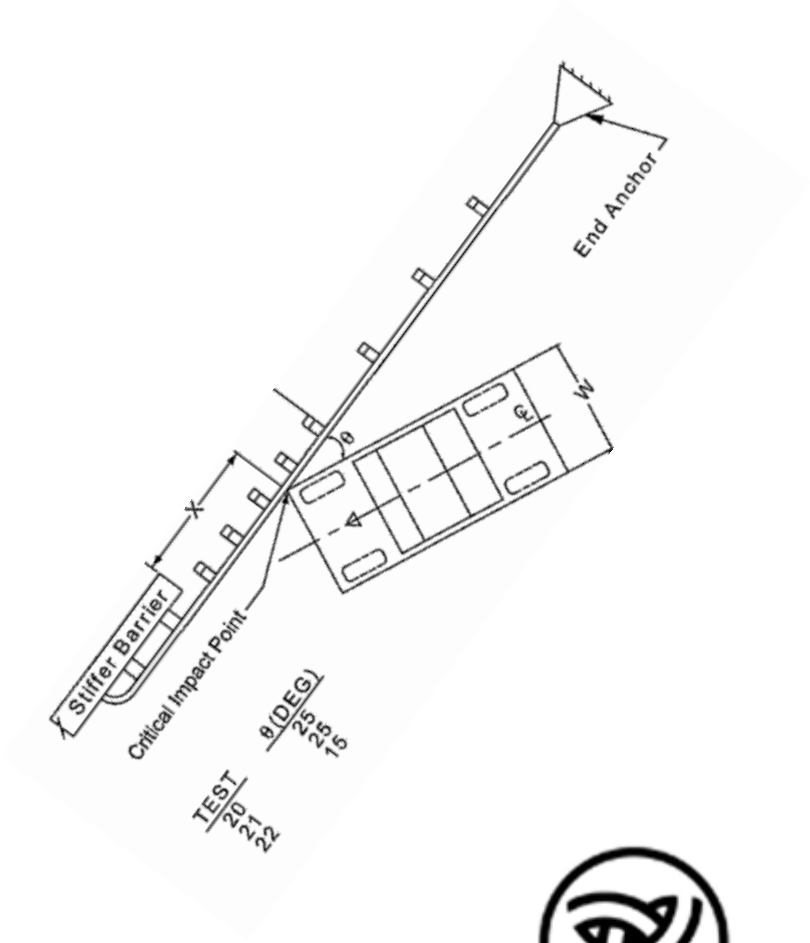
FHWA FAST Act Guardrail Training
Highway Barrier Design Training

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 today's training is to assist Illinois Department of Transportation (IDOT) by providing their personnel and consultant designers with the appropriate information needed to enhance the probability of optimal barrier designs.

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

- The PowerPoint presentations and the accompanying notebook on Highway Barrier Design Training
- IDOT Barrier Design Sheet
- 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:

Aimee Zhang	FHWA Office of Safety	Aimee.Zhang@dot.gov
Brad Sant	ARTBA (Agreement Manager)	bsant@artba.org
Karen L. Boodlal	KLS Engineering, LLC (Project Manager)	karen1.boodlal@kls-eng.com
Bill Fitzgerald	KLS Engineering, LLC (Technical Expert/Instructor)	william.fitzgerald@kls-eng.com
John Durkos	KLS Engineering, LLC (Technical Expert/Instructor)	John.durkos@kls-eng.com
Alan Ho	FHWA Division Office	alan.ho@dot.gov
Filiberto Sotelo	IDOT Engineering Policy Unit Chief	Filiberto.Sotelo@Illinois.gov
Edgar Galofre	IDOT Safety Design Engineer	Edgar.Galofre@Illinois.gov
Martha Brown	IDOT Safety Design Unit Chief	Martha.A.Brown@Illinois.gov

Target Audience

The target audience for this training includes design engineers and staff, as well as consultants working for IDOT and local agencies, having direct responsibilities for designing and/or specifying traffic barriers (including transitions), terminals, and impact attenuators in Illinois.

Course Goal and Outcomes

The overall course goal is to make design engineers aware of decisions that could improve the roadside safety of Illinois roads and issues that will affect the barriers' capability to function as intended. Specifically, participants should have a better understanding of the following:

- The clear zone concept
- When roadside and median barriers may be warranted
- Optimal design of barrier installations, including LON calculations
- Selection of the most appropriate end treatments per site conditions

Course Contents

This course consists of seven sessions:

Session 1: Introduction and Pre-Assessment – Includes a brief overview of the run off the road (ROR) problem as it exists in Illinois and tests the participants' pre-training familiarity with barrier design principles.

Session 2: Clear Zone and Guidelines for Barrier Need – Explains the clear zone concept and examines the sometimes difficult decision of when a barrier may be warranted to shield a hazard(s).

Session 3: Testing Requirements and Performance Characteristics of Common Barrier Systems – Identifies how selected safety barriers are tested and function under controlled crash tests.

Session 4: Testing Requirements and Performance Characteristics of Terminals and Impact Attenuators – Identifies how selected terminals and impact attenuators are tested and function under controlled crash tests.

Session 5: Design Principles – Provides guidance concerning selecting the barrier type and creating an optimal design based on the five design principles.

Session 6: Length of Need and Special Situations – Explains what Length of Need is based on and how it is calculated, and identifies design options to use in special situations.

Session 7: Design Workshop – Tests the participants' post-training knowledge of barrier design principles by providing an opportunity for attendees to demonstrate the overall effectiveness of the training in a workshop

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/

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-qa.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 omni-directional.

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 $50ft^2$ in area. Small roadside signs may be defined as those less than $50ft^2$ 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 comments 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."

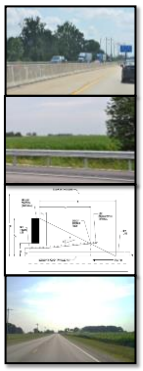
Working Width—The distance between the traffic face of the test article before the impact and the maximum lateral position of any major part of the system or vehicle after the impact.

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: Introduction and Pre-Assessment



FAST Act Guardrail Safety Training

Highway Barrier Design Training

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

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

Virtual Live Training
November 16 – 18, 2021

American Road & Transportation Builders Association

KLS Engineering

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.

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois | Session 1 | 1-2

Ground Rules

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

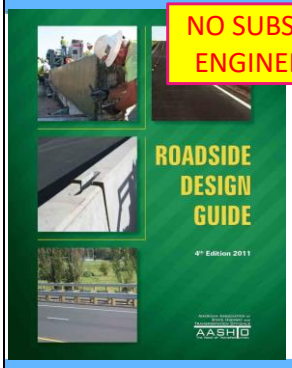
Virtual Training – participate with yes/no answers to questions
Use chat box to submit your questions/comments

Terminology: Page v

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois | Session 1 | 1-3

Guidance Presented

NO SUBSTITUTE FOR GOOD ENGINEERING JUDGMENT



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

Session 1

1-4

Objectives of Course

At the end of this training you will be able to:

- Identify when a traffic barrier may be the best treatment to use at a specific site.
- Select a barrier that will adequately shield the identified hazard(s).
- Assess the topography of the site to provide for an optimal barrier system installation.

U.S. Department of Transportation Federal Highway Administration

Session 1

1-5

Session 1:
Introduction and Pre-assessment

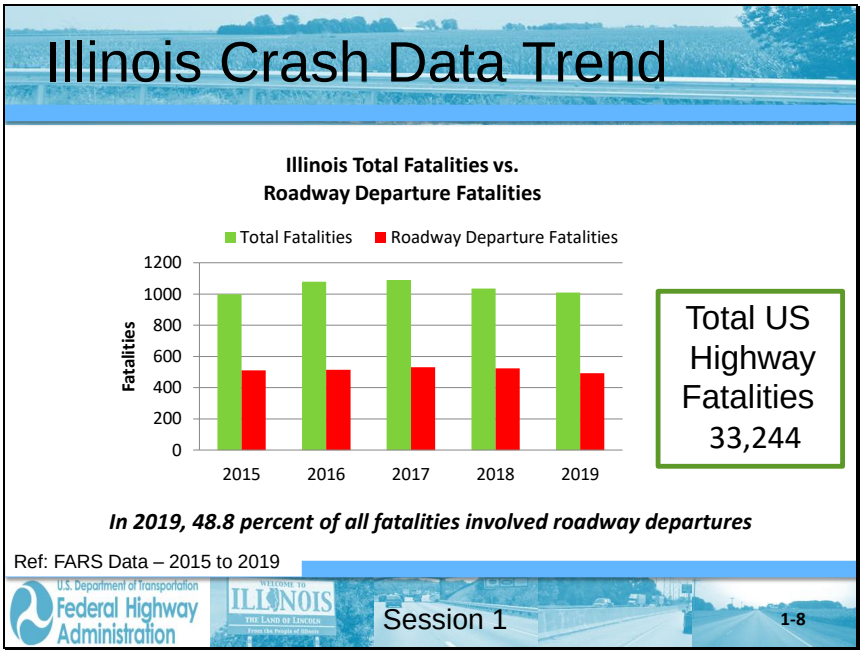
U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 1 | 1-6

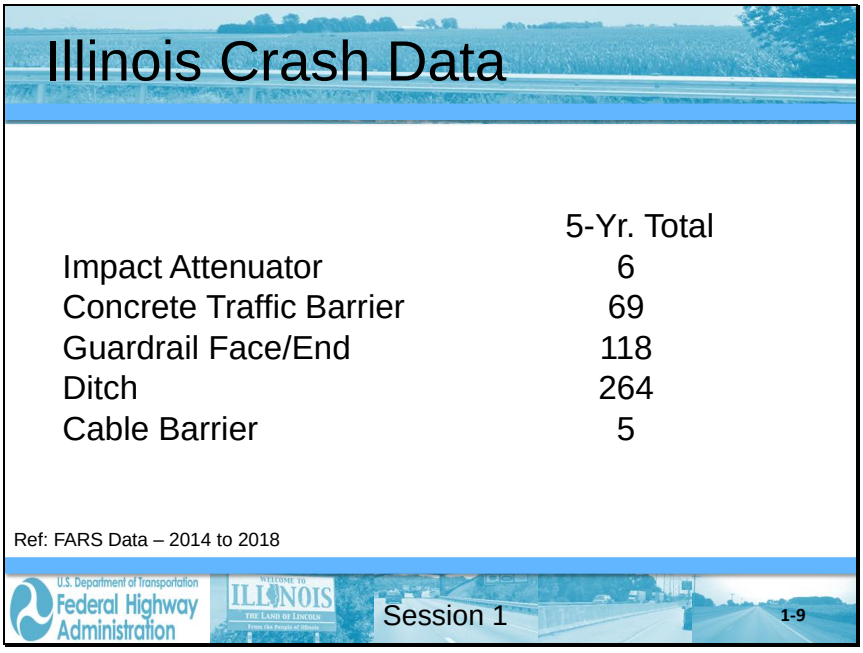
Session 1 Learning Outcomes

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

- Identify the primary Roadside Safety Concerns in Illinois.
- Assess your current knowledge of Barrier Design Principles.

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 1 | 1-7


Illinois Crash Data Trend
Illinois Total Fatalities vs.
Roadway Departure Fatalities
Total Fatalities
Roadway Departure Fatalities
1200
1000
800
600
400
200
0
Fatalities
2015
2016
2017
2018
2019
Total US Highway Fatalities 33,244
In 2019, 48.8 percent of all fatalities involved roadway departures
Ref: FARS Data – 2015 to 2019
U.S. Department of Transportation Federal Highway Administration
Session 1
1-8


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
U.S. Department of Transportation Federal Highway Administration
Session 1
1-9


Strategic Highway Safety Plan
Illinois Strategic Highway
Safety Plan 2017
EMS
ENFORCEMENT
EDUCATION
ENGINEERING
Driving Zero Fatalities to a Reality
Partnering for Illinois
07.28.2017
Roadway Departure
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 1
1-10


Real World Crashes
Video Clip
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 1
1-11

Need for Training

Potential consequences of poorly designed barrier systems include:

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

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 1 | 1-13

Need for Training

The next 8 slides show locations where barrier was installed. For each photo, decide at a glance whether you believe it to be:

1. Good example,
2. Bad example, or
3. Cannot decide without more information.

We will discuss these slides in further detail in later applicable sessions, so please record and save your responses.


U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
Session 1
1-16

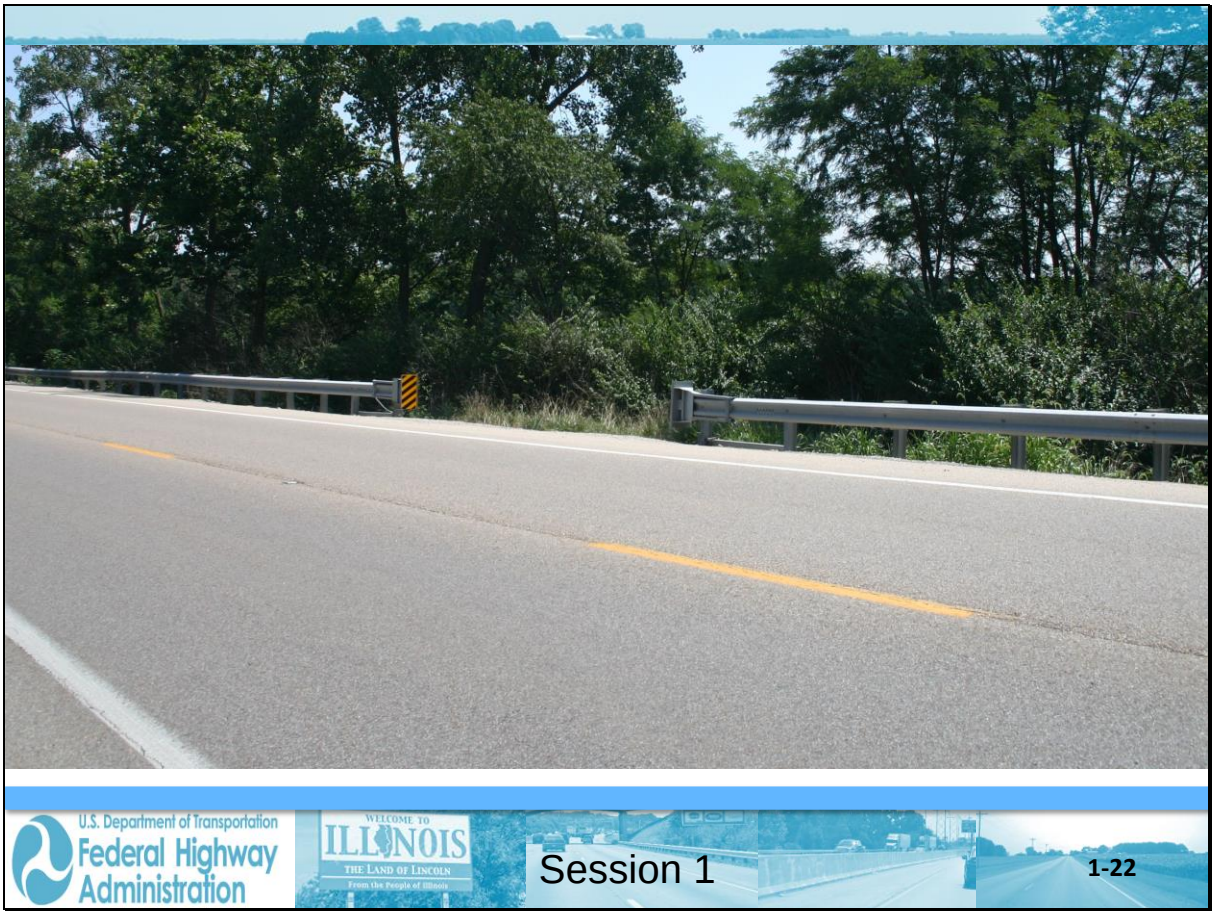

U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
Session 1
1-17


U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 1
1-18


U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 1
1-19


U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 1
1-20


U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 1
1-21


U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 1
1-22

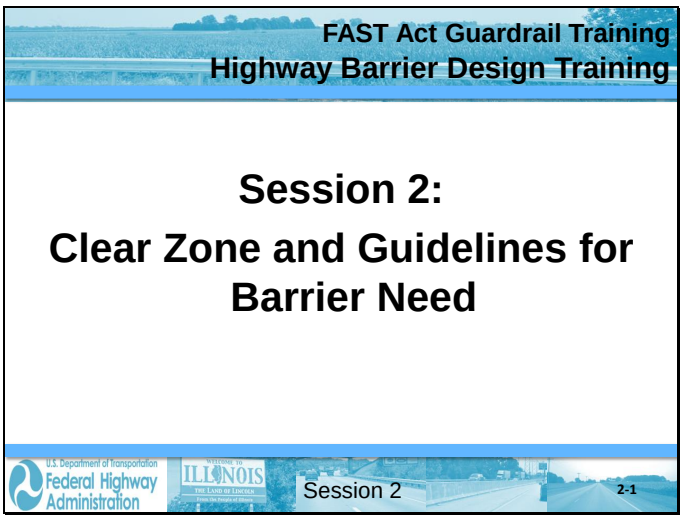
_____

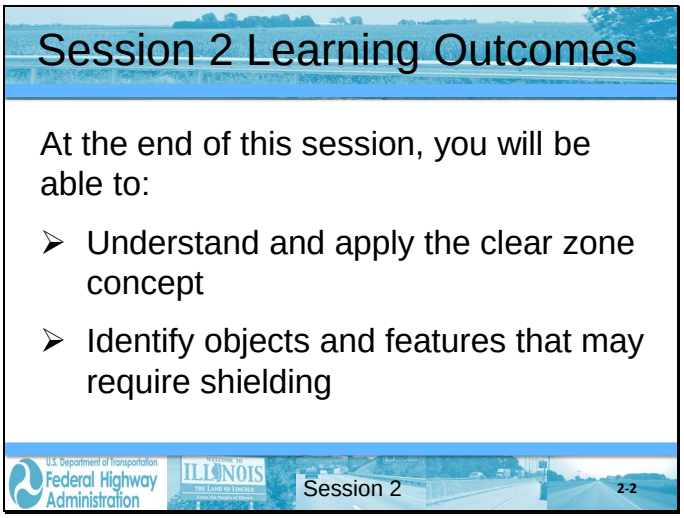
_____

Review Learning Outcomes

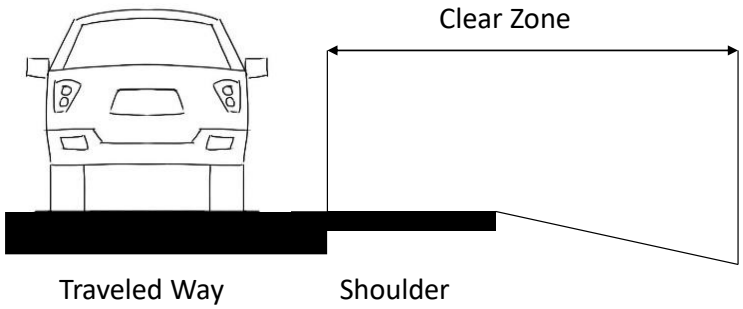
- Identify the primary Roadside Safety Concerns in Illinois.
- Assess your current knowledge of Barrier Design Principles.

Session 2: Clear Zone and Guidelines for Barrier Need


FAST Act Guardrail Training
Highway Barrier Design Training
Session 2:
Clear Zone and Guidelines for Barrier Need
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 2
2-1


Session 2 Learning Outcomes
At the end of this session, you will be able to:
Understand and apply the clear zone concept
Identify objects and features that may require shielding
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 2
2-2

Clear Zone: A Definition



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, 4th Edition, Glossary

U.S. Department of Transportation Federal Highway Administration | Session 2 | 2-3

_____

_____

Clear Zone Principle

Get

MAXIMUM,

COST-EFFECTIVE

width

U.S. Department of Transportation Federal Highway Administration | Session 2 | 2-4

_____

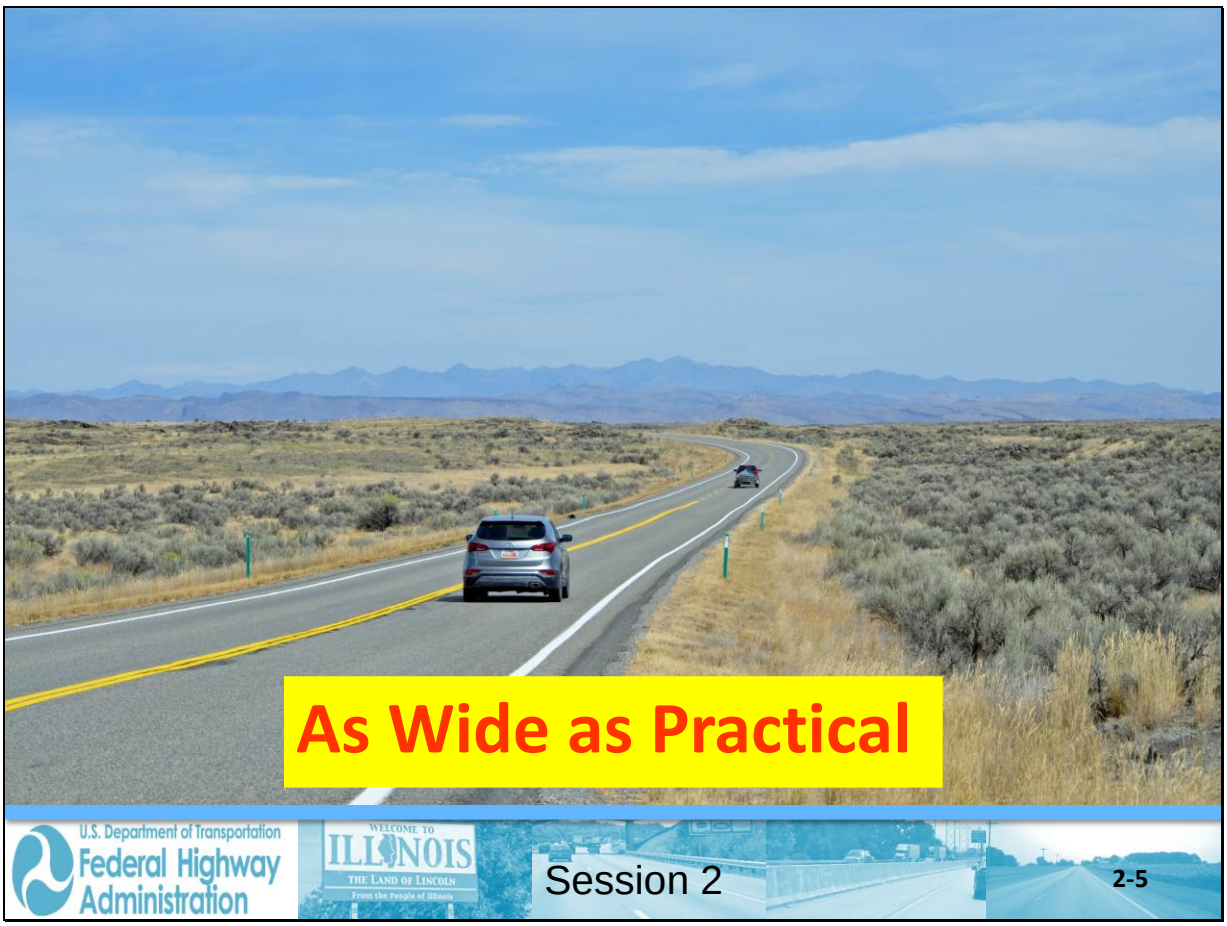
_____

_____

_____

_____

_____



_____

_____

Clear Zone Factors

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

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 2 | 2-6

_____

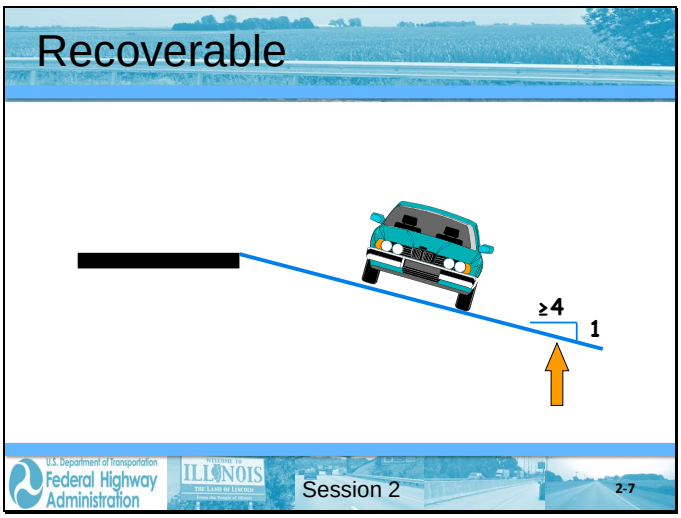
_____

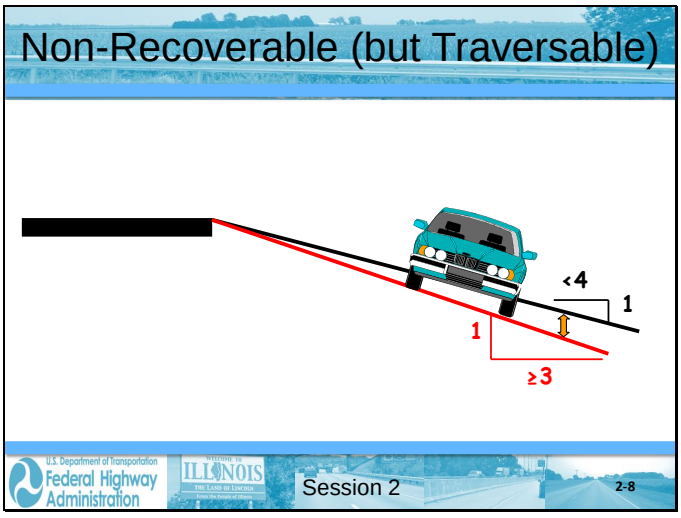
_____

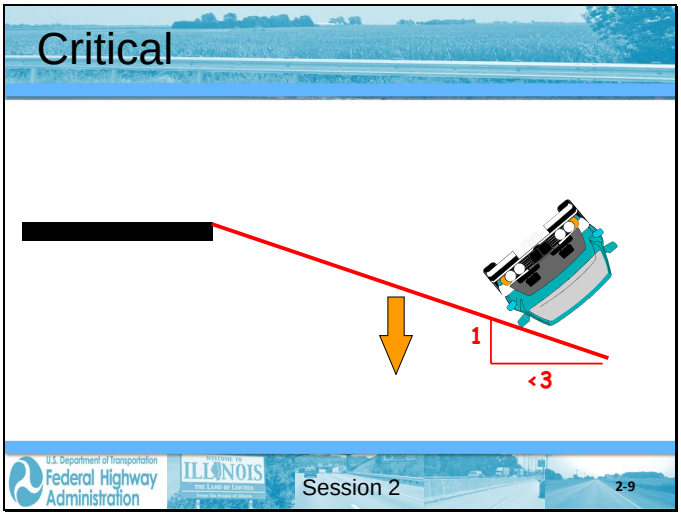
_____

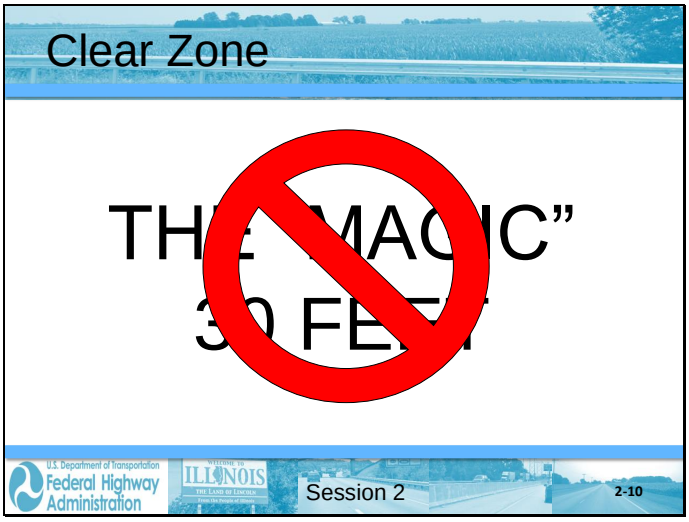
_____

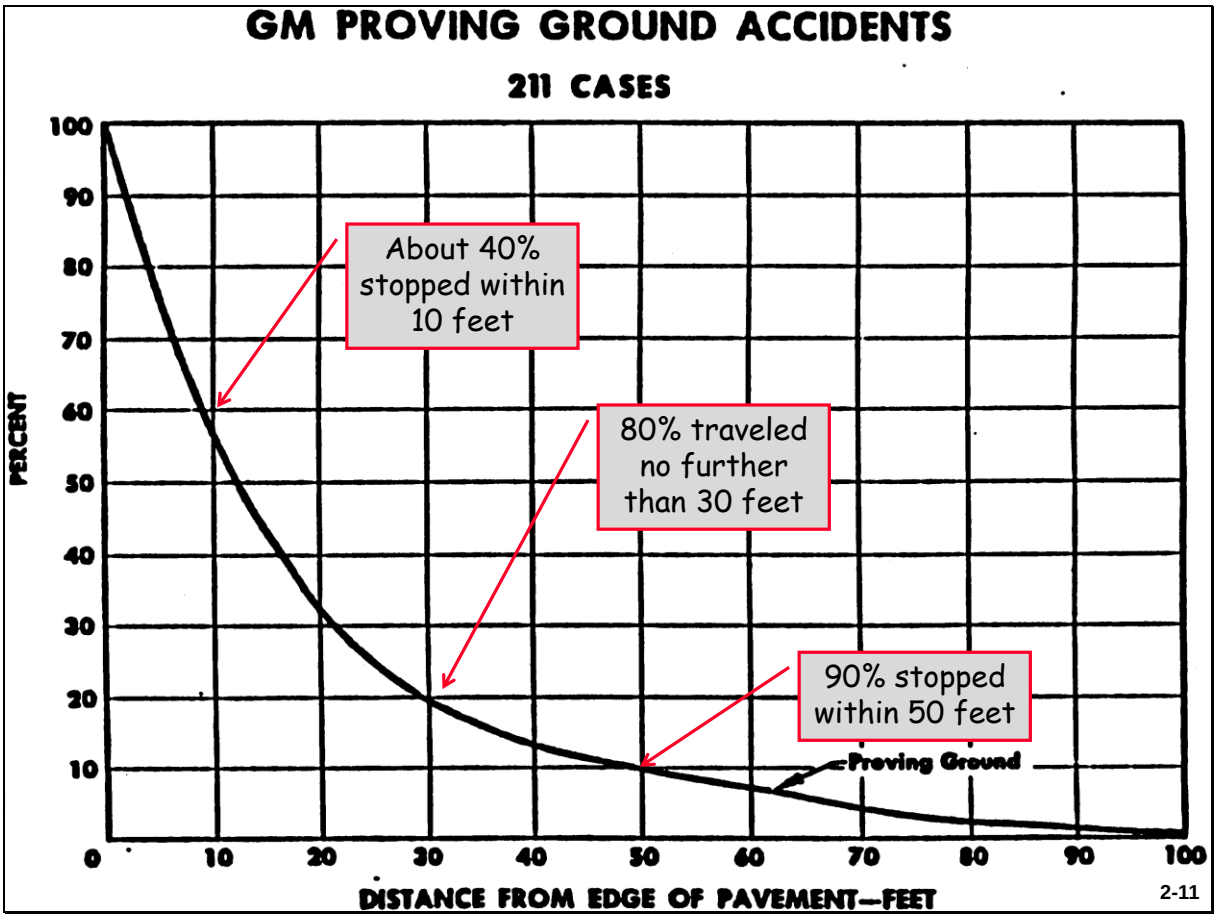
_____


Recoverable
≥4
1
Federal Highway Administration
Session 2
2-7


Non-Recoverable (but Traversable)
<4
1
1
≥3
Federal Highway Administration
Session 2
2-8


Critical
1
<3
Federal Highway Administration
Session 2
2-9

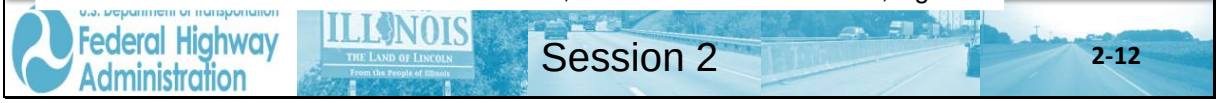

Clear Zone
U.S. Department of Transportation
Federal Highway Administration
Session 2
2-10


GM PROVING GROUND ACCIDENTS
211 CASES
PERCENT
100
90
80
70
60
50
40
30
20
10
0
About 40% stopped within 10 feet
80% traveled no further than 30 feet
90% stopped within 50 feet
Proving Ground
10
20
30
40
50
60
70
80
90
100
DISTANCE FROM EDGE OF PAVEMENT—FEET
2-11

AASHTO Clear Zone Table

Design Speed (mph)	Design ADT	Foreslopes			Backslopes		
		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[c]	7-10	7-10	b	7-10	7-10	7-10
	750-1500	10-12	12-14	b	10-12	10-12	10-12
	1500-6000	12-14	14-16	b	12-14	12-14	12-14
	OVER 6000	14-16	16-18	b	14-16	14-16	14-16
45-50	UNDER 750[c]	10-12	12-14	b	8-10	8-10	10-12
	750-1500	14-16	16-20	b	10-12	12-14	14-16
	1500-6000	16-18	20-26	b	12-14	14-16	16-18
	OVER 6000	20-22	24-28	b	14-16	18-20	20-22
55	UNDER 750[c]	12-14	14-18	b	8-10	10-12	10-12
	750-1500	16-18	20-24	b	10-12	14-16	16-18
	1500-6000	20-22	24-30	b	14-16	16-18	20-22
	OVER 6000	22-24	26-32[a]	b	16-18	20-22	22-24
60	UNDER 750[c]	16-18	20-24	b	10-12	12-14	14-16
	750-1500	20-24	26-32[a]	b	12-14	16-18	20-22
	1500-6000	26-30	32-40[a]	b	14-18	18-22	24-26
	OVER 6000	30-32[a]	36-44[a]	b	20-22	24-26	26-28
65-70[d]	UNDER 750[c]	18-20	20-26	b	10-12	14-16	14-16
	750-1500	24-26	28-36[a]	b	12-16	18-20	20-22
	1500-6000	28-32[a]	34-42[a]	b	16-20	22-24	26-28
	OVER 6000	30-34[a]	38-46[a]	b	22-24	26-30	28-30

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – TABLE 3.1, Pg. 3-3



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	**18-20**	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[a]	36-44*	**	20-22	24-26	26-28
65-70[6]	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.

Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN From the People of Illinois | Session 2 | 2-13

IDOT Clear Zone Guidance

38-3.01 Background

The clear zone widths are based on limited empirical data that has then been extrapolated to a wide range of conditions. Therefore, the distances imply a degree of accuracy that does not exist. They do, however, provide a good frame of reference for making decisions on providing a safe roadside area. Each application of the clear zone distance must be evaluated individually, and the designer must exercise good judgment.

1. Project Scope of Work. The clear zone distances in Section 38-3 apply to all freeway projects and to new construction/reconstruction projects on non-freeways. Chapter 49 presents the criteria for 3R projects on non-freeways.

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

IDOT Clear Zone Guidance – 3R

Illinois 3R GUIDELINES FOR RURAL AND URBAN HIGHWAYS November 2019

Regulatory Approach Speed and ADT	Proposed Ditch Cross Section (1)	Clear Zone
50 mph (80 km/h) or greater and ADT > 1000	Traversable	18 ft (5.5 m) or ROW line (2)
	Non-Traversable	18 ft (5.5 m) or Toe of Back Slope (2)
All Others		12 ft (3.6 m) or Non-Traversable Ditch (2)

Notes:

(1) *A traversable ditch cross section is one where the following configuration applies: 1V:4H front slopes, 2 ft (600 mm) wide ditch bottom, and 1V:3H back slopes. If any of these minimum criteria are not satisfied, the ditch cross section is considered non-traversable.*

(2) *Use whichever is less.*

CLEAR ZONES ON TANGENT SECTIONS
(3R Rural Arterial Projects)

Figure 49-3.D

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

IDOT Clear Zone Guidance

38-3 ROADSIDE CLEAR ZONES

38-3.01 Background

2. Context. If a formidable obstacle lies just beyond the clear zone, it may be appropriate to remove or shield the obstacle if costs are reasonable. Conversely, the clear zone should not be achieved at all costs..
3. Boundaries. The designer should not use the clear zone distances as boundaries for introducing roadside hazards (e.g., bridge piers, non-breakaway sign supports, utility poles, landscaping features). These should be placed as far from the traveled way as practical.

