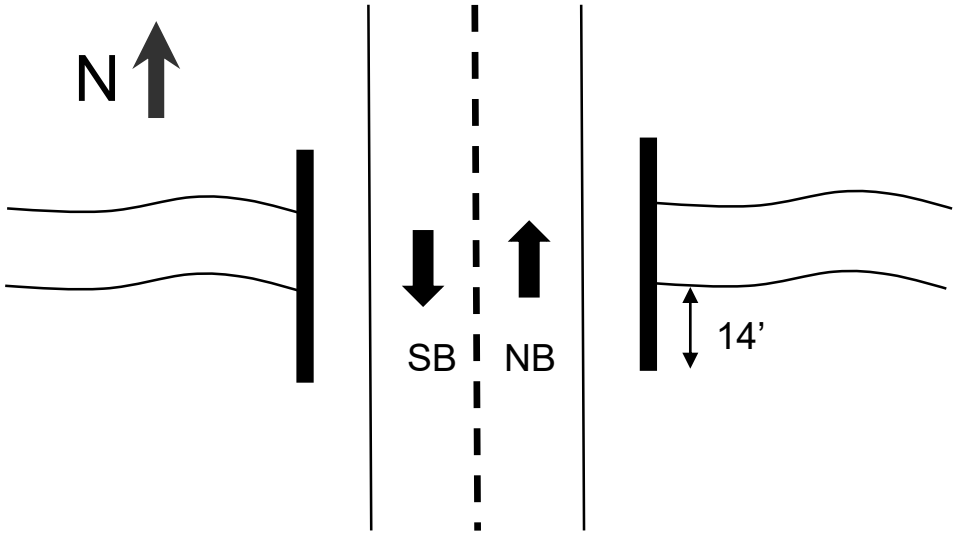
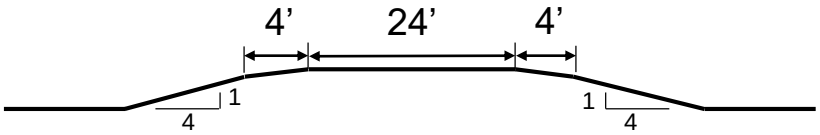
Highway Barrier Design Workshop Solutions

WORKSHOP PROBLEM 1 – BRIDGE ON RURAL ROAD WITH TWO-WAY TRAFFIC

Design speed – 55 mph
AADT – 1,800 vpd





Roadway Section

Lane width: 12 ft.

Shoulder width: 4 ft.

Side slope: 4:1

Design for both sides of road, NB

Determine Design Clear Zone (L_C) – NDDOT DESIGN MANUAL, Appendix III-14-B, Revised Jan 26, 2016

Design speed – 55 mph
AADT – 1,800 vpd
Slope – 4:1

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	28	32*	34*	42*	**	16-20	22	24	26	28
	OVER 6000	30	34*	38*	46*	**	22-24	26	30	28	30

Select Design Clear Zone = 30’ Right Side

Left Side Combination: 16’ flat and remainder 4:1

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

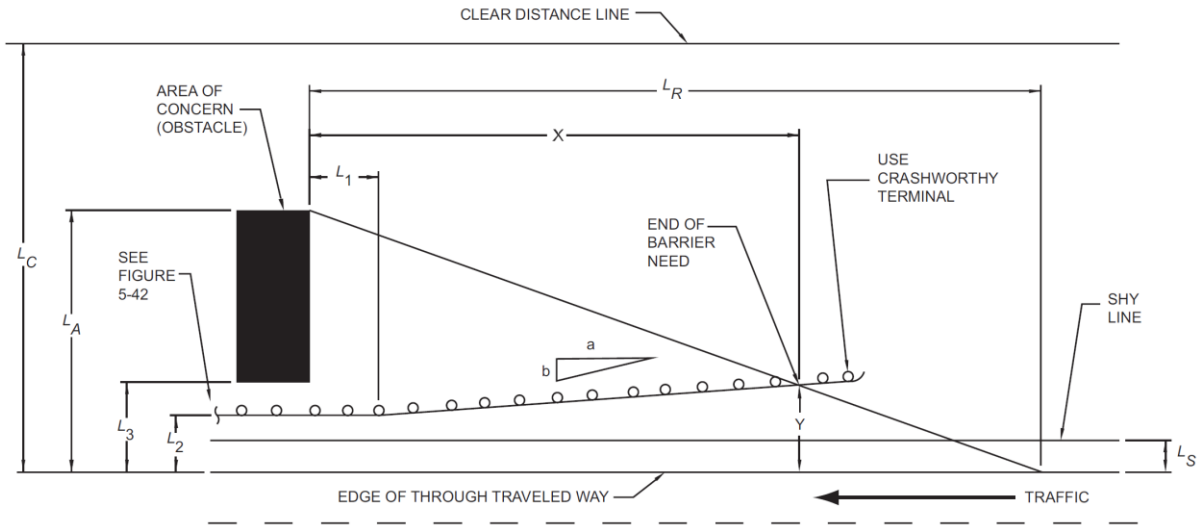
Combined slope design clear zone –

20’ to 30’, Use 24’

Identify all obstacles

a. Bridge rail ends
b. River

Determine the Length of Need (X)



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

<u>Determine the Lateral distance to the backside edge of the area of concern (L_A)</u>.

