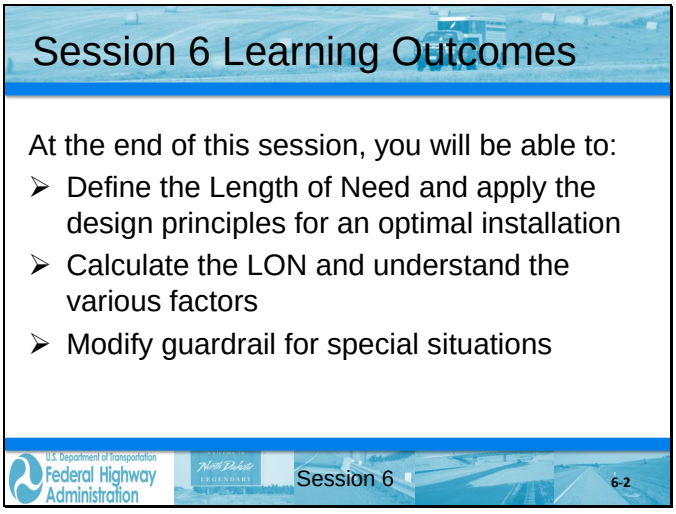
Session 6: Length of Need and Special Considerations


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
Calculate the LON and understand the various factors
Modify guardrail for special situations
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-2

Design Options in Order of Preference

1. Remove the obstruction
2. Make the obstruction traversable
3. Relocate obstruction beyond the clear zone
4. Reduce impact severity by using an appropriate breakaway system
5. SHIELD the obstruction with a longitudinal barrier or crash cushion (only if obstruction cannot be removed, relocated, or redesigned)
6. Delineate obstruction (only if all above options are not appropriate.)

Ref: NDDOT DESIGN MANUAL, Appendix III-14-B, Revised Jan 26, 2016

U.S. Department of Transportation Federal Highway Administration

Session 6

6-3

Length of Need (LON) Definition

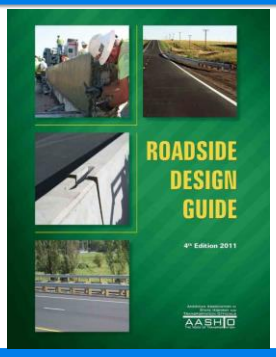
The length of effective barrier needed IN ADVANCE OF the area of concern to intercept and redirect an encroaching vehicle.

U.S. Department of Transportation Federal Highway Administration

Session 6

6-4

Basis for Guidance Presented

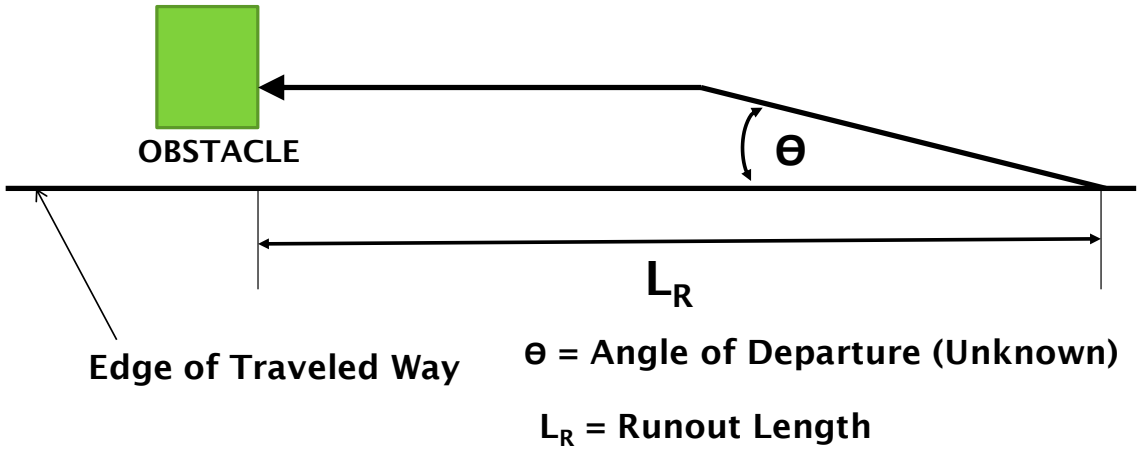


NDDOT follow:

- NDDOT Design Manual (Chp. III, Section 13, App. A, and B),
- NDDOT Standard Drawings (D-764), and
- AASHTO Roadside Design Guide, 2011

U.S. Department of Transportation Federal Highway Administration | Session 6 | 6-5

Length of Need (LON) Theory



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

Runout Lengths - AASHTO

Table 5-10(b). Suggested Runout Lengths for Barrier Design (U.S. Customary Units)

Design Speed (mph)	Runout Length (L_R) Given Traffic Volume (ADT) (ft)			
	Over 10,000	5,000 to 10,000	1,000 to 5,000	Under 1,000
80	470	430	380	330
70	360	330	290	250
60	300	250	210	200
50	230	190	160	150
40	160	130	110	100
30	110	90	80	70

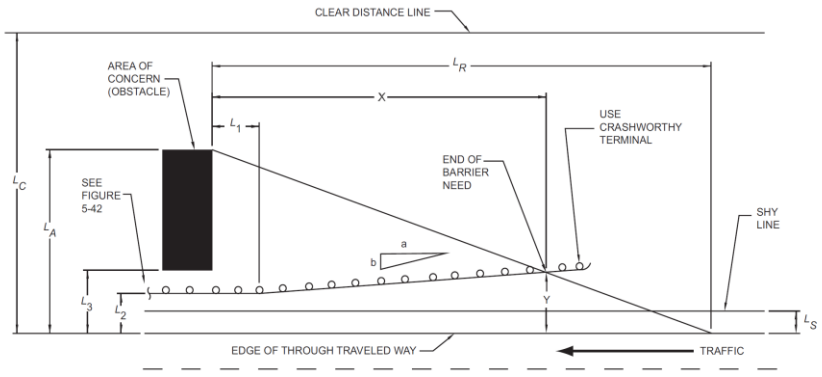
Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – TABLE 5.10, Pg. 5-50

Runout Lengths - NDDOT

Design Speed (mph)	Runout Length (L_R) Given Traffic Volume (ADT) (ft)			
	Over 6,000	2,000 to 6,000	800 to 2,000	Under 800
75	520	485	430	395
70	475	445	395	360
65	450	425	370	345
60	425	400	345	330
55	360	345	315	280
50	330	300	260	245
45	260	245	215	200
40	230	200	180	165
30	165	165	150	140

Ref: NDDOT Design Manual, Section III-13, Pg 188, October 2007

LON Design for Approach Barrier Layout



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

Length of Need

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

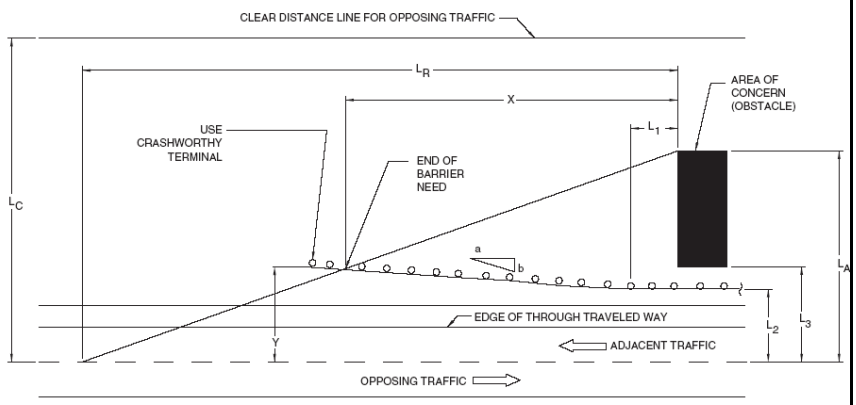
$$X = \frac{L_A + (b/a)(L_1) - L_2}{(b/a) + (L_A/L_R)}$$

  - 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

LON Design Procedure for Opposing Traffic Layout

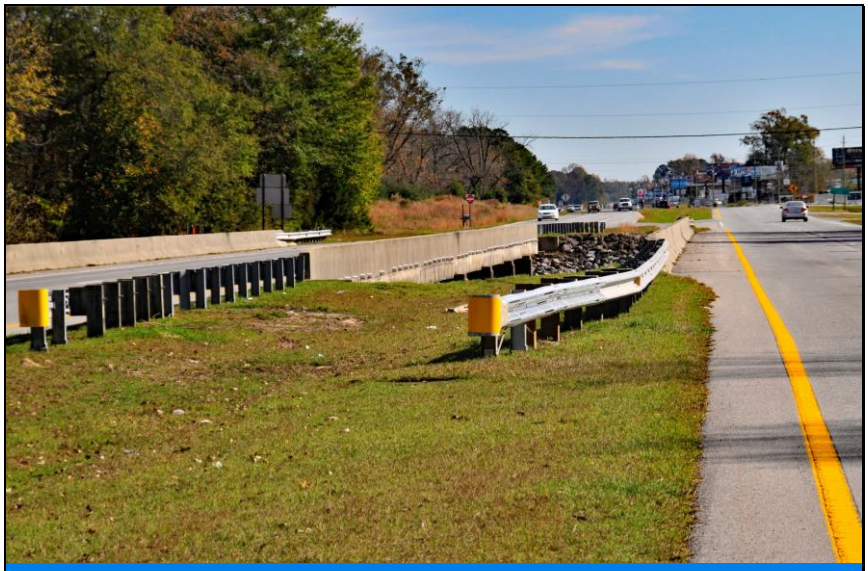


Ref: AASHTO Roadside Design Guide, 4th Edition, Figure 5.42, Pg. 5-54

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

_____

_____



U.S. Department of Transportation Federal Highway Administration | Session 6 | 6-12

