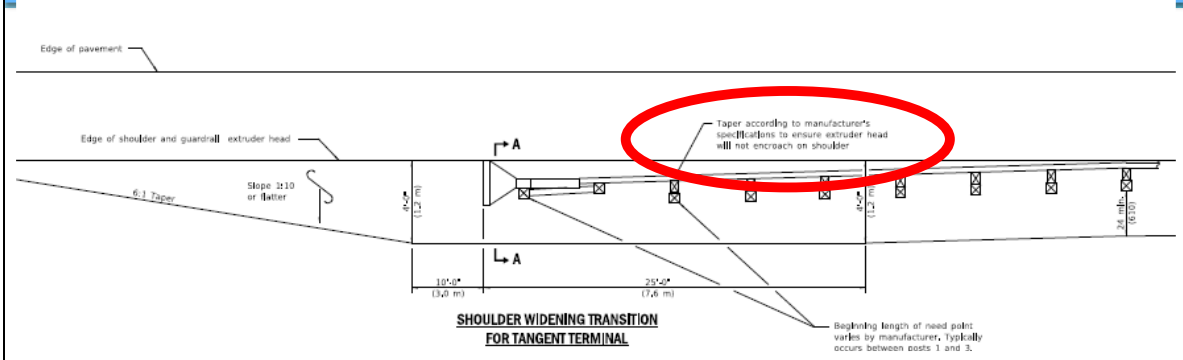
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# TBT Type 1 (Tangent) Special Considerations



Taper according to manufacturer's specifications to ensure extruder head will not encroach on shoulder

**No spec; 1' offset to face of rail at Post 1**

**SHOULDER WIDENING FOR  
TYPE 1 (SPECIAL)  
GUARDRAIL TERMINALS**  
(Sheet 1 of 2)  
**STANDARD 630301-09**

Ref: IDOT Standard 630301-09. Shoulder Widening for Type 1 (Special) Guardrail Terminals



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## Terminal for Guardrail on Flare

If the standard run of guardrail is flared, the flare (or offset) of the terminal is based on the line of the roadway, regardless of the flare rate of the standard run.

- For tangent terminals, if the flare rate is sharper than 25:1, this will result in a bend at the downstream end of the terminal toward traffic (for its full length)
- For flared terminals, depending on the type, the terminal could be bent either toward or away from the roadway (outside of the terminal length)



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## Tangent Terminals on Flared Standard Run Schematic

**Standard Run Flare of 25:1 or flatter**

**Standard Run Flare is sharper than 25:1**

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**Federal Highway Administration**

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## Terminal with Curb

Although a terminal adjacent to a curb should be avoided, if a terminal end is needed along the section with curb, provide a tangent terminal with a 50:1 flare so that the impact head of the terminal does not protrude on the roadway. Note that the height of this installation is referenced from the edge of pavement in front of the guardrail face. 38-6.05 Terrain

**Caution: If the terminal has a bearing plate (MSKT), it MUST not be buried. Other terminals would need to be modified to comply; TERMINALS SHOULD NOT BE MODIFIED**

Ref: BDE Manual Chp. 38-6.05 Terrain



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# Things to Remember about Terminals

Even Energy Absorbing Terminals will not shield objects directly behind and within Terminal limits



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EXISTING Terminals  
350 and before  
(Briefly)

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## TBT Type 1 (Tangent)

- SKT 350 (Sequential Kinking Terminal)(NCHRP 350)
  - Kinks panels when hit head-on or at a shallow angle
  - Wood or Steel post system (many options)
  - TL-3 at 50' long; BLON at 3<sup>rd</sup> Post
  - Cable-anchored, Compression system



Ref: FHWA Eligibility Letter CC-88 dated 3/8/05

# TBT Type 1 (Tangent)

- ET Plus (Guardrail Extruder Terminal)(NCHRP 350)
  - Flattens the rail element when hit head-on
  - Weakened wood or steel posts (several options available)
  - 50' long; attaches to either height w-beam system
  - BLON at 3<sup>rd</sup> Post
  - Cable-anchored, compression system



Ref: FHWA Eligibility Letter CC-12Q dated 3/15/10

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Turndown - Video

Video Clip

Failed Test! Causes vaulting

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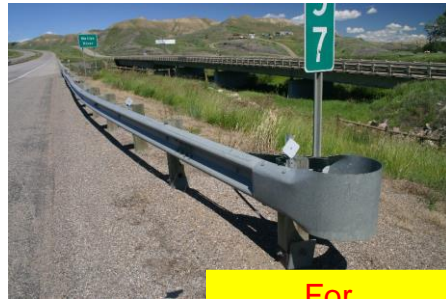
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# BCT Terminal

- Breakaway Cable Terminal (BCT) NCHRP 230
  - W-Beam rail with a parabolic curve and 4-ft offset.
  - No impact head or ground strut between the two end posts.
  - Only two breakaway posts.
  - Rail bolted to all posts.



For  
Identification  
Only



# Guardrail Terminals - Median

Illinois Department of Transportation  
 Bureau of Materials  
 (Maintained by Bureau of Safety Programs and Engineering)  
**QUALIFIED PRODUCT LIST OF IMPACT ATTENUATORS**  
 Effective **November 27, 2019**  
 This list supersedes the **March 15, 2019** list.  
 Standard Specification for Road and Bridge Construction Section 643 (Adopted April 1, 2016)


**IMPACT ATTENUATOR (PARTIALLY REDIRECTIVE)**

MANUFACTURER	NCHRP 350		MASH	
	PRODUCT NAME	TEST LEVEL	PRODUCT NAME	TEST LEVEL
Trinity Highway Products, LLC (Energy Absorption Systems, Inc.) 2525 N. Stemmons Freeway Dallas, Tx 75207 Phone: (800) 644 - 7976 or (801) 292 - 4461	CAT 350™	3		
Road Systems, Inc. 3616 Old Howard County Airport Big Spring, TX 79720 Phone: (915) 263 - 2493	FLEAT - MT	3		

Note: For Impact Attenuator Severe use wide and partially redirective the NCHRP 350 tested devices listed above will continue to be accepted for future lettings until such time as MASH 16 devices are available.

## Session 3



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# Guardrail Terminal - Median 28"

- CAT (Crash Cushion Attenuating Terminal) (NCHRP 350, TL-3)
  - Special HS bolts tear tabs between multiple slots in rail upon head-on impact.
  - Typically used to terminate a double-faced strong-post median W-Beam barrier
  - Can be attached directly to a double-sided concrete median barrier with appropriate transition section.
  - compression system
  - Length of needs begins at post 4.



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“Double-Faced” Terminal  
27” CAT (230 video/350 passed)

Video Clip

Session 3

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## Guardrail Terminal - Median

### FLEAT-MT (FLared Energy Absorbing Terminal-Median Terminal)

- NCHRP 350 TL-3
- Intended for use in wide medians.
- Attaches directly to a W-Beam median barrier, or to a Thrie-Beam median barrier using the standard W-Beam to Thrie beam transition piece.
- During an impact, the vehicle pushes the leading impact head down the rail section while sequentially kinking the rail element.
- Most components interchangeable with the Tangent SKT and Flared FLEAT roadside terminals.





**Crash Cushion = Impact Attenuator**

Crash test with blunt end:

Video Clip

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### Crash Cushion = Impact Attenuator

Crash test with ramped end:



Video Clip

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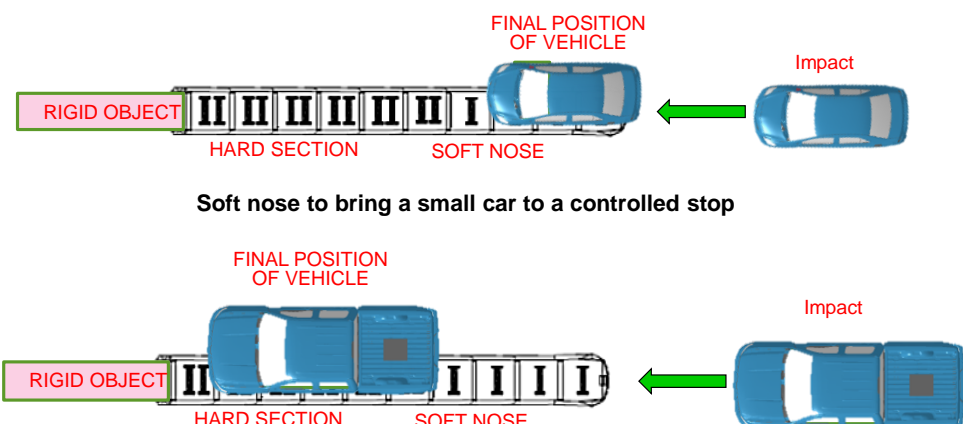
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## Impact Attenuator Theory



**Soft nose to bring a small car to a controlled stop**

**Harder back section to bring a pick-up truck to a controlled stop**

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## Impact Attenuator – Non-Redirective (aka: Sand Barrels)

- Individual barrel designs vary in shape by manufacturer, but they all function the same
- Arrays of sand barrels may be designed to shield any shape hazard
- Impacting vehicles will not be redirected.
- Since no re-directive capability, the corner of the hazard must be reasonably shielded.



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# Impact Attenuator – Non-Redirective (aka: Sand Barrels)

**IMPACT ATTENUATOR (NON-REDIRECTIVE)**

MANUFACTURER	NCHRP 350		MASH	
	PRODUCT NAME	TEST LEVEL	PRODUCT NAME	TEST LEVEL
Trinity Highway Products, LLC (Energy Absorption Systems, Inc.) 2525 N. Stemmons Freeway Dallas, Tx 75207 Phone: (800) 644 - 7976 or (801) 292 - 4461	ENERGITE® III	2 & 3		
Plastic Safety Systems, Inc 3616 Old Howard County Airport Big Spring, TX 79720 Phone: (915) 263 - 2493	CRASHGARD SAND BARREL	3		
Traffix Devices, Inc. 160 Avenida La Pata San Clemente, CA 92673 Phone: (949) 361 - 5663	BIG SANDY® SAND BARRERLS	3		

**Note: For Impact Attenuator Non-Redirective the NCHRP 350 tested devices listed above will continue to be accepted for future lettings until such time as MASH 16 devices are available.**



# Impact Attenuator – Non-Redirective (aka: Sand Barrels)

➤ Sand Barrels:



Energite



Traffix Big Sandy (MASH)



CrashGard (MASH)

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Sand-Filled Array

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# Sand-Filled Array

**GORE INSTALLATION**  
(Traffic approaches on both sides)  
(See Level 2 array shown)

**ROADSIDE INSTALLATION**  
(Traffic approaches on one side)  
(See Level 2 array shown)

**TEST LEVEL 2 ARRAY**  
(For design speed less than or equal to 45 mph)  
(Numbers indicate sand module weight in pounds.)

**TEST LEVEL 3 ARRAY**  
(For design speed greater than 45 mph)  
(Numbers indicate sand module weight in pounds.)

**GENERAL NOTES**  
All dimensions are in inches (millimeters) unless otherwise shown.

DATE	REVISIONS
2-1-14	Revised (distance from barrier to hazard)
1-1-13	Changed 'posted speed' to 'design speed'

SAND MODULE IMPACT ATTENUATORS	
STANDARD 643001-02	

Illinois Department of Transportation  
 Approved: [Signature]  
 Date: 2/14/14  
 Project: [Blank]

Ref: IDOT Standard 643001-02. Sand Module Impact Attenuators



## Session 3

## Sand-Filled Array

### 38-8.03(c) Operational Principles

The sand module systems require no back-up support or connection to another system. However, they do require a firm and stable base. For permanent systems, an HMA or PCC base is required. For temporary installations not to be placed over a winter, an aggregate base may be used. Sand modules have no redirective capability and generate considerable debris upon impact. On the approaching traffic corner, the exterior modules must be laterally offset at least 2.5 ft (750 mm) from the corner of the hazard; see Figure 38-8.A.

Ref: BDE Manual Chp. 38-8.03(c) Operational Principles



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## Impact Attenuator – Fully Redirective

Non-gating as follows:

- Contains and redirects vehicles impacting along the sides of the device essentially its entire length
- Contains vehicles impacting the nose either head-on or at a 15° angle.
- Approved for TL-2 (350) & TL-3 systems.
- Designed to shield a point hazard; either attached or stand alone.



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# Impact Attenuator – Fully Redirective Narrow

**IMPACT ATTENUATOR (FULLY REDIRECTIVE, NARROW)**

MANUFACTURER	NCHRP 350		MASH	
	PRODUCT NAME	TEST LEVEL	PRODUCT NAME	TEST LEVEL
Lindsay Transportation Solutions (Barrier Systems, Inc.) 180 River Rd Rio Vista, CA 94571 Phone (888) 800 - 3691	UNIVERSAL TAU-II ®	2 & 3	TAU-M	3
	UNIVERSAL TAU-II-R ®	2 & 3		
Trinity Highway Products, LLC (Energy Absorption Systems, Inc.) 2525 N. Stemmons Freeway Dallas, Tx 75207 Phone: (800) 644 - 7976 or (801) 292 - 4461	QUADGUARD ®	2 & 3	QUADGUARD M10	3
	QUADGUARD® II	2 & 3	QUADGUARD M10	3
	QUADGUARD® ELITE	2 & 3		
	QUEST®	2 & 3		
	REACT 350®	2* & 3*		
	HEART	2 & 3		
Traffix Devices, Inc. 160 Avenida La Pata San Clemente, CA 92673 Phone (949) 361 - 5663	TRACC	2 & 3		
	COMPRESSOR®	2 & 3		
Hill and Smith (Work Area Protection Corp.) 2760 Airport Dr Suite 125 Columbus, OH 43207	SCI 100GM®	3	SCI 100GM®	3
	SCI 70GM®	2		

*\*TL 3 is nine (9) cylinder only and TL 2 is four (4) cylinder only*

**Note: For Impact Attenuator Fully Redirective Narrow: NCHRP 350 products are allowed on lettings prior to January 1, 2019. MASH products are required for any lettings on or after January 1, 2019.**

## Session 3

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## Impact Attenuator – Fully Redirective Narrow

- TAU-M (MASH)
  - Can be attached directly to a W-beam or Thrie-beam median barrier as well as to a concrete safety shape.
  - Comes in 30” width
  - Consists of Thrie-beam panels, expendable absorbing cartridges, steel diaphragms and two cables at the bottom to provide redirection.



# Impact Attenuator – Fully Redirective Narrow

➤ QuadGuard M10 (MASH)



- Slides back on a single track when struck head-on and uses specially fabricated side panels having four corrugations.
- Energy-absorbing cartridges in each bay; damaged cartridges need to be replaced after a crash.
- Available only at 24”


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# Impact Attenuator – Fully Redirective Narrow



QuadGuard M10 Tests  
CC 112  
Video Clip

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## Impact Attenuator – Fully Redirective Narrow

- SCI Smart Cushion (MASH)
  - Variable Reaction Force
  - Re-usable with minimal component replacement
  - Needs repair before next hit



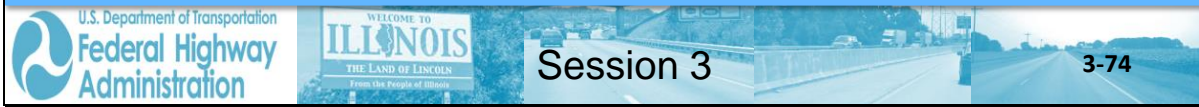
# Impact Attenuator – Fully Redirective WIDE

IMPACT ATTENUATOR (FULLY REDIRECTIVE, WIDE)

MANUFACTURER	NCHRP 350		MASH	
	PRODUCT NAME	TEST LEVEL	PRODUCT NAME	TEST LEVEL
Lindsay Transportation Solutions (Barrier Systems, Inc.) 180 River Rd Rio Vista, CA 94571 Phone (888) 800 - 3691	UNIVERSAL TAU-II®	2 & 3		
	UNIVERSAL TAU-II-R®	2 & 3		
Trinity Highway Products, LLC (Energy Absorption Systems, Inc.) 2525 N. Stemmons Freeway Dallas, Tx 75207 Phone: (800) 644 - 7976 or (801) 292 - 4461	QUADGUARD® WIDE	2 & 3		
	QUADGUARD® II WIDE	2 & 3		
	QUADGUARD® ELITE WIDE	2 & 3		
	REACT 350®	2* & 3*		
	TRACC	2 & 3		
Hill and Smith (Work Area Protection Corp.) 2760 Airport Dr Suite 125 Columbus, OH 43207	SCI 100GM®	3		
	SCI 70GM®	2		

*\*TL 3 is nine (9) cylinder only and TL 2 is four (4) cylinder only*

**Note: For Impact Attenuator Fully Redirective Wide the NCHRP 350 tested devices listed above will continue to be accepted for future lettings until such time as MASH 16 devices are available.**



## Impact Attenuator – Fully Redirective WIDE

- TAU II Wide (NCHRP 350)
  - Can be attached directly to a W-beam or Thrie-beam median barrier as well as to a concrete safety shape.
  - Common set of parts for 36” to 102” widths in 6” increments (350)
  - Consists of Thrie-beam panels, expendable absorbing cartridges, steel diaphragms and two cables at the bottom to provide redirection.









