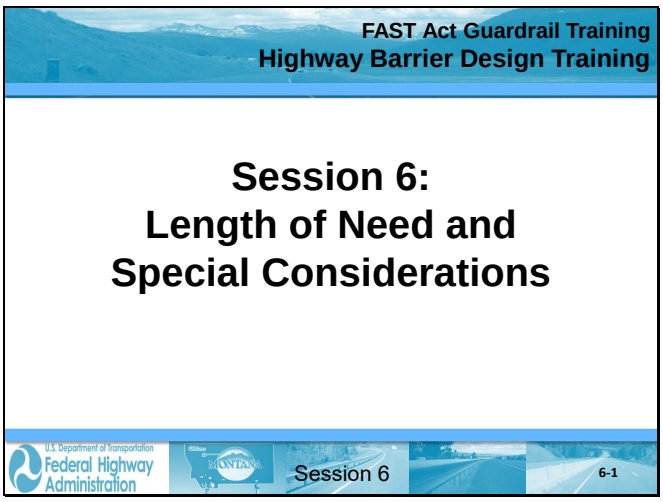
Session 6: Length of Need and Special Considerations


FAST Act Guardrail Training
Highway Barrier Design Training
Session 6:
Length of Need and
Special Considerations
U.S. Department of Transportation
Federal Highway Administration
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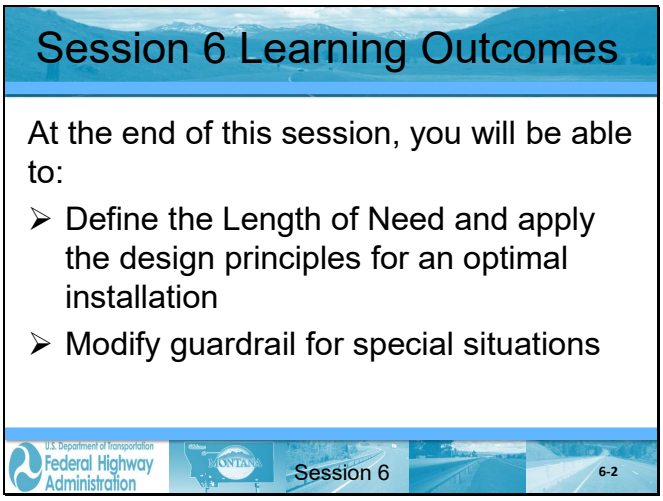
Session 6 Learning Outcomes
At the end of this session, you will be able to:
Define the Length of Need and apply the design principles for an optimal installation
Modify guardrail for special situations
U.S. Department of Transportation
Federal Highway Administration
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MDT Range of Treatments

1. Eliminate obstacles or design proposed features free of obstacles (such as slope flattening to avoid barrier warrants, removing rock outcroppings, and removing point obstacles);
2. Relocate the obstacle;
3. Where applicable, make the obstacle breakaway (such as sign posts and luminaire supports);
4. Shield the obstacle with a roadside barrier, which is also considered an obstacle and should only be used when other alternatives cannot be achieved; or
5. Delineate the obstacle.

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_____

_____

Length of Need (LON) Definition

AASHTO

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

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

_____

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_____

_____

_____

_____

Length of Need (L)

MDT

The following equation is used to determine the total barrier length for a given roadside condition:

$$L_{TOTAL} = L_{ADJACENT} + L_{OBSTACLE} + L_{OPPOSING}$$

Where:

$L_{ADJACENT}$	=	The length needed in advance of the obstacle required to protect traffic in adjacent lanes.
$L_{OBSTACLE}$	=	The length of the obstacle itself.
$L_{OPPOSING}$	=	The length in advance of the obstacle needed to protect traffic in opposing lanes.

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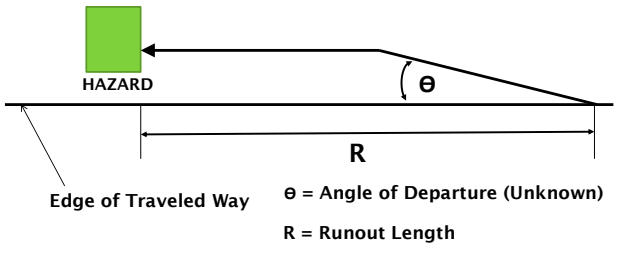
Length of Need (LON) Theory

AASHTO



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Runout Lengths AASHTO & MDT

Design Speed (mph)	Runout Length (L_R) (ft) Design Year Traffic Volume (AADT) >10,000	>5,000 ≤10,000	>1,000 ≤5,000	≤1,000	Shy Line Offset L_s (ft)
80	470	430	380	330	12
70	360	330	290	250	9
60	300	250	210	200	8
50	230	190	160	150	6.5
40	160	130	110	100	5
30	110	90	80	70	4

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Length of Need - AASHTO

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

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

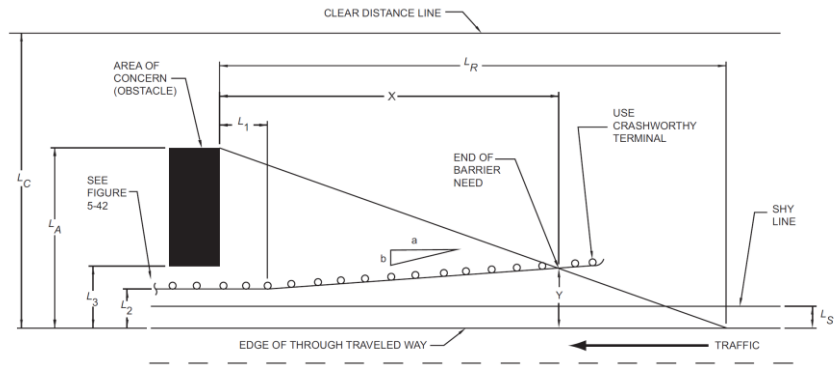
  - For parallel guardrail installations:

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

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

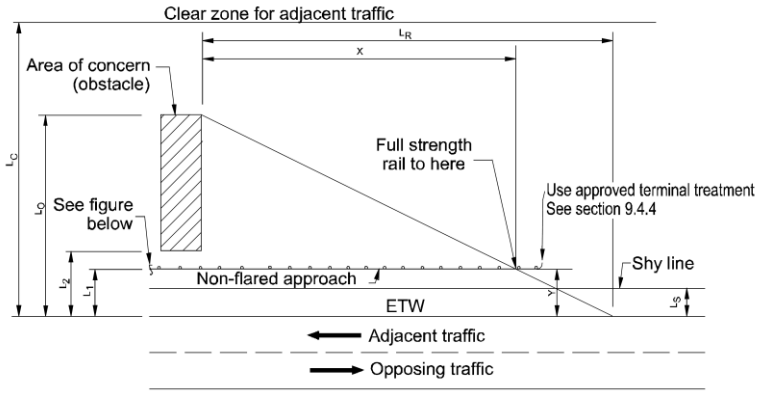
Federal Highway Administration Session 6 6-8

LON Design Procedure for Approach Barrier Layout



Ref: AASHTO Roadside Design Guide, 4th Edition, Figure 5.39, Pg. 5-49

MDT Guidance and Layout



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MDT Road Design Manual

MDT Procedure

Where:

X, Y = coordinates of beginning of barrier need.

$$X = \frac{L_R (L_O - L_1)}{L_O}$$

L_C = recommended clear zone.

L_O = distance from edge of traveled way to back of obstacle (i.e., the lateral extent of the obstacle). For a fixed object, the lateral extent of the obstacle (L_O) is the distance from the edge of the traveled way to the far side of the obstacle. If the obstacle is an embankment or a fixed object that extends beyond the clear zone, L_O is measured to the outside edge of the clear zone (L_C); i.e., $L_O = L_C$.

$$Y = L_1$$

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

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MDT Procedure – Modification

9.4.3.3 Length of Need (Obstacle Within Recoverable Clear Zone)

$$X = \frac{L_O - L_1}{\tan 5^\circ}$$

$$Y = L_1$$

Where:

X, Y = coordinates of beginning of barrier need.

L_O = distance from edge of traveled way to back of obstacle (i.e., the lateral extent of the obstacle).

L_1 = distance from edge of traveled way to face of barrier.

5° = departure angle.