L_A-

For the bridge end:

For a right side departure it is 5’ (shoulder width plus 1’ wall thickness)

For a left side departure it is 17’ (measured from the centerline)

For the river:

Since the river is continuous, the outside edge of the area of concern extends beyond the design clear zone. In such cases the back edge of the area of concern (L_A) may be limited to the design clear zone (L_C). Therefore, L_A will equal L_C = 30’ on right and L_C = 24’ on the left.

Find L_R – The theoretical Runout Length needed for a vehicle leaving the roadway to stop.

This is a look up value from the NDDOT Design Manual, Section III-13, Pg 188, October 2007

Design speed – 55 mph
AADT – 1,800 vpd

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

Therefore, L_R = 315' – for both sides.

First for right side departure

Determine L_2 – Guardrail offset from edge of travel lane.

The roadway has a 4' ft. shoulder. Guardrail should be placed as far from the travelled lane as practical – without affecting its function. The 4:1 slope is not acceptable for guardrail placement (**Principle** – slope in front of barrier); regrading would be necessary. Assume too costly, so place face of rail at edge of shoulder.

Guardrail posts should have a minimum of 2 ft. of **relatively** flat ground behind them for soil backing (**Principle** – soil backing). Provide widening for guardrail and terminal per NDDOT Drawing D764-48.

Therefore L_2 = 4 ft. (Shoulder width) on the right

Calculating the Length of Need

We'll only calculate the LON of the river; when shielding the river, that barrier will also shield the end of the bridge rail.

Using formula:

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

$$= \frac{30 - 4}{30/315}$$

= 273' Right side

Left Side departure

$$= \frac{24 - 16}{24/315}$$ Left side departure L_A = 24' and L_2 = 16' (measured from centerline)

= 105' Left side

LON is defined as the length of effective barrier upstream from the beginning of the area of concern – the stream bank. This will include:

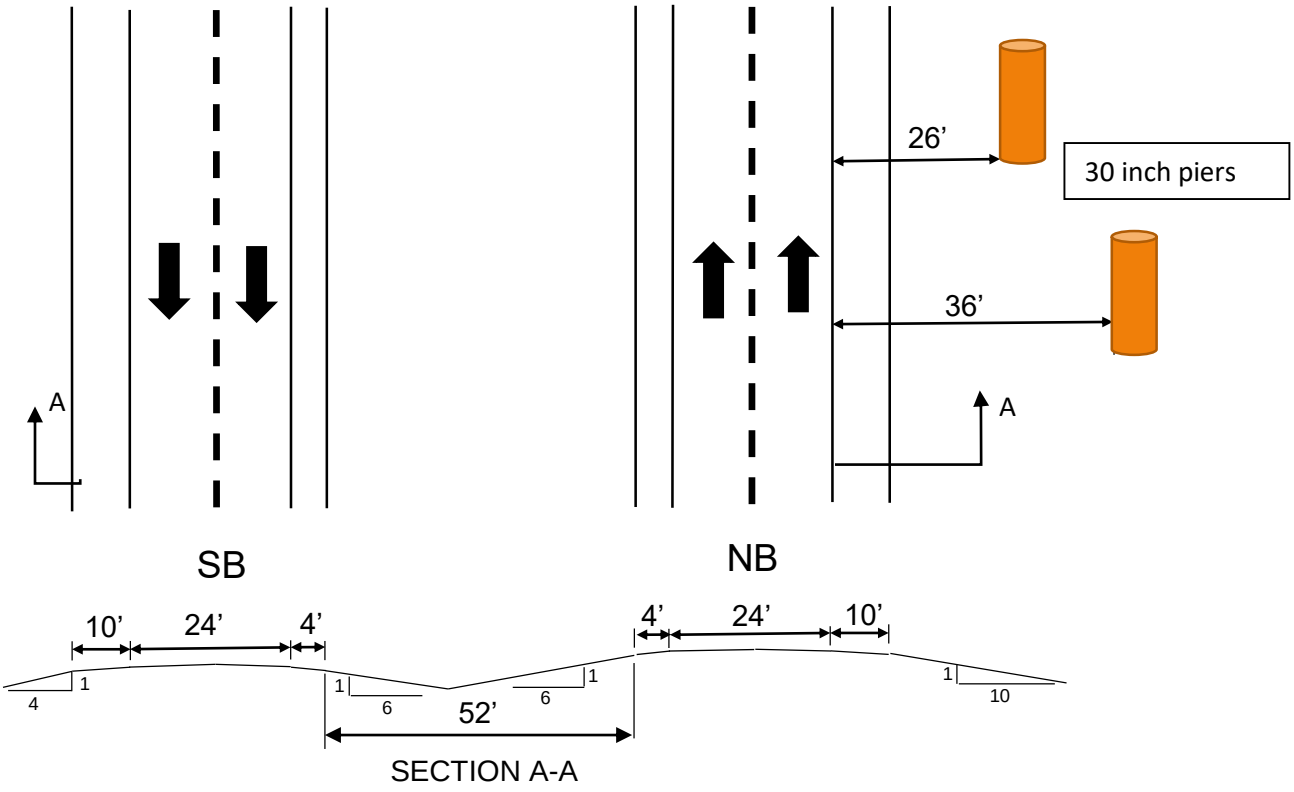
- 14' of the bridge railing,
- 25' (37.5'?)provided by the bridge transition, paid as Each
- 34.5' (34' 4 ½ ")effective barrier provided by the tangent terminal (Depends on Terminal type)