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

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

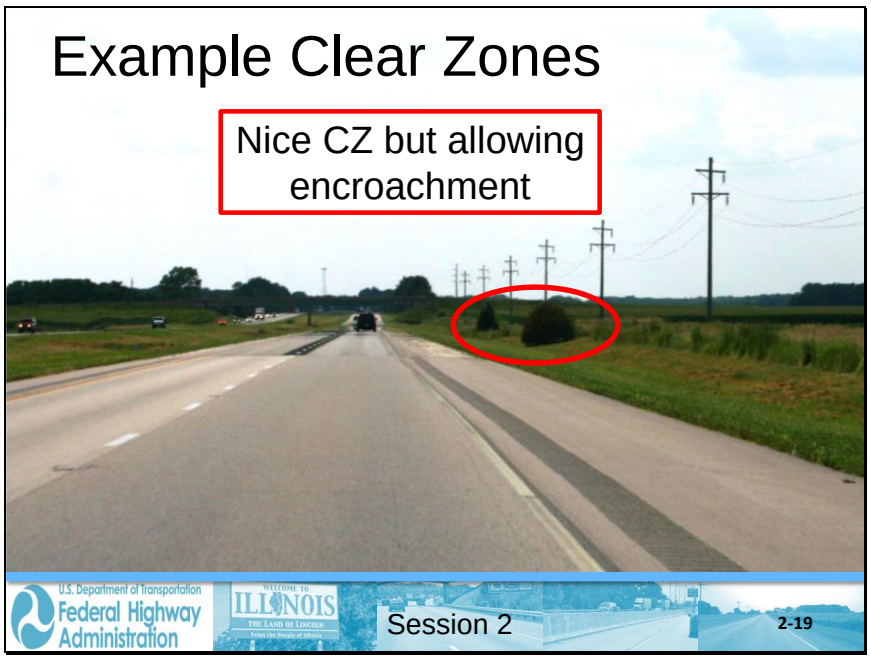
Do not compromise available clear zone

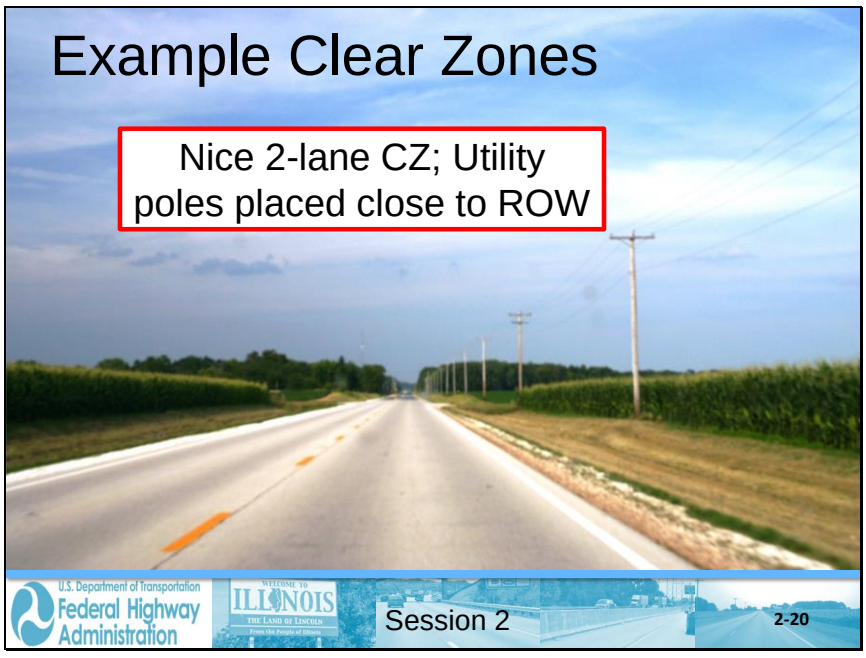
U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 2 | 2-17

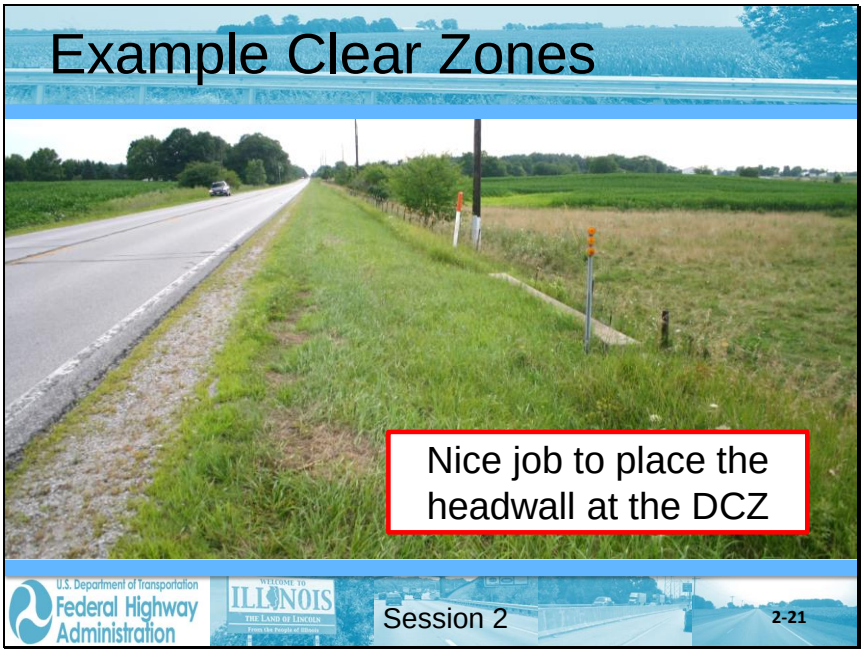
Example Clear Zones

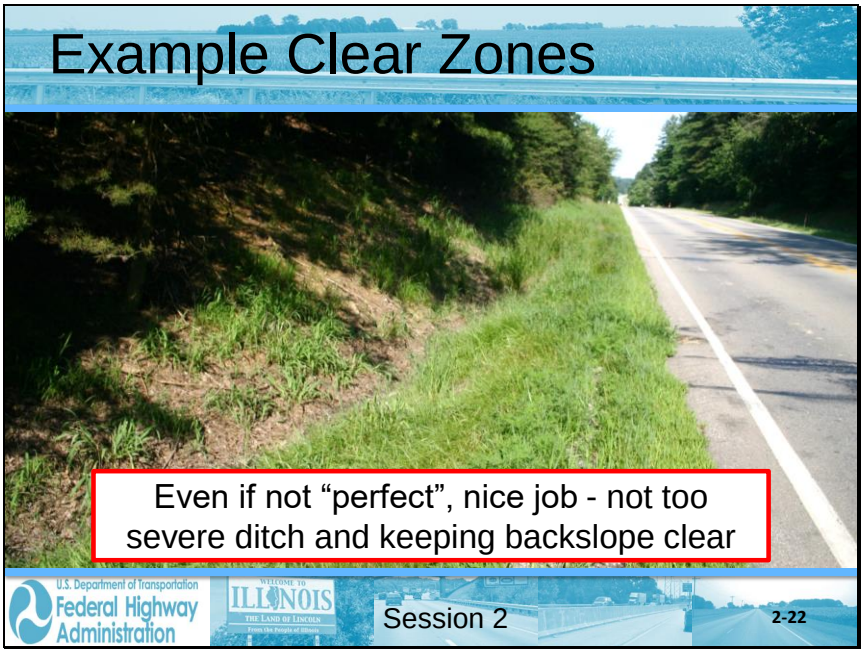
Very nice CZ (30'+); relatively easy to get on freeways

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 2 | 2-18


Example Clear Zones
Nice CZ but allowing encroachment
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 2
2-19

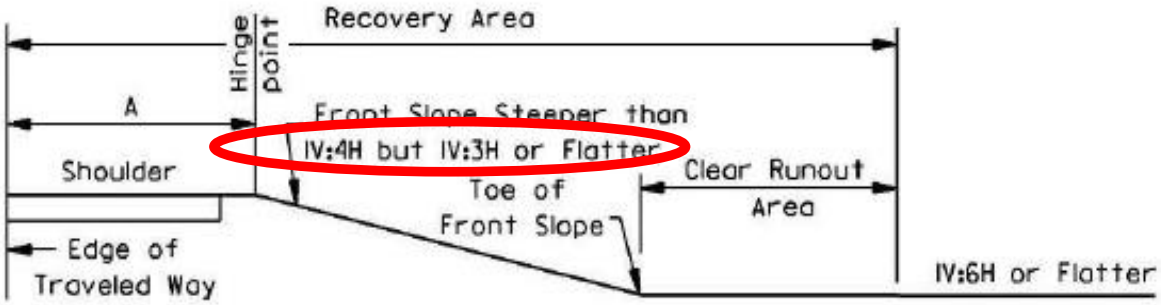

Example Clear Zones
Nice 2-lane CZ; Utility poles placed close to ROW
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 2
2-20


Example Clear Zones
Nice job to place the headwall at the DCZ
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 2
2-21


Example Clear Zones
Even if not “perfect”, nice job - not too severe ditch and keeping backslope clear
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 2
2-22


Example Clear Zones
Even if “perfect”, nothing works all the time – note memorial
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 2
2-23

Clear Zone Adjustments for Non-Recoverable (But Traversable) Slope



NON-RECOVERABLE FRONT SLOPE

CLEAR ZONE APPLICATION FOR FRONT SLOPES
(Uncurbed)

Figure 38-3.E

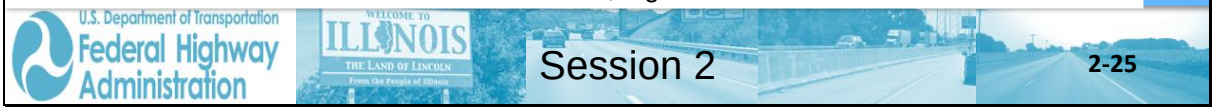
Ref: BDE Manual Ch. 38-3 Roadside Clear Zones, Figure 38-3.E

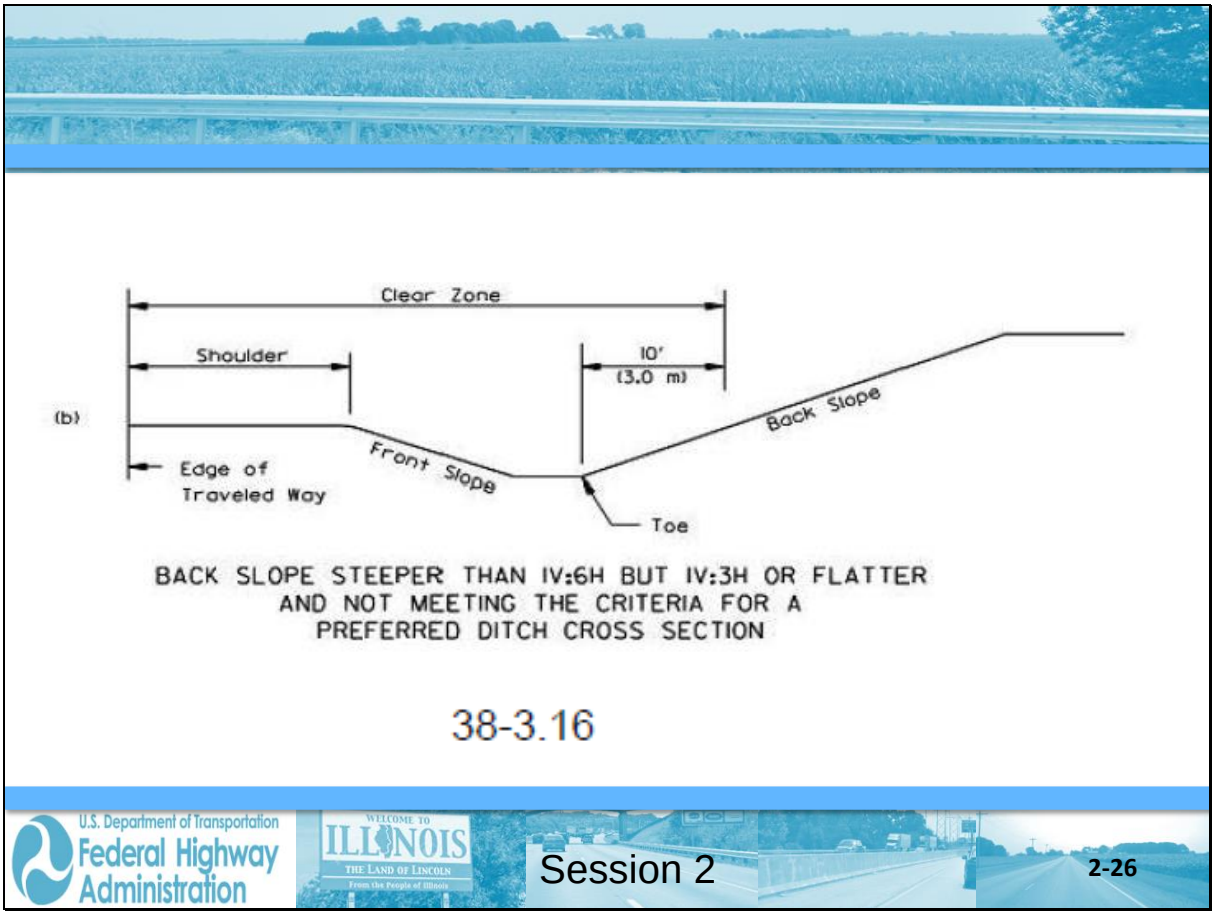
IDOT Clear Zone with a Ditch

PREFERRED DITCH CROSS SECTIONS		
Front Slope	Preferred Maximum Ditch Back Slope	
	Trapezoidal Ditch with Vee or <4 ft Flat Bottom	Trapezoidal Ditch with Minimum 4 ft Flat Bottom
1:8	1:3.5	1:2.5
1:6	1:4	1:3
1:5	1:5	1:3.5
1:4	1:6	1:4

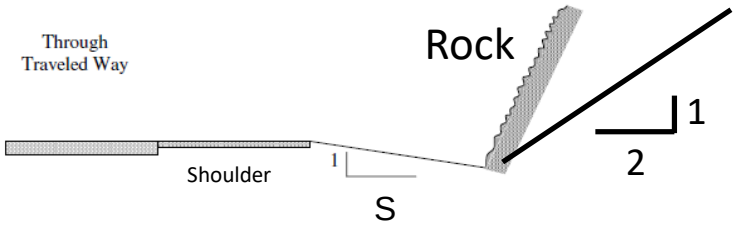
Note: For front or back slope values falling between those given above, round down to the next steeper slope, i.e., do not interpolate between slope values.

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




Clear Zone
Shoulder
10'
(3.0 m)
(b)
Back Slope
Front Slope
Edge of
Traveled Way
Toe
BACK SLOPE STEEPER THAN IV:6H BUT IV:3H OR FLATTER
AND NOT MEETING THE CRITERIA FOR A
PREFERRED DITCH CROSS SECTION
38-3.16
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 2
2-26

Clear Zone with a steep Cut Slope

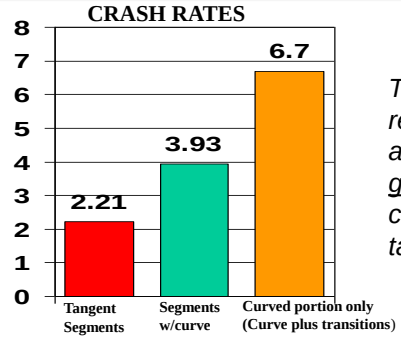


4. Clear Zones (Rock Cuts). No clear zone is required beyond the toe of back slope for rock cuts with steep back slopes. However, the rock cut should be relatively smooth to minimize the hazards of vehicular snagging. If the face of the rock is rough or rock debris is present, a barrier may be warranted.

38-3.15

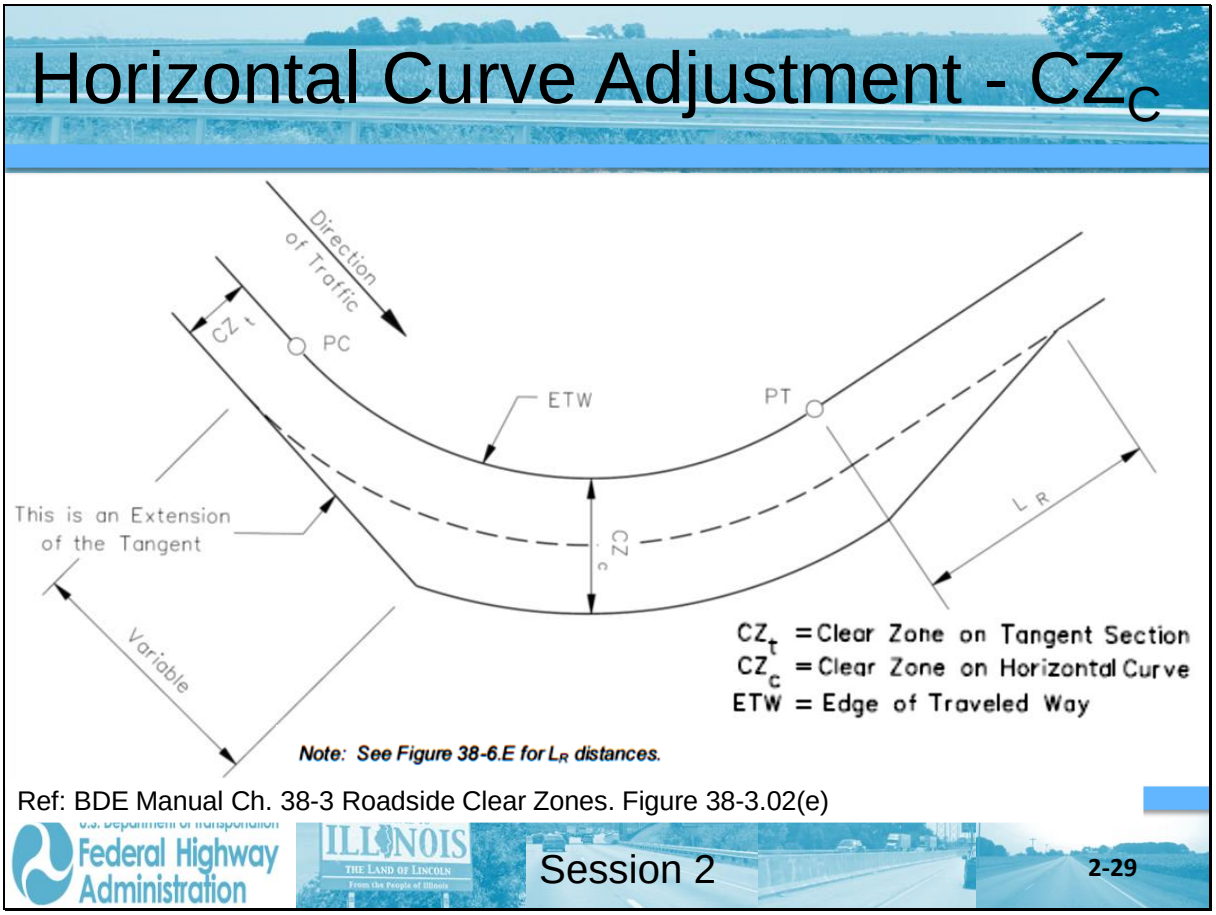
Ref: BDE Manual Ch. 38-3 Roadside Clear Zones

….Curves Present Particular Safety Problems



The risk of a reported crash is about three times greater on a curve than on a tangent

Source: Glennon, et al, 1985 study for FHWA



Ref: BDE Manual Ch. 38-3 Roadside Clear Zones. Figure 38-3.02(e)

Horizontal Curve Adjustment

Illinois ROADSIDE SAFETY October 2014

Radius (ft)	Design Speed (mph)						
	40	45	50	55	60	65	70
2860	1.1	1.1	1.1	1.2	1.2	1.2	1.3
2290	1.1	1.1	1.2	1.2	1.2	1.3	1.3
1910	1.1	1.2	1.2	1.2	1.3	1.3	1.4
1640	1.1	1.2	1.2	1.3	1.3	1.4	1.5
1430	1.2	1.2	1.3	1.3	1.4	1.4	
1270	1.2	1.2	1.3	1.3	1.4	1.5	
1150	1.2	1.2	1.3	1.4	1.5		
950	1.2	1.3	1.4	1.5	1.5		
820	1.3	1.3	1.4	1.5			
720	1.3	1.4	1.5				
640	1.3	1.4	1.5				
570	1.4	1.5					
380	1.5						

Notes:

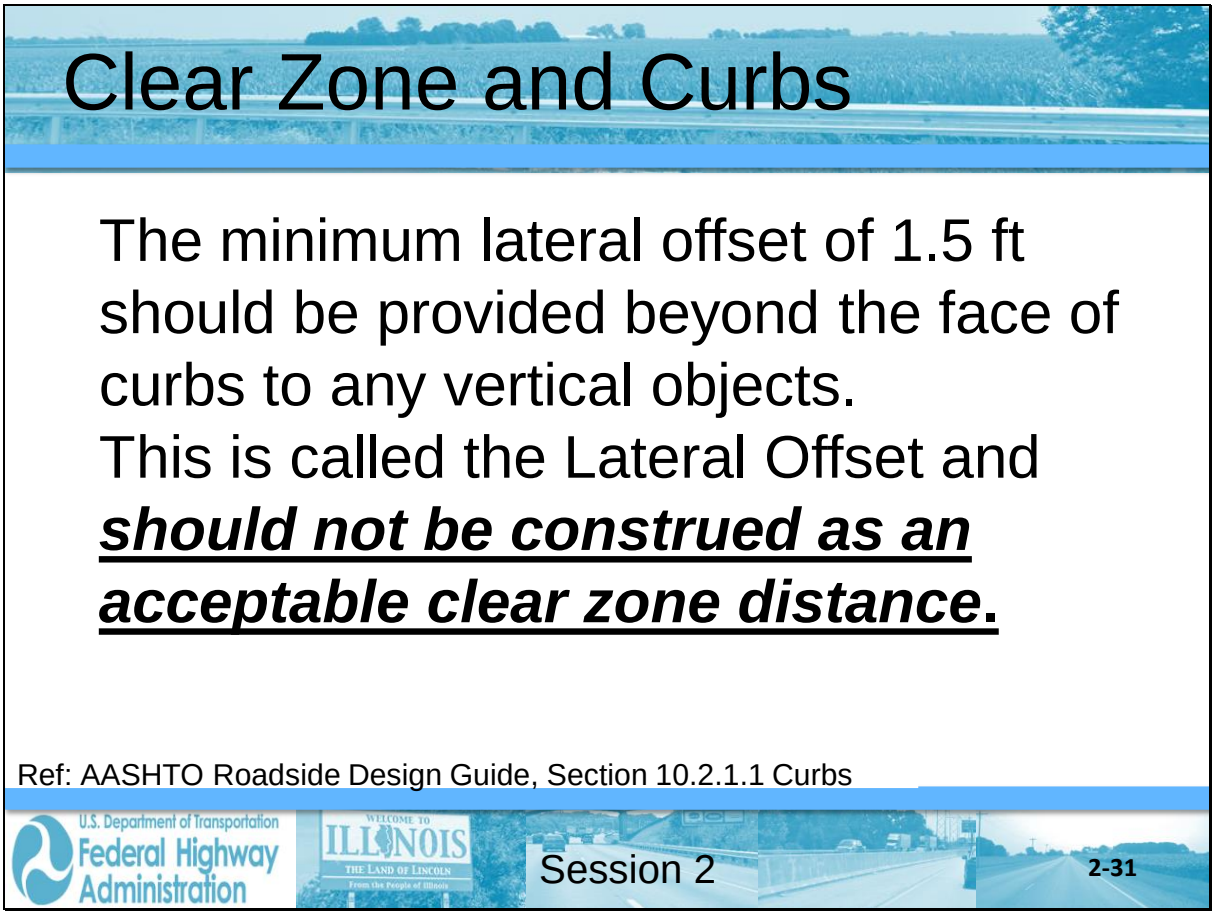
1. *Adjustments apply to the outside of a horizontal curve only.*
2. *No adjustments are warranted for curve radii greater than 2860 ft.*

$$CZ_c = (K_{cz})(CZ_t)$$

Figure 38-3.D

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

Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN | Session 2 | 2-30


Clear Zone and Curbs
The minimum lateral offset of 1.5 ft should be provided beyond the face of curbs to any vertical objects.
This is called the Lateral Offset and
should not be construed as an acceptable clear zone distance.
Ref: AASHTO Roadside Design Guide, Section 10.2.1.1 Curbs
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 2
2-31

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

Clear Zone and Curbs - IDOT

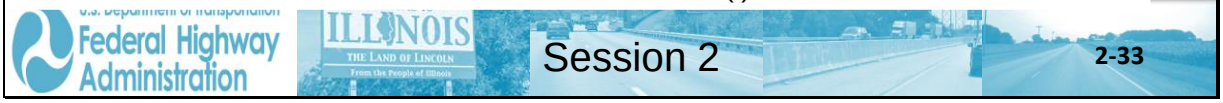
38-3.02(f) Curbed Sections

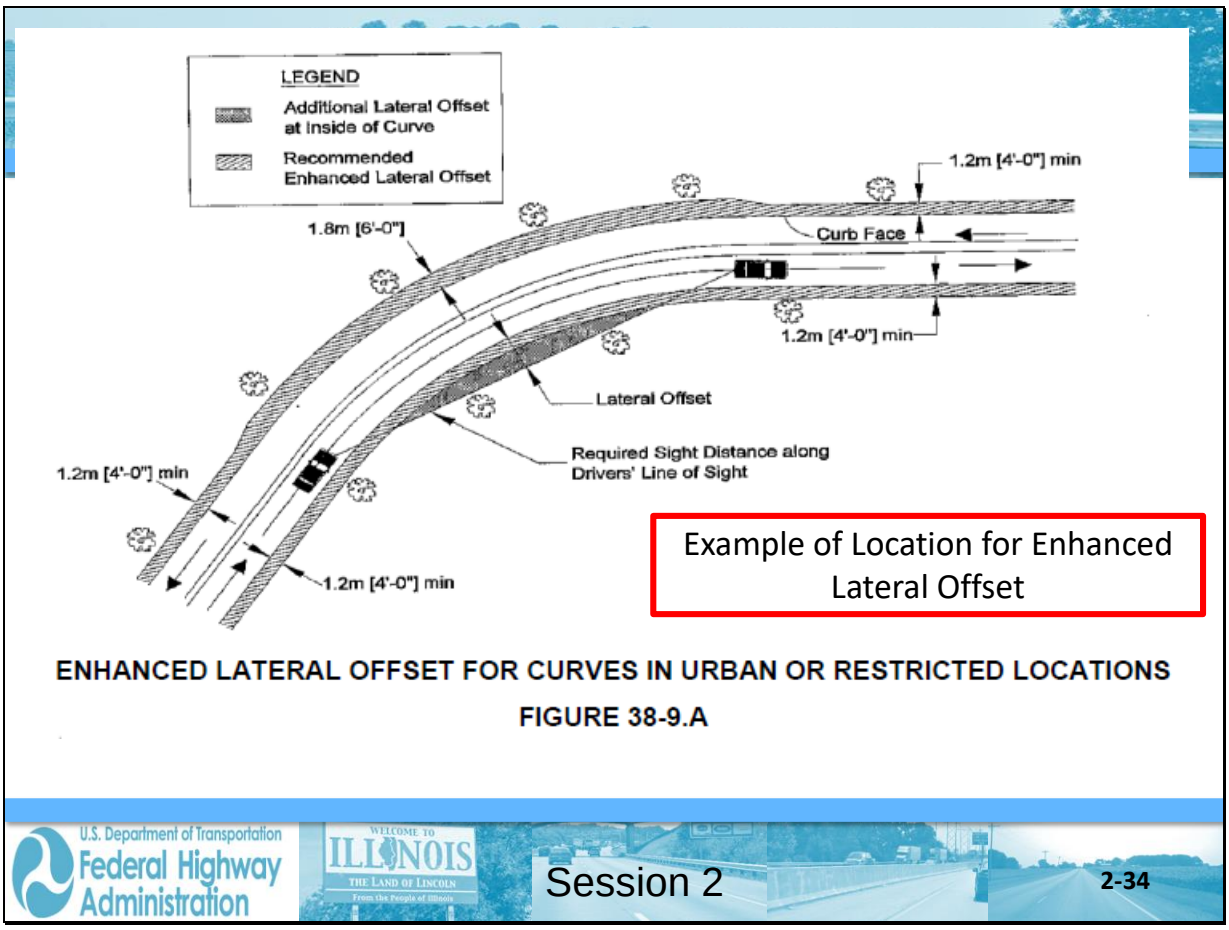
1. Urban/Suburban Facilities. Because curbs do not have re-directional capabilities, except at speeds below 25 mph, the presence of curbs does not affect determination or application of the calculated clear zone value. See Section 38-9 for more discussion of roadside safety for urban cross sections.

38-9 ROADSIDE SAFETY IN URBAN OR RESTRICTED ENVIRONMENTS

Within such areas, the application of open road clear zones may not be practical. This guidance will balance the need for a clear zone with practicality and demonstrated safety benefits in urban and restricted environments.

Ref: BDE Manual Ch. 38-3 Roadside Clear Zones. 38-3.02 (f) Curbed Sections




LEGEND
Additional Lateral Offset at Inside of Curve
Recommended Enhanced Lateral Offset
1.8m [6'-0"]
1.2m [4'-0"] min
Curb Face
1.2m [4'-0"] min
Lateral Offset
Required Sight Distance along Drivers' Line of Sight
1.2m [4'-0"] min
1.2m [4'-0"] min
Example of Location for Enhanced Lateral Offset
ENHANCED LATERAL OFFSET FOR CURVES IN URBAN OR RESTRICTED LOCATIONS
FIGURE 38-9.A
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO ILLINOIS
THE LAND OF LINCOLN
Session 2
2-34

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.


Barriers Must Be
Less of a Hazard
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
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 2
2-36


U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 2
2-37

AASHTO Barrier Guidelines

Obstacle	Guidelines
Bridge piers, abutments, and railing ends	Shielding generally required
Boulders	Judgment decision based on nature of fixed object and likelihood of impact
Culverts, pipes, headwalls	Judgment decision based on size, shape and location of obstacle
Foreslopes and backslopes (smooth)	Shielding not generally required
Foreslopes and backslopes (rough)	Judgment decision based on likelihood of impact
Ditches (parallel)	Refer to Figures 3-6 and 3-7
Ditches (transverse)	Shielding generally required if likelihood of head-on impact is high
Embankment	Judgment decision based on fill height and slope (see Figure 5-1)
Retaining Walls	Judgment decision based on relative smoothness of wall and anticipated maximum angle of impact
Sign/Luminaire supports	Shielding generally required for non-breakaway supports
Traffic signal supports	Isolated traffic signals within clear zone on high-speed rural facilities may warrant shielding
Trees	Judgment decision based on site-specific circumstances
Utility poles	Shielding may be needed on a case by case basis.
Permanent bodies of water	Judgment decision based on location and depth of water and likelihood of encroachment.

Ref: AASHTO Roadside Design Guide, 4th Edition Chapter 5 Table 5-2, Pg. 5-9

Barrier Considerations – IDOT

38-4.01 Examples of Roadside Hazards

- non-breakaway sign supports, non-breakaway luminaire supports, traffic signal poles, and railroad signal poles;
- concrete footings, traffic signal foundations, etc., extending more than 4 in (100 mm) above the ground;
- bridge piers and abutments at underpasses;
- culvert headwalls;
- trees with diameters greater than 4 in (100 mm) (at maturity);
- rough rock cuts;
- large boulder;
- critical parallel slopes (i.e., embankments);
- streams or permanent bodies of water (where the depth of water ≥ 2 ft (600 mm));
- non-traversable ditches
- utility poles or towers;
- drainage appurtenances; and
- transverse slopes.

Ref: BDE Manual, Ch. 38-4.01 Examples of Roadside Hazards


U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 2
2-40

_____

_____

To Shield or Not to Shield

38-4.03 Warrant Methodologies

Warrants for roadside barriers imply that other options higher in the preference order for range of treatments (see Section 38-4.02) have first been considered. Whether objectively or subjectively, the decision will be based upon the traffic volumes, roadway geometry, proximity of the hazard to the traveled way, nature of the hazard, expected crash severity, installation costs and, where applicable, crash experience. The following briefly discusses the Department's decision-making methods for barrier warrants.

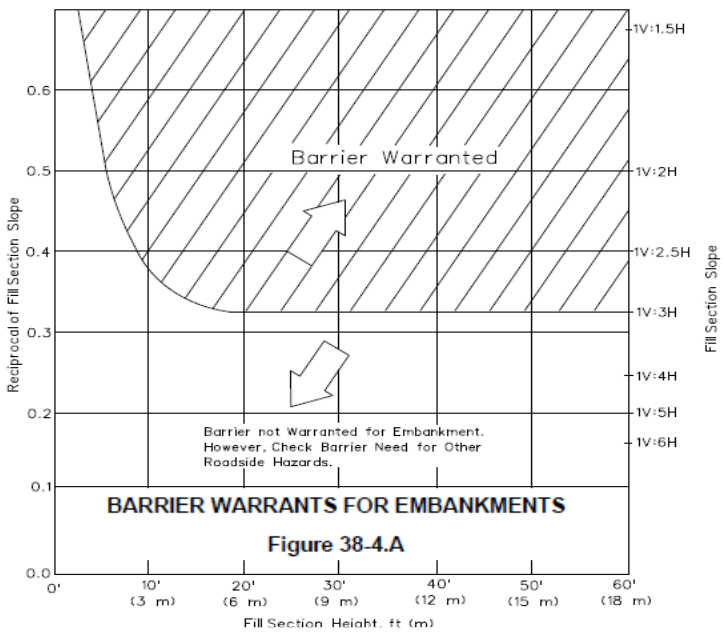
38-4.03(c) Engineering Judgment Method

DOCUMENT

Ref: BDE Manual, Ch. 38-4.03 Warrant Methodologies

Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN | Session 2 | 2-41

Embankment "Warrants"



BARRIER WARRANTS FOR EMBANKMENTS

Figure 38-4.A

Ref: BDE Manual, Ch. 38-4.Barrier Warrants for Embankment – Figure 38-4A

Transverse Embankments

The bridge cones of overhead roadway structures also introduce transverse slopes. Both the transverse slope intersecting the ditch and the transverse slope beyond the ditch, but within the clear zone, should be addressed with the slopes given in Figure 38-4.C.

Type of Facility	Desirable (V:H)	Acceptable (V:H)
Freeway	1:10	1:6
Rural Non-Freeways (V ≥ 50 mph (80 km/h))	1:10	1:6
Urban Non-Freeways (V ≥ 50 mph (80 km/h))	1:6	1:4
Urban and Rural Low-Speed Facilities (V ≤ 45 mph (70 km/h))	1:6	1:4

RECOMMENDED TRANSVERSE SLOPES

Figure 38-4.C

38-4.05 Transverse Slopes

Ref: BDE Manual, Ch. 38-4.05 Traverse Slopes

Federal Highway Administration

ILLINOIS THE LAND OF LINCOLN

Session 2

2-43

_____

_____

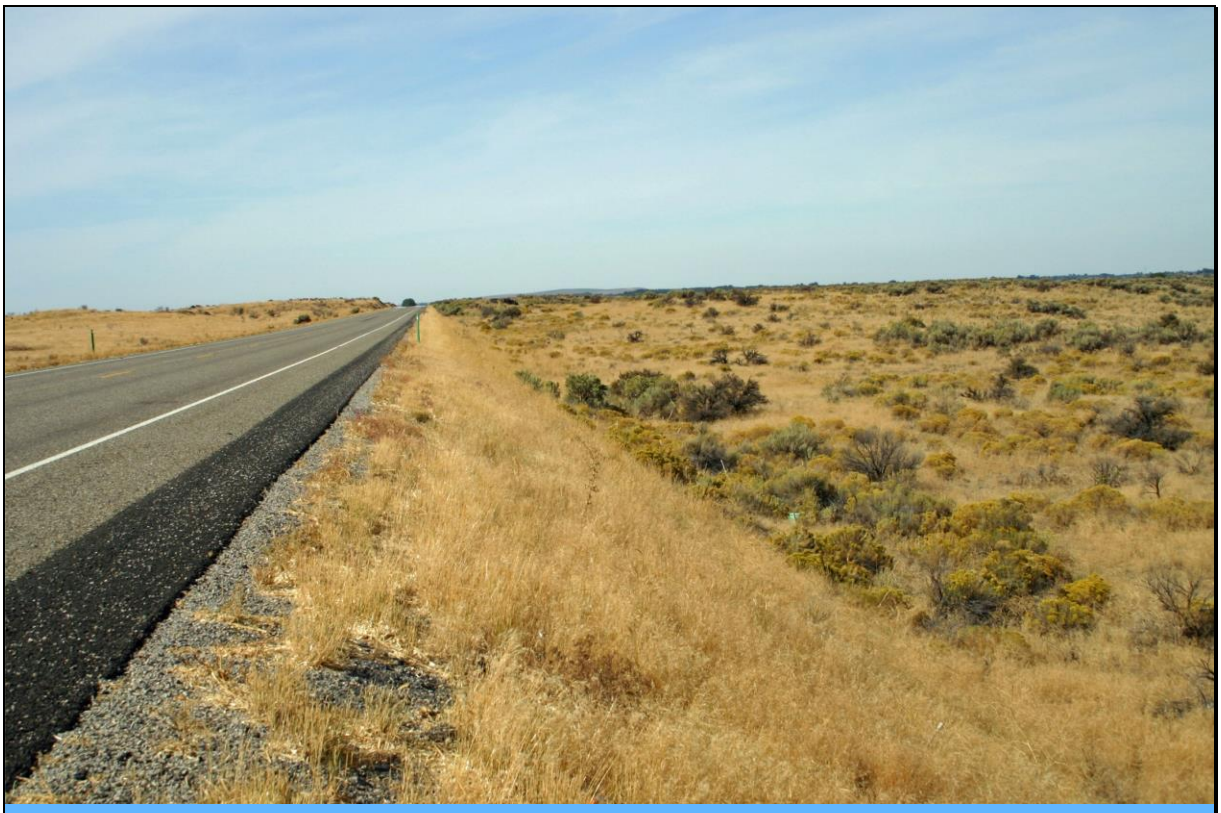
Is barrier warranted at the eight locations shown in the next photos?

Do not consider effectiveness of existing barrier (if any).

U.S. Department of Transportation Federal Highway Administration

Session 2

2-44



U.S. Department of Transportation Federal Highway Administration

Session 2

2-45


U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 2
2-46

_____

_____


U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 2
2-47

_____

_____


EXIT 134A
55
SOUTH
St Louis
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
Session 2
2-48

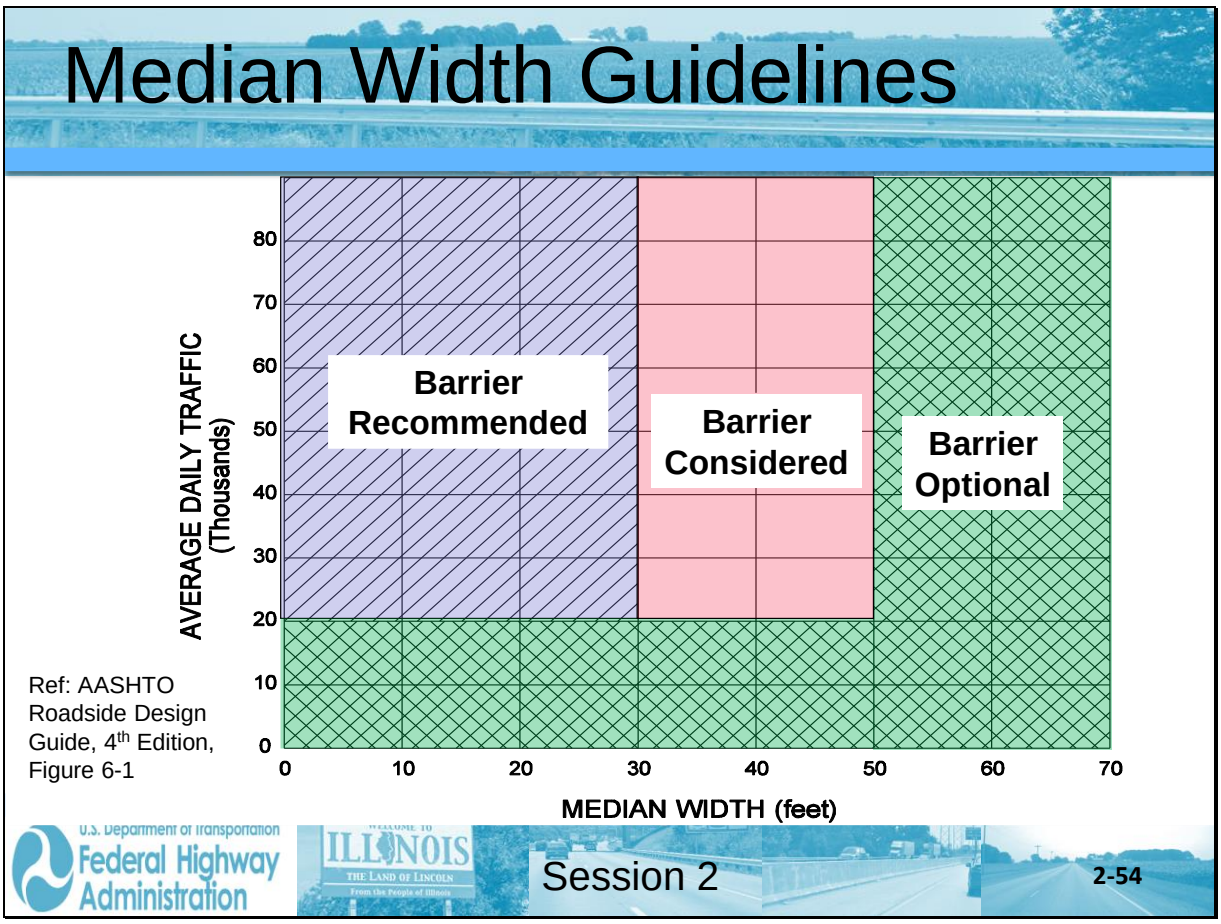

U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
Session 2
2-49


U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
Session 2
2-50


U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
Session 2
2-51


U.S. Department of Transportation
Federal Highway Administration
Session 2
2-52

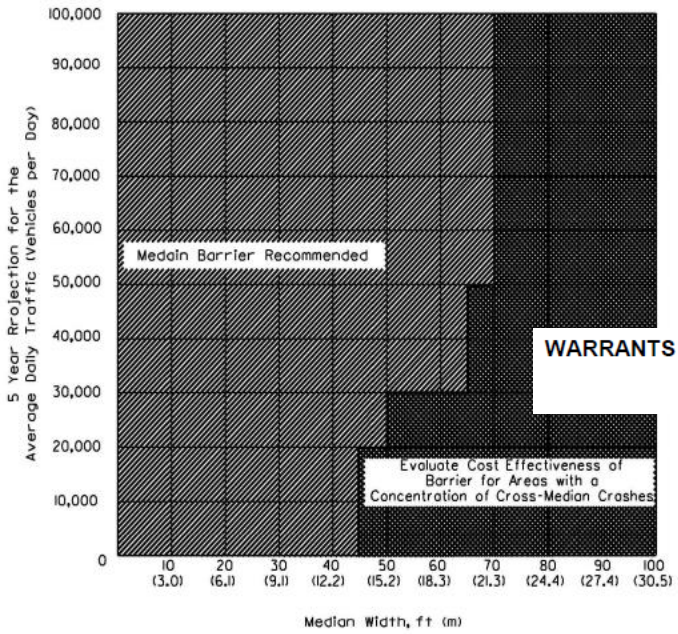

SPEED
LIMIT
50
U.S. Department of Transportation
Federal Highway Administration
Session 2
2-53


Median Width Guidelines
AVERAGE DAILY TRAFFIC (Thousands)
80
70
60
50
40
30
20
10
0
Barrier Recommended
Barrier Considered
Barrier Optional
0
10
20
30
40
50
60
70
MEDIAN WIDTH (feet)
Ref: AASHTO Roadside Design Guide, 4th Edition, Figure 6-1
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
THE LAND OF LINCOLN
Session 2
2-54

_____

_____

Median Width Guidelines - IDOT



WARRANTS FOR MEDIAN BARRIERS ON FREEWAYS

Figure 38-7.B

Ref: BDE Manual, Ch. 38-7.Figure 38-7.B

Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN | Session 2 | 2-55

Medians – Object

38-8.02 Warrants

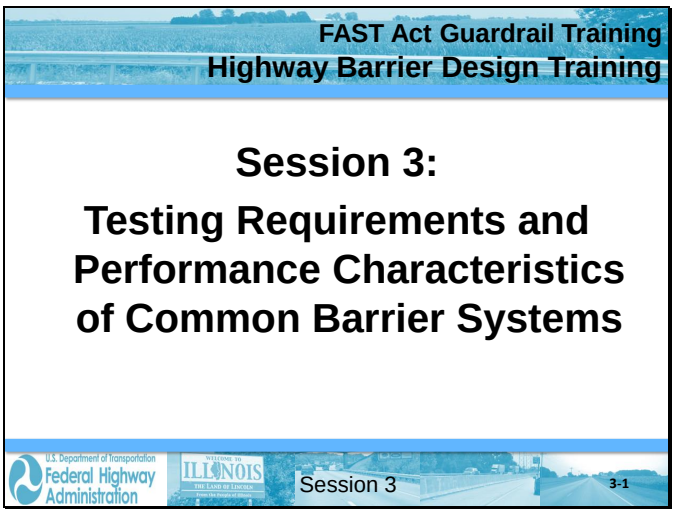
For median widths of 84 ft (26 m) or less, all piers, sign foundations, and similar hazards in medians of divided highways warrant shielding. For median widths greater than 84 ft (26 m), the need should be considered on a case-by-case basis.

