Guardrail Design

MDOT/ACEC Design Basic Training
Guardrail Design
March 20, 2025
9:00 a.m. to 4:30 p.m.
Virtual Training, via Teams

AGENDA

Our presenter today is Carlos Torres. Carlos is the Roadside Safety Engineer Specialist and the Chairperson of the Barrier Advisory Committee for MDOT. He has held that role since 2004.

9:00 a.m.-12:00 p.m. Guardrail Design
Topics to be covered in this training include:

- Provide an overview of guardrail design
    - Clear zone concept
    - Roadside topography and its effects on guardrail design
    - Overview of different guardrail types and related features
        - Guardrail types
        - Approach terminals
        - Departing terminals
        - Anchorages
        - Curved guardrail
        - Long span details
        - Other guardrail features
    - Guardrail design terminology and applications
    - Methodology for calculating minimum length of need
    - Knowing which guardrail features to use for different applications
    - Solve a guardrail design example problem

- Provide a brief overview of MDOT standards and guidelines related to guardrail

12:00 p.m.-1:00 p.m. - Lunch Break -

1:00 p.m.- 4:30 p.m. Guardrail Design – *continuation of above topics*

Total CEHs offered for A.M. and P.M. sessions: 6.50

Thank you for attending today's training. The following are helpful links:

Event Links: A.M. Session: Guardrail A.M. Session P.M. Session: Guardrail P.M. Session

Design Basic Training Wiki Page: DBT Wiki Page *Survey:* Guardrail Survey

The CEH's are being listed as a guide and the Michigan Department of Transportation (MDOT) is not awarding CEH's. Please note that a final determination on what qualifies as a CEH credit ultimately lies between the license holder and the Michigan Department of Licensing and Regulatory Affairs (LARA).

Presenter

Carlos Torres, P.E.

- MDOT Roadside Safety Engineer (2004)
- Chairman – Barrier Advisory Committee (2004)
- Statewide roadside design and safety specialist

Objectives

- Provide an overview of guardrail design
  - Clear Zone Concept
  - Roadside Topography and Its Effects on Guardrail Design
  - Overview of Guardrail Types and Related Features
  - Methodology for Calculating Minimum Length of Need

Objectives

- Provide an overview of guardrail design
  - Guidelines and Standards Related to Guardrail Design
    - Michigan Road Design Manual – Chapter 7

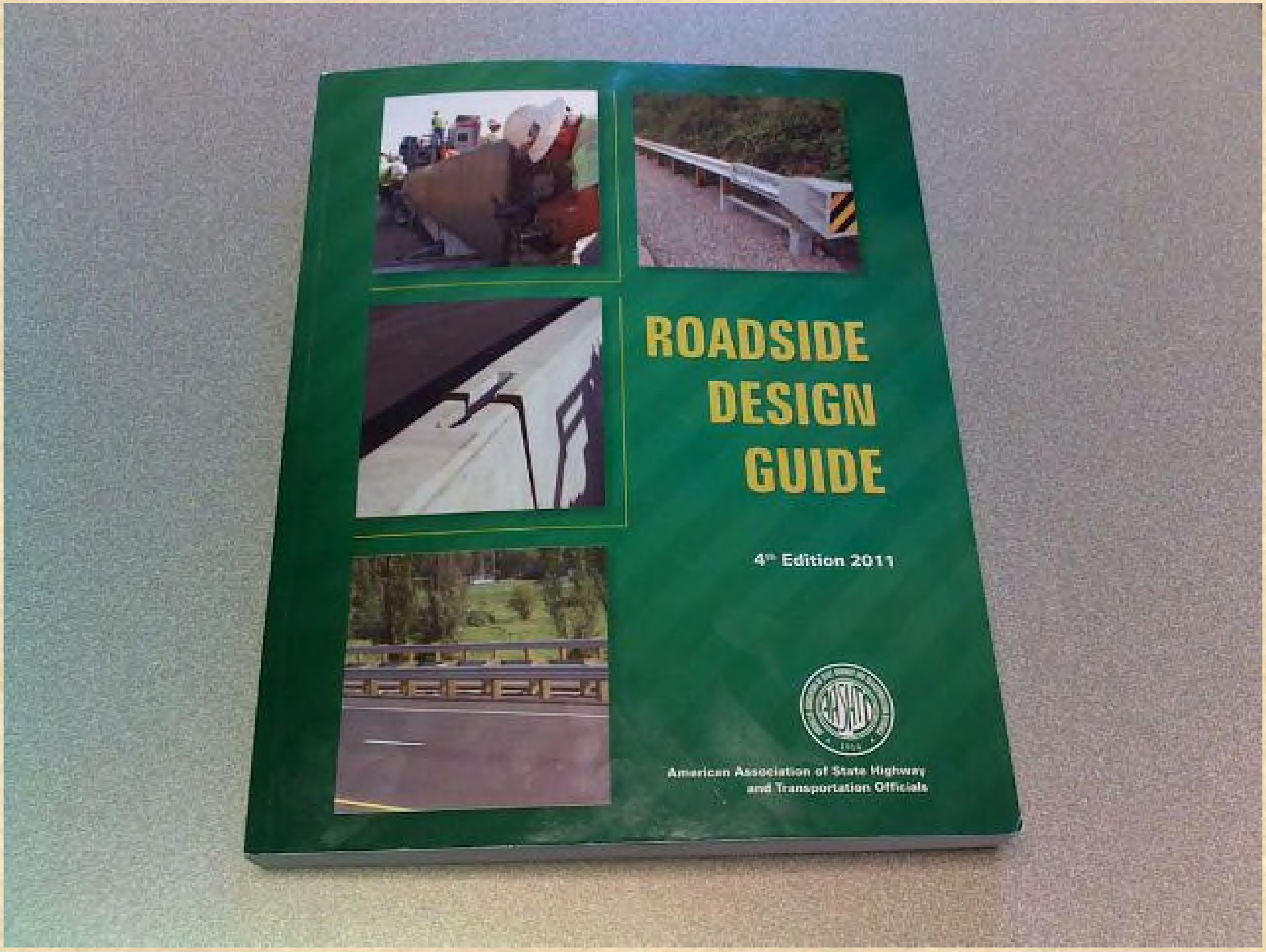
    https://mdotjboss.state.mi.us/stdplan/englishroadmanual.htm

    - MDOT Standard Plans and Special Details

    https://mdotjboss.state.mi.us/stdplan/standardPlansHome.htm

    - 2011 AASHTO Roadside Design Guide
      - Available for purchase through AASHTO website
      - MDOT employees can access electronically through ASTM/AASHTO Web Portal (in MDOT-CFS Sharepoint page)

4th Edition, 2011
AASHTO Roadside Design Guide



Other Reference Documents

- MDOT 2020 Standard Specifications for Construction
  https://mdotjboss.state.mi.us/SpecProv/specBookHome.htm

  MDOT Previously Approved Special Provisions (PASPs)
  https://mdotjboss.state.mi.us/SpecProv/specProvHome.htm

- MDOT Frequently Used Special Provisions (FUSPs)
  - SOM employees only: Available through MDOT Supplemental Specs and Special Provisions (SS/SP) app using MILogin
    - » Must request access to use this app

Objectives

- Solve guardrail design example problems
  - Guardrail Types
  - Guardrail Terminals
  - Guardrail Anchorages
  - MDOT Guardrail Worksheet

*** Disclaimers ***

- The contents of this class represent current Michigan DOT (MDOT) guardrail design practices and principles

- Many of the terms and some of the design principles/practices presented in this class are specific to MDOT and may not reflect the terms and design principles/practices utilized by other agencies

*** Disclaimers ***

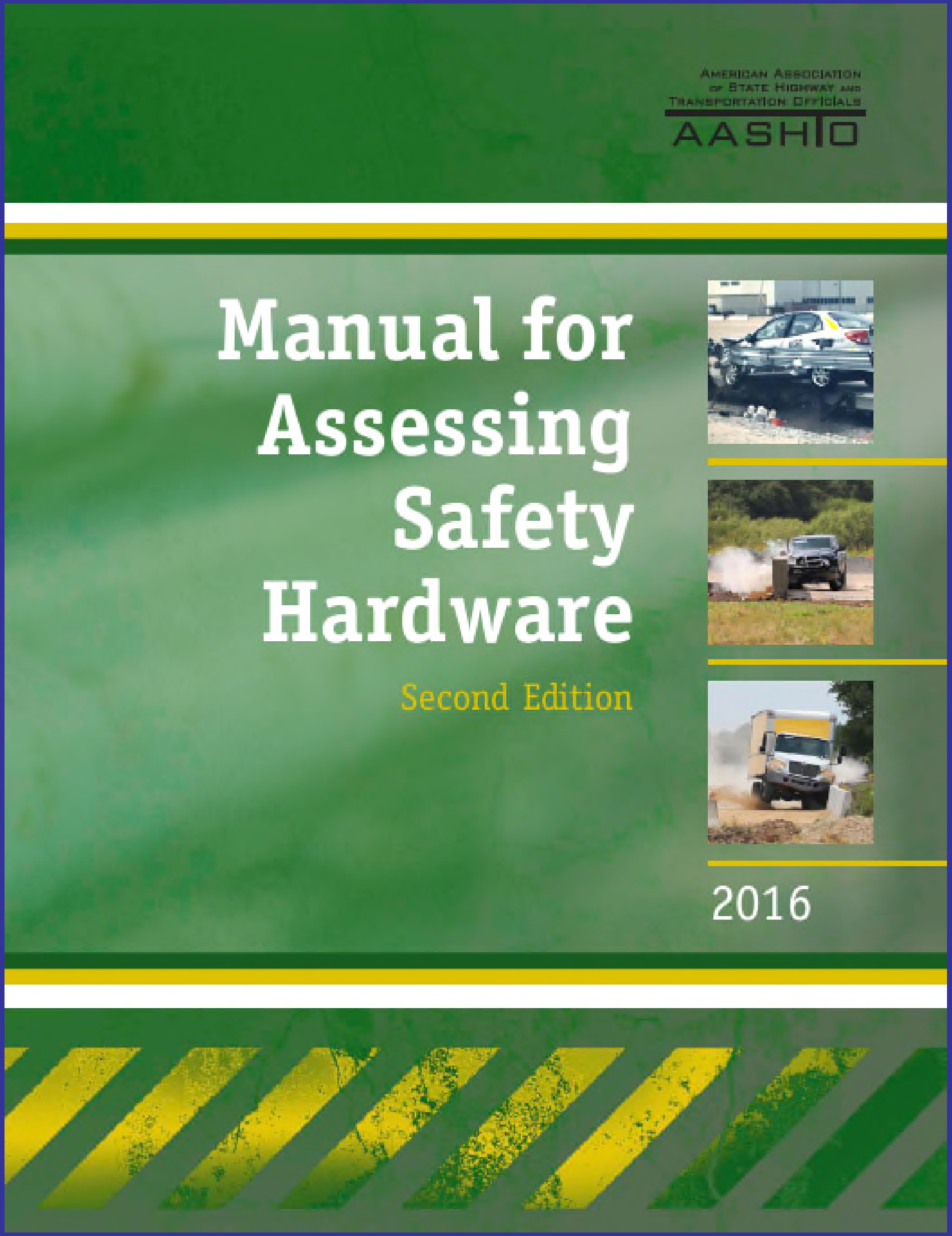
- The concepts presented in this class are intended to serve as general guidelines
  - *There are exceptions to the norms!*

- Guardrail design can be subjective and usually requires detailed knowledge of the conditions and constraints at each proposed installation site
  - Engineering judgment may need to be utilized
  - What works at one location may not be suitable at a different location

What is MASH?

- MASH stands for *Manual for Assessing Safety Hardware*
  - AASHTO Publication

- *MASH is the current standard for establishing the crash worthiness of roadside safety features*



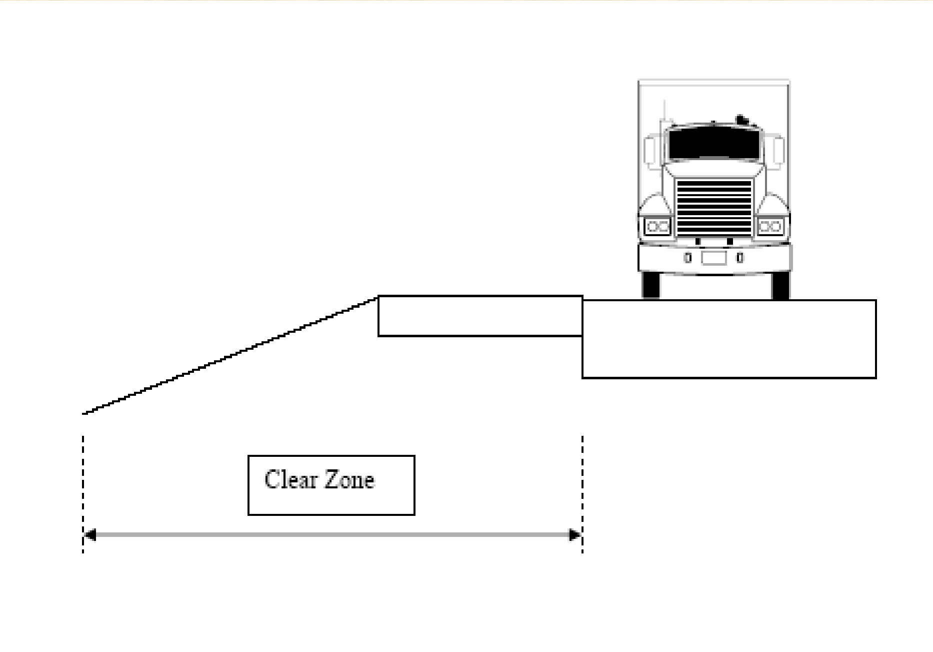
History of Crash Testing Standards

- 1962: HRB 482
- 1971: NCHRP 115
- 1972: NCHRP 118
- 1974: NCHRP 153
- 1978: TRC 191
- 1981: NCHRP 230
- 1993: NCHRP 350
- 2009: MASH 2009 (MASH-09)
- 2016: MASH 2016 (MASH-16)

Roadside Topography

Clear Zone Concept

- An area available for use by an errant vehicle
- This area should be free of hazards
- If hazards exists within this area, appropriate action should be taken



Clear Zone Concept

- In the early 1970s, most state agencies used *30 feet* as the clear zone distance
  - However, a 30-foot clear zone is not adequate for certain applications
- In the late 1970s, AASHTO developed a clear zone table, taking into consideration:
  - Design Speed
  - Traffic Volume (ADT)
  - Roadside Geometry

AASHTO RDG Clear Zone Table
*** July 2015 Errata ***

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

Notes:

a) When a site-specific investigation indicates a high probability of continuing crashes or when such occurrences are indicated by crash history, the designer may provide clear-zone distances greater than the clear zone shown in Table 3-1. Clear zones may be limited to 30 ft for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

b) Because recovery is less likely on the unshielded, traversable 1V:3H fill slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of slope. Determination of the width of the recovery area at the toe of slope should consider right-of-way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of slope. While the application may be limited by several factors, the foreslope parameters that may enter into determining a maximum desirable recovery area are illustrated in Figure 3-2. A 10-ft recovery area at the toe of slope should be provided for all traversable, non recoverable fill slopes.

c) For roadways with low volumes it may not be practical to apply even the minimum values found in Table 3-1. Refer to Chapter 12 for additional considerations for low-volume roadways and Chapter 10 for additional guidance for urban applications.

d) When design speeds are greater than the values provided, the designer may provide clear-zone distances greater than those shown in Table 3-1.

MDOT Clear Zone Table
Section 7.01.11.C – Michigan Road Design Manual

CLEAR ZONE DISTANCES
(IN FEET FROM EDGE OF DRIVING LANE)

DESIGN SPEED	DESIGN ADT	FILL SLOPES			CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3	1:3	1:4 TO 1:5	1:6 OR FLATTER
40 mph or Less	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 mph	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	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	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 mph	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 mph	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

* Where a site-specific investigation indicates a high probability of continuing or higher than expected crashes, or such occurrences are indicated by crash history, the designer may provide clear zone distances greater than 30 feet as indicated. Clear zones may be limited to 30 feet for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

** Since recovery is less likely on the unshielded, traversable 1:3 slopes, fixed objects should not be present in the vicinity of the toe of these slopes.

MDOT and AASHTO Clear Zone Tables have Identical Values

MDOT

CLEAR ZONE DISTANCES
(IN FEET FROM EDGE OF DRIVING LANE)

DESIGN SPEED	DESIGN ADT	FILL SLOPES			CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3	1:3	1:4 TO 1:5	1:6 OR FLATTER
40 mph or Less	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 mph	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	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	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 mph	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 mph	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

AASHTO

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

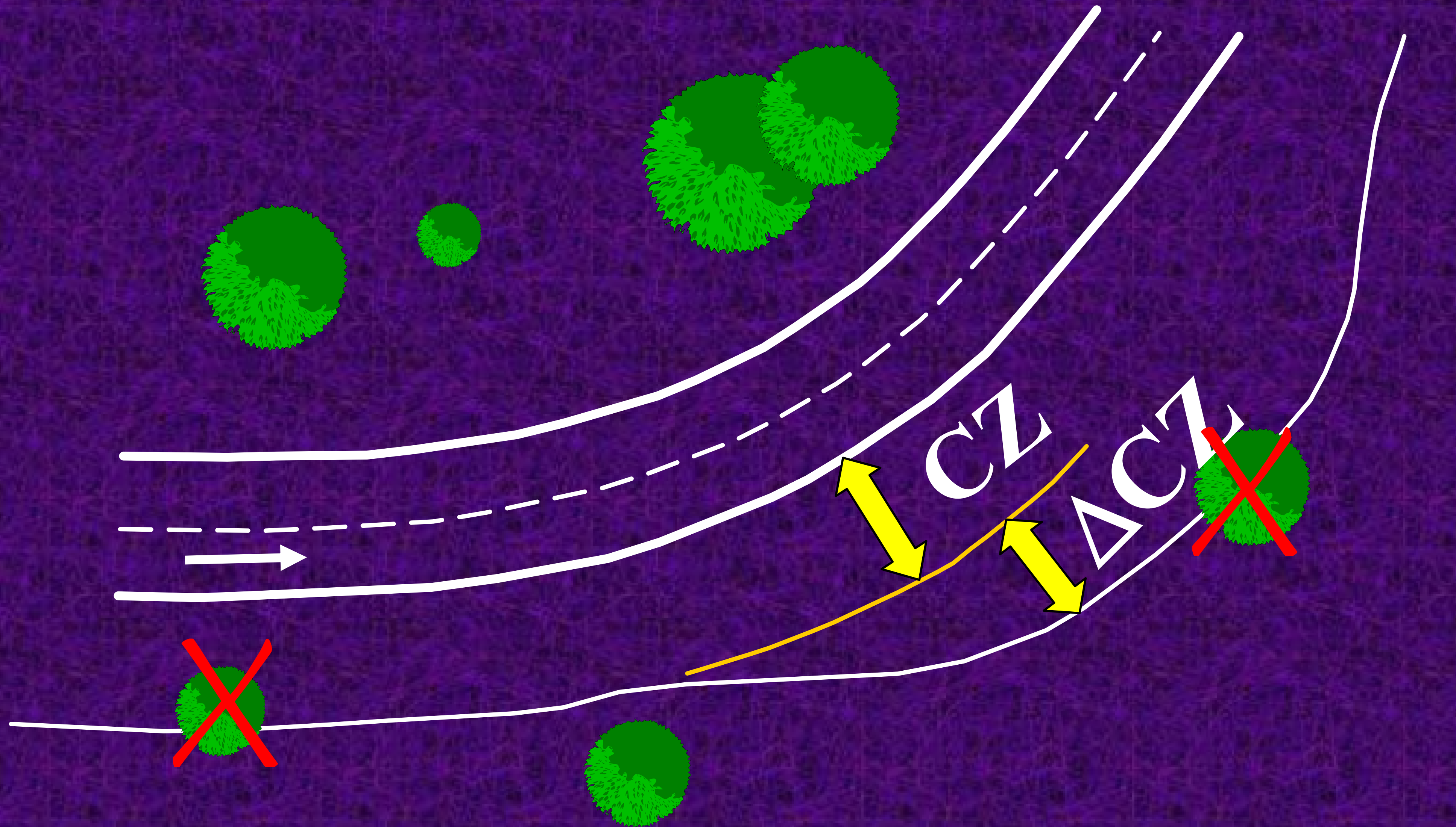
MDOT Clear Zone Table
30’ Clear Zone is Still Present

CLEAR ZONE DISTANCES
(IN FEET FROM EDGE OF DRIVING LANE)

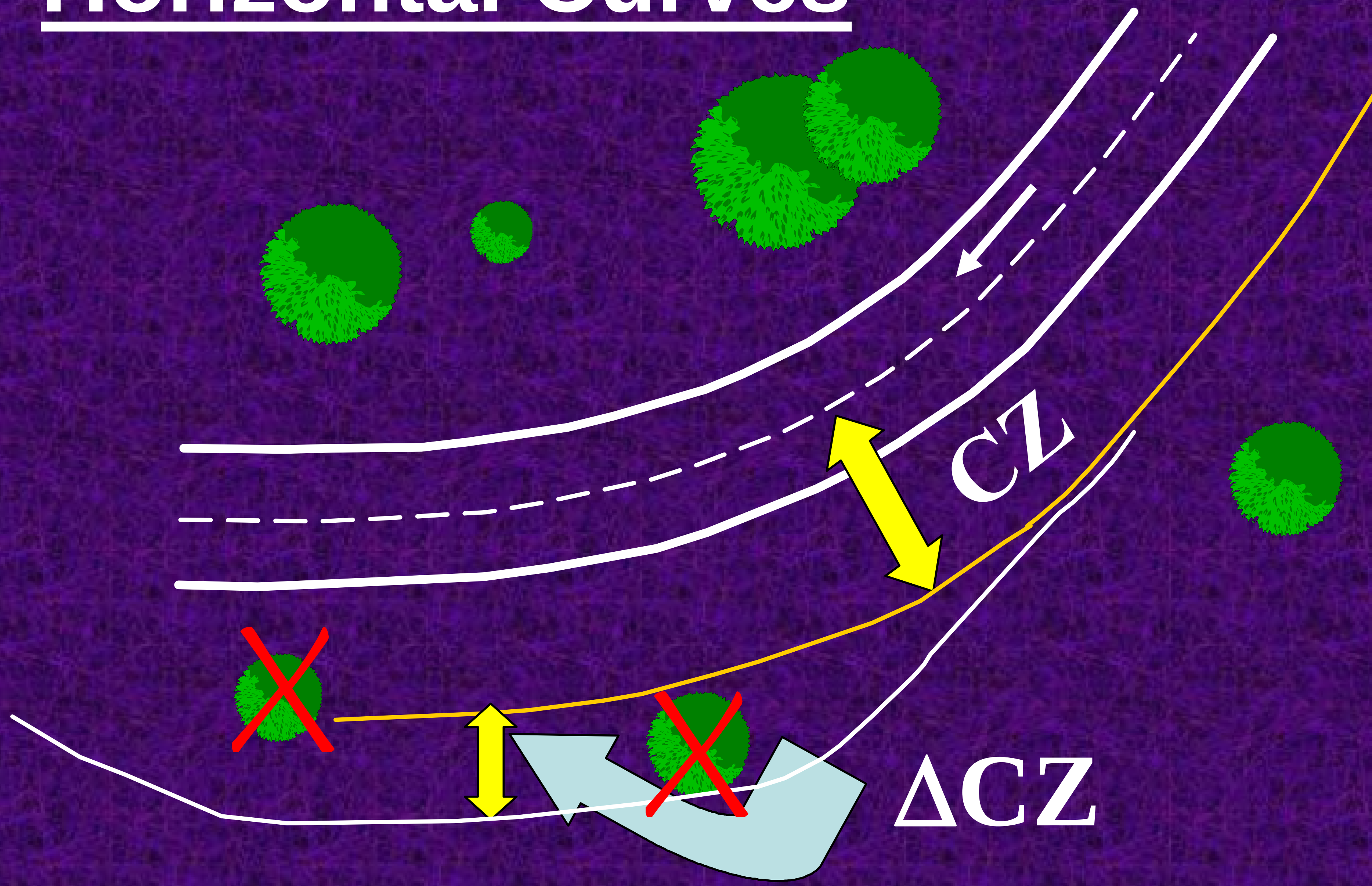
DESIGN SPEED	DESIGN ADT	FILL SLOPES			CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3	1:3	1:4 TO 1:5	1:6 OR FLATTER
40 mph or Less	under 750	7 - 10	7 - 10	**	7 - 10	7 - 10	7 - 10
	750 - 1500	10 - 12	12 - 14	**	10 - 12	10 - 12	10 - 12
	1500 - 6000	12 - 14	14 - 16	**	12 - 14	12 - 14	12 – 14
	over 6000	14 - 16	16 - 18	**	14 - 16	14 - 16	14 – 16
45-50 mph	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	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	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 mph	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 mph	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

* Where a site-specific investigation indicates a high probability of continuing or higher than expected crashes, or such occurrences are indicated by crash history, the designer may provide clear zone distances greater than 30 feet as indicated. Clear zones may be limited to 30 feet for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

Horizontal Curves



Horizontal Curves



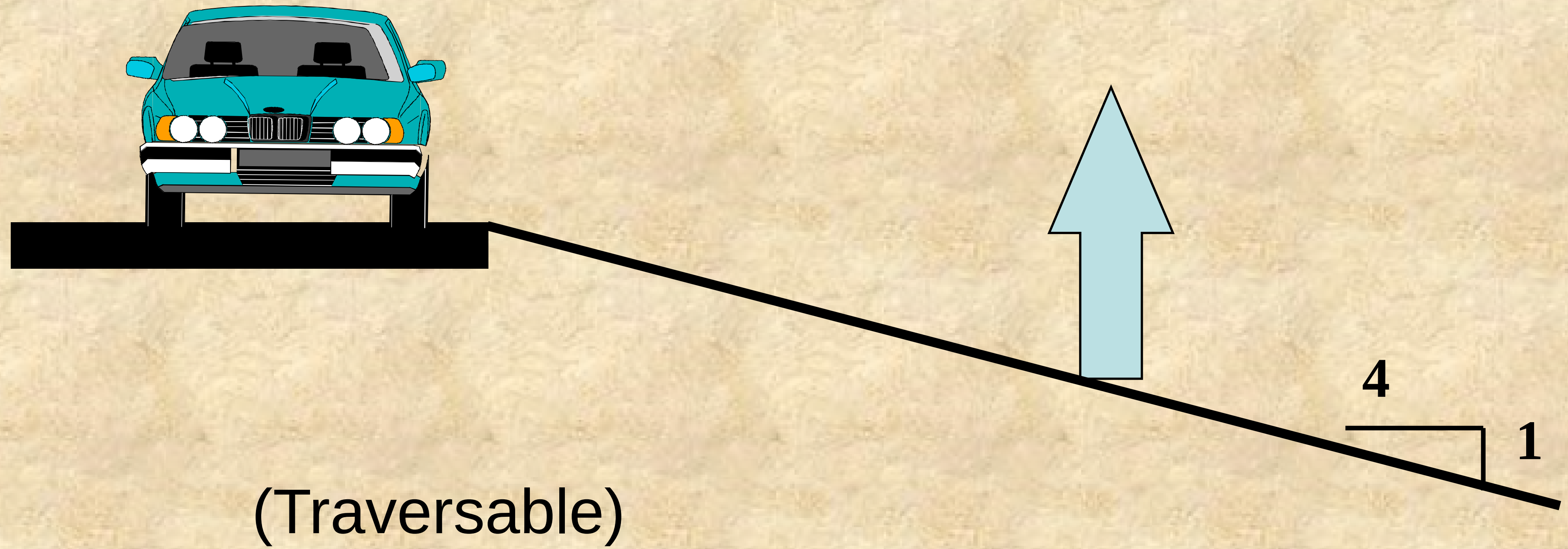
Horizontal Curve Adjustments

CURVE CORRECTION FACTORS (Kcz)