_____

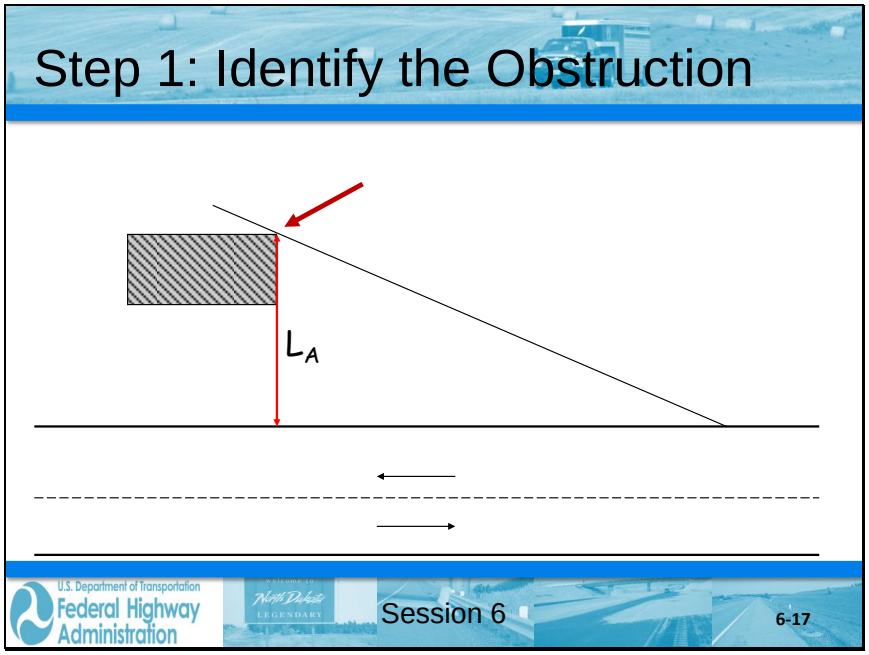
_____

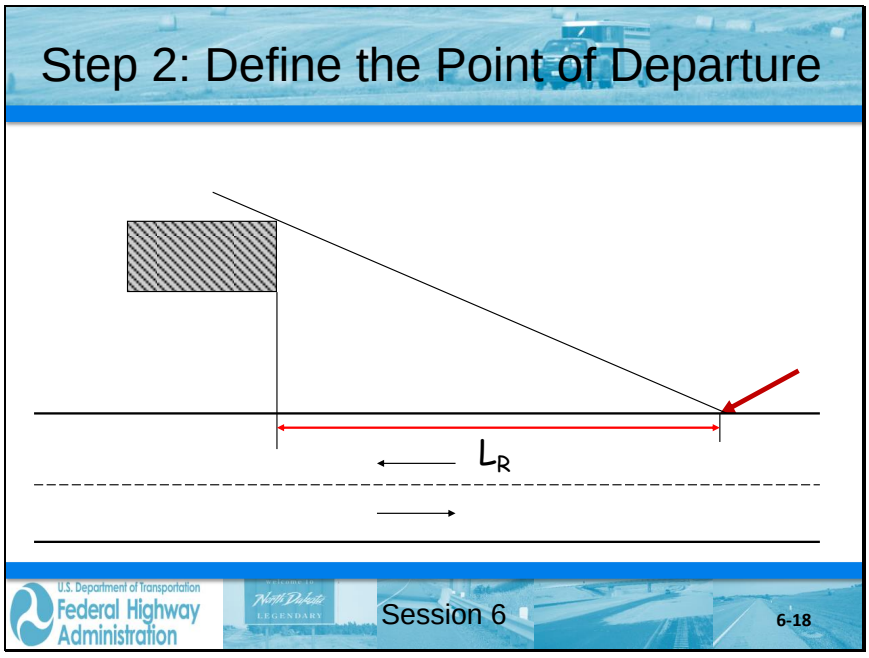

PRE-ASSESSMENT PHOTO
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-13


U.S. Department of Transportation
Federal Highway Administration
Session 6
6-14

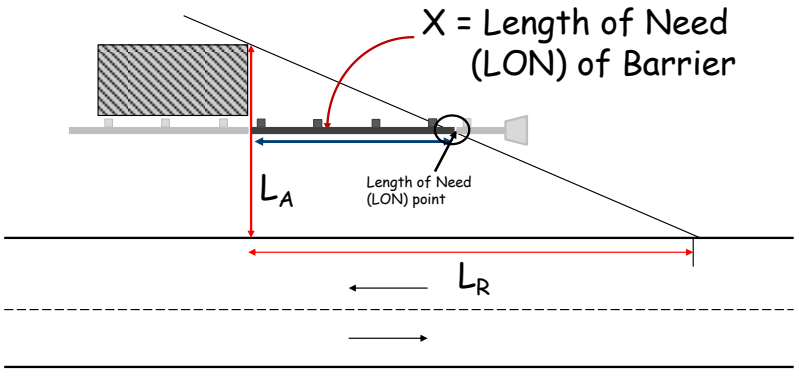

U.S. Department of Transportation
Federal Highway Administration
Session 6
6-15


PRE-ASSESSMENT PHOTO
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-16


Step 1: Identify the Obstruction
L_A
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-17


Step 2: Define the Point of Departure
L_R
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-18

Step 3: Intersect the Hypotenuse



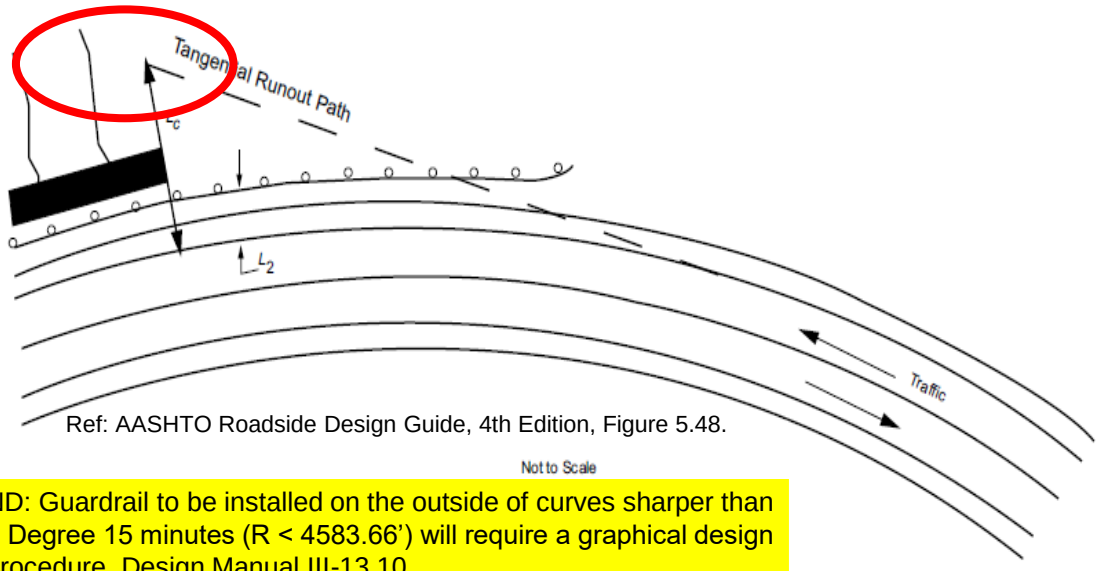
U.S. Department of Transportation Federal Highway Administration
Session 6
6-19

Length of Need (LON) Field Check

- Identify upstream face of obstruction
- Identify back of obstruction –(if the obstruction extends a significant distance away from the travel way – such as a river – limit the back of obstacle to the clear zone)
- Beginning at the upstream face of obstruction, pace upstream along edgeline appropriate runout length
- From this position, sight to the upstream, back edge of obstruction (or clear zone)
- If the proposed (or actual) guardrail installation crosses that line of sight to the back of the obstruction (or clear zone), then the area is adequately covered.

U.S. Department of Transportation Federal Highway Administration
Session 6
6-20

Length of Need on the Outside of a Horizontal Curve



Ref: AASHTO Roadside Design Guide, 4th Edition, Figure 5.48.