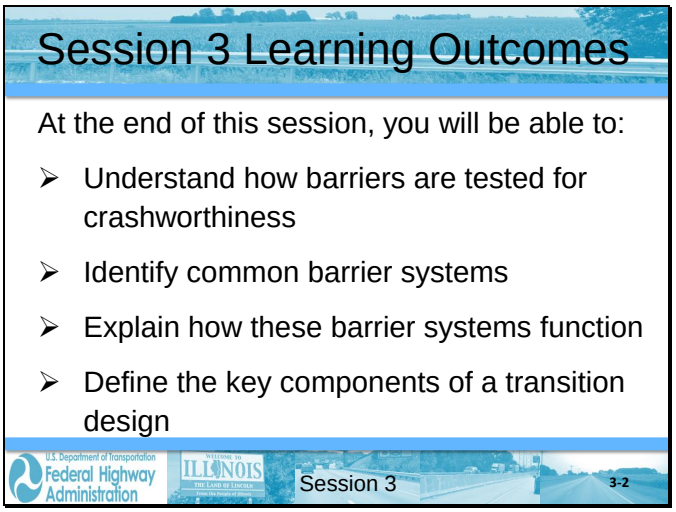
Ref: BDE Manual, Ch. 38-8.02 Warrants

Review Learning Outcomes

- Understand and apply the clear zone concept
- Identify objects and features that may require shielding

Session 3: Testing Requirements and Performance Characteristics of Common Barrier Systems


FAST Act Guardrail Training
Highway Barrier Design Training
Session 3:
Testing Requirements and Performance Characteristics of Common Barrier Systems
U.S. Department of Transportation
Federal Highway Administration
Session 3
3-1


Session 3 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
U.S. Department of Transportation
Federal Highway Administration
Session 3
3-2

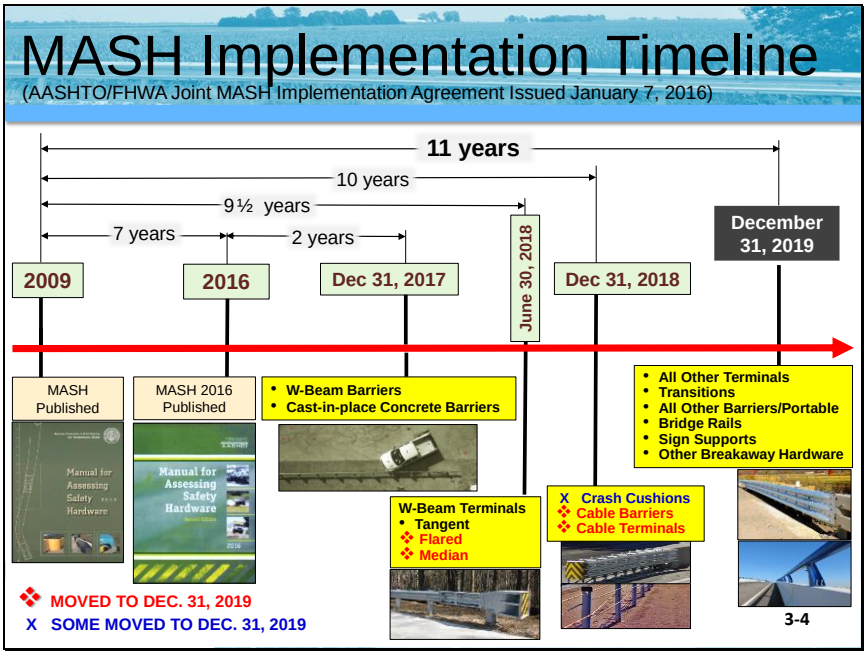
Crash Testing Guidelines

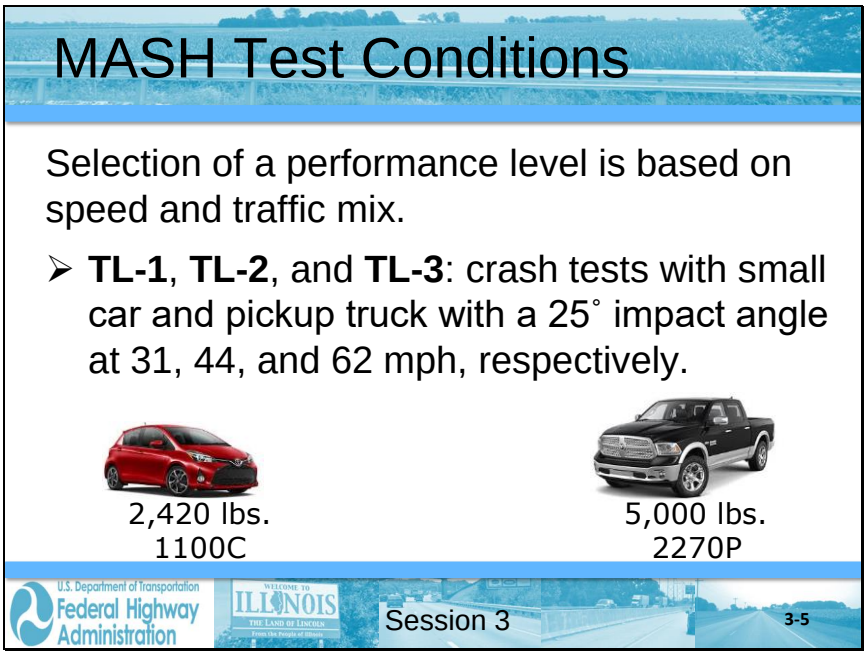
- In 1993, crash testing and evaluation criteria were published as NCHRP Report 350
- In 2009, the Manual for Assessing Safety Hardware (MASH) was published by AASHTO. It was used by FHWA as the testing standard for all new products
- In 2016, an update to MASH was adopted and a timetable for implementation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

U.S. Department of Transportation Federal Highway Administration

Session 3

3-3


MASH Implementation Timeline
(AASHTO/FHWA Joint MASH Implementation Agreement Issued January 7, 2016)
11 years
10 years
9½ years
7 years
2 years
2009
2016
Dec 31, 2017
June 30, 2018
Dec 31, 2018
December 31, 2019
MASH Published
MASH 2016 Published
W-Beam Barriers
Cast-in-place Concrete Barriers
All Other Terminals
Transitions
All Other Barriers/Portable
Bridge Rails
Sign Supports
Other Breakaway Hardware
W-Beam Terminals
Tangent
Flared
Median
X Crash Cushions
Cable Barriers
Cable Terminals
MOVED TO DEC. 31, 2019
X SOME MOVED TO DEC. 31, 2019
3-4


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
U.S. Department of Transportation
Federal Highway Administration
Session 3
3-5

NCHRP 350 comparison with MASH Crew Cab Truck

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 3 | 3-6

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.

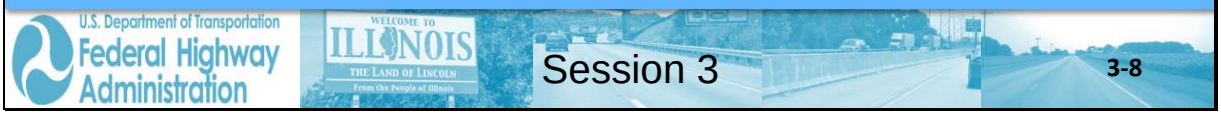
80,000 lbs.

80,000 lbs.

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 3 | 3-7

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



IDOT Positions

38-5 ROADSIDE BARRIERS

The FHWA requires roadside safety hardware used on the National Highway System (NHS) to be crashworthy. IDOT then extends this requirement to all State jurisdiction routes for consistency.

38-5.01(e) Other Systems

Many other roadside barrier systems are available which may have application at specific sites (e.g., thrie-beam guardrail). The designer should reference the latest edition of the AASHTO *Roadside Design Guide* for information on these systems. Both BDE and BSPE must approve the use of any system not included on one of the several QPLs or in the *Illinois Highway Standards*.

Ref: BDE Manual Ch. 38-5 Roadside Barriers

Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN | Session 3 | 3-9

_____

_____

Standard Barrier Systems

- Rigid Systems
- Semi-Rigid Systems
- Flexible Systems
- Median Barrier Systems

U.S. Department of Transportation Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN | Session 3 | 3-10

_____

_____

_____

_____

_____

_____

Barrier Systems: Rigid Barriers

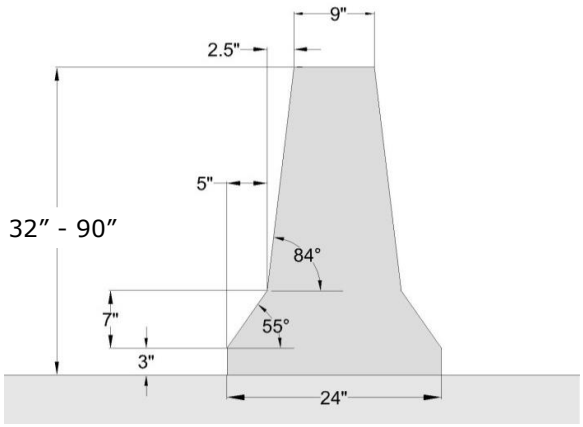
Rigid Barrier Systems have little (between 0 to 1 ft.) deflection under the TL-3 pickup impact. They are generally anchored by some acceptable means.

Examples include:

- New Jersey Safety Shape Concrete Barrier
- F-shape Concrete Barrier
- Single Slope Concrete Barrier
- Vertical Wall

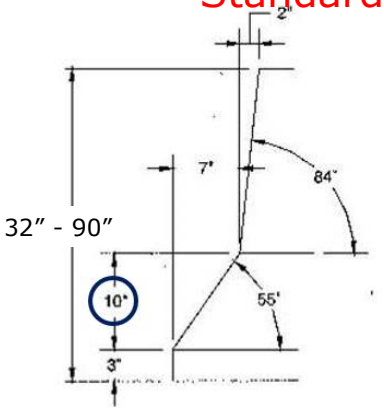
Rigid Barrier - Historical

Previous Standard



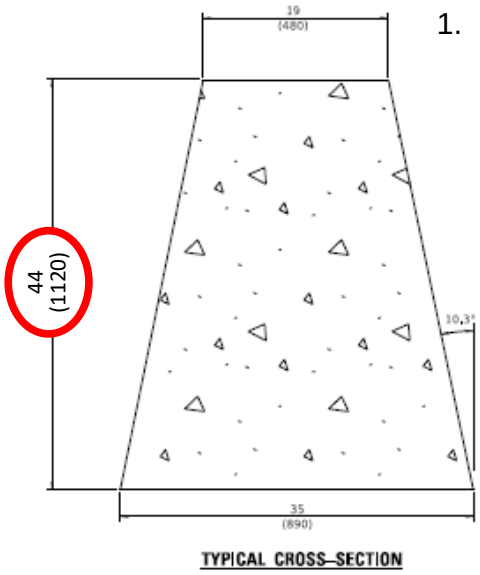
F-Shape

Really Previous Standard



NJ Shape

Rigid Barrier – Current



TYPICAL CROSS-SECTION

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

Federal Highway Administration

ILLINOIS
THE LAND OF LINCOLN

Session 3

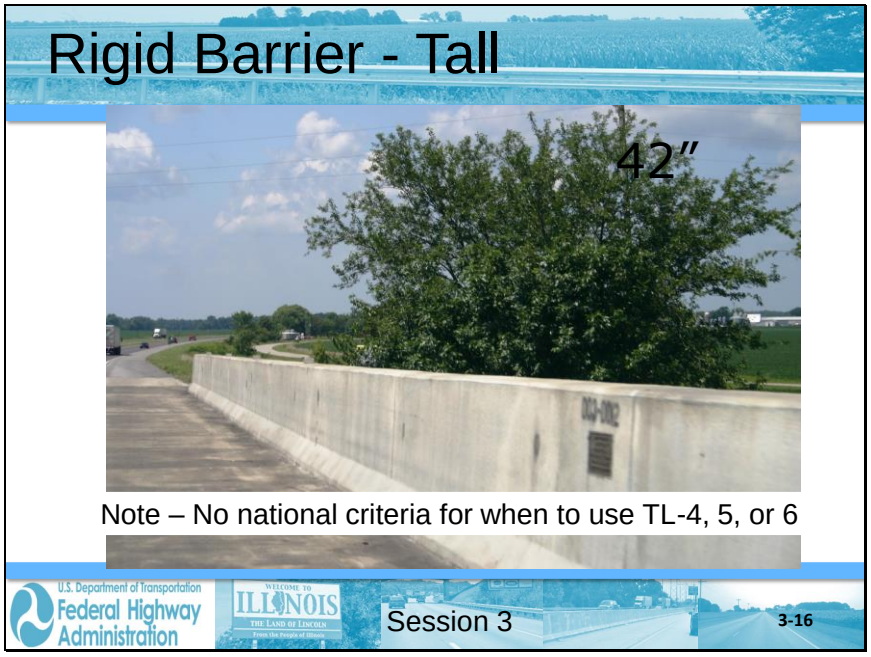
3-13

Rigid Barrier – Roadside Use

38-5.01(b) Concrete Barrier (Rigid Type)

For use of concrete barrier as a roadside barrier (i.e. a single faced barrier), the standard single slope shape should be used along the traffic side with a vertical face on the back. Backfill behind the barrier for lateral support (retaining wall design) or use a special footing design (e.g., barrier tied to a concrete footing with reinforcing steel). Contact BSPE for design parameters.

Ref: BDE Manual Ch. 38-5 Roadside Barriers


Rigid Barrier - Tall
42″
Note – No national criteria for when to use TL-4, 5, or 6
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 3
3-16


Rigid Barrier – 44” Single Slope
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 3
3-17


Rigid Barrier: TL-5 Test video
Video Clip
U.S. Department of Transportation
Federal Highway Administration
Session 3
3-18


Use of a vertical barrier may be appropriate: Limit lift and space
U.S. Department of Transportation
Federal Highway Administration
Session 3
3-19

Barrier Systems: Semi-Rigid

Semi-Rigid Barrier Systems have deflections of a few feet (between 2 to 5 ft.) under the TL-3 pickup impact.

Typically consist of beam and post elements.

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 ¾”
  - Rail splice at the post.
  - Typically one post:
    - Steel, W6 x 9 x 6’- 0” long.
  - Blockouts: 6” x 8” wood or plastic.


27” with Wood Post & Wood Block-Out 27 5/8” Height
Video Clip
Failed Test!!!
Federal Highway Administration
Session 3
3-22


27” with Steel Post & Wood Block-Out 27 5/8” Height
Video Clip
Federal Highway Administration
Session 3
3-23

Raising Guardrail

- MASH Tested
- Raised Blockout up on post (steel)
- Tested with a height of 28” (raised from 24”)
- Caution higher than 29”

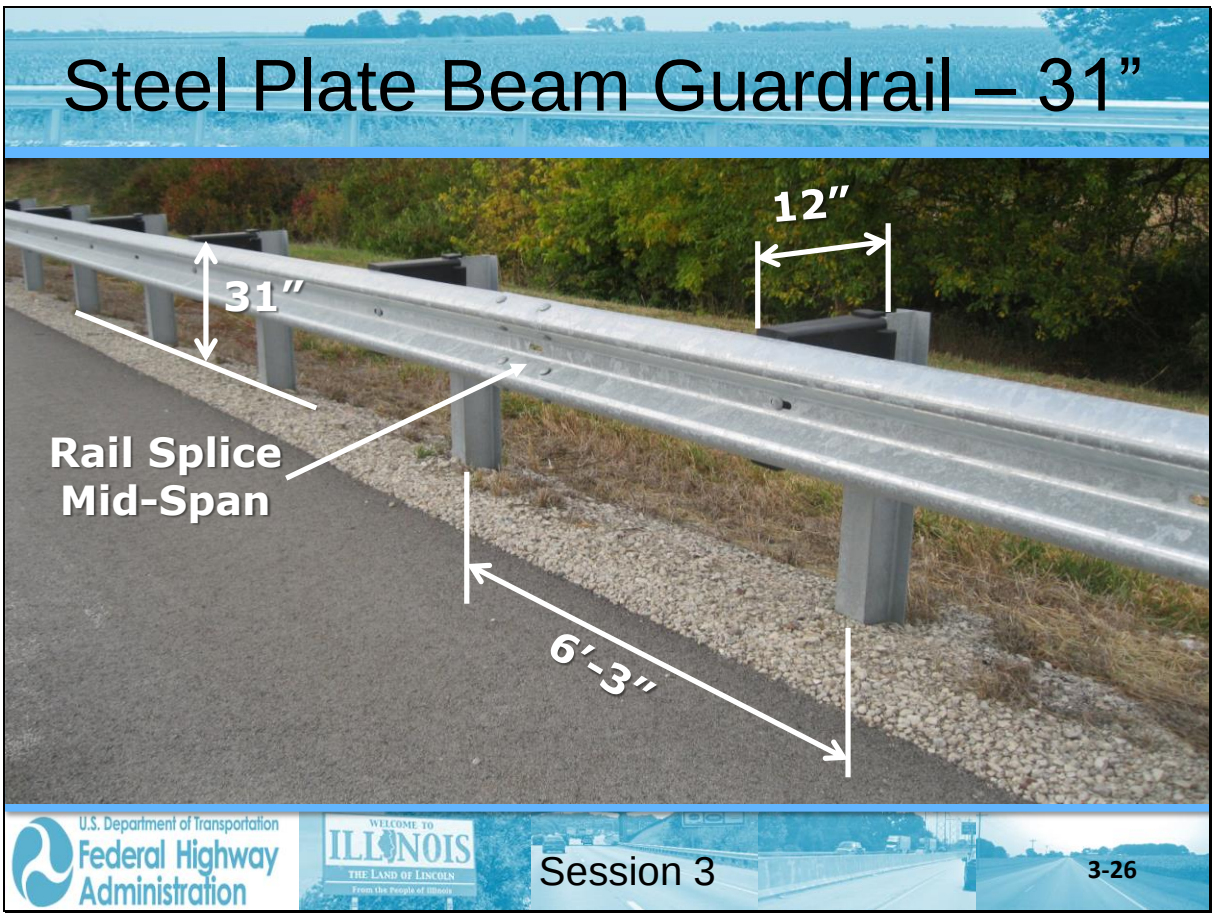
NOT an IDOT Standard
Contact BSPE

3-24

Barrier Systems: Semi-Rigid

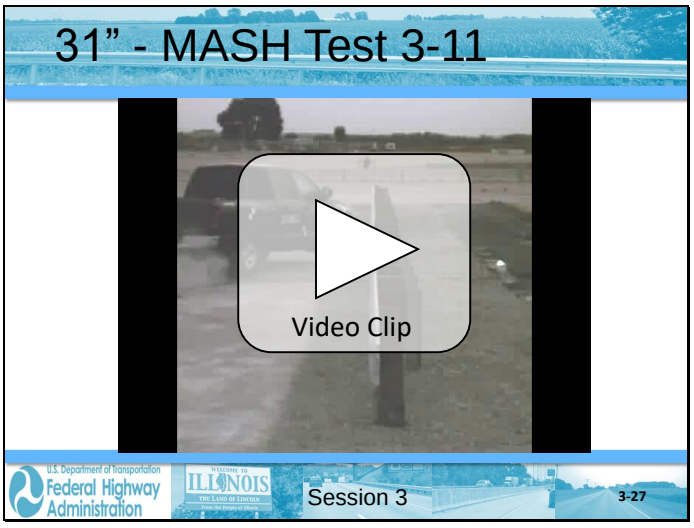
- Steel Plate Beam Guardrail (MGS) – 31”
  - 31” Height
  - Rail Splice mid-span.
  - Post spacing 6’-3”
  - Two post options:
    - Steel posts, W6 x 8.5/9.0 x 6’
    - Wood posts, 6” x 8” x 6’
    - Blockouts: 12” wood or composite

U.S. Department of Transportation Federal Highway Administration
Session 3
3-25


Steel Plate Beam Guardrail – 31”
12”
31”
Rail Splice
Mid-Span
6’-3”
U.S. Department of Transportation
Federal Highway Administration
Session 3
3-26

_____

_____


31” - MASH Test 3-11
Video Clip
U.S. Department of Transportation
Federal Highway Administration
Session 3
3-27

_____

_____

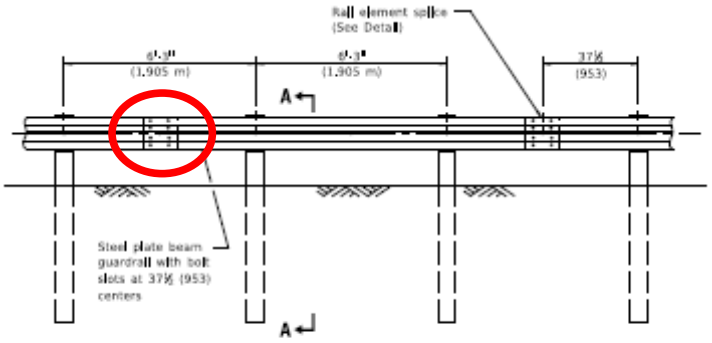
_____

_____

_____

_____

IDOT 31” Standard



ELEVATION

TYPE A

6'-3" (1,905 m) Typical post spacing

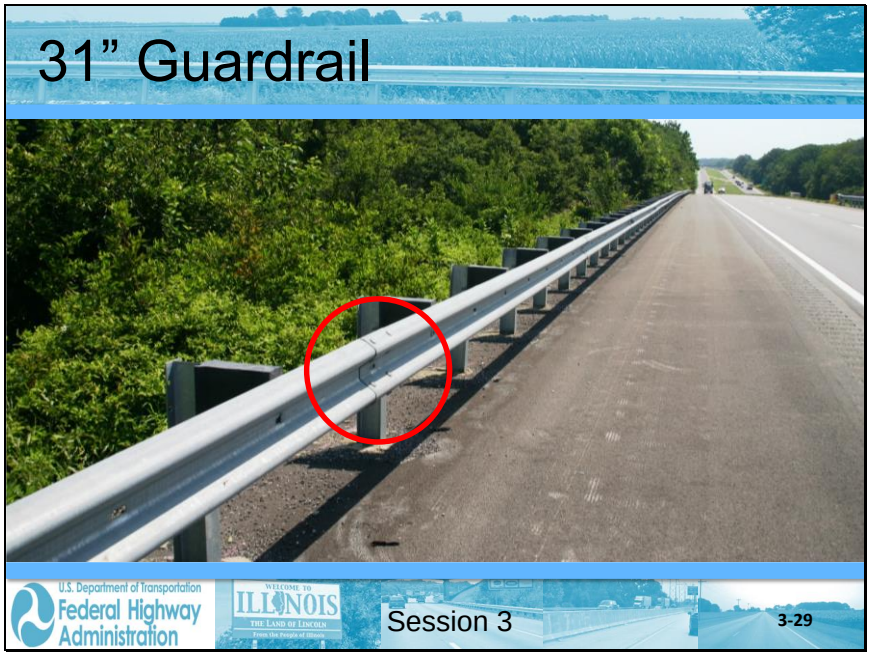
STEEL PLATE BEAM GUARDRAIL (Sheet 1 of 4)
STANDARD 630001-12

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

U.S. Department of Transportation Federal Highway Administration

Session 3

3-28


31” Guardrail
U.S. Department of Transportation
Federal Highway Administration
Session 3
3-29


Existing Guardrail Height
Must be ≥ 27” to remain in place
U.S. Department of Transportation
Federal Highway Administration
Session 3
3-30

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)

Barrier Systems: Flexible Barriers

Advantages of cable systems include:

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

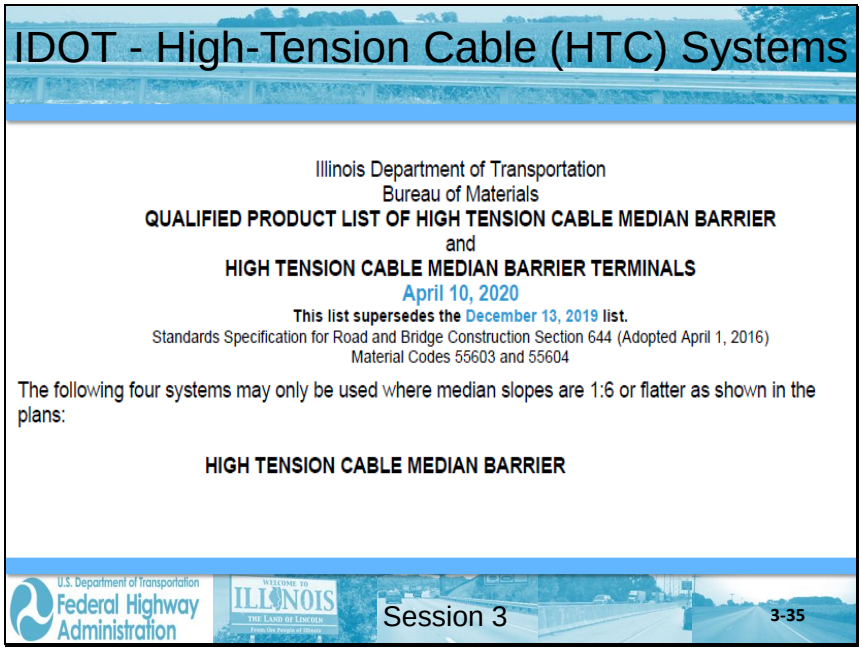
Barrier Systems: Flexible Barriers

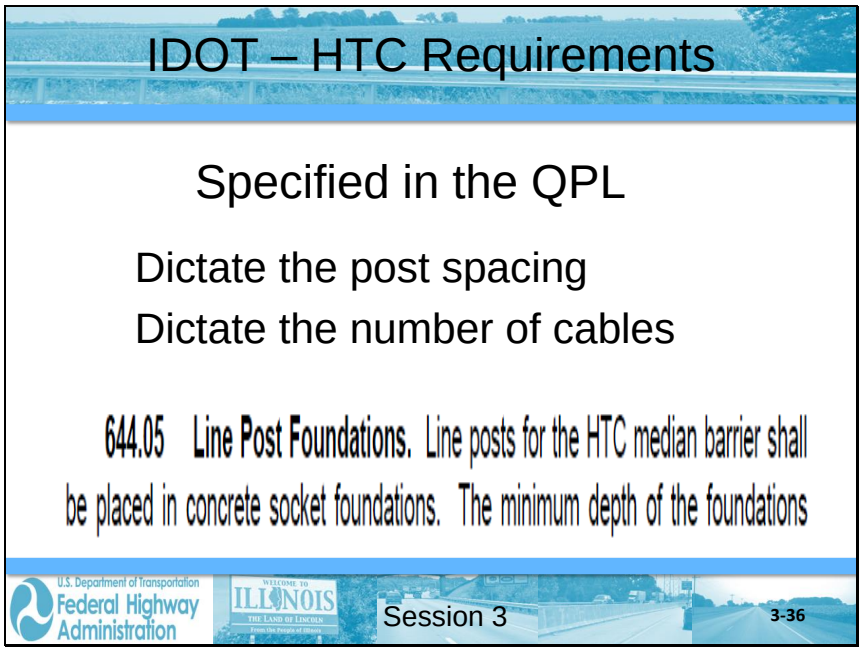
- High Tensioned Cable (HTC) Barrier
  - Five different proprietary designs available
  - Each requires a unique proprietary terminal
  - Somewhat reduced deflections
  - Generally easier maintenance
  - Can retain effectiveness after most impacts

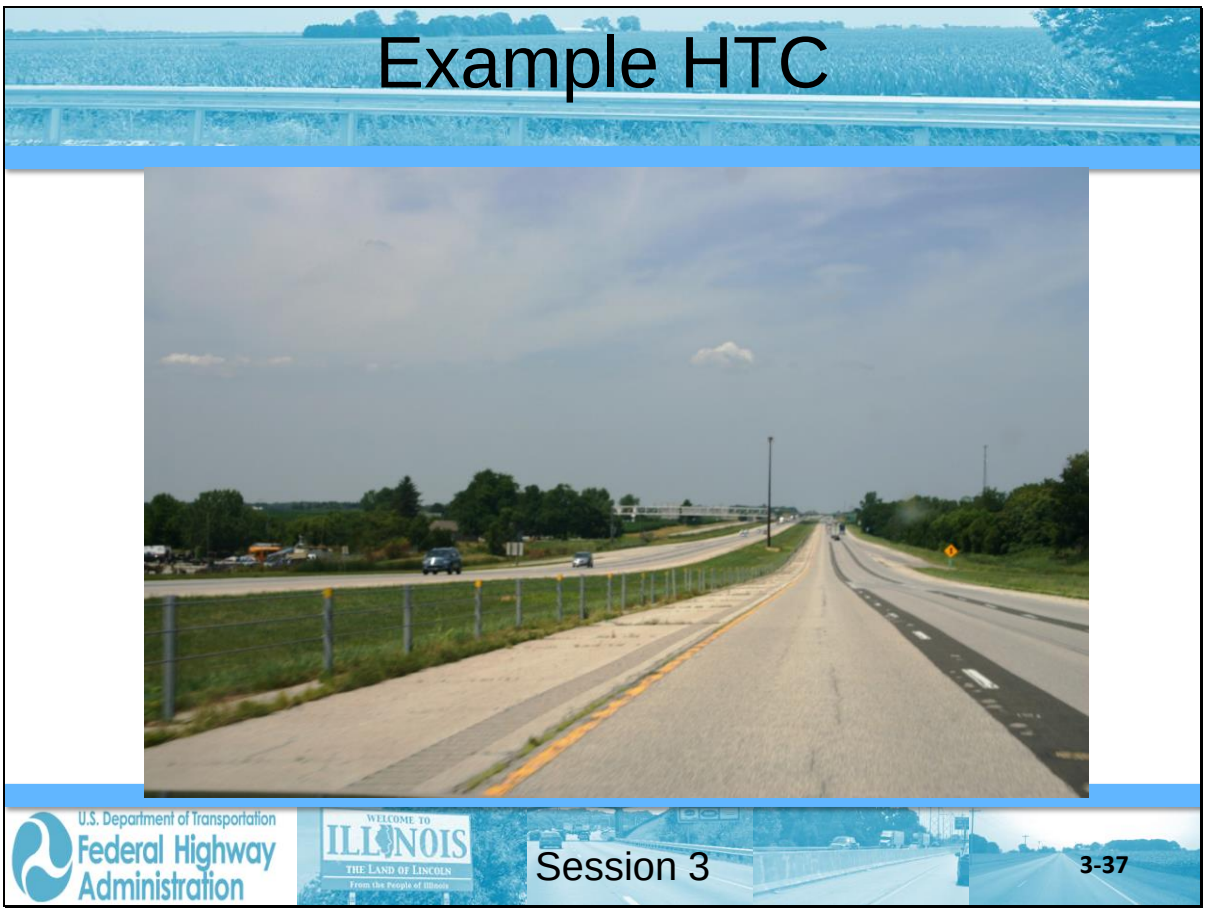
High Tension Cable (HTC) Systems

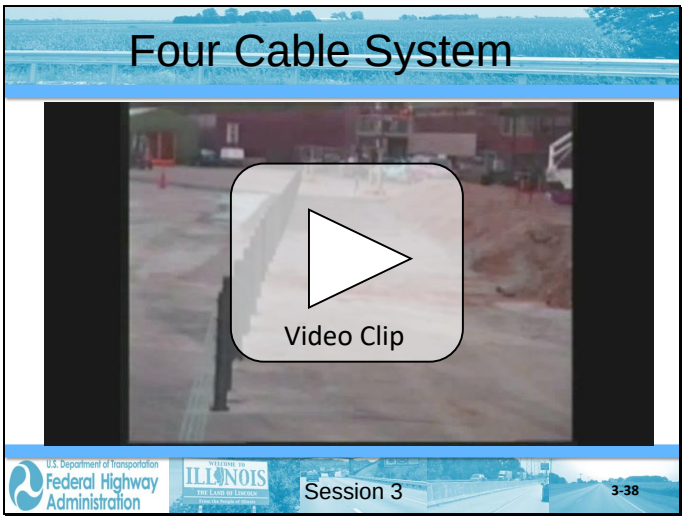
★ = On IDOT QPL

- ★ Brifen
- Safence
- ★ CASS (Trinity Steel)
- ★ Nucor
- ★ Gibraltar

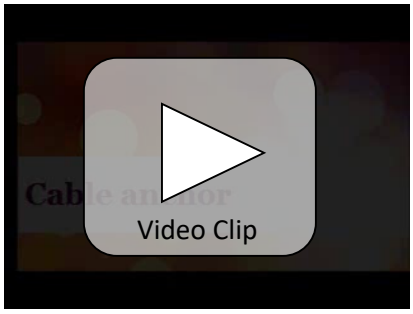

IDOT - High-Tension Cable (HTC) Systems
Illinois Department of Transportation
Bureau of Materials
QUALIFIED PRODUCT LIST OF HIGH TENSION CABLE MEDIAN BARRIER
and
HIGH TENSION CABLE MEDIAN BARRIER TERMINALS
April 10, 2020
This list supersedes the December 13, 2019 list.
Standards Specification for Road 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
U.S. Department of Transportation
Federal Highway Administration
Session 3
3-35


IDOT – HTC Requirements
Specified in the QPL
Dictate the post spacing
Dictate the number of cables
644.05 Line Post Foundations. Line posts for the HTC median barrier shall be placed in concrete socket foundations. The minimum depth of the foundations
U.S. Department of Transportation
Federal Highway Administration
Session 3
3-36


Example HTC
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 3
3-37


Four Cable System
Video Clip
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 3
3-38

Post Foundation and Typical Terminal

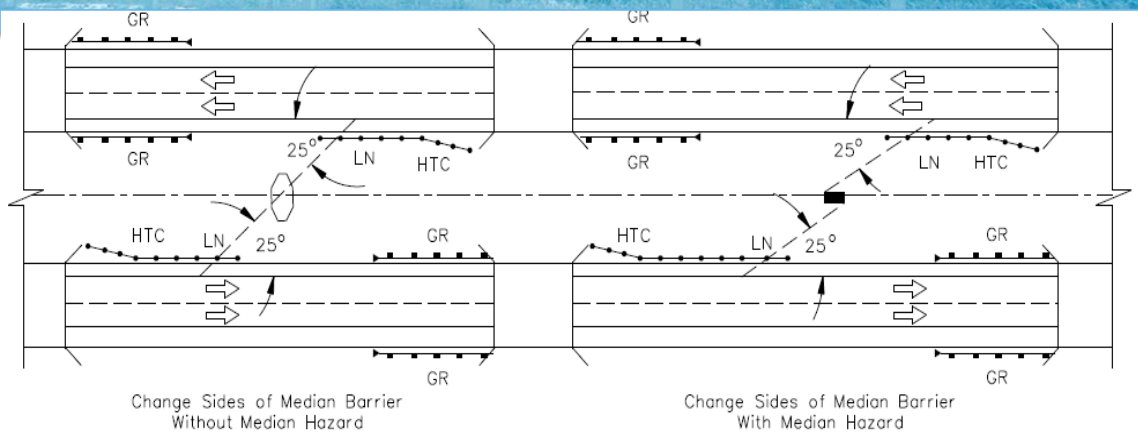


U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln
Session 3
3-39

HTC On 4:1 Slope

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln
Session 3
3-40

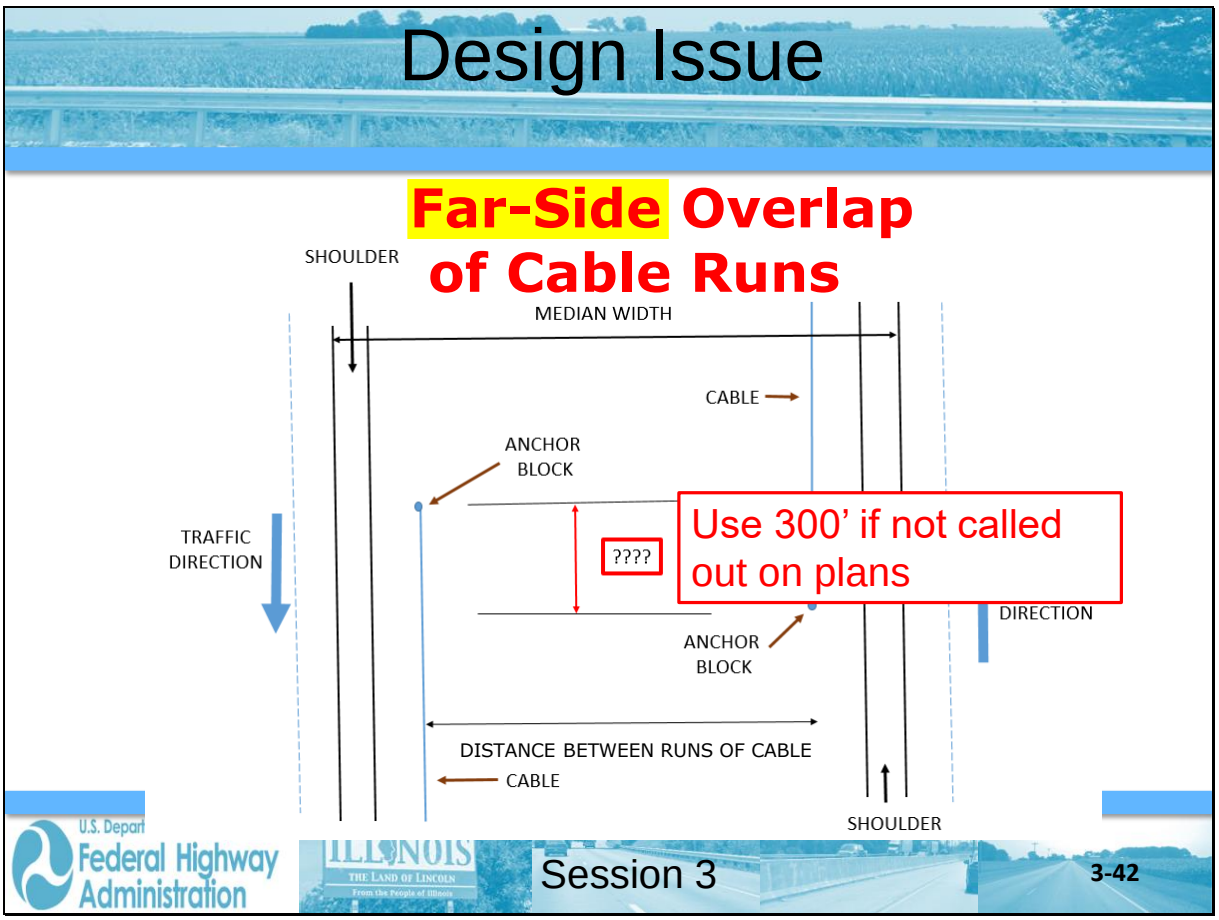
Design Issue



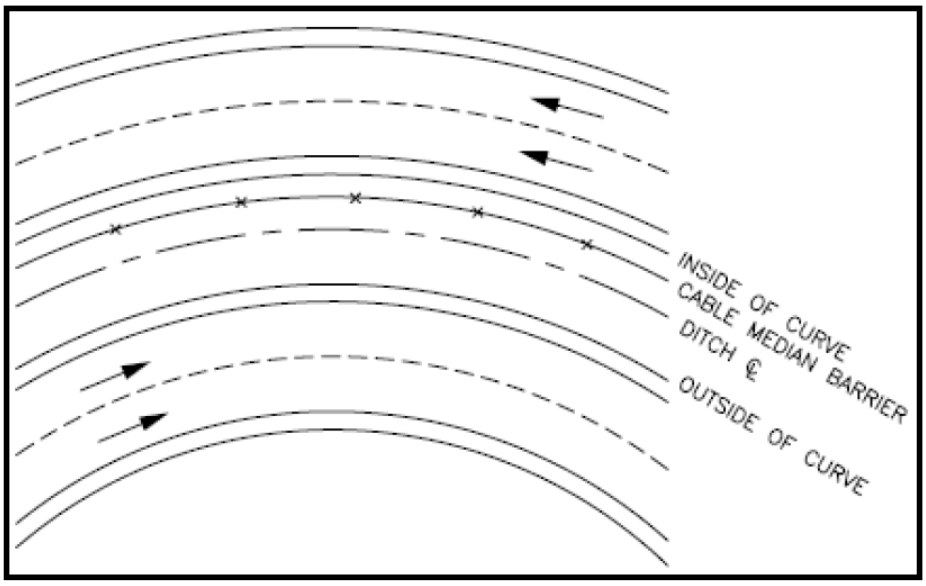
LN = Length of Need Point
GR = Guardrail
HTC = High Tension Cable

COORDINATION OF HIGH TENSION CABLE WITH STRUCTURES AND CROSSOVERS

Figure 38-7.E


Design Issue
Far-Side Overlap of Cable Runs
SHOULDER
MEDIAN WIDTH
CABLE
ANCHOR BLOCK
TRAFFIC DIRECTION
????
Use 300' if not called out on plans
DIRECTION
ANCHOR BLOCK
DISTANCE BETWEEN RUNS OF CABLE
CABLE
SHOULDER
U.S. Depart
Federal Highway Administration
ILLINOIS
THE LAND OF LINCOLN
Session 3
3-42

Which Side of the Median Should Cable Barrier be Placed?