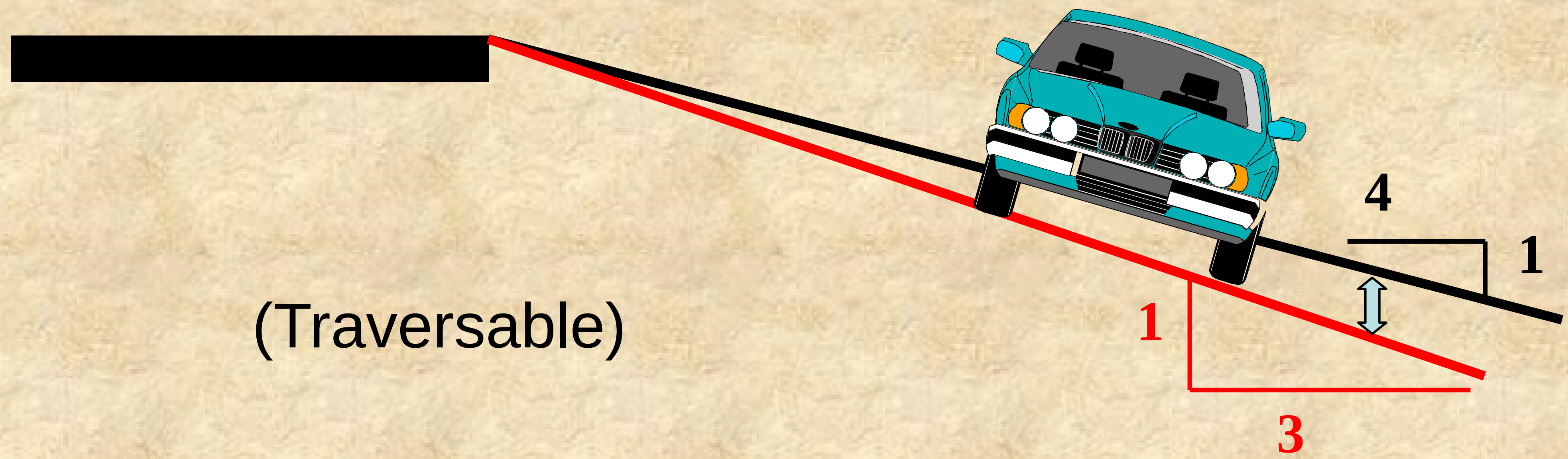
Radius (ft)	DESIGN SPEED (mph)						
	40	45	50	55	60	65	70
2950	1.1	1.1	1.1	1.2	1.2	1.2	1.2
2300	1.1	1.1	1.2	1.2	1.2	1.2	1.3
1970	1.1	1.2	1.2	1.2	1.3	1.3	1.4
1640	1.1	1.2	1.2	1.3	1.3	1.3	1.4
1475	1.2	1.2	1.3	1.3	1.4	1.4	1.5
1315	1.2	1.2	1.3	1.3	1.4	1.4	
1150	1.2	1.2	1.3	1.4	1.5	1.5	
985	1.2	1.3	1.4	1.5	1.5	1.5	
820	1.3	1.3	1.4	1.5			
660	1.3	1.4	1.5				
495	1.4	1.5					
330	1.5						

$$CZ_{corr} = CZ + \Delta CZ = K_{cz} \times CZ$$

Recoverable
(1:4 or Flatter)



Non-Recoverable
(Steeper than 1:4, Up to 1:3)

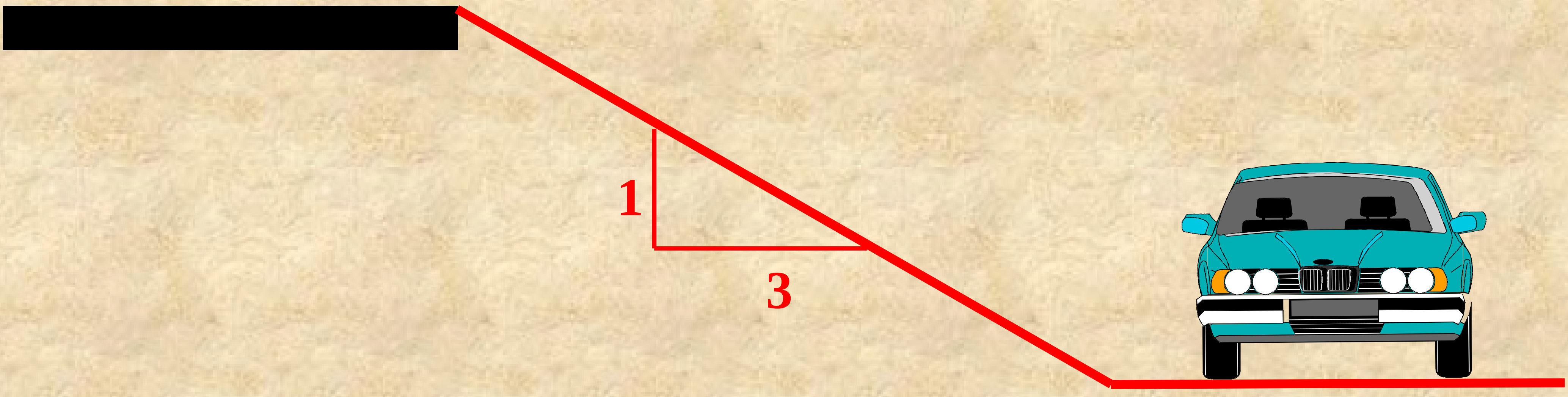


Is a Non-Recoverable Slope a Hazard?

- **Maybe**…it depends on two things:
  - Is the slope relatively even and free of hazards?
  - Is there a clear recovery area (10-foot minimum width) at the bottom of the slope?

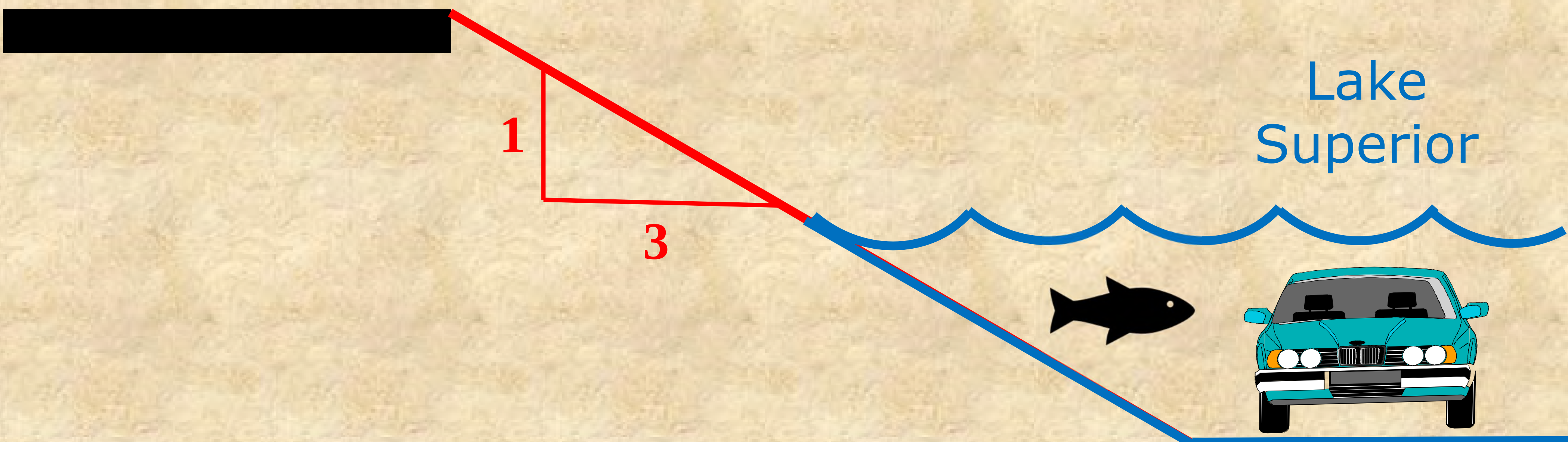
Is a Non-Recoverable Slope a Hazard?

- In this case, 1:3 slope is not a hazard.
  - Slope is free and clear of hazards.
  - There is a clear recovery area (10' minimum width) at the bottom of the slope.

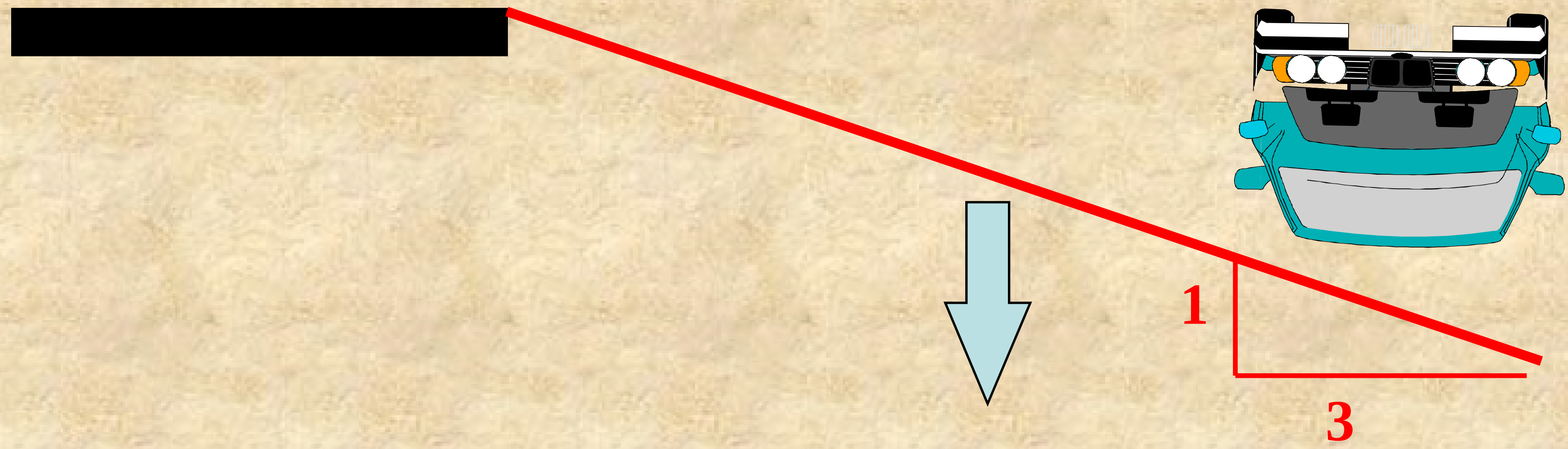


Is a Non-Recoverable Slope a Hazard?

- In this case, 1:3 slope is a hazard.
  - Deep body of water at the bottom of the slope.



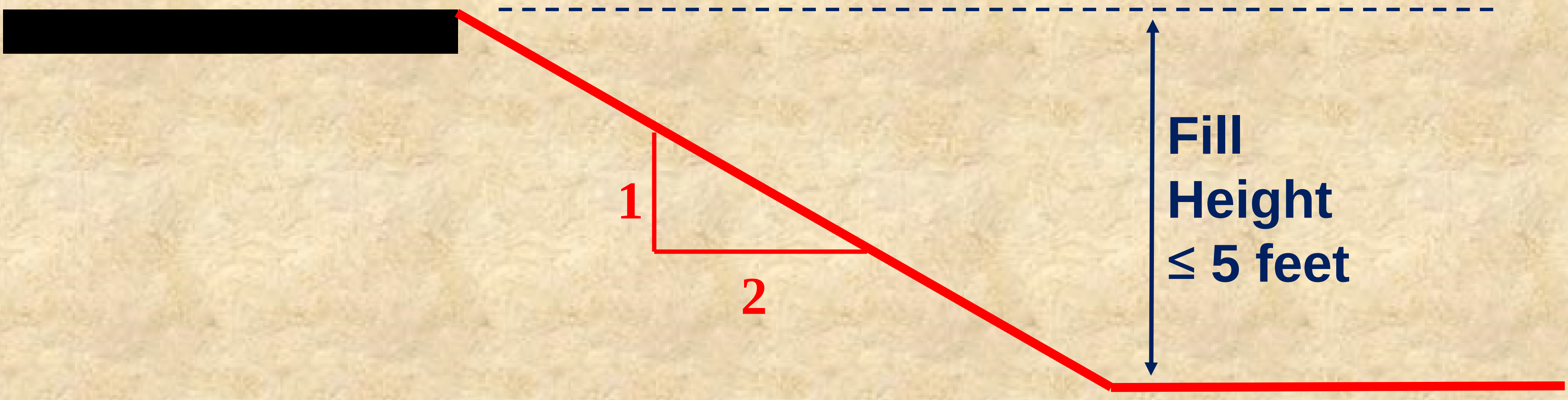
Critical
(Steeper than 1:3)



(Non-Traversable, Non-Recoverable)

Exception: 1:2 Slopes with Fill Heights up to 5 Feet

- Barrier is not warranted on 1:2 fill slopes with fill heights up to 5 feet
  - RDM – Subsection 7.01.30.C



MDOT Clear Zone Table
What is the Clear Zone of a 1:3 Fill Slope?

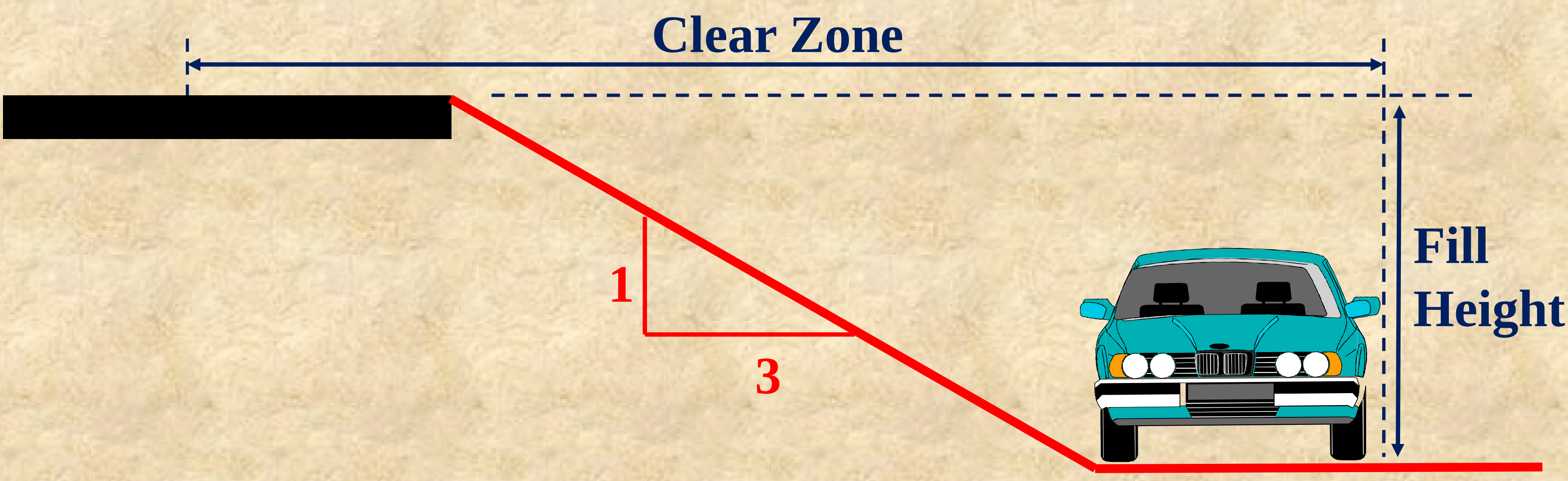
CLEAR ZONE DISTANCES
(IN FEET FROM EDGE OF DRIVING LANE)

DESIGN SPEED	DESIGN ADT	FILL SLOPES			CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3	1:3	1:4 TO 1:5	1:6 OR FLATTER
40 mph or Less	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 mph	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	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	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 mph	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 mph	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

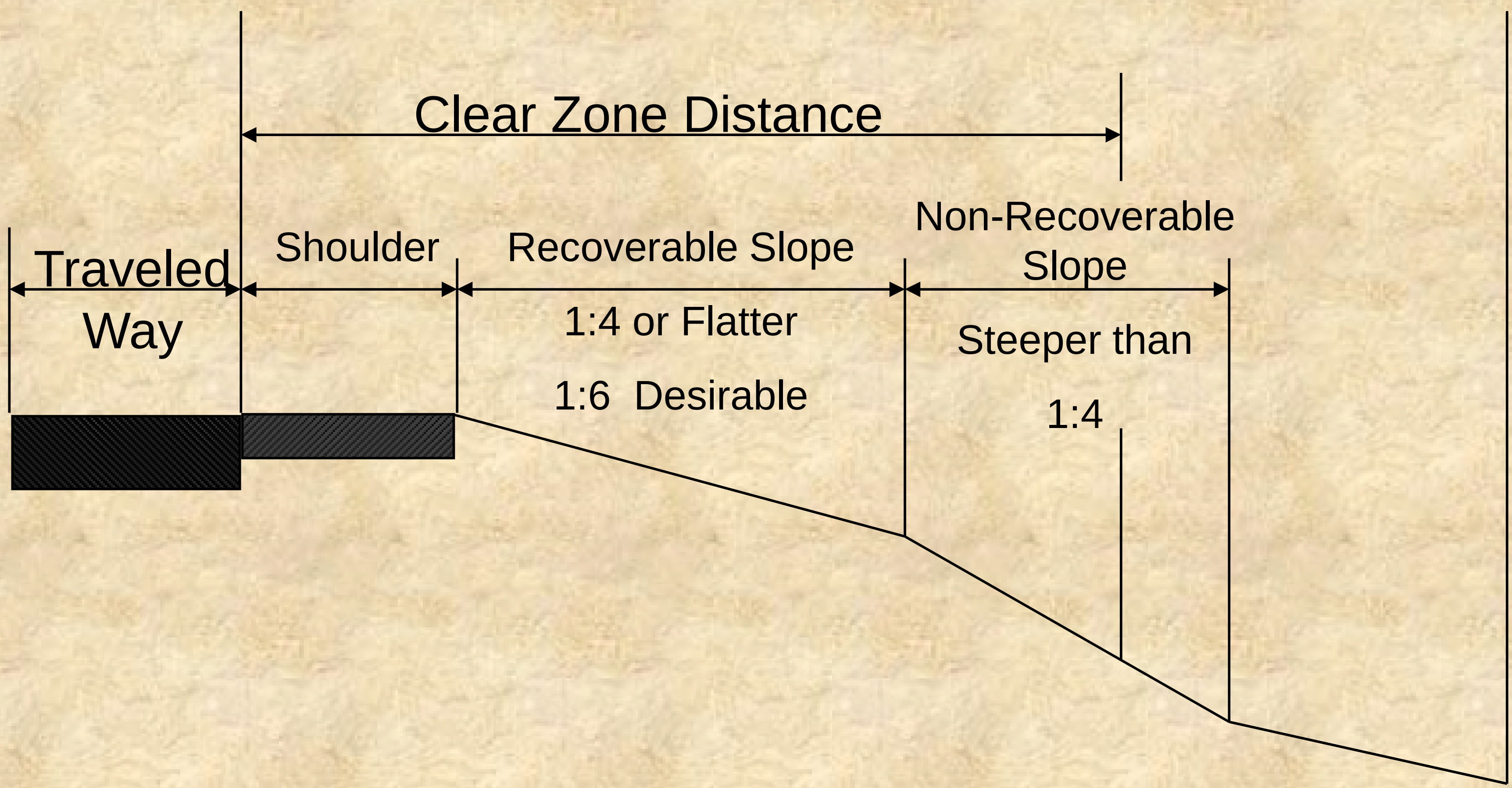
** Since recovery is less likely on the unshielded, traversable 1:3 slopes, fixed objects should not be present in the vicinity of the toe of these slopes.

Clear Zone of Non-Recoverable Slopes

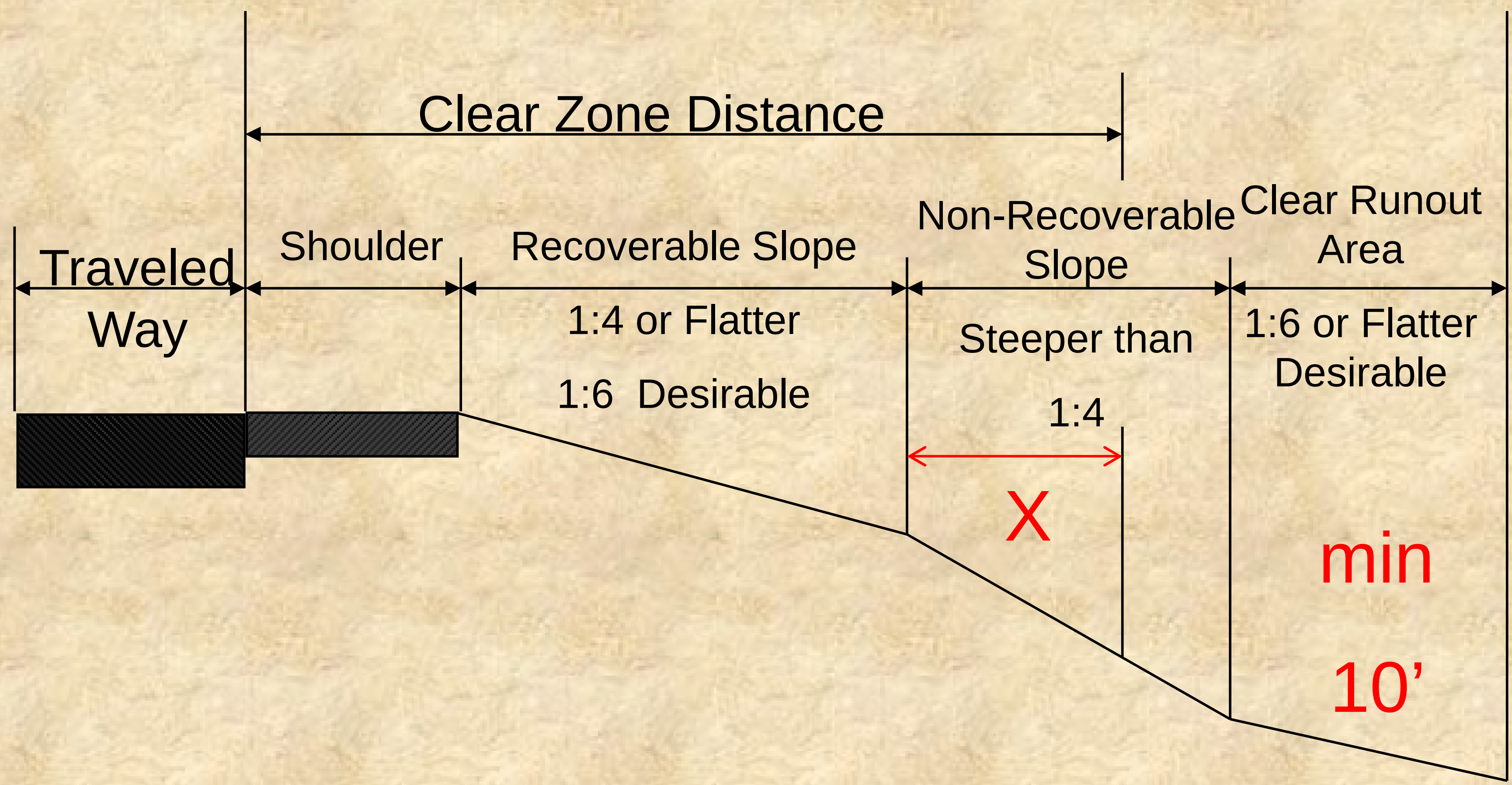
- Clear Zone varies and is a function of Fill Height
  - It is assumed a vehicle will travel to the bottom of the slope
- As Fill Height Increases, Clear Zone Increases



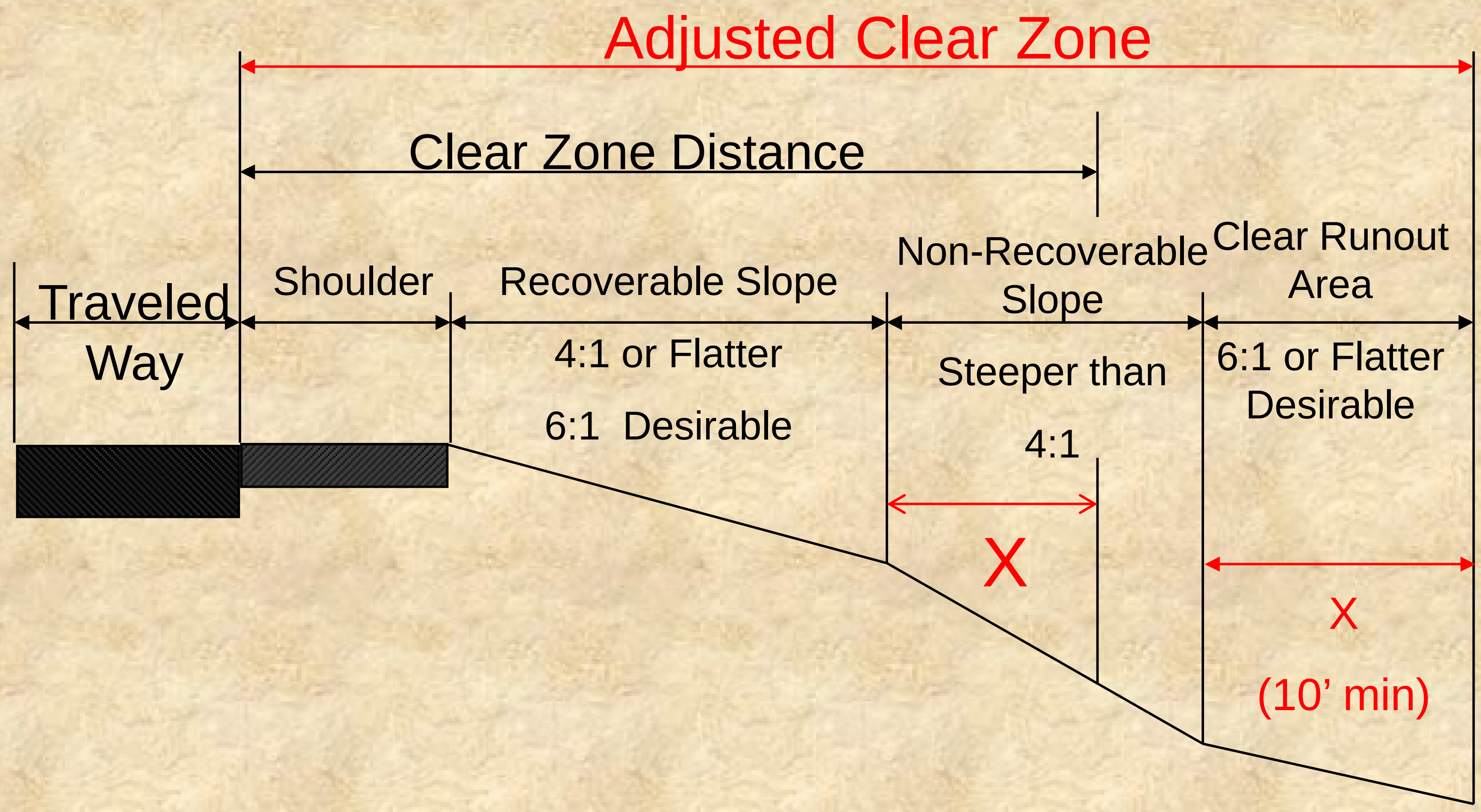
Clear Runout Area



Clear Runout Area



Adjusted Clear Zone



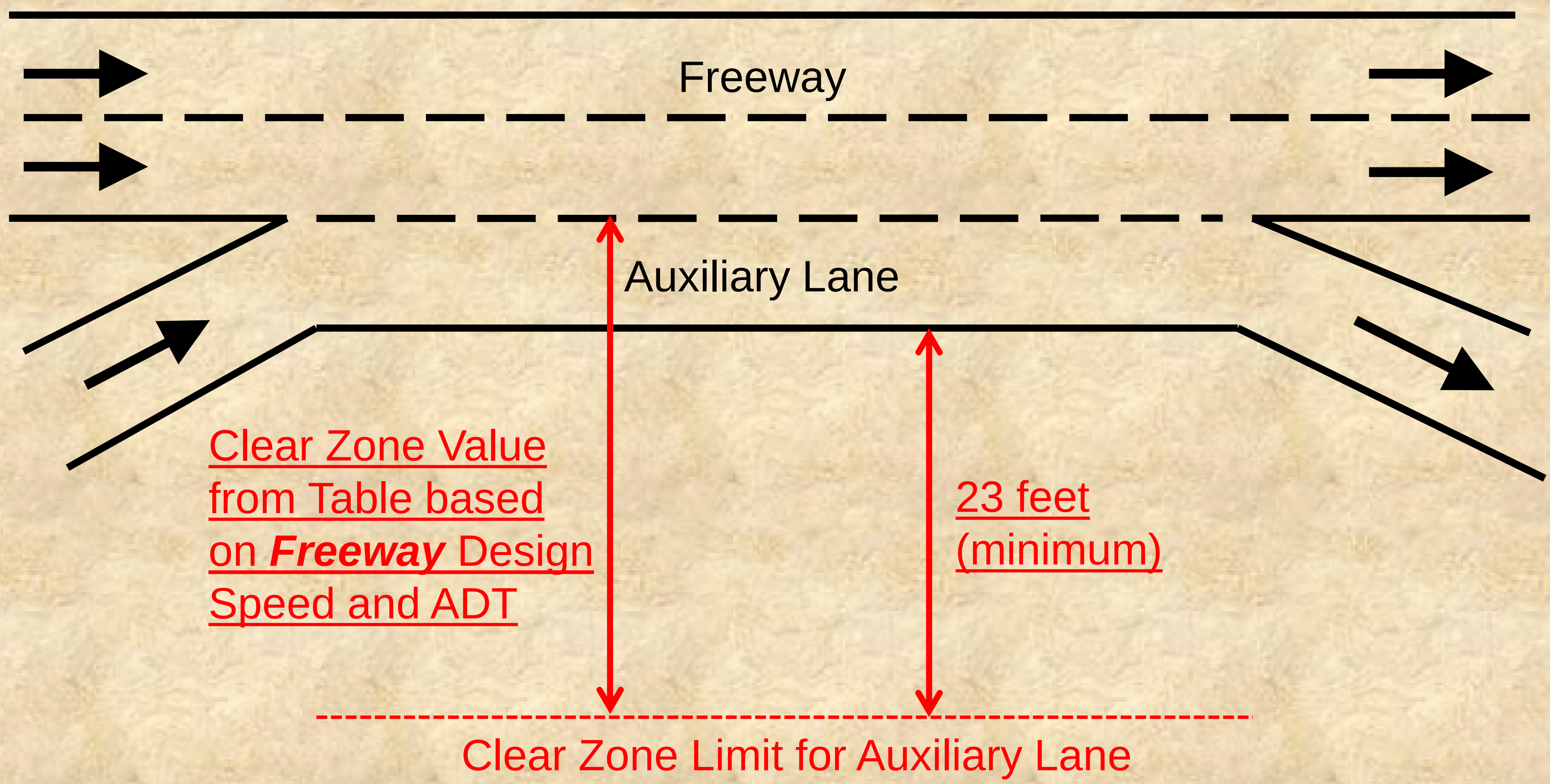
Clear Zone for Auxiliary Lanes

MDOT Method

Section 7.01.11 of the Michigan Road Design Manual

- Obtain clear zone value from the clear zone table based on design speed and traffic volume (ADT) of adjacent through lanes
- Resulting clear zone distance:
  1) Should be measured from the outer edge of the *through lane*, and;
  2) Should not be less than 23 feet from the outer edge of the auxiliary lane.