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MDT Procedure – Modification

9.4.3.3 Length of Need (Obstacle Within Recoverable Clear Zone)

For obstacles located near the clear zone limit, check the necessary barrier length using both the LR formulas (Section 9.4.3.2) and the 5-degree angle formulas (Section 9.4.3.3). Use the method that produces the shorter overall length of barrier.

Suggestion: If $L_R/L_O < 11.4$, use the L_R formula

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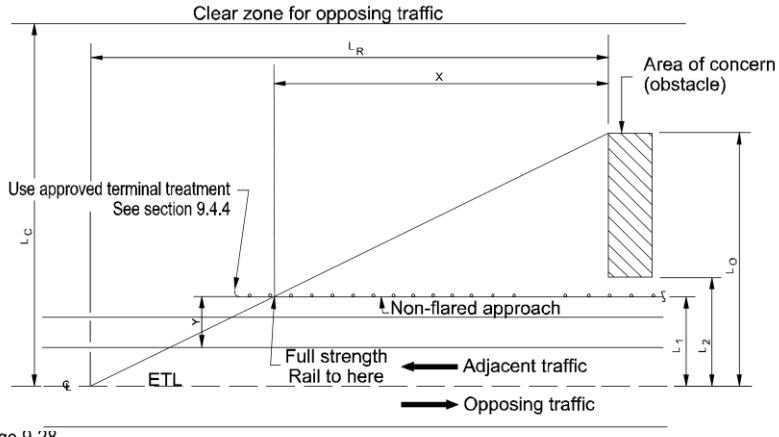
LON Design for Opposing Traffic



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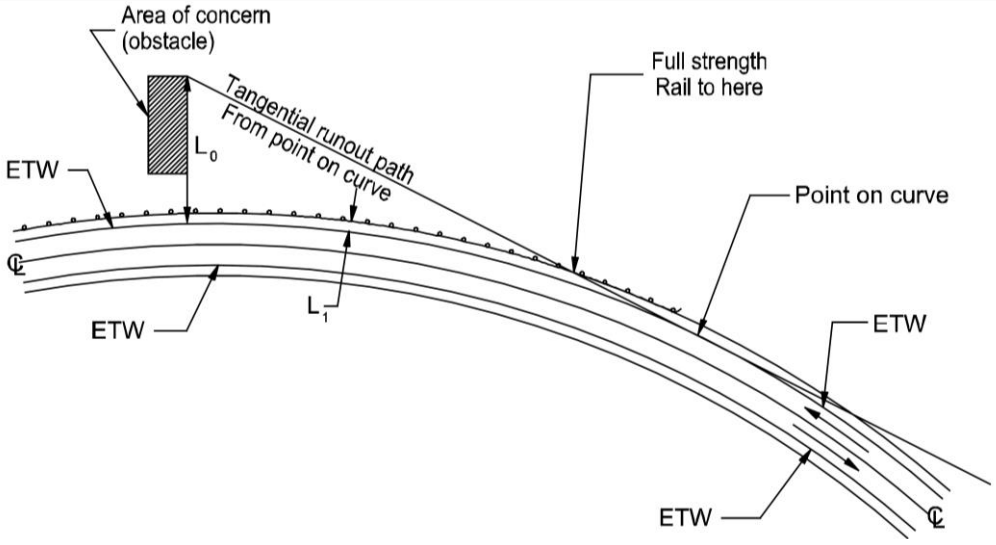
Length of Need on the Outside of a Horizontal Curve



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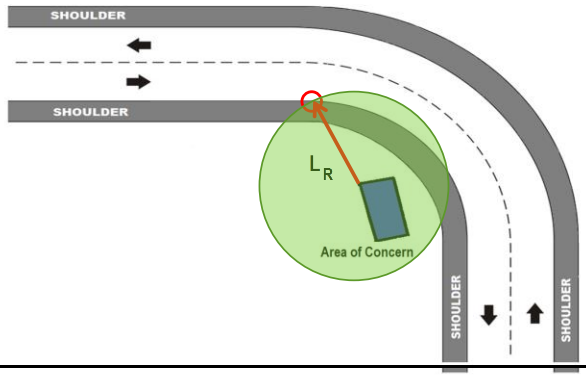
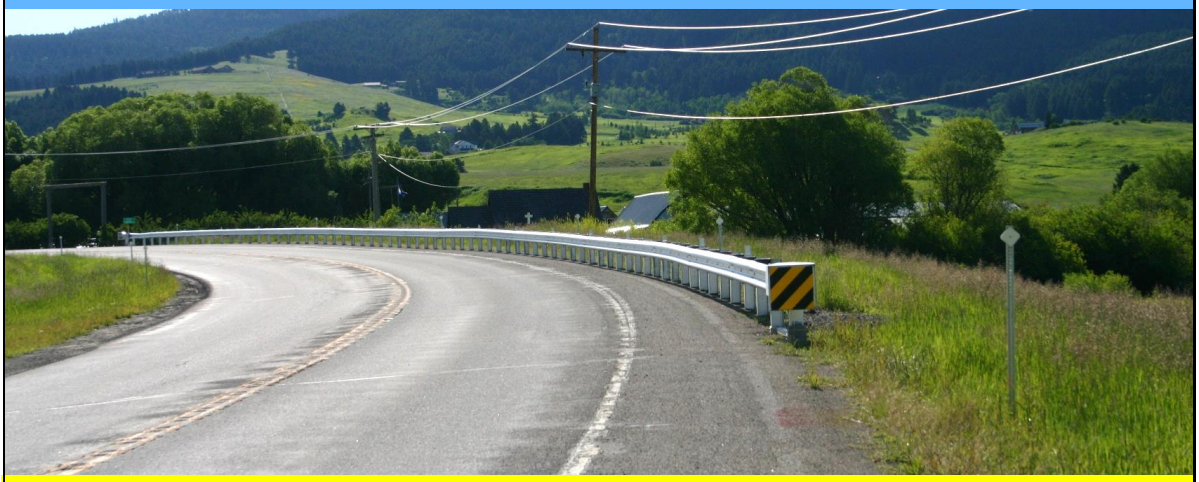
Length of Need on the Inside of a Horizontal Curve



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.

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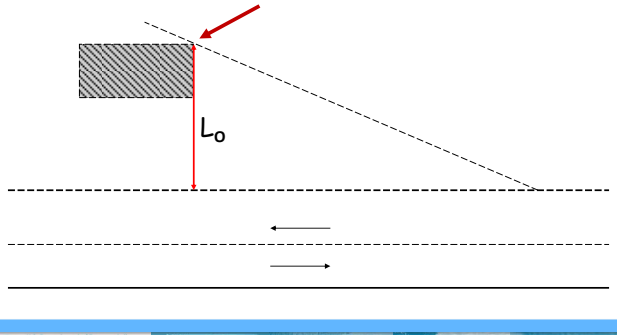
Step 1: Identify the Hazard



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Length of Need – Adequate?
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Length of Need – Adequate?
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PRE-ASSESSMENT PHOTO
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Federal Highway Administration
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PRE-ASSESSMENT PHOTO
U.S. Department of Transportation
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PRE-ASSESSMENT PHOTO
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PRE-ASSESSMENT PHOTO
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LON – with Box Beam
Still inadequate
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Length of Need – Adequate?
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Length of Need – Adequate?
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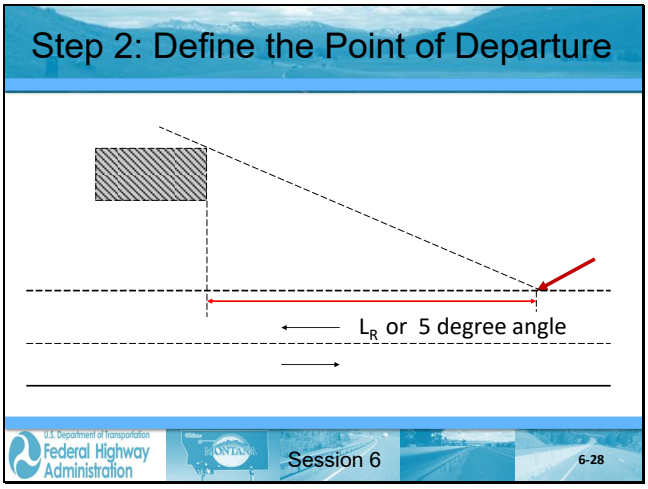
Step 2: Define the Point of Departure
L_R or 5 degree angle
U.S. Department of Transportation
Federal Highway Administration
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MDT Runout Lengths