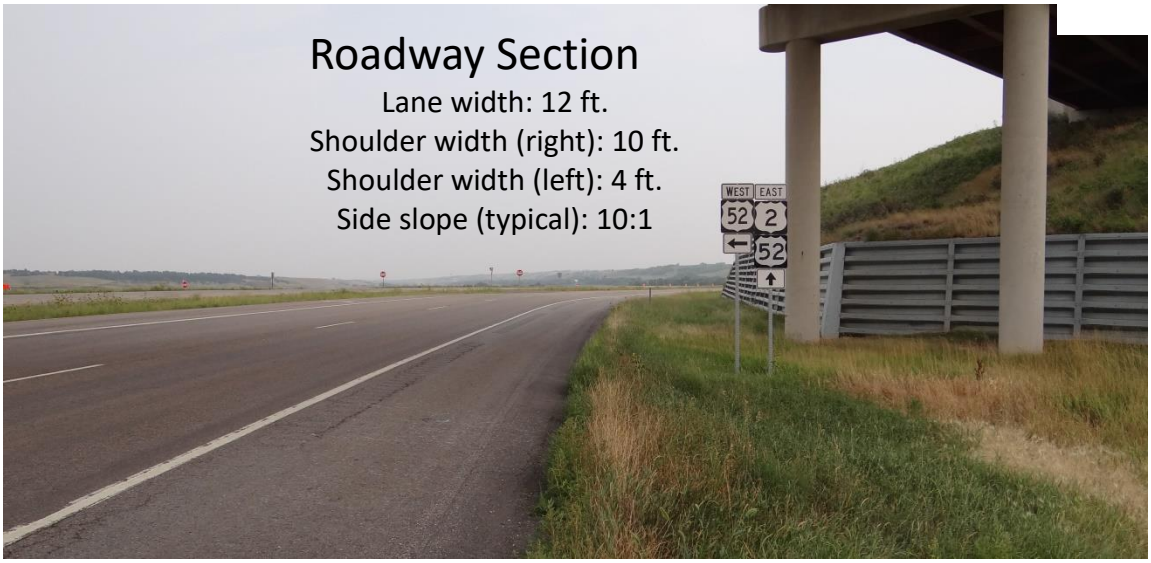
For the right side departure
Therefore, the amount of line guardrail needed = 273-14-25-34.5 = 199.5'; converting to full 12.5' panels (199.5 ÷ 12.5=16) is 16 panels or 200 LF of standard guardrail

For the left side departure
X = 105'
Therefore, the amount of line guardrail needed = 105-14-25-34.5 = 31.5'; converting to full 12.5' panels (31.5 ÷ 12.5=2.52) is 3 panels or 37.5 LF of standard guardrail

WORKSHOP PROBLEM 2 – PIER

Design speed: 70 mph
ADT: 38,000
Side slope: 10:1 Typical





Calculate the Length of Need (X) for the **NB Right side departure**

Determine Design Clear Zone (L_C) – NDDOT DESIGN MANUAL, Appendix III-14-B, Revised Jan 26, 2016