Clear Zone for Auxiliary Lane MDOT Method



Clear Zone for Freeway Ramps

MDOT Method

Preferred:

Clear Zone Based on Speed, Volume, and Horizontal Curvature of Ramp at Selected Point

- Engineering Judgment must be used

Acceptable Alternative:

May also use Clear Zone of 30 feet if:

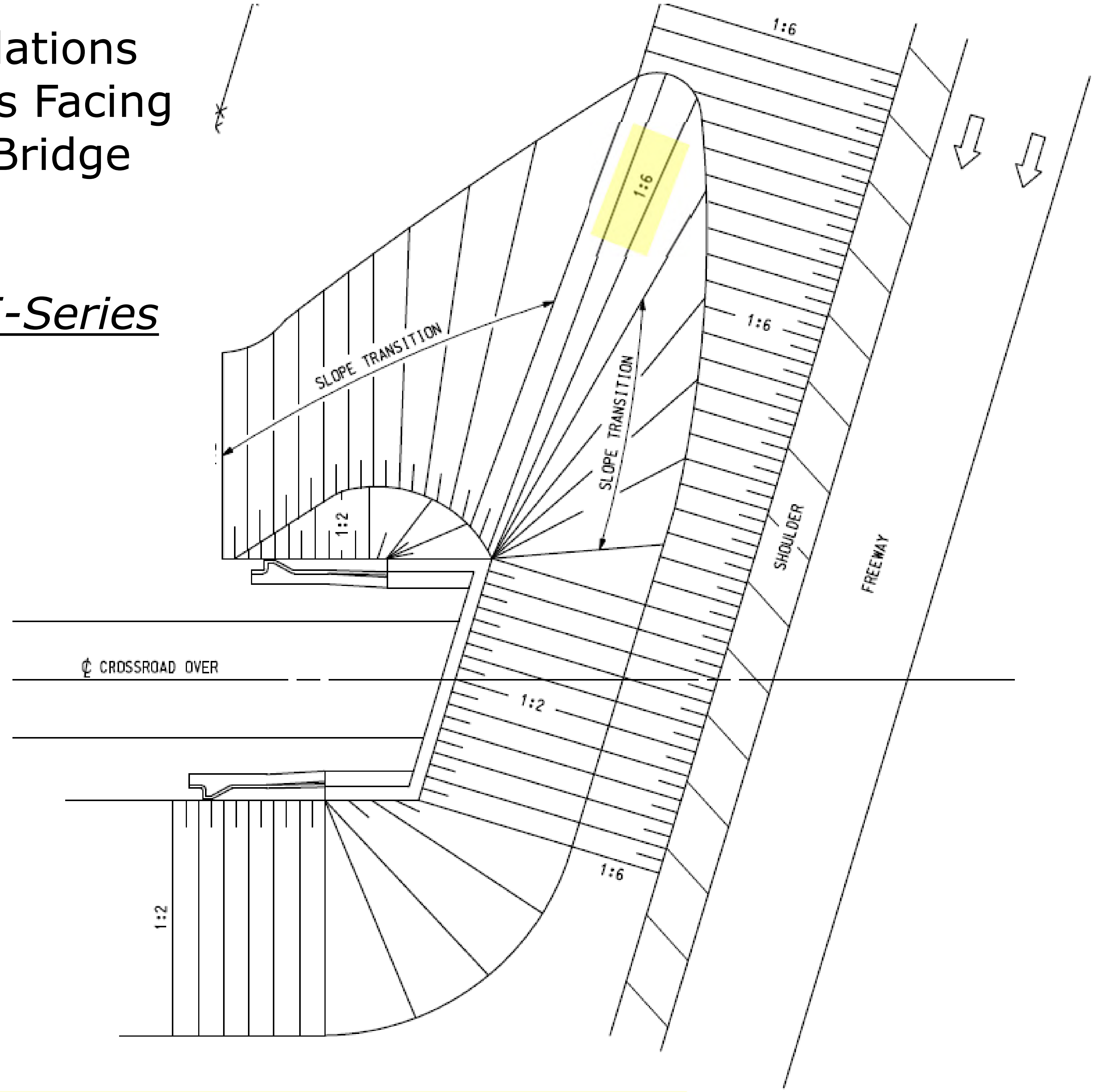
- Traffic Volume and/or Speed at Selected Point are unknown or not well established, or
- Previous satisfactory experience with similar designs

Transverse Slopes

- 1:10 or flatter desirable
- 1:6 or flatter for high-speed roadways, especially within clear zone
- May be considered a hazard under certain conditions
  - steep transverse slopes

Grading Recommendations for Transverse Slopes Facing Oncoming Traffic at Bridge Approach Berms

Standard Plan R-105-Series

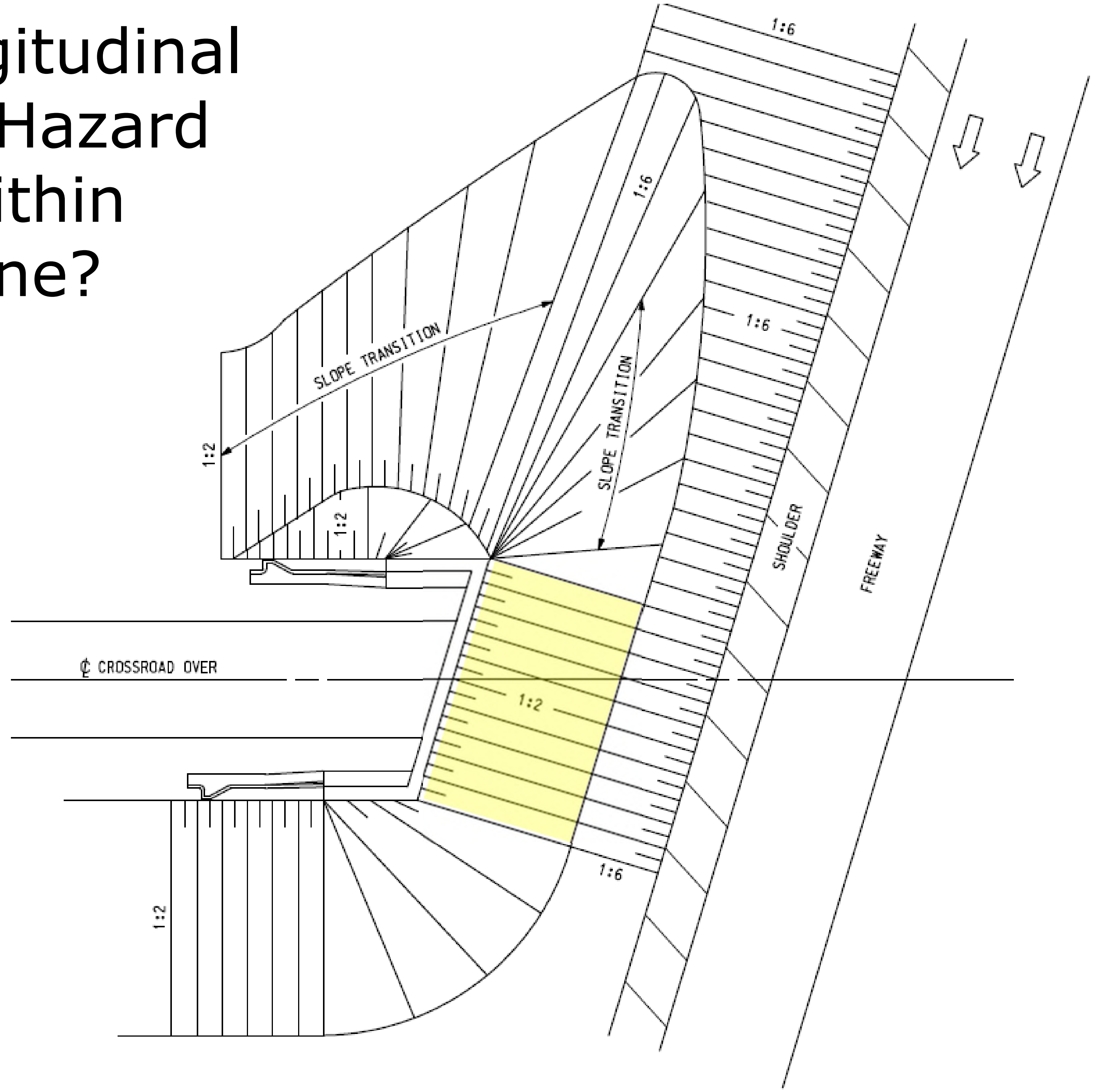


NOTE:

THE 1:6 SLOPE FACING FREEWAY TRAFFIC SHOULD BE USED ON ALL NEW CONSTRUCTION UNLESS THE DISTANCE FROM THE EDGE OF THE NEAREST FREEWAY THROUGH LANE TO THE TOE OF THE 1:2 SLOPE UNDER THE BRIDGE EXCEEDS THE CLEAR ZONE.


14 FT 10 IN
ADOPT-A-HIGHWAY
NEXT 2 MILES
THETA CHI FRATERNITY
ZETA TAU CHAPTER

Is a 1:2 Longitudinal Backslope A Hazard If Located Within The Clear Zone?



NOTE:

THE 1:6 SLOPE FACING FREEWAY TRAFFIC SHOULD BE USED ON ALL NEW CONSTRUCTION UNLESS THE DISTANCE FROM THE EDGE OF THE NEAREST FREEWAY THROUGH LANE TO THE TOE OF THE 1:2 SLOPE UNDER THE BRIDGE EXCEEDS THE CLEAR ZONE.

A 1:2 backslope generally is not a hazard if:

- Relatively Smooth, and;
- Obstacle Free, and;
- Foreslope between roadway and toe of backslope is traversable (1:3 or flatter)


- Aug 2018

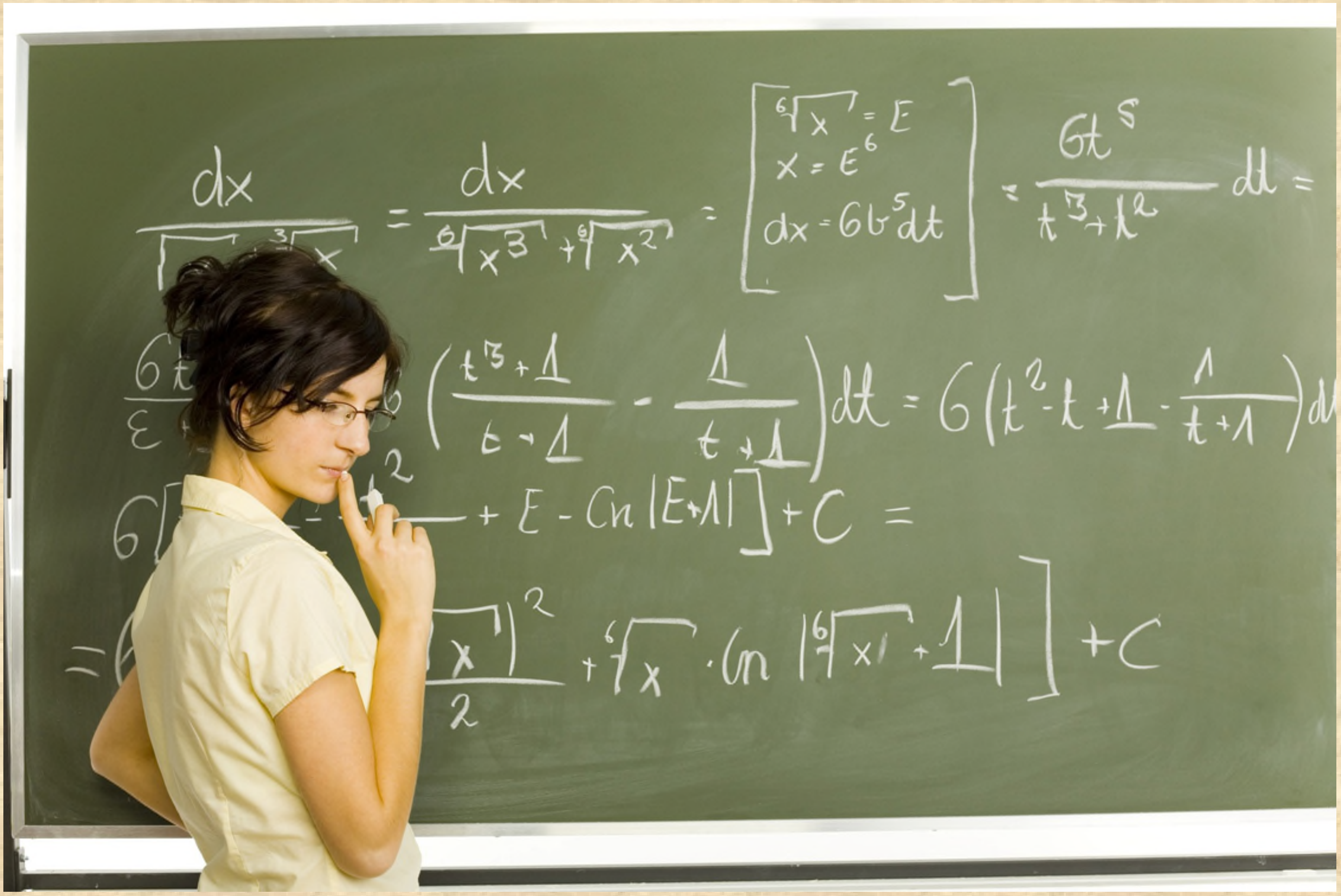
Shielding Bodies of Water
RDM - 7.01.31

- Permanent water > 2' in depth usually require shielding if within the CZ
- May be necessary to shield for bodies of water outside the CZ if there is potential for entry

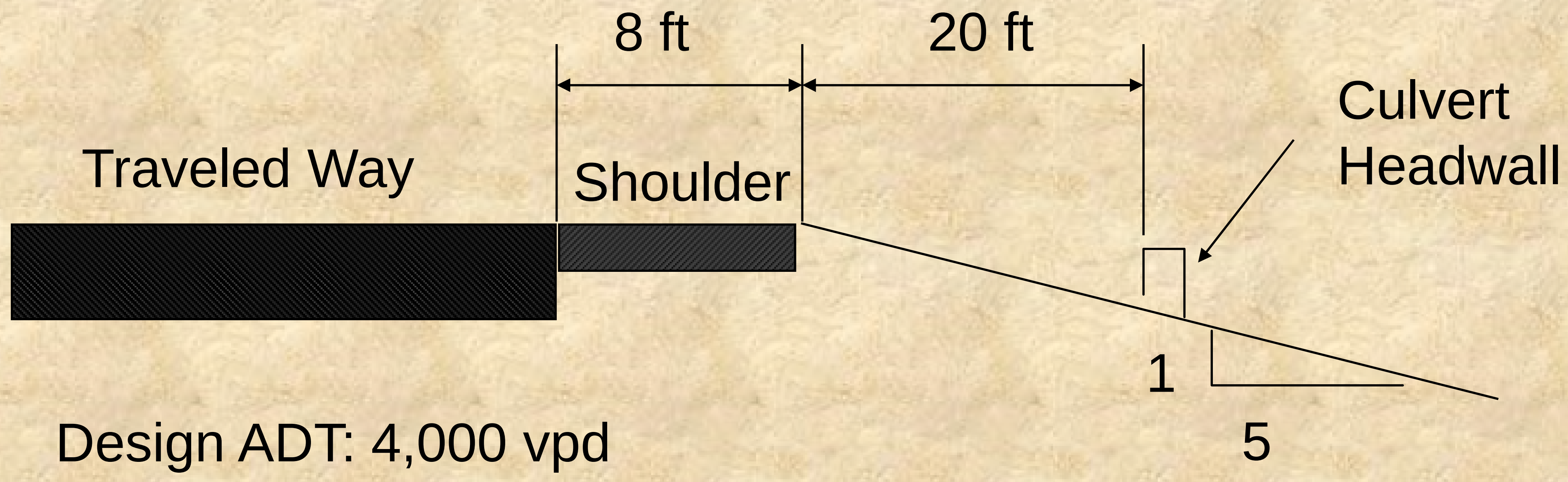
Bridge Columns and Foundations in 70' Medians

- At one time these were considered outside the CZ
- Shielding columns and foundation new construction/ reconstruction should be according to Standard Plan R-56 Series
- Standard Plan R-56 also covers medians 36' – 70'
- Note, bridge piers may have additional shielding requirements
  - Concrete barriers or struts may be required in certain cases
  - Bridge Design Manual: 7.01.04.K (Vehicle Collision Force) and 12.08.08 (Protection of Existing Piers in the Clear Zone)

Clear Zone Examples



Clear Zone Example #1



Design ADT: 4,000 vpd

Design Speed: 60 mph

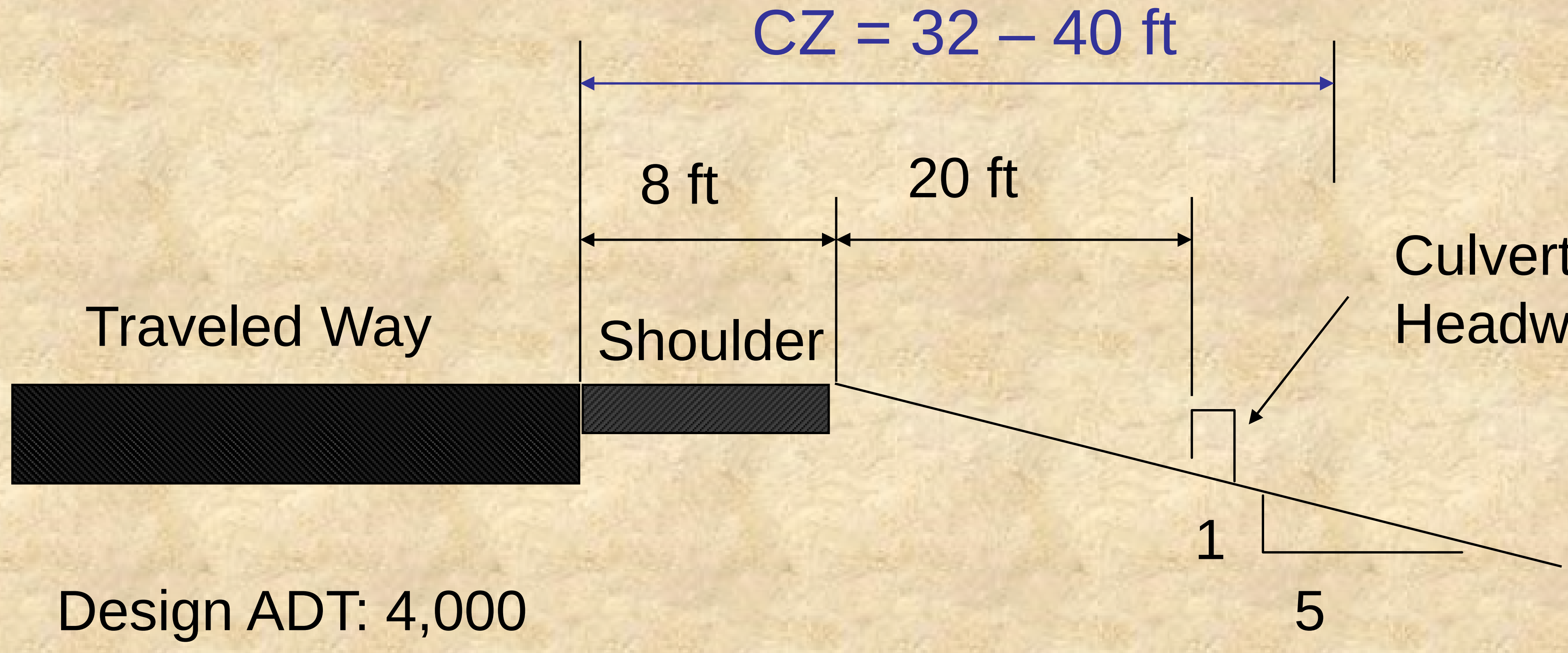
CLEAR ZONE DISTANCES
(IN FEET FROM EDGE OF DRIVING LANE)

DESIGN SPEED	DESIGN ADT	FILL SLOPES			CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3	1:3	1:4 TO 1:5	1:6 OR FLATTER
40 mph or Less	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 mph	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	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	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 mph	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 mph	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

CLEAR ZONE DISTANCES
(IN FEET FROM EDGE OF DRIVING LANE)

DESIGN SPEED	DESIGN ADT	FILL SLOPES			CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3	1:3	1:4 TO 1:5	1:6 OR FLATTER
40 mph or Less	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 mph	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	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	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 mph	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 mph	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

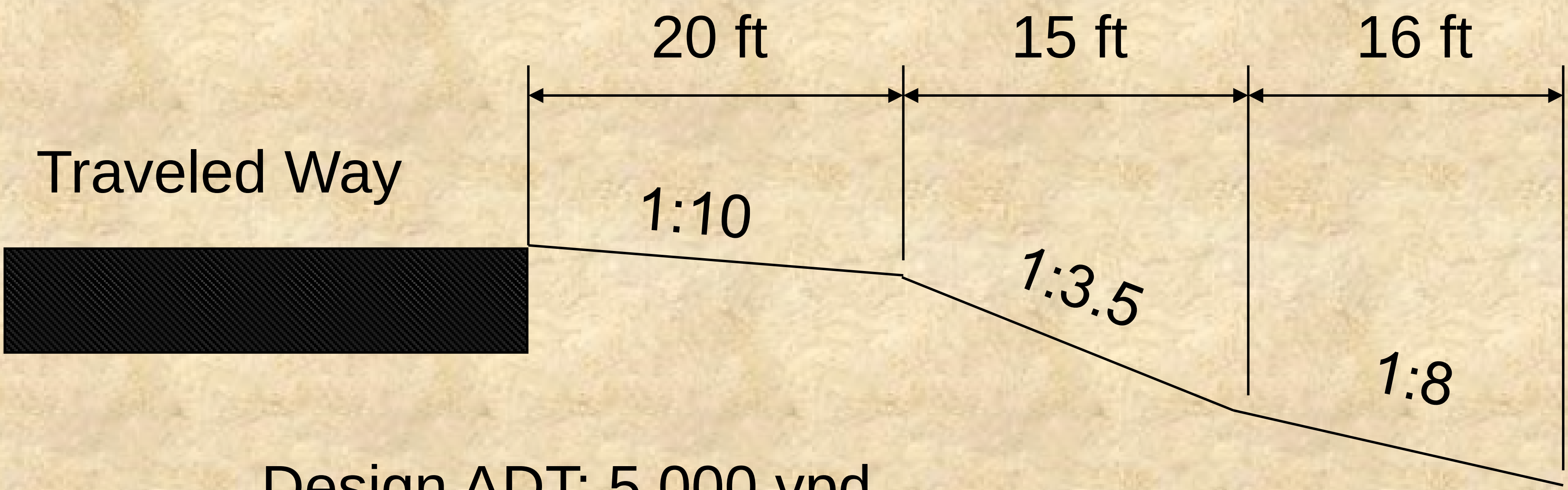
Clear Zone Example #1



Design ADT: 4,000

Design Speed: 60 mph

Clear Zone Example #2



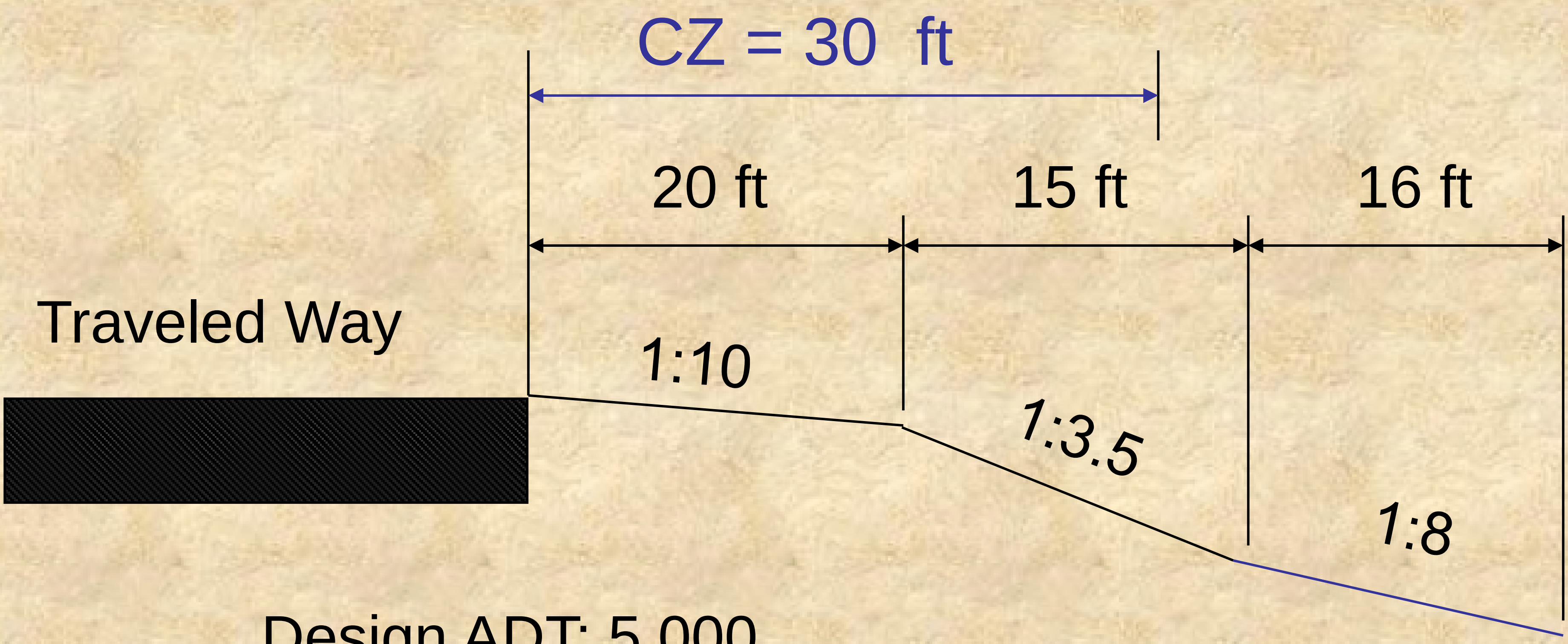
Design ADT: 5,000 vpd

Design Speed: 60 mph

CLEAR ZONE DISTANCES
(IN FEET FROM EDGE OF DRIVING LANE)