Design Speed (mph)	Runout Length (L_R) (ft) Design Year Traffic Volume (AADT) >10,000	>5,000 ≤10,000	>1,000 ≤5,000	≤1,000	Shy Line Offset L_s (ft)
80	470	430	380	330	12
70	360	330	290	250	9
60	300	250	210	200	8
50	230	190	160	150	6.5
40	160	130	110	100	5
30	110	90	80	70	4

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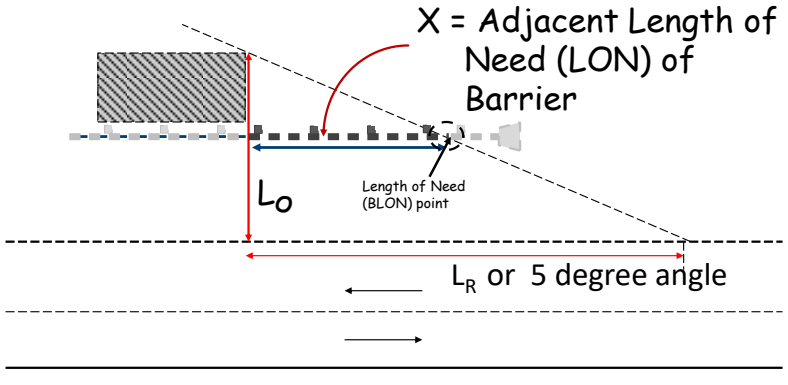
Step 3: Intersect the Hypotenuse



U.S. Department of Transportation Federal Highway Administration Session 6 6-30

Quick Field Check of LON

1. Stand on roadway edgeline opposite the upstream edge of the hazard.
2. Pace upstream along edgeline 12 times the distance from ETL to the outside edge of hazard (L_O - MDT procedure)
3. Turn and look at the upstream, outside edge of hazard.
4. If planned (or existing) barrier run intercepts this line of sight, it satisfies design procedure for adjacent length of need.
5. Check for ALL hazards that should be shielded in this area
6. Check for better terminal location if needed by extending barrier a short distance.

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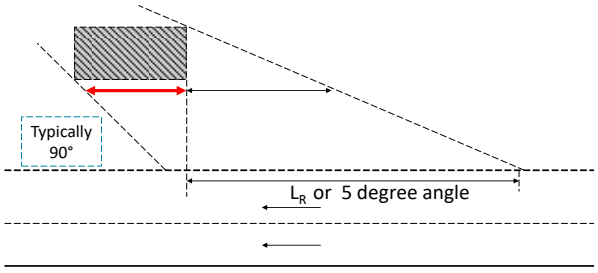
Downstream Termination One Direction Traffic

An anchor must be ADDED at the end



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Guardrail Placement

Place as far from traffic as practical
(without affecting performance)

Guardrail Placement in Special Situations

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

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Turnout Conflict

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Intersecting Roadway Terminal
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Federal Highway Administration
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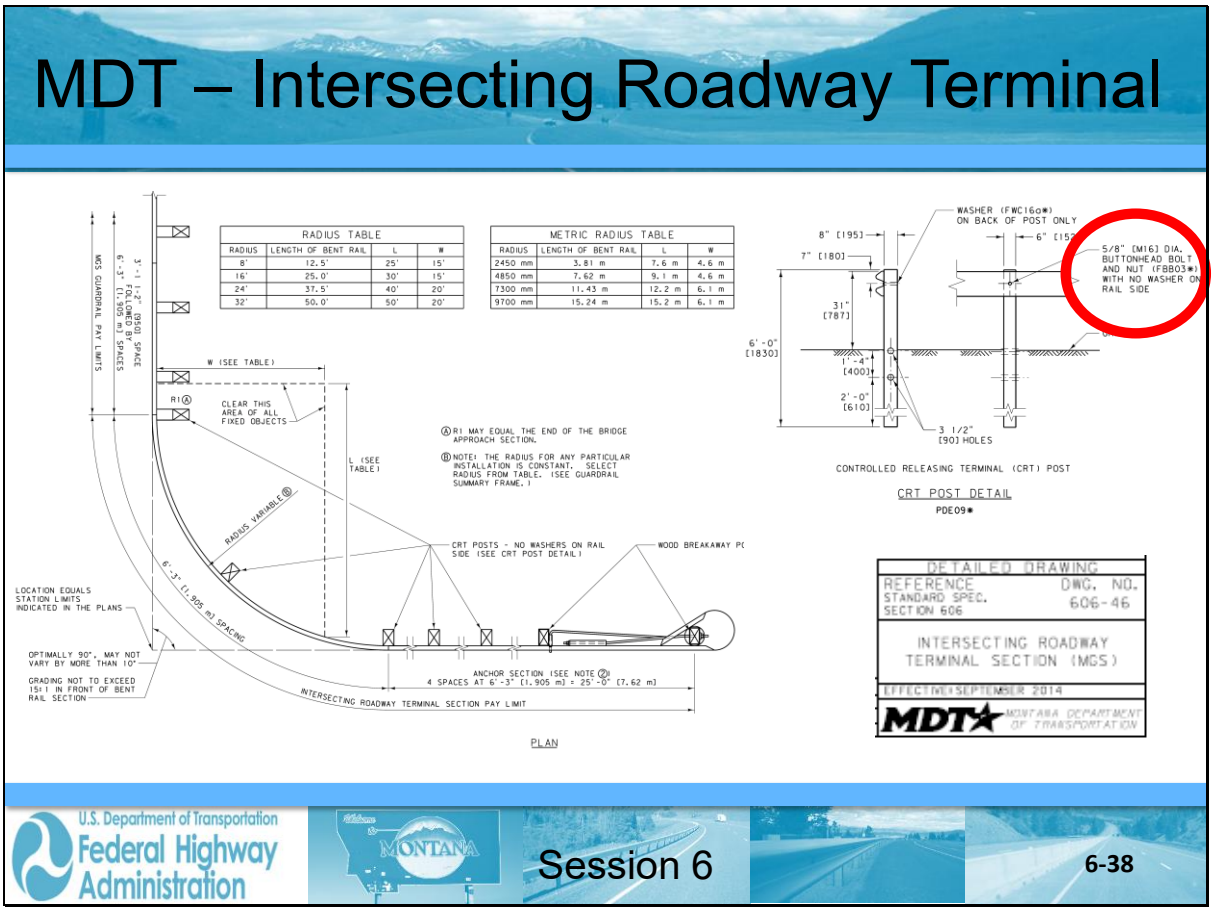
MDT – Intersecting Roadway Terminal
RADIUS TABLE
RADIUS | LENGTH OF BENT RAIL | L | W
8' | 12.5' | 25' | 15'
16' | 25.0' | 30' | 15'
24' | 37.5' | 40' | 20'
32' | 50.0' | 50' | 20'
METRIC RADIUS TABLE
RADIUS | LENGTH OF BENT RAIL | L | W
2450 mm | 3.81 m | 7.6 m | 4.6 m
4850 mm | 7.62 m | 9.1 m | 4.6 m
7300 mm | 11.43 m | 12.2 m | 6.1 m
9700 mm | 15.24 m | 15.2 m | 6.1 m
MGS GUARDRAIL PAY LIMITS
W (SEE TABLE)
CLEAR THIS AREA OF ALL FIXED OBJECTS
L (SEE TABLE)
RADIUS VARIABLE
CRT POSTS - NO WASHERS ON RAIL SIDE (SEE CRT POST DETAIL)
WOOD BREAKAWAY P
LOCATION EQUALS STATION LIMITS INDICATED IN THE PLANS
OPTIMALLY 90°, MAY NOT VARY BY MORE THAN 10°
GRADING NOT TO EXCEED 15:1 IN FRONT OF BENT RAIL SECTION
ANCHOR SECTION (SEE NOTE 2)
4 SPACES AT 6'-3" (1.905 m) = 25'-0" (7.62 m)
INTERSECTING ROADWAY TERMINAL SECTION PAY LIMIT
PLAN
WASHER (FWC16a*) ON BACK OF POST ONLY
8" [195]
7" [180]
6" [15
5/8" [M16] DIA. BUTTONHEAD BOLT AND NUT (FBB03*) WITH NO WASHER ON RAIL SIDE
31" [787]
6'-0" [1830]
1'-4" [400]
2'-0" [610]
3 1/2" [90] HOLES
CONTROLLED RELEASING TERMINAL (CRT) POST
CRT POST DETAIL
PDE09*
DETAILED DRAWING
REFERENCE STANDARD SPEC. SECTION 606
DWG. NO. 606-46
INTERSECTING ROADWAY TERMINAL SECTION (MGS)
EFFECTIVE SEPTEMBER 2014
MDT MONTANA DEPARTMENT OF TRANSPORTATION
U.S. Department of Transportation
Federal Highway Administration
MONTANA
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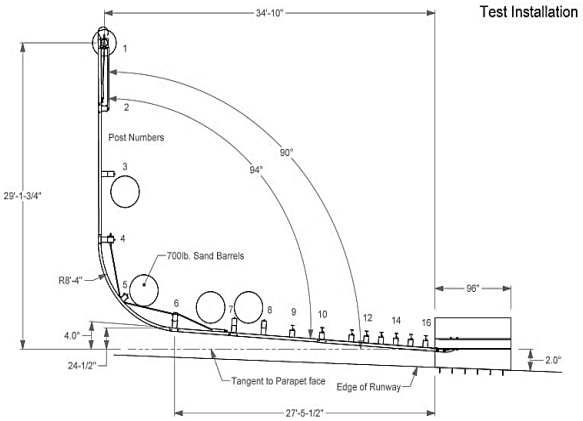
TxDOT MASH TL-3 Short Radius