U.S. Department of Transportation Federal Highway Administration

Session 3

3-43

_____

_____

Barrier Selection – IDOT Guidance

System	Advantages	Disadvantages	Typical Usage
High Tension Cable Barrier	1. Lower initial cost. 2. More forgiving impact. 3. Weak-post systems maintain vehicle stability. 4. Relatively easy installation. 5. Remains functional after moderate collisions. 6. Some systems have features that make repair more efficient. 7. Minimizes snow drifting.	1. Larger deflection spaces needed. 2. Less likely to contain large vehicles than concrete barrier, although the systems used by IDOT have passed Test Level 4 (single-unit truck crash test) on slopes of 1:6 or flatter. 3. Some potential for vehicles to under ride the barrier. 4. Cannot be used in conjunction with curbing. 5. Any impact requires repair.	1. Non-freeways. 2. Rural freeways. 3. Side hazards where deflection space is adequate and a Test Level 4 barrier is preferred.
W-Beam Guardrail	1. Lower initial cost. 2. High level of familiarity by maintenance personnel. 3. Can safely accommodate a wide range of impact conditions for passenger vehicles. 4. Relatively easy installation. 5. Remains functional after nuisance collisions. 6. Can be used in conjunction with curbing.	1. Less likely to contain large vehicles than concrete barrier or cable barrier. 2. At high-impact locations, will require frequent maintenance. 3. Will cause more snow drifting than cable barrier. 4. Hits that redirect or contain vehicles will require repair.	1. Non-freeways with narrow medians. 2. Rural freeways. 3. Side hazards where deflection space is adequate.
Concrete Barrier	1. Can accommodate most vehicular impacts without penetration. 2. No deflection distance required behind barrier. 3. Little or no damage sustained for most vehicular impacts; therefore, least need for maintenance. 4. Minimal vehicular under ride/ override potential for snagging potential.	1. Highest initial cost. 2. For given impact conditions, highest occupant decelerations; therefore, least forgiving of barrier systems 3. Reduced performance where offset between traveled way and barrier exceeds 12 ft (3.6 m). 4. Usually requires subsurface drainage. 5. Increased snow drifting.	1. Urban freeways. 2. Where very high traffic volumes are present. 3. Where high volumes of large vehicles are present. 4. Narrow medians.

ROADSIDE BARRIER SELECTION

Figure 38-5.A

One of several Examples of Use guidance

U.S. Department of Transportation Federal Highway Administration

WELCOME TO ILLINOIS THE LAND OF LINCOLN From the People of Illinois

Session 3

3-44

Barrier Selection – IDOT Guidance

38-5.02 Barrier Selection

1. Test Levels. The designer should consider the expected speeds and vehicle composition when selecting a test level for a barrier. Barriers that have passed Test Level 3 criteria are required on high-speed roadways (design speeds higher than 45 mph [70 km/hr]). There is no Test Level defined for speeds higher than 60 mph (100 km/hr) and studies of crashes have shown that Test Level 3 is adequate for the typical mix of vehicles where the design speed is higher than 60 mph (100 km/hr). However, if the objective is a higher probability of containing large trucks or commercial passenger vehicles such as buses, a barrier that has passed Test Level 4 or 5 may be appropriate. Barriers tested at Test Level 2 may be appropriate for roadways where the design speed is 45 mph (70 km/hr) or less and this is judged to represent the typical roadway operating speed.

Ref: BDE Manual Ch. 38-5 Roadside Barriers

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.

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln From the People of Illinois
Session 3
3-46

_____

_____

MASH Median Barrier Test

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln
Session 3
3-47

_____

_____

_____

_____

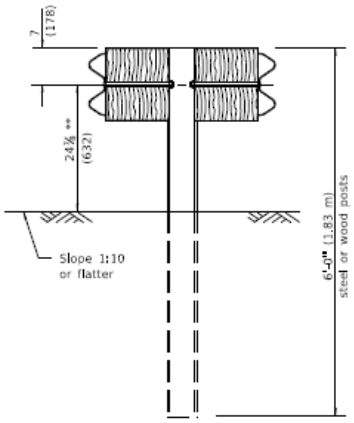
_____

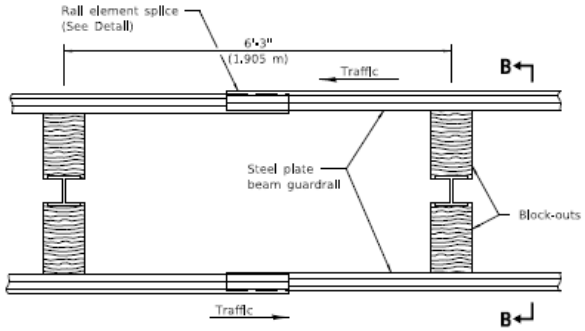
_____

_____

MASH 31” Median Barrier Test

31” Median Guardrail





PLAN

TYPE D
Double steel plate beam guardrail
6'-3" (1,905 m) typical post spacing

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.

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln
Session 3
3-50

Flexible Median Barriers

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln
Session 3
3-51

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.

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois – The Land of Lincoln
Session 3
3-52

_____

_____

Inadequate Transition

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois – The Land of Lincoln
Session 3
3-53

_____

_____

_____

_____

_____

_____

_____

Transition Sections

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

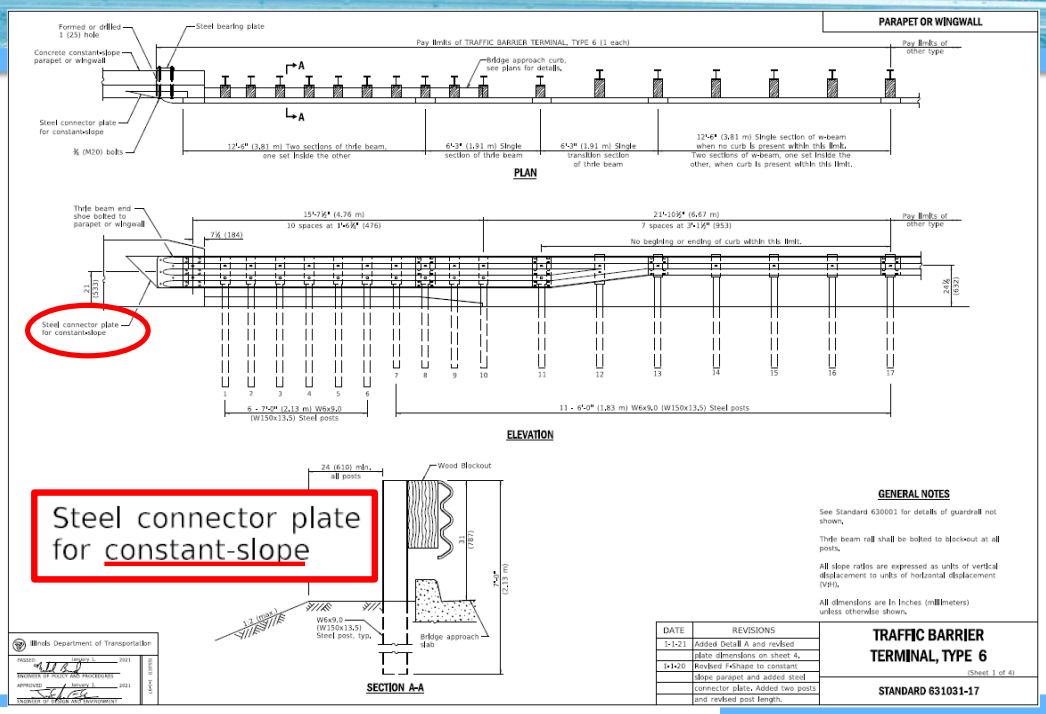
- Additional and/or Larger Posts
- Nested rail (w-beam or Thrie-beam)
- Curbs (only as crash-tested transition unit), Rub Rails, and/or Flared Parapet Wall to Prevent Snagging

U.S. Department of Transportation Federal Highway Administration
Session 3
3-54

27” Transition

U.S. Department of Transportation Federal Highway Administration
Session 3
3-55

31” Transition Standard



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


31” Transition
Note length of curb
U.S. Department of Transportation
Federal Highway Administration
Session 3
3-57


31” Transition Test
Video Clip
Session 3
3-58

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

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 3 | 3-59

Transition: HTC to Guardrail (Spatial)

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 3 | 3-60

Transition: HTC to Guardrail
NO CONTINUITY

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois – The Land of Lincoln – From the People of Illinois
Session 3
3-61

_____

_____

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

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois – The Land of Lincoln
Session 3
3-62

_____

_____

_____

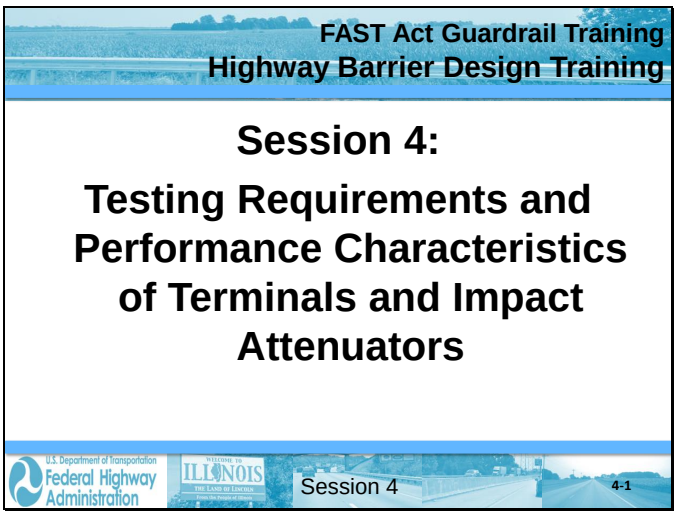
_____

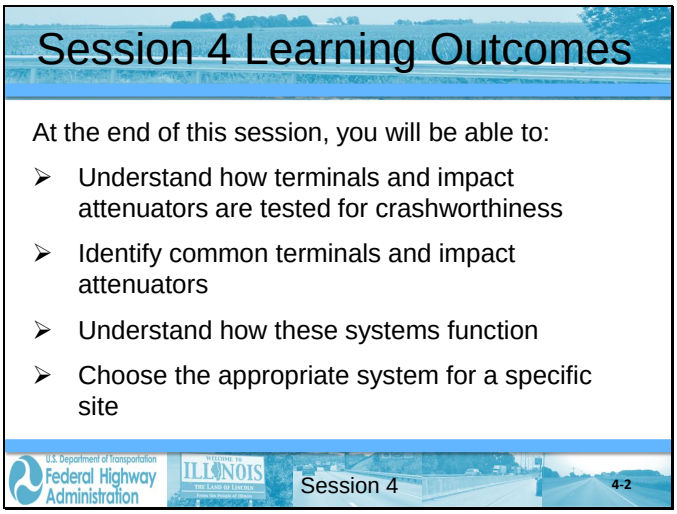
_____

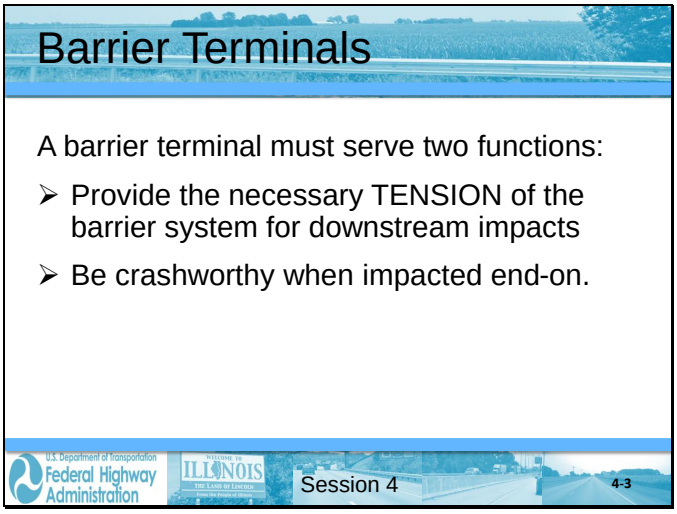
_____

_____

Session 4: Testing Requirements and Performance Characteristics of Terminals and Impact Attenuators


FAST Act Guardrail Training
Highway Barrier Design Training
Session 4:
Testing Requirements and Performance Characteristics of Terminals and Impact Attenuators
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-1


Session 4 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
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-2


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.
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-3

Anchor System - MASH

- 2 Design Tested
- Both have a strut between last 2 posts

TxDOT Design
9'- 4 ½ " rail element
Rail ends at last post

Eligibility Letter B-256

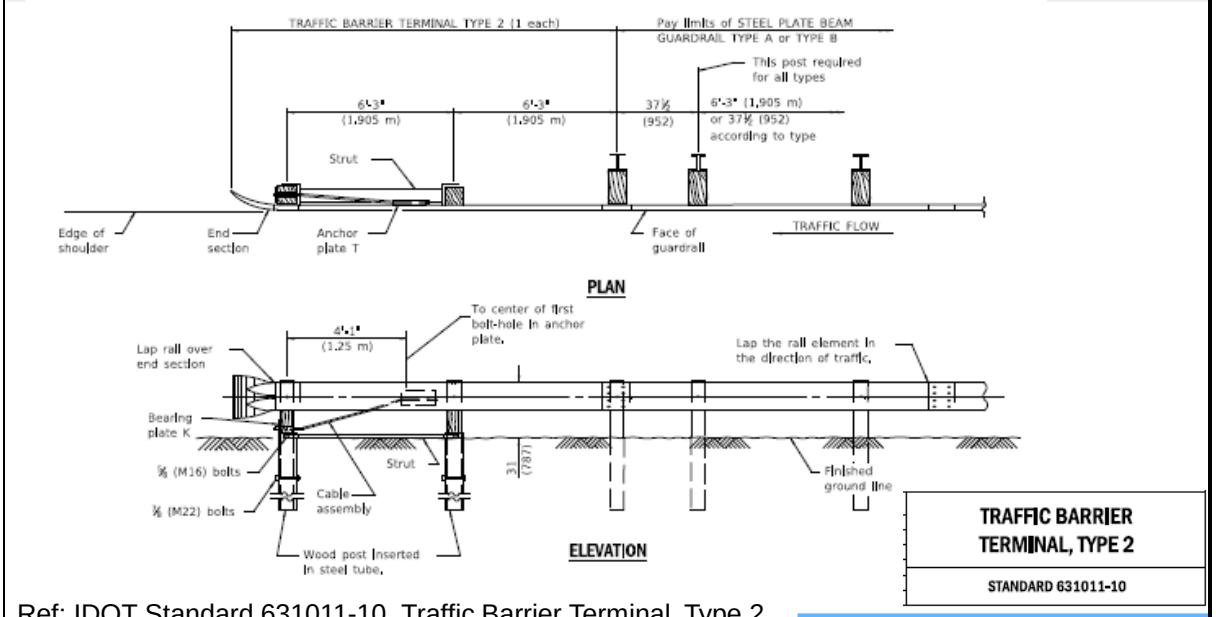
MwRSF Design
12'- 6" rail
Rail extends past last post

U.S. Department of Transportation Federal Highway Administration
Session 4
4-4

Anchor System - Tension

U.S. Department of Transportation Federal Highway Administration
Session 4
4-5

TBT Type 2

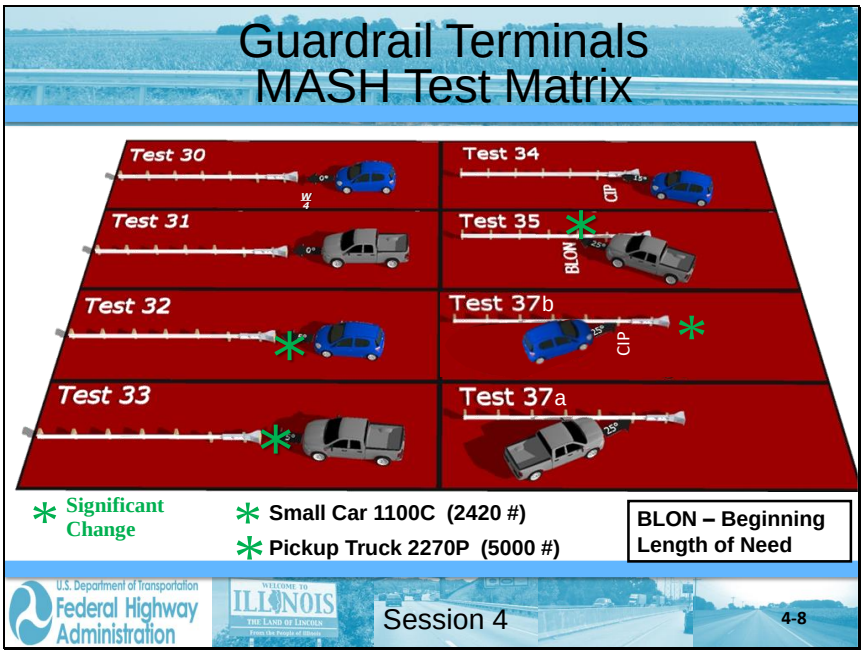


Ref: IDOT Standard 631011-10. Traffic Barrier Terminal, Type 2

_____

_____

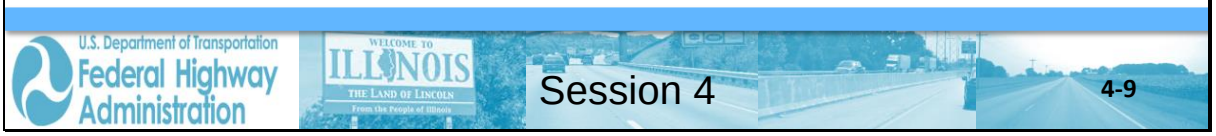

HTC Terminal – Placement
Re-emphasize hiding it so it won't release
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-7


Guardrail Terminals
MASH Test Matrix
Test 30
Test 34
Test 31
Test 35
Test 32
Test 37b
Test 33
Test 37a
BLON
CIP
Significant Change
Small Car 1100C (2420 #)
Pickup Truck 2270P (5000 #)
BLON – Beginning Length of Need
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-8

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 (≤ 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



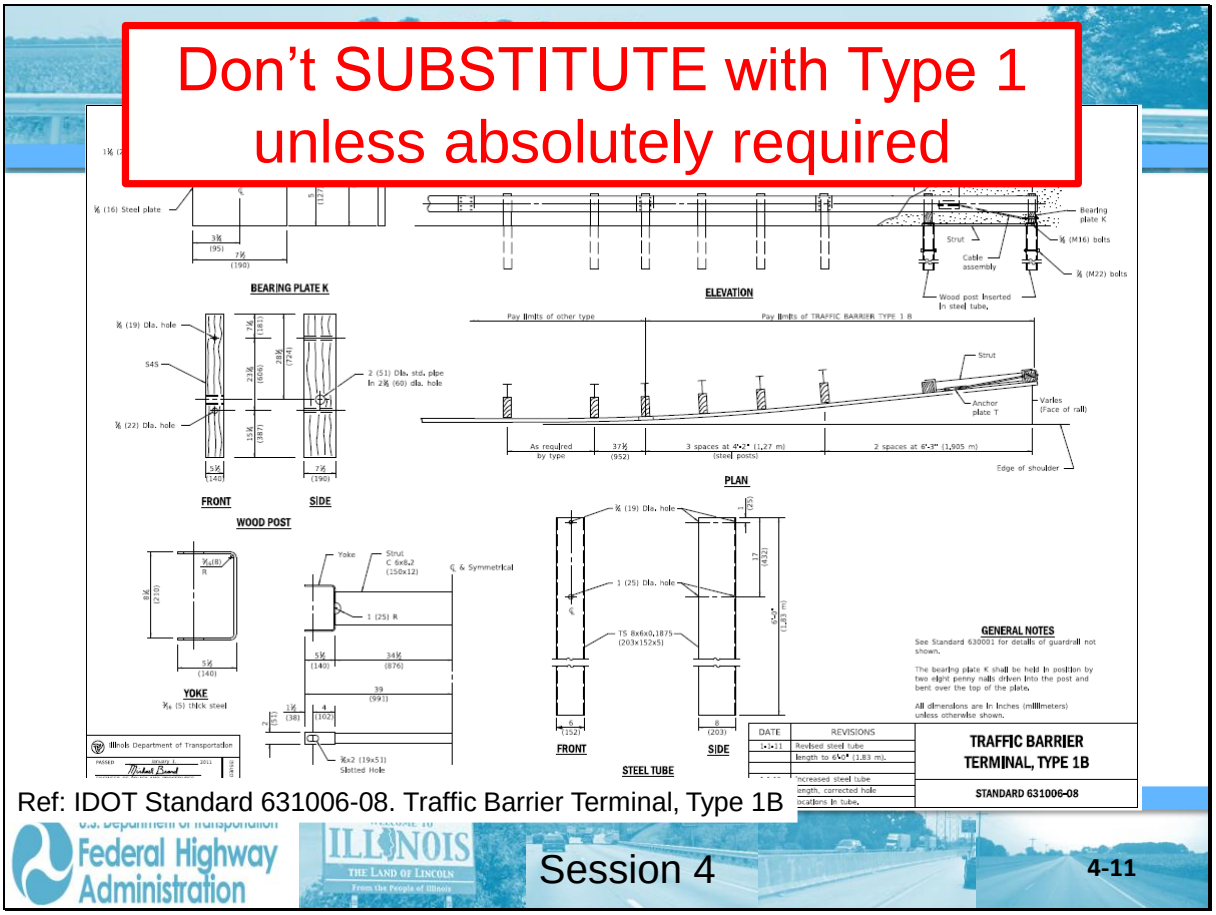
TBT Type 1B – Buried-in-Backslope

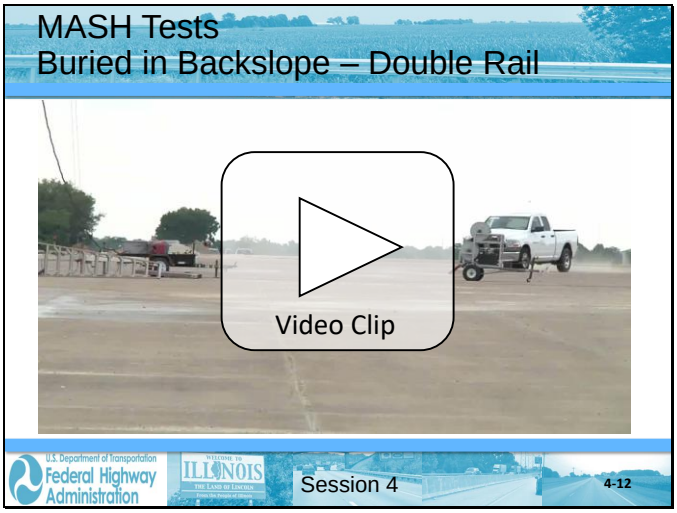
- Key design considerations:
  - For slopes steeper than 10:1, keep the height of the w-beam rail constant relative to the roadway grade until the barrier crosses the ditch flow line (but a max height of 47”)
  - Use a flare rate, either 14:1 or appropriate for the design speed,
  - Add a w-beam rubrail 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

U.S. Department of Transportation Federal Highway Administration

Session 4

4-10


Don't SUBSTITUTE with Type 1 unless absolutely required
BEARING PLATE K
ELEVATION
FRONT
SIDE
WOOD POST
PLAN
YOKE
FRONT
SIDE
STEEL TUBE
GENERAL NOTES
TRAFFIC BARRIER TERMINAL, TYPE 1B
STANDARD 631006-08
Ref: IDOT Standard 631006-08. Traffic Barrier Terminal, Type 1B
Federal Highway Administration
ILLINOIS
Session 4
4-11


MASH Tests
Buried in Backslope – Double Rail
Video Clip
Federal Highway Administration
ILLINOIS
Session 4
4-12

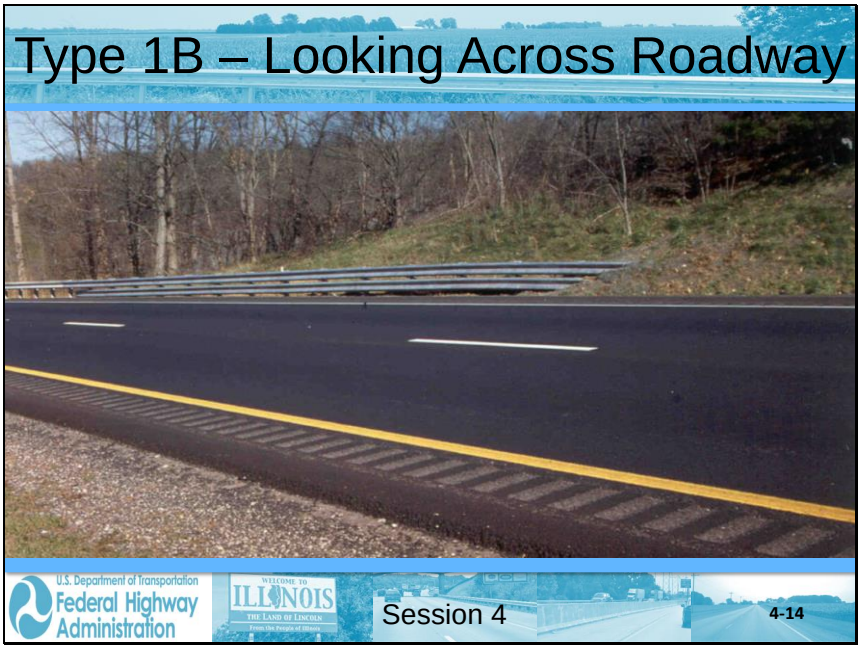
TBT Type 1B - Buried in Backslope

38-6.06(a) Guardrail End Terminals

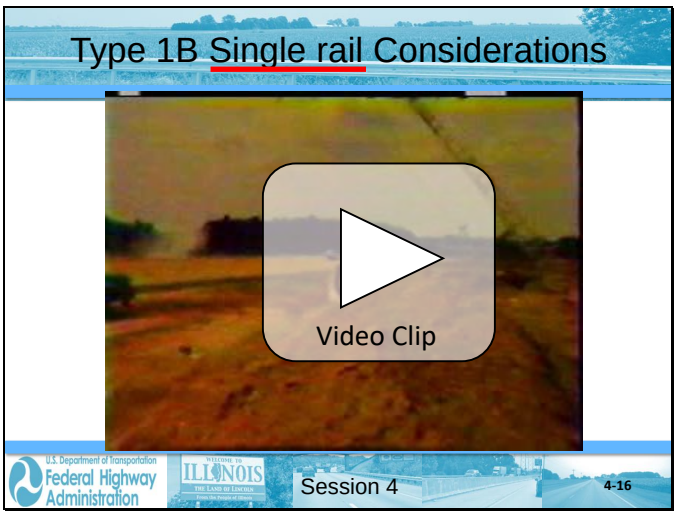
3. Type 1B. In areas of cut sections on the roadway, or where the road is transitioning from cut to fill, it is sometimes possible to terminate a guardrail installation by burying the end in the back slope. When properly designed and located, this system provides full shielding of the identified hazard, eliminates the possibility of any end-on impact with the terminal, and minimizes the likelihood of the vehicle passing behind the rail. The length of need point for this terminal begins at the transition from cut to fill, and the guardrail and terminal extend more than 75 ft (23 m) beyond this point.

Ref: BDE Manual Chp. 38-6.06 Guardrail End Terminals

Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN | Session 4 | 4-13

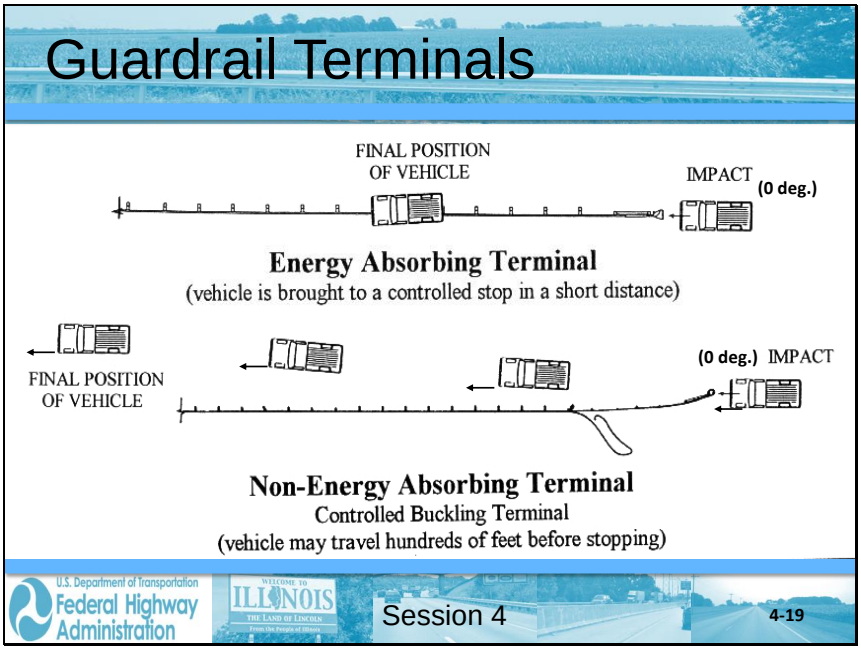

Type 1B – Looking Across Roadway
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-14

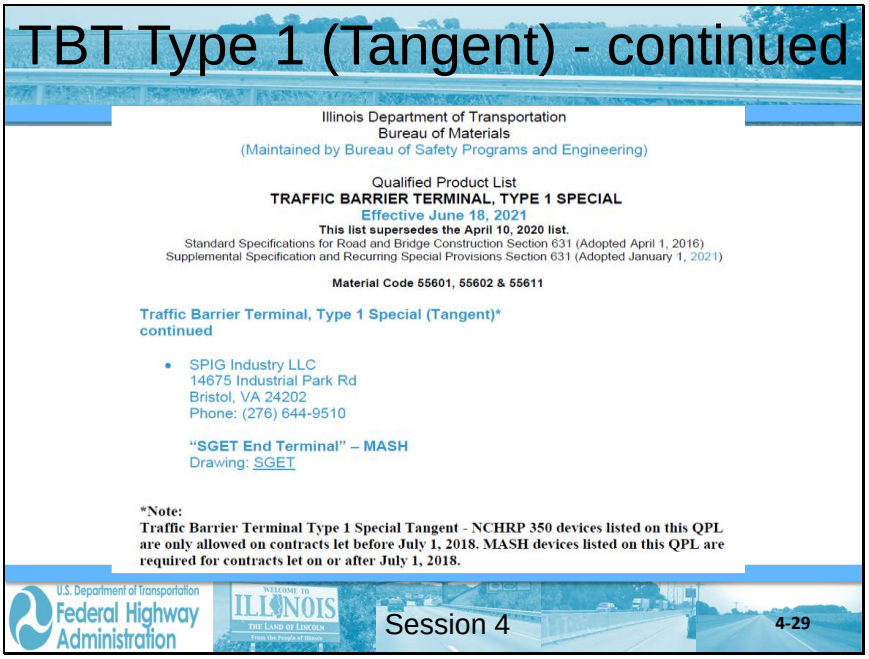

Be careful about FLARE and LON
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-15

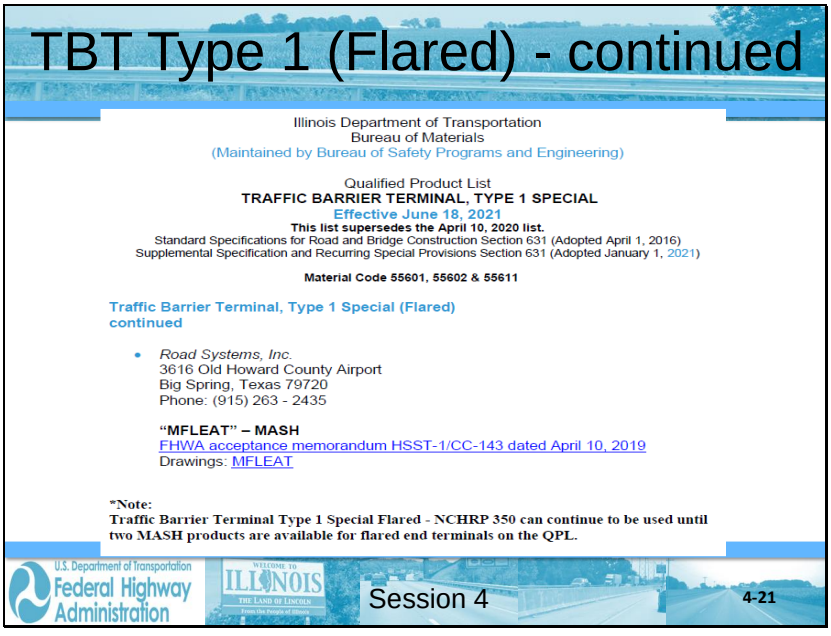

Type 1B Single rail Considerations
Video Clip
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 4
4-16


Type 1B – Considerations
Any concerns with this installation?
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 4
4-17


PRE-ASSESSMENT PHOTO
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-18


Guardrail Terminals
FINAL POSITION OF VEHICLE
IMPACT
(0 deg.)
Energy Absorbing Terminal
(vehicle is brought to a controlled stop in a short distance)
FINAL POSITION OF VEHICLE
(0 deg.) IMPACT
Non-Energy Absorbing Terminal
Controlled Buckling Terminal
(vehicle may travel hundreds of feet before stopping)
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-19


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.
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-29


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.
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-21

Guardrail Terminals
Flared, Non-Energy Absorbing

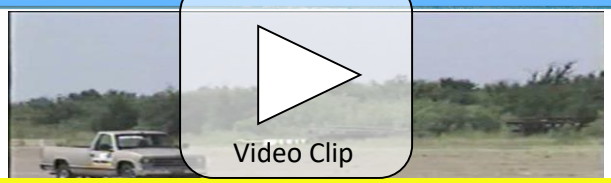
- SRT-31 (Slotted Rail Terminal) – NCHRP 350
  - Modified w-beam panels containing horizontal slots; installed in a straight line flare.
  - Many different post configurations throughout system
  - System is 37'-6" long and connects to 31" high guardrail.