DESIGN SPEED	DESIGN ADT	FILL SLOPES			CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3	1:3	1:4 TO 1:5	1:6 OR FLATTER
40 mph or Less	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 mph	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	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	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 mph	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 mph	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

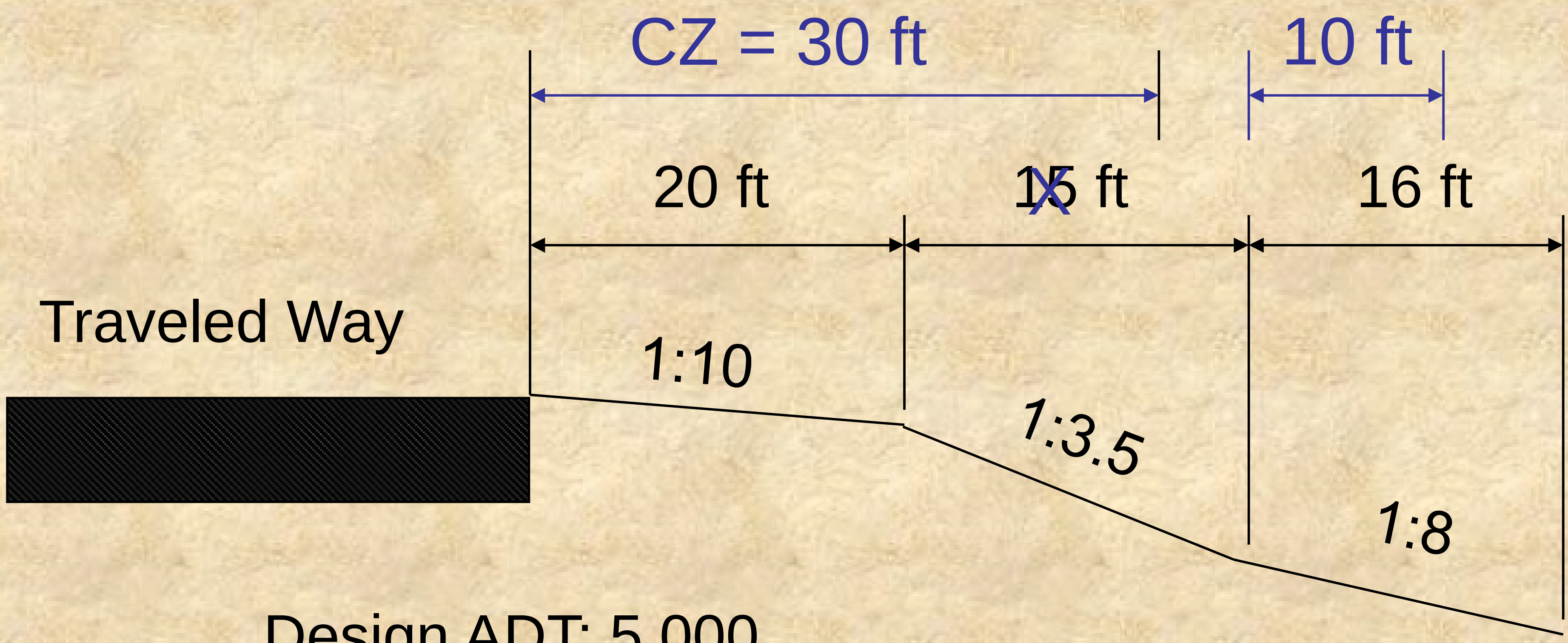
Clear Zone Example #2



Design ADT: 5,000

Design Speed: 60 mph

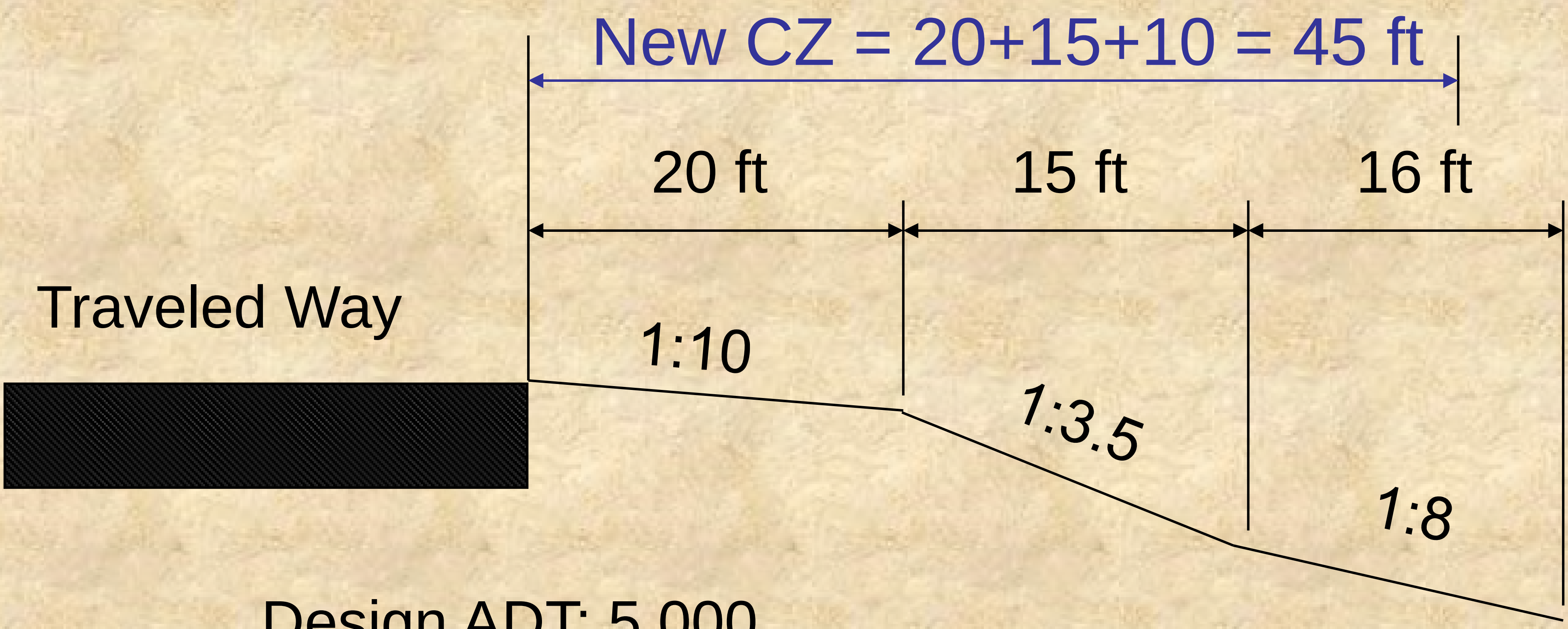
Clear Zone Example #2



Design ADT: 5,000

Design Speed: 60 mph

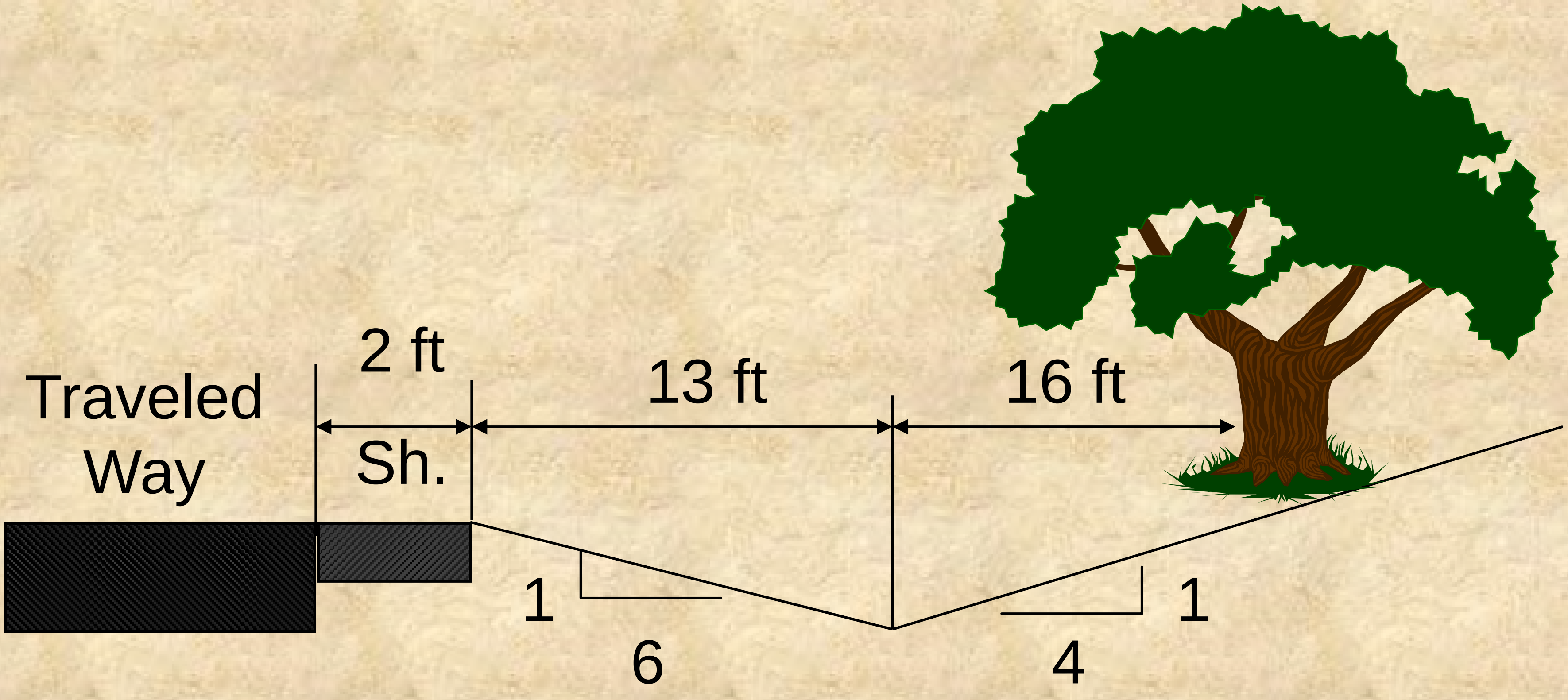
Clear Zone Example #2



Design ADT: 5,000

Design Speed: 60 mph

Clear Zone Example #3



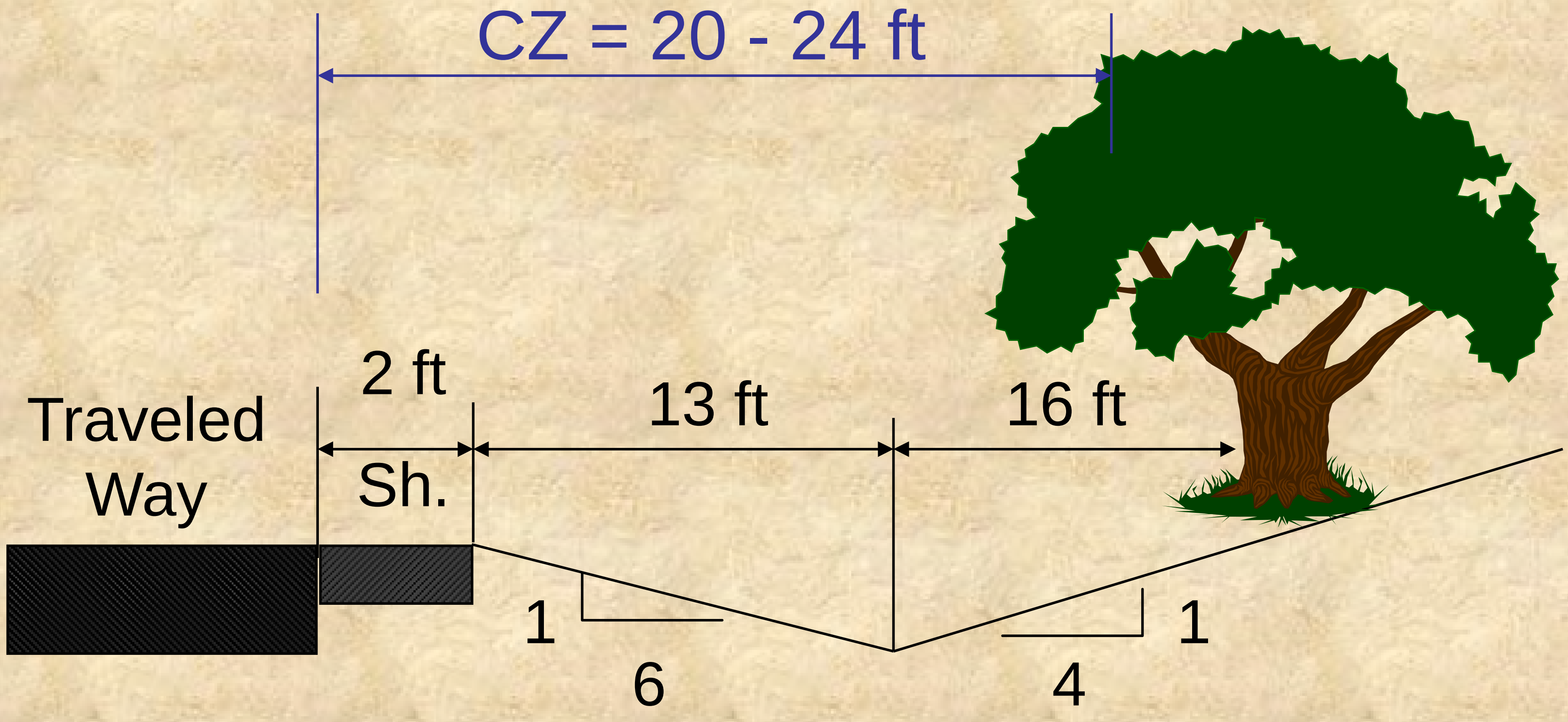
Design ADT: 1,400 vpd

Design Speed: 60 mph

CLEAR ZONE DISTANCES
(IN FEET FROM EDGE OF DRIVING LANE)

DESIGN SPEED	DESIGN ADT	FILL SLOPES			CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3	1:3	1:4 TO 1:5	1:6 OR FLATTER
40 mph or Less	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 mph	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	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	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 mph	under 750	16 - 18	20 - 24	**	10 - 12	12 - 14	14 - 16
	750 - 1500	$\boxed{20 - 24}$	26 - 32*	**	12 - 14	$\boxed{16 - 18}$	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 mph	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

Clear Zone Example #3

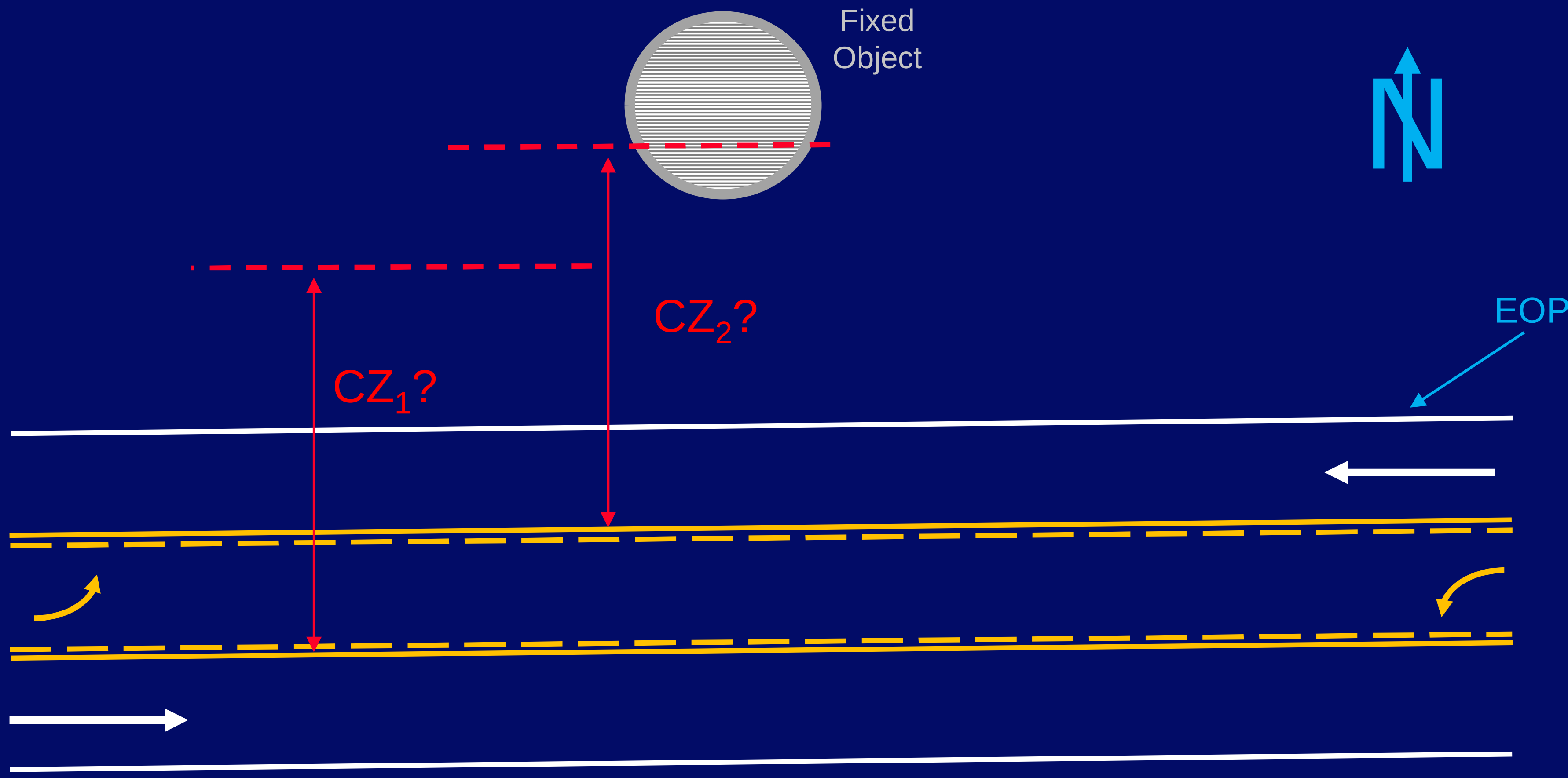


- 2011 AASHTO RDG Method (e.g., Example 3-F)

➢ Use larger of the two clear zones

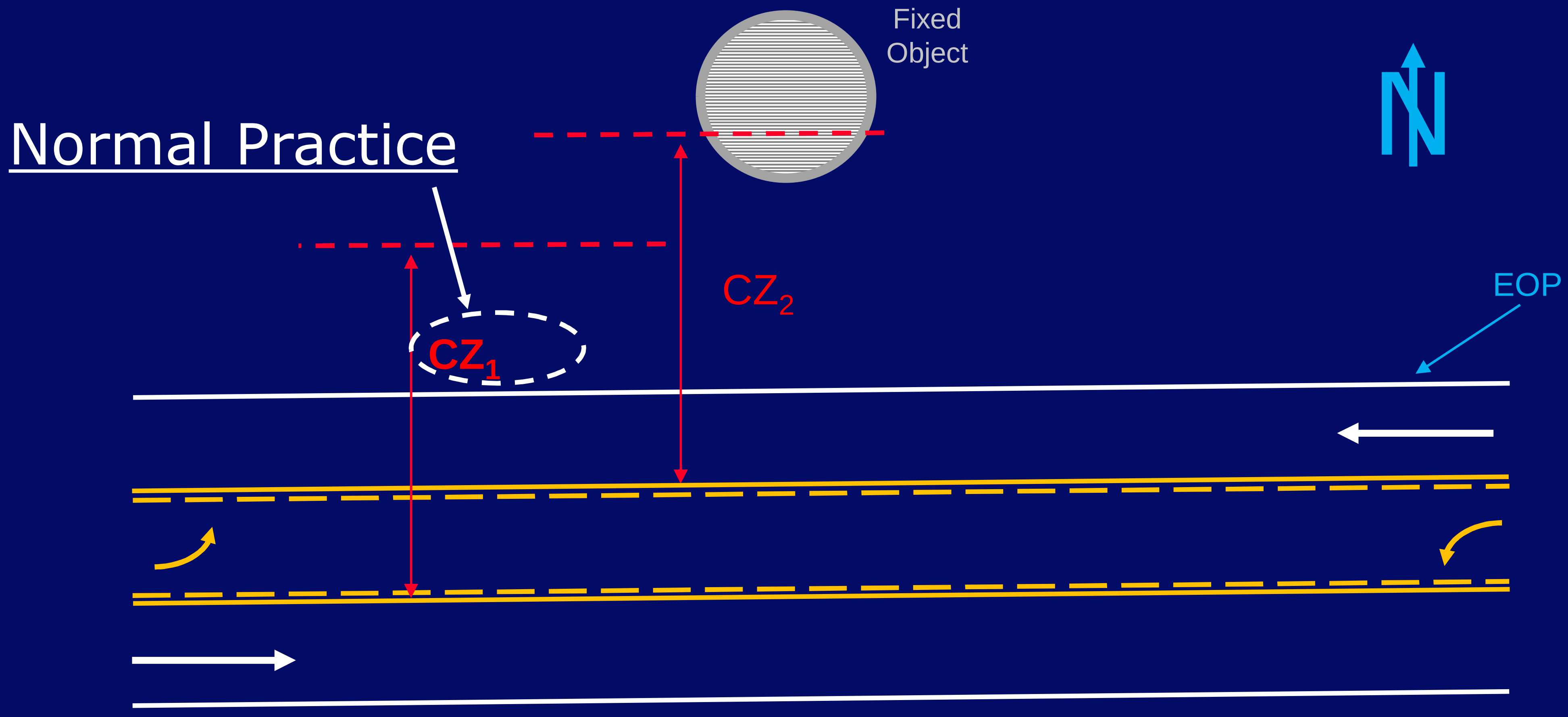
Clear Zone Example #4

Where should the clear zone for EB traffic be measured from?



Clear Zone Example #4

Where should the clear zone for EB traffic be measured from?



Roadside Barriers

Design Options in Order of Preference

- Remove Obstacle
- Relocate Obstacle
- Reduce Impact Severity
- Shield Obstacle
- Delineate Obstacle

Barrier Types

- Roadside Barriers
- Median Barriers
- Bridge Railings

Barrier Classifications

TYPE	*DEFLECTION*
Flexible	Over 5 Feet
Semi-Rigid	2 - 5 Feet
Rigid	0 - 1 Foot

MDOT
Semi-Rigid Systems (Guardrail)

NCHRP 350 or Older Guardrail Systems

- Type A (Standard Plan R-60 Series)
- Type B (Standard Plan R-60 Series)
- Type BD (Standard Plan R-60 Series)
- Type C (old Standard Plan III-60 E)
- Type CD (old Standard Plan III-60 E)
- Type T (Standard Plan R-60 Series)
- Type TD (Standard Plan R-60 Series)

MASH-Compliant Guardrail Systems

- Type MGS-8 (Standard Plan R-60 Series)
- Type MGS-8D (Standard Plan R-60 Series)

Type A Guardrail

Key Features

- No offset blocks
- 12’-6” post spacing (typical)
- Typical top rail height is 28 inches
- Current use:
  - Cul-de-sacs
  - Parking lots
  - Locations not exposed to through traffic

Type B Guardrail

<u>*Key Features*</u>

- W-beam guardrail with 8” offset blocks
  - Offset blocks are made of wood or plastic
- 6’-3” post spacing (typical)
- Typical top rail height is 28 inches
- <u>IN MOST CASES</u>, NOT PERMITTED FOR CONSTRUCTING NEW GUARDRAIL RUNS
- Current use:
  - Repairing existing runs of Type B guardrail

Type BD Guardrail

<u>*Key Features*</u>

- Double-sided Type B guardrail
- W-beam guardrail and offset blocks on both sides
- Same post spacing and guardrail height as Type B
- <u>IN MOST CASES</u>, NOT PERMITTED FOR CONSTRUCTING NEW GUARDRAIL RUNS
- Current use:
  - Repairing existing runs of Type BD guardrail

Type C Guardrail

Key Features

- Consists of two w-beams
- Upper beam has offset blocks
- Lower beam (rub rail) has no offset blocks
- 6’-3” post spacing (typical)
- Typical top rail height is 32 inches
- Current use:
    - Repairing existing runs of Type C guardrail

NOT PERMITTED FOR CONSTRUCTING NEW GUARDRAIL RUNS

Type CD Guardrail

Key Features

- Double-sided Type C guardrail
- Same post spacing and guardrail height as Type C
- Current use:
  - Repairing existing runs of Type CD guardrail

NOT PERMITTED FOR CONSTRUCTING NEW GUARDRAIL RUNS

Type T Guardrail

Key Features

- Thrie-beam guardrail with 8” offset blocks
- 6’-3” post spacing (typical)
- Typical top rail height is 34 inches
- IN MOST CASES, NOT PERMITTED FOR CONSTRUCTING NEW GUARDRAIL RUNS
- Current use:
  - Repairing existing runs of Type T guardrail

Type TD Guardrail

Key Features

- Double-sided Type T guardrail
- Same post spacing and guardrail height as Type T
- IN MOST CASES, NOT PERMITTED FOR CONSTRUCTING NEW GUARDRAIL RUNS
- Current use:
  - Repairing existing runs of Type TD guardrail

Type MGS-8 Guardrail

Key Features

- W-beam guardrail with 8" offset blocks
  - Offset blocks are made of wood or plastic
- 6'-3" post spacing (typical)
- Typical top rail height is 31 inches
- Beam element splice located at midspan
- MASH, TL-3 Compliant
- Current use:
  - Basic type for all roadways; free access roads, limited access roads, and freeways