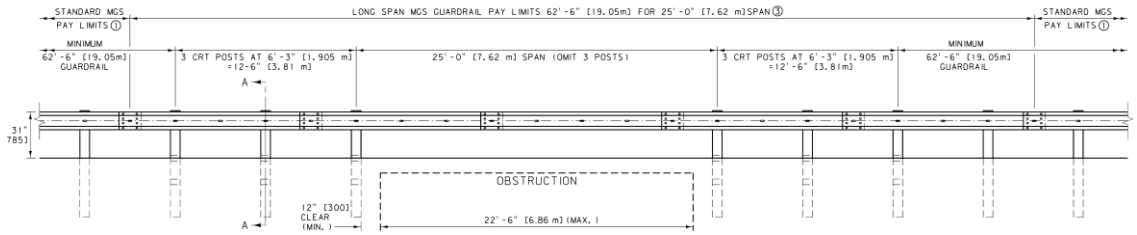
On-going Research by Pool Fund – No Eligibility Letter

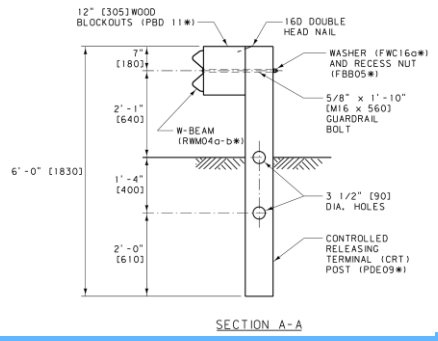
TxDOT MASH TL-3 Short Radius

MGS – Omitting 3 posts

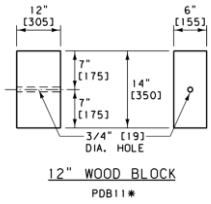
Working Width – 94”
Eligibility Letter B-189

MDT – Omitting 3 posts

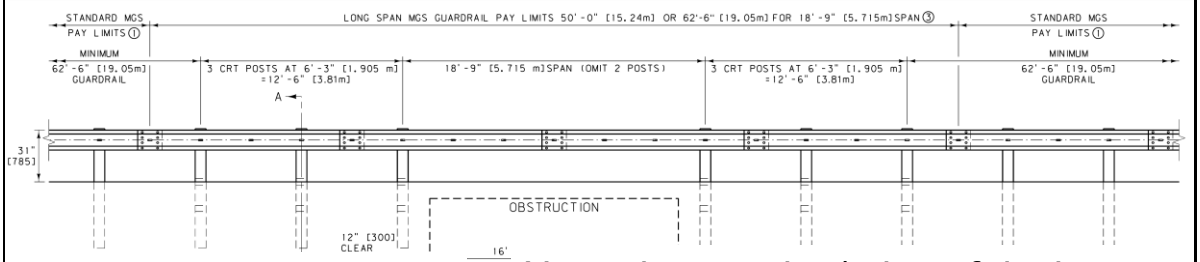




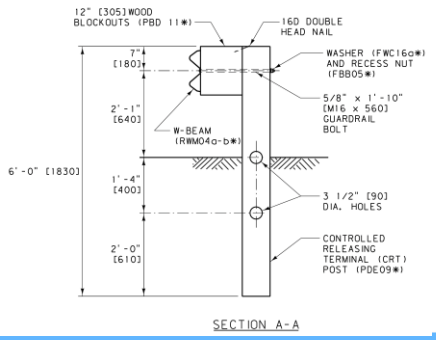
Note: the opening/edge of deck must be located at or outside the back of the CRT posts.

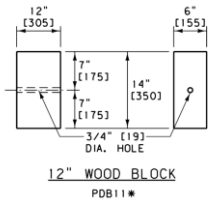


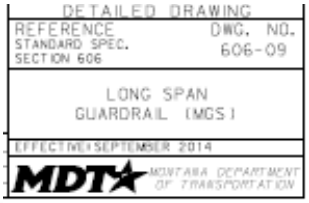
MDT – Omitting 2 posts



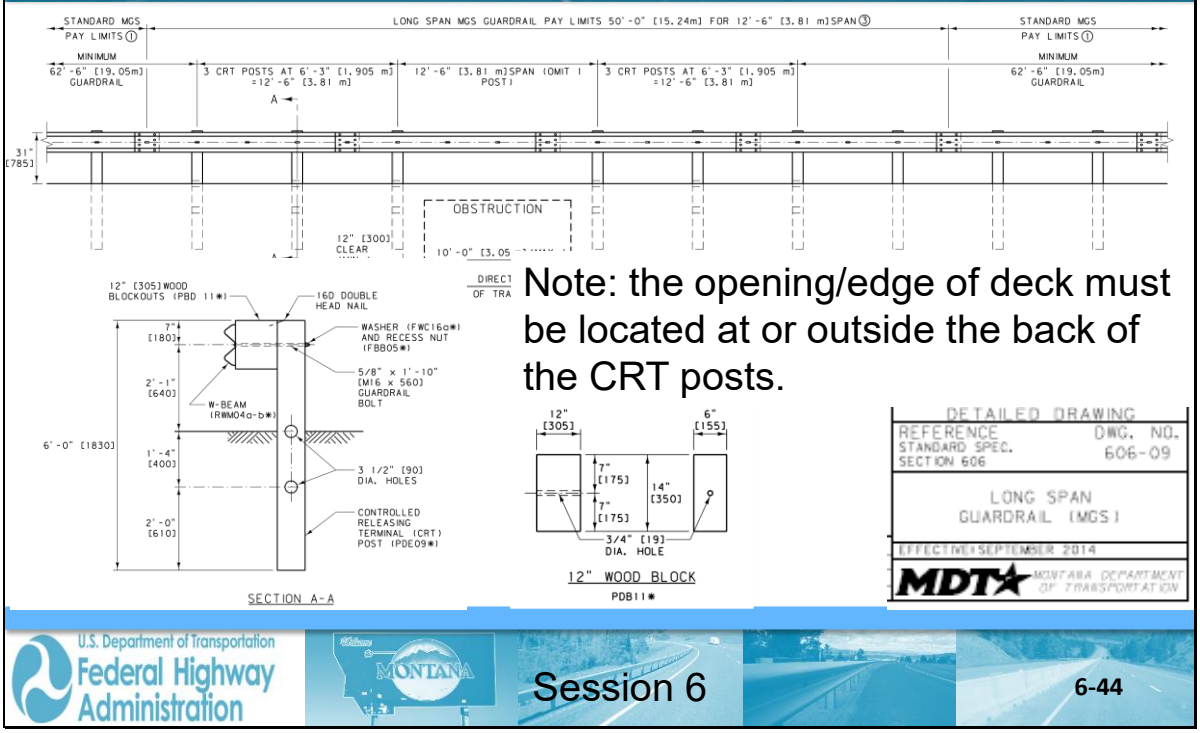
Note: the opening/edge of deck must be located at or outside the back of the CRT posts.