Design speed: 70 mph
ADT: 12,000
Side slope: 10:1 Typical

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
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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
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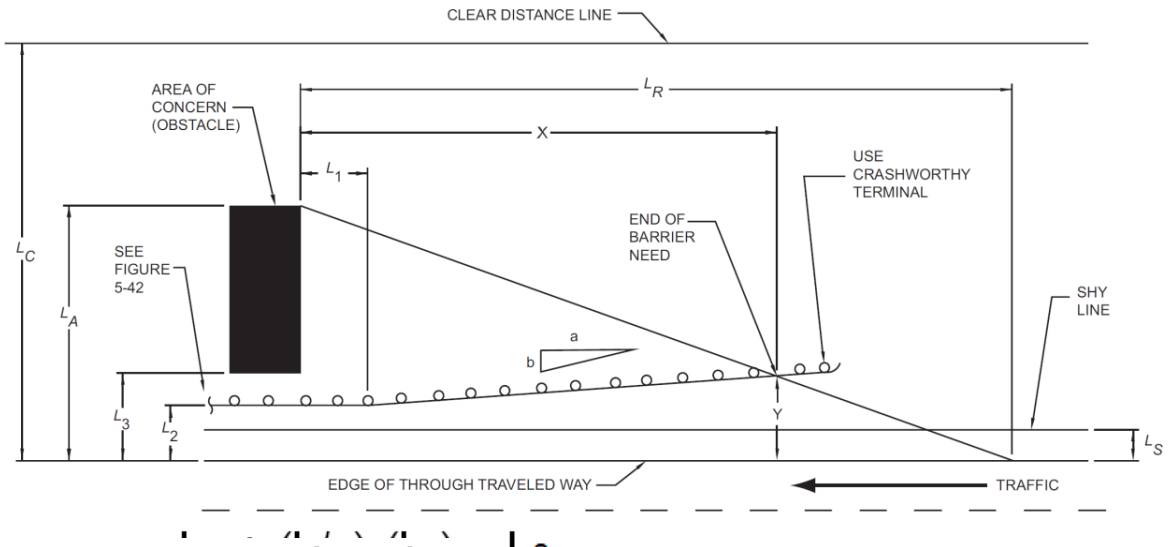
	750-1500	20	24	26	32*	**	12-14	16	18	20	22
	1500-6000	26	30	32*	40*	**	14-18	18	22	24	26
	OVER 6000	30	32*	36*	44*	**	20-22	24	26	26	28
65-75	UNDER 750	18	20	20	26	**	10-12	14-16	14-16	14-16	14-16
	750-1500	24	26	28	36*	**	12-16	18	20	20	22
	1500-6000	28	32*	34*	42*	**	16-20	22	24	26	28
	OVER 6000	30	34*	38*	46*	**	22-24	26	30	28	30

Select Design Clear Zone = 30'

Identify the Area of Concern

Pier located 26' to 36' off of travelway

Determine the Length of Need (X)



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

<u>Find L_R – The theoretical Runout Length needed for a vehicle leaving the roadway to stop.</u>

This is a look up value from the NDDOT Design Manual, Section III-13, Pg 188, October 2007

Design speed – 70 mph
AADT 12,000 vpd

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
30	165	165	150	140

Therefore, L_R = 475’

Determine the Lateral distance to the backside of the area of concern (L_A).

The far side of piers are 28.5’ and 38.5’; L_C = 30 ft. Therefore use L_A = 28.5’

Calculating the Length of Need

Placing the guardrail just outside the shoulder (L_2 = 10’) and using formula:

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

$$= \frac{28.5 - 10}{28.5/475}$$

= 308 ft. in advance of obstacle

It is desirable to always try to maximize the barrier offset: to gain more clear area, reduce impacts and nuisance hits, locate the terminal farther away from traffic and reduce the amount of barrier. Since the slopes are 10:1 we can locate the barrier farther from the travel way and closer to the object keeping in mind the deflection of the guardrail system. In this case we allowed for 5’ of working distance and set the barrier at 21’.

Therefore L_2 = 21 ft.

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

$$= \frac{28.5 - 21}{28.5/475}$$

= 125 ft.

A reduction of 183 ft. of guardrail and opening up over 20 ft. of recovery area and locating the terminal farther from the travelway.

In addition place the barrier on a flare beginning 25 ft. from obstacle with a 15/1 taper at 70 mph and using the formula:

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

$$= \frac{28.5 + (1/15)\ (25) - 21}{(1/15) + (28.5/475)}$$

= 72 ft.

A farther reduction of 53 ft. of guardrail is realized and the guardrail and terminal are located even farther from the travelway.

However there is still that second pier which is as serious an obstacle which can be reached by a portion of the errant departures. Shielding the second obstacle, the L_A = 38.5 ft. and using the formula:

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

$$= \frac{38.5 + (1/15)\,(25) - 21}{(1/15) + (38.5/475)}$$

129.75 ft. An additional 58 ft.to shield both piers.

34.5’ (34’ 4 1/2”, D764-38) is provided by the flared terminal.
Therefore 129.5’ – 34.5’ = 95’ of standard barrier, plus the length beyond the obstacle (25’ or 12.5’ depending on end anchor) is required.
Convert to panels, then to LF for pay item for w-beam guardrail.