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois – The Land of Lincoln | Session 4 | 4-22

_____

_____

NCHRP 350 - Test 3-31: SRT-31



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

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois | Session 4 | 4-23

_____

_____

_____

_____

_____

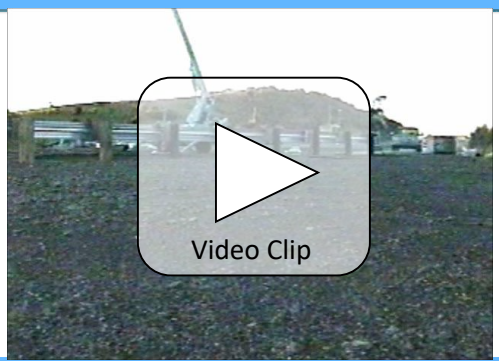
_____

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

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois, The Land of Lincoln | Session 4 | 4-24

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



U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois, The Land of Lincoln | Session 4 | 4-25

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 4th 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

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois – The Land of Lincoln – From the People of Illinois | Session 4 | 4-26

_____

_____

MASH – Test 3-31 MFLEAT

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois – The Land of Lincoln | Session 4 | 4-27

_____

_____

_____

_____

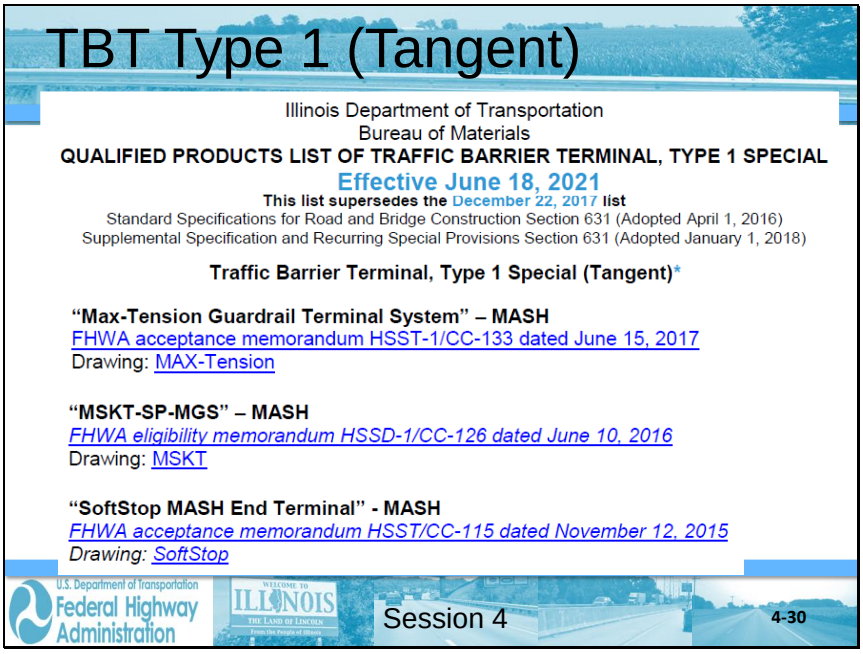
_____

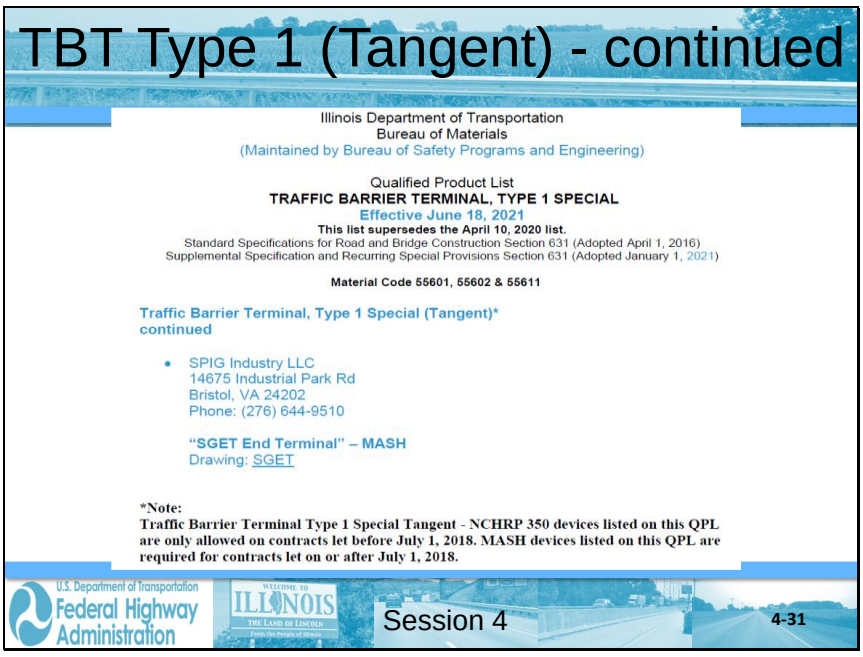
_____

_____


EXCELLENT APPLICATION!!!!!
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 4
4-28


POOR APPLICATION!!!!!
No LON and Minimal Grading
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 4
4-29


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
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-30


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.
U.S. Department of Transportation
Federal Highway Administration
Session 4
4-31

TBT Type 1 (Tangent)

- MAX-Tension (MASH 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 ½”; 31” only

MUST BE STRAIGHT

U.S. Department of Transportation Federal Highway Administration
ILLINOIS THE LAND OF LINCOLN From the People of Illinois
Session 4
4-32

_____

_____

MASH TL-3: MAX-Tension

U.S. Department of Transportation Federal Highway Administration
ILLINOIS
Session 4
4-33

_____

_____

_____

_____

_____

_____

_____

TBT Type 1 (Tangent)

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

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln
Session 4
4-34

_____

_____

MASH TL-3 MSKT

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln
Session 4
4-35

_____

_____

_____

_____

_____

_____

_____

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

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 4 | 4-36

MASH TL-3
Soft Stop

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 4 | 4-37


Soft Stop
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 4
4-38

TBT Type 1 (Tangent)

- **SGET** (MASH 16)
  - Flattens guardrail when hit head-on or at a shallow angle
  - Steel and wood post system; BLON at 3rd Post
  - TL-3 at 47’ long; attachment to 31” MGS Barrier
  - Cable-anchored system, Compression system

U.S. Department of Transportation Federal Highway Administration
Session 4
4-39

_____

_____

MASH – Test 3-31 SGET

U.S. Department of Transportation Federal Highway Administration
Session 4
4-40

_____

_____

_____

_____

_____

_____

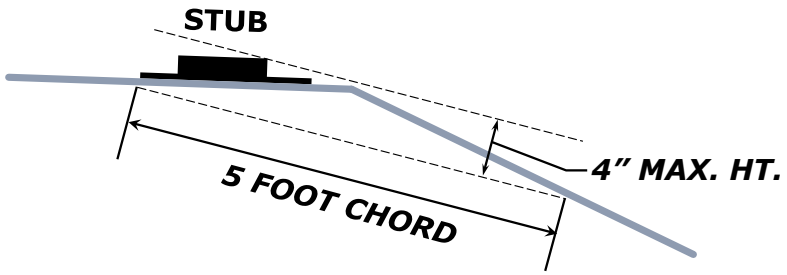
_____

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, 4th Edition, Section 8.3.3.

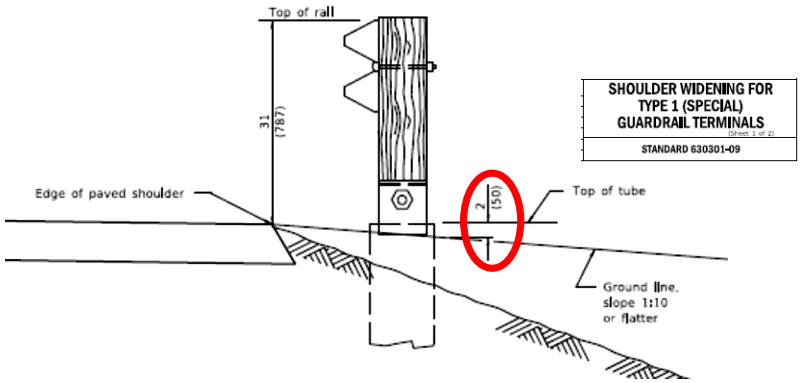
Stub Height Criteria



Although Figure is for sign supports, it applies to all hardware that is expected to have the vehicle pass over

RDG Figure 4.1

Stub Height Criteria – IDOT

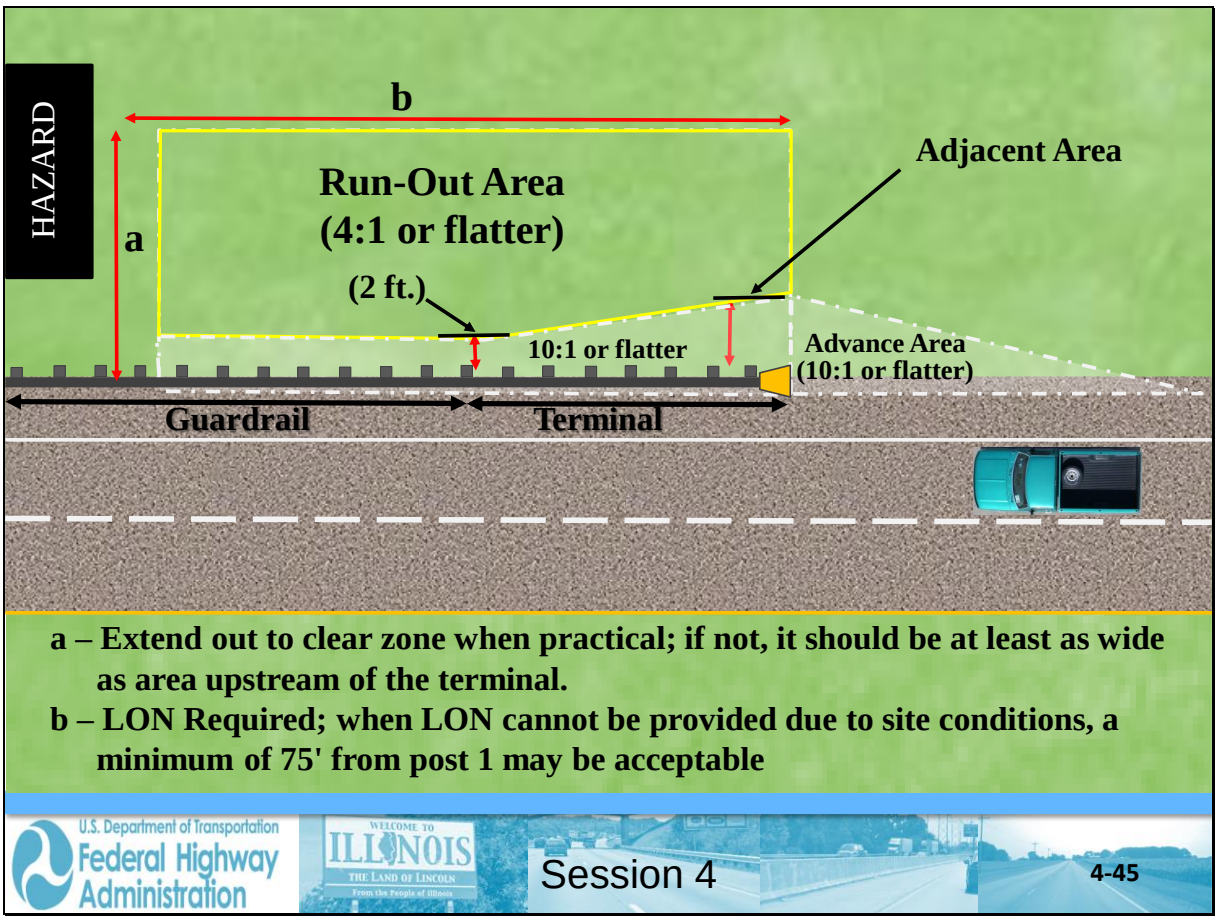


Ref: IDOT Standard 630301-09. Shoulder Widening for Type 1 (Special) Guardrail Terminals

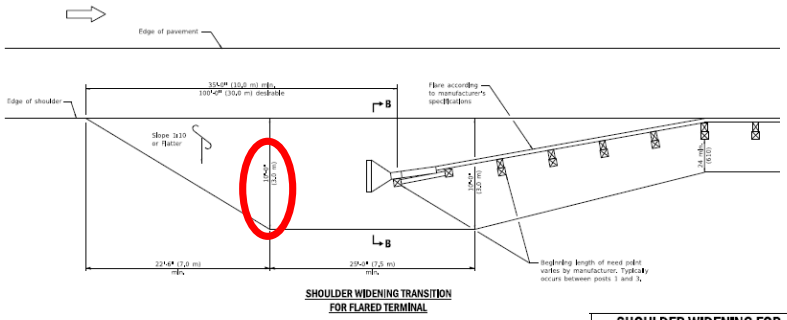
Terminal Grading

- **Runout Distance Grading** - refers to the area into which a vehicle may travel after impacting a terminal ahead of its length-of-need point.
  - The lateral runout distance directly behind a terminal ideally should be at least as wide as the roadside clear distance immediately upstream of terminal.
  - The minimum recovery obstacle-free area behind and beyond an terminal should be approximately 75 ft. long.

Ref: AASHTO Roadside Design Guide, 4th Edition, Section 8.3.3.


HAZARD
b
a
Run-Out Area
(4:1 or flatter)
Adjacent Area
(2 ft.)
10:1 or flatter
Advance Area
(10:1 or flatter)
Guardrail
Terminal
a – Extend out to clear zone when practical; if not, it should be at least as wide as area upstream of the terminal.
b – LON Required; when LON cannot be provided due to site conditions, a minimum of 75' from post 1 may be acceptable
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO ILLINOIS THE LAND OF LINCOLN
Session 4
4-45

TBT Type 1 (Flared) Grading

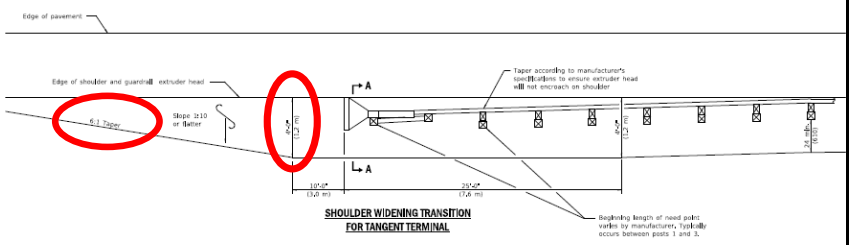


Need special Borrow bid item for 3R projects and Density Spec

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

TBT Type 1 (Tangent) Grading



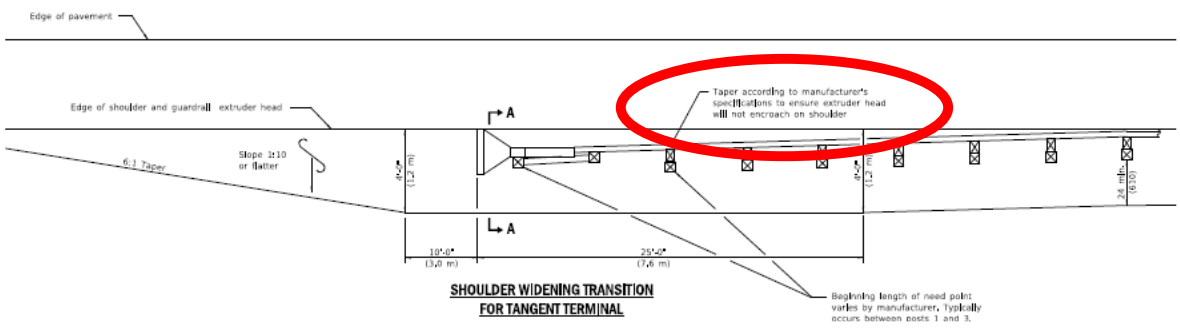
Need special Borrow bid item for 3R projects and Density Spec

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


Substandard Grading – DOCUMENT
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 4
4-48

TBT Type 1 (Tangent) Special Considerations



SHOULDER WIDENING TRANSITION FOR TANGENT TERMINAL

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

U.S. Department of Transportation Federal Highway Administration

Session 4

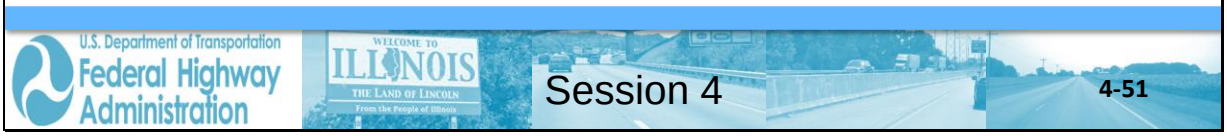
4-49

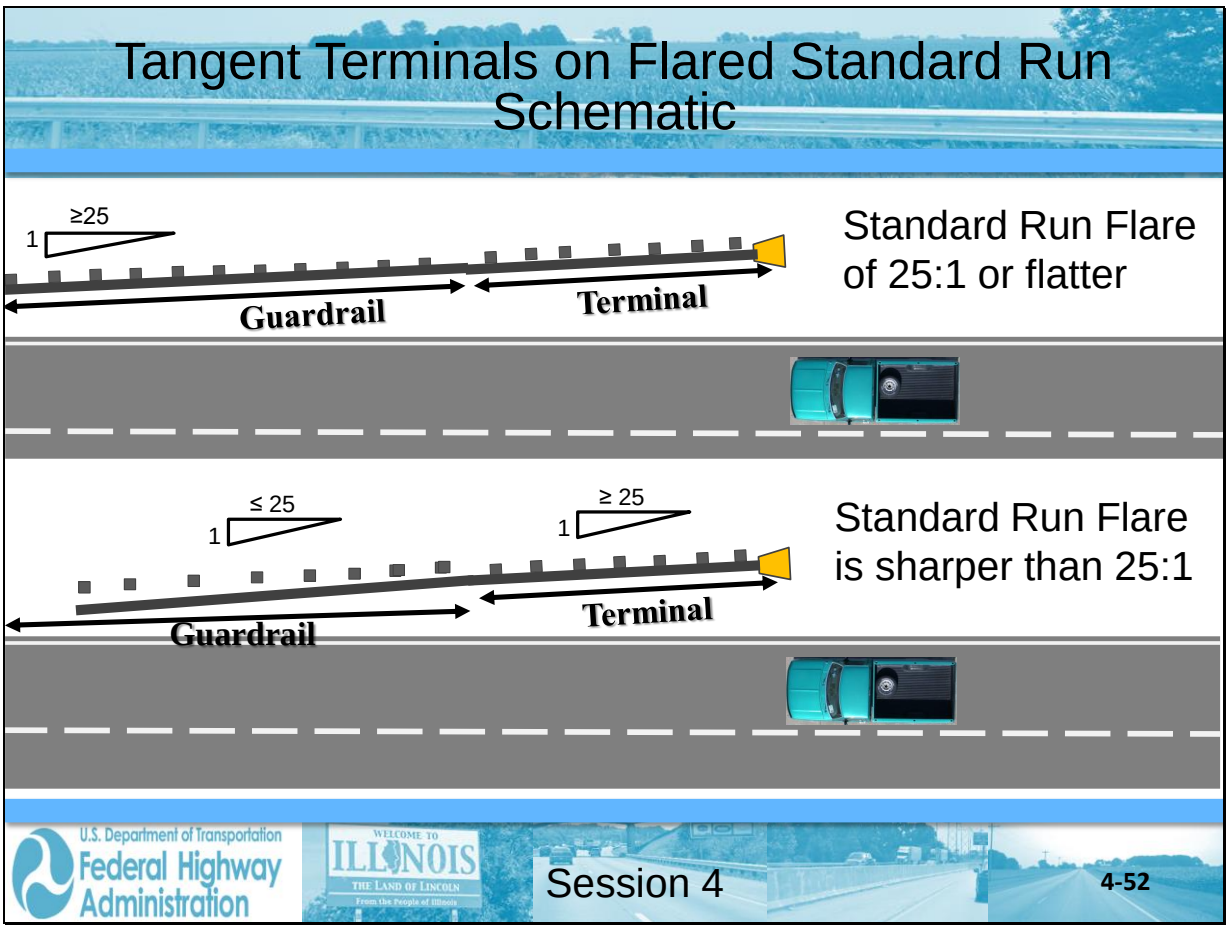

U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 4
4-50

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)




Tangent Terminals on Flared Standard Run Schematic
≥25
1
Guardrail
Terminal
Standard Run Flare of 25:1 or flatter
≤ 25
1
≥ 25
1
Guardrail
Terminal
Standard Run Flare is sharper than 25:1
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 4
4-52

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

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 4 | 4-53

Things to Remember about Terminals

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

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois The Land of Lincoln | Session 4 | 4-54

EXISTING Terminals
350 and before
(Briefly)

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 3rd 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 3rd Post
  - Cable-anchored, compression system

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

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois – The Land of Lincoln | Session 4 | 4-57

Turndown - Video

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois | Session 4 | 4-58

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

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois – The Land of Lincoln | Session 4 | 4-59

_____

_____

Non-crashworthy terminal

BCT terminal

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois | Session 4 | 4-60

_____

_____

_____

_____

_____

_____

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.

U.S. Department of Transportation Federal Highway Administration
WELCOME TO ILLINOIS THE LAND OF LINCOLN From the People of Illinois
Session 4
4-61

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.

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln From the People of Illinois
Session 4
4-62

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

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln
Session 4
4-63

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.

U.S. Department of Transportation Federal Highway Administration

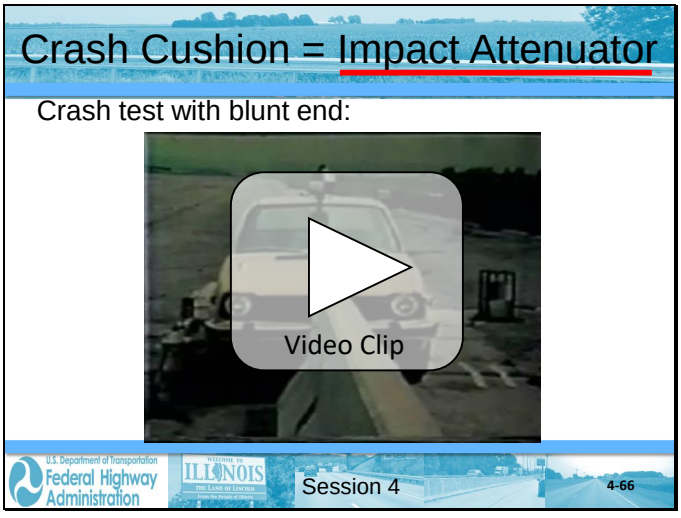
Session 4

4-64


U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 4
4-65

_____

_____


Crash Cushion = Impact Attenuator
Crash test with blunt end:
Video Clip
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 4
4-66

_____

_____

_____

_____

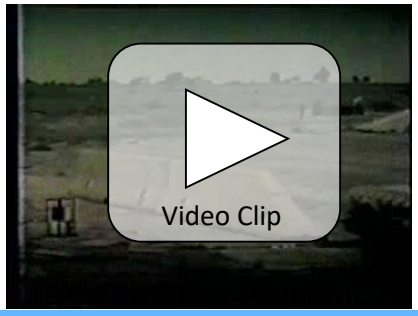
_____

_____

_____

Crash Cushion = Impact Attenuator

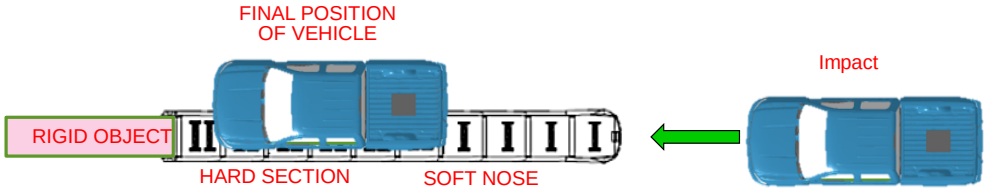
Crash test with ramped end:



U.S. Department of Transportation Federal Highway Administration | Session 4 | 4-67

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

U.S. Department of Transportation Federal Highway Administration | Session 4 | 4-68

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.

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 (MASH)

TrafFix Big Sandy (MASH)

CrashGard (MASH)

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln
Session 4
4-71

_____

_____

Sand-Filled Array

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln
Session 4
4-72

_____

_____

_____

_____

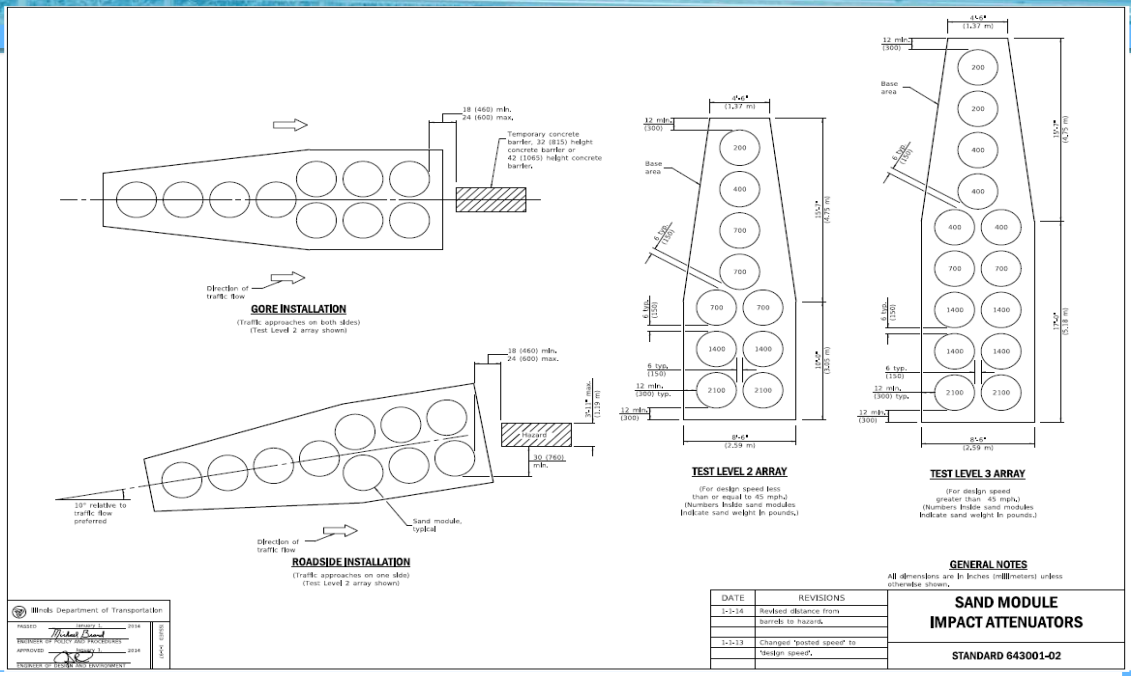
_____

_____

_____


Sand Barrels – Good Application
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 4
4-73

Sand-Filled Array



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

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

U.S. Department of Transportation Federal Highway Administration

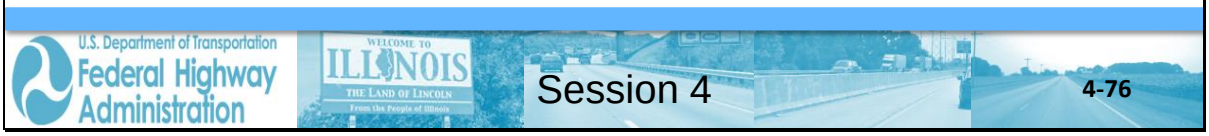
Session 4

4-75

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 15º angle.
- Approved for TL-2 (350) & TL-3 systems.
- Designed to shield a point hazard; either attached or stand alone.



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 ® UNIVERSAL TAU-II-R ®	2 & 3 2 & 3	TAU-M	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 ® QUADGUARD® II QUADGUARD® ELITE QUEST® REACT 350® HEART TRACC	2 & 3 2 & 3 2 & 3 2 & 3 2* & 3* 2 & 3 2 & 3	QUADGUARD M10 QUADGUARD M10	3 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 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.

U.S. Department of Transportation Federal Highway Administration

Session 4

4-77

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.

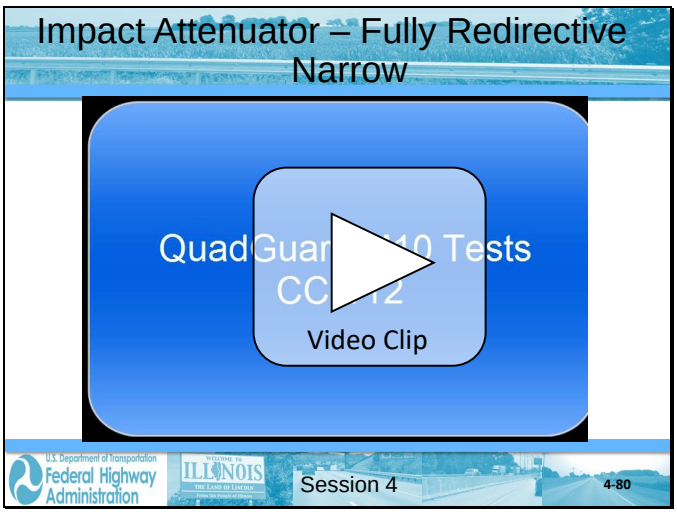
U.S. Department of Transportation Federal Highway Administration
Session 4
4-78

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 at 24” width

U.S. Department of Transportation Federal Highway Administration
Session 4
4-79



Impact Attenuator – Fully Redirective Narrow

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

Very Appropriate Use

U.S. Department of Transportation Federal Highway Administration
Session 4
4-82

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 ® UNIVERSAL TAU-II-R ®	2 & 3 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 QUADGUARD® II WIDE QUADGUARD® ELITE WIDE REACT 350® TRACC	2 & 3 2 & 3 2 & 3 2* & 3* 2 & 3		
Hill and Smith (Work Area Protection Corp.) 2760 Airport Dr Suite 125 Columbus, OH 43207	SCI 100GM® SCI 70GM®	3 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.

U.S. Department of Transportation Federal Highway Administration
Session 4
4-83

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.

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois – The Land of Lincoln
Session 4
4-84

_____

_____

Impact Attenuator – Fully Redirective WIDE

REACT

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois – The Land of Lincoln
Session 4
4-85

_____

_____

_____

_____

_____

_____

_____

Impact Attenuator – Fully Redirective WIDE

U.S. Department of Transportation Federal Highway Administration
Session 4
4-86

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.

U.S. Department of Transportation Federal Highway Administration
Session 4
4-87

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.

U.S. Department of Transportation Federal Highway Administration

Session 4

4-88

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-directive 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.

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois – The Land of Lincoln | Session 4 | 4-89

_____

_____

Impact Attenuator – Fully Redirective Severe Use, Narrow

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois | Session 4 | 4-90

_____

_____

_____

_____

_____

_____

_____

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.

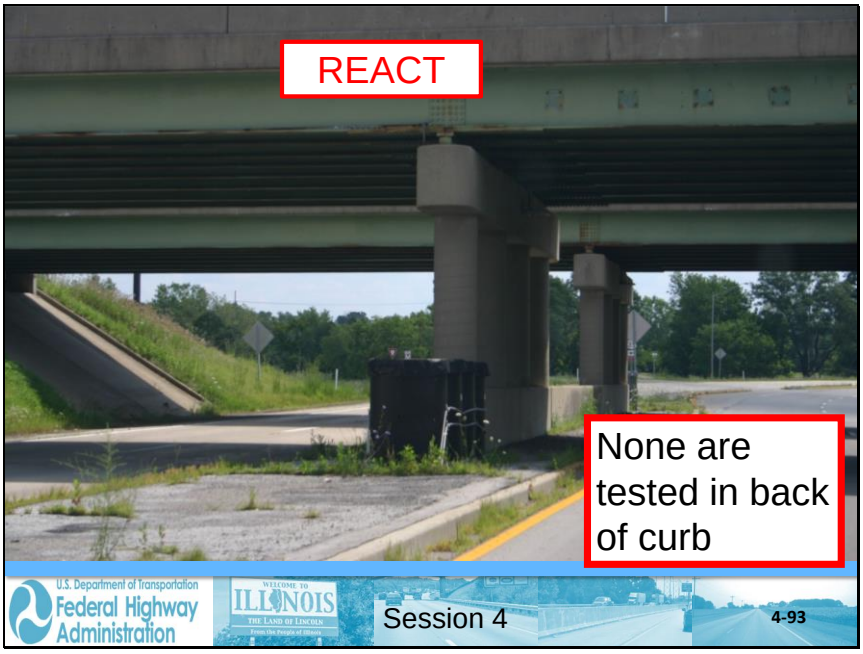
Impact Attenuator – IDOT Guidance

One of several Examples of Use guidance

Systems and Allowable Products to Fit Needs	Typical Applications
Impact Attenuators (fully redirective, narrow) QuadGuard, QuadGuard Elite, QuadGuard LMC, QuadGuard II, REACT 350, Universal TAU-II, Universal TAU-II-R TRACC family, SCI-100GM (Test Level 3), SCI-70GM (Test Level 2), QUEST Compressor, HEART	• Where the expected rate of crashes involving the system are rare to infrequent (less than 1 crash per 3 years). • *Narrow median (< 40 ft (12 m)). • Narrow hazard, concrete barrier, narrow pier. • End of median barrier or Type D rail. • Alignment or traffic operations do not contribute to added likelihood of run off the road incidents.
Impact Attenuators (fully redirective, wide) QuadGuard, QuadGuard Elite, QuadGuard LMC, QuadGuard II, React 350, TRACC family, Universal TAU-II, Universal TAU-II-R, SCI-100GM (Test Level 3), SCI-70GM (Test Level 2)	• *Narrow median (< 40 ft (12 m)). • Up to 90 in (2.25 m) wide hazard, sign base, pier, etc. • Narrow gap between bridges. • Alignment or traffic operations do not contribute to added likelihood of run off the road incidents. • Hazards where space does not allow development of width transitions from other impact attenuators.
Impact Attenuators (fully redirective, resettable) REACT 350, SCI-100GM (Test Level 3), SCI-70GM (Test Level 2), Universal TAU-II, Universal TAU-II-R, Compressor, HEART	• Where crashes are expected to be more than 1 per 3 years. • Similar locations to fully redirective, narrow.
Impact Attenuators (severe use, narrow) QuadGuard Elite, REACT 350, QuadGuard LMC, Universal TAU-II-R	• *Narrow median (< 40 ft (12 m)). • Expect repeated impacts (> 2/yr). • Narrow hazard, concrete barrier, narrow pier. • End of median barrier or Type D rail. • Outside of curves, areas near weaving, lane drops. • Near entrances/exits on freeways/ expressways. • Also appropriate on outside shoulder hazards where repeated impacts and traffic levels make continued capability and ease of repairs critical.

IMPACT ATTENUATORS – PERMANENT INSTALLATIONS

Figure 38-8.H



Impact Attenuator/Curb – IDOT Guidance

38-8.06 <u>Physical Placement Requirements</u>

2. <u>Curbs.</u> No curbs higher than 2 in. (50 mm) should be constructed at impact attenuator installations. On existing highways, all curbs higher than 4 in. (100 mm) should be removed at proposed installations, if feasible.

Ref: BDE Manual Chp. 38-8.06 Physical Placement Requirements

Placement – on Level Ground

U.S. Department of Transportation Federal Highway Administration

Session 4

4-95

Review Learning Outcomes

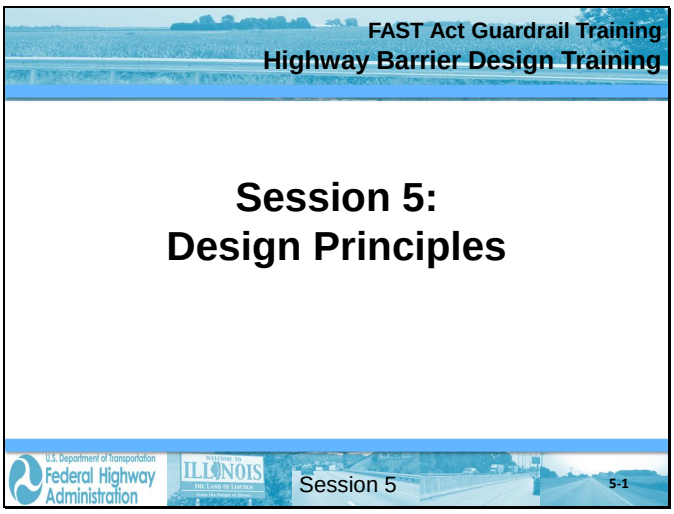
- Understand how terminals and impact attenuators are tested for crashworthiness
- Identify common terminals and impact attenuators
- Explain how these systems function
- Choose the best system for a specific site

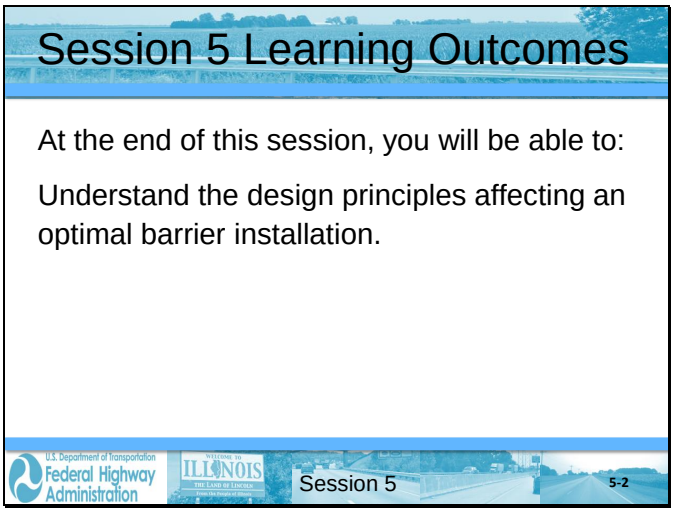
U.S. Department of Transportation Federal Highway Administration

Session 4

4-96

Session 5: Design Principles


FAST Act Guardrail Training
Highway Barrier Design Training
Session 5:
Design Principles
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-1


Session 5 Learning Outcomes
At the end of this session, you will be able to:
Understand the design principles affecting an optimal barrier installation.
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-2

IDOT Guidance

38-4.02 Range of Treatments

- 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.

Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN | Session 5 | 5-3

Guardrail Placement

Place AS FAR AWAY as Possible

without affecting function

Guardrail Placement - IDOT

38-6.03 Barrier Offset

Generally, roadside hardware should be placed as far as practical from the edge of traveled way consistent with proper operation and performance of the barrier system.

2. Shoulder. Typically, the roadside barrier is located with the face of barrier at the edge of the shoulder unless flared away from the shoulder.

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

Barrier Design Principles

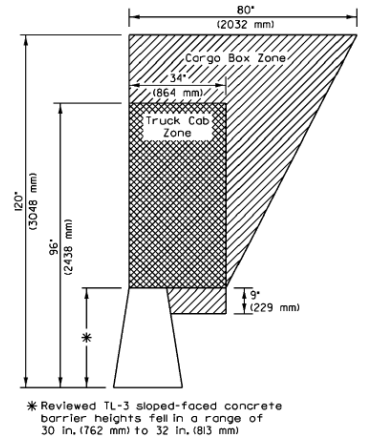
1. Deflection
2. Slope in Front of Barrier
3. Guardrail and Curb
4. Soil Backing for Fill Locations
5. Flare Rate

Principle 1: Deflection

Adequate room must be left behind the barrier to allow for lateral deflection in an impact.

- If the barrier is shielding a vertical rigid object, the distance between the barrier and the object should be sufficient to avoid the vehicle impacting or snagging on the object.
- Note that, even for rigid barriers with no lateral deflection, large vehicles may roll behind the top of the barrier even if the barrier itself does not deflect – referred to as Zone of Intrusion (ZOI)

Zone of Intrusion ZOI

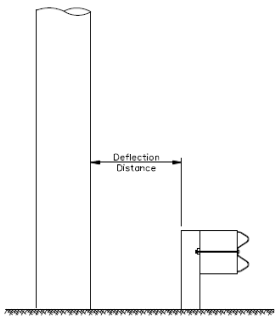


SELECTED ZONE of INTRUSION VALUES

Figure 38-6.W

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

Deflection Distance



DEFLECTION DISTANCE FOR W-BEAM GUARDRAIL

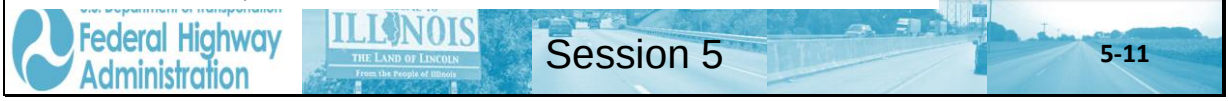
Figure 38-6.S

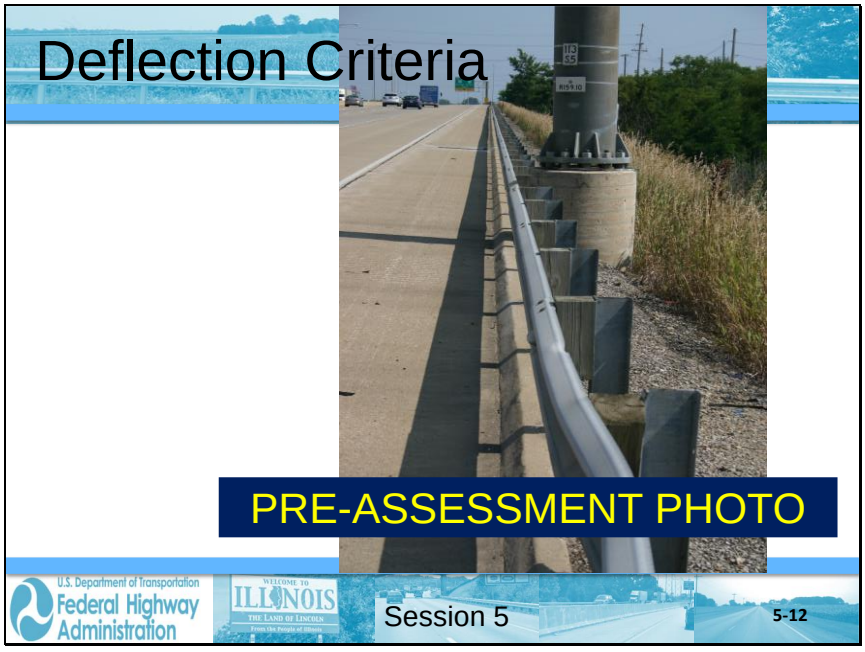
Ref: BDE Manual, Ch. 38-6.03. Barrier Offset

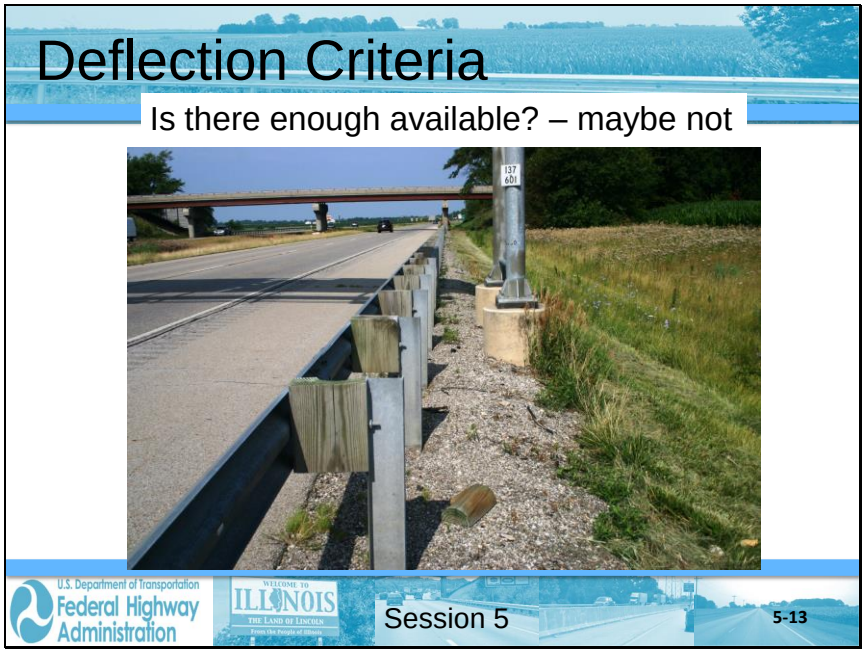
Dynamic Deflection of Guardrail
Figure 38-6.V

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 ½" (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 ¾" (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)

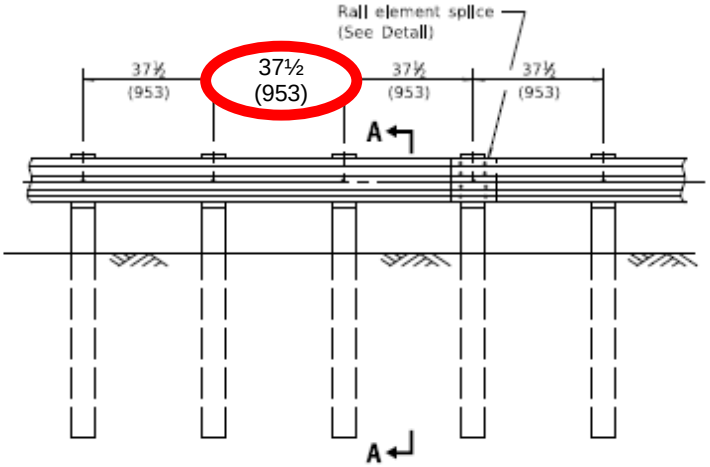
Ref: BDE Manual, Ch. 38-6.03. Barrier Offset.