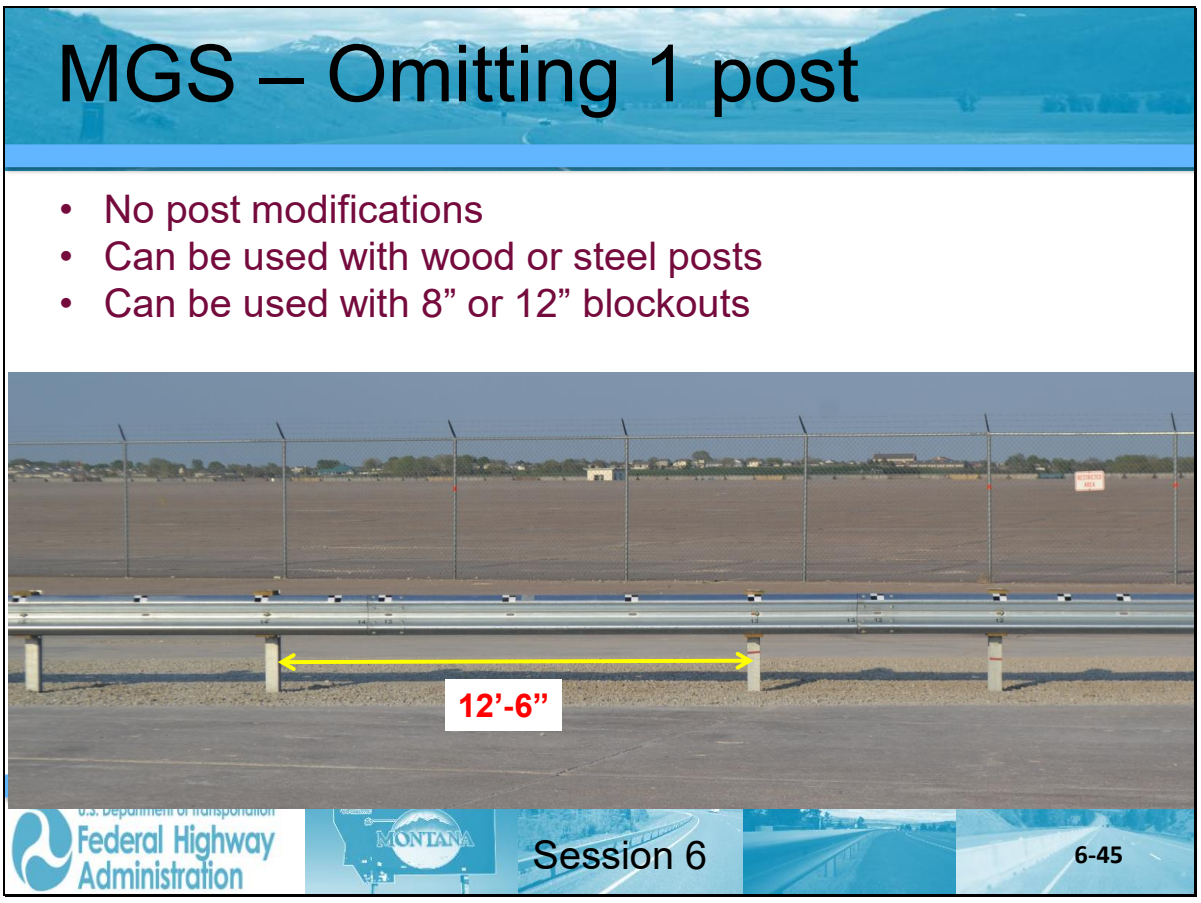




MDT – Omitting 1 posts



Note: the opening/edge of deck must be located at or outside the back of the CRT posts.


MGS – Omitting 1 post
• No post modifications
• Can be used with wood or steel posts
• Can be used with 8” or 12” blockouts
12’-6”
Federal Highway Administration
MONTANA
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MGS – Omitting 1 post
Video Clip
?
Working Width 50.1”
Limit 1 per 50’
Federal Highway Administration
MONTANA
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Openings in Barriers

Check with maintenance, ROW, etc

U.S. Department of Transportation Federal Highway Administration | MONTANA | Session 6 | 6-47

Openings in Barriers

9.4.3.9 Minimum Length/Gaps

Short runs of barrier have limited value and should be avoided. Generally, a barrier should have at least 100 feet of standard rail section exclusive of terminal sections and/or transition sections (does not include rail connected to structures or other blunt ends). Short gaps between runs of barrier are undesirable. Therefore, gaps of less than 165 feet between barrier termini should be connected into a single run. Exceptions may be necessary for access, or other project considerations.

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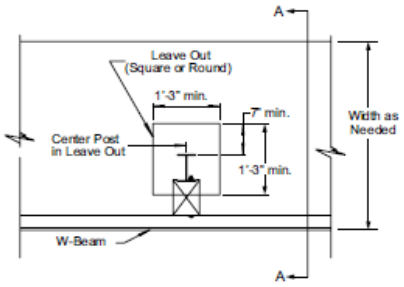
Extra Blocks – National Guidance

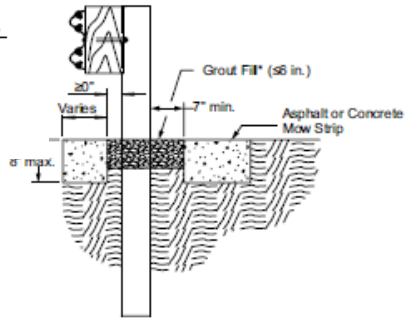
- Two block-outs (up to 16” deep) may be used at any time, for any number of posts.
- Three block-outs may be used at one or two posts in a section of guardrail.