# Impact Attenuator – Fully Redirective Severe Use, Narrow

**IMPACT ATTENUATOR (SEVERE USE, NARROW)**


MANUFACTURER	NCHRP 350		MASH	
	PRODUCT NAME	TEST LEVEL	PRODUCT NAME	TEST LEVEL
Lindsay Transportation Solutions (Barrier Systems, Inc.) 180 River Rd Rio Vista, CA 94571 Phone (888) 800 - 3691	UNIVERSAL TAU-II-R®	2 & 3		
Trinity Highway Products, LLC (Energy Absorption Systems, Inc.) 2525 N. Stemmons Freeway Dallas, Tx 75207 Phone: (800) 644 - 7976 or (801) 292 - 4461	REACT 350® QUADGUARD® ELITE	2* & 3* 2 & 3		
Traffix Devices, Inc. 160 Avenida La Pata San Clemente, CA 92673 Phone (949) 361 - 5663	COMPRESSOR®	2 & 3		
Hill and Smith (Work Area Protection Corp.) 2760 Airport Dr Suite 125 Columbus, OH 43207	SCI 100GM® SCI 70GM®	3 2	SCI 100GM®	3

*\*TL 3 is nine (9) cylinder only and TL 2 is four (4) cylinder only*

**Note: For Impact Attenuator Severe Use Narrow: NCHRP 350 tested devices listed above will continue to be accepted for future lettings until such time as MASH 16 devices are available.**

## Session 3



**3-78**

## Impact Attenuator – Fully Redirective Severe Use, Narrow


➤ TAU IIR Systems (NCHRP 350)



- Can be attached directly to a W-beam or Thrie-beam median barrier as well as to a concrete safety shape.
- Designed to attach to a median barrier.
- Consists of Thrie-beam panels, self-restoring absorbing cartridges, steel diaphragms and two cables at the bottom to provide redirection.



# Impact Attenuator – Fully Redirective Severe Use, Narrow

- REACT 350 (Reusable Energy Absorbing Crash Terminal)
  - Permanent or Construction Zone attenuator adjustable for various speeds.
  - Best used in locations where frequent hits are expected.
  - Consists of 9, 6 or 4 cylinders (3' in diameter, 4' tall) with varying wall thickness, re-redirective side cables, and front and back anchorage.
  - Caution if Sight Distance is a concern.
  - Cylinders are made of High Density Polyethylene; essentially self-restoring and requires little maintenance.



Session 33-80

## Impact Attenuator – Fully Redirective Severe Use, Narrow



Session 33-81

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# Impact Attenuator – Fully Redirective Severe Use, Wide

**IMPACT ATTENUATOR (SEVERE USE, WIDE)**

MANUFACTURER	NCHRP 350		MASH	
	PRODUCT NAME	TEST LEVEL	PRODUCT NAME	TEST LEVEL
Lindsay Transportation Solutions (Barrier Systems, Inc.) 180 River Rd Rio Vista, CA 94571 Phone (888) 800 - 3691	UNIVERSAL TAU-II-R ®	2 & 3		
Trinity Highway Products, LLC (Energy Absorption Systems, Inc.) 2525 N. Stemmons Freeway Dallas, Tx 75207 Phone: (800) 644 - 7976 or (801) 292 - 4461	REACT 350® QUADGUARD® ELITE WIDE	2* & 3* 2 & 3		

\*TL 3 is nine (9) cylinder only and TL 2 is four (4) cylinder only

Note: For Impact Attenuator Severe use wide and partially redirective the NCHRP 350 tested devices listed above will continue to be accepted for future lettings until such time as MASH 16 devices are available.

## Session 3

3-82



# Placement – on Level Ground



**SEE  
INSTALLATION  
MANUAL**

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Session 3

3-83

## Review Learning Outcomes

- Understand how terminals and impact attenuators are tested for crashworthiness
- Identify common terminals and impact attenuators
- Explain how these systems function
- Choose the best system for a specific site

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Federal Highway Administration

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Session 3

3-84

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## Session 4: Guardrail Design, Length of Need and Site-specific Installation Considerations

FAST Act Guardrail Training  
Highway Barrier Installer, Inspector and  
Maintenance Training

## Session 4: Guardrail Design, Length of Need, and Site-specific Installation Considerations

U.S. Department of Transportation  
Federal Highway Administration

ILLINOIS  
THE LAND OF LINCOLN

Session 4 4-1

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## Session 4 Learning Outcomes

At the end of this session, you will be able to:

- Understand the design principles affecting an optimal barrier installation
- Apply a field procedure to check Length of Need
- Be familiar with special designs to address site-specific installation considerations

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Federal Highway Administration

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Session 4 4-2

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## Guardrail Placement

**Place AS FAR AWAY  
as Possible**

*without affecting function*

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Federal Highway Administration

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THE LAND OF LINCOLN

Session 4 4-3

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## Barrier Design Principles

1. Deflection
2. Slope in Front of Barrier
3. Guardrail and Curb
4. Soil Backing for Fill Locations
5. Flare Rate

U.S. Department of Transportation  
Federal Highway Administration

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THE LAND OF LINCOLN

Session 4 4-4

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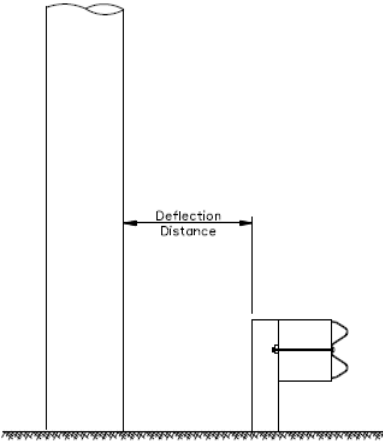
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# Deflection Distance



DEFLECTION DISTANCE FOR W-BEAM GUARDRAIL

Figure 38-6.S

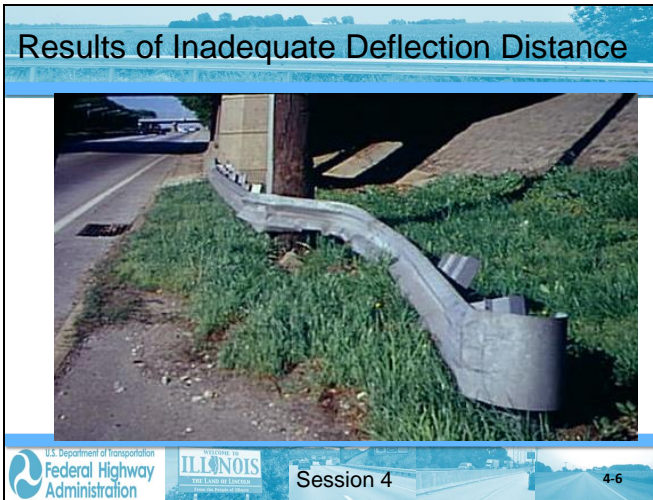
Ref: BDE Manual, Ch. 38-6.03. Barrier Offset

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Federal Highway Administration

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Session 4 4-5






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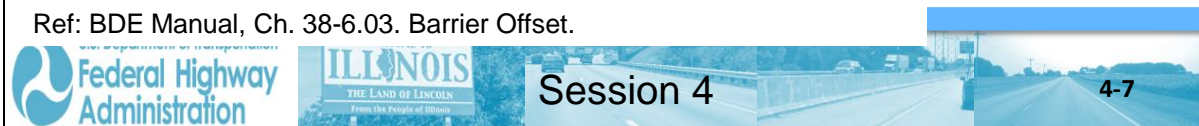


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## Dynamic Deflection of Guardrail Figure 38-6.V

Guardrail Type	Deflection Distance Condition					
	Tangent	1:13 flare	1:7 flare	0 in. to 6 in. behind 6 in. curb (0 mm to 150 mm behind 150 mm curb)	*4 ft to 12 ft behind 6 in. curb *(1.2 m to 3.6 m behind 150 mm curb)	**Long span
Type A W-Beam Guardrail @ 6'-3" (1905 mm) post spacing	38 in. (965 mm)	63 in. (1.60 m)	83 in. (2.11 m)	47 in. (1.19 m)	25 in. (635 mm)	73 in. (1.85 m)
Type B W-Beam Guardrail @ 3' 1 1/2" (953 mm) post spacing	30 in. (762 mm)	Do not flare Type B	Do not flare Type B	Do not use Type B	Do not use Type B	Do not use Type B
W-Beam Guardrail @ 1' 6 3/4" (476 mm) post spacing	22 in. (559 mm)	Do not flare	Do not flare	Do not use	Do not use	Do not use
Weak Post SPBGR Attached to Culverts	38 in. (965 mm)	Do not flare	Do not flare	Do not use	Do not use	Do not flare
Non-Blocked SPBGR	34 in. (864 mm)	Do not flare	Do not flare	Do not use	Do not use	34 in. (864 mm) (Use only beyond required CRT posts)

Ref: BDE Manual, Ch. 38-6.03. Barrier Offset.



# Closed Post Spacing

37½ (953) Closed post spacing




ELEVATION  
TYPE B

**STEEL PLATE BEAM  
GUARDRAIL**  
(Sheet 3 of 4)

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**STANDARD 630001-12**




Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail

Session 44-8

## Introducing Stiffened Guardrail

Rule of thumb:

Each stiffening  
method takes 25'  
- In order to  
prevent “pocketing”

Session 44-9

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## Deflection of HTC Barrier

- e. Deflection. Flexible median barriers will deflect more than the other median barrier types. When laying out a flexible barrier, allow for 12 ft (3.6 m) of deflection.

If designs for reduced deflection are needed, refer to Figure 38-7.F.

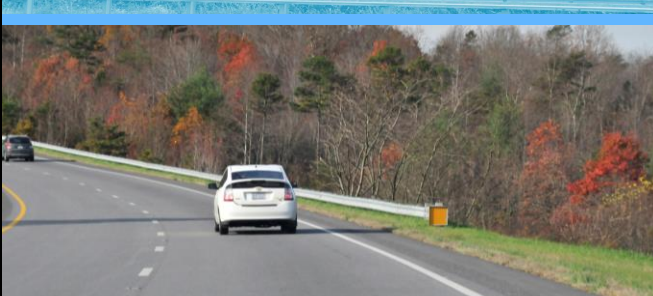
Ref: BDE Manual, Ch. 38-7.03(b) Design Considerations



Session 4

4-10

## Principle 2: Slope in Front of Barrier



Any barrier may be placed anywhere on a 10H:1V or flatter slope.



Session 4

4-11

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### Principle 2: Slope in Front of Barrier



Video Clip

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Session 4

4-12

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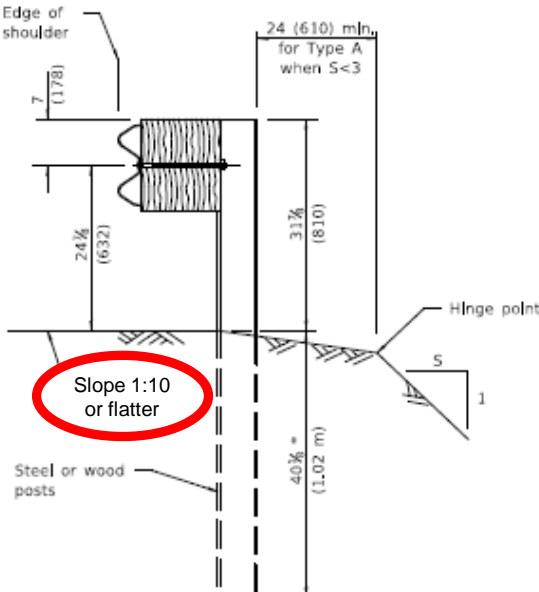
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## Slope in Front of Barrier



Edge of shoulder

7 (178)

24 1/2 (632)

24 (610) min. for Type A when S < 3

31 1/2 (810)

Hinge point

5

1

**Slope 1:10 or flatter**

Steel or wood posts

40% (1.02 m)

**STEEL PLATE BEAM GUARDRAIL**  
(Sheet 1 of 4)  
STANDARD 630001-12

Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail

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**NCHRP 350 TL-3 of 31" on 8:1 Slope**



8:1 Slope  
5-ft  
Video Clip

Vehicle is contained and redirected but shows instability

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Federal Highway Administration

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Session 4

4-14

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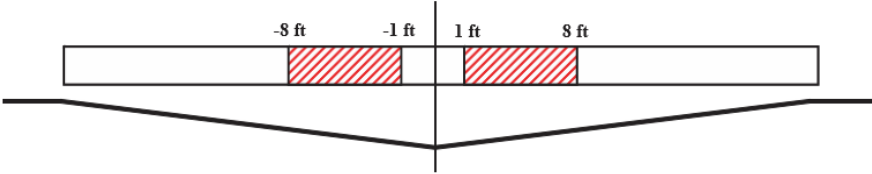
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## Slope in Front of Cable Barrier

- Cable barrier may be placed anywhere on a 10:1 or flatter slope.
- Cable barrier may be placed on slopes of 6:1, but not in the area from 1 ft. to 8 ft. from the ditch bottom.



(a) Medians shallower than 6H:1V slope (NCHRP Report 711)

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4<sup>th</sup> EDITION – 6.6.1.1, Pg. 6-18


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### Location of Cable in Swales



Video Clip

**CABLE SHOULD NOT BE PLACED BETWEEN 1' AND 8' BEYOND THE BOTTOM OF A DITCH**

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## Principle 3: Guardrail and Curbs



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4-17

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### Guardrail and Curbs – Historical



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THE GREAT STATE

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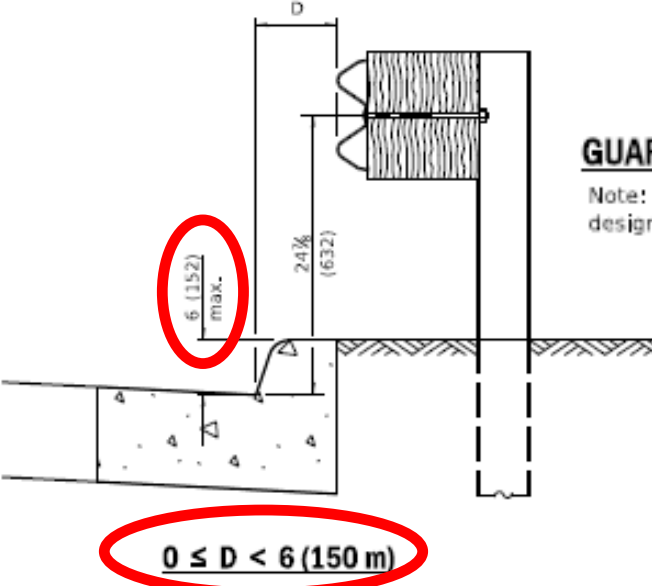
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## Guardrail and Curbs - IDOT



**GUARDRAIL PLACED BEHIND CURB**

Note: 'D' shall not exceed 6 (152) for design speeds greater than 45 mph.