Type MGS-8 Guardrail

Source: TTI

Type MGS-8D Guardrail

Key Features

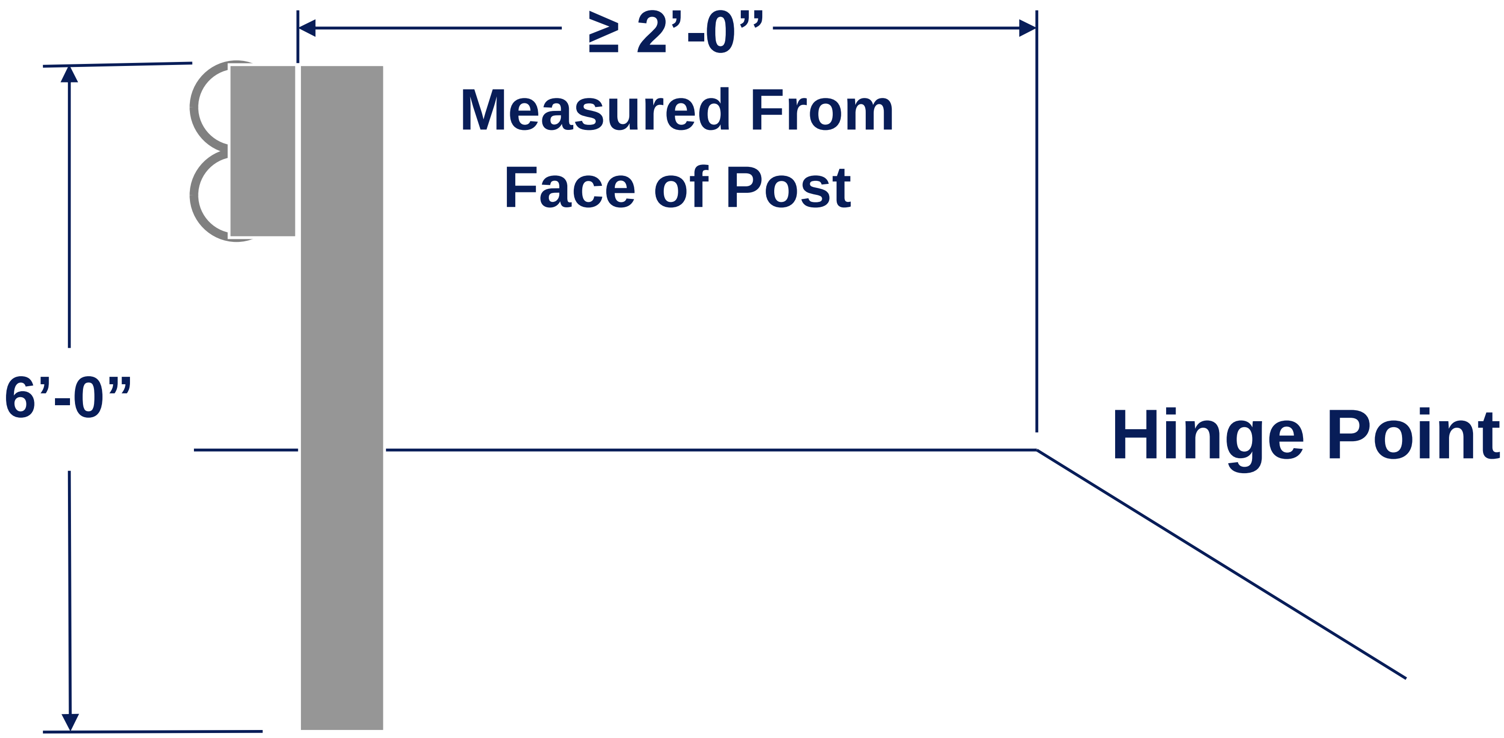
- Double-sided Type MGS-8 guardrail
- Same post spacing and guardrail height as Type MGS-8
- Beam element splice located at midspan
- MASH, TL-3 Compliant
- Current use:
    - Basic median guardrail type for all roadways; free access roads, limited access roads, and freeways

Type MGS-8 Guardrail Details & Guidelines

- MDOT Standard Plan (Special Detail) R-60-J
  - Type MGS-8 & MGS-8D Details
  - Transition Details from Type MGS-8 to Other Guardrail Types
    - Type MGS-8/8D to Type B/BD
    - Type MGS-8/8D to Type T/TD
  - Transition Details from Type MGS-8 to Guardrail Anchorages
  - Transition Details from Type MGS-8 to Type 1B and Type 2B Guardrail Approach Terminals

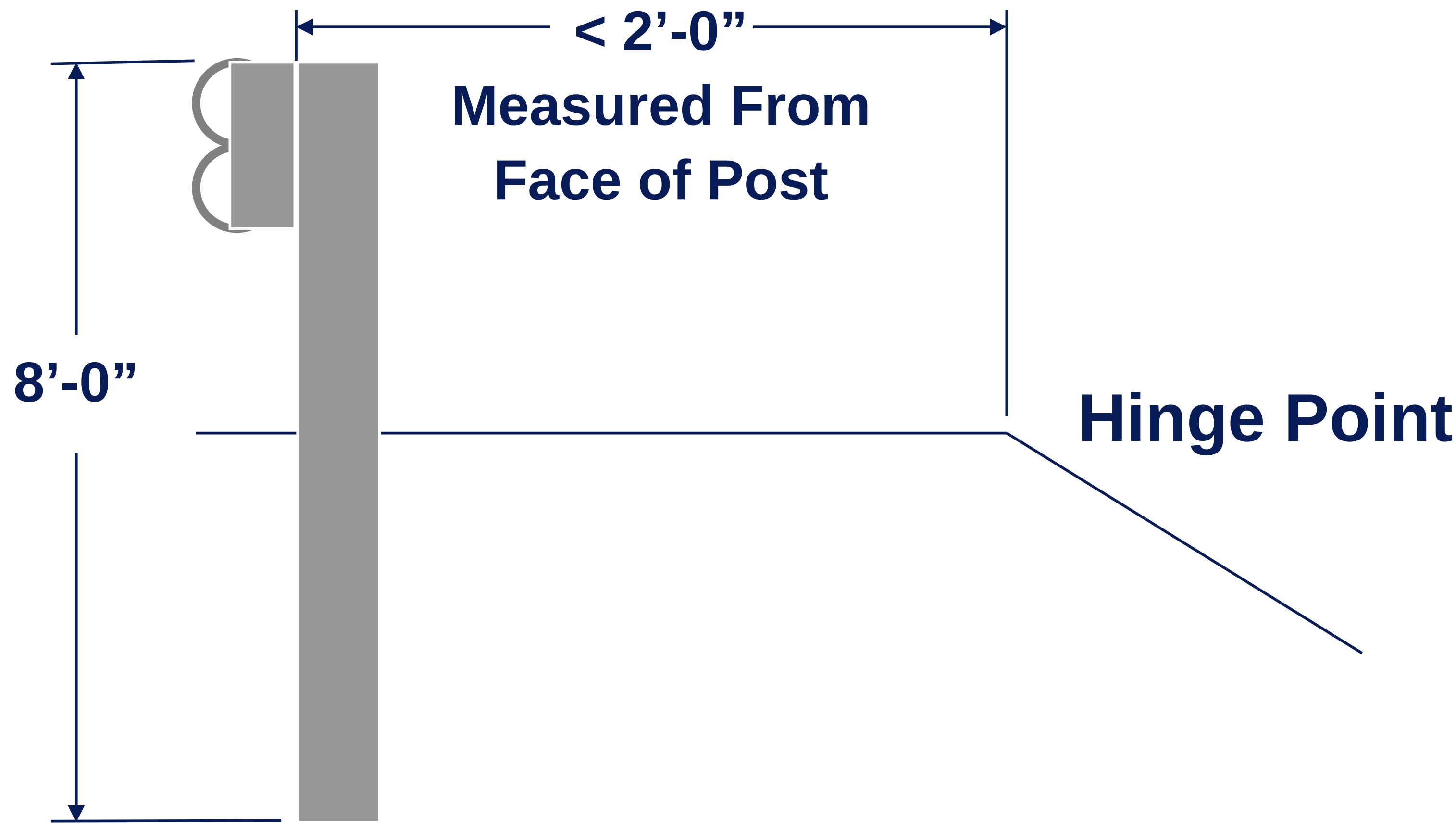
- Chapter 7 – Road Design Manual
  - Guidelines Pertaining to Type MGS-8 Guardrail
  - Guardrail Worksheet Includes Type MGS-8 Guardrail Information

Type B
Post Length Requirements



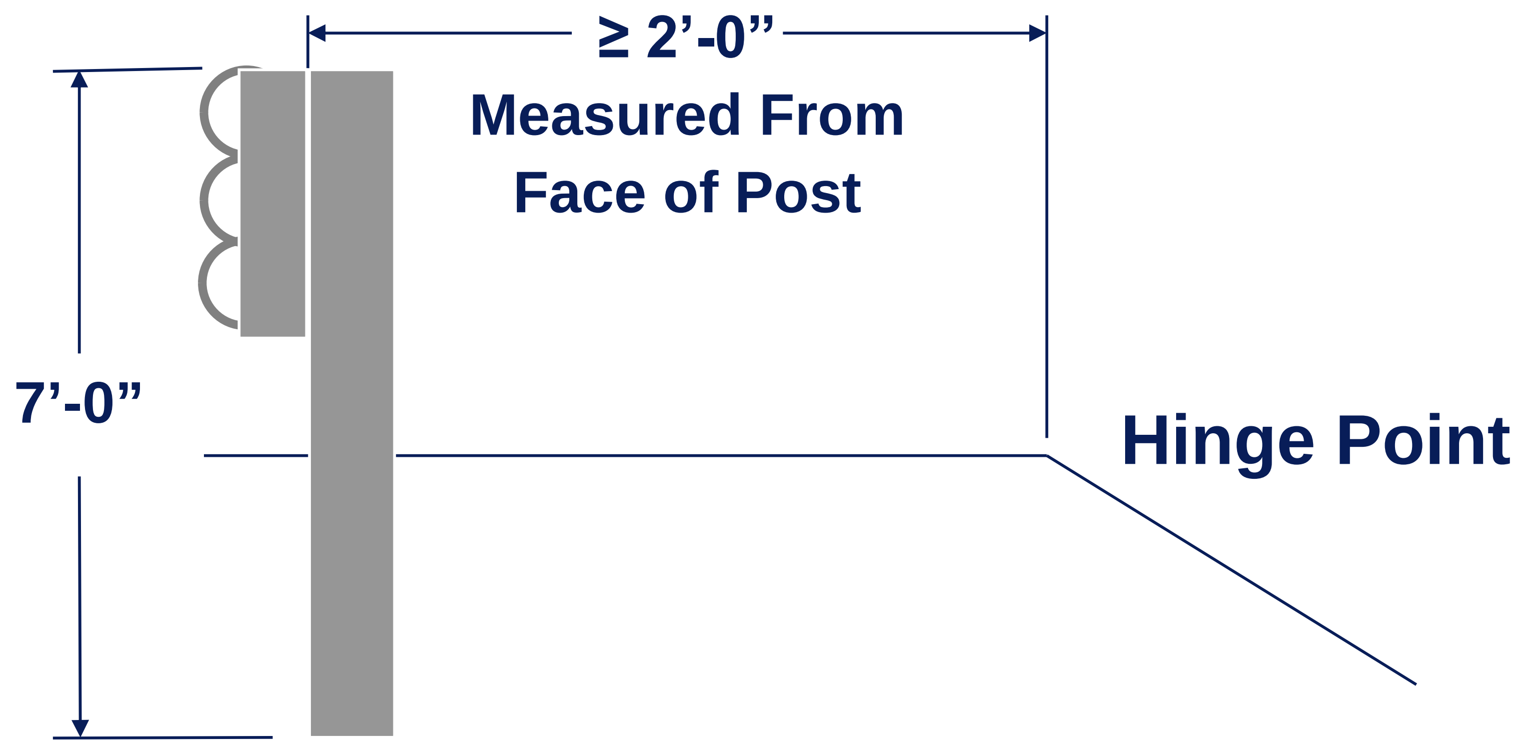
Specified in Standard Plan R-60-Series

Type B
Post Length Requirements



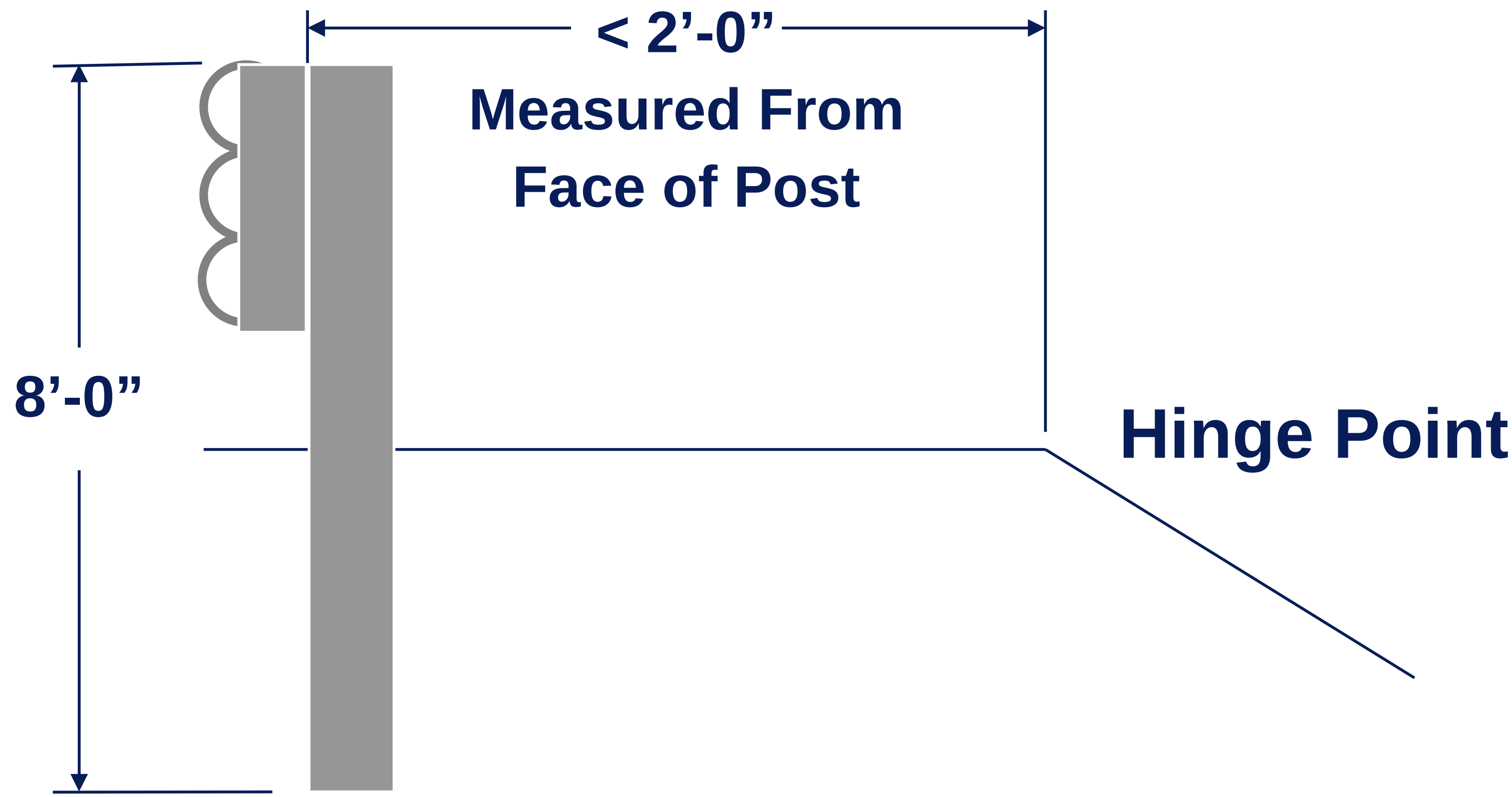
Specified in Standard Plan R-60-Series

Type T
Post Length Requirements



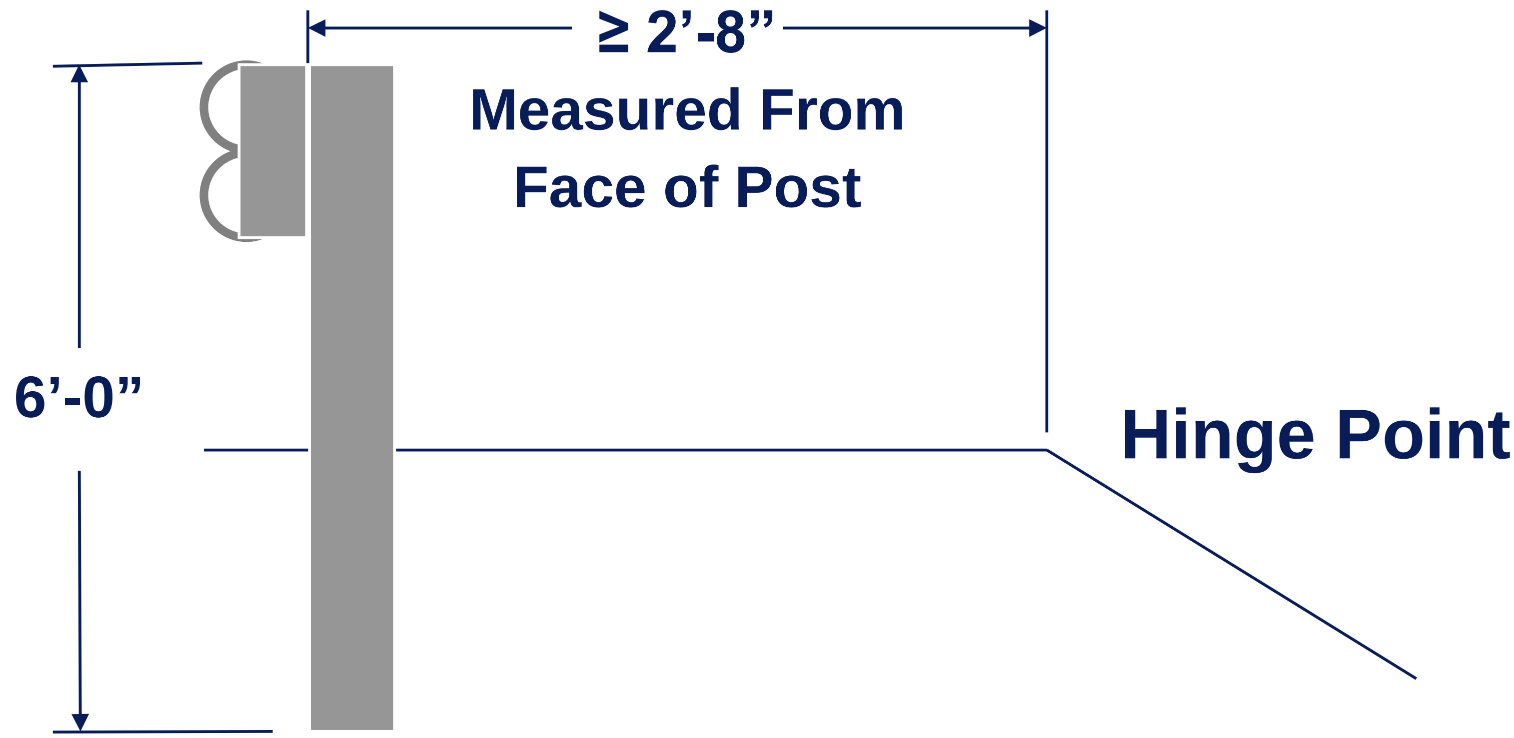
Specified in Standard Plan R-60-Series

Type T
Post Length Requirements



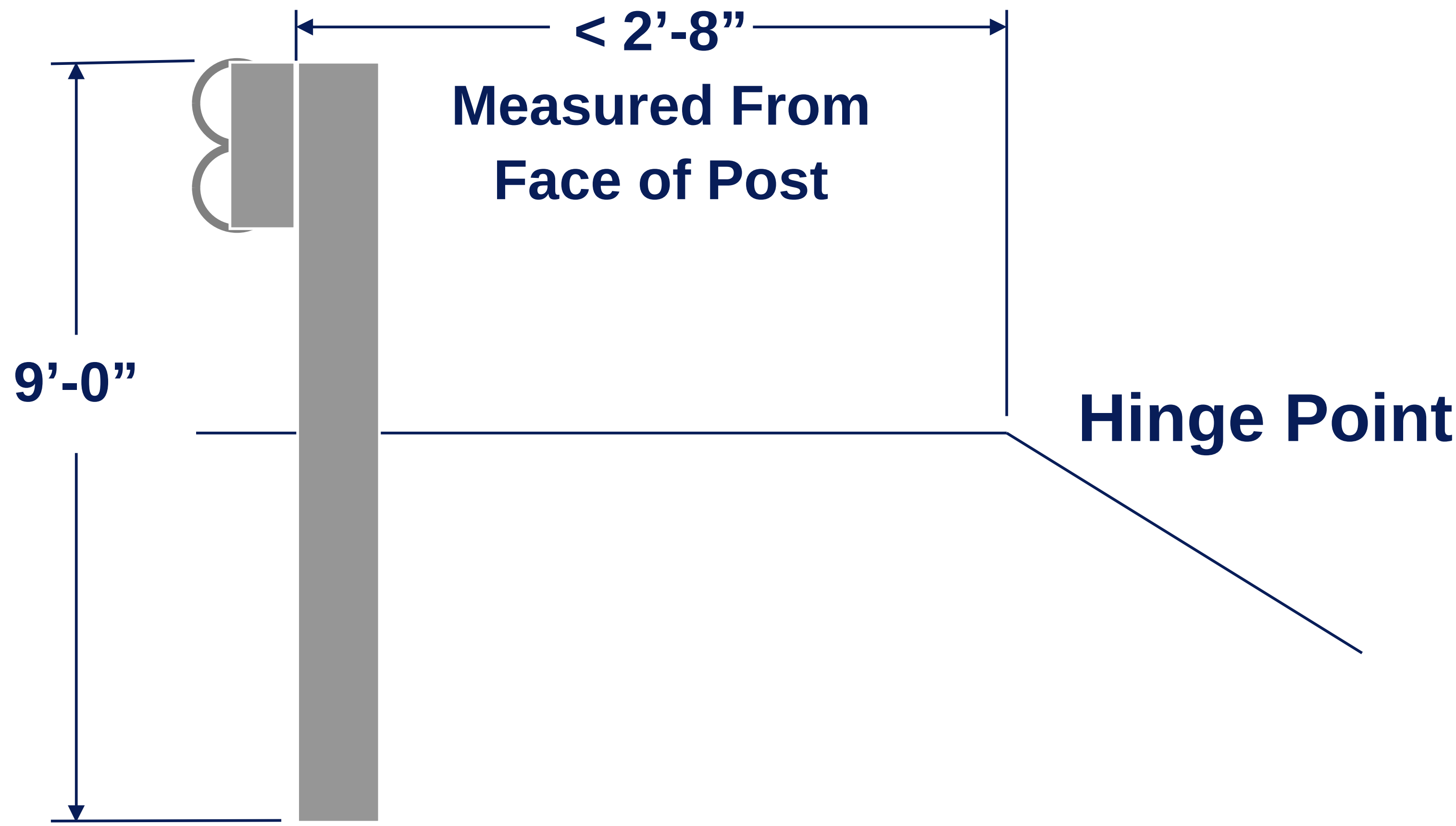
Specified in Standard Plan R-60-Series

Type MGS-8
Post Length Requirements



Specified in Standard Plan R-60-Series

Type MGS-8
Post Length Requirements



Specified in Standard Plan R-60-Series

Guardrail Post Length Requirements

Identified in Guardrail Pay Items

Pay Item	**Pay Unit**
Guardrail, Type __, __ inch Post	Foot
Guardrail, Temp, Type __, __ inch Post	Foot
Guardrail, Curved, Type __, __ inch Post	Foot
Guardrail, Curved, Temp, Type __, __ inch Post	Foot

- Defined in Frequently Used Special Provision (FUSP) 20SP-807H
- Designers must determine the required post length(s) when setting up pay items
- A single guardrail run may have sections with different post lengths

Barrier Location

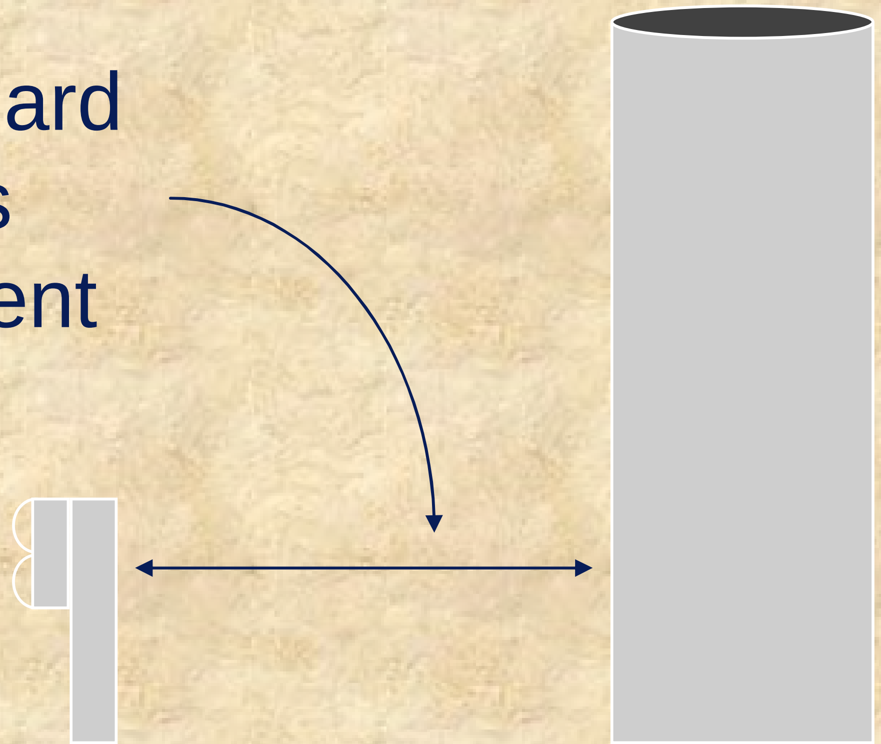
Place Barrier

As Far From Traveled Way As Possible

Without Adversely Affecting Barrier Performance

Barrier Location

Barrier to Hazard Distance Is Critical Element



MDOT Guardrail Deflection Table

- Guardrail deflections are typical values
- Deflection may vary:
  - Soil Type
  - Thawed/Frozen Ground
  - Length of installation
  - Impact Characteristics
- Treat deflections from table as minimums
  - If possible, consider adding factor of safety (e.g., 1') to guardrail deflections listed in table

Guardrail Deflection

Guardrail	Post Spacing	Minimum Design Offset *
Type T	1'-6¾"	1'-2"
Type T	3'-1½"	1'-8"
Type T	6'-3"	2'-0"
Type B	1'-6¾"	1'-6"
Type B	3'-1½"	2'-0"
Type B	6'-3"	3'-0"
Type MGS-8	1'-6¾"	2'-5"
Type MGS-8	3'-1½"	2'-11"
Type MGS-8	6'-3"	3'-6"
Type MGS-8 Adjacent to Curb	6'-3"	4'-1"
Type MGS-8 Near Shoulder Hinge Point **	6'-3"	4'-1"