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

Leaveouts in Structural Pavement

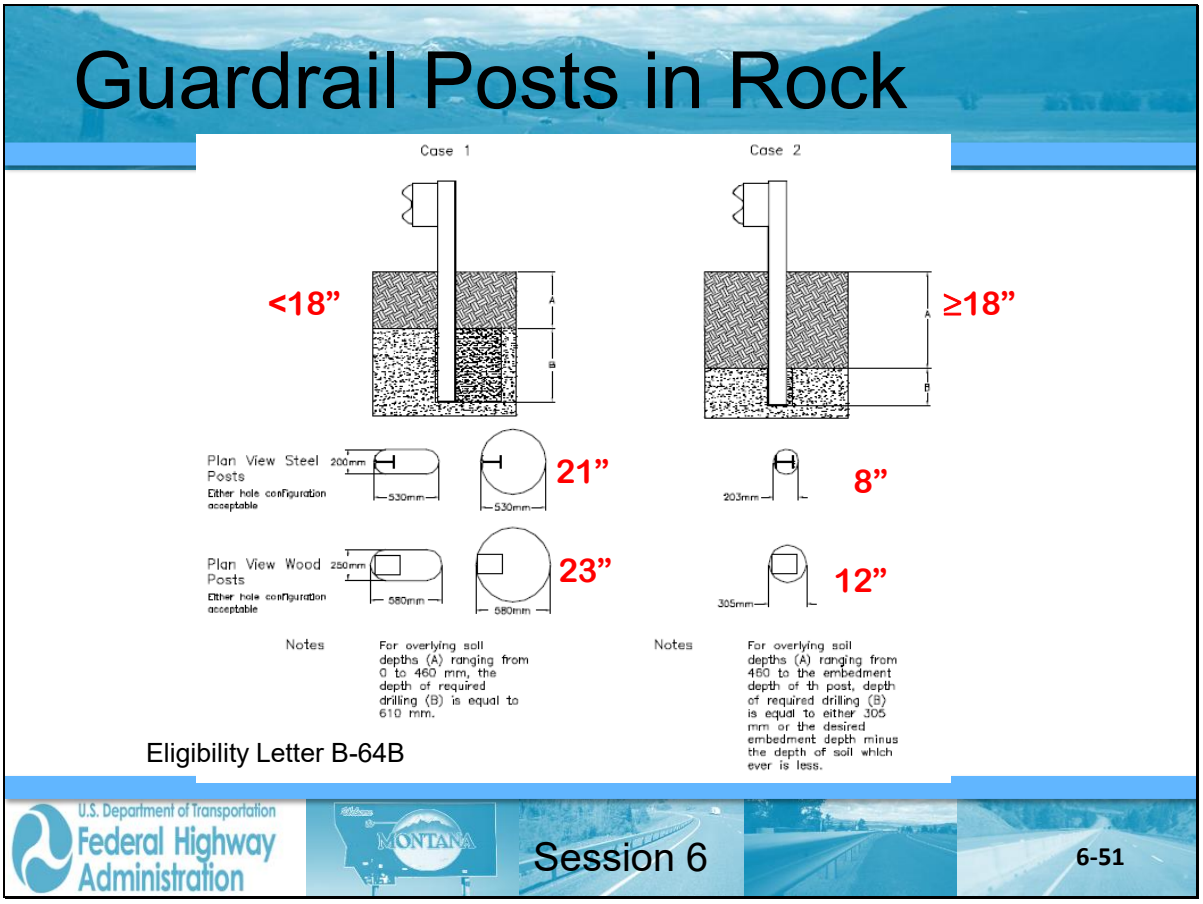


Steel Post Detail



Section A-A

Ref: AASHTO Roadside Design Guide – 4th Edition, Figure 5-52


Guardrail Posts in Rock
Case 1
Case 2
<18”
≥18”
Plan View Steel Posts
Either hole configuration acceptable
200mm
530mm
530mm
21”
203mm
8”
Plan View Wood Posts
Either hole configuration acceptable
250mm
580mm
580mm
23”
305mm
12”
Notes
For overlying soil depths (A) ranging from 0 to 460 mm, the depth of required drilling (B) is equal to 610 mm.
Notes
For overlying soil depths (A) ranging from 460 to the embedment depth of th post, depth of required drilling (B) is equal to either 305 mm or the desired embedment depth minus the depth of soil which ever is less.
Eligibility Letter B-64B
U.S. Department of Transportation
Federal Highway Administration
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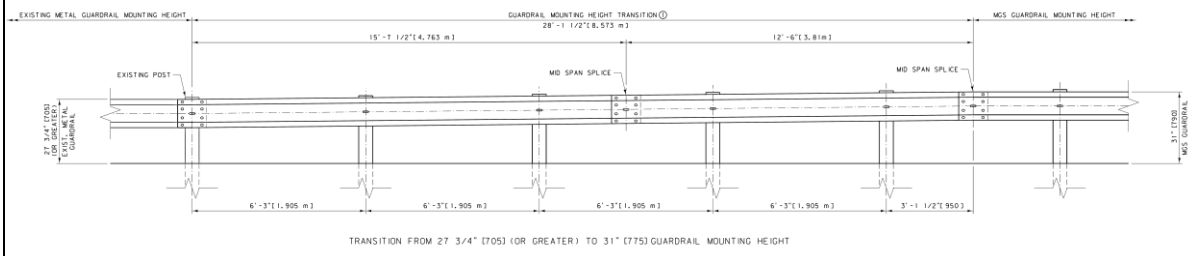
Height Transition – MGS to Metal Guardrail



TRANSITION FROM 27 3/4" (705) (OR GREATER) TO 31" (775) GUARDRAIL MOUNTING HEIGHT

DETAILED DRAWING	
REFERENCE STANDARD SPEC. SECTION 606	DWG. NO. 606-20
MGS TO METAL GUARDRAIL TRANSITION	
EFFECTIVE: JANUARY 2018	
MDT MONTANA DEPARTMENT OF TRANSPORTATION	

U.S. Department of Transportation Federal Highway Administration

Welcome to MONTANA

Session 6

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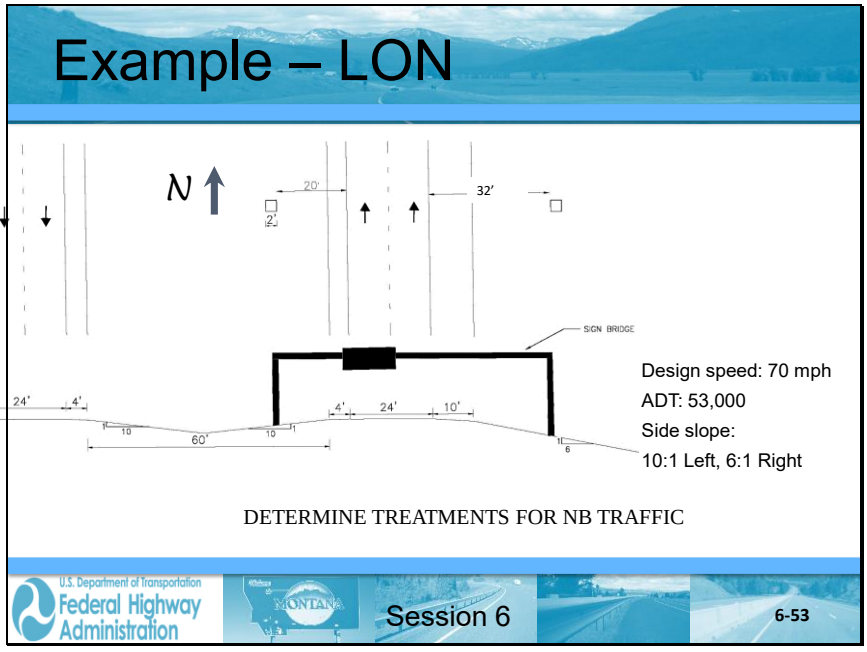
Example – LON
N
20'
32'
2'
SIGN BRIDGE
10'
24'
4'
10
60'
10
4'
24'
10'
6
6
Design speed: 70 mph
ADT: 53,000
Side slope:
10:1 Left, 6:1 Right
DETERMINE TREATMENTS FOR NB TRAFFIC
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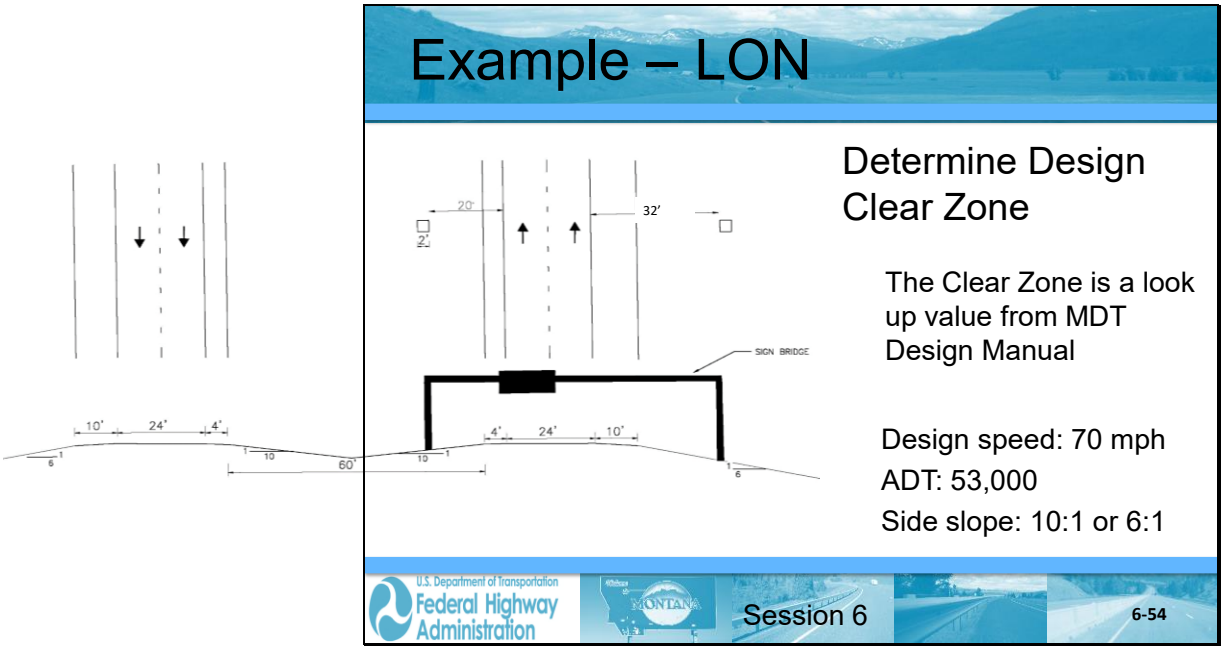
Example – LON
20'
32'
2'
SIGN BRIDGE
10'
24'
4'
10
60'
10
4'
24'
10'
6
6
Determine Design Clear Zone
The Clear Zone is a look up value from MDT Design Manual
Design speed: 70 mph
ADT: 53,000
Side slope: 10:1 or 6:1
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MDT Design Clear Zone Distance – Fill

Design Speed	Design AADT	Fill Slopes/Foreslopes 6:1 or Flatter	5:1	4:1
40 mph or less	< 750	8	8	10
	750-1499	10	12	14
	1500-6000	12	14	16
	> 6000	14	16	18
45 mph	< 750	10	12	14
	750-1499	14	16	18
	1500-6000	16	20	24
	> 6000	20	24	26
50 mph	< 750	12	12	14
	750-1499	16	18	20
	1500-6000	18	22	26
	> 6000	22	26	28
55 mph	< 750	12	14	18
	750-1499	16	20	24
	1500-6000	20	24	30
	> 6000	22	26	32
60 mph	< 750	16	20	24
	750-1499	20	26	32
	1500-6000	26	32	40
	> 6000	30	36	44
70 mph	< 750	20	22	26
	750-1499	24	30	36
	1500-6000	30	36	42
	> 6000	32	38	46
80 mph	< 750	24	26	30
	750-1499	28	32	38
	1500-6000	34	40	46
	> 6000	38	44	50

Design Speed 70 mph
AADT = 53,000

L_C = 32 ft.