**STEEL PLATE BEAM  
GUARDRAIL**  
(Sheet 4 of 4)  
STANDARD 630001-12

Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail


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# Terminals and Curbs



**CURRENTLY UNDER STUDY –  
DO NOT BURY BEARING PLATE**

**2” maximum height recommended**

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## MASH TL-2: 31” Guardrail 6 ft. behind curb



Video Clip

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**Federal Highway Administration**

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# Guardrail and Curbs - IDOT

$4'-0'' (1.2 \text{ m}) \leq D \leq 12'-0'' (3.7 \text{ m})$

**GUARDRAIL PLACED BEHIND CURB**  
Note: 'D' shall not exceed 6 (152) for design speeds greater than 45 mph.

<b>STEEL PLATE BEAM GUARDRAIL</b> <small>(Sheet 4 of 4)</small>
<b>STANDARD 630001-12</b>

Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail

Session 44-22

## Principle 4: Soil Backing For Fill Locations

Session 44-23

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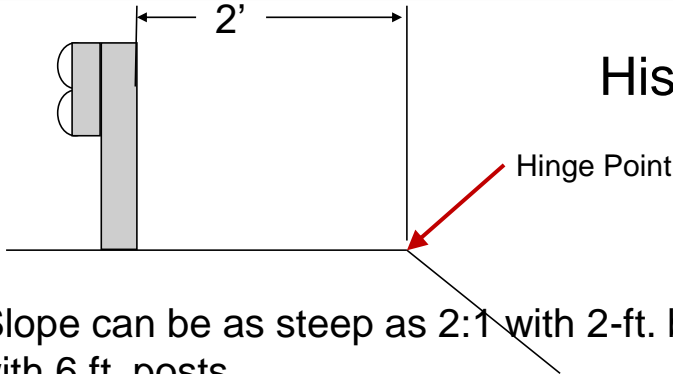
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# Soil Backing Recommendation



Historical Guidance

1. Slope can be as steep as 2:1 with 2-ft. backing in strong soil with 6 ft. posts.
2. Backing can be less than 2 ft. with 2:1 slope in strong soil with 7 ft. posts. NCHRP 350 requires half post spacing – **ONLY applied to 27" system**

Ref: AASHTO Roadside Design Guide, 4<sup>th</sup> Edition – Figure 5.33, Pg. 5-41

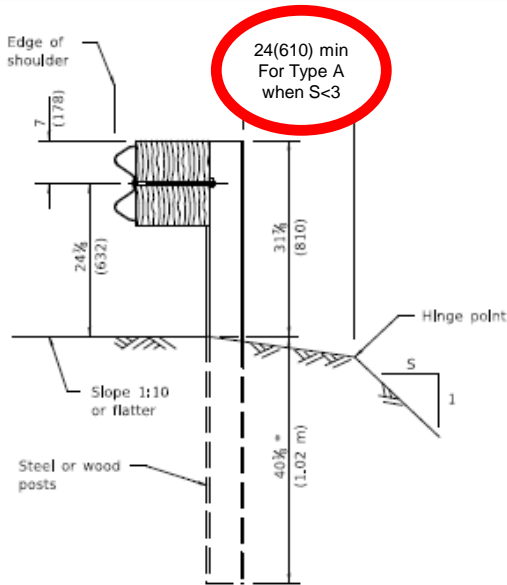
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# Soil Backing



\* When "S" is less than 3 and the distance from the back of post is less than 24 (610), the post shall be steel and the embedment shall be 76 1/8 (1.93 m) and the minimum top of rail height shall be 31 (787) (9' Post).

**NOTE: Long posts are NOT to be used within TBT Type 1 systems**

STEEL PLATE BEAM  
GUARDRAIL  
(Sheet 1 of 4)  
STANDARD 630001-12

Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail



Session 4

4-25

# Non-Blocked Steel Plate Beam Guardrail

**ELEVATION**

Steel plate beam guardrail with bolt slots at 37½ (953) centers

Back-up plate at steel post

Rail element splice

65'-0" (19,805 m)

65'-0" (19,805 m)

37½ (953)

37½ (953)

Ⓞ When connecting to bridge guardrail over culvert, the next post may be the ring (farthest from culvert) CRT wood post. (See Standard 630100).

**SECTION A-A**

Edge of shoulder

7 (178)

24 (610) min when S=3

24 (610)

31½ (800)

40½ (1,028)

Hinge point

Slope 1:10 or flatter

Steel post

When "S" is less than 3 and the distance from the back of post is less than 24 (610), the post embedment shall be 76½ (1,953) and the minimum top of rail height shall be 31 (787).

**BACK-UP PLATE**

6 (152)

12 (305)

12 (305)

¾ x 2½ (19 x 64) slotted hole

6 (152)

**DETAIL AT POST**

7 (178)

Back-up plate nested between guardrail and steel post.

24 (610)

W6x9 (W150x13,5) or W6x5 (W150x12,75) steel post.

**GENERAL NOTES**

All slope ratios are expressed as units of vertical displacement to units of horizontal displacement (V:H).

For details of guardrail elements not shown, see Standard 630001.

All dimensions are in inches (millimeters) unless otherwise shown.

DATE	REVISIONS
1-1-17	New standard.

**NON-BLOCKED STEEL PLATE BEAM GUARDRAIL**  
STANDARD 630006  
(Sheet 1 of 2)

Illinois Department of Transportation

U.S. Department of Transportation  
**Federal Highway Administration**

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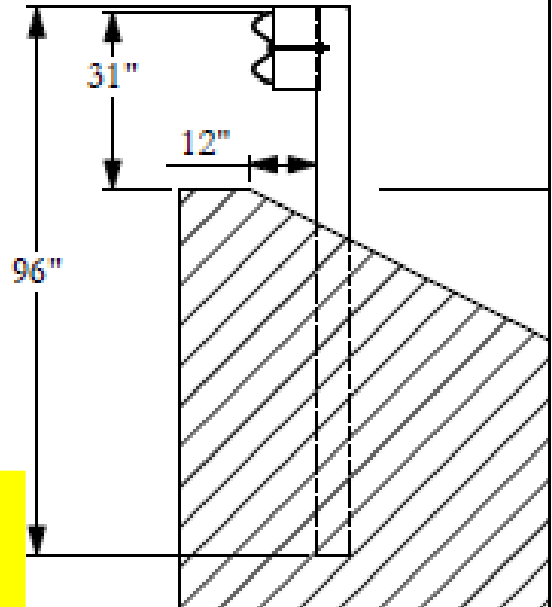
4-26



# 31" Guardrail ON 2:1 Slope

MASH– 1100C & 2270P  
MGS with face of rail at slope  
break point of 2:1 slope

- 8' long W6x9 posts
- 6'-3" spacing
- Tested with 8" block
- 12" block OK – max post offset still 12" from SBP



**Not a standard –  
Contact BSPE**



Session 4

4-27

## 31" Guardrail Adjacent to 2:1 Slope

MASH Testing of  
MGS adjacent to a  
2:1 slope  
8" breakout  
8' long posts at  
6'-3" spacing



Video Clip



Session 4

4-28

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# Flare Rate

Trade offs and restrictions of flared barriers:

- Flare increases the angle at which the barrier can be hit.
- Flare may increase the angle of redirection after an impact.
- **Flared barriers can only be placed on 10:1 or flatter slopes.**
- **Maximum flare rate varies with design speed.**



## Tangent Terminal on Flared Standard Run Schematic

**Standard Run Flare of 25:1 or flatter**

**Standard Run Flare is sharper than 25:1**

2. Type 1, Special (Tangent). This terminal section is for use with steel plate beam guardrail. Each device has a maximum flare rate measured versus normal traffic flow. Note that this flare rate can potentially be flatter than a flare rate proposed for a guardrail run.

**38-6.06(a) Guardrail End Terminals**

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## Length of Need (LON) Definition

### AASHTO

The length of effective barrier needed IN ADVANCE OF the hazard to intercept and redirect an encroaching vehicle.

Only L<sub>1</sub> for IDOT

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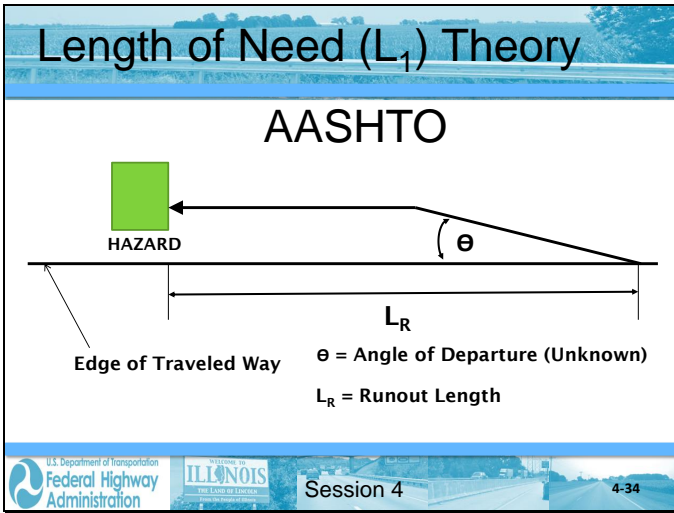
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## Runout Lengths – IDOT

Design Speed		Traffic Volume (ADT)*							
		Over 10,000		5000-10,000		1000-4999		Under 1000	
mph	(km/h)	Runout Length		Runout Length		Runout Length		Runout Length	
		$L_R$		$L_R$		$L_R$		$L_R$	
		ft	(m)	ft	(m)	ft	(m)	ft	(m)
75	(130)	415	(127)	380	(116)	335	(102)	290	(86)
70	(110)	360	(110)	330	(101)	290	(88)	250	(76)
60	(100)	300	(91)	250	(76)	210	(64)	200	(61)
55	(90)	265	(81)	220	(67)	185	(57)	175	(54)
50	(80)	230	(70)	190	(58)	160	(49)	150	(46)
45	(70)	195	(60)	160	(49)	135	(42)	125	(38)
40	(60)	160	(49)	130	(40)	110	(34)	100	(30)
30	(50)	110	(34)	90	(27)	80	(24)	70	(21)

*\*Based on a 10 year projection from the anticipated date of construction.*

**RUNOUT LENGTHS ( $L_R$ ) FOR BARRIER DESIGN**

**Figure 38-6.E**

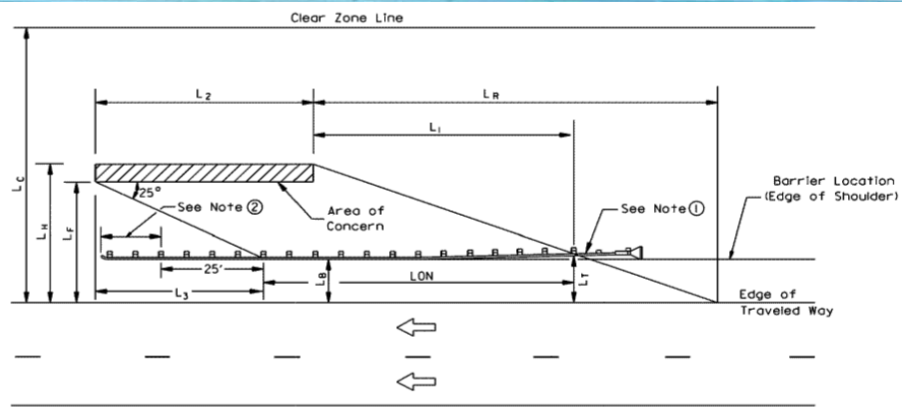
Ref: BDE Manual, Ch. 38-6 Roadside Barrier Layout. Figure 38-6.E

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Session 4 4-35

# LON – L<sub>1</sub> Procedure - IDOT



$$LON = L_1 + L_2 - L_3$$

**Notes:**

- ① Use appropriate crashworthy terminal. See Section 38-6.06.
- ② Use a Type 2 terminal for one-way traffic. For two way traffic where  $L_c$  for opposing traffic  $> (L_r + 12)$ , use an appropriate crashworthy terminal, with LON point passing through the third post of the crashworthy terminal.


- L<sub>1</sub> = Distance to the barrier at the third post of the terminal
- L<sub>2</sub> = Distance to the barrier
- L<sub>3</sub> = Distance to the clear zone
- L<sub>4</sub> = Distance to the back of the hazard
- L<sub>5</sub> = Distance to the front of the hazard
- L<sub>6</sub> = Runout length (see Figure 38-6.E)
- L<sub>7</sub> = Length of need for the approach end
- L<sub>8</sub> = Length of the hazard
- L<sub>9</sub> = Distance from the downstream end of the hazard
- LON = Length of Need

**BARRIER LENGTH OF NEED LAYOUT**  
 (One-Way Roadways or Two-Way Roadways Where the Hazard and Guardrail are Beyond the Clear Zone of Opposing Traffic)

Figure 38-6.A

Ref: BDE Manual, Ch. 38-6 Roadside Barrier Layout.





# Determining $L_1$

- Calculating the length of need (X) for straight or nearly straight sections of roadway:

$$X = \frac{L_A + \left(\frac{b}{a}\right)(L_1) - L_2}{\left(\frac{b}{a}\right) + \left(\frac{L_A}{L_R}\right)}$$

Flared Installation

$$X = \frac{L_A - L_2}{\left(\frac{L_A}{L_R}\right)}$$



Parallel Installation

IDOT also has a Nomograph procedure


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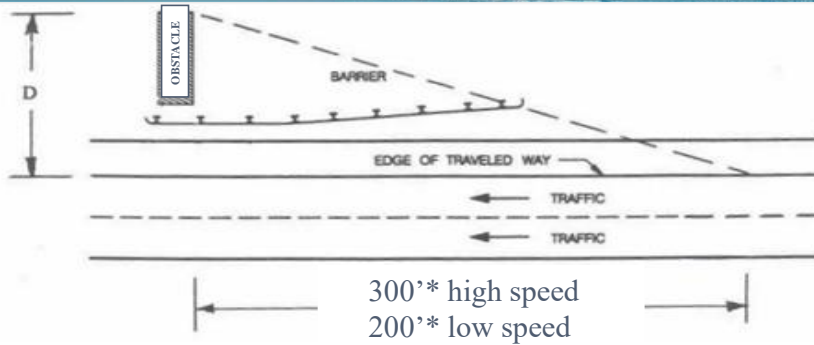



Session 4



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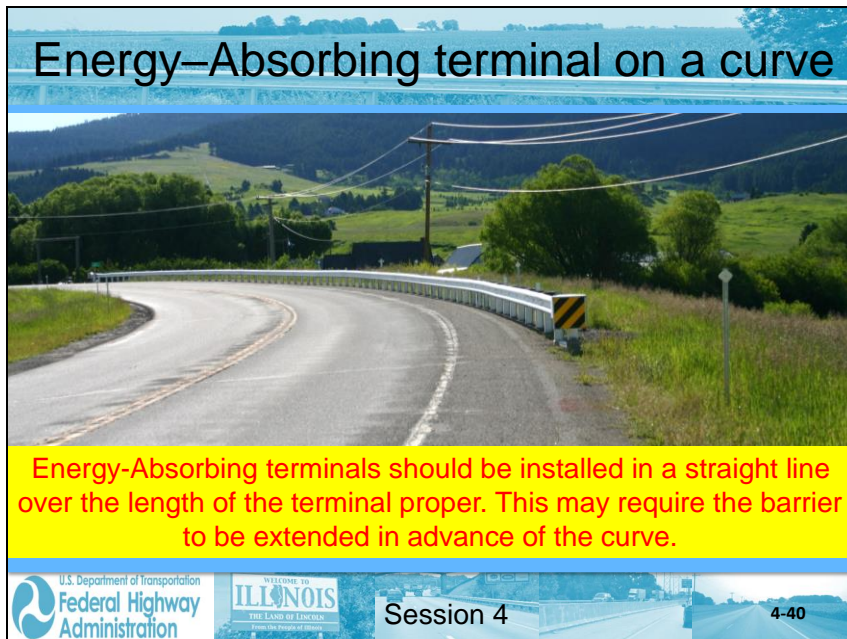
# Length of Need Field Check



## Procedure

- Identify upstream face of hazard
- Identify back of hazard D – limit to 30'
- Walk upstream along the white edge line, beginning at the upstream side of the hazard, 300'\* for high speed, or 200'\* for low speed (45 mph or less)
- Sight from this position to the upstream face, back edge of hazard (limited to 30')
- End of terminal should intercept line of sight ( $\pm \approx 30'$ )





**Guardrail Placement in Special Situations**

- Turnout Conflict (Intersecting Roadway)
- Long Span (Omitted Post{s})
- Gaps between runs of barrier
- Extra Blocks
- Leaveouts (Blockouts) for Posts in Structural Pavement
- Guardrail Post in Rock

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# Intersecting Roadway Terminal

**Weak Post Radius  
No longer Acceptable by IDOT**



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# Intersecting Roadway - RDG

The diagram shows a plan view of a roadway with a bridge structure on the left. An intersecting roadway crosses the main roadway from the top. A 'Curved Roadside Barrier (or Impact Attenuator)' is shown curving around the intersection point. A 'Standard Roadside Barrier' is shown extending straight along the main roadway, starting upstream from the intersection. A note explains that the standard barrier should be placed as if the intersection were not there to narrow the angle of impact.

Curved Roadside Barrier (or Impact Attenuator)

Standard Roadside Barrier

Note: The standard barrier installation should be introduced as far from the structure as it would be if the intersection roadway were not present. The section of barrier upstream from the intersection roadway significantly reduces the risk to a motorist by narrowing the angle at which the curved barrier or crash cushion can be hit.