Not to Scale

ND: Guardrail to be installed on the outside of curves sharper than 1 Degree 15 minutes (R < 4583.66') will require a graphical design procedure. Design Manual III-13.10

U.S. Department of Transportation Federal Highway Administration

Session 6

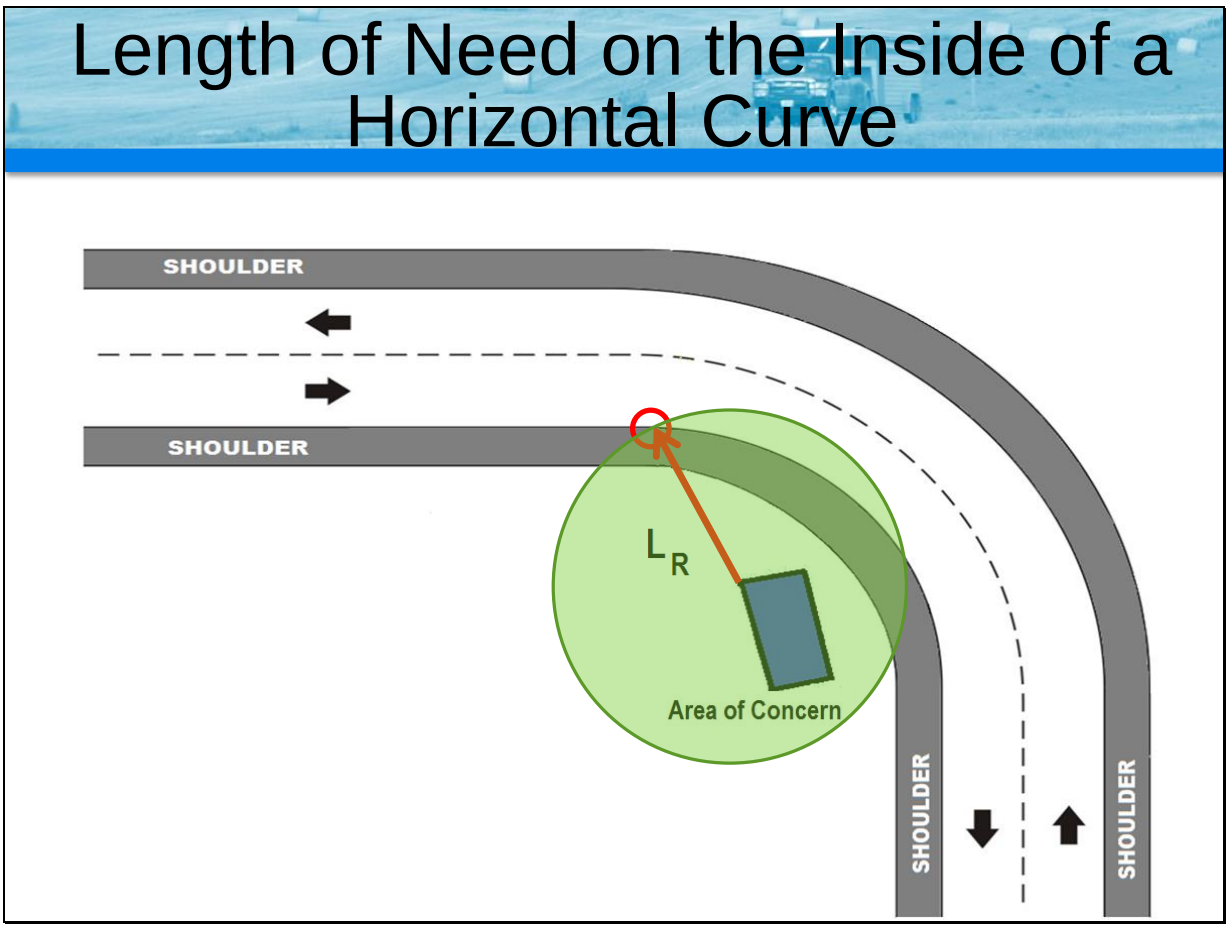
6-21

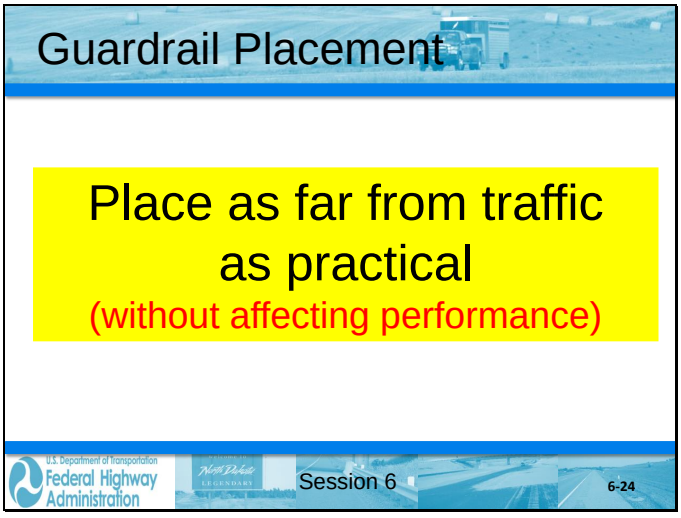
Length of Need on the Outside of a Horizontal Curve - ND

NDDOT Design Manual Chapter III Section 13.10

The ND procedure is largely equivalent to the procedure discussed in the AASHTO Roadside Design.

- The fundamental difference is that, when using the ND method some limited flaring of the guardrail is achieved relative to the roadway curvature.
- The use of a shallow flare for the guardrail results in a decrease in guardrail length of need, decreased snow accumulation and fewer nuisance hits.
- The flaring provided by this method shall be limited to provide an anticipated vehicle impact angle with the guardrail of no more than 10 degrees. Most often, an impact angle ranging between 7 and 8 degrees has been used by NDDOT.
- This angle is determined most easily by simple graphical means.


Length of Need on the Inside of a Horizontal Curve
SHOULDER
SHOULDER
L_R
Area of Concern
SHOULDER
SHOULDER


Guardrail Placement
Place as far from traffic as practical
(without affecting performance)
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-24

Guardrail Placement in Special Situations

- Short Radius at Intersecting roadways
- Long Span Guardrail
- Omitted Posts
- Extra Blockouts
- Post in Rock
- Leaveout in Mowing Pads
- Height Transition – G4 to MGS


Guardrail Placement at Intersections
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-27


Guardrail Placement at Intersections
SPEED LIMIT 35
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-28

Guardrail Placement at Intersections

- Some designers eliminate this non-crashworthy aspect by using an offset energy-absorbing terminal (if there is room) along the main highway with a run of barrier upstream of the access point based on the LON. Although crashworthy, there is still some risk of a vehicle gating through or passing behind it to enter the area of concern.

Guardrail Placement at Intersections

- Wherever possible, approaches should be relocated rather than providing breaks in the guardrail installation.
- On low-volume, low-speed roadways a curved rail may be placed as shown on Standard Drawing D-764-13. The speeds on the main roadway shall be 55 mph or less and the 750 ADT or less.
- Some alternate designs are illustrated in the following slides.

Ref. Design Manual III- 13.09.01.

Transportation Pooled Fund Program

Roadside Safety Pooled Fund

Texas Transportation Institute Proving Ground

Report No. 405160-10
Report Date: August 2010

EVALUATION OF EXISTING T-INTERSECTION GUARDRAIL SYSTEMS FOR EQUIVALENCY WITH *NCHRP REPORT 350* TL-2 TEST CONDITIONS

by

Akram Y. Abu-Odeh
Associate Research Scientist

Kang-Mi Kim
Post Doctoral Research Associate

and

Dean Alberson
Research Engineer

Contract No.: T4541-AJ
Test No.: 405160-10

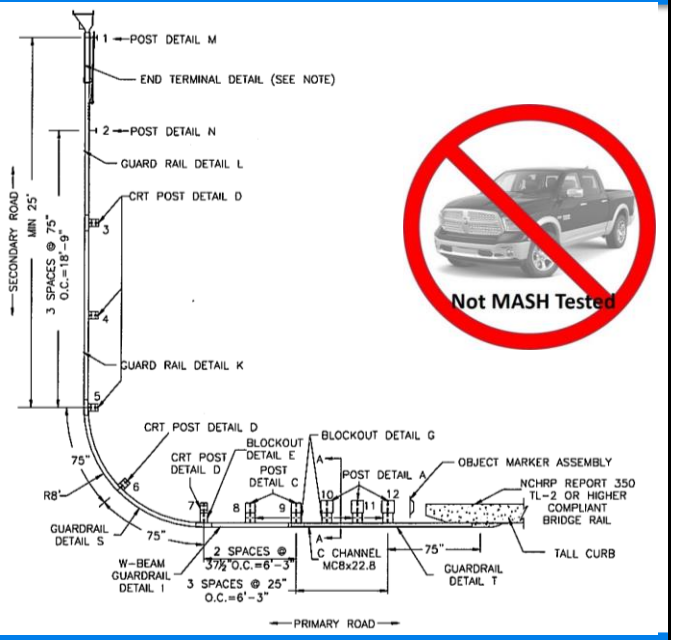
Sponsored by
Roadside Safety Research Program Pooled Fund Study

TEXAS TRANSPORTATION INSTITUTE PROVING GROUND

Mailing Address:
Roadside Safety & Physical Security
Texas A&M University System
3135 TAMU
College Station, TX 77843-3135

Located at:
Texas A&M Riverside Campus
Building 7091
3100 State Highway 47
Bryan, TX 77807