* An additional 12" or more is desirable where feasible

** Less than 2'–8" from the shoulder hinge point to the face of guardrail post

Terrain Effects

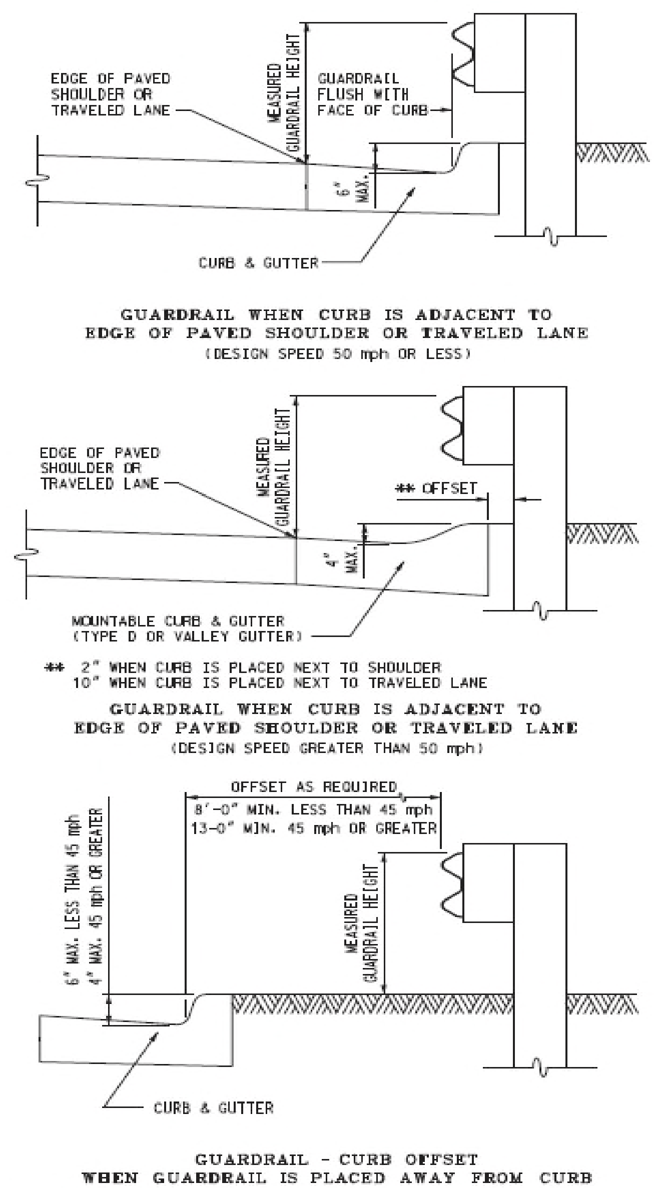
- Curbs
- Slopes

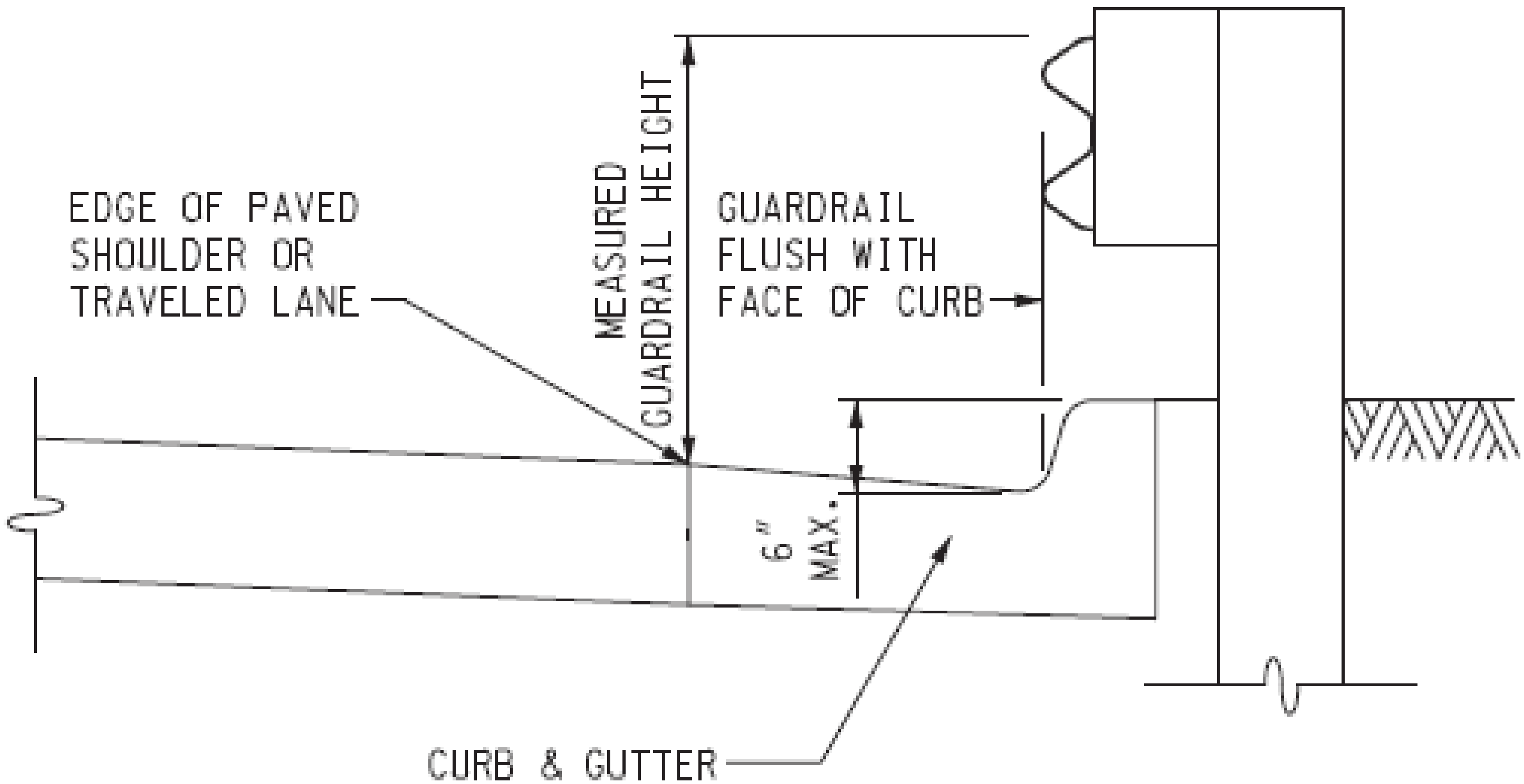
Curbs and Guardrail

MUST Take Certain Precautions!!

MDOT Guidelines Curb & Guardrail

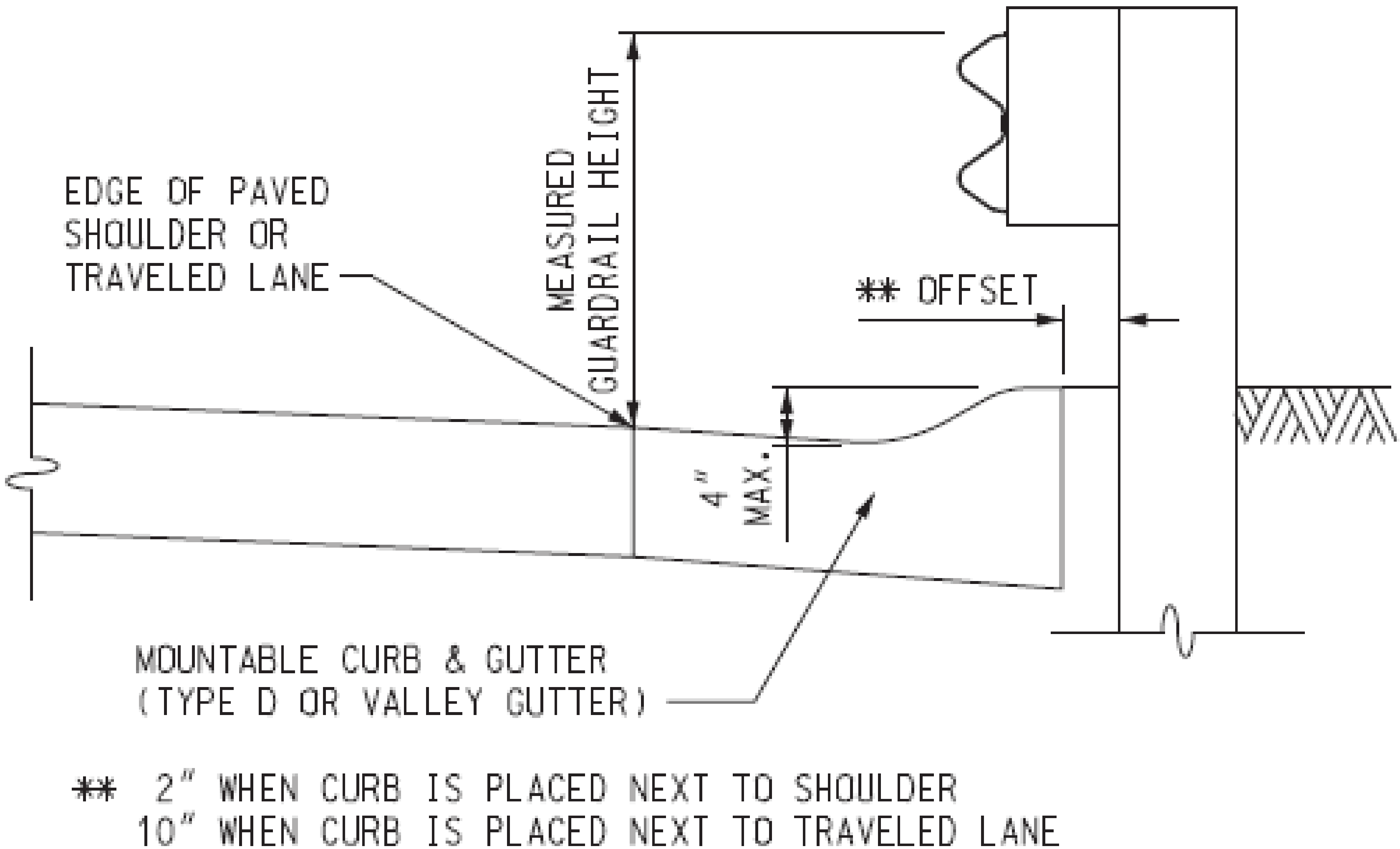
- Section 7.01.34 of the RDM discusses curb & guardrail
- Use only Type D or valley gutter when design speed >50 mph
- Follow offset and max curb height recommendations when guardrail is placed away from curb





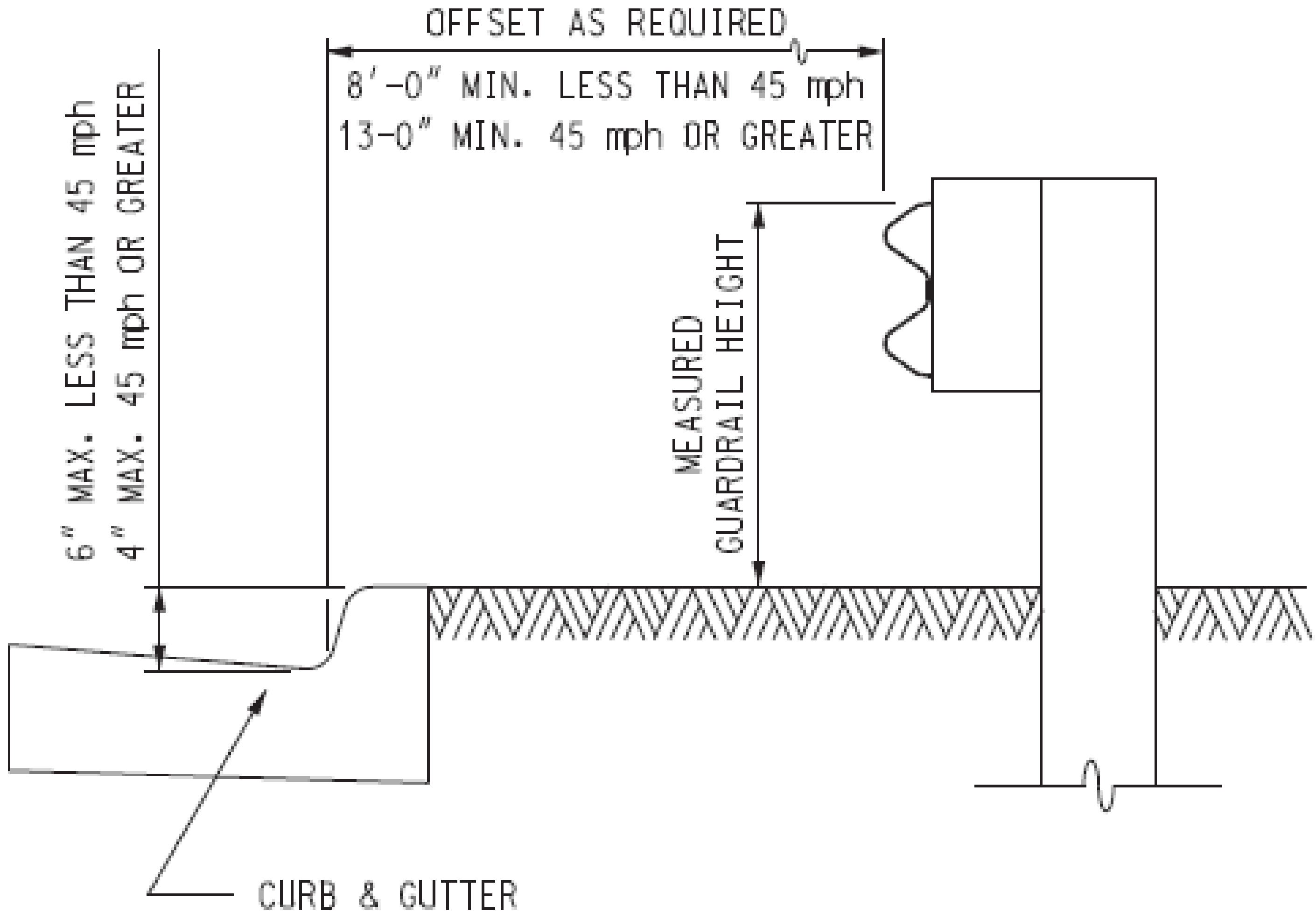
GUARDRAIL WHEN CURB IS ADJACENT TO EDGE OF PAVED SHOULDER OR TRAVELED LANE

(DESIGN SPEED 50 mph OR LESS)



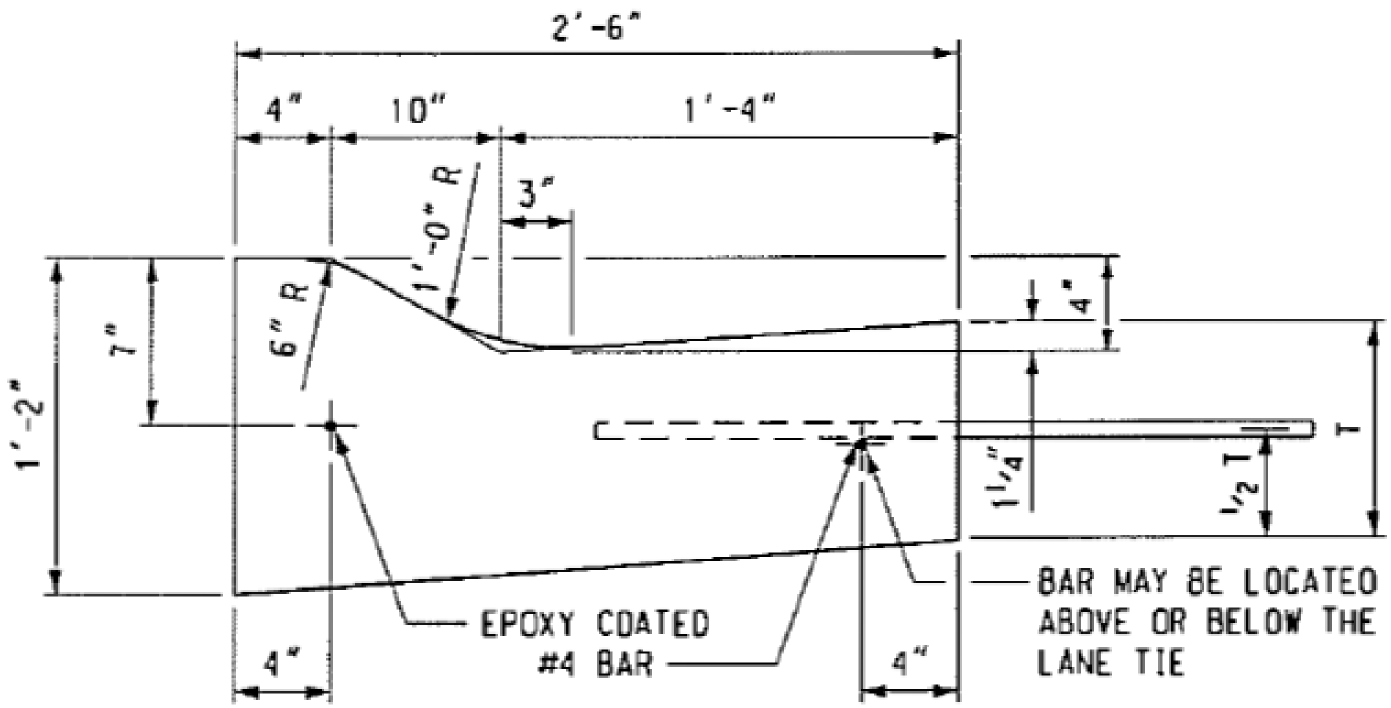
GUARDRAIL WHEN CURB IS ADJACENT TO EDGE OF PAVED SHOULDER OR TRAVELED LANE

(DESIGN SPEED GREATER THAN 50 mph)



GUARDRAIL - CURB OFFSET
WHEN GUARDRAIL IS PLACED AWAY FROM CURB

Type D Curb & Gutter
MDOT Standard Plan R-30 Series

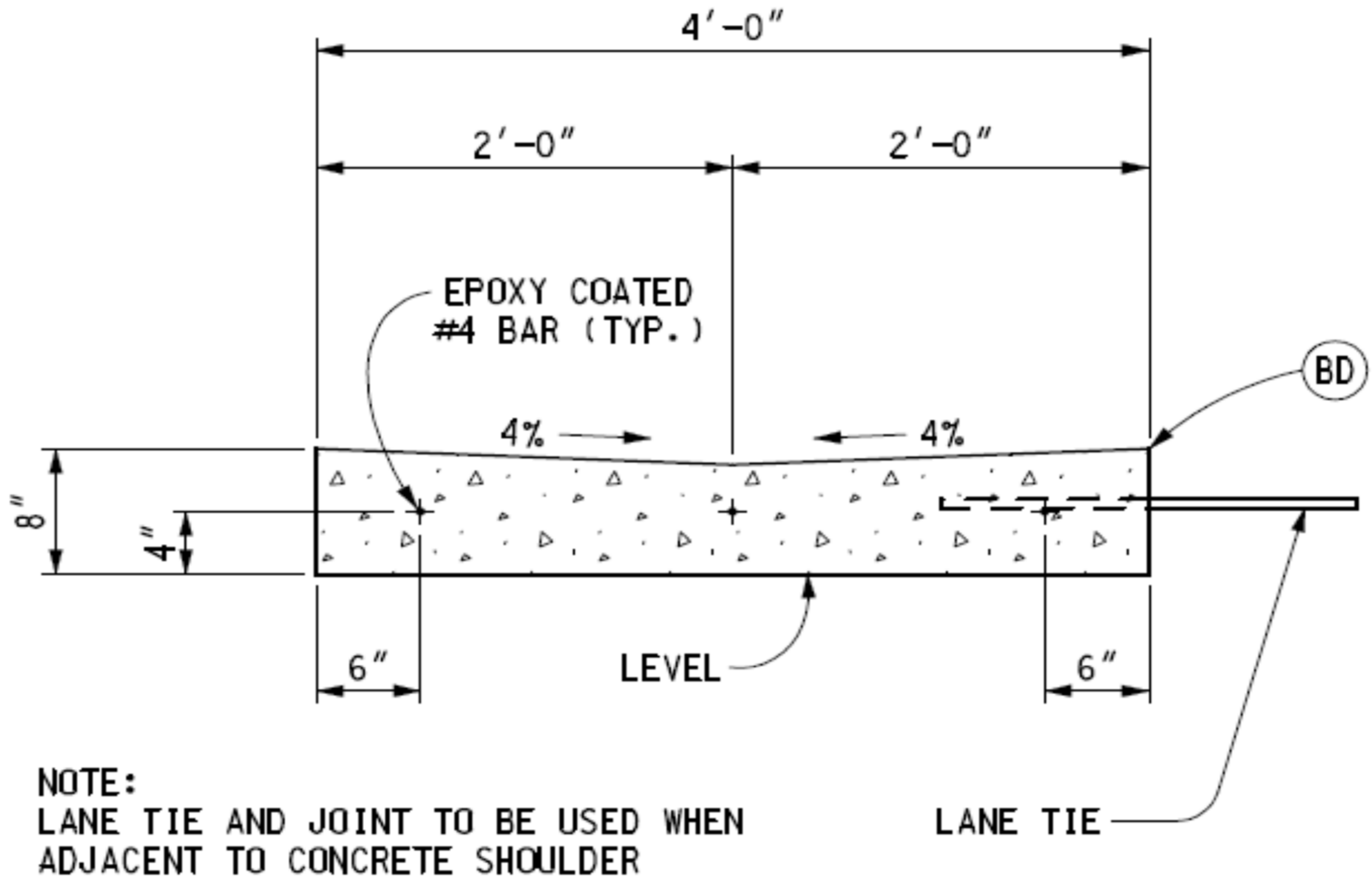


SEE NOTES WHEN PAVEMENT JOINT
IS SEALED WITH NEOPRENE

DETAIL	DIMENSION T	LANE TIES	CONCRETE CYD / LFT
D1	9"	AS SHOWN	0.0788
D2	9"	OMITTED	0.0788
D3	10"	AS SHOWN	0.0826

D

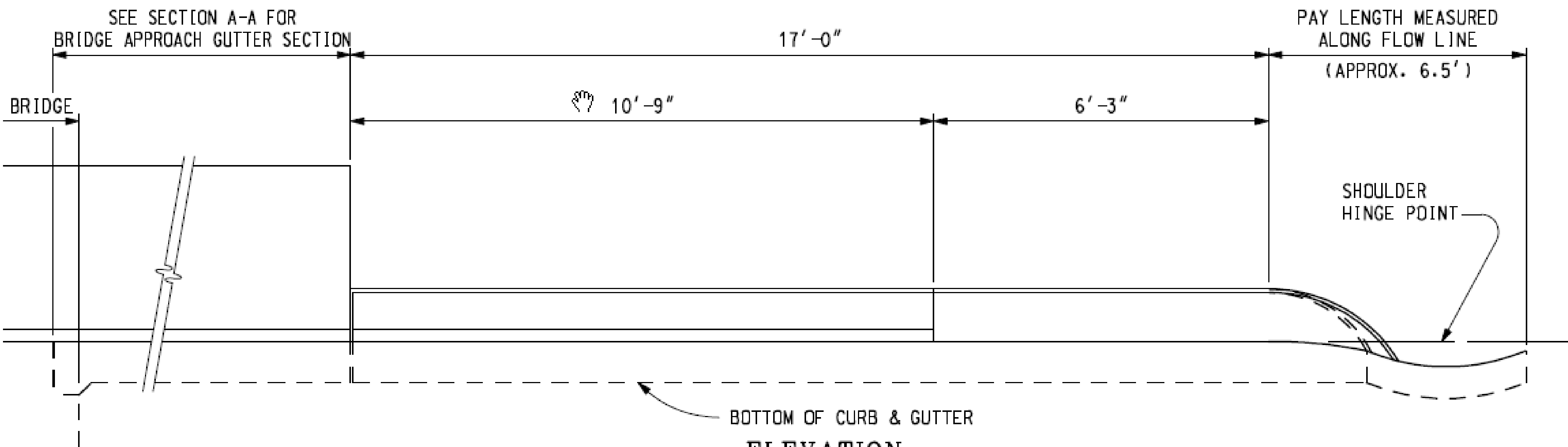
Valley Gutter
MDOT Standard Plan R-33 Series



CONCRETE VALLEY GUTTER

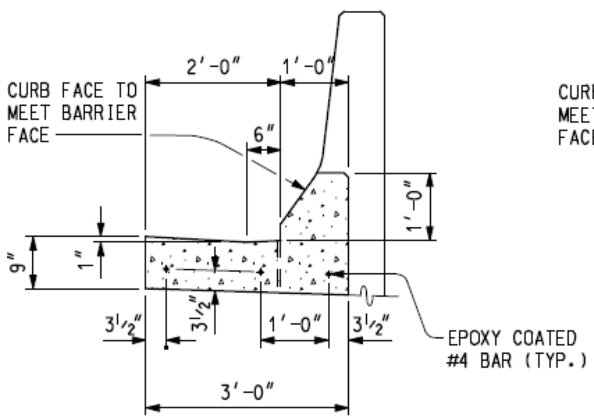
Looks OK?

MDOT Standard Plan R-32-Series

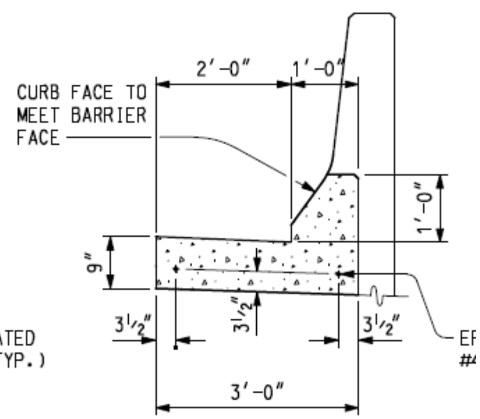


ELEVATION

BRIDGE APPROACH CURB & GUTTER, DETAIL 2



CROSS SECTION WHEN
APPROACH GUTTER IS USED



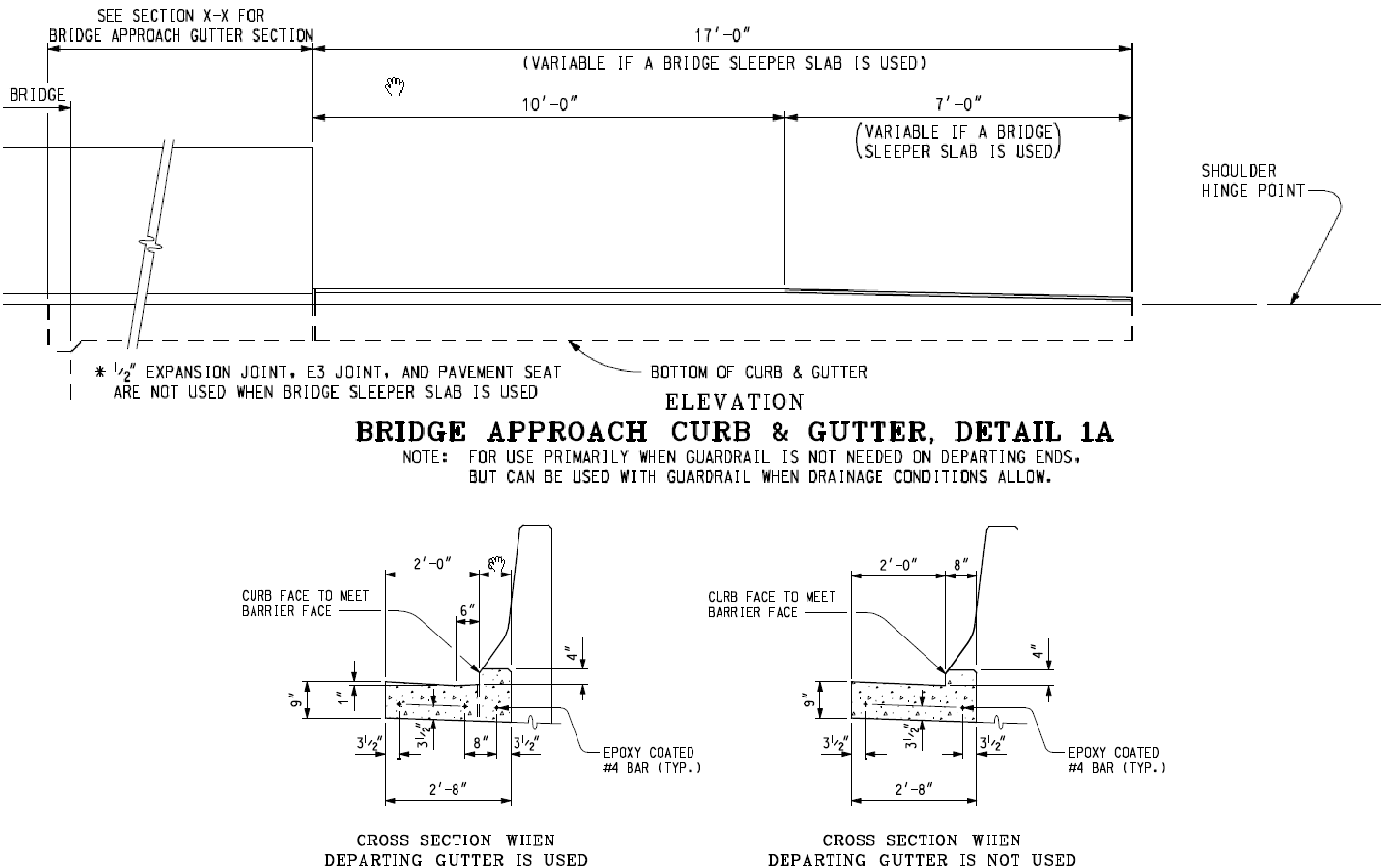
CROSS SECTION WHEN
APPROACH GUTTER IS NOT USED

Looks OK?