Deflection Criteria
PRE-ASSESSMENT PHOTO
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-12


Deflection Criteria
Is there enough available? – maybe not
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-13

Closed Post Spacing



ELEVATION

TYPE B

37½ (953) Closed post spacing

Also have quarter post spacing – not in standards

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

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

Introducing Stiffened Guardrail

Rule of thumb:

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

Deflection of HTC Barrier

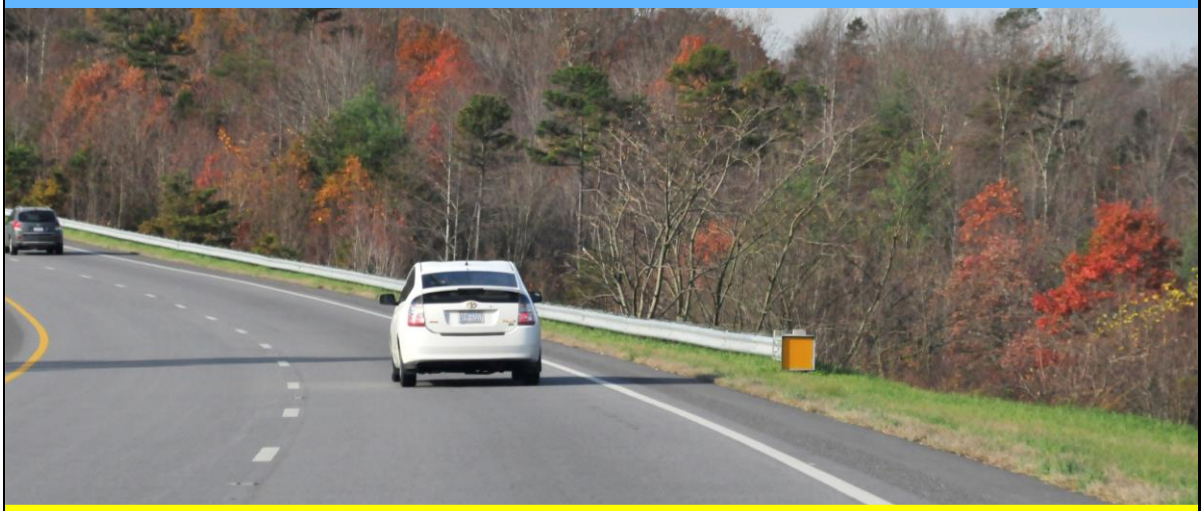
e. Deflection. Flexible median barriers will deflect more than the other median barrier types. When laying out a flexible barrier, allow for 12 ft (3.6 m) of deflection.

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

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

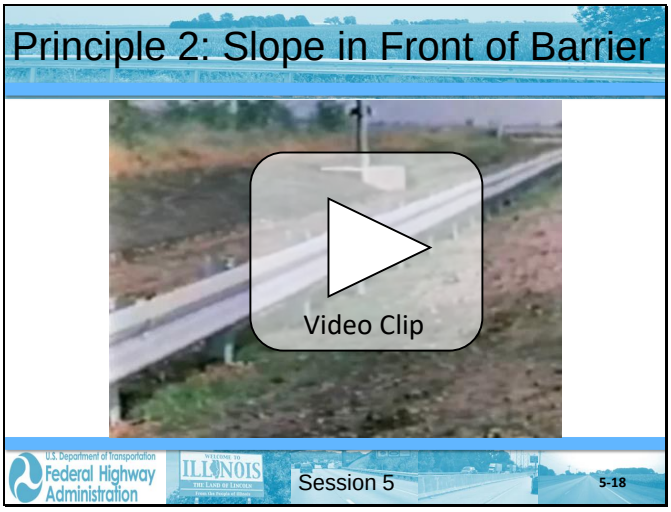
U.S. Department of Transportation Federal Highway Administration | Session 5 | 5-16

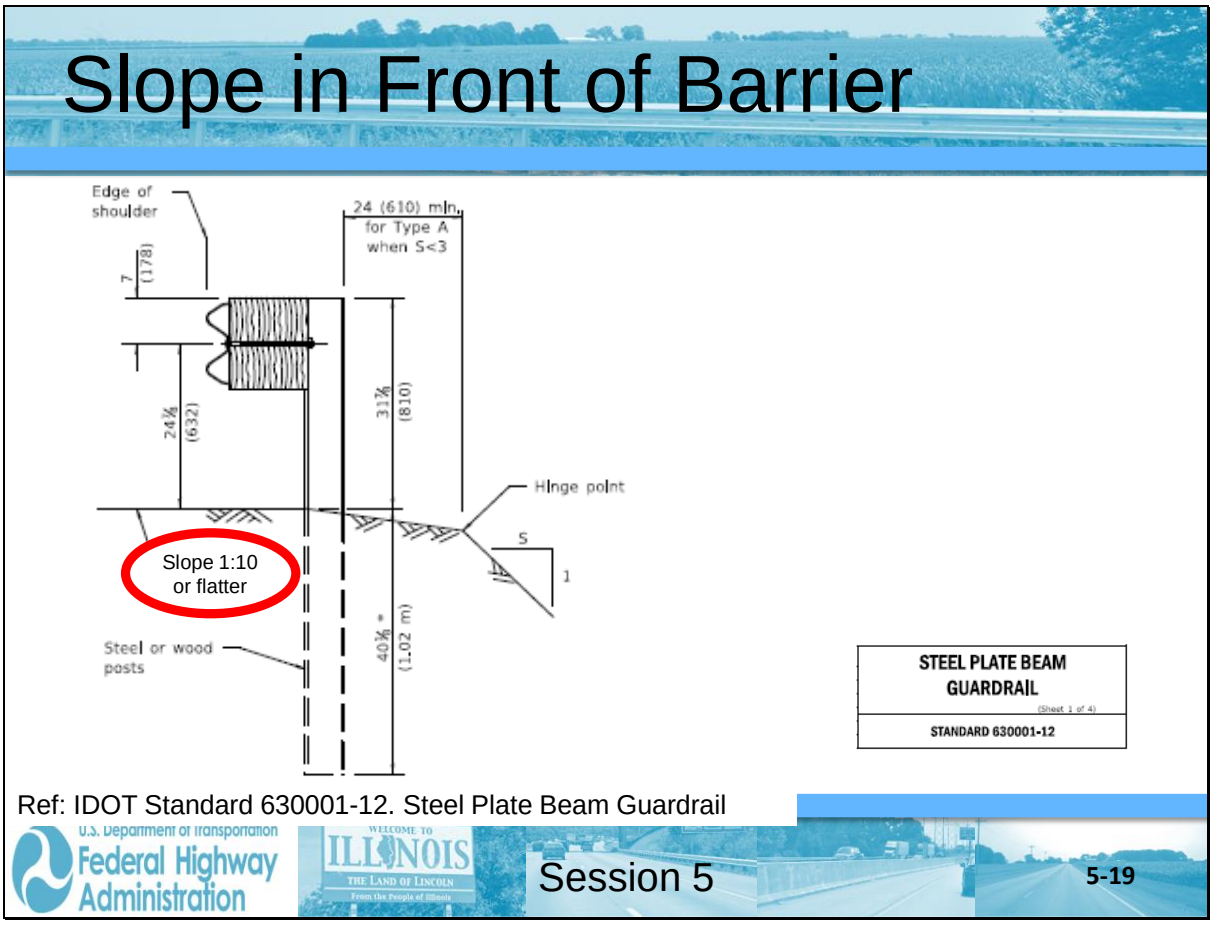
Principle 2: Slope in Front of Barrier



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

U.S. Department of Transportation Federal Highway Administration | Session 5 | 5-17


Principle 2: Slope in Front of Barrier
Video Clip
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-18

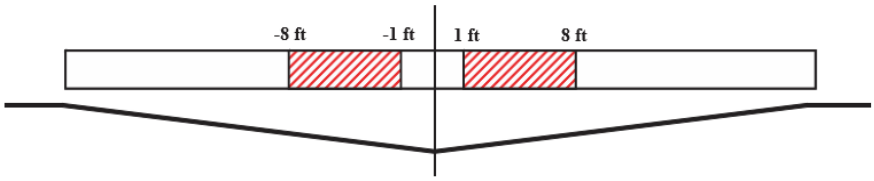

Slope in Front of Barrier
Edge of shoulder
24 (610) min. for Type A when S<3
7 (178)
24⅛ (632)
31⅞ (810)
Hinge point
5
1
Slope 1:10 or flatter
Steel or wood posts
40⅛ * (1.02 m)
STEEL PLATE BEAM GUARDRAIL
(Sheet 1 of 4)
STANDARD 630001-12
Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-19


NCHRP 350 TL-3 of 31” on 8:1 Slope
ft
8:1 Slope
Video Clip
Vehicle is contained and redirected but shows instability
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-20


Barrier in Sloped Median
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-21

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)

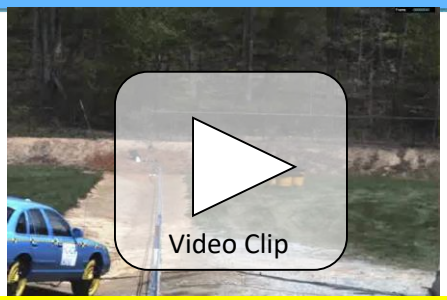
Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – 6.6.1.1, Pg. 6-18

U.S. Department of Transportation Federal Highway Administration

Session 5

5-22

Location of Cable in Swales



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

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

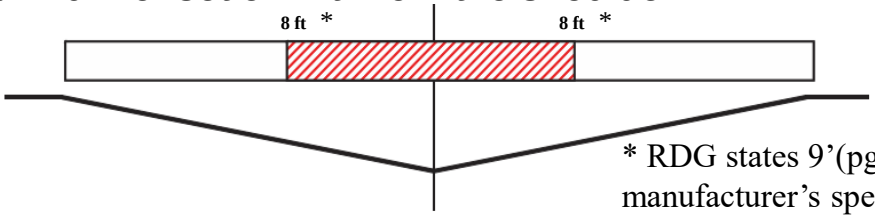
U.S. Department of Transportation Federal Highway Administration

Session 5

5-23

Slope in Front of Cable Barrier

- Cable barrier may be placed on ***4:1*** slopes with a maximum offset of 4 ft. from the shoulder.



* RDG states 9'(pg. 6-7); See manufacturer's specification

(b) Medians steeper than 6H:1V slope

Figure 6.1. Underride criteria for V-shaped medians. (NCHRP Report 711)

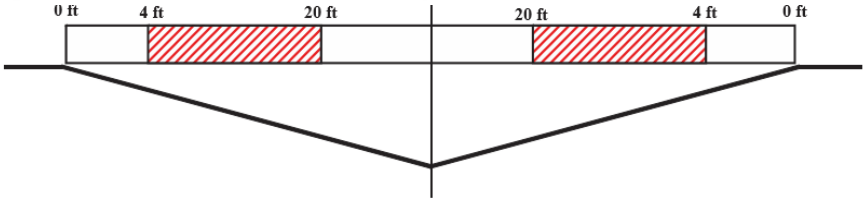


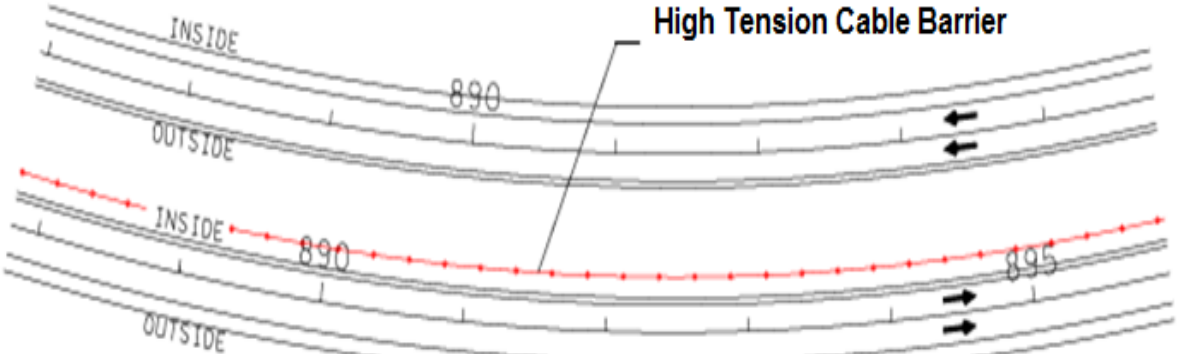
Figure 6.2. Override criteria for V-shaped medians steeper than 6H:1V slope. (NCHRP Report 711)

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


Barrier in Sloped Median
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 5
5-25

Barrier in Sloped Median

Which Side of the Median Should the Cable Barrier be Placed?



When placing HTC near a shoulder around a curve, it should ideally be located where the near traffic is making the left-hand curve (inside of curve relative to near traffic). This may reduce nuisance hits and allow more vehicles leaving the opposing roadway to come to a stop in the median before reaching the barrier.

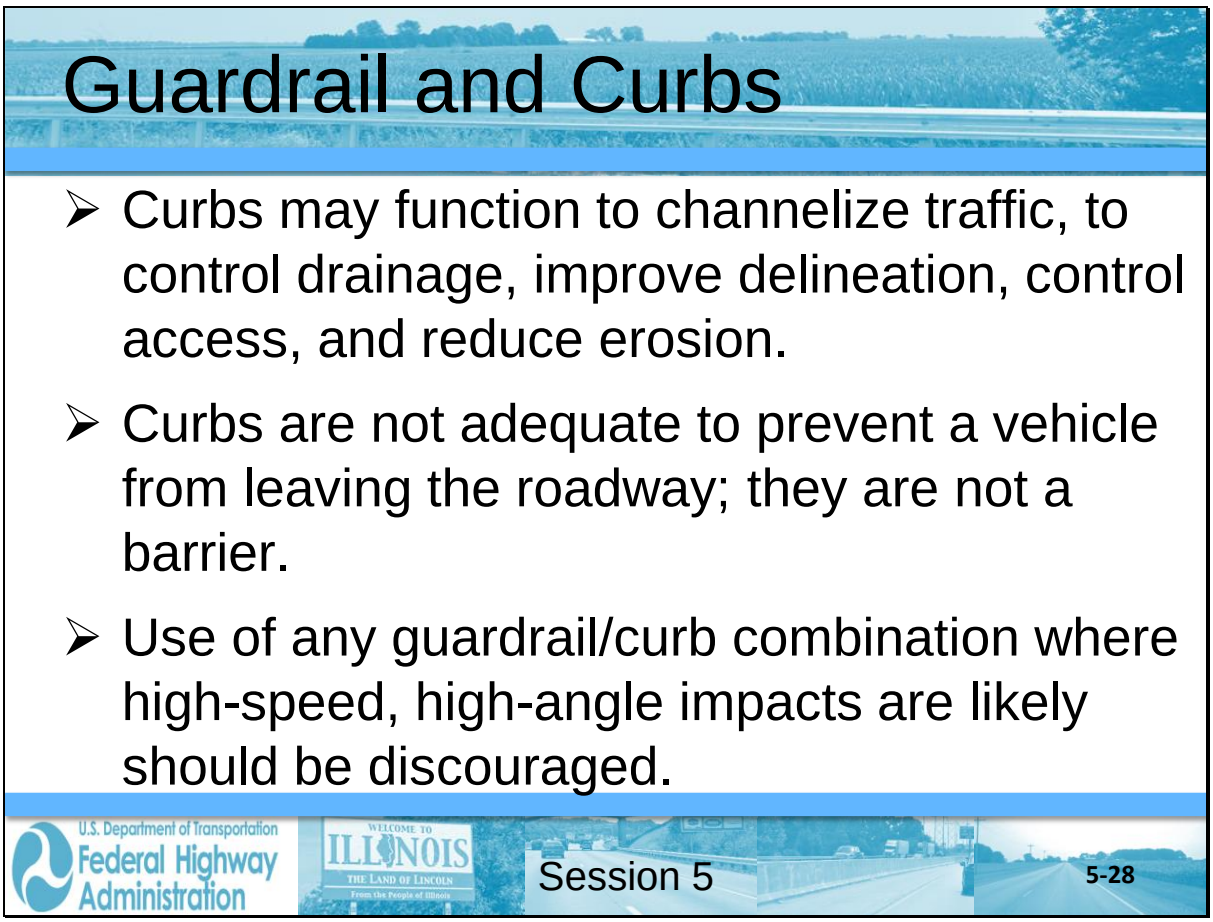
Ref: BDE Manual, Ch. 38-7.03(b) Design Considerations

Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN From the People of Illinois | Session 5 | 5-26

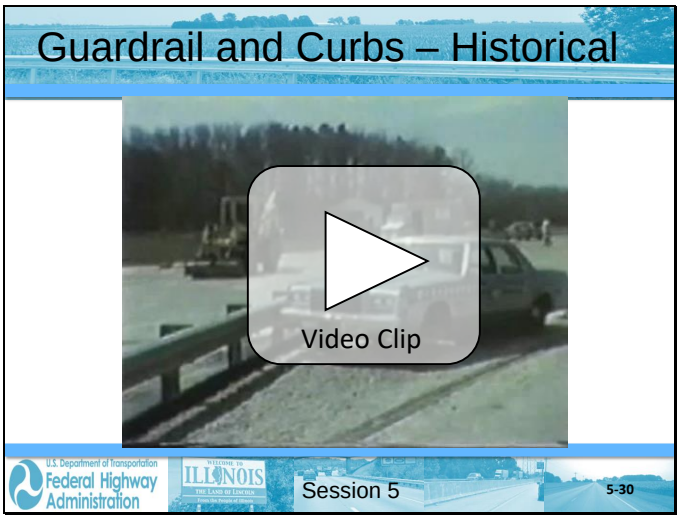

Principle 3: Guardrail and Curbs
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 5
5-27

_____

_____

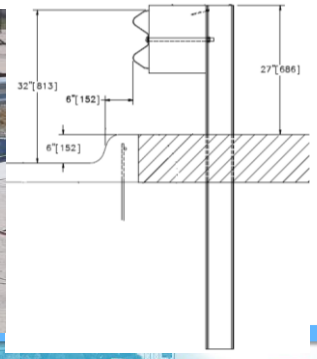

Guardrail and Curbs
Curbs may function to channelize traffic, to control drainage, improve delineation, control access, and reduce erosion.
Curbs are not adequate to prevent a vehicle from leaving the roadway; they are not a barrier.
Use of any guardrail/curb combination where high-speed, high-angle impacts are likely should be discouraged.
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-28


PRE-ASSESSMENT PHOTO
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 5
5-29


Guardrail and Curbs – Historical
Video Clip
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 5
5-30

31” Guardrail and Curbs

Successfully tested to MASH placed 6” behind a 6” high curb at TL-3

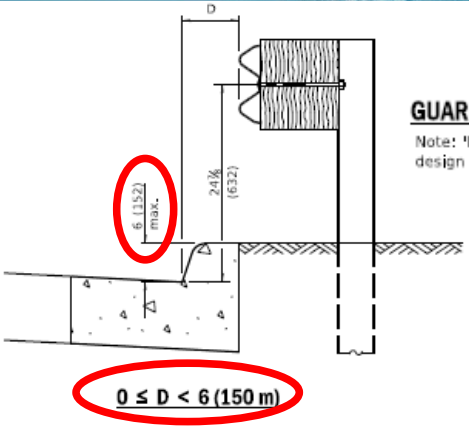


U.S. Department of Transportation Federal Highway Administration

Session 5

5-31

Guardrail and Curbs - IDOT



GUARDRAIL PLACED BEHIND CURB

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

0 ≤ D < 6 (150 m)

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

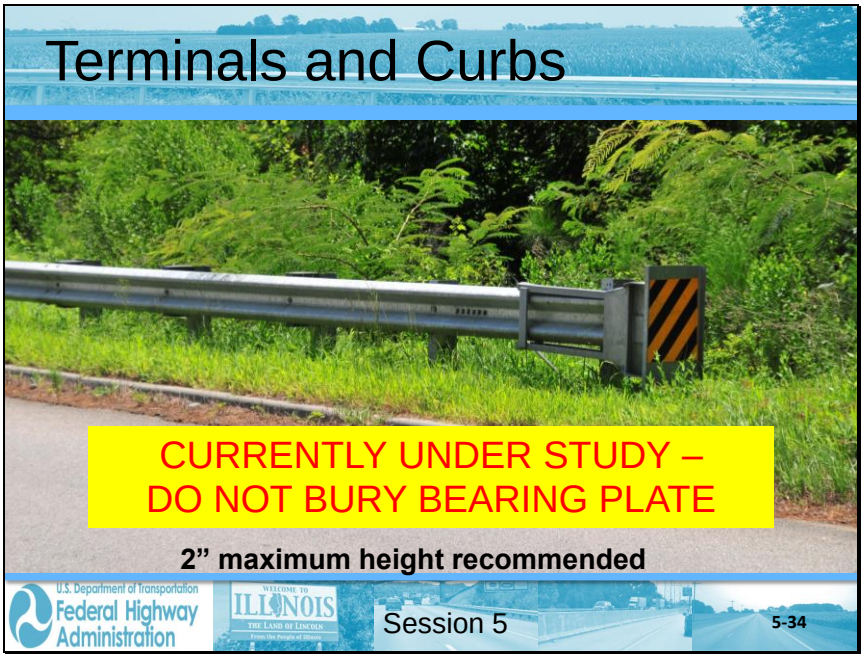
Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail

Federal Highway Administration

Session 5

5-32


Terminals and Curbs
NO CRASH TESTED DESIGN
WITH CURB
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-33


Terminals and Curbs
CURRENTLY UNDER STUDY –
DO NOT BURY BEARING PLATE
2" maximum height recommended
U.S. Department of Transportation
Federal Highway Administration
Session 5
5-34

Terminals and Curbs

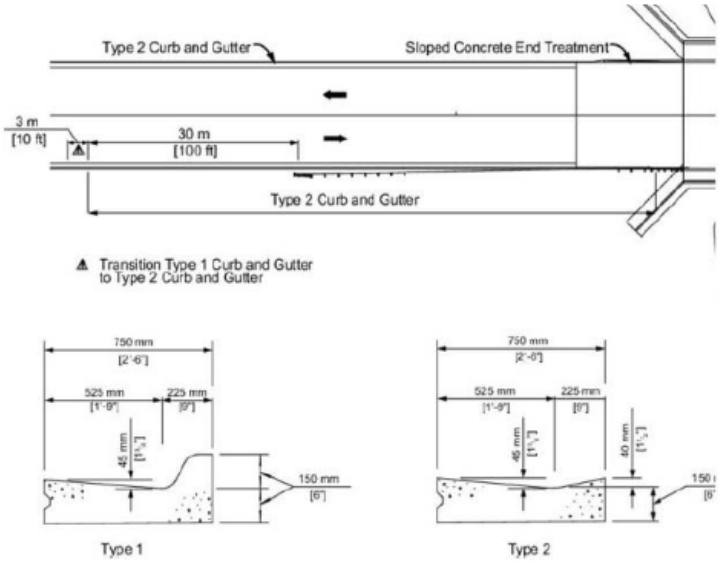


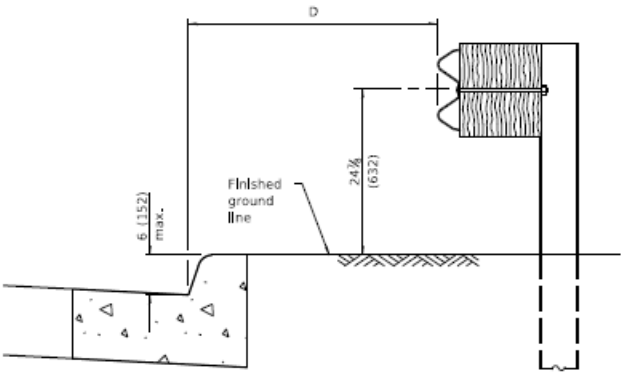
Figure 5-35b. Example Laydown Curb near End Terminal

AASHTO RDG


MASH Tested – TL-2
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 5
5-36


MASH TL-2: 31” Guardrail
6 ft. behind curb
Video Clip
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
Session 5
5-37

Guardrail and Curbs - IDOT



4'-0" (1.2 m) ≤ D ≤ 12'-0" (3.7 m)

GUARDRAIL PLACED BEHIND CURB

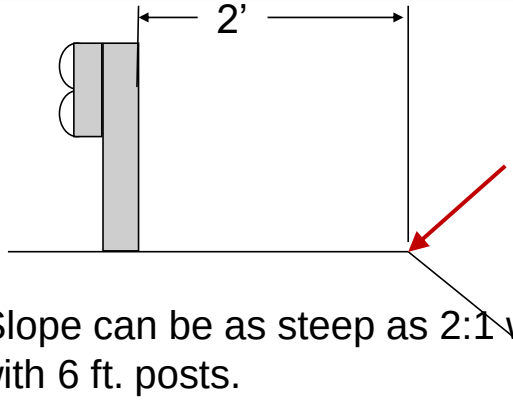
Note: 'D' shall not exceed 6 (152) for design speeds greater than 45 mph.

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

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

Principle 4: Soil Backing For Fill Locations

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, 4th Edition – Figure 5.33, Pg. 5-41

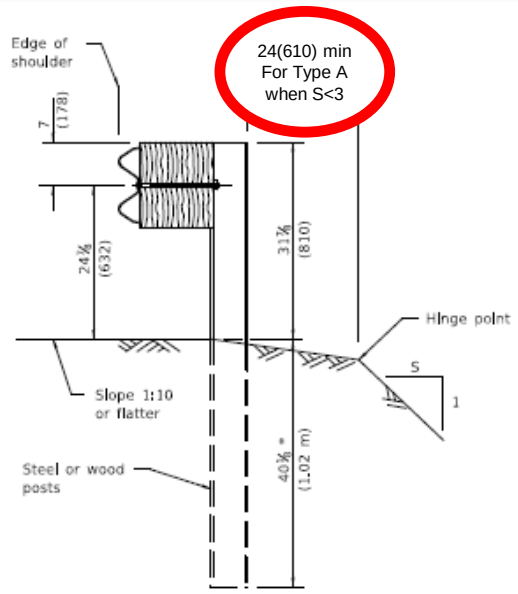
U.S. Department of Transportation Federal Highway Administration

Session 5

5-40

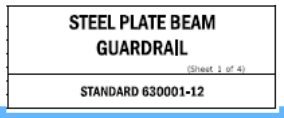

PRE-ASSESSMENT PHOTO
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 5
5-41

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 76⅛ (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



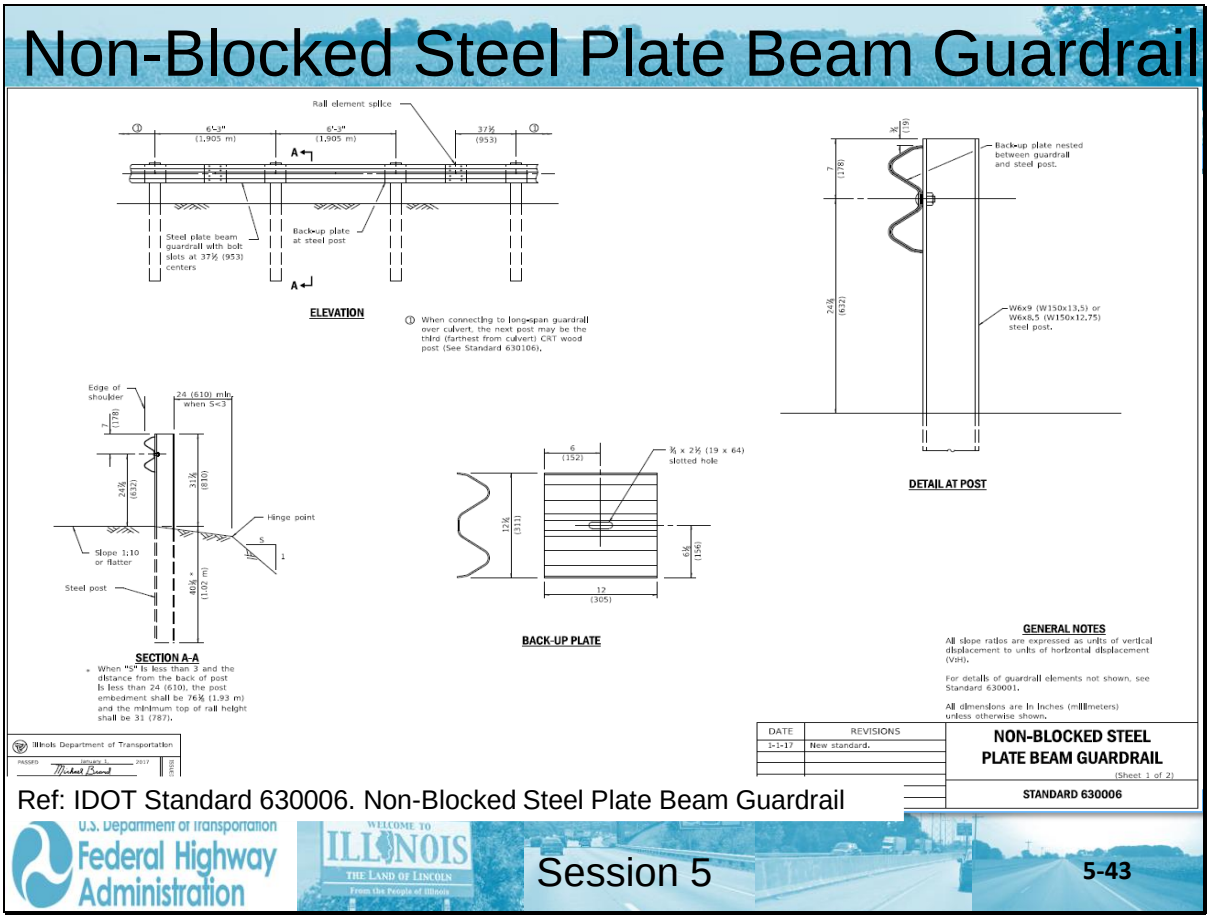
Ref: IDOT Standard 630001-12. Steel Plate Beam Guardrail

U.S. Department of Transportation Federal Highway Administration

Session 5

5-42

Non-Blocked Steel Plate Beam Guardrail



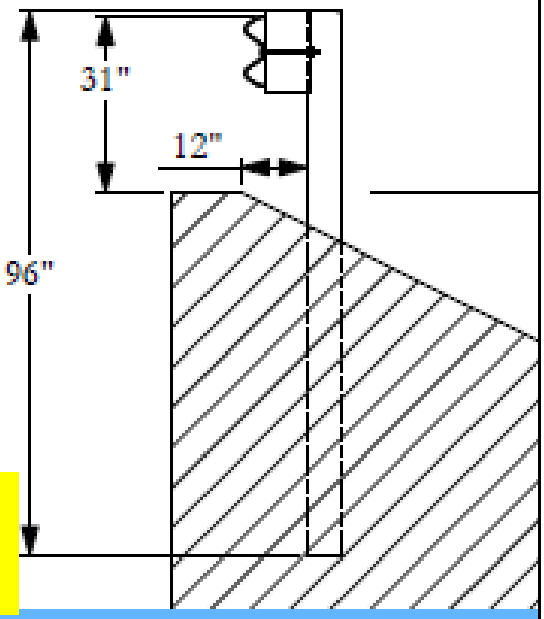
Ref: IDOT Standard 630006. Non-Blocked Steel Plate Beam Guardrail

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



U.S. Department of Transportation Federal Highway Administration
Session 5
5-44

31” Guardrail Adjacent to 2:1 Slope

Session 5
5-45

Flare Rate

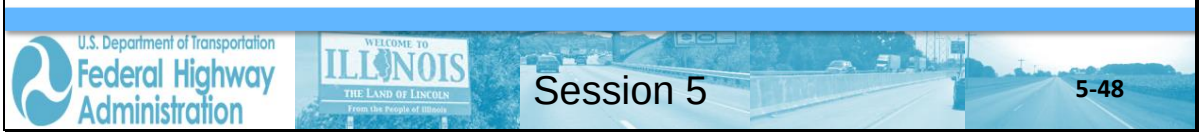
Flared barriers are those that are not parallel to the edge of the traveled way. They are used to:

- Locate terminals farther from the roadway.
- Lessen driver reaction to a roadside obstacle.
- Reduce total length of rail needed.
- Reduce nuisance hits.
- When tying to a bridge rail from a farther offset (in advance of transition)

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.




U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 5
5-49

IDOT Flare Guidance

Illinois ROADSIDE SAFETY February 2020

Design Speed		Flare Rate for Barrier Inside Shy Line*	Flare Rate for Barrier Beyond Shy Line*		
(mph)	(km/hr)		Rigid (Concrete)	Semi-Rigid (W-Beam)	Flexible (Cable)
70	110	1:30	1:20	1:15	1:50
60	100	1:26	1:18	1:14	1:50
55	90	1:24	1:16	1:12	1:50
50	80	1:21	1:14	1:11	1:50
45	70	1:18	1:12	1:10	1:50
40	60	1:16	1:10	1:8	1:50
30	50	1:13	1:8	1:7	1:50

MAXIMUM FLARE RATES FOR BARRIER DESIGN

Figure 38-6.X

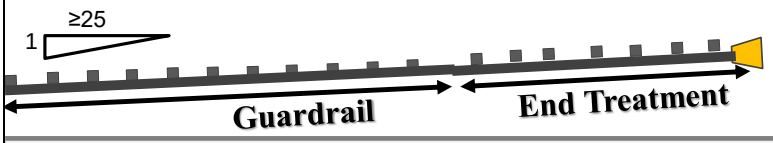
Ref: BDE Manual, Ch. 38-6.04 Barrier Flare

U.S. Department of Transportation Federal Highway Administration

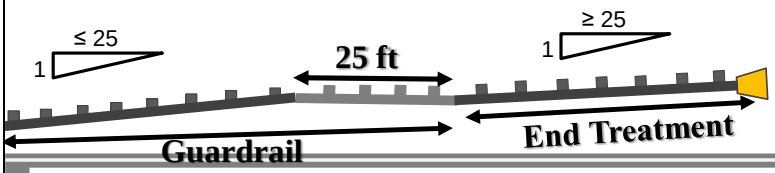
Session 5

5-50

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

Federal Highway Administration

Session 5

5-51

Review Learning Outcomes

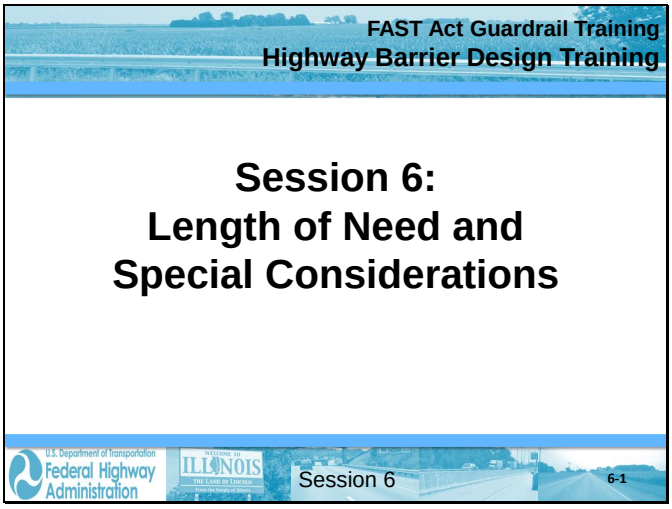
Understand the design principles affecting an optimal barrier installation.

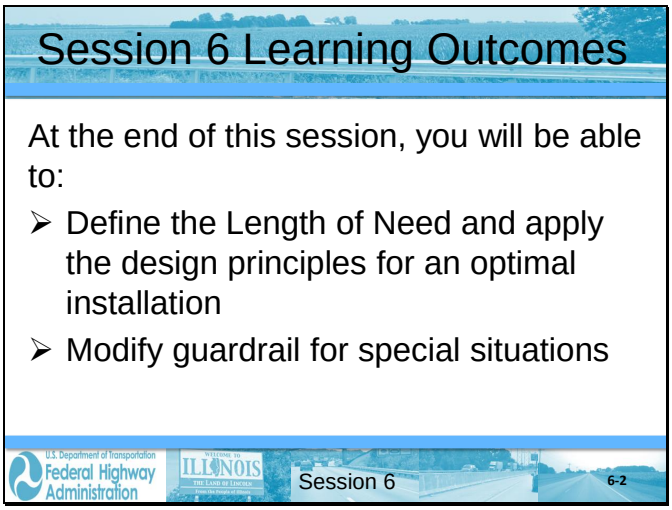
Federal Highway Administration

Session 5

5-52

Session 6: Length of Need and Special Considerations


FAST Act Guardrail Training
Highway Barrier Design Training
Session 6:
Length of Need and
Special Considerations
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-1


Session 6 Learning Outcomes
At the end of this session, you will be able to:
Define the Length of Need and apply the design principles for an optimal installation
Modify guardrail for special situations
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-2

IDOT Guidance

38-4.02 Range of Treatments

- 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.

Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN From the People of Illinois | Session 6 | 6-3

Length of Need (LON) IDOT Definition

Illinois ROADSIDE SAFETY November 2019

If barrier protection is warranted for only one direction of travel:

$LON = L_1 + L_2 - L_3$ Equation 38-6.1

If barrier protection is warranted for both directions of travel:

$LON = L_1$ approaching $+ L_2 + L_1$ opposing Equation 38-6.2

U.S. Department of Transportation Federal Highway Administration | ILLINOIS | Session 6 | 6-4

Length of Need – IDOT Guidance

38-6.01 Length of Need

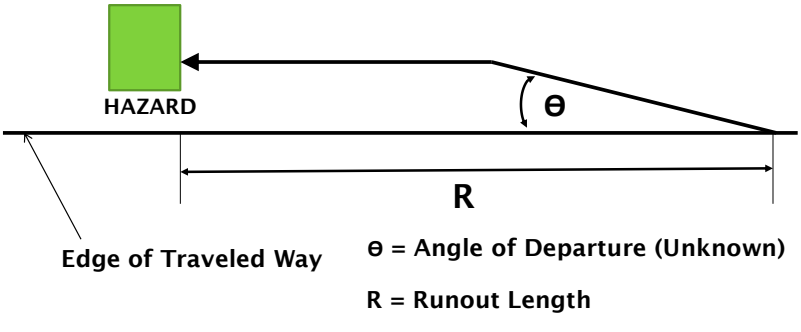
A roadside barrier must intercept and contain or redirect errant vehicles before they reach the roadside hazard or area to be shielded. The barrier should extend a sufficient distance upstream and/or downstream of the hazard such that a vehicle does not travel behind the barrier and reach the hazard.