Accepted at NCHRP Report 350 at TL-2

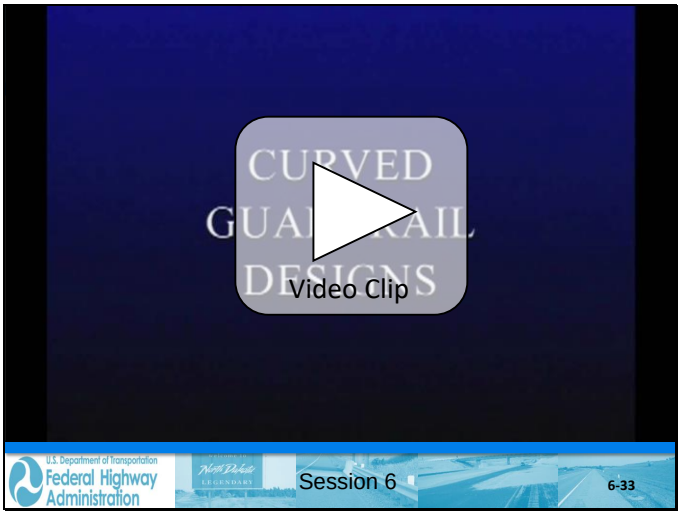


U.S. Department of Transportation Federal Highway Administration

Session 6

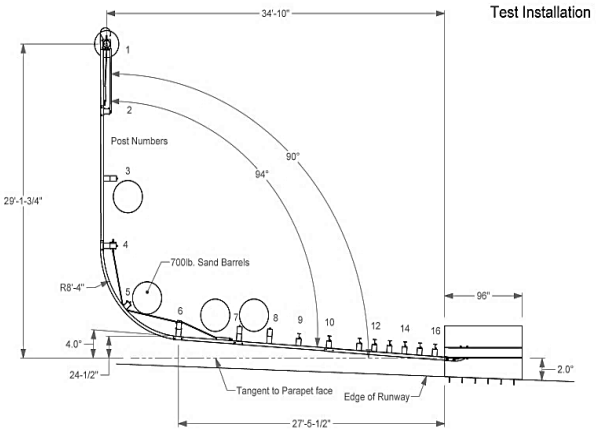
6-31


FHWA Technical Advisory T5040.32.
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-32


Video Clip
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-33

TxDOT MASH TL-3 Design

Short Radius at Intersecting roadways



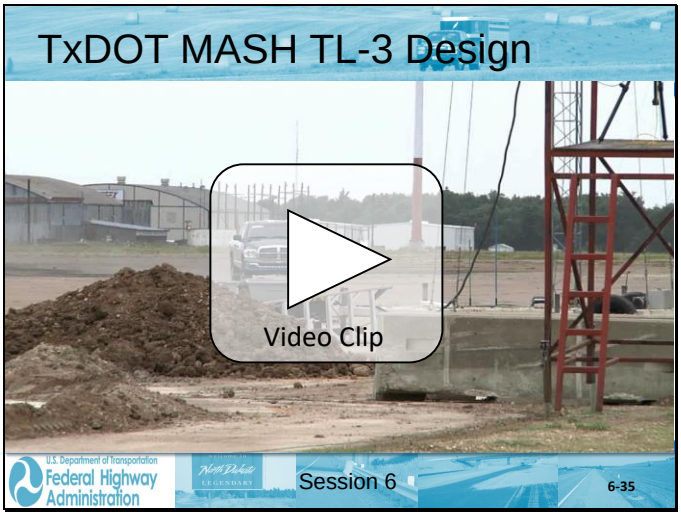
U.S. Department of Transportation Federal Highway Administration

Session 6

6-34

_____

_____



_____

_____

_____

_____

_____

_____

Long-Span Guardrail – MGS

Ref: FHWA Eligibility Letter B-189

Long-Span Guardrail

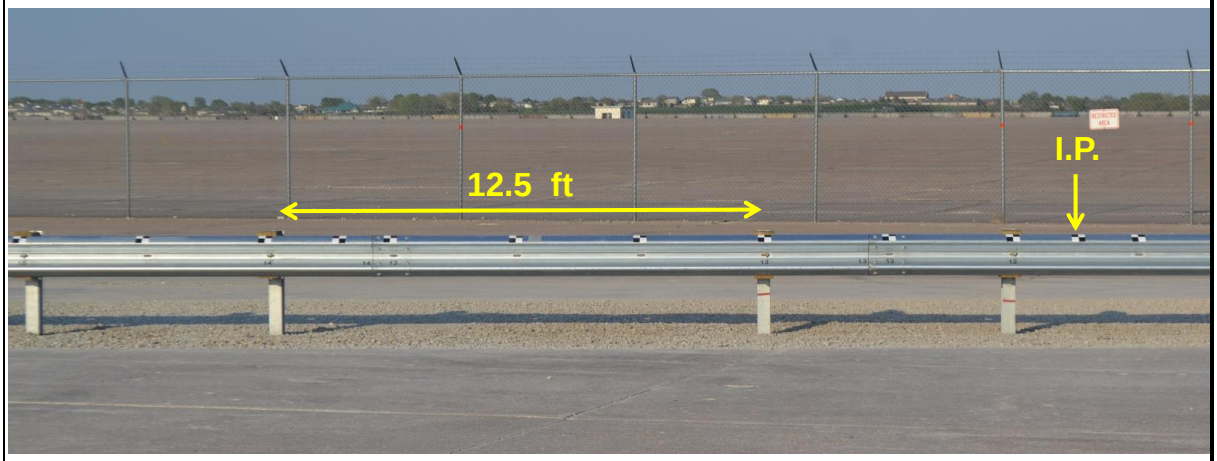
For 27 ¾" Guardrail

- 3 weakened posts on each side of span
- Double blockouts
- Nested rail

For 31" (MGS) Guardrail

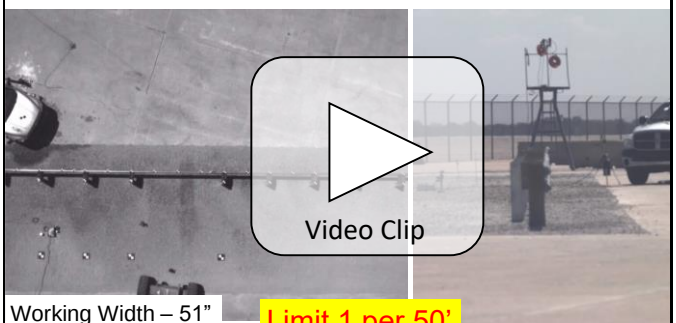
- Nested rail not necessary

Omitting 1 post – MGS



Removed one post – nothing else done

MASH TL-3 Omitting 1 post – MGS



Working Width – 51”

Limit 1 per 50’

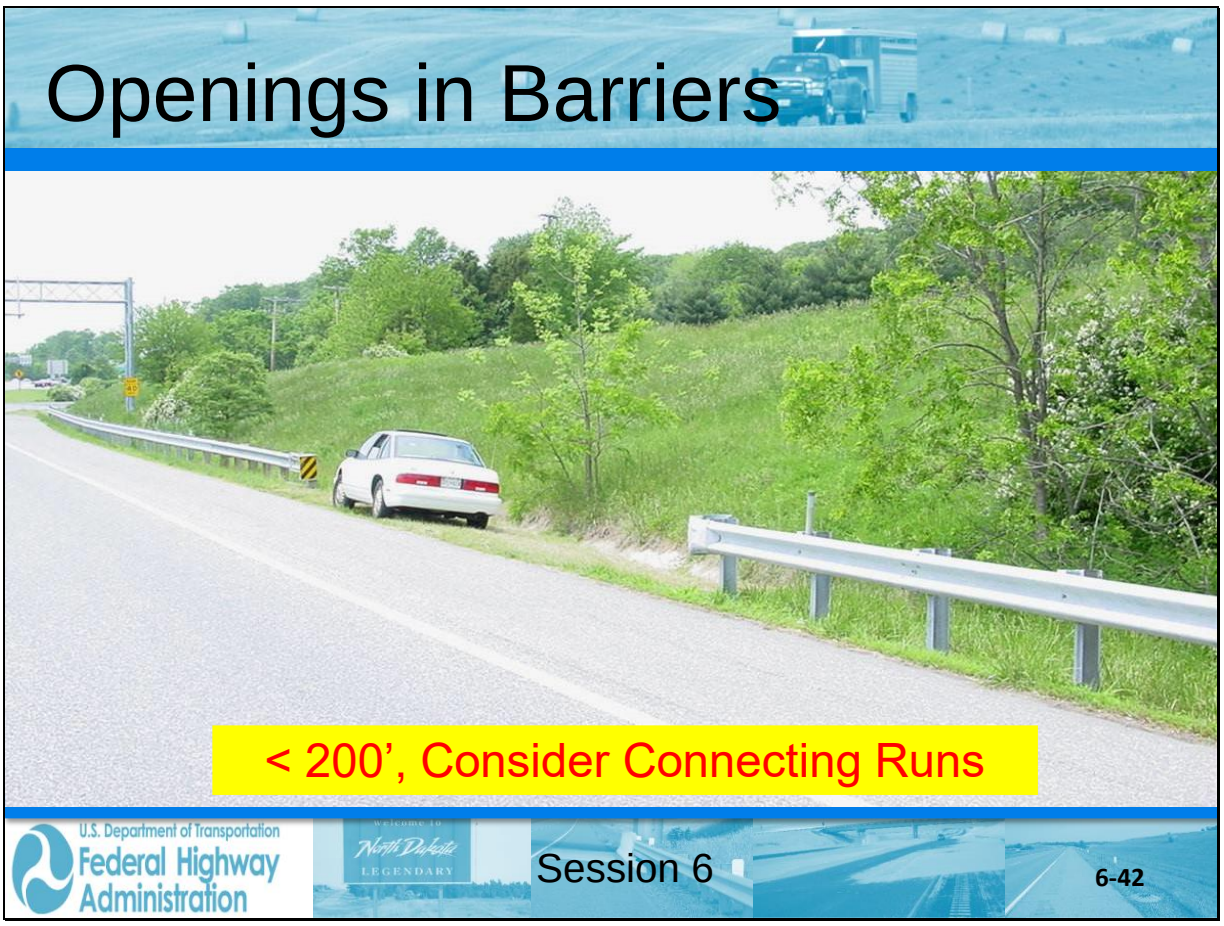
Condition: Interfering Post Placement

Extra Block-outs (Strong-post W-beam)