**Figure 5-50. Possible Solution to Intersection Side Road Near Bridge**

5-60 *Roadside Design Guide*

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# Long Span – 31” Guardrail



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# Long Span – 31” Guardrail



Video Clip

Working Width – 94”  
Eligibility Letter B-189

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# Long Span – 31" Guardrail

**PLAN**

**ELEVATION**

**FRONT**      **SIDE**

**CRT WOOD POST**

**SECTION A-A**

May be used with  
Wood Posts

**GENERAL NOTES**  
 See Standard 630003 for details of guardrail not shown.  
 Backcuts shown at steel posts shall be omitted when NON-BLOCKED STEEL PLATE BEAM GUARDRAIL is specified. See Standard 630006 for details not shown.  
 All dimensions are in Inches (millimeters) unless otherwise shown.

DATE	REVISIONS
1-10-17	Revised general notes for non-blocked guardrail options.
	Revised pay limits.
1-12-13	Added min. dim. from guardrail to heaviest. Added dim. from A-A.

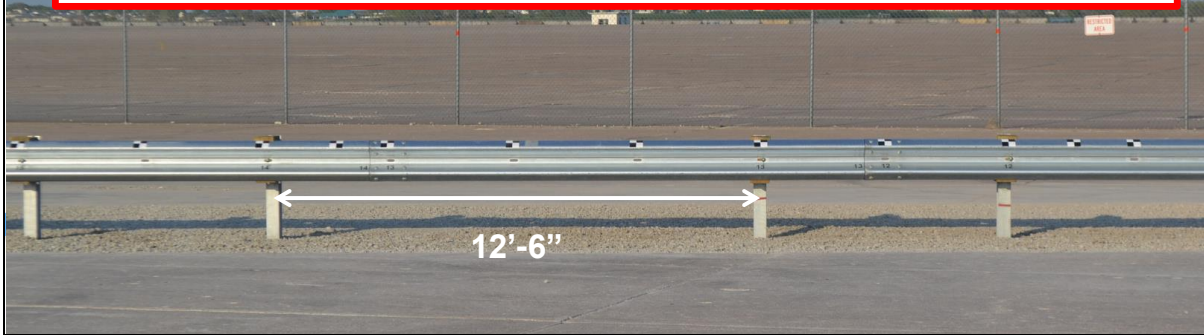
Illinois Department of Transportation ROADWAY DESIGN DIVISION PROJECT NO. 10000000000000000000 APPROVED BY: [Signature] DATE: 10/11/17	<b>LONG-SPAN GUARDRAIL OVER CULVERT</b>  <b>STANDARD 630106-02</b>
--	--

Ref: IDOT Standard 630106-02. Long-span Guardrail over Culvert

## 31" Guardrail - Omitting 1 post

- No post modifications
- Can be used with wood or steel posts
- Can be used with 12" blockouts but not with the non-blocked system

Contact BSPE for use; 50' minimum of standard barrier on either side



31" Guardrail TL-3 Videos  
Omitting 1 post

Video Clip

Working Width 50.1"  
Limit 1 per 50'

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Federal Highway Administration

ILLINOIS  
THE GREAT STATE

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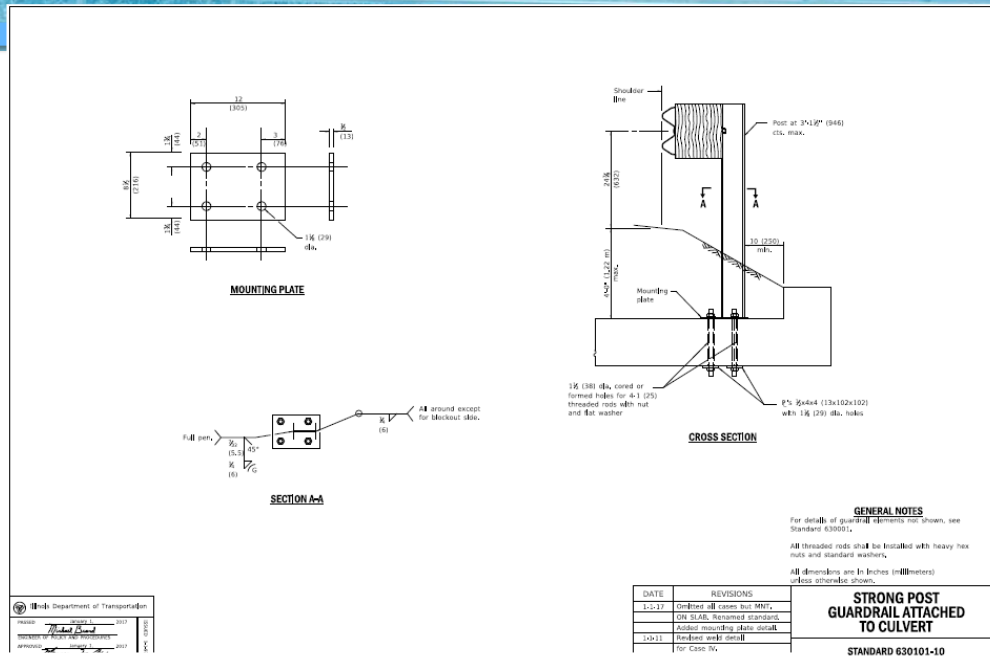
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# Structure Mounted Guardrail



Ref: IDOT Standard 630101-10. Strong Post Guardrail attached to Culvert



Session 4

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# 31" with Headwall-Mounted Posts

**PLAN**

**SECTION A-A**

**GENERAL NOTES**

See Standard 630001 for details of guardrail not shown.

See Standard 630006 for details of non-blocked guardrail not shown.

All threaded rods and bolts shall be installed with heavy hex nuts and standard washers unless noted otherwise.

All dimensions are in inches (millimeters) unless otherwise shown.

DATE	REVISIONS
1-15-20	Revised into 10-1003 by Top View on sheets 2-5.
1-15-17	New Standard.

**WEAK POST GUARDRAIL ATTACHED TO CULVERT**  
(Sheet 1 of 6)  
STANDARD 630111-01

Ref: IDOT Standard 630111-01. Weak Post Guardrail attached to Culvert

## Session 4

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## 31" with Headwall-Mounted Posts Video

Video Clip

Session 4

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# Openings in Barriers

## **38-6.07 Minimum Length/Gaps**

Where gaps exist in the need for a roadside barrier, it is typically economically justified to provide continuous runs of guardrail, rather than to leave gaps of 200 ft (60 m) or less.



Ref: BDE Manual, Ch. 38-6.07 Minimum Length/Gaps



Session 4

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## Extra Blockouts – National Guidance

- Two blockouts (up to 16” deep) may be used at any time, for any number of posts.
- Two/three blockouts (24” max) may be used at one or two posts in a section of guardrail.

Ref: AASHTO Roadside Design Guide – 3<sup>rd</sup> Edition, Section 5.4.1.6



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# Leaveouts in Structural Pavement

**PLAN**

**ELEVATION**

**LEAVE-OUT FOR POST WHEN PAVED MATERIAL IS ENCOUNTERED**

**STEEL PLATE BEAM GUARDRAIL**

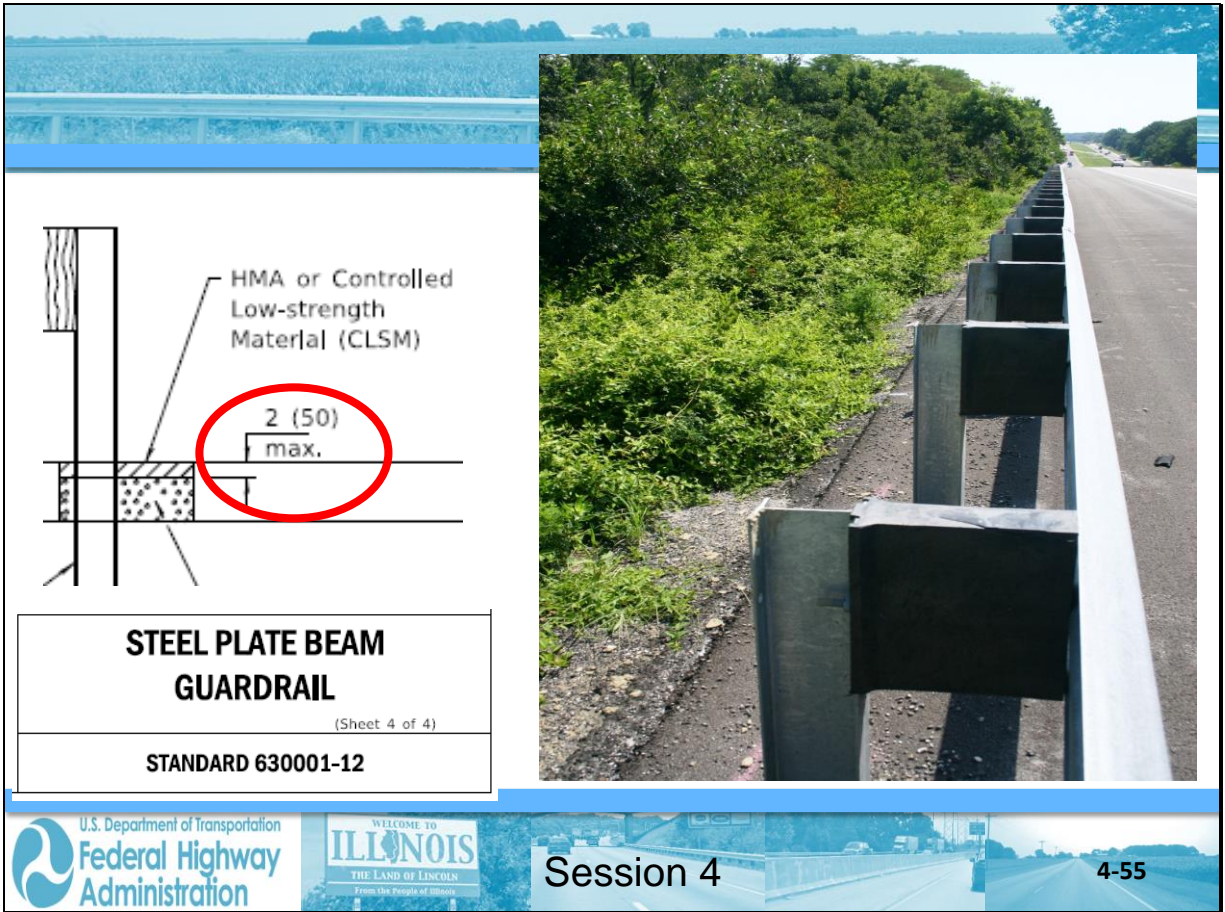
(Sheet 4 of 4)

**STANDARD 630001-12**

Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail

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The image contains a technical drawing on the left and a photograph on the right. The technical drawing shows a cross-section of a guardrail post and its connection to a steel plate beam. A red circle highlights a dimension of 2 (50) max. The drawing is labeled 'HMA or Controlled Low-strength Material (CLSM)' and 'STEEL PLATE BEAM GUARDRAIL'. Below the drawing, it says '(Sheet 4 of 4)' and 'STANDARD 630001-12'. The photograph shows a long stretch of a steel plate beam guardrail installed along a highway, with green vegetation on the left side.

HMA or Controlled Low-strength Material (CLSM)

2 (50) max.

**STEEL PLATE BEAM GUARDRAIL**

(Sheet 4 of 4)

**STANDARD 630001-12**

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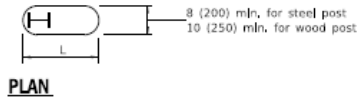
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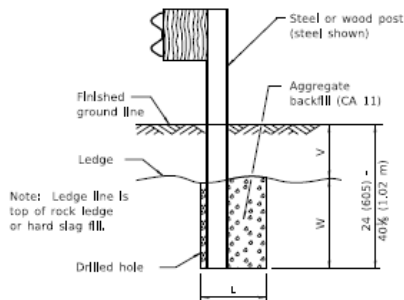
4-55



# Guardrail Posts in Rock (Impervious Material)



V	W	L	
		Steel Post	Wood Post
0 - 6 (0 • 152)	24 (610)	21 (530)	23 (580)
> 6 - 18 (> 152 • 458)	18 (458)	14½ (368)	16½ (419)
> 18 - 31 (> 458 • 787)	12 (305)	8 (203)	10 (250)
> 31 - 40½ (> 787 • 1,02 m)	12 - 0 (305 • 0)	8 (203)	10 (250)



**FOOTING FOR POST WHEN IMPERVIOUS MATERIAL IS ENCOUNTERED**

**STEEL PLATE BEAM GUARDRAIL**  
(Sheet 4 of 4)  
**STANDARD 630001-12**

Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail



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4-56



# Height Transition – 27” to 31”

## An Example from one state

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### Review Learning Outcomes

- Understand the design principles affecting an optimal barrier installation
- Apply a field procedure to check Length of Need
- Be familiar with special designs to address site-specific installation considerations

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# Session 5: Installation/Common Errors of Systems

FAST Act Guardrail Training  
Highway Barrier Installer, Inspector and  
Maintenance Training

**Session 5:  
Installation/Common  
Errors of System**

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**Session 5 Learning Outcomes**

At the end of this session, you will be able to:

- Describe key components of barrier systems
- Identify common installation errors

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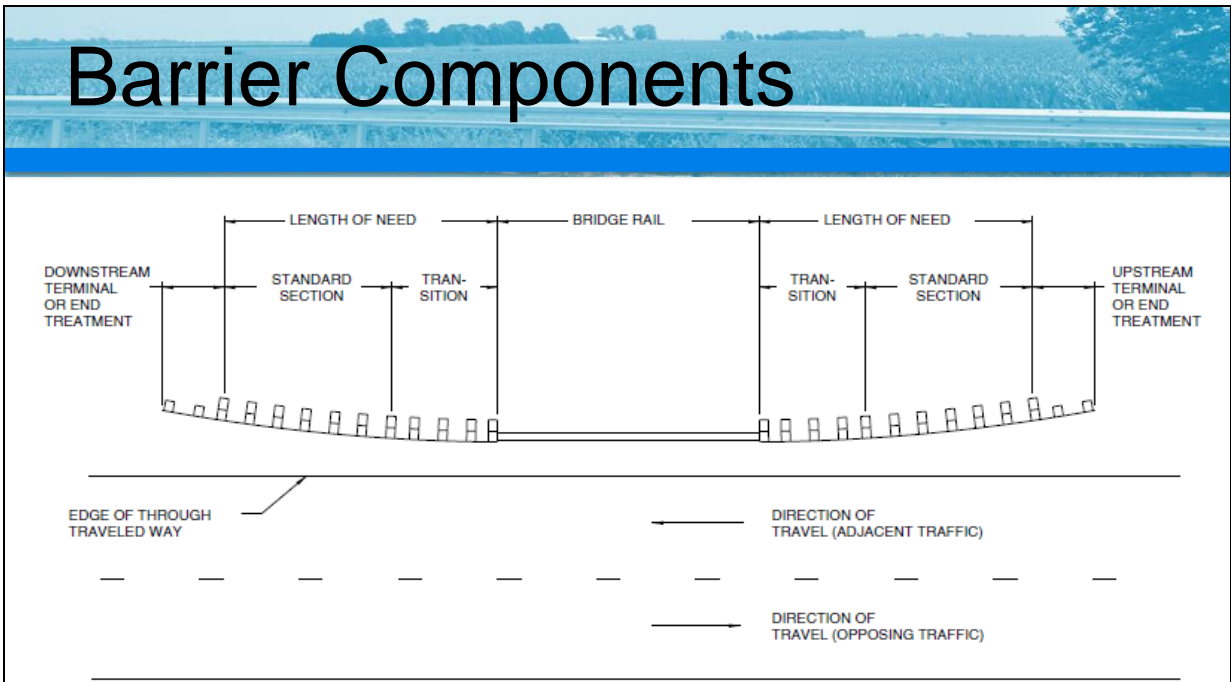


Figure 5-4. Definition of Roadside Barriers

REF: AASHTO Roadside Design Guide, 4<sup>th</sup> Edition, Figure 5-4



### Key Components of Barrier Systems

1. Standard Run of Barrier
2. Transition to a Stiffer System
3. Terminal
4. Impact Attenuator

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### 1. Standard Run of Barrier

- a. Barrier Design Principles
- b. Height Measurement
- c. Tension Continuity
- d. Other Considerations
- e. Barriers in Work Zones