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

Federal Highway Administration | ILLINOIS | Session 6 | 6-5

Length of Need (L_1) Theory

AASHTO



U.S. Department of Transportation Federal Highway Administration | ILLINOIS | Session 6 | 6-6

Runout Lengths – IDOT

Design Speed		Traffic Volume (ADT)*							
		Over 10,000		5000-10,000		1000-4999		Under 1000	
		Runout Length L_R		Runout Length L_R		Runout Length L_R		Runout Length L_R	
mph	(km/h)	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)

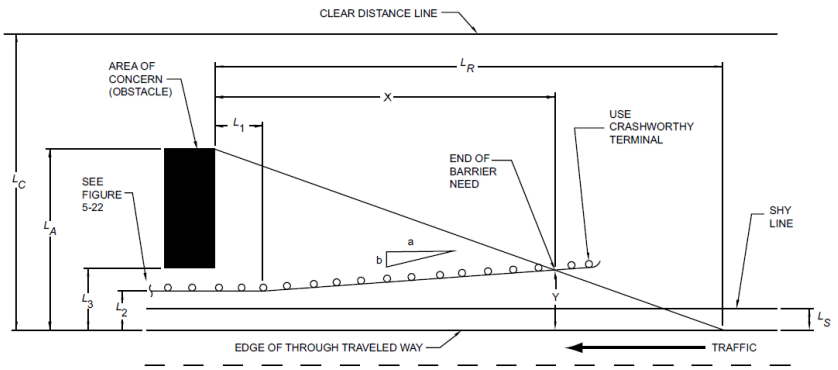
*Based on a 10 year projection from the anticipated date of construction.

RUNOUT LENGTHS (L_R) FOR BARRIER DESIGN

Figure 38-6.E

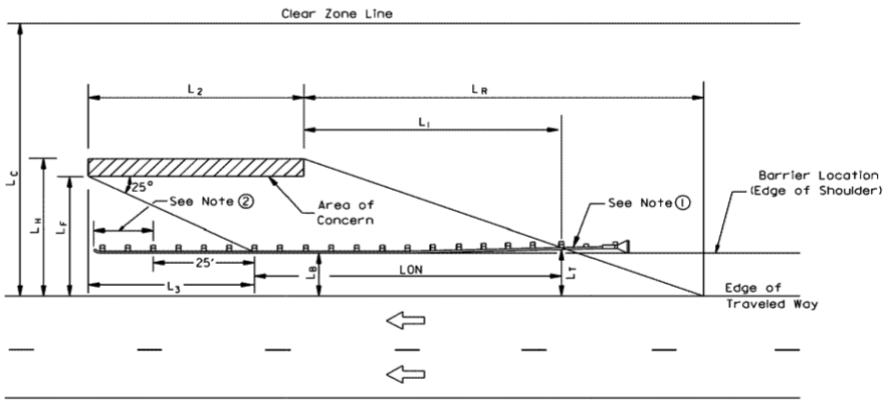
Ref: BDE Manual, Ch. 38-6 Roadside Barrier Layout. Figure 38-6.E

LON – L_1 Procedure - AASHTO



Ref: AASHTO RDG Figure 5-39

LON – L_1 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_F + 12), use an appropriate crashworthy terminal, with LON point passing through the third post of the crashworthy terminal.

L_T = Distance to the barrier at the third post of the terminal
L_B = Distance to the barrier
L_C = Distance to the clear zone
L_H = Distance to the back of the hazard
L_F = Distance to the front of the hazard
L_R = Runout length (see Figure 38-6.E)
L_1 = Length of need for the approach end
L_2 = Length of the hazard
L_3 = 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 - AASHTO

- 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

U.S. Department of Transportation Federal Highway Administration | Session 6 | 6-10

Determining L_1 - IDOT

38-6.01(a) Graphical Solution

Whether on tangent or curved alignment, the preferred way to lay out guardrail and determine the length of need is by drawing and measuring the installation in plan view using CADD software.
Designing graphically offers several advantages:

38-6.01(b) Nomograph Solution – L_1

If the installation is on a tangent section of roadway, the nomograph in Figure 38-6.F can be used to determine the length of need. The procedure for using the nomograph is as follows, assuming a hazard is present requiring protection:

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

U.S. Department of Transportation Federal Highway Administration | Session 6 | 6-11

Determining L_1 - Nomograph

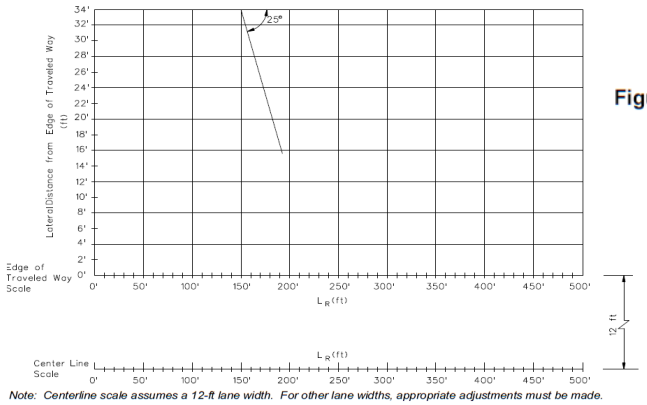
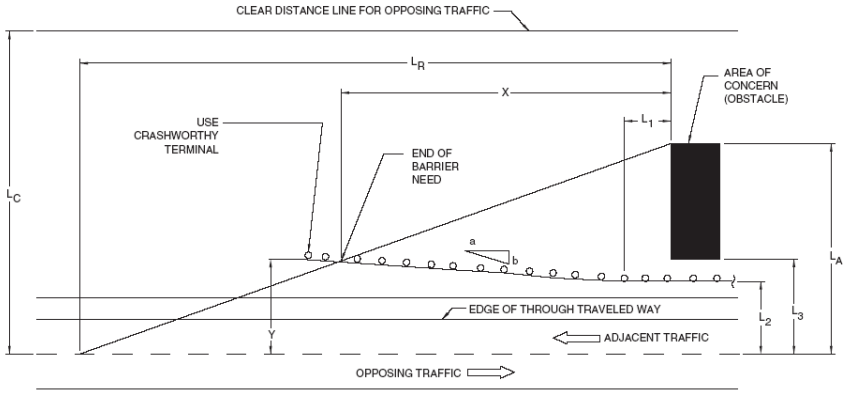


Figure 38-6.F

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

LON L_1 Design for Opposing Traffic



Ref: AASHTO Roadside Design Guide, 4th Edition, Figure 5.42, Pg. 5-54

Treatment of Downstream End

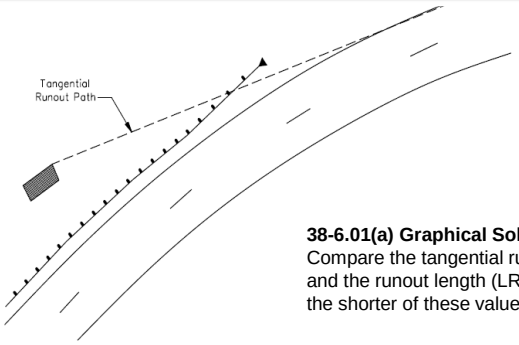
38-6 ROADSIDE BARRIER LAYOUT

38-6.01 Length of Need

The clear zone on the right begins at the edge of the traveled way. For traffic on a two-way roadway without a median, the clear zone on the left begins at the centerline of the roadway. The departure end of a roadside barrier on a two-way roadway may or may not be within the clear zone of the opposing traffic. However, this departure end of the roadside barrier is a formidable hazard introduced to the roadside and should typically be shielded, regardless of lateral offset. When beyond the clear zone for opposing traffic, at a minimum, provide an approved crashworthy end section to the end of the roadside barrier facing opposing traffic.

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

Length of Need L_1 on the Outside of a Horizontal Curve



38-6.01(a) Graphical Solution
Compare the tangential runout path and the runout length (LR) and use the shorter of these values for design.

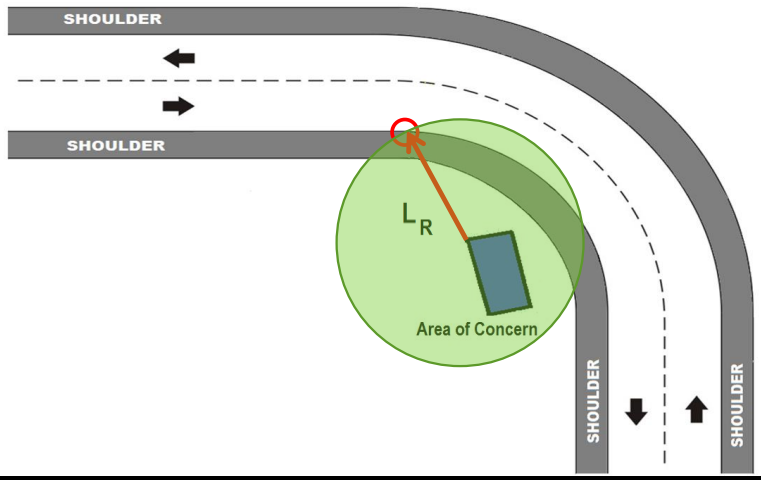
GRAPHICAL LAYOUT OF GUARDRAIL ALONG A HORIZONTAL CURVE

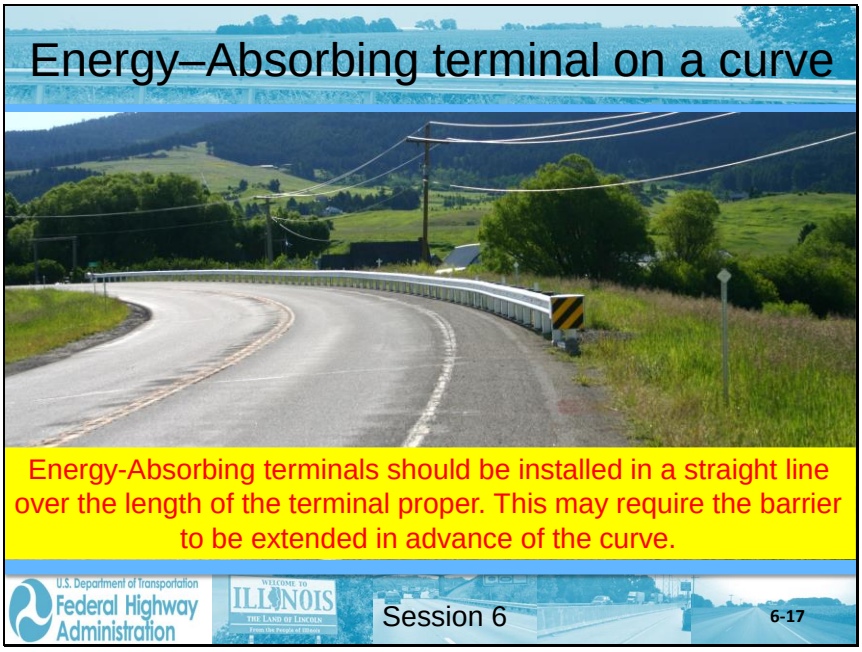
Figure 38-6.C

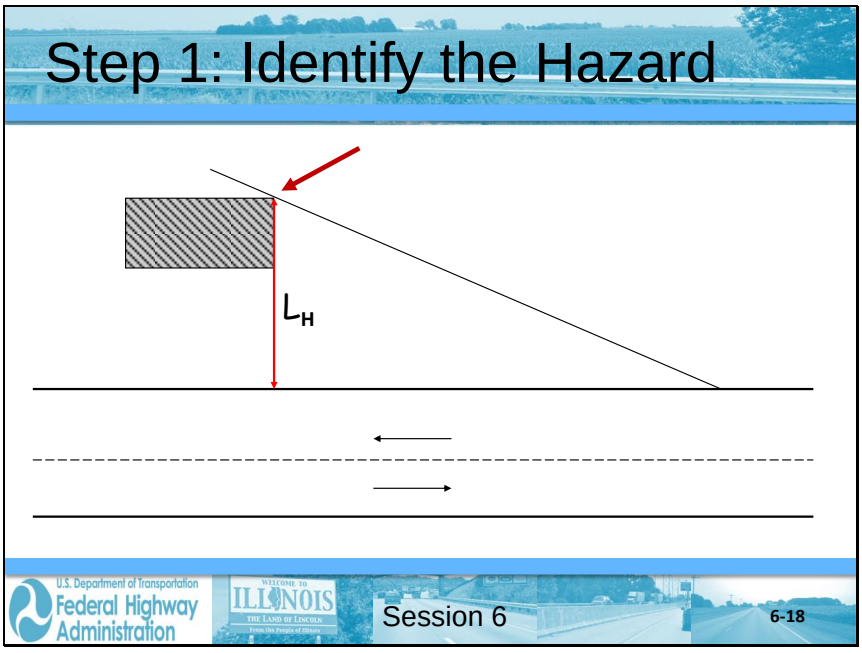
Ref: BDE Manual, Ch. 38-6 Roadside Barrier Layout. Figure 38-6.C

Federal Highway Administration | ILLINOIS | Session 6 | 6-15

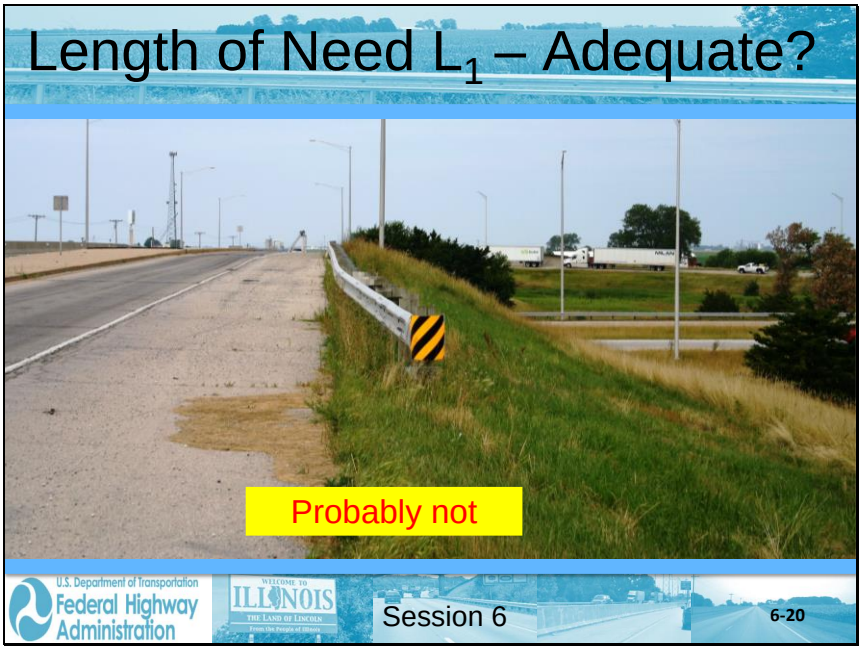
Length of Need L_1 on the Inside of a Horizontal Curve




Energy–Absorbing terminal on a curve
Energy-Absorbing terminals should be installed in a straight line over the length of the terminal proper. This may require the barrier to be extended in advance of the curve.
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-17


Step 1: Identify the Hazard
L_H
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-18


Length of Need L_1 – Adequate?
PRE-ASSESSMENT PHOTO
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 6
6-19


Length of Need L_1 – Adequate?
Probably not
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-20


Good Length of Need - L_1
Pier and Transverse Embankment
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-21

Transverse Embankments (REPEAT)

The bridge cones of overhead roadway structures also introduce transverse slopes. Both the transverse slope intersecting the ditch and the transverse slope beyond the ditch, but within the clear zone, should be addressed with the slopes given in Figure 38-4.C.

Type of Facility	Desirable (V:H)	Acceptable (V:H)
Freeway	1:10	1:6
Rural Non-Freeways (V ≥ 50 mph (80 km/h))	1:10	1:6
Urban Non-Freeways (V ≥ 50 mph (80 km/h))	1:6	1:4
Urban and Rural Low-Speed Facilities (V ≤ 45 mph (70 km/h))	1:6	1:4

RECOMMENDED TRANSVERSE SLOPES

Figure 38-4.C

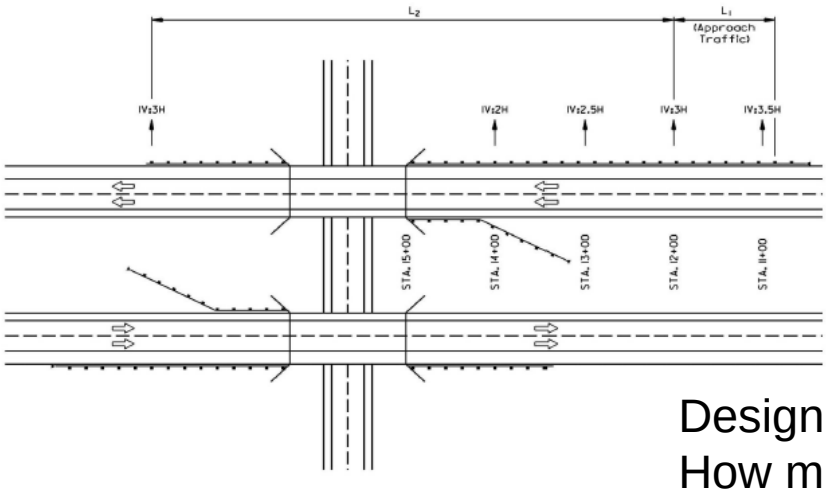
38-4.05 Transverse Slopes

Ref: BDE Manual, Ch. 38-4.05 Traverse Slopes


PRE-ASSESSMENT PHOTO
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-23


Length of Need - L1
Not Reasonable to Provide
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-24

Length of Need - L_1
Dual Bridge Shielding



PLAN VIEWW
EXAMPLE 38-6.01(6)
Figure 38-6.Q

What is L_H?

Typically L_C = 30'

Design for FULL width.
How much more?

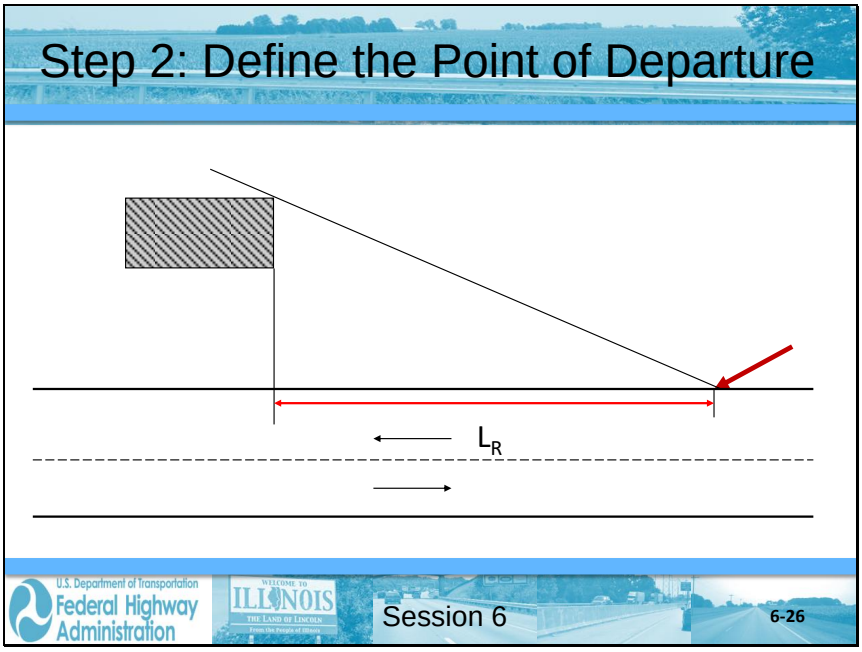
Probably about TWO more panels

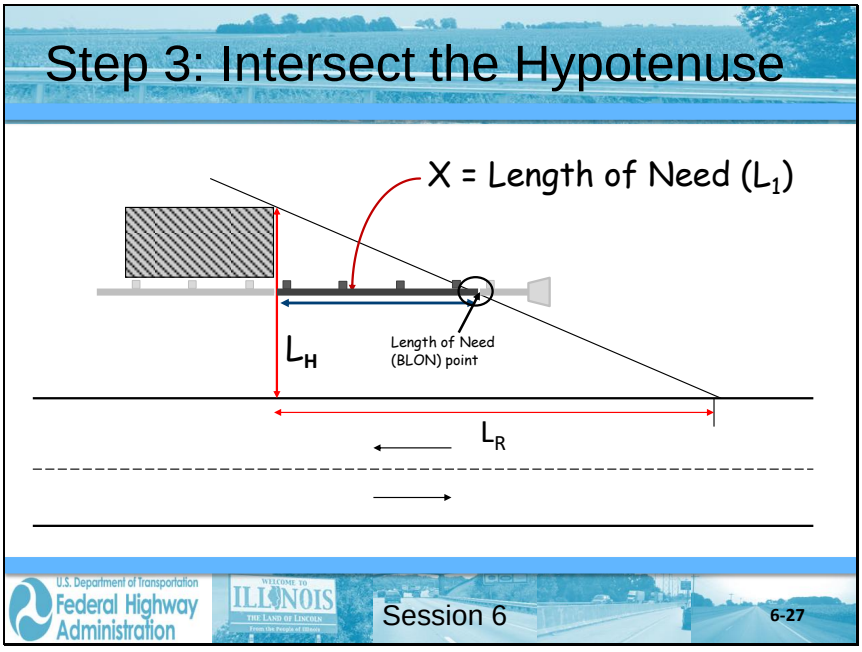
U.S. Department of Transportation
Federal Highway Administration

WELCOME TO ILLINOIS THE LAND OF LINCOLN From the People of Illinois

Session 6

6-25


Step 2: Define the Point of Departure
L_R
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-26

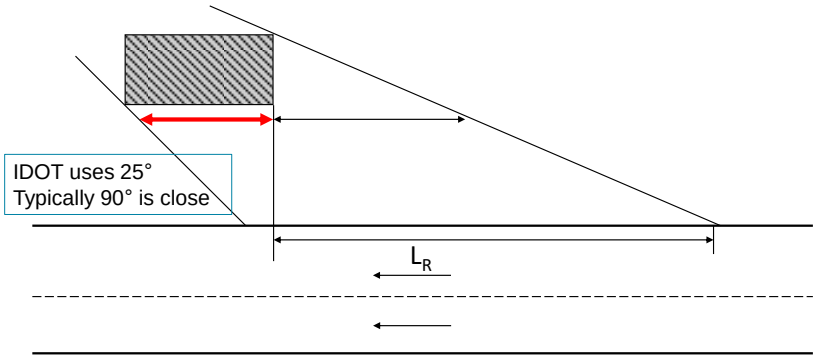

Step 3: Intersect the Hypotenuse
X = Length of Need (L_1)
L_H
Length of Need
(BLON) point
L_R
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-27

Quick Field Check of LON L_1

1. Stand on roadway edgeline opposite the upstream edge of the hazard.
2. Pace upstream along edgeline appropriate runout length (based on speed of roadway and traffic volume).
3. Turn and look at far lateral edge of hazard.
4. If planned (or existing) guardrail run intercepts this line of sight, it satisfies basic design length of need.
5. Check for ALL hazards that should be shielded in this area
6. Check for better terminal location by extending barrier a short distance (especially on curves!!!)

Downstream Termination One Direction Traffic

End of effective barrier – determining L_3



Downstream Termination One Direction Traffic - IDOT

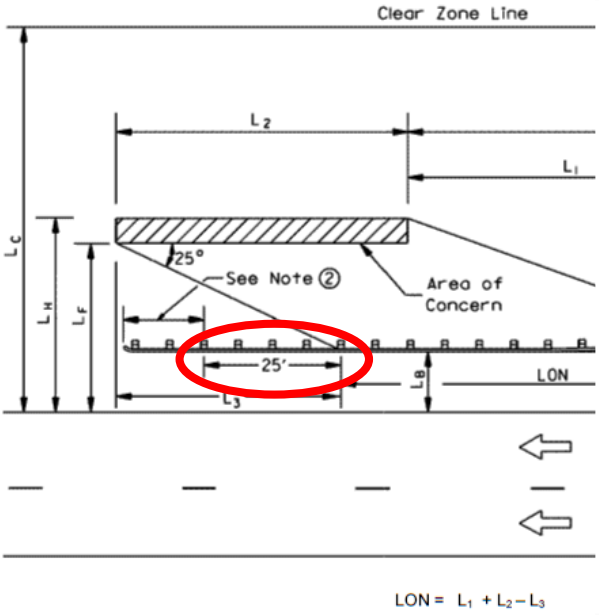
38-6.01(b) Nomograph Solution – Step 9

For a TBT T2 the length of need begins at 37.5 ft (11.43 m) from the end post of the TBT T2. This means that the TBT T2 and the adjacent 25 ft (3.81 m) of guardrail do not contribute to the LON. Using a TBT T2 requires adding at least 25 ft (3.81 m) of guardrail beyond the LON when calculating the pay item quantities.

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

Downstream Termination One Direction Traffic - IDOT

Figure 38-6.A



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

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

Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN | Session 6 | 6-31

Downstream Termination One Direction Traffic

Maybe old guidance – not new

U.S. Department of Transportation Federal Highway Administration

Welcome to Illinois – The Land of Lincoln – From the People of Illinois

Session 6

6-32

Downstream Termination
Two Direction Traffic (REPEAT)

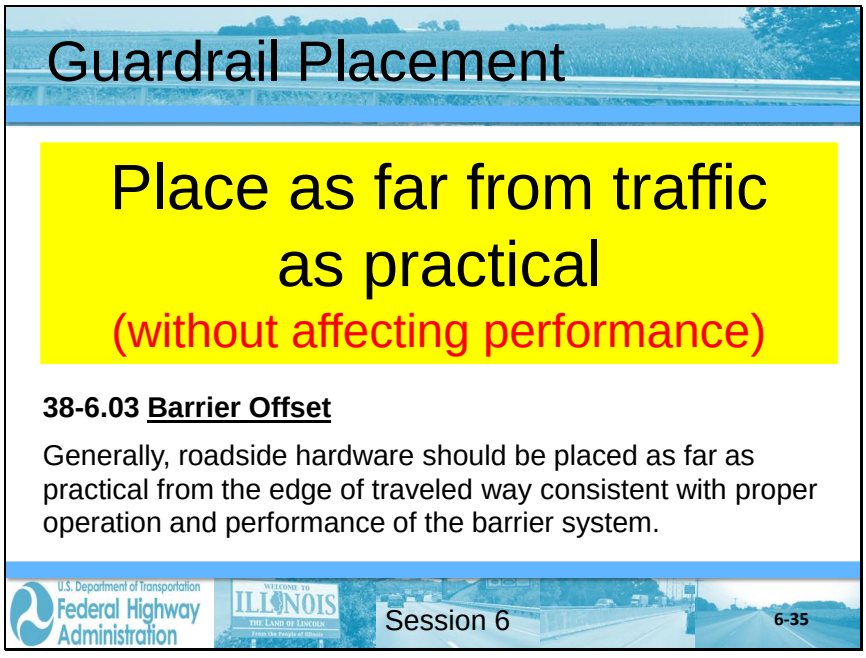
38-6 ROADSIDE BARRIER LAYOUT

38-6.01 Length of Need

The clear zone on the right begins at the edge of the traveled way. For traffic on a two-way roadway without a median, the clear zone on the left begins at the centerline of the roadway. The departure end of a roadside barrier on a two-way roadway may or may not be within the clear zone of the opposing traffic. However, this departure end of the roadside barrier is a formidable hazard introduced to the roadside and should typically be shielded, regardless of lateral offset. When beyond the clear zone for opposing traffic, at a minimum, provide an approved crashworthy end section to the end of the roadside barrier facing opposing traffic.

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


Secondary Hazard
PRE-ASSESSMENT PHOTO
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 6
6-34

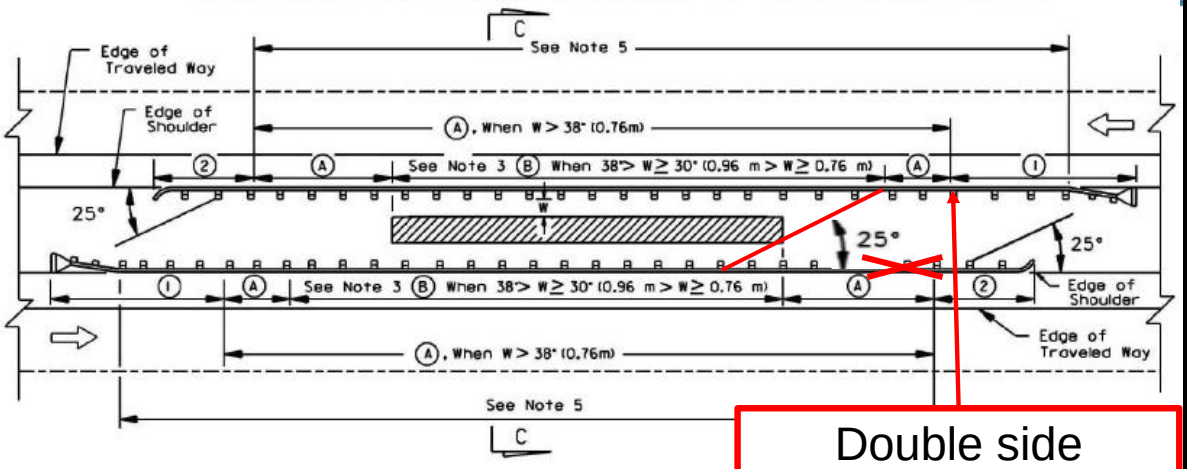

Guardrail Placement
Place as far from traffic as practical
(without affecting performance)
38-6.03 Barrier Offset
Generally, roadside hardware should be placed as far as practical from the edge of traveled way consistent with proper operation and performance of the barrier system.
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 6
6-35


Maybe a little EXTREME!!!!
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 6
6-36


A little more reasonable Offset
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 6
6-37


U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 6
6-38

IDOT Guidance vs Alternative



DIVIDING STEEL PLATE BEAM GUARDRAIL

Figure 38-7.H

U.S. Department of Transportation Federal Highway Administration

Session 6

6-39

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

U.S. Department of Transportation Federal Highway Administration

Session 6

6-40

Intersecting Roadway Terminal

Weak Post Radius
No longer Acceptable by IDOT

Intersecting Roadway – IDOT Guidance

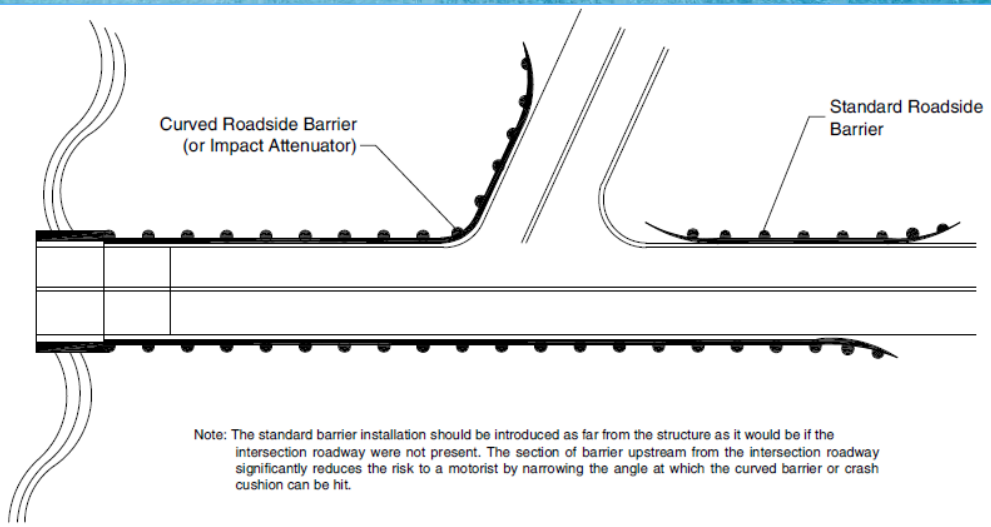
38-6.09 <u>Short Radius Guardrail</u>

There are currently no short radius (radius = 150 ft (45 m) or less) guardrail systems that the Department has identified and adopted as a standard design element.

Steel Plate Beam Guardrail, Type A is the only current system usable for a short radius installation. The design should introduce strong posts likely to rotate out of a vehicle's path and minimize vaulting, blockouts to minimize snagging, and mounting height to minimize override. This system has not met any crash testing criteria, but when a short radius guardrail installation is required, it represents an effort to provide a forgiving installation.

Ref: BDE Manual, Ch. 38-6.09 Short Radius Guardrail

Intersecting Roadway - RDG



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

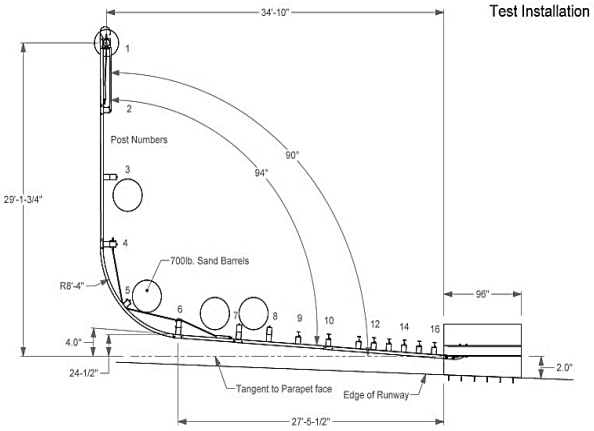
5-60 *Roadside Design Guide*

U.S. Department of Transportation Federal Highway Administration

Session 6

6-43

TxDOT MASH TL-3 Short Radius



On-going Research by Pool Fund – No Eligibility Letter

TxDOT MASH TL-3 Short Radius

Preliminary Design from NCHRP 15-53

Key Characteristics:

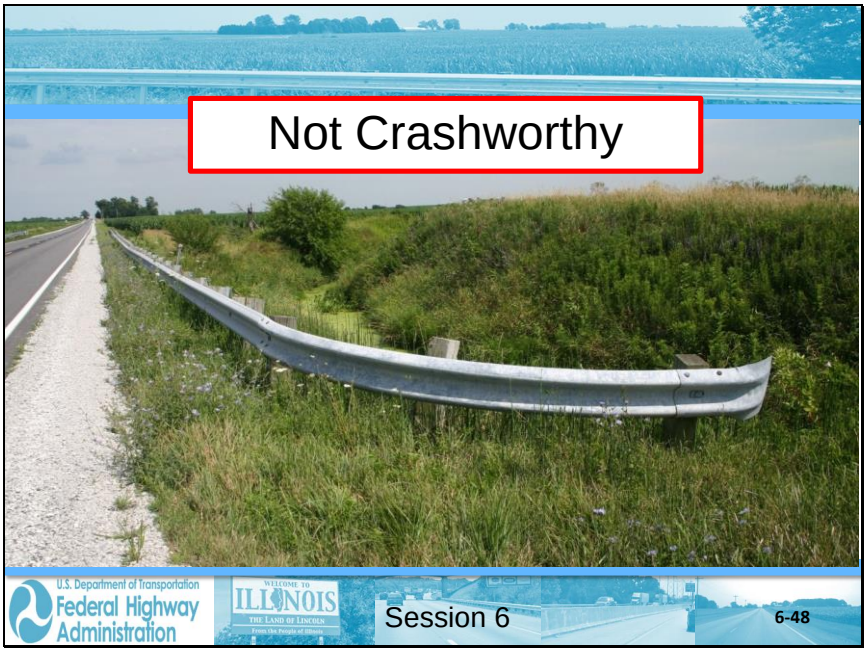
- W-beam barrier (31” height) steel posts with 8” wood blockouts
- 10-gauge thickness for all rails
- 24 ft tangent section on primary road
- 35 ft tangent section on secondary road
- 3/4” diameter cable placed at 12-in from ground (about 5 in from rails)
- Another cable placed along the center of the w-beam

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois – The Land of Lincoln | Session 6 | 6-46

Test 3-33 on a 2:1 Slope at **50 mph** ONLY

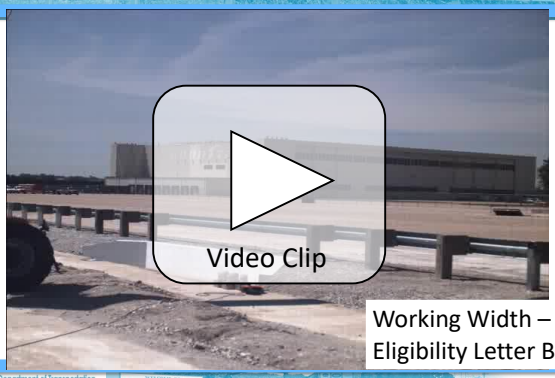
On-going Research by NCHRP – No Eligibility Letter

U.S. Department of Transportation Federal Highway Administration | Welcome to Illinois | Session 6 | 6-47


Not Crashworthy
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-48

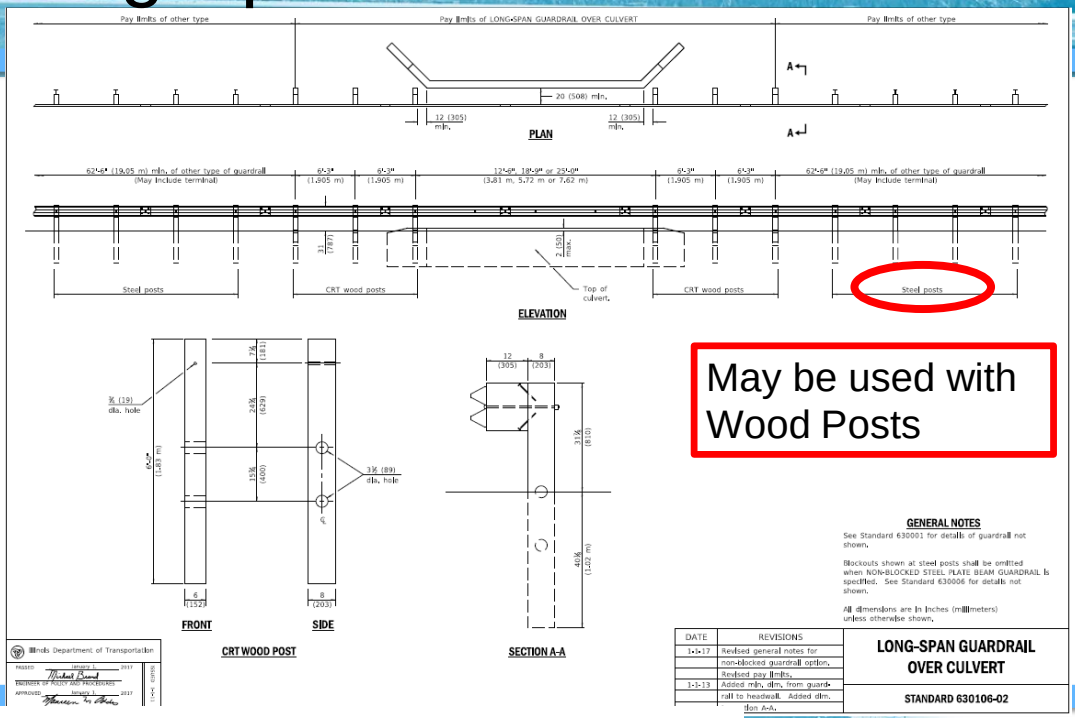

Long Span – 31” Guardrail
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-49