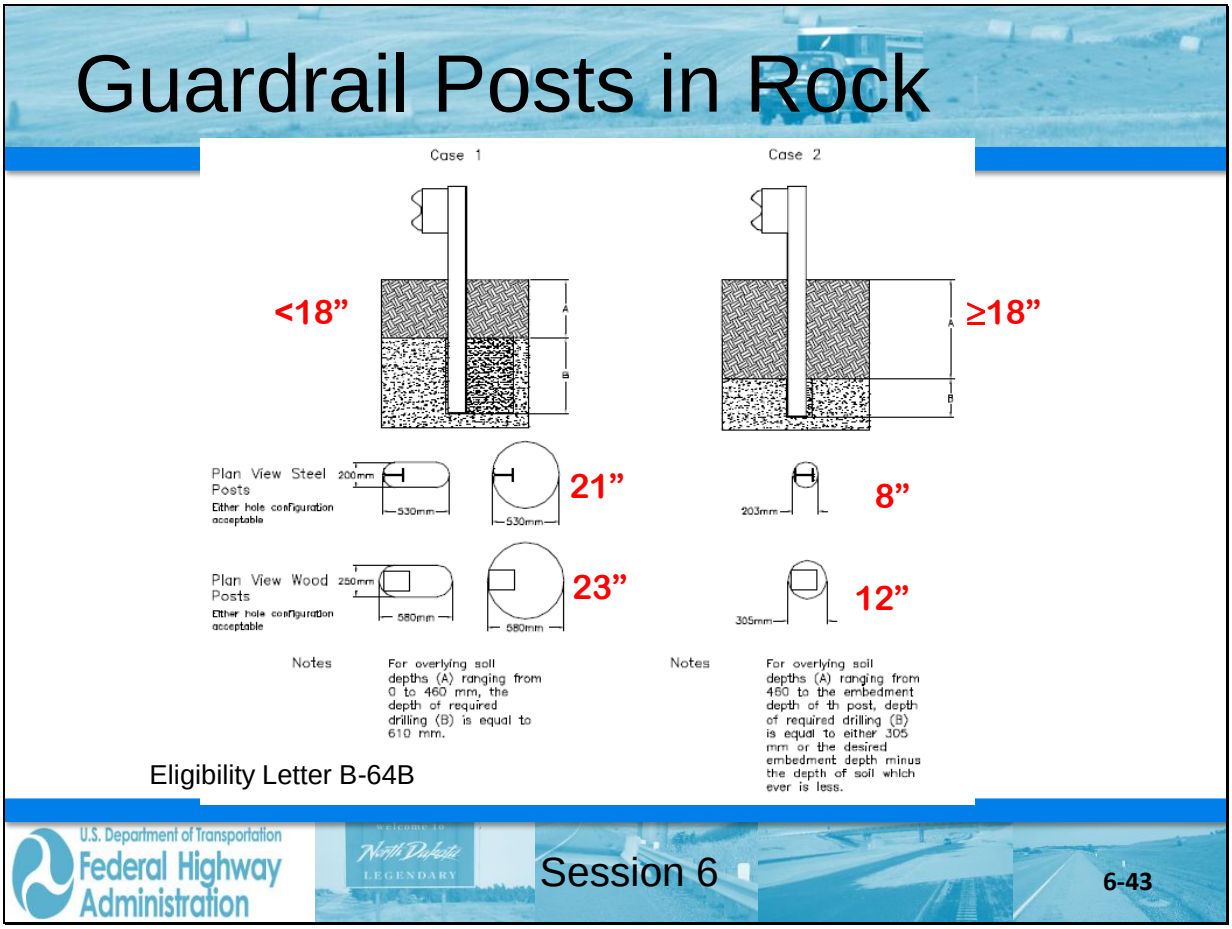
- Two block-outs (up to 16” deep) may be used at any time, for any number of posts.
- Three block-outs may be used at one or two posts in a section of guardrail.

No crash tests to date

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

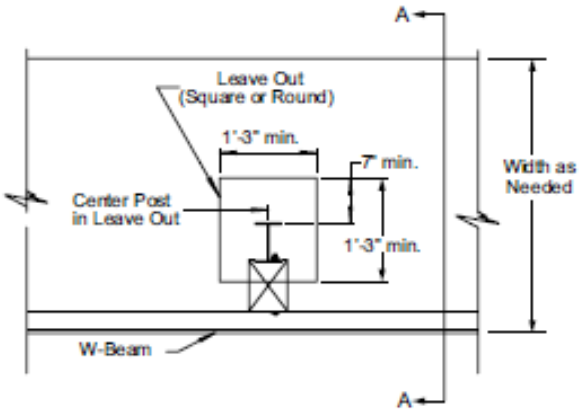

Openings in Barriers
< 200', Consider Connecting Runs
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-42

Guardrail Posts in Rock

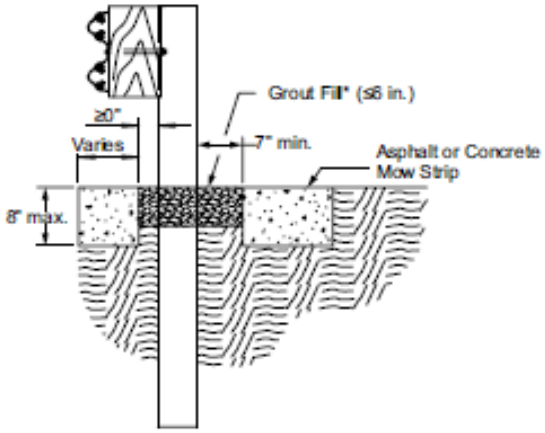


Eligibility Letter B-64B

Leaveouts in Structural Pavement



Steel Post Detail



Section A-A

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

U.S. Department of Transportation Federal Highway Administration

Session 6

6-44

_____

_____

Leaveouts in Structural Pavement

U.S. Department of Transportation Federal Highway Administration

Session 6

6-45

_____

_____

_____

_____

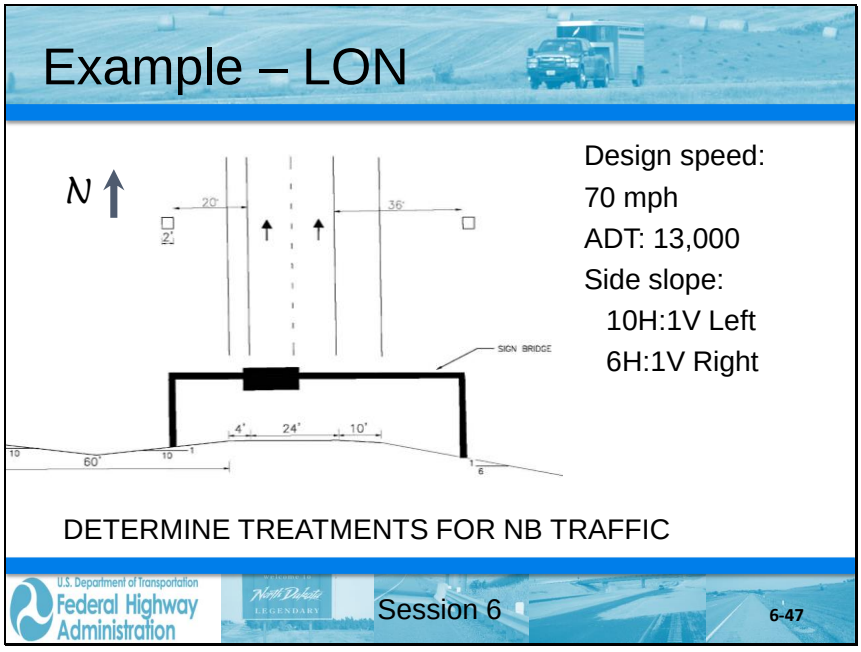
_____

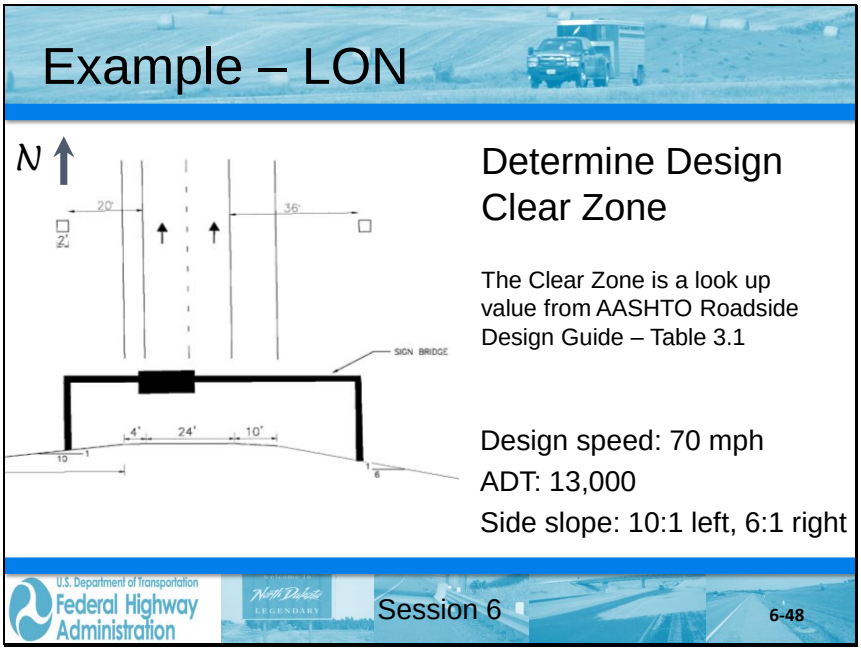
_____

Height Transition – G4 to MGS

FHWA recommendation:

You should transition from a 27-3/4 inch tall barrier or terminal to a 31-inch tall barrier over the span of two 12-foot, 6-inch pieces of w-beam rail. When replacing or repairing long portions of a damaged rail the new rail should be installed at the proper design height, transitioning down to the existing rail over the length of two 12 foot, six inch, pieces of rail at either end.