Session 5

5-5

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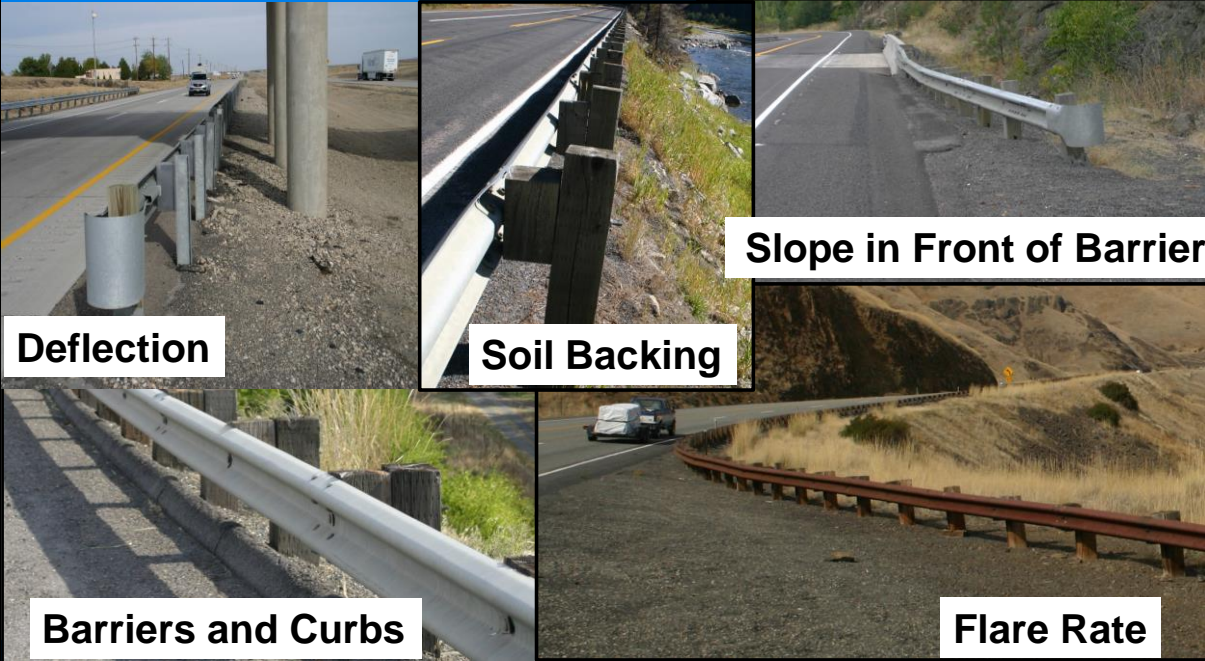
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## a. Barrier Design Principles





**Deflection**

**Soil Backing**

**Slope in Front of Barrier**

**Barriers and Curbs**

**Flare Rate**



Session 5

5-6

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## b. Height Measurement

### ➤ Concrete Median Barrier Standard

- 44" Single Slope



## b. Height Measurement

### ➤ High Tension Cable (HTC) Barrier

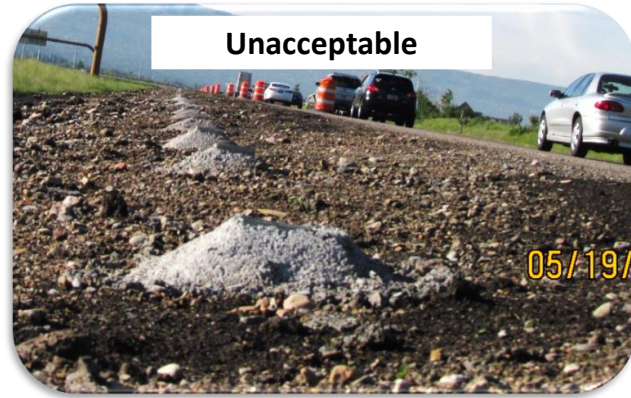
- Dependent on Manufactured System



## b. Height Measurement

### ➤ High Tension Cable (HTC) Barrier

- If the contractor uses foundations, ensure top is at proper height. This will effect the height of the cable.





## High Tension Cable (HTC) Systems

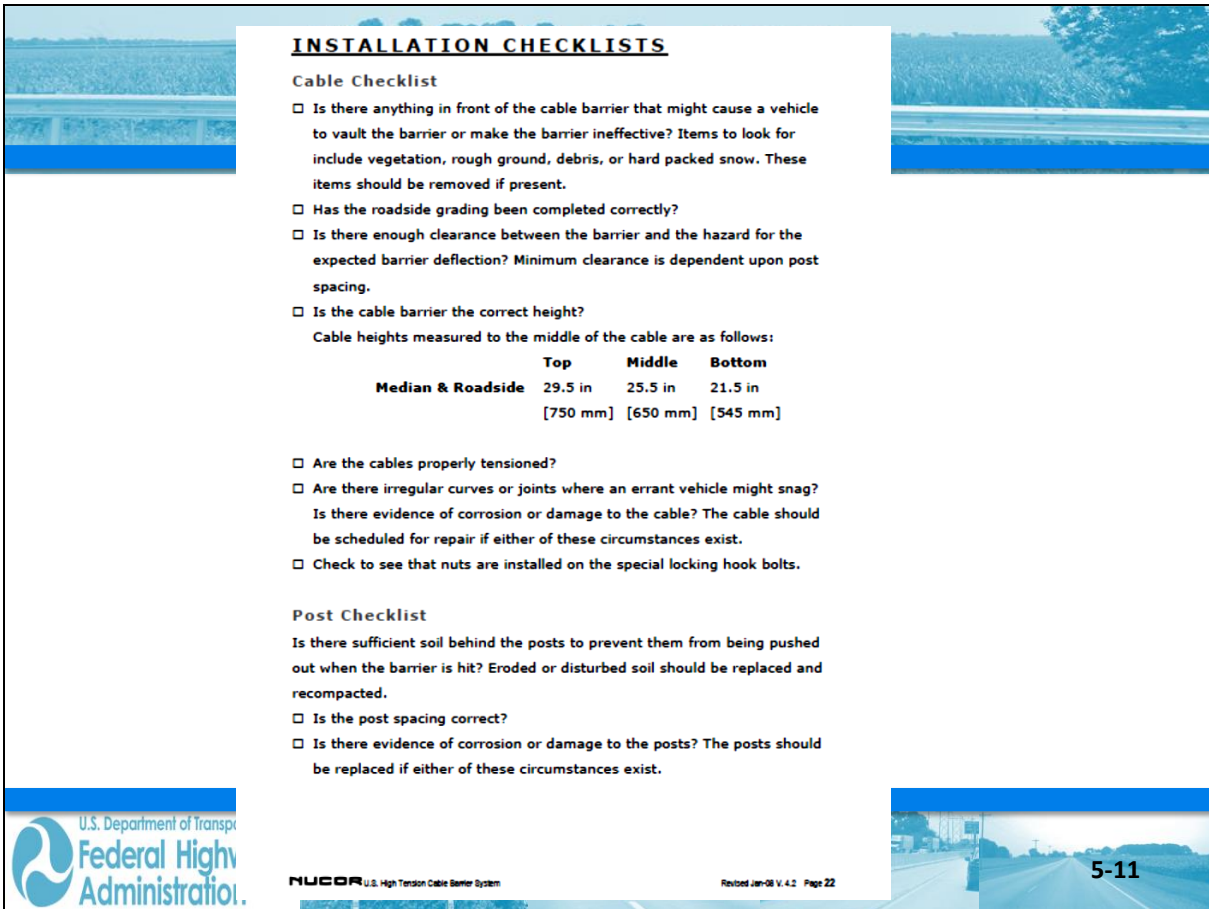
- The installation requirements are specific to the manufacturer. Referral to the manufacturer's installation manual is essential.
- The next slide shows an example of a installation checklist from a manufacturer's manual.



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### INSTALLATION CHECKLISTS

#### Cable Checklist


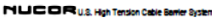
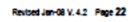

- Is there anything in front of the cable barrier that might cause a vehicle to vault the barrier or make the barrier ineffective? Items to look for include vegetation, rough ground, debris, or hard packed snow. These items should be removed if present.
- Has the roadside grading been completed correctly?
- Is there enough clearance between the barrier and the hazard for the expected barrier deflection? Minimum clearance is dependent upon post spacing.
- Is the cable barrier the correct height?  
Cable heights measured to the middle of the cable are as follows:

	Top	Middle	Bottom
Median & Roadside	29.5 in [750 mm]	25.5 in [650 mm]	21.5 in [545 mm]
- Are the cables properly tensioned?
- Are there irregular curves or joints where an errant vehicle might snag?  
Is there evidence of corrosion or damage to the cable? The cable should be scheduled for repair if either of these circumstances exist.
- Check to see that nuts are installed on the special locking hook bolts.

#### Post Checklist

Is there sufficient soil behind the posts to prevent them from being pushed out when the barrier is hit? Eroded or disturbed soil should be replaced and recompact.

- Is the post spacing correct?
- Is there evidence of corrosion or damage to the posts? The posts should be replaced if either of these circumstances exist.

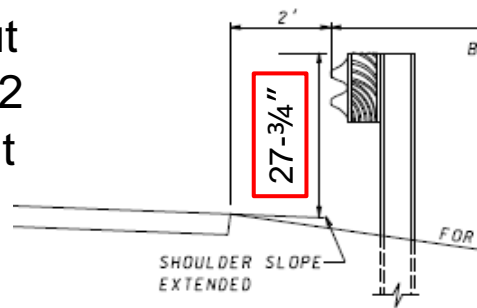
   

## 27" Guardrail - Height Measurement

For slopes 10:1 or flatter, the height is measured from the ground directly beneath the rail

For slopes steeper than 10:1 but no steeper than 6:1, and within 2 feet of the breakpoint, the height is measured from the shoulder slope extended as shown

**Only for the 27" Guardrail**



**PLACEMENT ON SLOPE**



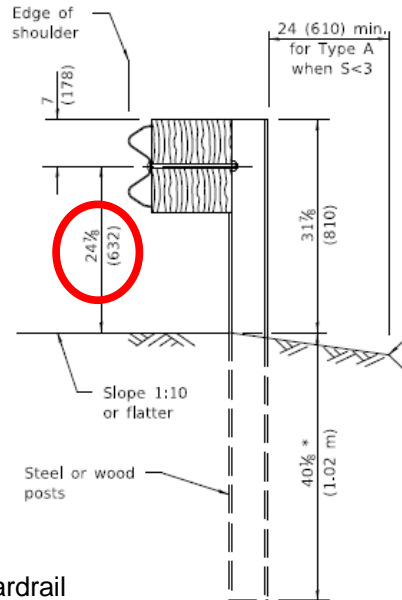
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# 31" Guardrail - Height Measurement

**Tolerance =  $\pm 1"$**

**STEEL PLATE BEAM  
GUARDRAIL**  
(Sheet 1 of 4)  
**STANDARD 630001-12**



Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail



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## b. Height Measurement



**Rail too high**



**Rail too low**



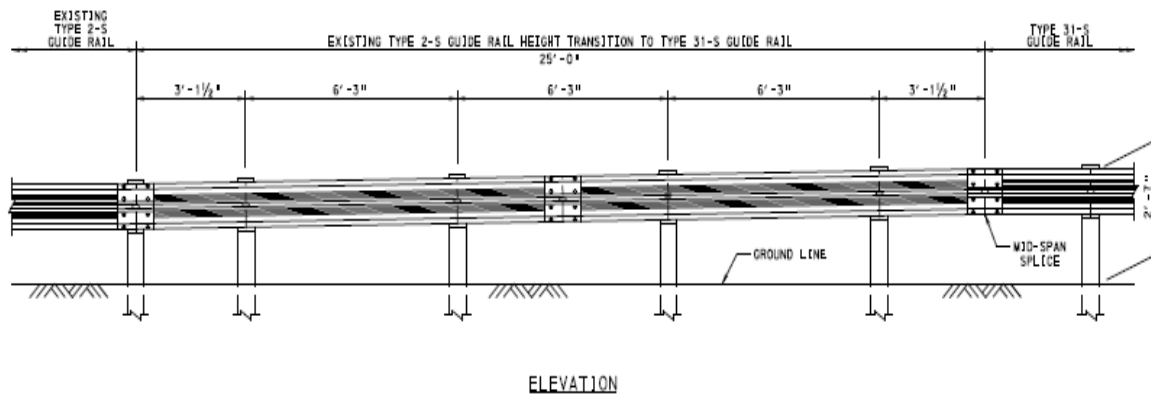
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## b. Height Transition Measurement

An Example from one state



Session 5

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## c. Tension Continuity

- Concrete Barrier
  - The mass of the large concrete barrier (19” top width) allows for the use of non-reinforced barrier
- W-Beam
  - Splices with 8 bolts tying panels together, and some type of end anchor or structural tie to a rigid object/bridge rail (transition)
- High Tension Cable
  - Proprietary systems typically use a type of turn buckle between successive cables and terminal anchors.

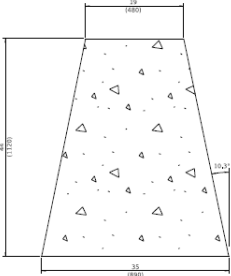


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## c. Tension Continuity

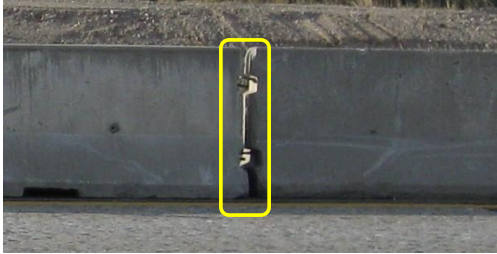
Cast In Place Concrete Barrier



TYPICAL CROSS-SECTION

No reinforcement called for

Precast Concrete Barrier



Missing connection pin  
NO TENSION

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## c. Tension Continuity

➤ W-Beam Guardrail

- 8 bolts tying panels together
- structural connection to a rigid barrier with 5 thru bolts (thrie)



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### c. Tension Continuity

Missing bolts

No Structural connection

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### d. Other Considerations

➤ Lapping

**630.03 General.** Steel plate beam guardrail and posts shall be furnished and erected as shown on the plans and as specified herein. All holes in posts and blockouts shall be  $\frac{3}{4}$  in. (19 mm). All rail elements shall be lapped in the direction of traffic in the adjacent lane.

Ref: IDOT Standard Specifications 630.03

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### d. Other Considerations



Incorrectly Lapped

Correctly Lapped

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### Extra Blocks – National Guidance

- Two block-outs (up to 16” deep) may be used at any time, for any number of posts.
- Two full block-outs (24”) may be used at one or two posts in a section of guardrail.

Ref: AASHTO Roadside Design Guide – 3<sup>rd</sup> Edition, Section 5.4.1.6

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## d. Other Considerations

**Typically NO WASHERS  
Unless called for in the plans**



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## d. Other Considerations

### Delineators



**Placed on the RAIL  
bolt – NOT GOOD**



**Placed on the  
SPLICE bolt – GOOD**

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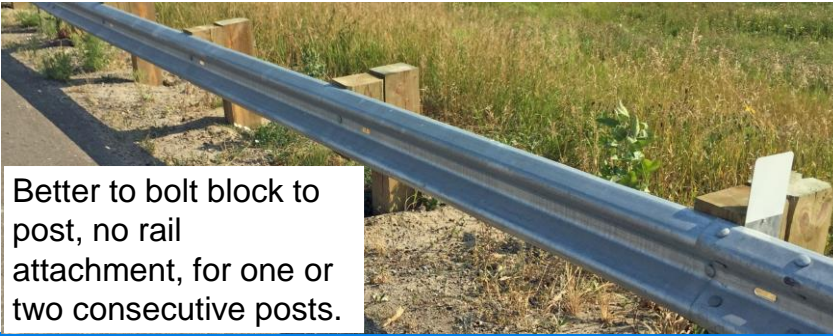
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### d. Other Considerations

Drilling of holes into the rail FOR THE RAIL TO POST CONNECTION is not allowed – IDOT spec.



Better to bolt block to post, no rail attachment, for one or two consecutive posts.

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### d. Other Considerations

**Cutting a slot, hole or a rail section with a torch is NOT PERMISSIBLE**



Using a torch on the rail element may compromise the strength of the rail.

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## e. Barriers in Work Zones

Barrier should be in GOOD condition



**This is not in good condition**

### 704.04 Installation.


Barriers or attachments damaged during transportation or handling, or by traffic during the life of the installation, shall be repaired or replaced. The Engineer will be the sole judge in determining which units or attachments require repair or replacement.