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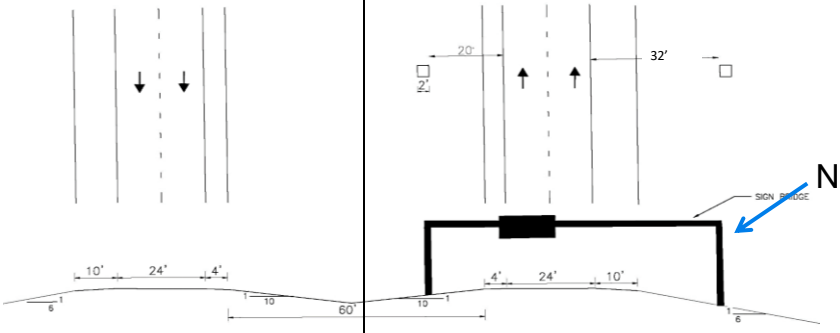
Example – LON



Identify ALL the hazards

NOT SHIELDED

Sign supports – both sides

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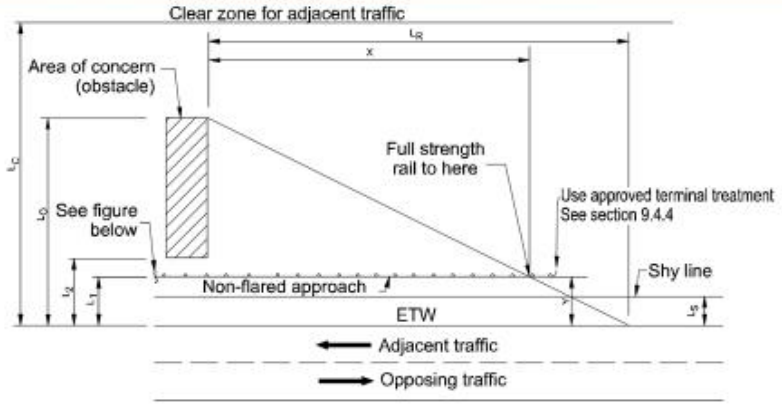
Calculating the Adjacent length of need (X) - MDT



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Calculating the Adjacent length of need (X) - MDT

$$X = \frac{L_R (L_O - L_1)}{L_O}$$

$L_O \geq L_C$

$$X = \frac{L_O - L_1}{\tan 5^\circ}$$

$L_O < L_C$

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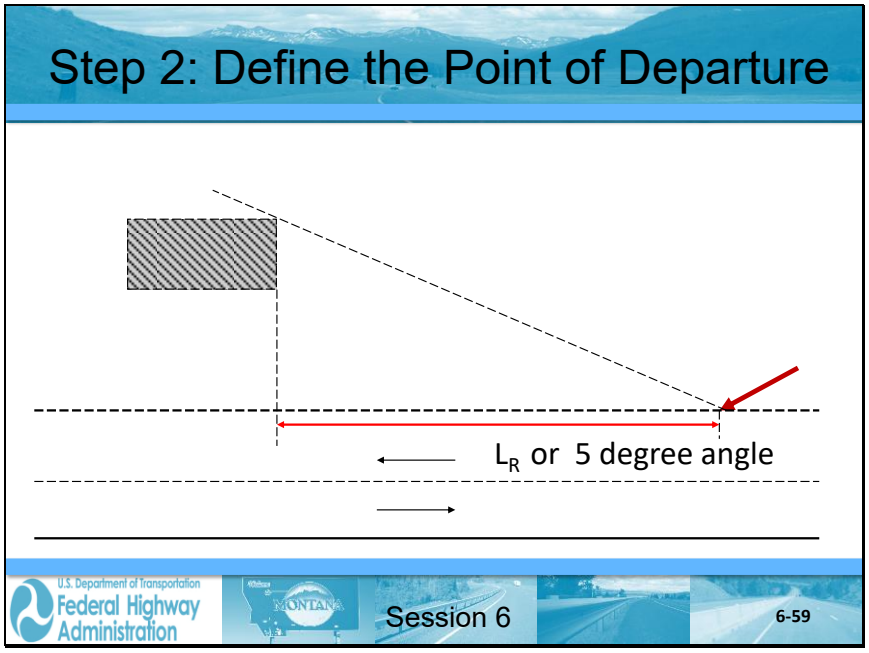
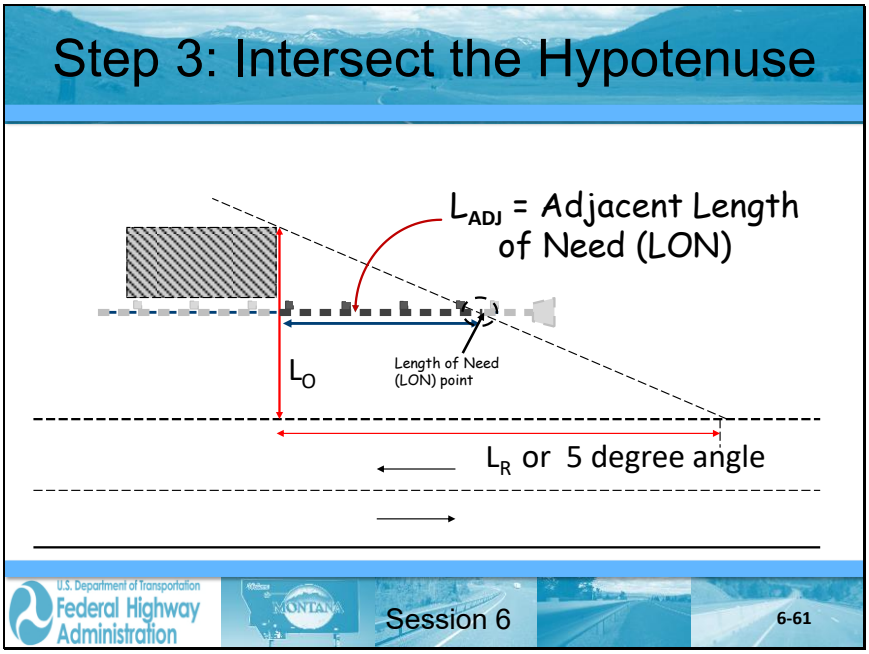


Look up L_R: Design Speed 70 mph, AADT = 53,000

Design Speed (mph)	Runout Length (L_R) (ft) — Design Year Traffic Volume (AADT) >10,000	>5,000 ≤10,000	>1,000 ≤5,000	≤1,000	Shy Line Offset L_s (ft)
80	470	430	380	330	12
70	360	330	290	250	9
60	300	250	210	200	8
50	230	1[illegible]	[illegible]	150	6.5
40	160	1[illegible]	[illegible]	100	5
30	110	90	80	70	4

L_R= 360 ft.