No !!

Use Detail 1A Bridge Approach Curb & Gutter (Std. Plan R-32 Series) when there is no guardrail

MDOT Standard Plan R-32-Series

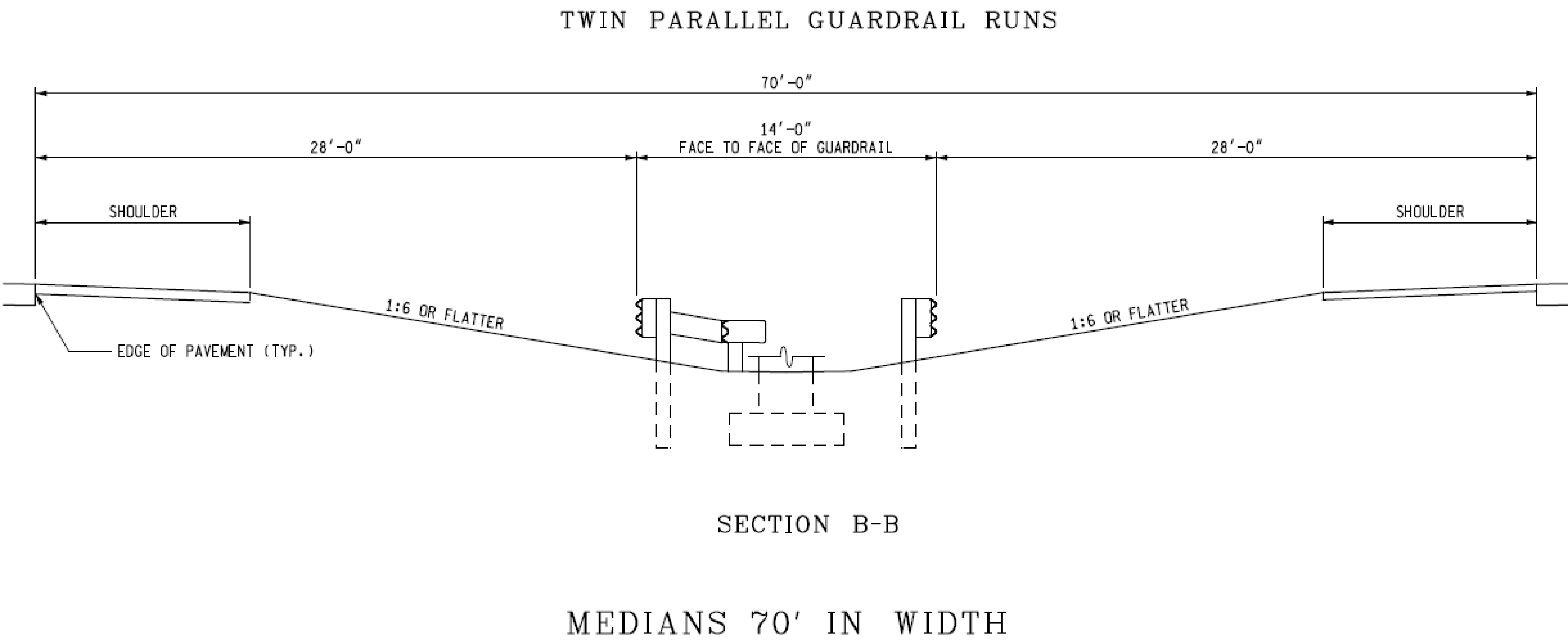



Slopes
1:10 or Flatter in
Front of Barriers
6 29 '97

Guardrail on Slopes

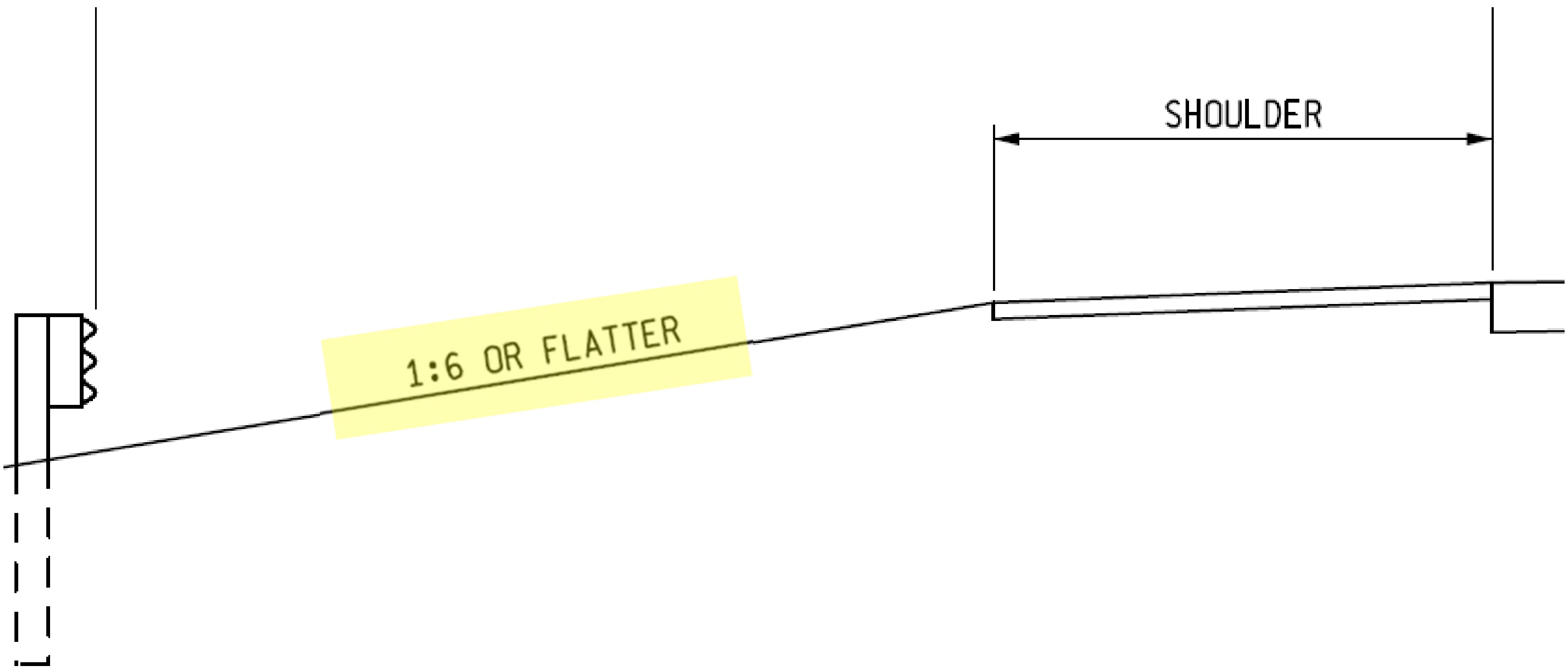
- Optimum performance on 1:10 slopes or flatter
- May be installed on slopes as steep as 1:6 under certain (site-specific) conditions:
  - Consult with the Geometric Design Unit (MDOT - Design Division)

Type T Guardrail



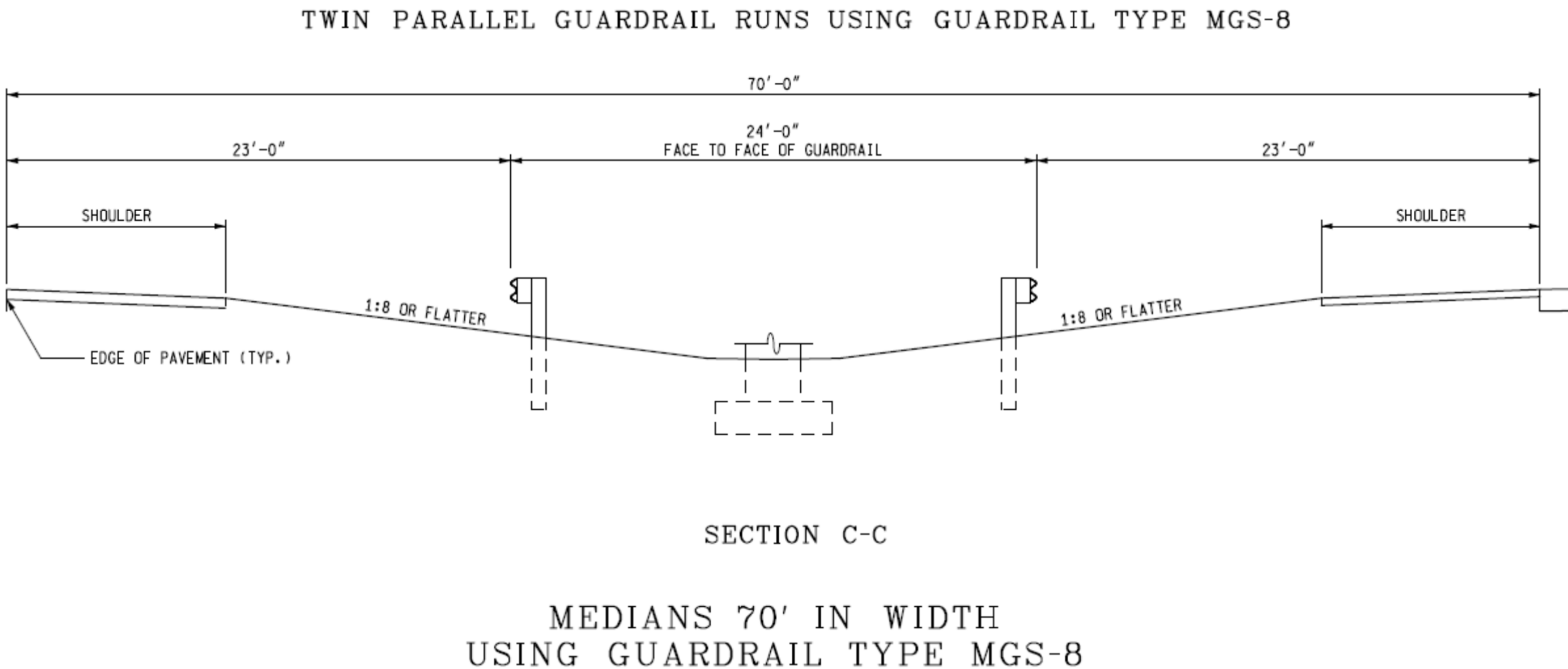
Standard Plan R-56-Series

Type T Guardrail



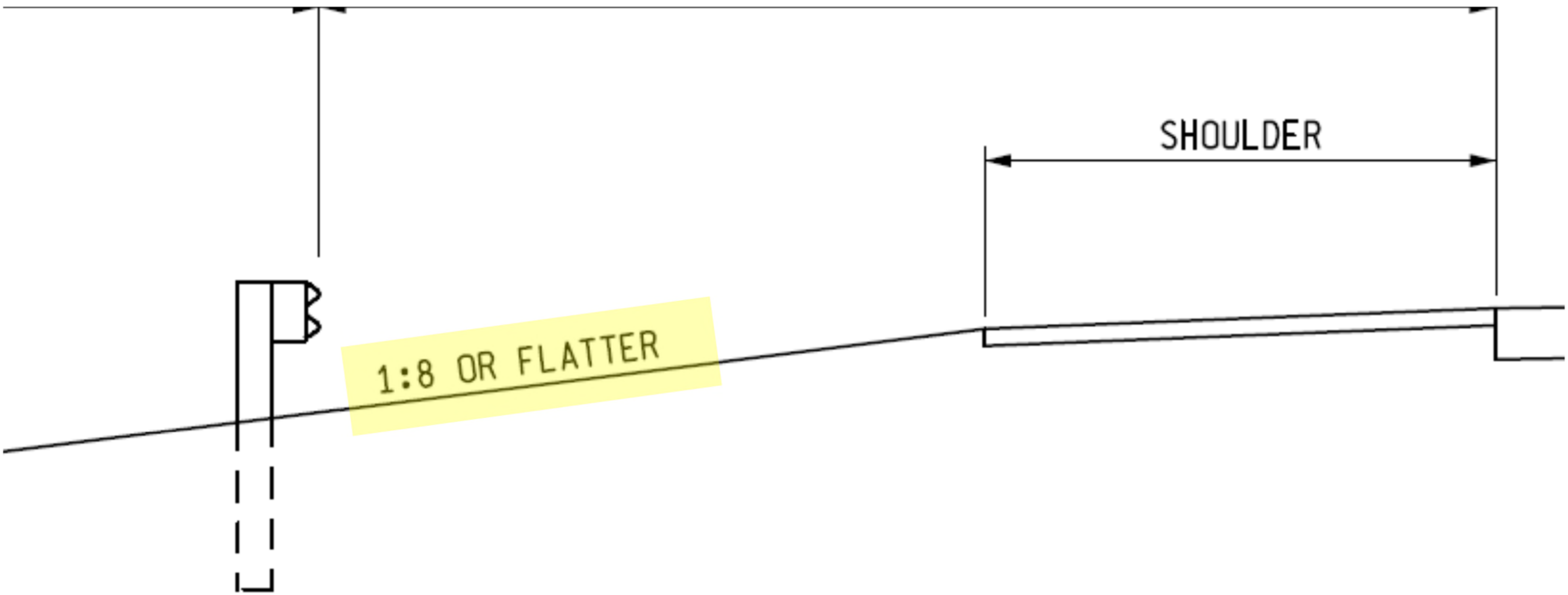
Standard Plan R-56-Series

Type MGS-8 Guardrail



Standard Plan R-56-Series

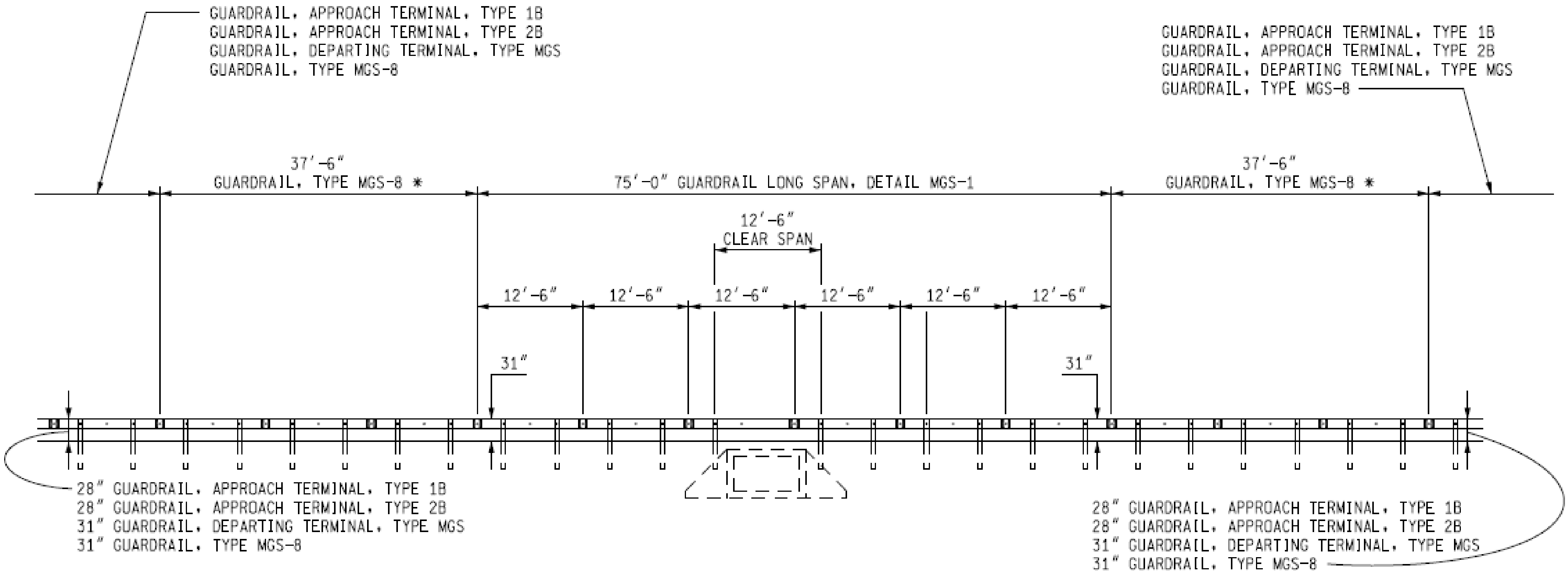
Type MGS-8 Guardrail



Standard Plan R-56-Series

MGS Long Span Details

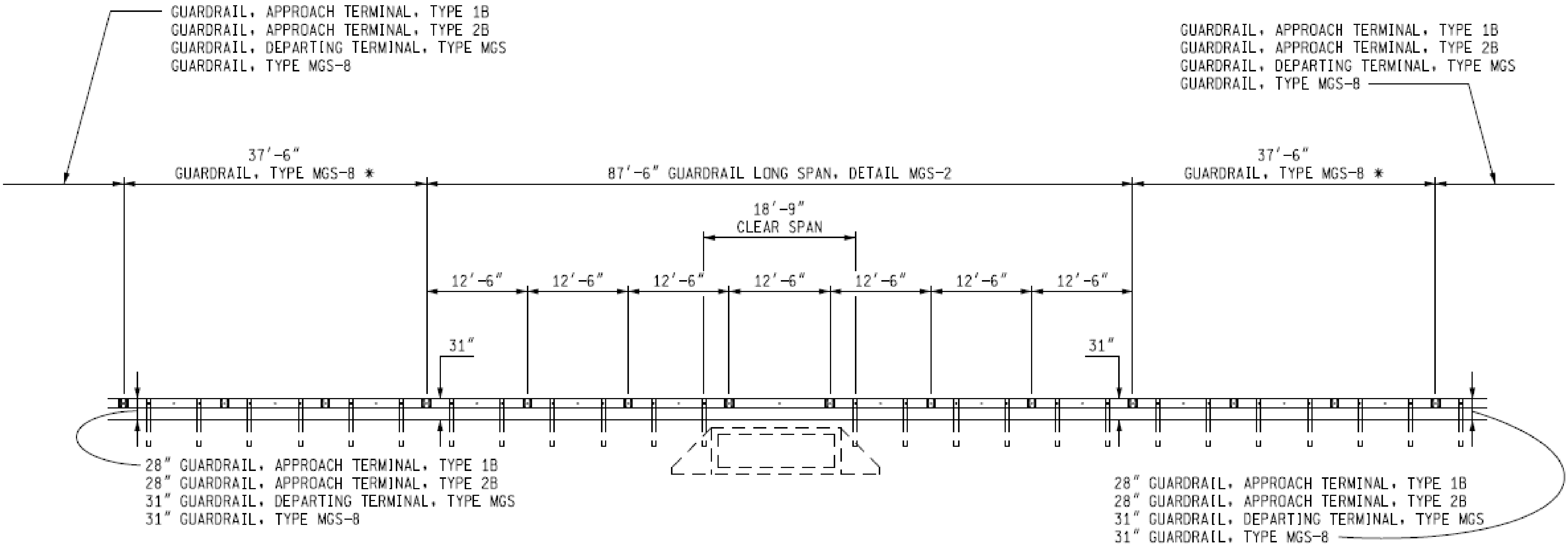
Picture Source: MwRSF Research Report No. TRP-03-187-07