Example – LON
N
20'
36'
SIGN BRIDGE
4'
24'
10'
60'
10
1
6
Design speed:
70 mph
ADT: 13,000
Side slope:
10H:1V Left
6H:1V Right
DETERMINE TREATMENTS FOR NB TRAFFIC
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-47


Example – LON
N
20'
36'
SIGN BRIDGE
4'
24'
10'
10
1
6
Determine Design Clear Zone
The Clear Zone is a look up value from AASHTO Roadside Design Guide – Table 3.1
Design speed: 70 mph
ADT: 13,000
Side slope: 10:1 left, 6:1 right
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-48

Design Clear Zone Table:

Design Speed 70 mph
AADT = 13,000

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			20-22
60	UNDER 750[c]	16-18	20-24	b			12-14
	750-1500	20-24	26-32[a]	b			16-18
	1500-6000	26-30	32-40[a]	b			18-22
	OVER 6000	30-32[a]	36-44[a]	b			20-22
65-70[d]	UNDER 750[c]	18-20	20-26	b			14-16
	750-1500	24-26	28-36[a]	b			20-22
	1500-6000			b			
	OVER 6000	30-34[a]	38-46[a]	b	22-24	26-30	28-30

L_C = 34 ft.

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

U.S. Department of Transportation Federal Highway Administration

Session 6

6-49

NDDOT Design Clear Zone Determination

Design Speed (mph)	Design ADT***	Foreslopes					Backslopes				
		FLAT	1V:6H	1V:5H	1V:4H	1V:3H	1V:3H	1V:4H	1V:5H	1V:6H	FLAT
≤40	UNDER 750	7-10	7-10	7-10	7-10	**	7-10	7-10	7-10	7-10	7-10
	750-1500	10	12	12	14	**	12-14	12-14	12-14	12-14	12-14
	1500-6000	12	14	14	16	**	14-16	14-16	14-16	14-16	14-16
	OVER 6000	14	16	16	18	**	16-18	16-18	16-18	16-18	16-18
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	15
	1500-6000	16	18	20	26	**	12-14	14	16	16	18
	OVER 6000	20	22	24	28	**	14-16	18	20	20	22
55	UNDER 750	12	14	14	18	**	8-10	10-12	10-12	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*	36*	44*	**	20-22	24	26	26	28
65-75	UNDER 750	18	20	20	26	**	10-12	14-16	14-16	14-16	14-16
	750-1500	24	26	28	36*	**	12-16	18	20	20	22
	1500-6000	26	32*	34*	42*	**	16-20	22	24	26	28
	OVER 6000	30	34*	38*	46*	**	22-24	26	30	28	30

L_C = 34 ft

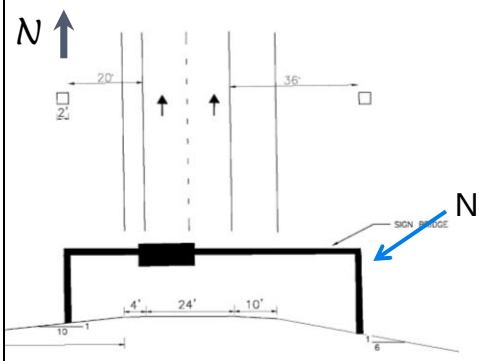
Ref: NDDOT DESIGN MANUAL, Appendix III-14-B, Revised Jan 26, 2016

Federal Highway Administration

Session 6

6-50

Example – LON



Identify ALL the obstacles

NOT SHIELDED

Sign supports – both sides

U.S. Department of Transportation Federal Highway Administration

Session 6

6-51

Right Side Support

- 36’ from travelway
- Design clear zone 34’
- Consequences of a crash

Options

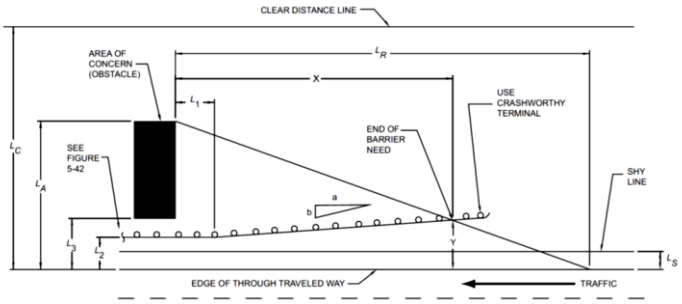
1. Do nothing
2. Place barrier at shoulder
3. Place barrier down 6:1 slope
4. Use impact attenuator

U.S. Department of Transportation Federal Highway Administration

Session 6

6-52

Calculating the length of need (X) for left side



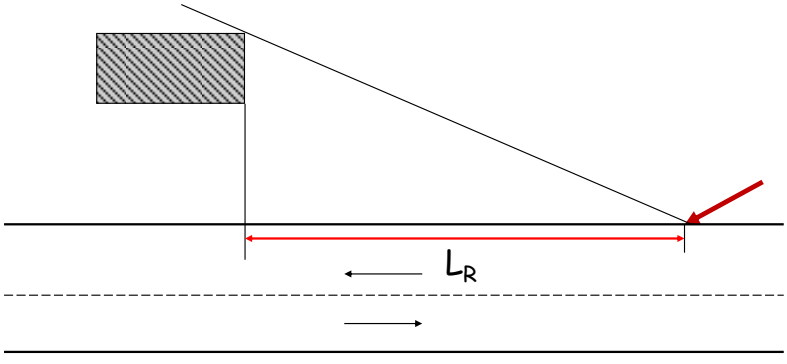
Using a parallel Installation

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

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

U.S. Department of Transportation Federal Highway Administration | Session 6 | 6-53

Define the Point of Departure



U.S. Department of Transportation Federal Highway Administration | Session 6 | 6-54

Look up L_R:

Design Speed 70 mph
AADT = 13,000

Table 5-10(b). Suggested Runout Lengths for Barrier Design (U.S. Customary Units)

Design Speed (mph)	Runout Length (L_R) Given Traffic Volume (ADT) (ft)			
	Over 10,000	5,000 to 10,000	1,000 to 5,000	Under 1,000
80	470	430	380	330
70	360	330	290	250
60	300	250	210	200
50	230		160	150
40	160	130	110	100
30	110	90	80	70

L_R= 360 ft.

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – TABLE 5.10, Pg. 5-50

U.S. Department of Transportation Federal Highway Administration

Session 6

6-55

Runout Lengths - NDDOT

Design Speed (mph)	Runout Length (L_R) Given Traffic Volume (ADT) (ft)			
	Over 6,000	2,000 to 6,000	800 to 2,000	Under 800
75	520	485	430	395
70	475	445	395	360
65	450	425	370	345
60	425	400	345	330
55	360	345	315	280
50	330	300	260	245
45	260	245	215	200
40	230	200	180	165
30	165	165	150	140

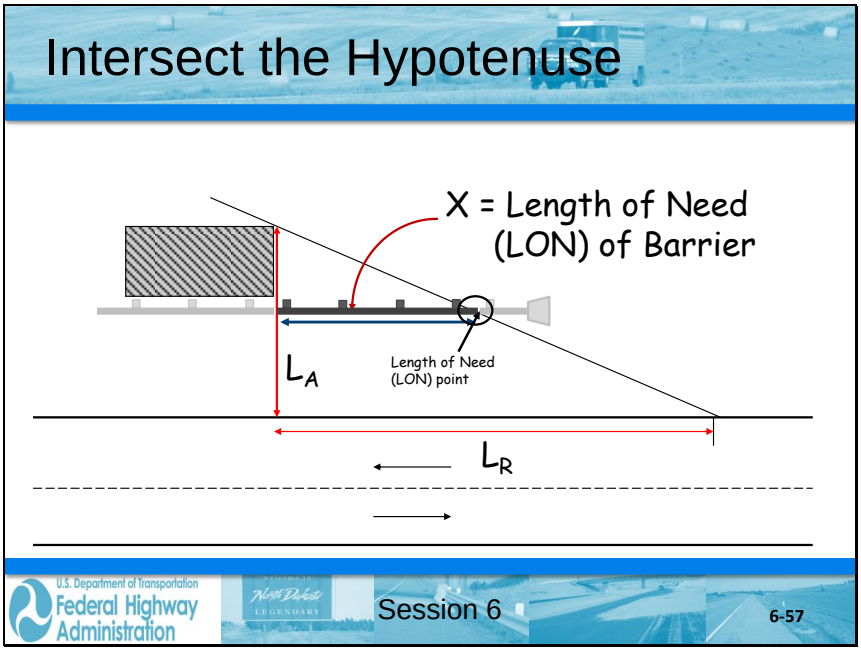
L_R= 475 ft.