## e. Barriers in Work Zones

Flare rate appears to be too excessive here



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## e. Barriers in Work Zones

Work Zone Design Speed	Flare Rate
45 mph (70 km/h) and above	12:1
Less than 45 mph (70 km/h)	8:1

**TEMPORARY TRAFFIC BARRIER FLARE RATES**

Figure 55-4.A

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# 2. IDOT Transition – SHORT Curb

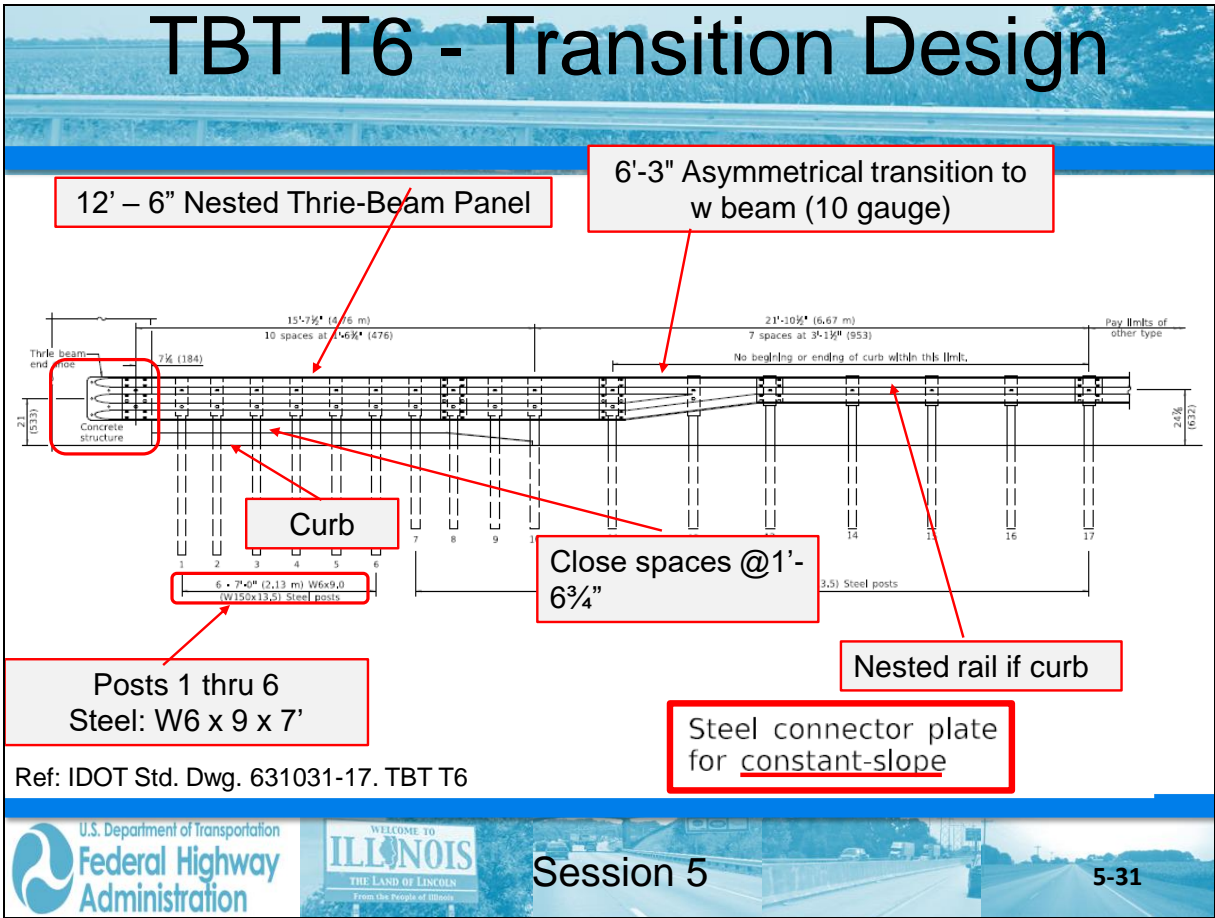


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# Legacy Problems



1. Inadequate stiffening
2. Transverse curb could vault vehicle

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## 3. Terminals

- a. Manufacturers Manuals
- b. Post types
- c. Panel requirements
- d. Grading
- e. Breakaway Cable **Anchorage**
- f. Other Common Errors
- g. Delineation

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### 3. Terminals – TBT Type 1B



Although the Buried-in-backslope (TBT T1B) is the preferred (and best) terminal, it can be constructed incorrectly

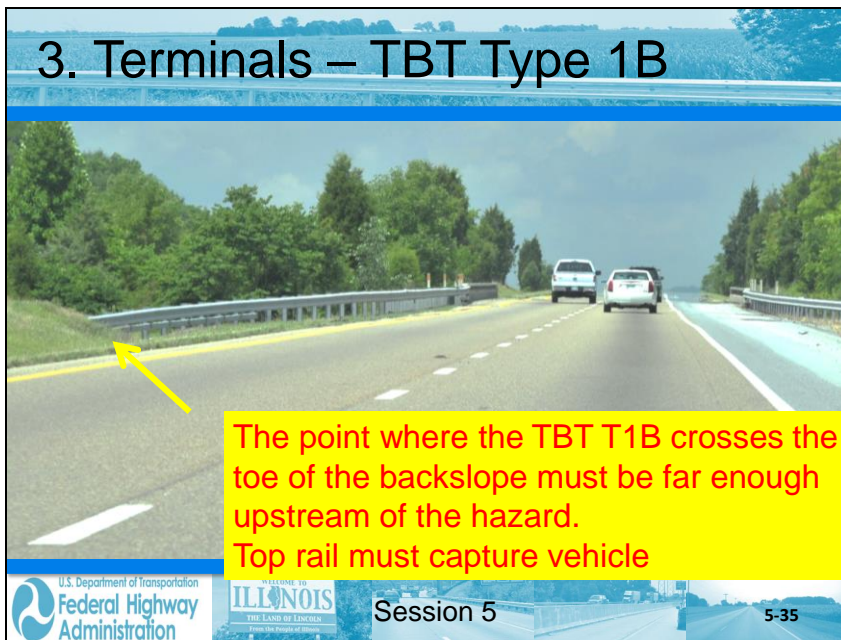
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### 3. Terminals – TBT Type 1B



The point where the TBT T1B crosses the toe of the backslope must be far enough upstream of the hazard.  
Top rail must capture vehicle

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# TBT Type 1B – Buried-in-Backslope

- Key design considerations:
  - For slopes steeper than 10:1, keep the height of the w-beam rail constant relative to the roadway grade until the barrier crosses the ditch flow line (but a max height of 47")
  - Use a flare rate, either 14:1 or appropriate for the design speed,
  - Add a w-beam rubrail when the distance between the bottom of the w-beam rail and the ground exceeds ~19" and increasing,
  - Use an anchor of steel posts capable of developing the full tensile strength of the w-beam rail and buried 1' below ground



### 3. Terminals – TBT T1

**RULE #1:  
Follow  
manufacturers  
instructions  
and standard  
plans.**



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### 3. Terminals

a. Manufacturers Manuals

**Must follow manufacturer's installation instructions and State standards.**



**These are all readily available online**

**Example of installation manuals**

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**TAKE ADVANTAGE OF  
MANUFACTURER TRAINING  
FOR DETAILED INSTRUCTION  
ON INSTALLING ANY OF THE  
PROPRIETARY TERMINALS**

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# Additional Resources

- Manufacturers website – online training, installation manuals, etc.
- Maine DOT’s Guardrail Inspection Series videos  
<http://www.dot.state.mn.us/design/roadsidesafety/links.html>

**GUARDRAIL INSPECTION SERIES**  
MaineDOT’s Guardrail Garden

**Manufacturer:** Trinity Highway Products, LLC  
**End Terminal:** SoftStop®

**GUARDRAIL INSPECTION SERIES**  
MaineDOT’s Guardrail Garden

**Manufacturer:** Road Systems, Inc  
**End Terminal:** SKT 350 & MSKT

Other videos are also available

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Session 5: Installation/Common Errors of Systems

**BEAT and BEAT-MT Installation Inspection Checklist**

State: \_\_\_\_\_ Date: \_\_\_\_\_  
 Project #: \_\_\_\_\_ Inspection performed by: \_\_\_\_\_  
 Location: \_\_\_\_\_

- The 6"x 6" end tube section is the special 1.8" thickness tube as supplied by the manufacturer with the corners cut at the approach and where the impact head is placed.
- Both the Roadside BEAT terminal and Median BEAT-MT terminal have at least one 18'-0" long 6"x 6" x 3/16" standard tube section joining with the special 12'-0" long end tube section.
- The end tube section is bolted to the standard tube section with the special rail tie splice.
- The height of the 6"x 6" box beam tubing is in accordance with the plans:  
 -Roadside BEAT rail height = 2'-4"  
 -Median BEAT-MT rail height = 2'-4"
- The 6"x 6" box beam tubing is attached to rail support brackets with proper hardware:  
 -Roadside BEAT post bolt = 5/16" x 7 1/2" hex bolt  
 -Median BEAT-MT post bolt = 5/16" x 7 1/2" hex bolt
- The rail support brackets are attached to posts with proper hardware:  
 -Roadside BEAT posts #1 & #2 support bracket bolts = 1/2" x 3" hex bolt  
 -Median BEAT-MT posts #2 through #5 support bracket bolts = 3/4" x 1 1/4" hex bolt  
 -Median BEAT-MT post #1 support bracket bolt = 1/2" x 2" hex bolt
- The upper and lower sections of post #1 are properly connected with a 5/8" x 8" hex bolt.
- The 3" weak posts have the soil plate positioned the same direction as the rail.  
 -Roadside BEAT has a 3" weak post at post location #2 plus at least three more 3" weak posts spaced at 6'-0" within the standard downstream 6"x 6" box beam barrier.  
 -Median BEAT-MT has a 3" weak post at post locations #2 through #5.
- The impact head is properly inserted into the end tube section with the large triangular gusset plates facing down. The bottom of the impact head is approx 12" above ground.
- The post breaker is installed on the proper side of post #1 and stabilized with two bolts.
- The 8" x 8" bearing plate at post 1 is correctly positioned with the 5" dimension up & the 3" dimension down. The anchor cable is taut and correctly installed.
- The Median BEAT-MT has a tether cable properly attached to restrain the impact head.
- If the posts were augered, be sure the backfill material around the posts is compacted.

Additional notes: \_\_\_\_\_

5-41

**INSTALLING THE RAIL PANEL TO THE POST WITHOUT OFFSET BLOCK AT POST 2**

Complete the following steps to attach the rail panel to the post without offset block at Post 2:

Step	Actions
1.	Select the Option A, Option B, or Option C to install the rail panel without offset block at Post 2:
Option A For Wood Post	1. Insert a 5/8" (16 mm) diameter x 10" (255 mm) HGR Post Bolt (PN-3500G) through the rail and the wood post at location 2. 2. Place a 5/8" (16 mm) Round Washer (PN-3300G) under a 5/8" (16 mm) HGR Nut (PN-3340G) on the inserted bolt. Tighten the bolts. (There is no torque requirement for these bolts.)
Option B For SYTP™	1. Insert a 7/8" (16 mm) diameter x 1 1/4" (31 mm) HGR Bolt (PN-3360G) through the rail panel and the hole in the SYTP™. Note: For SYTP stubs, use the hole in the SYTP™ that will place the rail at the correct height. (If there are two (2) sets of holes in the SYTP™ stub for attaching the rail.) 2. Place a 5/8" (16 mm) Round Washer (PN-3300G) under a 5/8" (16 mm) HGR Nut (PN-3340G) on the inserted bolt.
Option C For HBA™ Post	Do NOT bolt the rail panel to the HBA™ post at location 2.

**WARNING:** Do NOT bolt the rail to the HBA™ post at location 2. Failure to follow this warning could result in serious injury or death in the event of a collision.

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## 3. Terminals

### b. Post Types

Each manufacturer may have several different types of post, even for the same system - both currently approved and previously used.

Must consult with the installation manual of the specific model being worked with for proper post type.

Only one generic special post (used in some terminals and special designs) - the CRT post with large holes to weaken it.



**Controlled  
Release Terminal  
(CRT) Post**

### 3. Terminals

#### c. Panel Types

Each system may have one or more different rail panels.

Must consult with the installation manual of the specific system for proper panel type



Session 5

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### 3. Terminals

#### c. Panel Types

SKT rail 1 is different than an ET rail 1

**Ensure correct components are used**



Session 5

5-45

## 3. Terminals

### d. Grading

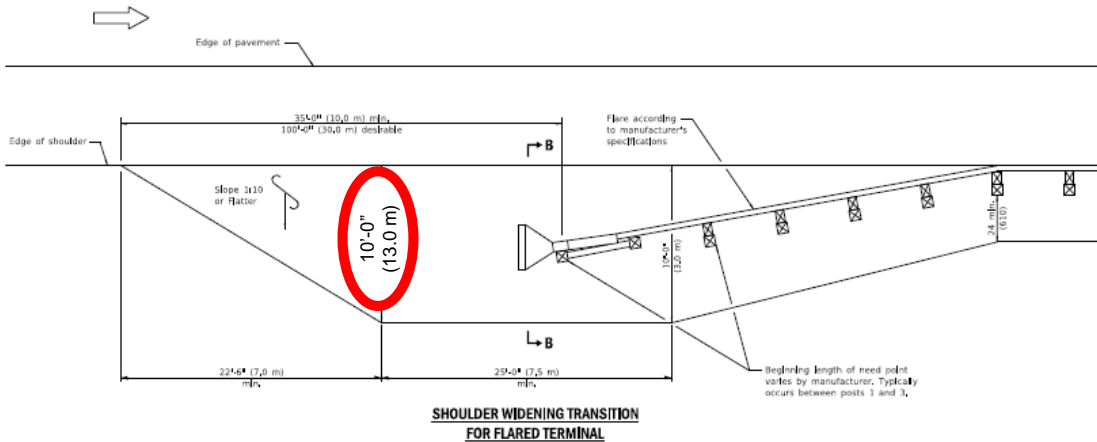
Check grading compliance with Standard Drawing (or plan details).

Check grading material for proper density. (Material must be compacted so it won't erode.)





# TBT Type 1 (Flared) Grading



Need special Borrow bid item for 3R projects and Density Spec

**SHOULDER WIDENING FOR TYPE 1 (SPECIAL) GUARDRAIL TERMINALS**  
(Sheet 1 of 2)  
STANDARD 630301-09

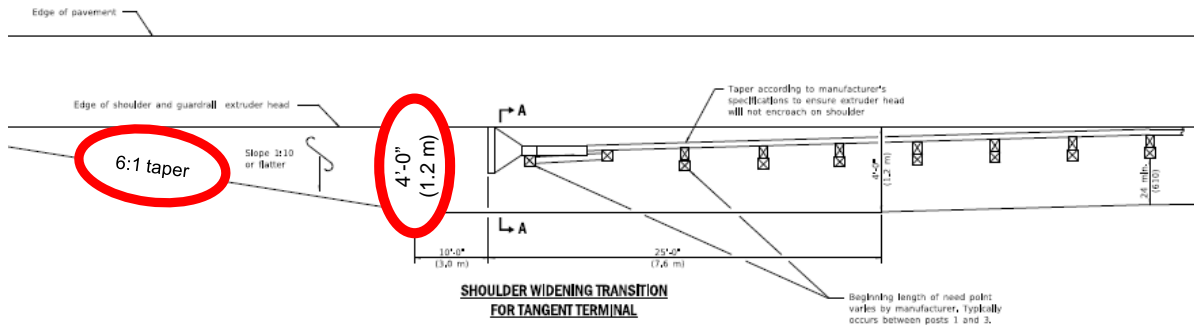
Ref: IDOT Standard 630301-09. Shoulder Widening for Type 1 (special)



Session 5

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# TBT Type 1 (Tangent) Grading



Need special Borrow bid item for 3R projects and Density Spec

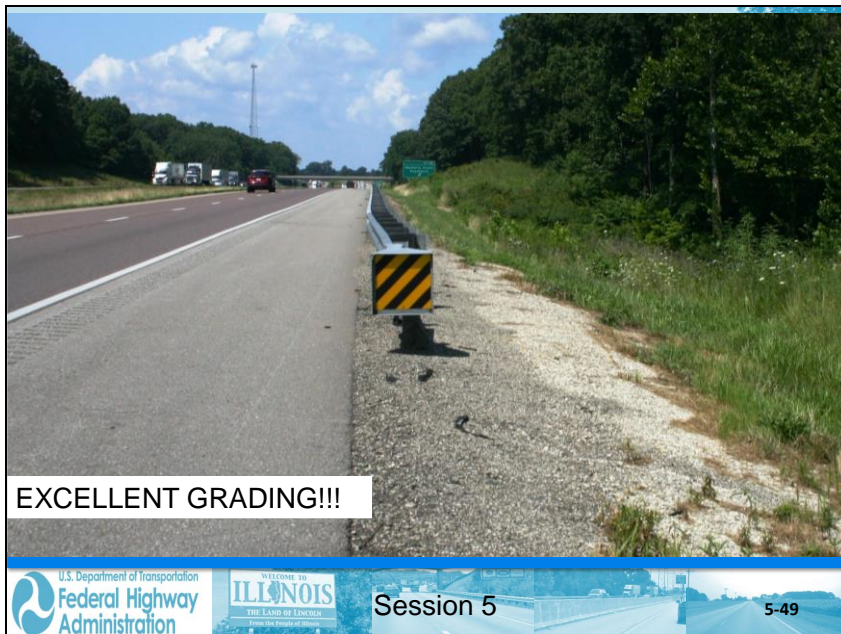
**SHOULDER WIDENING FOR TYPE 1 (SPECIAL) GUARDRAIL TERMINALS**  
STANDARD 630301-09  
(Sheet 1 of 2)

Ref: IDOT Standard 630301-09. Shoulder Widening for Type 1 (special)



Session 5

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# Stub Height Criteria - IDOT

Top of rail

31 (787)

Edge of paved shoulder

2 (50)

Top of tube

Ground line, slope 1:10 or flatter

**SHOULDER WIDENING FOR TYPE 1 (SPECIAL) GUARDRAIL TERMINALS**  
(Sheet 1 of 2)  
**STANDARD 630301-09**

Ref: IDOT Standard 630301-09. Shoulder Widening for Type 1 (special)

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### 3. Terminals

d. Grading

*Improper Grading*



A common error with all terminal types.