Long Span – 31” Guardrail



Working Width – 94”
Eligibility Letter B-189

Long Span – 31” Guardrail



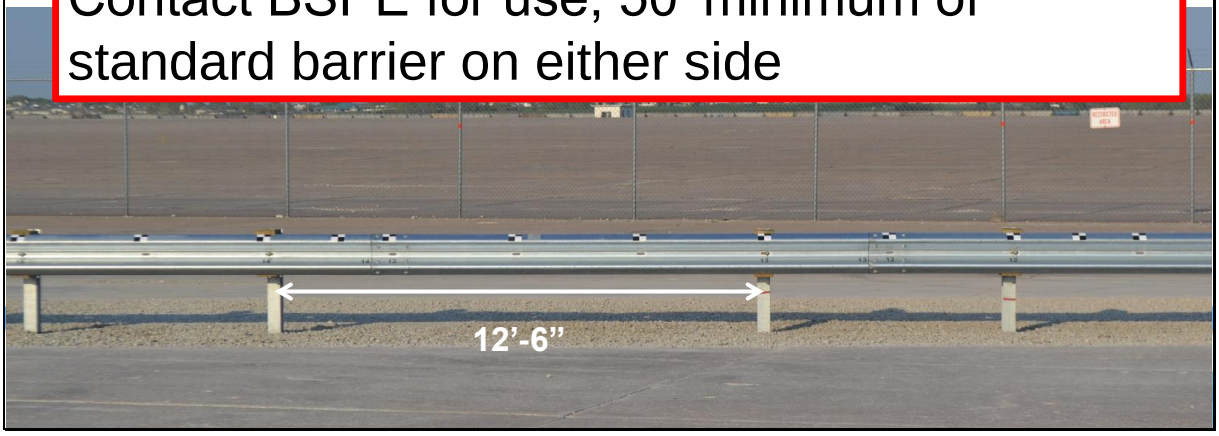
May be used with Wood Posts

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

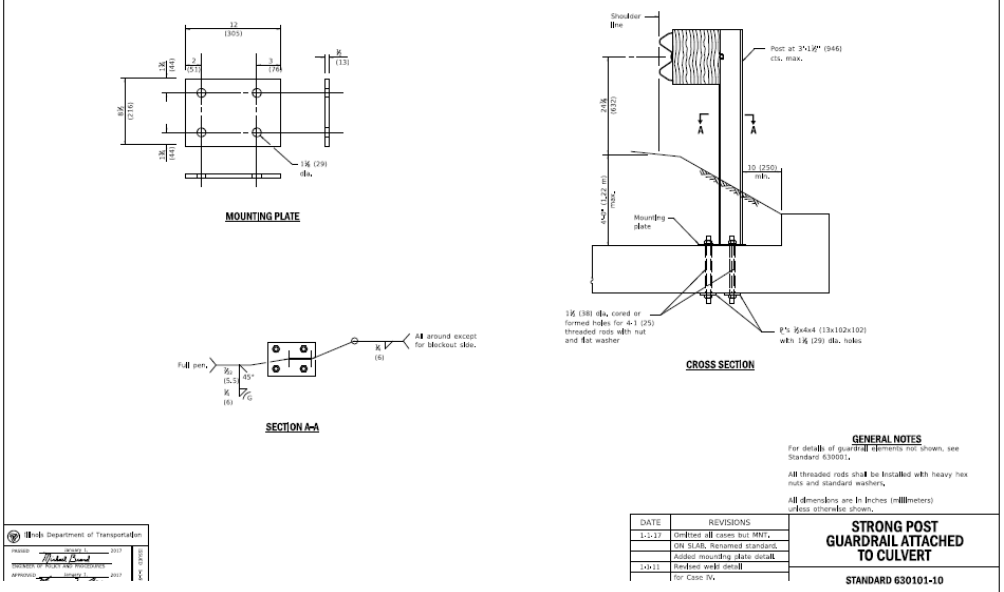
31” Guardrail - Omitting 1 post

- 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

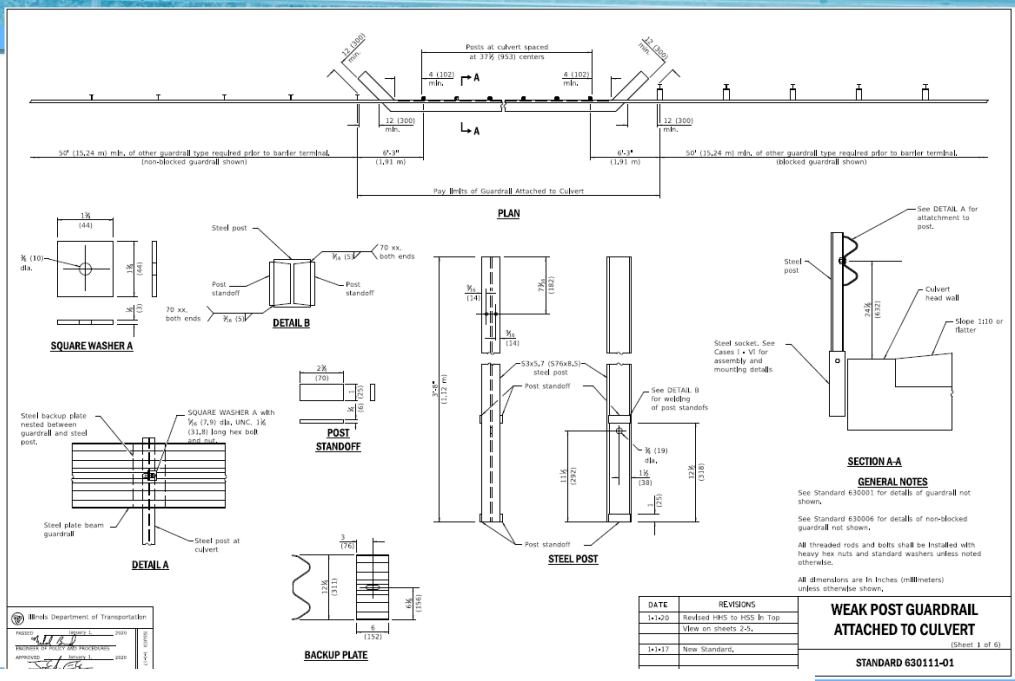


Structure Mounted Guardrail



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

31” with Headwall-Mounted Posts



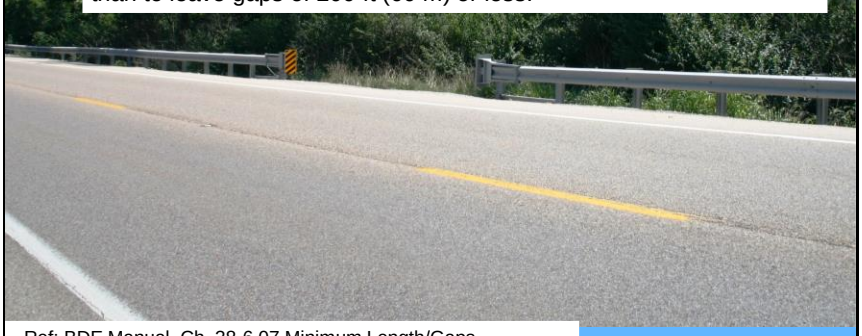
Ref: IDOT Standard 630111-01. Weak Post Guardrail attached to Culvert

31” with Headwall-Mounted Posts Video

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

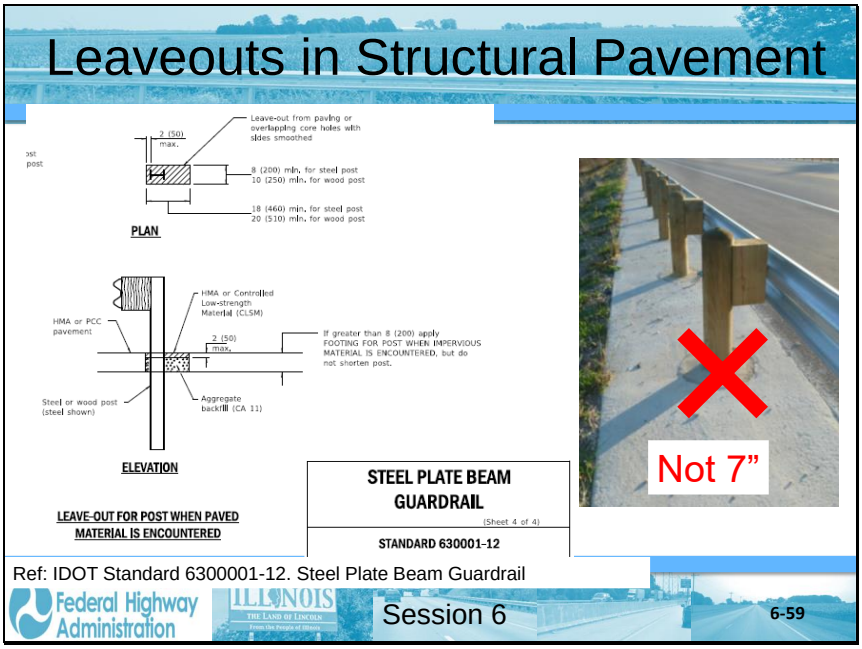
Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN | Session 6 | 6-57

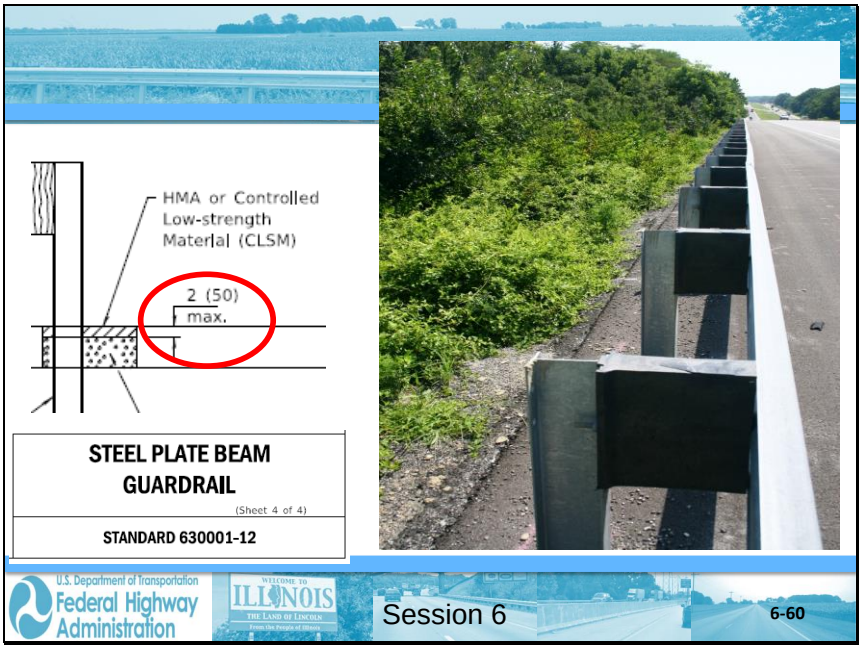
Extra Blockouts – National Guidance

- 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.

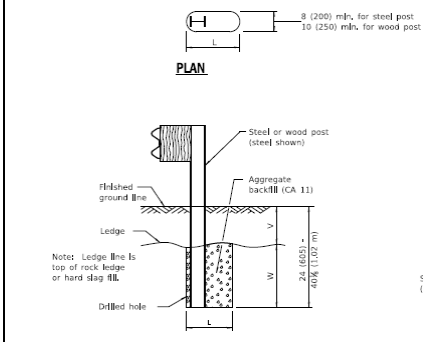
Ref: AASHTO Roadside Design Guide – 3rd Edition, Section 5.4.1.6

U.S. Department of Transportation Federal Highway Administration | ILLINOIS THE LAND OF LINCOLN | Session 6 | 6-58


Leaveouts in Structural Pavement
2 (50) max.
Leave-out from paving or overlapping core holes with sides smoothed
8 (200) min. for steel post
10 (250) min. for wood post
18 (460) min. for steel post
20 (510) min. for wood post
PLAN
HMA or PCC pavement
HMA or Controlled Low-strength Material (CLSM)
2 (50) max.
If greater than 8 (200) apply FOOTING FOR POST WHEN IMPERVIOUS MATERIAL IS ENCOUNTERED, but do not shorten post.
Steel or wood post (steel shown)
Aggregate backfill (CA 11)
ELEVATION
LEAVE-OUT FOR POST WHEN PAVED MATERIAL IS ENCOUNTERED
STEEL PLATE BEAM GUARDRAIL
(Sheet 4 of 4)
STANDARD 630001-12
Not 7”
Ref: IDOT Standard 6300001-12. Steel Plate Beam Guardrail
Federal Highway Administration
ILLINOIS
Session 6
6-59


HMA or Controlled Low-strength Material (CLSM)
2 (50) max.
STEEL PLATE BEAM GUARDRAIL
(Sheet 4 of 4)
STANDARD 630001-12
U.S. Department of Transportation
Federal Highway Administration
ILLINOIS
Session 6
6-60

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 - 40⅛ (> 787 - 1.02 m)	12 - 0 (305 - 0)	8 (203)	10 (250)

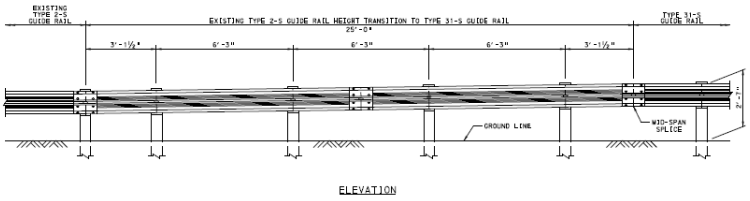
STEEL PLATE BEAM GUARDRAIL
(Sheet 4 of 4)
STANDARD 630001-12

FOOTING FOR POST WHEN IMPERVIOUS MATERIAL IS ENCOUNTERED

Ref: IDOT Standard 6300001-12. Steel Plate Beam Guardrail

Height Transition – 27” to 31”

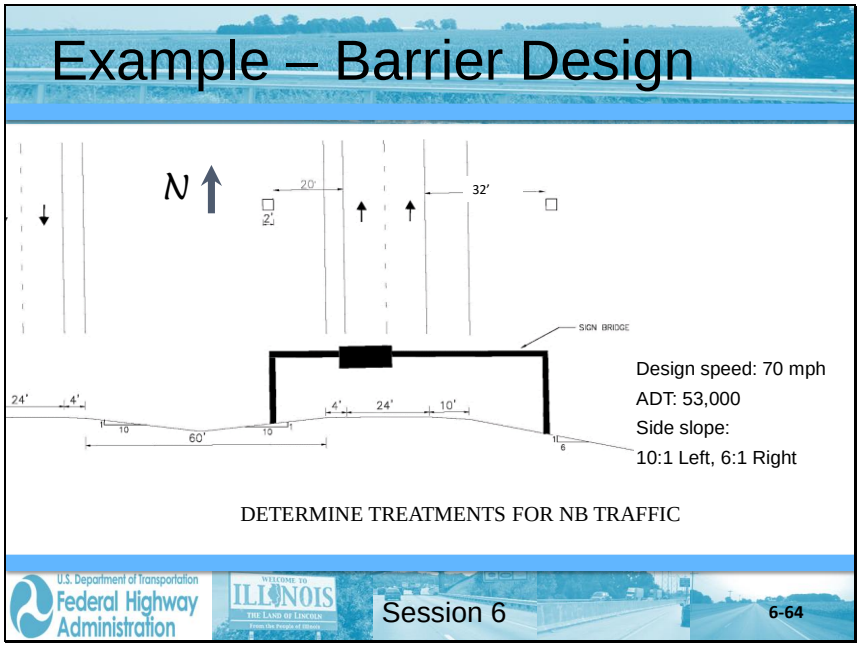
An Example from one state

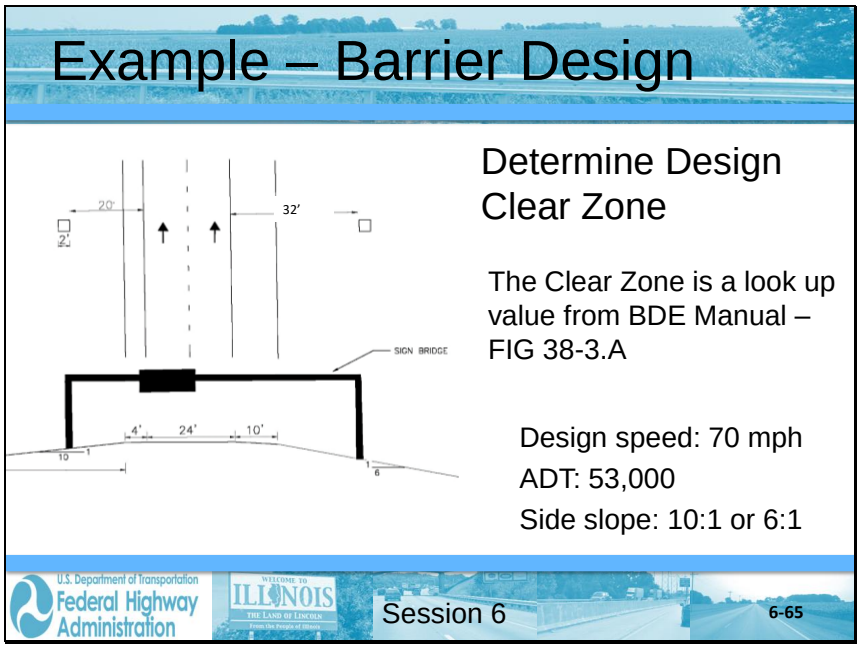



Example – Barrier Design
U.S. Department of Transportation
Federal Highway Administration
WELCOME TO
ILLINOIS
THE LAND OF LINCOLN
From the People of Illinois
Session 6
6-63

_____

_____


Example – Barrier Design
N
20'
2'
32'
SIGN BRIDGE
24'
4'
10
60'
10
4'
24'
10'
6
Design speed: 70 mph
ADT: 53,000
Side slope:
10:1 Left, 6:1 Right
DETERMINE TREATMENTS FOR NB TRAFFIC
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-64


Example – Barrier Design
20'
2'
32'
SIGN BRIDGE
4'
24'
10'
10
6
Determine Design Clear Zone
The Clear Zone is a look up value from BDE Manual – FIG 38-3.A
Design speed: 70 mph
ADT: 53,000
Side slope: 10:1 or 6:1
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-65

Design Clear Zone Distance

Design Speed (mph)	Design Year ADT	Front Slopes 1V:6H or Flatter	Front Slopes 1V:5H to 1V:4H
≤ 40	Under 750	7 – 10	7 – 10
	750 – 1500	10 – 12	12 – 14
	1500 – 6000	12 – 14	14 – 16
	Over 6000	14 – 16	16 – 18
45 – 50	Under 750	10 – 12	12 – 14
	750 – 1500	12 – 14	16 – 20
	1500 – 6000	16 – 18	20 – 26
	Over 6000	18 – 20	24 – 28
55	Under 750	12 – 14	14 – 18
	750 – 1500	16 – 18	20 – 24
	1500 – 6000	20 – 22	24 – 30
	Over 6000	22 – 24	26 – 32*
60	Under 750	16 – 18	20 – 24
	750 – 1500	20 – 24	26 – 32*
	1500 – 6000	26 – 30	32 – 40*
	Over 6000	30 – 32*	36 – 44*
65 – 70[6]	Under 750	18 – 20	20 – 26
	750 – 1500	24 – 26	28 – 36*
	1500 – 6000	28 – 32	34 – 42*
	Over 6000	30 – 34*	38 – 46*

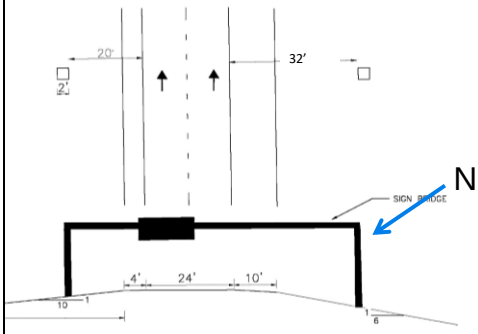
Design Speed 70 mph
AADT = 53,000

L_C = 32 ft.

RECOMMENDED CLEAR ZONE DISTANCES (ft)
(New Construction/Reconstruction)
(US Customary)

Figure 38-3.A

Example – LON



Identify ALL the hazards

NOT SHIELDED

Sign supports – both sides

Calculating the LON – L_1

L_T = Distance to the barrier at the third post of the terminal
L_B = Distance to the barrier
L_C = Distance to the clear zone
L_H = Distance to the back of the hazard
L_F = Distance to the front of the hazard
L_R = Runout length (see Figure 38-6.E)
L_1 = Length of need for the approach end
L_2 = Length of the hazard
L_3 = Distance from the downstream end of the hazard
LON = Length of Need

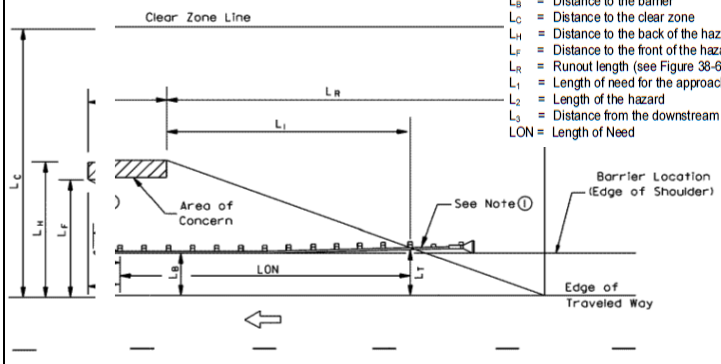


Figure 38-6.A

Calculating Length of Need AASHTO

- Calculating the length of need (X) for straight or nearly straight sections of roadway:
  - For <u>flared</u> guardrail installations:

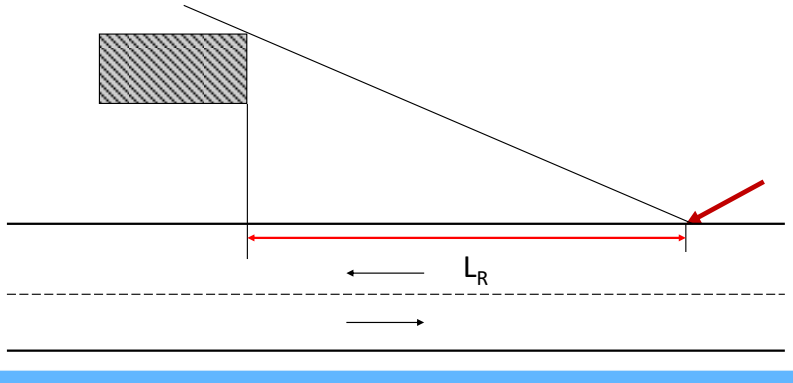
$$X = \frac{L_A + (b/a)\,(L_1) - L_2}{(b/a) + (L_A/L_R)}$$

  - For <u>parallel</u> guardrail installations:

$$X = \frac{L_A - L_2}{L_A/L_R}$$

Ref: AASHTO Roadside Design Guide, 4th Edition, Equation 5-1 and 5-2, Pg 5-51

Step 2: Define the Point of Departure



U.S. Department of Transportation Federal Highway Administration
Session 6
6-70

Look up L_R:

Design Speed 70 mph
AADT = 53,000

Design Speed		Traffic Volume (ADT)*							
		Over 10,000		5000-10,000		1000-4999		Under 1000	
		Runout Length L_R		Runout Length L_R		Runout Length L_R		Runout Length L_R	
mph	(km/hr)	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)				(30)
30	(50)	110	(34)	90	(27)				(21)

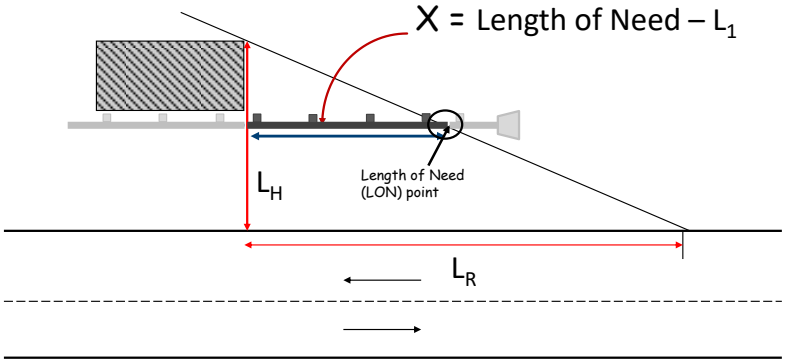
L_R= 360 ft.

RUNOUT LENGTHS (L_R) FOR BARRIER DESIGN

Figure 38-6.E

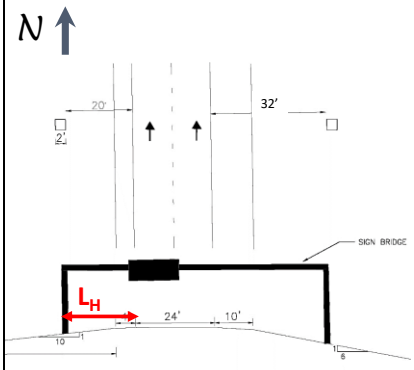
U.S. Department of Transportation Federal Highway Administration
Session 6
6-71

Step 3: Intersect the Hypotenuse



U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln
Session 6
6-72

Example – LON_1



Determine L_H – distance to the backside of hazard

For the back of the sign support:

$L_H = 20 + 2 = 22'$

U.S. Department of Transportation Federal Highway Administration
Welcome to Illinois The Land of Lincoln
Session 6
6-73

Determine L_B

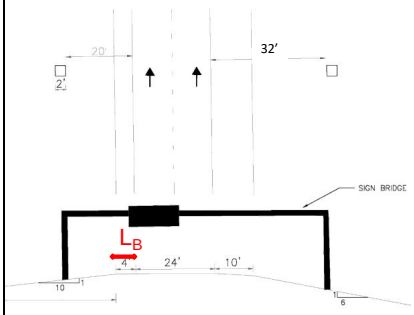
L_B – Guardrail offset from edge of travel lane.

The AASHTO Greenbook "suggests" that barrier be placed 2' beyond the usable shoulder,

38-6.03 Barrier Offset

2. Shoulder. Typically, the roadside barrier is located with the face of barrier at the edge of the shoulder unless flared away from the shoulder.

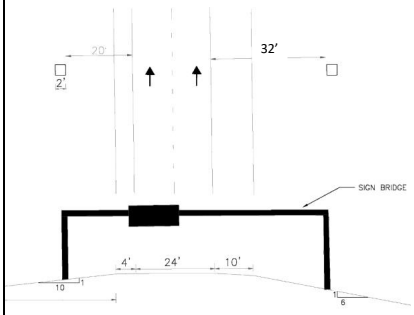
Determine L_B



L_B – Guardrail offset from edge of travel lane.

L_B = 6 ft.

Calculate L_1



L_H = 22 ft L_T = 6 ft (+.75) L_R = 360

Using the formula X =

$$X = \frac{L_H - L_T}{L_H/L_R}$$

$$= \frac{22 - (6+.75)}{.061}$$

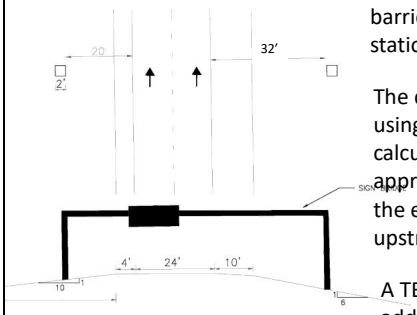
$$= 250 \text{ ft.}$$

U.S. Department of Transportation Federal Highway Administration

Session 6

6-76

Determine Bid Items



NO Grading needed (10:1)

L_1 – 250' – is the distance from the upstream face of the hazard to the beginning of effective barrier – the upstream BLON point. This is the station placed on the plans.

The downstream BLON point is determined using L3. Although the 25 degree line calculation would give an exact value, a quick approximation is 2 X (L_F – L_B) or 28'. Therefore the end of Effective barrier would be 28' upstream from the end of the hazard.

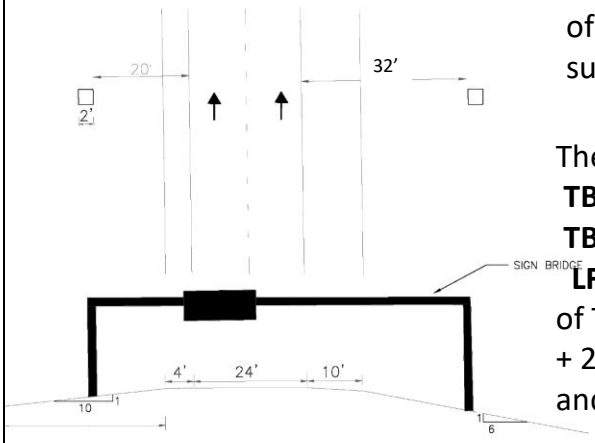
A TBT Type 2 + 25' of guardrail must be added beyond end of Effective barrier

U.S. Department of Transportation Federal Highway Administration

Session 6

6-77

Determine Bid Items - continued



The TBT Type 1 (Tangent) provides about 35' of Effective barrier – this would be subtracted from the guardrail bid item length

Therefore, the bid items would be:

TBT Type 1 (tangent) – 1 ea

TBT Type 2 – 1 ea

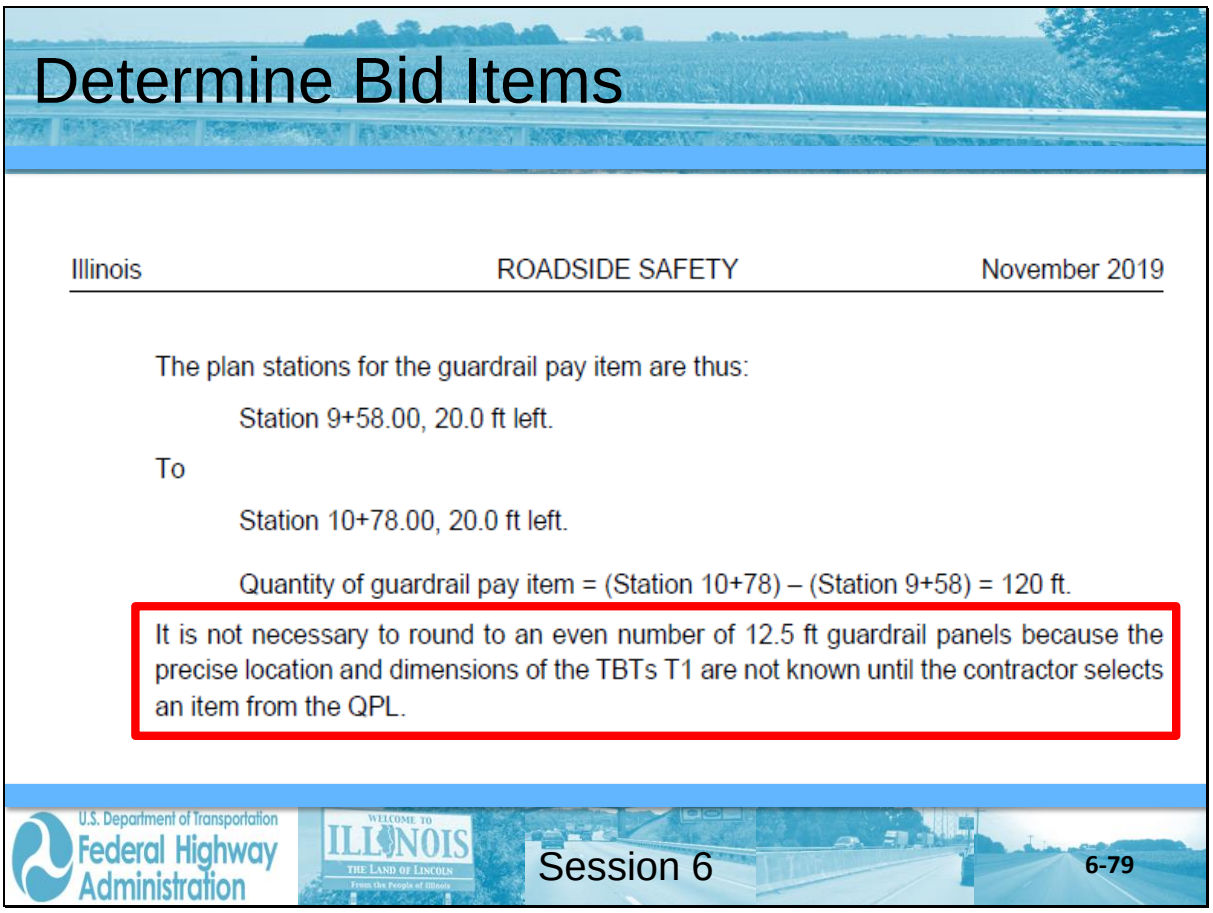
LF of guardrail : 250' (L_1) – 35' (effective part of TBT Type 1) + 2' (Length of hazard) – 28' (L_3) + 25' (Required between TBT Type 2 pay item and end of effective barrier need = 214'

NO Grading needed (10:1)

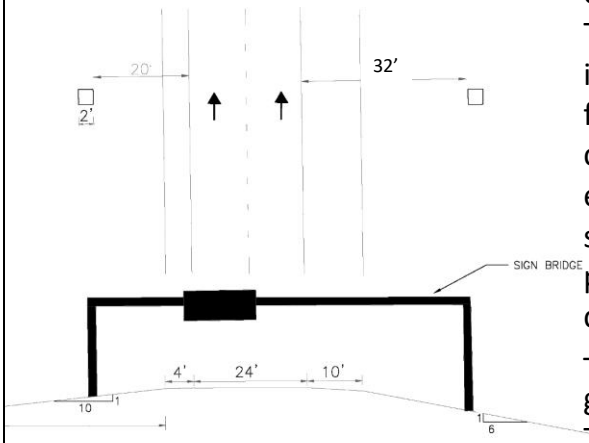
U.S. Department of Transportation Federal Highway Administration

Session 6

6-78


Determine Bid Items
Illinois
ROADSIDE SAFETY
November 2019
The plan stations for the guardrail pay item are thus:
Station 9+58.00, 20.0 ft left.
To
Station 10+78.00, 20.0 ft left.
Quantity of guardrail pay item = (Station 10+78) – (Station 9+58) = 120 ft.
It is not necessary to round to an even number of 12.5 ft guardrail panels because the precise location and dimensions of the TBTs T1 are not known until the contractor selects an item from the QPL.
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-79

Optional Design



NO Grading needed (10:1)

Since LON is satisfied AND 10:1 grading exists, a TBT Type 1 (**Flared**) could be used. The offset to the upstream BLON point increases (from .75') to 2.67' (the minimum for any flared terminal. This changes the calculation for LON (from 250') to **219'** which establishes a different upstream BLON station. However, the flared TBT only provides 25' of effective barrier, so the calculation for LF of guardrail changes to: 219 – 25 + 2 – 28 + 25 = 193'. So less length of guardrail and possibly a less expensive TBT!!!! And the TBT delineator is about 2' farther from EOTL.

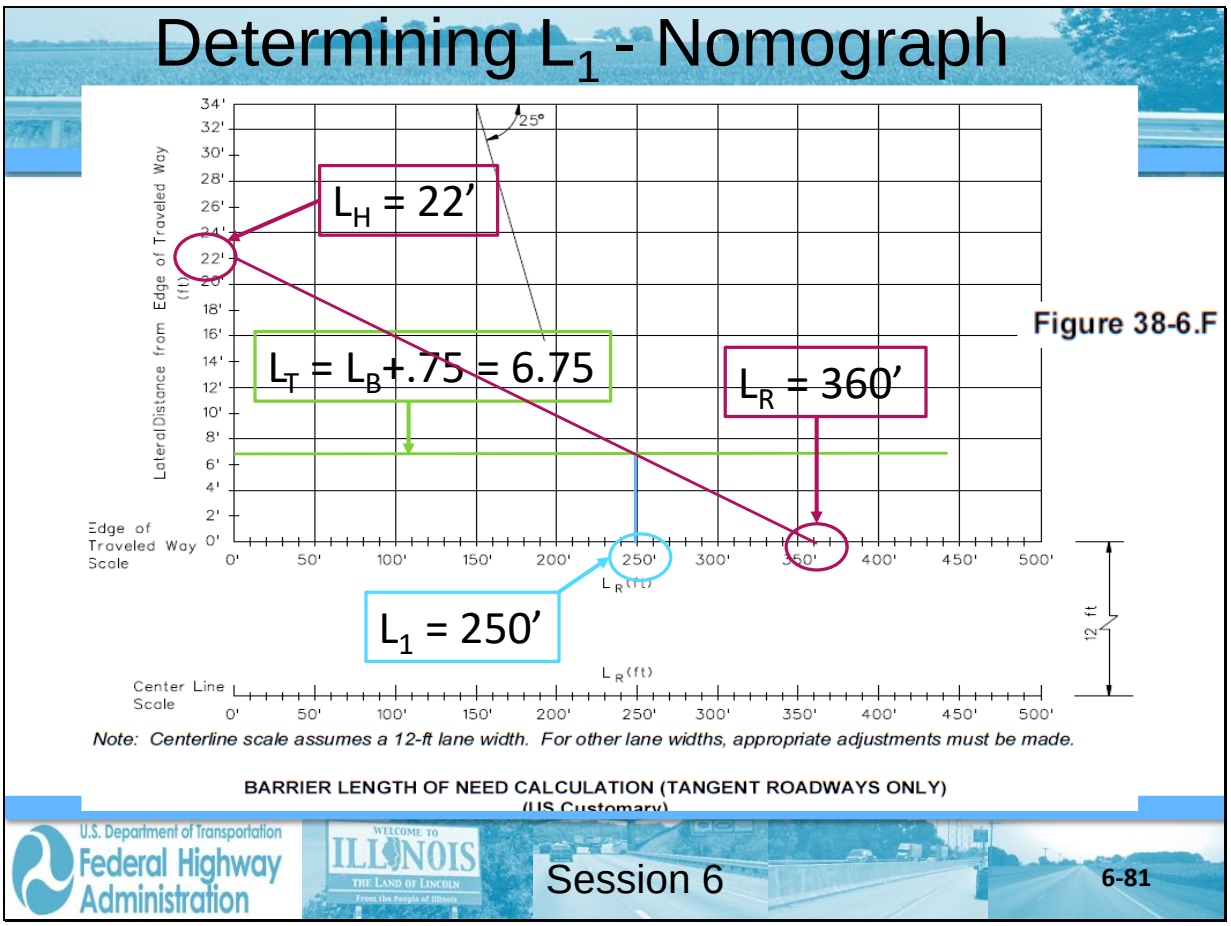
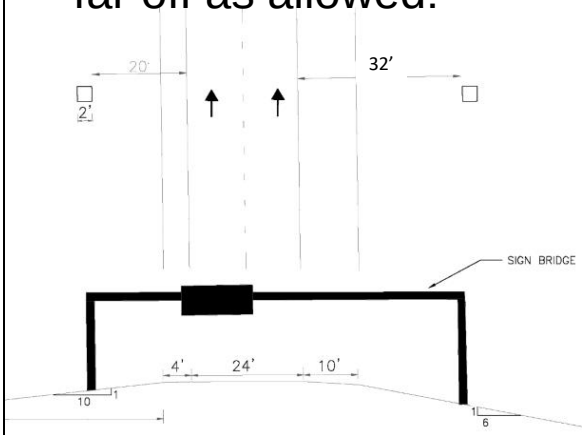

Determining L_1 - Nomograph
Lateral Distance from Edge of Traveled Way (ft)
25°
L_H = 22'
$L_T = L_B + .75 = 6.75$
L_R = 360'
L_1 = 250'
Edge of Traveled Way Scale
Center Line Scale
L_R (ft)
12 ft
Note: Centerline scale assumes a 12-ft lane width. For other lane widths, appropriate adjustments must be made.
BARRIER LENGTH OF NEED CALCULATION (TANGENT ROADWAYS ONLY)
(US Customary)
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-81

Figure 38-6.F

Calculate LON (L_1) – Additional Offset

If guardrail is placed as far off as allowed:



L_H = 22 ft L_2 = (20'-5') =15' L_R = 360'

Using the formula X =

$$X = \frac{L_H - L_2}{L_H/L_R}$$

$$= \frac{22 - 15}{.061}$$

= 115 ft.

Just comparing LON (L_1)

BIG savings by offsetting the barrier

Review Learning Outcomes

- Define the Length of Need and apply the design principles for an optimal installation
- Modify guardrail for special situations