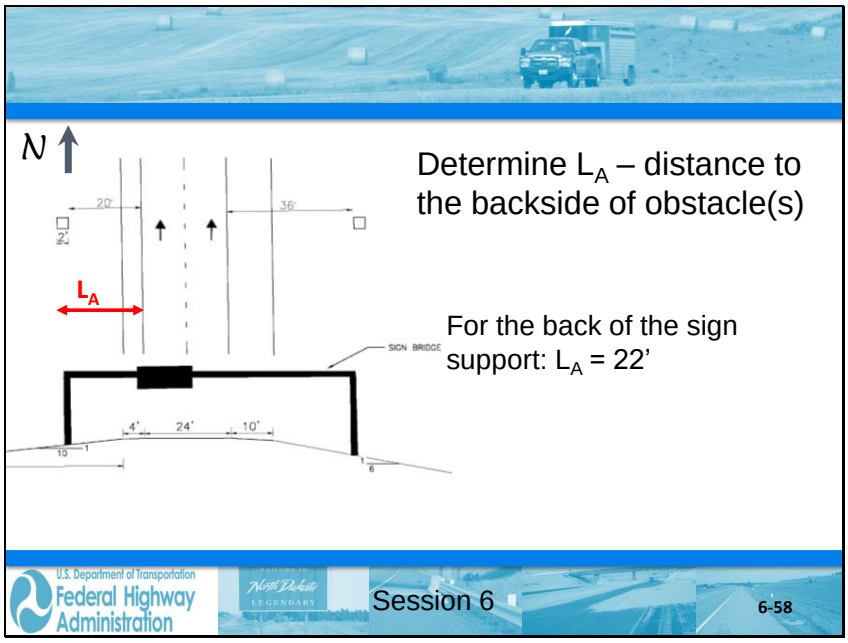
Ref: NDDOT Design Manual, Section III-13, Pg 188, October 2007

U.S. Department of Transportation Federal Highway Administration

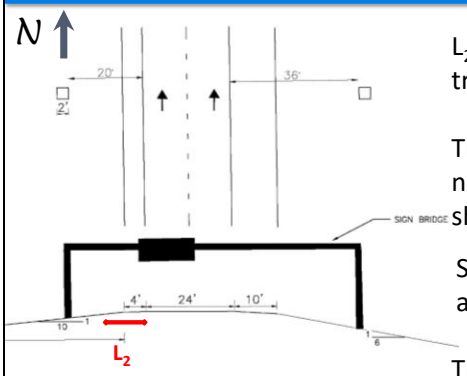
Session 6

6-56


Intersect the Hypotenuse
X = Length of Need (LON) of Barrier
L_A
Length of Need (LON) point
L_R
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-57


N
20'
36'
2'
L_A
SIGN BRIDGE
4'
24'
10'
10
1
6
Determine L_A – distance to the backside of obstacle(s)
For the back of the sign support: L_A = 22'
U.S. Department of Transportation
Federal Highway Administration
Session 6
6-58

Find L_2



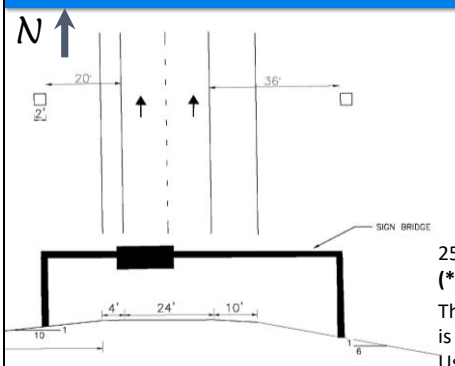
L_2 – Guardrail offset from edge of travel lane.

The goal is to maximize L_2, but normal placement is 2' beyond the shoulder

Since it is a 10H:1V slope, this is acceptable

Therefore L_2 is (4 + 2) 6'

Calculate X



L_A = 22 ft L_2 = 6 ft L_R = 360 ft

Using the formula X =

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

$$= \frac{22 - 6}{22/360}$$

$$= 262 \text{ ft.}$$

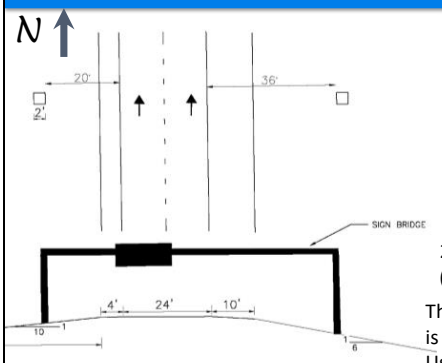
25' *is provided by the end flared terminal
(* Depends on terminal type.)

Therefore 262 – 25 = 237' of standard barrier is required

Using 12.5 ft. panels, no of panels needed = 237/12.5 = 18.9 panels; use 19; 237.5' of LF of Guardrail

An End anchor needs to be added

Calculate X –Using NDDOT L_R



L_A = 22 ft L_2 = 6 ft L_R = 475 ft

Using the formula X =

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

$$= \frac{22 - 6}{22/475}$$

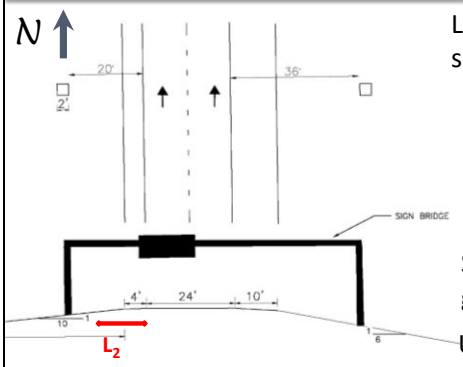
$$= 345 \text{ ft.}$$

25' is provided by the end flared terminal
(* Depends on terminal type.)

Therefore 345 – 25 = 320' of standard barrier is required
Using 12.5 ft. panels, no of panels needed = 320/12.5 = 25.6 panels; use 26; 325' of LF of Guardrail

An End anchor needs to be added

Find L_2 - Maximizing offset



L_A = 22' and L_R = 360'
same as previous

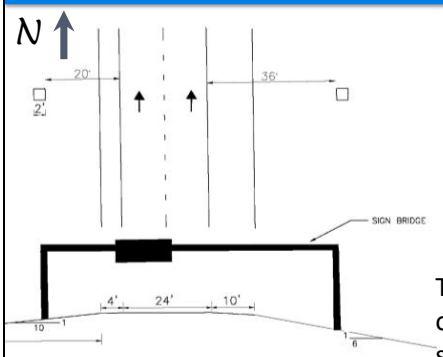
L_2 – Guardrail offset from edge of travel lane.

The goal is to maximize L_2.

Since the slope is 10H:1V, the guardrail can be placed anywhere

Using a conservative **Deflection** working width of 5', L_2 at the support is (20 – 5) = 15'

Calculating X - Maximizing offset



L_A = 22 ft L_2 = 15ft L_R = 360 ft

Using the formula X =

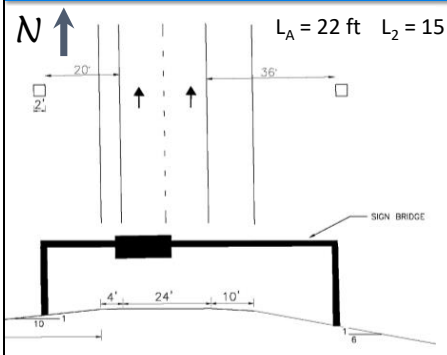
$$X = \frac{L_A - L_2}{L_A/L_R}$$

$$= \frac{22 - 15}{22/360}$$

$$= 115 \text{ ft.}$$

Therefore 147' of barrier – a obstacle – was eliminated (and saved) by moving the barrier from a 6' offset to 15',besides the fewer hits (and repair) benefit

Calculate X – Offset ***plus Flare***



L_A = 22 ft L_2 = 15 ft L_1 = 25ft L_R = 360 ft b/a= 1/15

Using the formula X =

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

$$= \frac{22 + (1/15)25 - 15}{1/15 + 22/360}$$

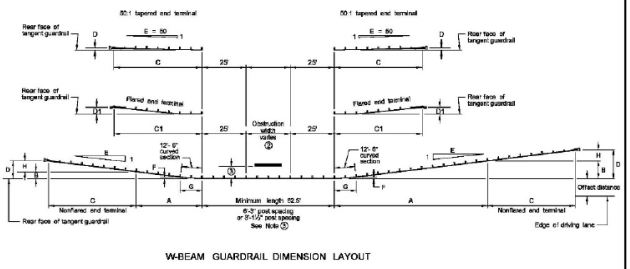
$$= 67.8'$$

Therefore, even more benefit can be obtained by **Flaring** the barrier as well.