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### 3. Terminals

d. Grading

Telltails of poor grading



- Soil tubes/foundation posts installed too high
- Soil plate showing
- Strut too high

(Also bearing plate misaligned)

Common Error applies to both energy absorbing and non energy absorbing Terminals

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Federal Highway Administration

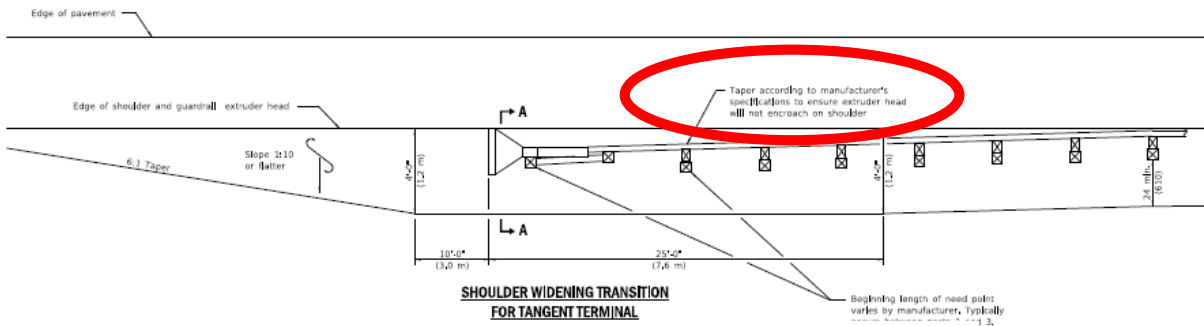
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# TBT Type 1 (Tangent) Special consideration



Taper according to manufacturer's specifications to ensure extruder head will not encroach on shoulder

**SHOULDER WIDENING FOR  
TYPE 1 (SPECIAL)  
GUARDRAIL TERMINALS**  
(Sheet 1 of 2)  
**STANDARD 630301-09**

Ref: IDOT Standard 630301-09. Shoulder Widening for Type 1 (special)



Session 5

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## 3. Terminals

### e. Breakaway Cable Anchorage Assembly

For the current MASH approved **TANGENT** terminals, the MSKT and the SGET utilize the Breakaway Cable Anchorage Assembly. But most of the legacy terminals have also used this design approach, so it will be covered in the following slides



Session 5

5-56



### 3. Terminals

#### e. Breakaway Cable Anchorage Assembly

Bearing Plate & Strut

- Should be in up position and secured to post.
- Strut secured at posts required locations.



Strut secured at breakaway posts 1 & 2



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### 3. Terminals

#### e. Breakaway Cable Anchorage Assembly

Upside down bearing plate – may not release




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### 3. Terminals

#### e. Breakaway Cable Anchorage Assembly

Buried and upside down bearing plate – won't release



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### 3. Terminals


#### e. Breakaway Cable Anchorage Assembly

Most systems require an anchor bracket and anchor cable.

- Anchor block must release from rail if system has impact head
- Non-energy absorbing system does not have to release from rail.



Energy absorbing



Non-energy absorbing

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### 3. Terminals

#### e. Breakaway Cable Anchorage Assembly

- Check the type and combination of breakaway posts against the State standards and the manufacturer's instructions.
- Not all posts in all terminals use a block-out.
- Check to see that the correct cable anchor bracket is used and it is properly attached to the rail.



### 3. Terminals

#### e. Breakaway Cable Anchorage Assembly

##### Anchor Cable

- Should be taut, lift up 1" or less
- Tightened by holding cable at bottom, not allowing cable twist.





### 3. Terminals

#### f. Other Common Errors

Terminals with an impact head: the end of the first W-beam rail section should be pushed against the throat area of the impact head so the end of the rail cannot be seen.



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### 3. Terminals

#### f. Other Common Errors

#### Post Installed Backwards



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### 3. Terminals

#### f. Other Common Errors

Terminals with an impact head should be parallel\* with the top of the rail.



\* For Softstop see manufacturers manual

### 3. Terminals

#### f. Other Common Errors

~~ALL Energy Absorbing~~  
Terminals MUST be  
installed on a **straight**  
line



# 3. Terminals

## f. Other Common Errors

The photograph shows a close-up of a guardrail terminal assembly. Three labels with arrows point to specific components: 'SKT Impact Head' points to the end of the rail, 'ET Plus Rail & Anchor Bracket' points to a bracket on the rail, and 'Post Installed Backwards' points to a post on the right side of the terminal. The background shows a road and trees.

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# 3. Terminals

## f. Other Common Errors (video)

A video player interface is shown, featuring a large play button in the center and the text 'Video Clip' below it. The background of the video player shows a guardrail terminal.

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### 3. Terminals

#### f. Other Common Errors



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### 3. Terminals

#### f. Other Common Errors

Bolt only impact head to post #1, NOT rail panel.

- Wood Post – Lag Screws (screwed in only)
- Steel Post – Hex Bolts



Refer to manufacturer's installation instructions.

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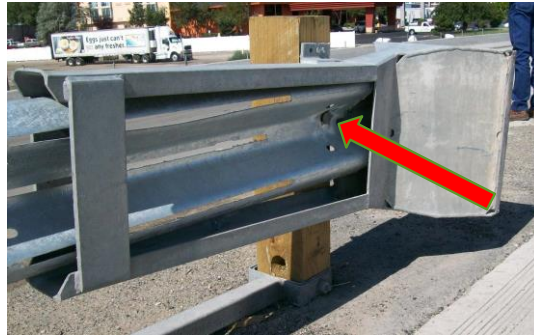


### 3. Terminals

#### f. Other Common Errors

**NO** rail to post connection at post 1 of systems with impact heads.

Note the **WRONG** rail for this Terminals



### 3. Terminals

#### f. Other Common Errors

**DO NOT** place any washers or delineators on the face of a guardrail terminal unless specifically called for or allowed in manufacturer's installation instructions






### 3. Terminals

#### f. Other Common Errors

Improper bolt @ post 2



Refer to manufacturer's installation instructions.

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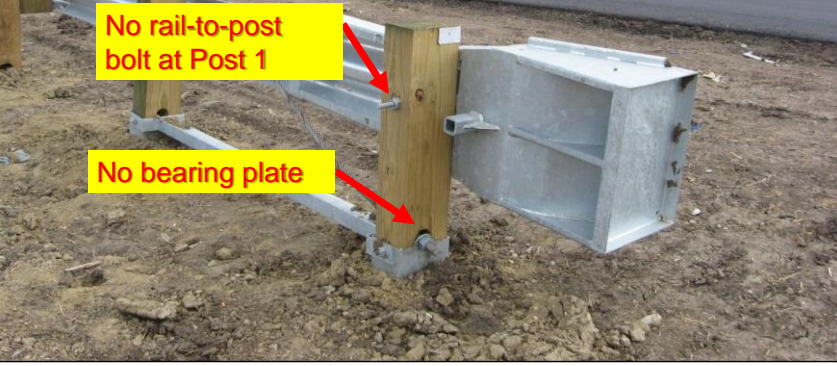
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### 3. Terminals

#### f. Other Common Errors



No rail-to-post bolt at Post 1

No bearing plate

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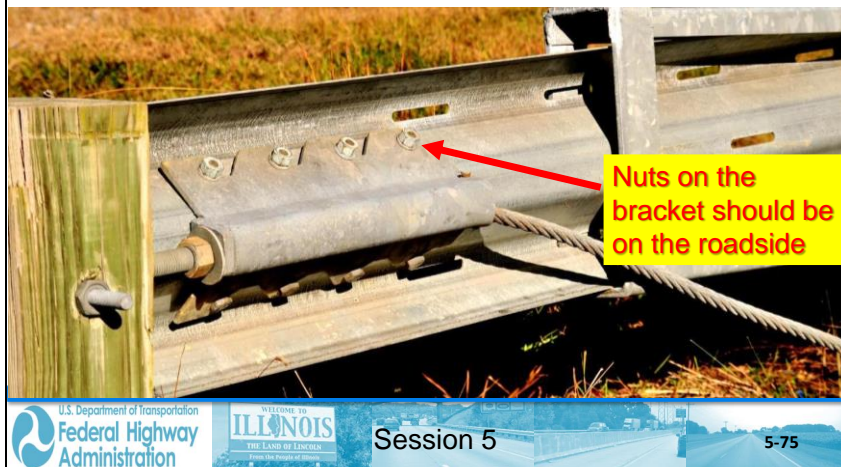
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### 3. Terminals

#### f. Other Common Errors



### 3. Terminals


#### f. Other Common Errors

Excessive flare on a terminal



### 3. Terminals

f. Other Common Errors



**Improper Application – Hazard within terminal length**

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### 3. Terminals

f. Other Common Errors



**Improper Application – Terminals should have 7' separation (and the sign should be beyond the terminal system)**

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## Terminals: W-Beam Median

### FLEAT-MT (FLared Energy Absorbing Terminal-Median Terminal)

- Intended for use in wide medians.
- Attaches directly to a W-Beam median barrier, or to a Thrie-Beam median barrier using the standard W-Beam to Thrie beam transition piece.
- During an impact, the vehicle pushes the leading impact head down the rail section while sequentially kinking the rail element.
- Most components interchangeable with the Tangent SKT and Flared FLEAT roadside terminals.



**Must have manufacturer's installation instructions.**



# Terminals: W-Beam Median 28"

- CAT (Crash Cushion Attenuating Terminal) (NCHRP 350)
  - Special HS bolts tear tabs between multiple slots in rail upon head-on impact.
  - Typically used to terminate a double-faced strong-post median W-Beam barrier
  - Can be attached directly to a double-sided concrete median barrier with appropriate transition section.
  - compression system
  - Length of needs begins at post 4.



**Must have manufacturer's installation instructions.**

## 3. Terminals

### g. Delineation



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# 4. Impact Attenuators

- a. Manufacturers Manuals
- b. Grading



# 4. Impact Attenuators

- a. Manufacturers Manuals

**Must follow manufacturer's installation instructions and State standards.**



**These are all readily available online**

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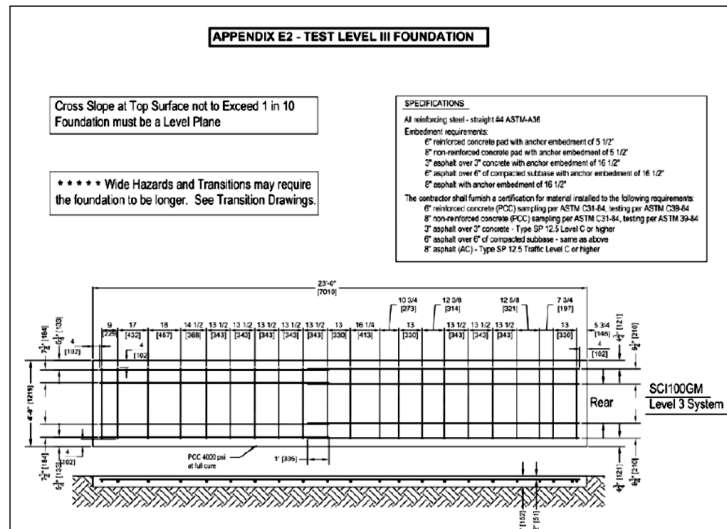
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# 4. Impact Attenuators

## a. Manufacturers Manuals

Construct concrete pad if called for per manufacturer's requirements or state standards.

Clean out drilled holes WELL!!



## 4. Impact Attenuators

### a. Manufacturers Manuals

- Anchor bolts are required to secure the system to concrete pad. Number of bolts and length of bolts vary with systems.
- Bolts are typically required to be epoxied into concrete pad.
- Bolts may have a torque value.

**Full bolt depth required**



**Cutting bolt prohibited**




**Must follow manufacturer's installation instructions.**




## 4. Impact Attenuators

a. **Manufacturers Manuals**

- Backup varies among systems.
- May be connected to a barrier or may be a stand alone



Ex: Tension Strut Backup



Ex: Concrete Backup

**Must follow manufacturer's installation instructions.**

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## 4. Impact Attenuators

a. **Manufacturers Manuals**

- When system is placed in a bidirectional application a transition is required to prevent back side snagging



Acceptable



Unacceptable

**Must follow manufacturer's installation instructions.**

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## 4. Impact Attenuators

a. **Manufacturers Manuals**

- Place appropriate delineation on front of system



**Must follow manufacturer's installation instructions and state guidance**

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## 4. Impact Attenuators

b. **Grading**

Grading should be so an errant vehicle impacts the system in a stabled condition – same as terminals



**Suspect Grading**

**Must follow manufacturer's installation instructions.**

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# 4. Impact Attenuators

Ex: results of improper torque values applied to fender panels.



**Must follow manufacturer's installation instructions.**



Session 5

5-90

## Review Learning Outcomes

- Describe key components of barrier systems
- Identify common installation errors

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Session 5

5-91

## Session 6: Maintenance of Systems



FAST Act Guardrail Training  
Highway Barrier Installer, Inspector and  
Maintenance Training

## Session 6: Maintenance of Systems

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### Session 6 Learning Outcomes

At the end of this session, you will be able to:

- Know how damaged barrier MAY BE assessed for maintenance response.
- Understand when a damaged barrier terminal MAY no longer function.
- Effectively delineate damaged hardware prior to repair.

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### Introduction

- Barriers need routine inspection and maintenance.
- Barrier may need to be repaired after crashes or long term exposure.