Step 3: Intersect the Hypotenuse
L_{ADJ} = Adjacent Length of Need (LON)
L_O
Length of Need (LON) point
L_R or 5 degree angle
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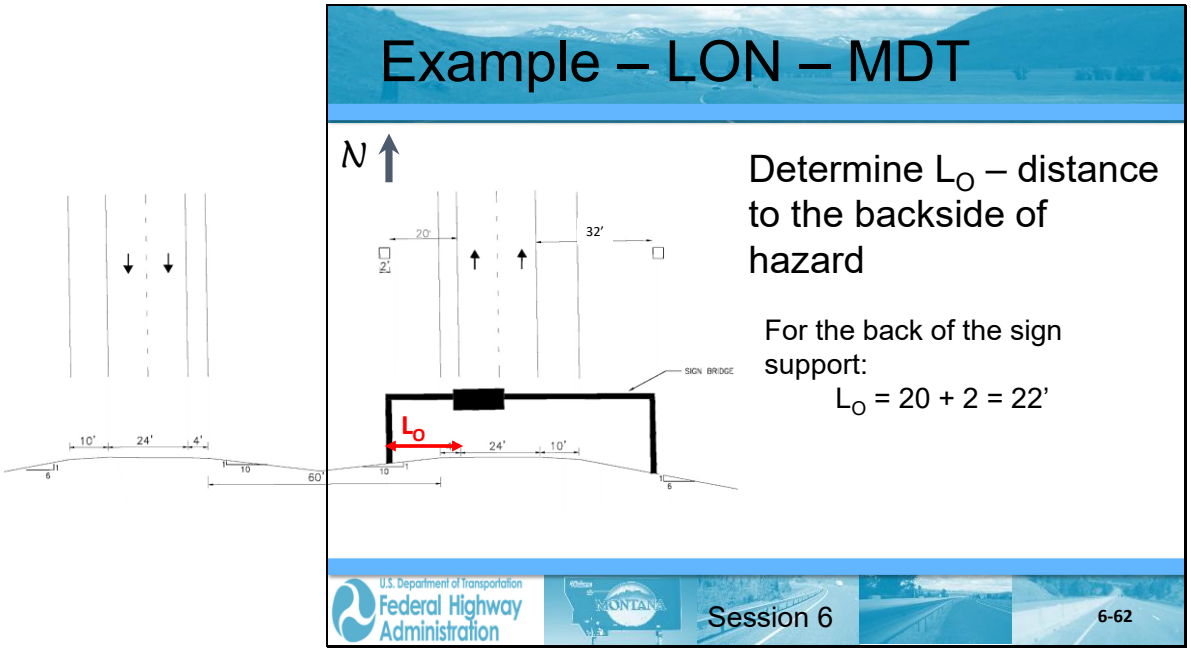
Example – LON – MDT
N
20'
2'
32'
SIGN BRIDGE
L_O
10'
24'
4'
60'
24'
10'
Determine L_O – distance to the backside of hazard
For the back of the sign support:
L_O = 20 + 2 = 22'
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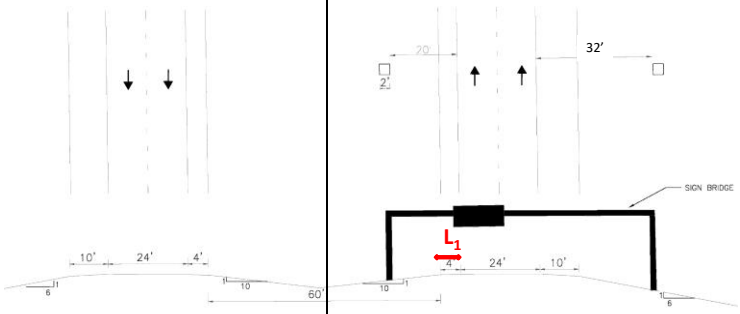
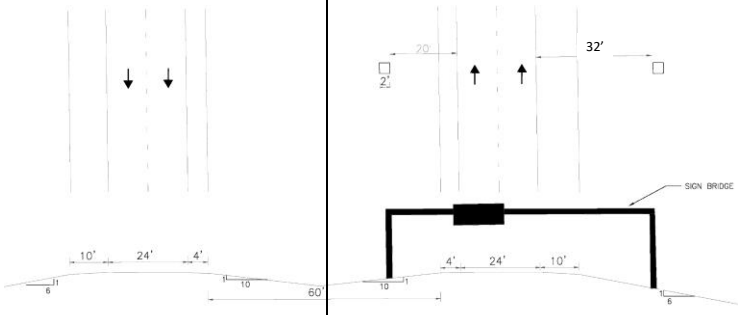
Find L_1



L_1 – Guardrail offset from edge of travel lane.

L_1 = 6 ft.

Calculate LON – Determine Bid Item MDT



L_O = 22 ft L_1 = 6 ft L_R = NA

Using the formula X =

$$X = \frac{L_O - L_1}{\tan 5^\circ}$$

$$= \frac{22 - 6}{.087}$$

= 184 ft.

34.4' is provided by the tangent terminal

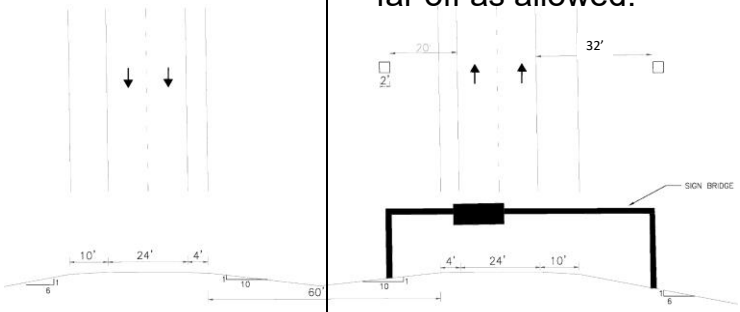
Therefore 184 – 34.4 = 149.6' of standard barrier is required

Using 12.5 ft. panels, no of panels needed = 149.6/12.5 = 12 panels; 150' of guardrail required

A "One Way Departure Terminal" must be added

Calculate LON – Additional Offset

If guardrail is placed as far off as allowed:



L_O = 22 ft L_1 = 14.5 ft L_R = NA

Using the formula X =

$$X = \frac{L_O - L_1}{\tan 5^\circ}$$

$$= \frac{22 - 14.5}{.085}$$

= 85 ft.

34.4' is provided by the tangent terminal

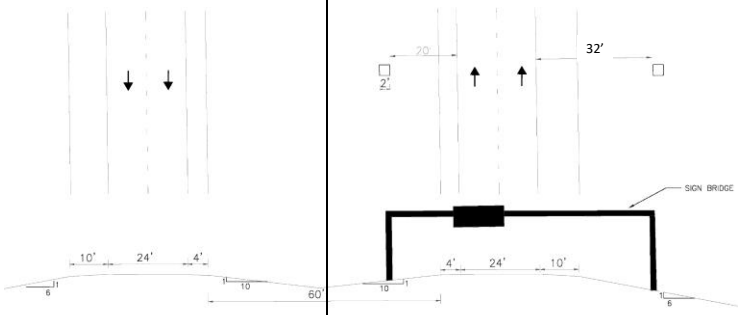
Therefore 85 – 34.4 = 50.6' of standard barrier is required

Using 12.5 ft. panels, no of panels needed = 50.4/12.5; use 4; 50' of guardrail required

A "One Way Departure Terminal" must be added

BIG savings by offsetting the barrier

Calculate LON AASHTO Procedure



L_O = 22 ft L_1 = 6 ft L_R = 360 ft

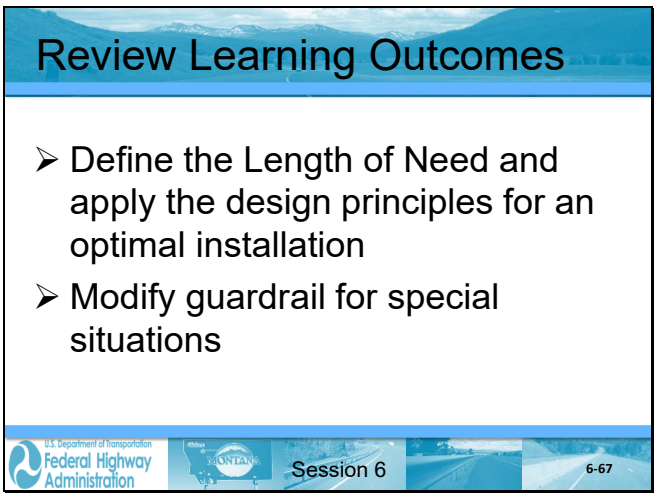
Using the formula X =

$$X = \frac{L_R(L_O - L_1)}{L_O}$$

$$= \frac{360(22 - 6)}{22}$$

= 262 ft.

vs. 184' using MDT procedure


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