LENGTH OF NEED TABLE 70 MPH DESIGN SPEED

DESIGN TRAFFIC VOLUME		APPROACH SIDE						OPPOSITE SIDE						TOTAL W-BEAM LENGTH ③						
	LONGITUDINAL OFFSET TO HAZARD	A	B	C	D	C1	D1	E	A	B	C	D	C1	D1	E	0 - 12.5' Obstruction width	13.0 - 25' Obstruction width	25 - 37.5' Obstruction width	37.5' - 50' Obstruction width	50' - 62.5' Obstruction width	62.5 - 75' Obstruction width	37.5' - 100' Obstruction width
		FT	FT	FT	FT	FT	FT		FT	FT	FT	FT	FT	FT		FT	FT	FT	FT	FT	FT	FT
UNDER 750 ADT	12	24.06	1.25	49.80	4.57			15	0.09	0.00	49.90	1.09	49.79	4.00	50	97.5	100.0	112.5	125.0	137.5	150.0	162.5
	11	37.43	2.66	49.80	5.43			15	0.09	0.00	49.90	1.09	49.79	4.00	50	100.0	112.5	125.0	137.5	150.0	162.5	175.0
	10	37.43	2.66	49.80	5.43			15	0.09	0.00	49.90	1.09	49.79	4.00	50	100.0	112.5	125.0	137.5	150.0	162.5	175.0
	9	49.91	2.91	49.80	6.24			15	0.09	0.00	49.90	1.09	49.79	4.00	50	112.5	125.0	137.5	150.0	162.5	175.0	187.5
	8	62.38	3.74	49.80	7.07			15	0.09	0.00	49.90	1.09	49.79	4.00	50	125.0	137.5	150.0	162.5	175.0	187.5	200.0
	7	62.38	3.74	49.80	7.07			15	0.09	0.00	49.90	1.09	49.79	4.00	50	125.0	137.5	150.0	162.5	175.0	187.5	200.0
	6	74.65	4.57	49.80	7.93			15	0.09	0.00	49.90	1.09	49.79	4.00	50	137.5	150.0	162.5	175.0	187.5	200.0	212.5
	5	87.32	5.40	49.80	8.73			15	0.09	0.00	49.90	1.09	49.79	4.00	50	150.0	162.5	175.0	187.5	200.0	212.5	225.0
	4	87.32	5.40	49.80	8.73			15	0.09	0.00	49.90	1.09	49.79	4.00	50	150.0	162.5	175.0	187.5	200.0	212.5	225.0
	3	99.99	6.24	49.80	9.56			15	12.49	0.42	49.80	3.74			15	175.0	187.5	200.0	212.5	225.0	237.5	250.0
	2	112.27	7.07	49.80	10.39			15	12.49	0.42	49.80	3.74			15	187.5	200.0	212.5	225.0	237.5	250.0	262.5
	1	112.27	7.07	49.80	10.39			15	12.49	0.42	49.80	3.74			15	187.5	200.0	212.5	225.0	237.5	250.0	262.5
	0	124.74	7.90	49.80	11.23			15	24.96	1.25	49.80	4.57			15	212.5	225.0	237.5	250.0	262.5	275.0	287.5
750 - 1500 ADT	12	62.38	3.74	49.80	7.07			15	0.09	0.00	49.90	1.09	49.79	4.00	50	125.0	137.5	150.0	162.5	175.0	187.5	200.0
	11	74.65	4.57	49.80	7.93			15	0.09	0.00	49.90	1.09	49.79	4.00	50	137.5	150.0	162.5	175.0	187.5	200.0	212.5
	10	74.65	4.57	49.80	7.93			15	0.09	0.00	49.90	1.09	49.79	4.00	50	137.5	150.0	162.5	175.0	187.5	200.0	212.5
	9	87.32	5.40	49.80	8.73			15	12.49	0.42	49.80	3.74			15	162.5	175.0	187.5	200.0	212.5	225.0	237.5
	8	99.99	6.24	49.80	9.56			15	12.49	0.42	49.80	3.74			15	175.0	187.5	200.0	212.5	225.0	237.5	250.0
	7	99.99	6.24	49.80	9.56			15	12.49	0.42	49.80	3.74			15	175.0	187.5	200.0	212.5	225.0	237.5	250.0
	6	112.27	7.07	49.80	10.39			15	24.96	1.25	49.80	4.57			15	200.0	212.5	225.0	237.5	250.0	262.5	275.0
	5	112.27	7.07	49.80	10.39			15	24.96	1.25	49.80	4.57			15	200.0	212.5	225.0	237.5	250.0	262.5	275.0
	4	124.74	7.90	49.80	11.23			15	37.43	2.08	49.80	5.40			15	225.0	237.5	250.0	262.5	275.0	287.5	300.0
	3	137.21	8.73	49.80	12.06			15	37.43	2.08	49.80	5.40			15	237.5	250.0	262.5	275.0	287.5	300.0	312.5
	2	137.21	8.73	49.80	12.06			15	49.91	2.91	49.80	6.24			15	250.0	262.5	275.0	287.5	300.0	312.5	325.0
	1	149.69	9.56	49.80	12.89			15	62.38	3.74	49.80	7.07			15	275.0	287.5	300.0	312.5	325.0	337.5	350.0
	0	149.69	9.56	49.80	12.89			15	62.38	3.74	49.80	7.07			15	275.0	287.5	300.0	312.5	325.0	337.5	350.0
1500 - 3000 ADT	12	99.99	6.24	49.80	9.56			15	12.49	0.42	49.80	3.74			15	175.0	187.5	200.0	212.5	225.0	237.5	250.0
	11	112.27	7.07	49.80	10.39			15	24.96	1.25	49.80	4.57			15	200.0	212.5	225.0	237.5	250.0	262.5	275.0
	10	112.27	7.07	49.80	10.39			15	24.96	1.25	49.80	4.57			15	200.0	212.5	225.0	237.5	250.0	262.5	275.0
	9	124.74	7.90	49.80	11.23			15	37.43	2.08	49.80	5.40			15	225.0	237.5	250.0	262.5	275.0	287.5	300.0
	8	137.21	8.73	49.80	12.06			15	49.91	2.91	49.80	6.24			15	250.0	262.5	275.0	287.5	300.0	312.5	325.0
	7	137.21	8.73	49.80	12.06			15	49.91	2.91	49.80	6.24			15	250.0	262.5	275.0	287.5	300.0	312.5	325.0
	6	149.69	9.56	49.80	12.89			15	62.38	3.74	49.80	7.07			15	275.0	287.5	300.0	312.5	325.0	337.5	350.0
	5	149.69	9.56	49.80	12.89			15	62.38	3.74	49.80	7.07			15	275.0	287.5	300.0	312.5	325.0	337.5	350.0
	4	162.16	10.39	49.80	13.72			15	74.85	4.57	49.80	7.90			15	300.0	312.5	325.0	337.5	350.0	362.5	375.0
	3	162.16	10.39	49.80	13.72			15	87.32	5.40	49.80	8.73			15	312.5	325.0	337.5	350.0	362.5	375.0	387.5
	2	174.63	11.23	49.80	14.55			15	87.32	5.40	49.80	8.73			15	325.0	337.5	350.0	362.5	375.0	387.5	400.0
	1	187.10	12.06	49.80	15.38			15	99.80	6.24	49.80	9.56			15	350.0	362.5	375.0	387.5	400.0	412.5	425.0
	0	187.10	12.06	49.80	15.38			15	99.80	6.24	49.80	9.56			15	350.0	362.5	375.0	387.5	400.0	412.5	425.0
OVER 3000 ADT	12	112.27	7.07	49.80	10.39			15	37.43	2.08	49.80	5.40			15	212.5	225.0	237.5	250.0	262.5	275.0	287.5
	11	124.74	7.90	49.80	11.23			15	37.43	2.08	49.80	5.40			15	225.0	237.5	250.0	262.5	275.0	287.5	300.0
	10	137.21	8.73	49.80	12.06			15	49.91	2.91	49.80	6.24			15	250.0	262.5	275.0	287.5	300.0	312.5	325.0
	9	137.21	8.73	49.80	12.06			15	49.91	2.91	49.80	6.24			15	250.0	262.5	275.0	287.5	300.0	312.5	325.0
	8	149.69	9.56	49.80	12.89			15	62.38	3.74	49.80	7.07			15	275.0	287.5	300.0	312.5	325.0	337.5	350.0
	7	149.69	9.56	49.80	12.89			15	62.38	3.74	49.80	7.07			15	275.0	287.5	300.0	312.5	325.0	337.5	350.0
	6	162.16	10.39	49.80	13.72			15	74.85	4.57	49.80	7.90			15	300.0	312.5	325.0	337.5	350.0	362.5	375.0
	5	162.16	10.39	49.80	13.72			15	87.32	5.40	49.80	8.73			15	312.5	325.0	337.5	350.0	362.5	375.0	387.5
	4	174.63	11.23	49.80	14.55			15	87.32	5.40	49.80	8.73			15	325.0	337.5	350.0	362.5	375.0	387.5	400.0
	3	187.10	12.06	49.80	15.38			15	99.80	6.24	49.80	9.56			15	350.0	362.5	375.0	387.5	400.0	412.5	425.0
	2	187.10	12.06	49.80	15.38			15	99.80	6.24	49.80	9.56			15	350.0	362.5	375.0	387.5	400.0	412.5	425.0
	1	199.57	12.89	49.80	16.21			15	112.27	7.07	49.80	10.39			15	375.0	387.5	400.0	412.5	425.0	437.5	450.0
	0	199.57	12.89	49.80	16.21			15	112.27	7.07	49.80	10.39			15	375.0	387.5	400.0	412.5	425.0	437.5	450.0

GUARDRAIL AT OBSTRUCTIONS
70 MPH DESIGN LENGTH OF NEED TABLES



W-BEAM GUARDRAIL DIMENSION LAYOUT

DESIGN SPEED	F	G	H	R
	FT	FT	FT	FT
70	0.42	12.49	3.33	187.78

NOTES:

The contractor shall use wood posts for the W-beam guardrail and end terminal section.

① Does not include end terminal section.

② The width of the obstruction shall be rounded up to the nearest 12'-6" length.

③ Where distance from rear face of W-beam railing to a fixed object is 3' or more, post spacing in this area shall be 6'-3".

Where distance from rear face of W-beam railing to a fixed object is less than 3', post spacing in this area shall be 3'-1½".

NDDOT Design Manual Appendix III-13B

Review 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
- Calculate the LON and understand the various factors
- Modify guardrail for special situations