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**Need To Repair**



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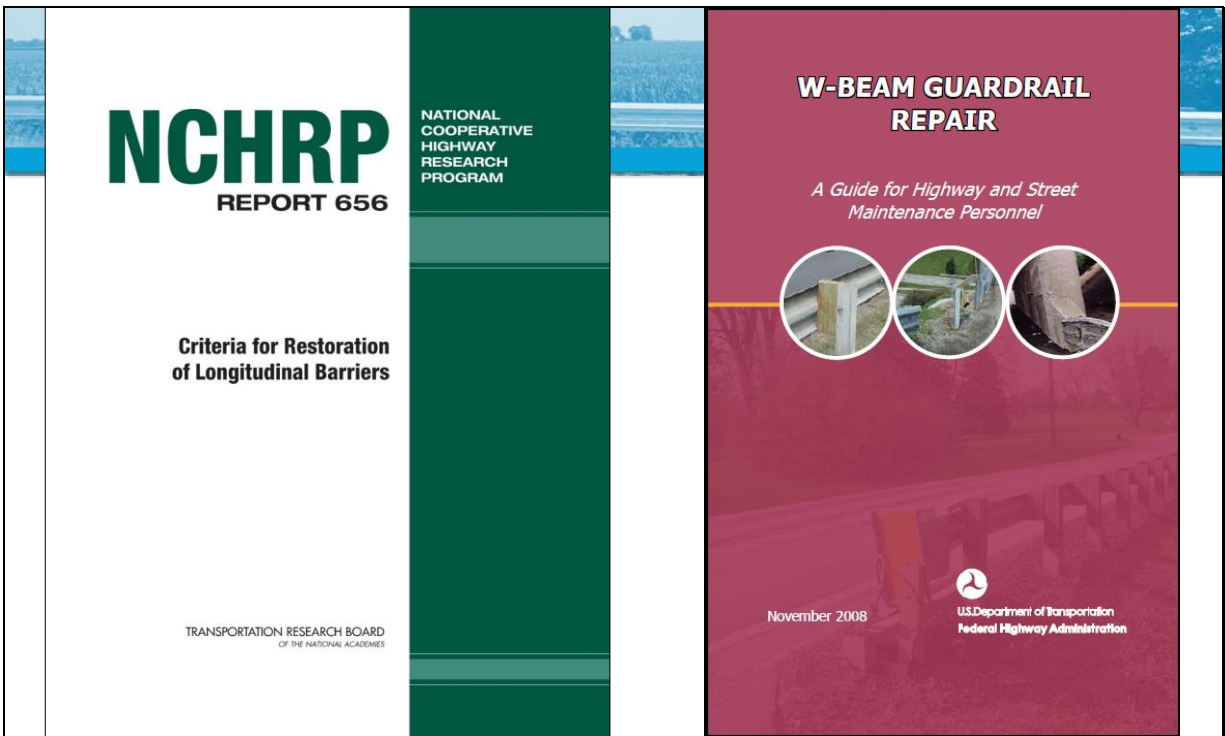
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**NCHRP**  
REPORT 656

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Criteria for Restoration of Longitudinal Barriers

TRANSPORTATION RESEARCH BOARD OF THE NATIONAL ACADEMIES

**W-BEAM GUARDRAIL REPAIR**

*A Guide for Highway and Street Maintenance Personnel*

November 2008

U.S. Department of Transportation  
Federal Highway Administration

Available for purchase

Available online



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Federal Highway Administration

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Session 6



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## Determine Extent of Damage

**NCHRP Report 656** is intended to identify methods to better determine whether minor damage to W-Beam barriers poses a crash safety risk. It is intended to enable maintenance crews to prioritize repairs.



REF: NCHRP 656 – Criteria for Restoration of Longitudinal Barriers



Session 6
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## Modes of Barrier Damage

<b><u>BARRIERS</u></b> (Based on experimental testing)	<b><u>TERMINALS</u></b> (Based on Engineering Judgment)
<ul style="list-style-type: none"> <li>• Post and rail deflection</li> <li>• Rail deflection only</li> <li>• Rail flattening</li> <li>• Posts separated from rail</li> <li>• Missing/broken posts</li> <li>• Missing blockouts</li> <li>• Twisted blockouts</li> <li>• Non-manufactured holes</li> <li>• Damage at a rail splice</li> <li>• Vertical tear</li> <li>• Horizontal tear</li> </ul>	<ul style="list-style-type: none"> <li>• Damaged end post</li> <li>• Anchor cable missing</li> <li>• Anchor cable loose</li> <li>• Anchor cable bracket</li> <li>• Stub height</li> <li>• Lag screws</li> <li>• Bearing plate</li> </ul> <p><b>Note: These evaluations were based on analysis of the “WBGA” system under 350 and not on MGSA system.</b></p>

REF: NCHRP 656 – Criteria for Restoration of Longitudinal Barriers



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### Low Speed Impact Prior to Damage



Video Clip

REF: NCHRP 656 – Criteria for Restoration of Longitudinal Barriers

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### Test Level 3 After Damage



Video Clip

REF: NCHRP 656 – Criteria for Restoration of Longitudinal Barriers

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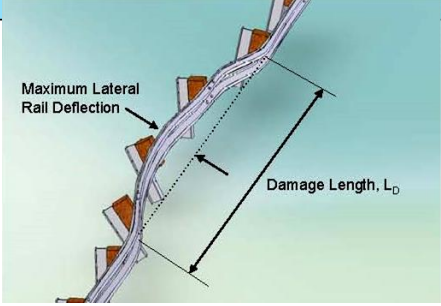
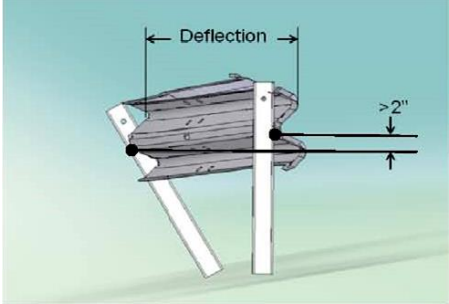
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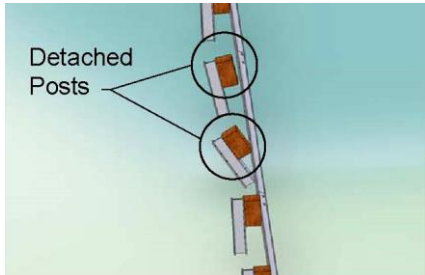
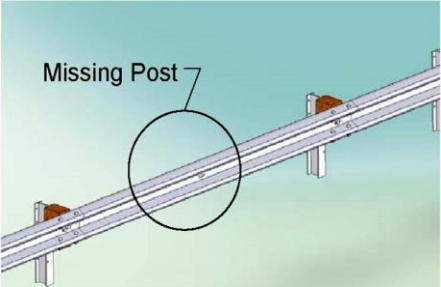
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Barriers			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Post and Rail Deflection	One or more of the following thresholds: <ul style="list-style-type: none"> <li>• More than <u>9 inches of lateral deflection</u> anywhere over a 25 ft length of rail.</li> <li>• Top of rail height 2 or more inches lower than original top of rail height.</li> </ul>	High	  <p>(Weak Post W-Beam Shown Only for Clarity. Each measurement taken at rail middle fold)</p>
	<u>6-9 inches lateral deflection</u> anywhere over a 25 ft length of rail.	Medium	
	<u>Less than 6 inches of lateral deflection</u> over 25 ft length of rail.	Low	




<div style="display: flex; justify-content: space-between; align-items: center;"> <span style="font-size: 2em; font-weight: bold;">Barriers</span> <div style="text-align: right;">  </div> </div>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Posts Separated from Rail	<ul style="list-style-type: none"> <li>• <u>2 or more</u> posts with blockout attached with post-rail separation less than <u>3 inches</u>.</li> <li>• 1 or more post with post-rail separation which <u>exceeds 3 inches</u>.</li> </ul>	Medium	<div style="text-align: center;">  <p>Detached Posts</p> </div> <p>Note:                      1.If the blockout is not firmly attached to the post, use the missing blockout guidelines.                      2.Damage should also be evaluated against post/rail deflection guidelines.</p>
	<ul style="list-style-type: none"> <li>• 1 post with blockout attached with post-rail separation less than 3 inches.</li> </ul>	Low	
Missing/Broken Posts	1 or more posts <ul style="list-style-type: none"> <li>• Missing</li> <li>• Cracked across the grain</li> <li>• Broken</li> <li>• Rotten</li> <li>• With metal tears</li> </ul>	High	<div style="text-align: center;">  <p>Missing Post</p> </div>

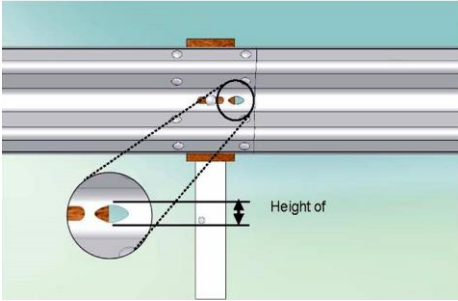








# Barriers



Damage Mode	Repair Threshold	Relative Priority	Measurement
Non-Manufactured holes  (such as crash induced holes, lug-nut damage, or holes rusted-through the rail)	<ul style="list-style-type: none"> <li><u>More than 2 holes less than 1" in height</u> in a 12.5' length of rail.</li> <li>Any holes greater than 1" height.</li> <li>Any hole which intersects either the top or bottom edge of the rail.</li> </ul>	High	
	1-2 holes less than 1" in height in a 12.5' length of rail.	Medium	






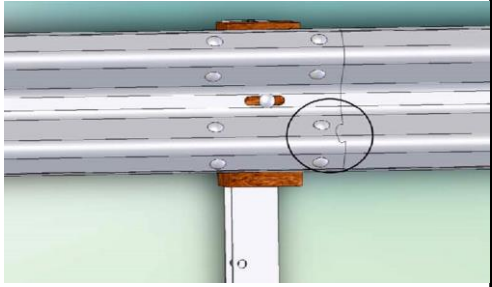
## Session 6


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# Barriers




Damage Mode	Repair Threshold	Relative Priority	Measurement
Damage at a rail splice	<p><u>More than 1 splice bolt:</u></p> <ul style="list-style-type: none"> <li>•Missing</li> <li>•Damaged</li> <li>•Visibly missing any underlying rail</li> <li>•Torn through rail</li> </ul>	High	
	<p>1 splice bolt:</p> <ul style="list-style-type: none"> <li>•Missing</li> <li>•Damaged</li> <li>•Visibly missing any underlying rail</li> <li>•Torn through rail</li> </ul>	Medium	




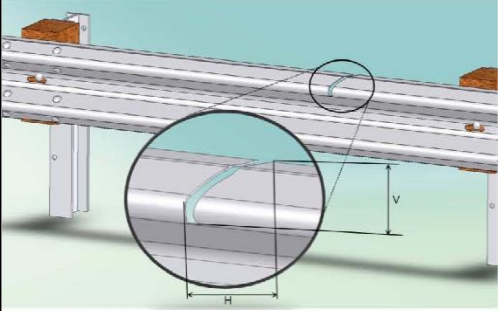
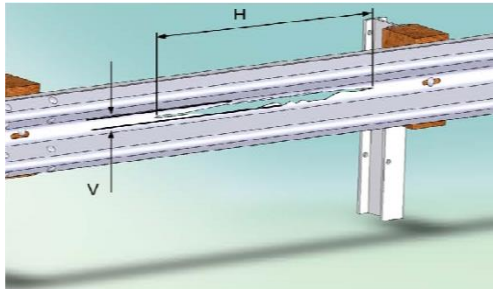


## Session 6


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<div style="display: flex; justify-content: space-between; align-items: center;"> <h1 style="margin: 0;">Barriers</h1> <div style="text-align: right;">  </div> </div>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Vertical Tear	<u>Any length vertical</u> (transverse) tear	High	
Horizontal Tear	Horizontal (longitudinal) tears <u>greater than 12 inches long</u> or greater than 0.5 inches wide.  Note: for horizontal tears less than 12 inches in length or less than 0.5 inches in height, use the non-manufactured holes guidelines.	Medium	


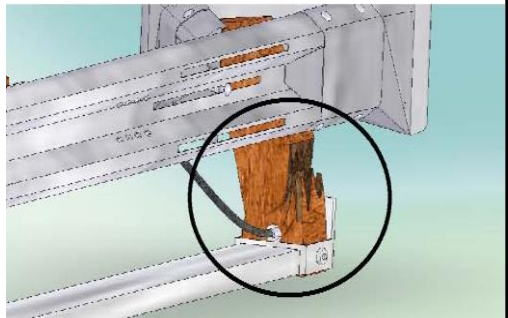
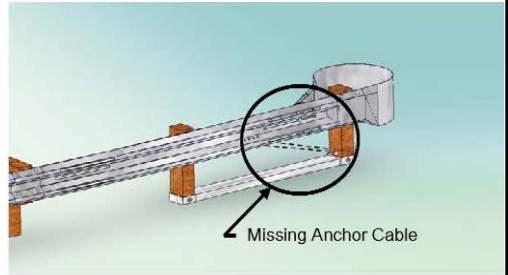


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<div style="display: flex; justify-content: space-between; align-items: center;"> <h1 style="margin: 0;">Terminals</h1> <div style="text-align: right;">  </div> </div>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Damage End Post	<u>Not functional</u> (sheared, rotted, cracked across the grain)	High	
Anchor Cable	Missing	High	

# Terminals


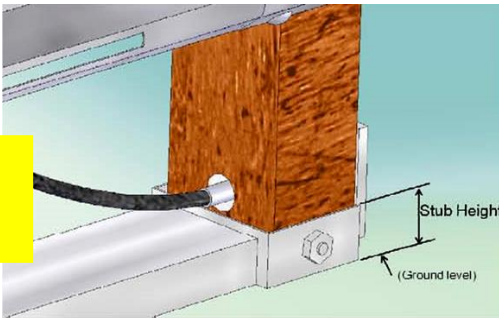
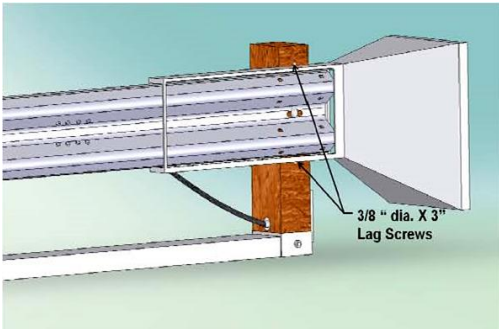
- Check for nuisance hits on terminals to be sure post #1 is not damaged.
- Even with claims of “reusability” – use best judgment and closely examine all salvageable parts.
- Impact Heads may be re-usable based on state policy and manufacturers recommendations (generally say no).

Just BAD - HIGH







<div style="display: flex; justify-content: space-between; align-items: center;"> <h1 style="margin: 0;">Terminals</h1> <div style="text-align: right;">  </div> </div>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Stub Height	Height which exceeds 4"	Medium	
<p><b>Caution: Excessive height could have severe consequences</b></p>			
Lag Screws (Energy Absorbing Terminals Only)	<u>Missing or failed lag Screws</u>	High	


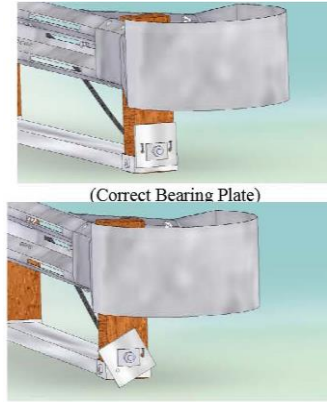
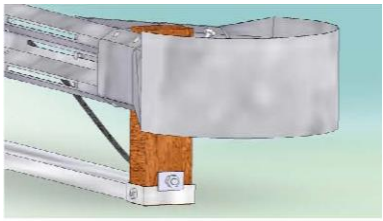
Session 6: Maintenance of Systems









<h1 style="margin: 0;">Terminals</h1>			
Damage Mode	Repair Threshold	Relative Priority	Measurement
Bearing Plate	Loose or Misaligned	Medium	 <p style="text-align: center;">(Correct Bearing Plate)</p> <p style="text-align: center;">(Misaligned Bearing Plate)</p>
	Missing Bearing Plate	High	 <p style="text-align: center;">(Missing Bearing Plate)</p>

# Terminals



**Bearing plate misaligned**

**Buried plate may not release**

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**No tension capability – the rail MAY go into head (which should be parallel to top of rail), may work on head-on hit - HIGH**



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## Temporary Barrier Delineation

Delineate damaged areas while evaluating damage. Make repairs as soon as practical.



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## Temporary Barrier Delineation



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## Damaged Terminals



Added end section still leaves blunt end

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## Temporary Barrier Delineation

Delineate damaged areas while evaluating damage. Make repairs as soon as practical.



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## Temporary Cable Repair

Removal of damaged posts will eliminate a spearing hazard for opposing traffic.



## Impact Attenuator Repair



This is a blunt end until repaired. Good delineation. Have manufacturer's Installation Manual available.



## Replacement In-Kind vs. Upgrade

- **On-Call Guardrail Contract (example)**
  - Entire guardrail sections may also be removed and replaced to current standards, if the major portion of the section is damaged beyond repair and if directed by the Engineer.
  - Damaged terminals should be replaced with upgraded TL-3 terminals.

The slide has a blue header with the title. The main content is on a white background. At the bottom, there is a blue banner with the U.S. Department of Transportation Federal Highway Administration logo, a 'WELCOME TO ILLINOIS THE LAND OF LINCOLN' sign, the text 'Session 6', and the slide number '6-43'.



## Timing of Repairs

### ➤ On-Call Guardrail Contract (example)

- Work to begin within 10 calendar days from receipt of work order, or
- Once started, repair work must be continuous until completed.



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## impact attenuator Repair



Ensure all mounting hardware is correct, in place & properly secured.



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# Impact Attenuator Repair



**Typical QuadGuard Cartridges**

Place proper cartridges in the correct system & in the proper order

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## Review Learning Outcomes

- Know how damaged barrier MAY BE assessed for maintenance response.
- Understand when a damaged barrier terminal MAY no longer function.
- Effectively delineate damaged hardware prior to repair.

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