ELEVATION

GUARDRAIL LONG SPAN, DETAIL MGS-1

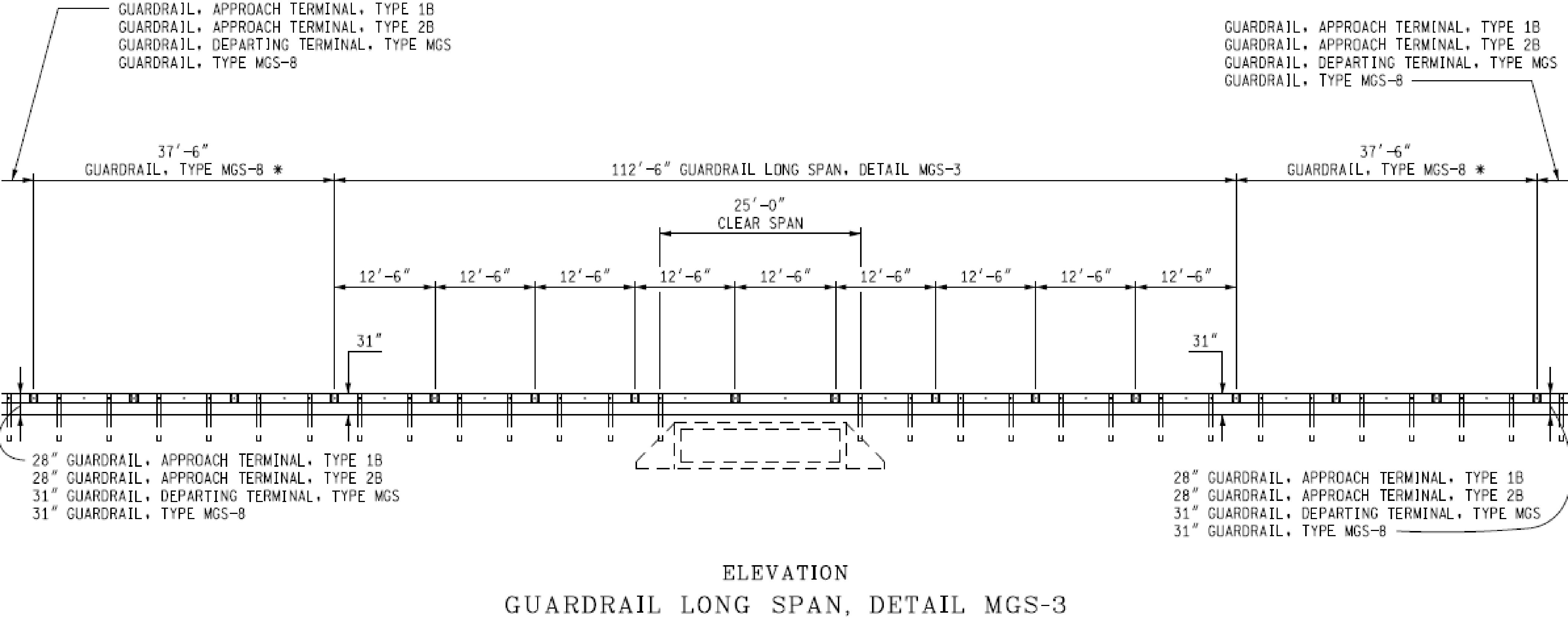
MDOT Standard Plan R-72-Series



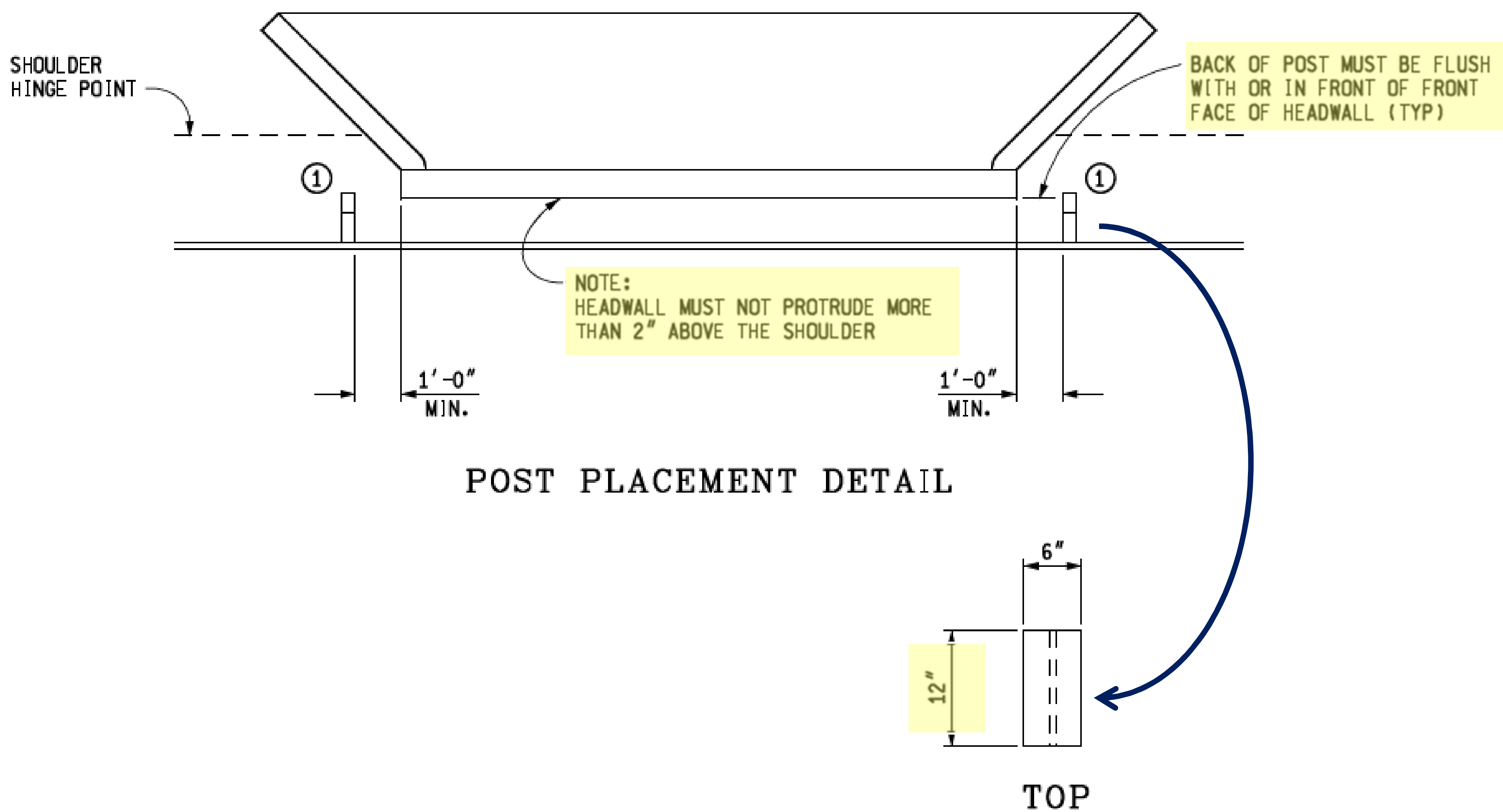
ELEVATION

GUARDRAIL LONG SPAN, DETAIL MGS-2

MDOT Standard Plan R-72-Series

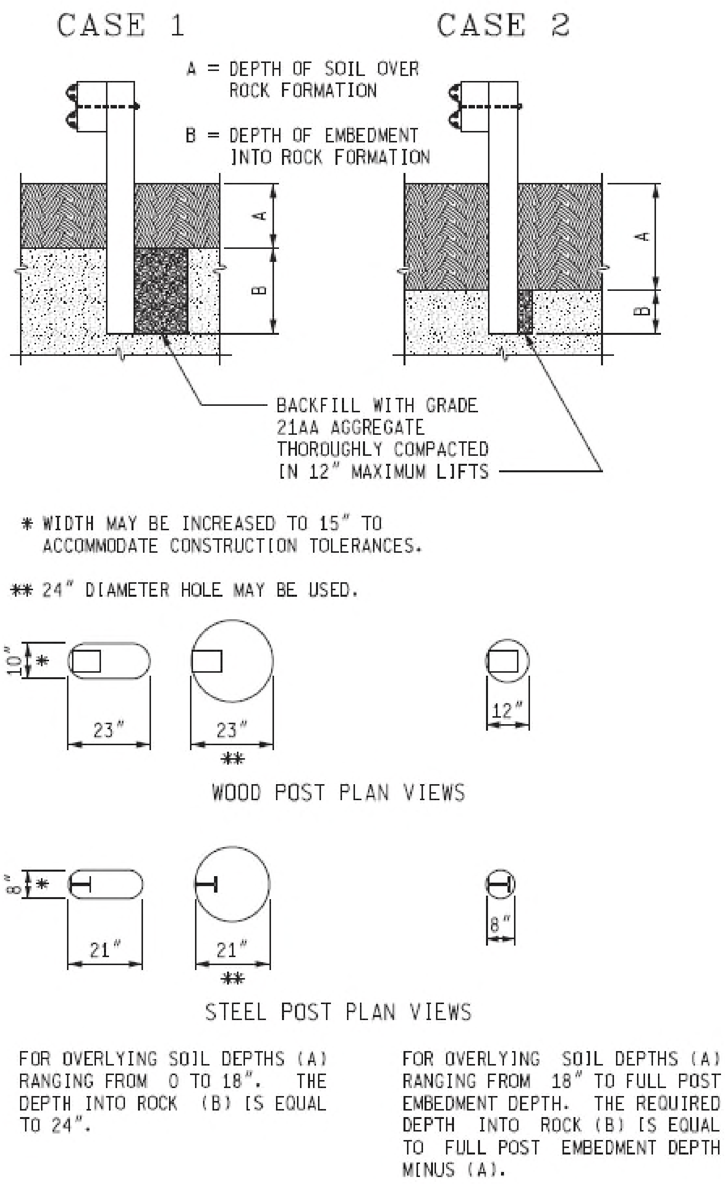


MDOT Standard Plan R-72-Series

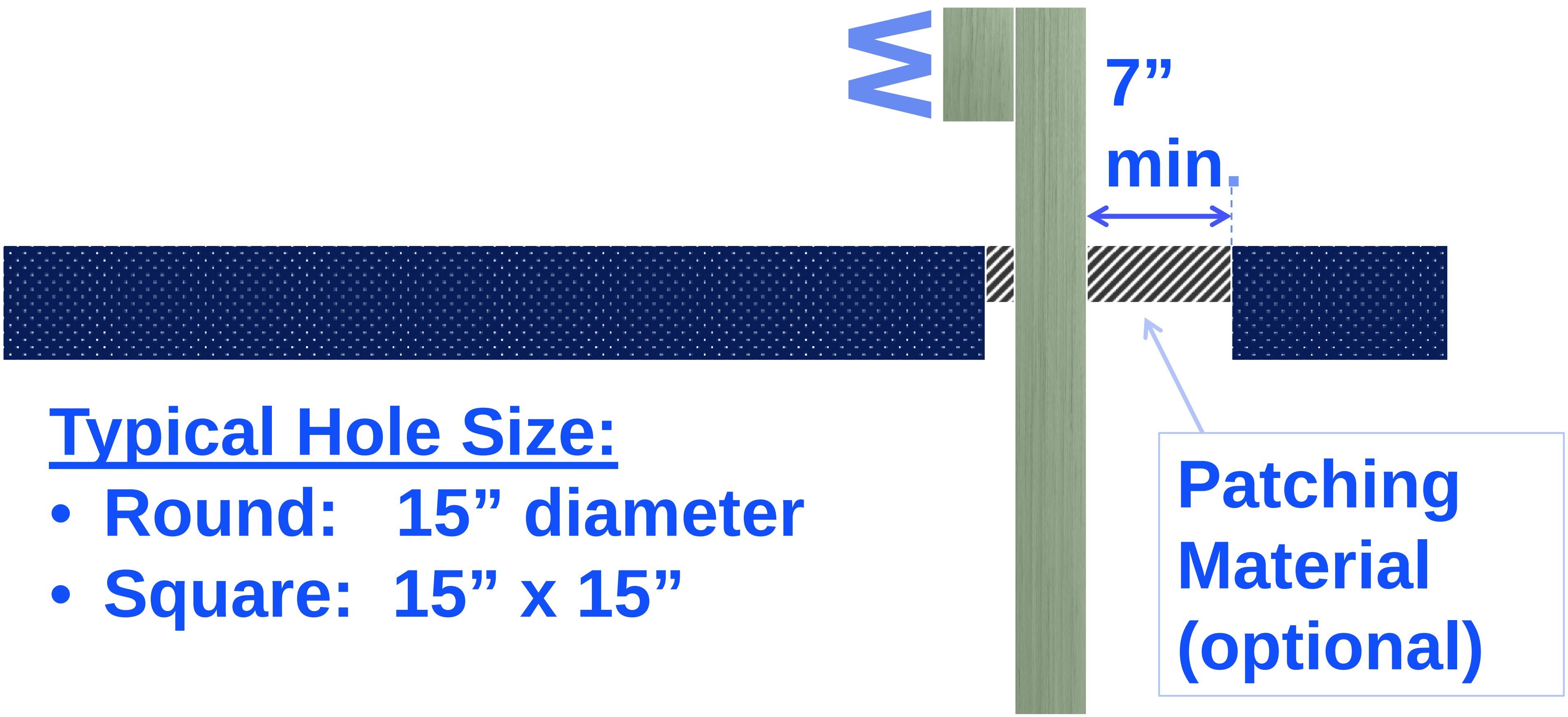


MDOT Standard Plan R-72-Series

Placing Guardrail in Rock 7.01.33.C



Guardrail Posts through Paved Surfaces 7.01.33.D



Typical Hole Size:

- **Round: 15" diameter**
- **Square: 15" x 15"**

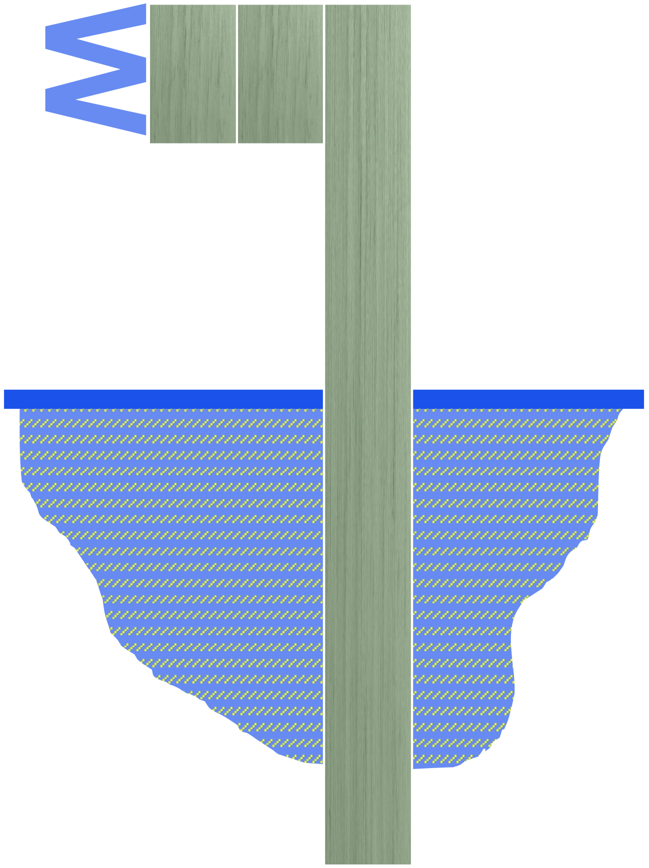
Additional Blockouts on Guardrail Posts 7.01.33.E

<u>**Double Blockouts (up to 16" deep)**</u>

- Not permitted on terminals
- No limit to the number of posts in a guardrail run that can have double blockouts

<u>**Multiple Blockouts (up to 36" deep)**</u>

- Not permitted on terminals
- Limited to one or two posts in a guardrail run
- May use up to four blockouts on one post

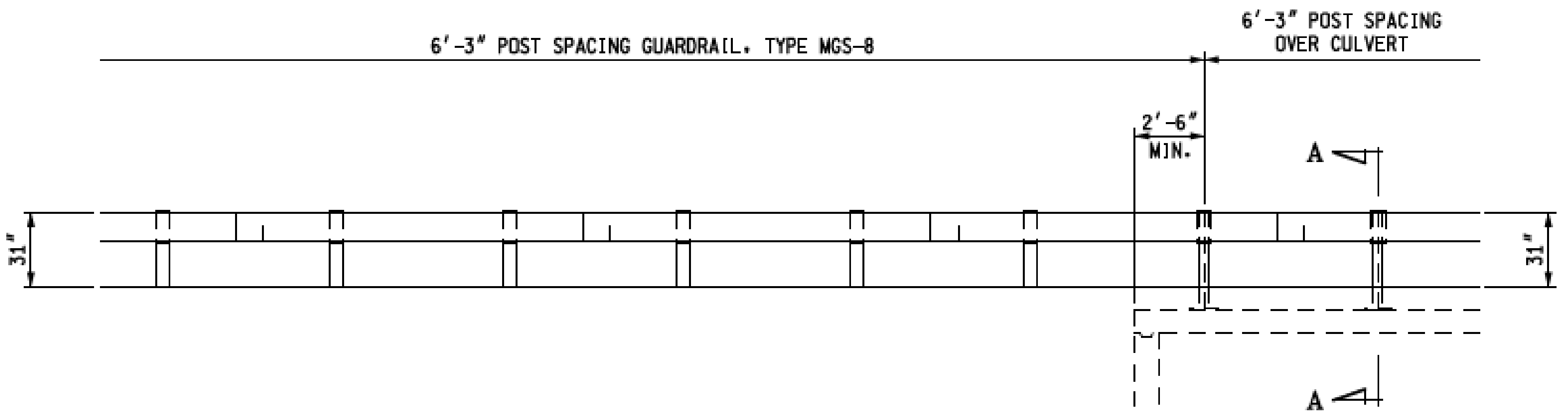


**** MUST TAKE SLOPE BEHIND POST INTO CONSIDERATION!!! ****

Guardrail Over Box/Slab Culverts

MDOT Standard Plan R-73-Series

- 31” Tall Type MGS-8 Guardrail over Box/Slab Culvert
- 6’-3” Post Spacing Over Box/Slab Culvert
  - Previous Version of R-73-Series Required a 3’-1½“ Post Spacing

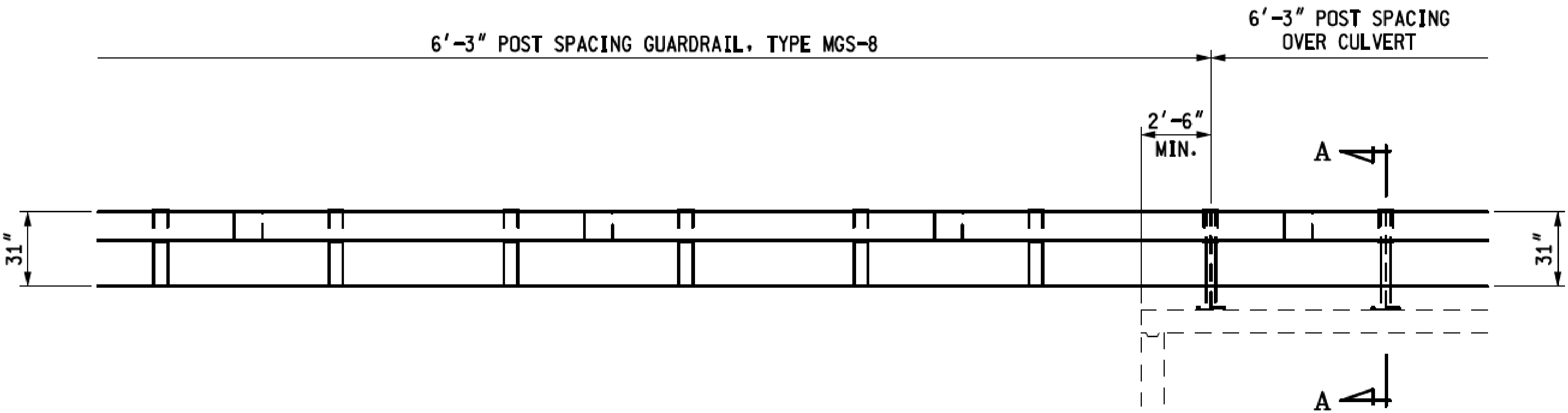


ELEVATION SHOWING GUARDRAIL, TYPE MGS-8

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF DEVELOPMENT STANDARD PLAN FOR

GUARDRAIL OVER BOX OR SLAB CULVERTS

F.H.W.A. APPROVAL	8-1-2019 PLAN DATE	R-73-F	SHEET 1 OF 3

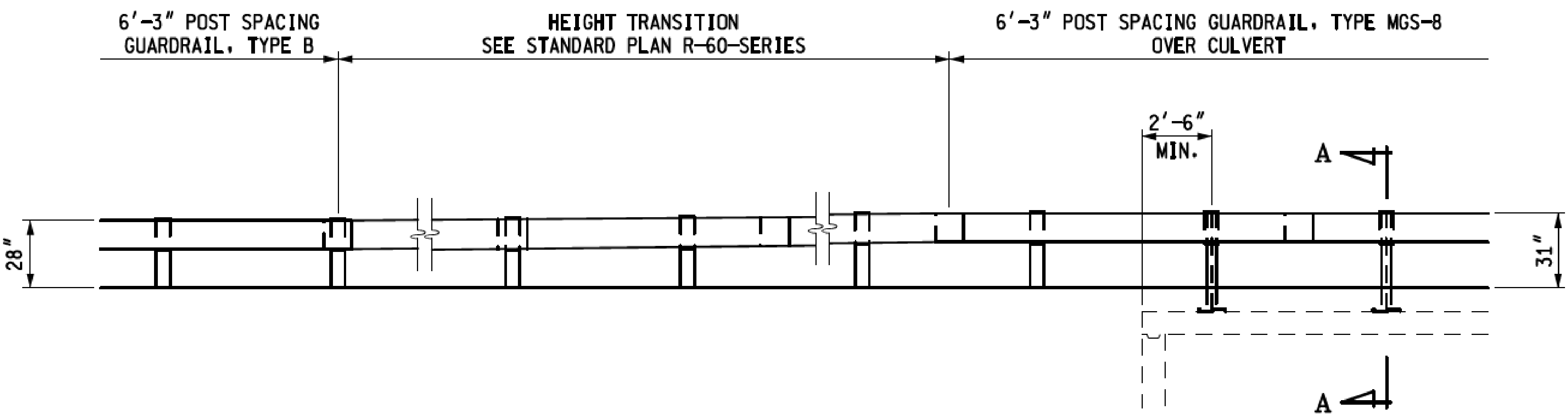


ELEVATION SHOWING GUARDRAIL, TYPE MGS-8

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF DEVELOPMENT STANDARD PLAN FOR

GUARDRAIL OVER BOX OR SLAB CULVERTS

F.H.W.A. APPROVAL	8-1-2019 PLAN DATE	R-73-F	SHEET 1 OF 3

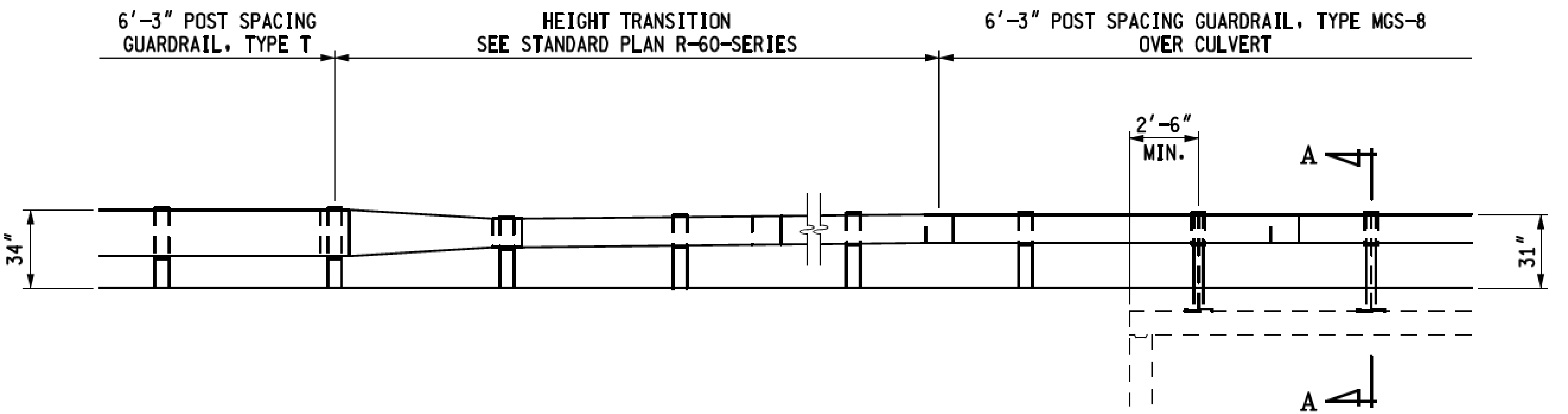


ELEVATION SHOWING GUARDRAIL, TYPE B

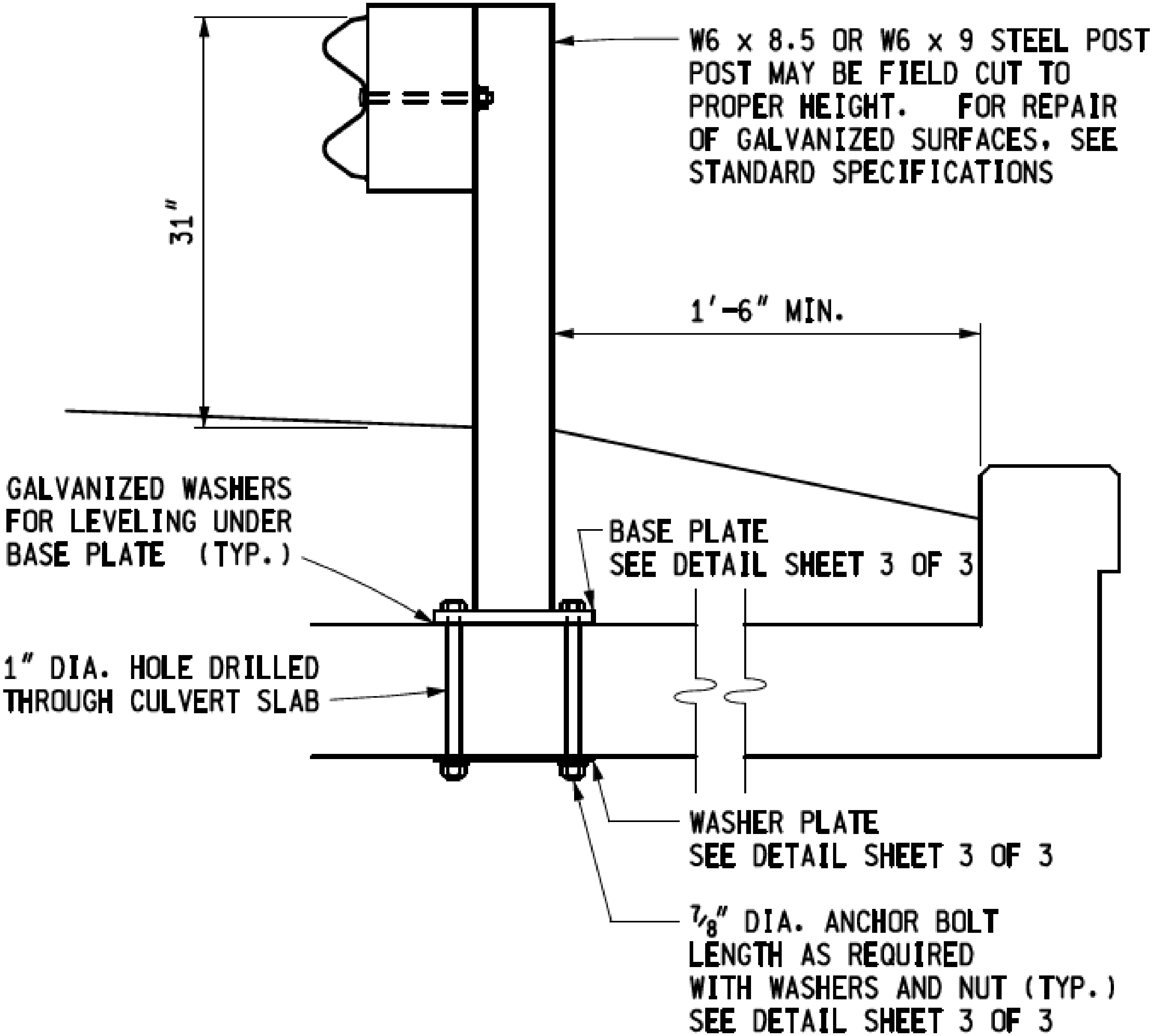
MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF DEVELOPMENT STANDARD PLAN FOR

GUARDRAIL OVER BOX OR SLAB CULVERTS

F.H.W.A. APPROVAL	8-1-2019 PLAN DATE	R-73-F	SHEET 1 OF 3

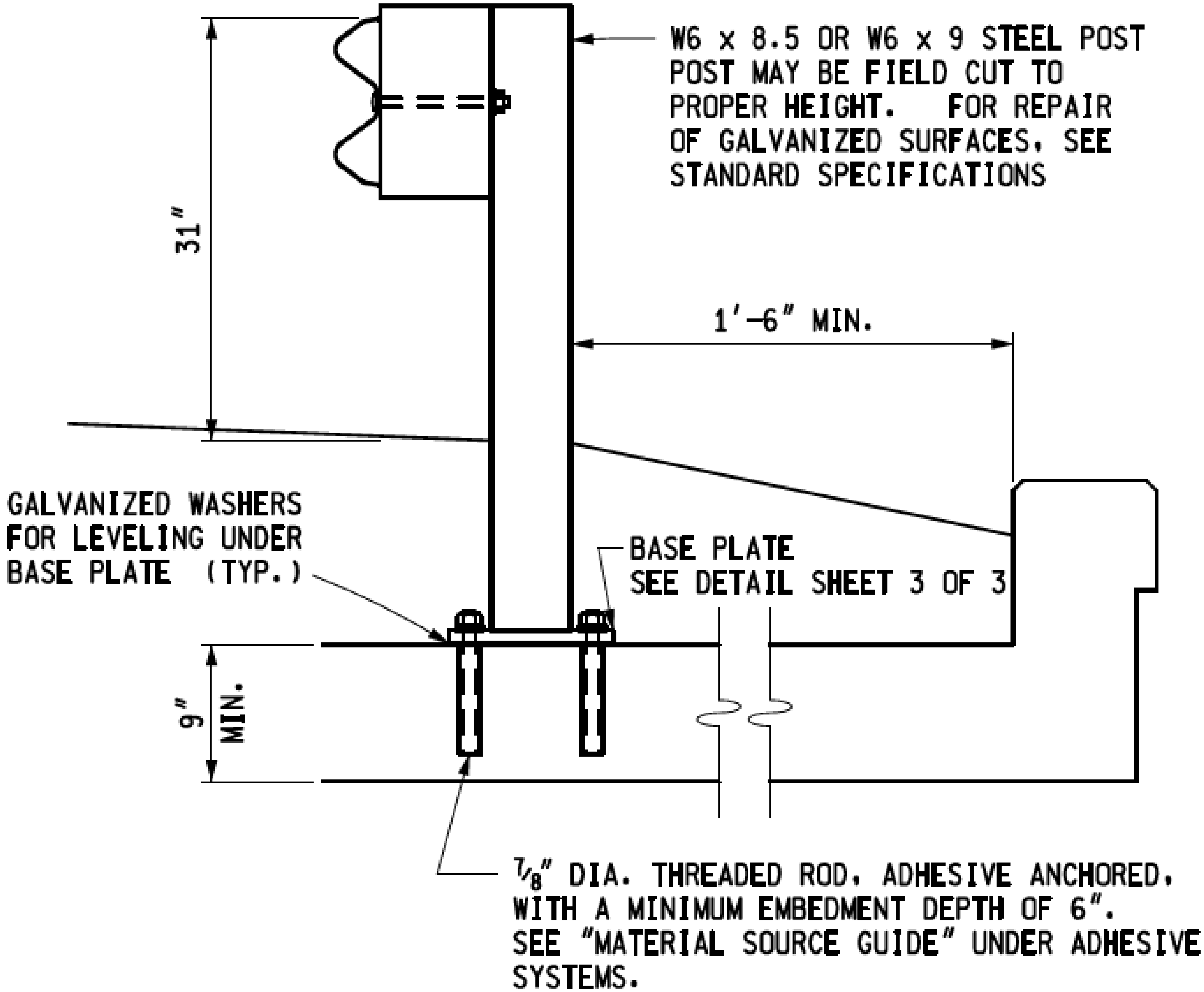


ELEVATION SHOWING GUARDRAIL, TYPE T



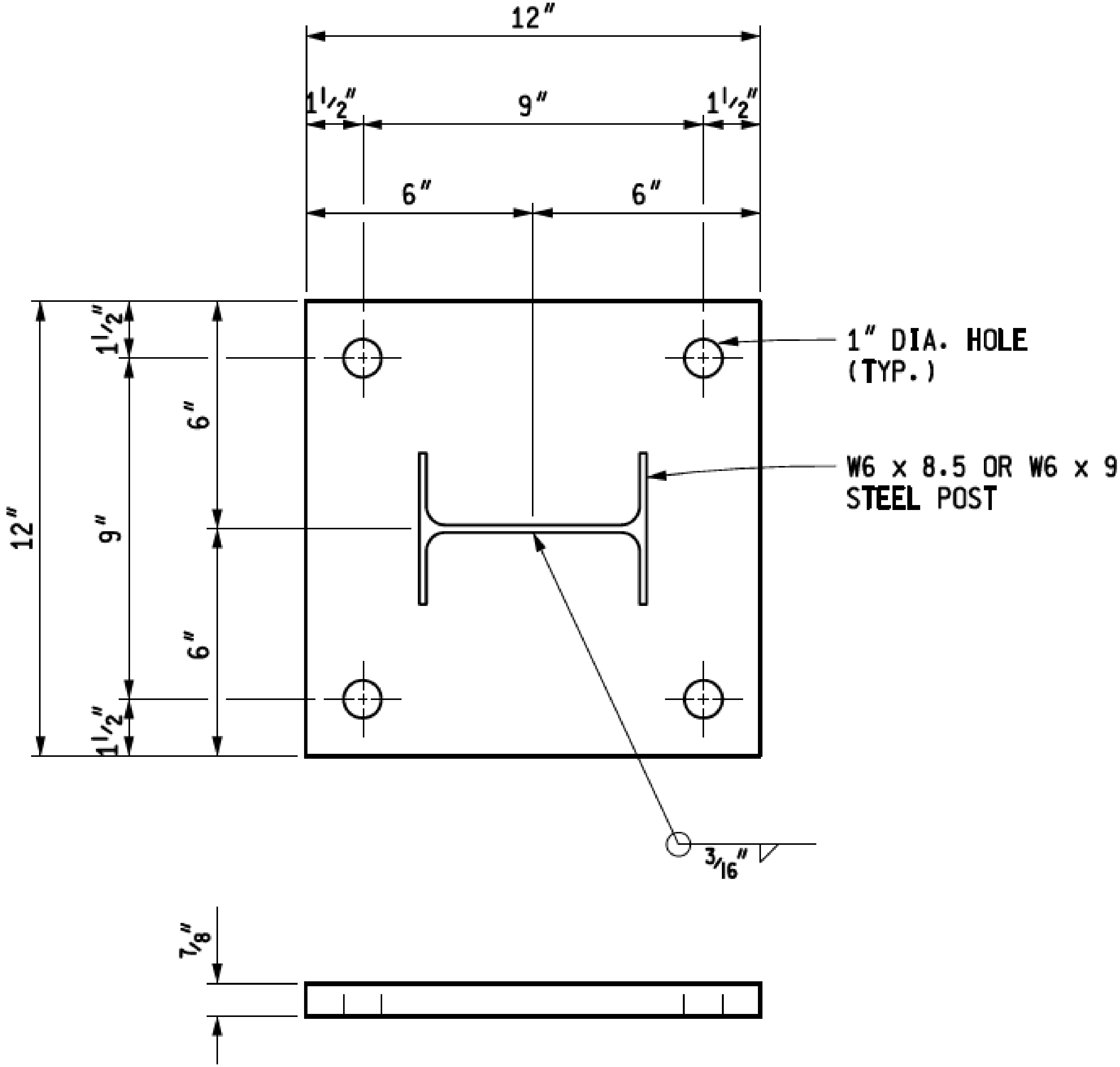
SECTION A - A

PREFERRED CONSTRUCTION METHOD



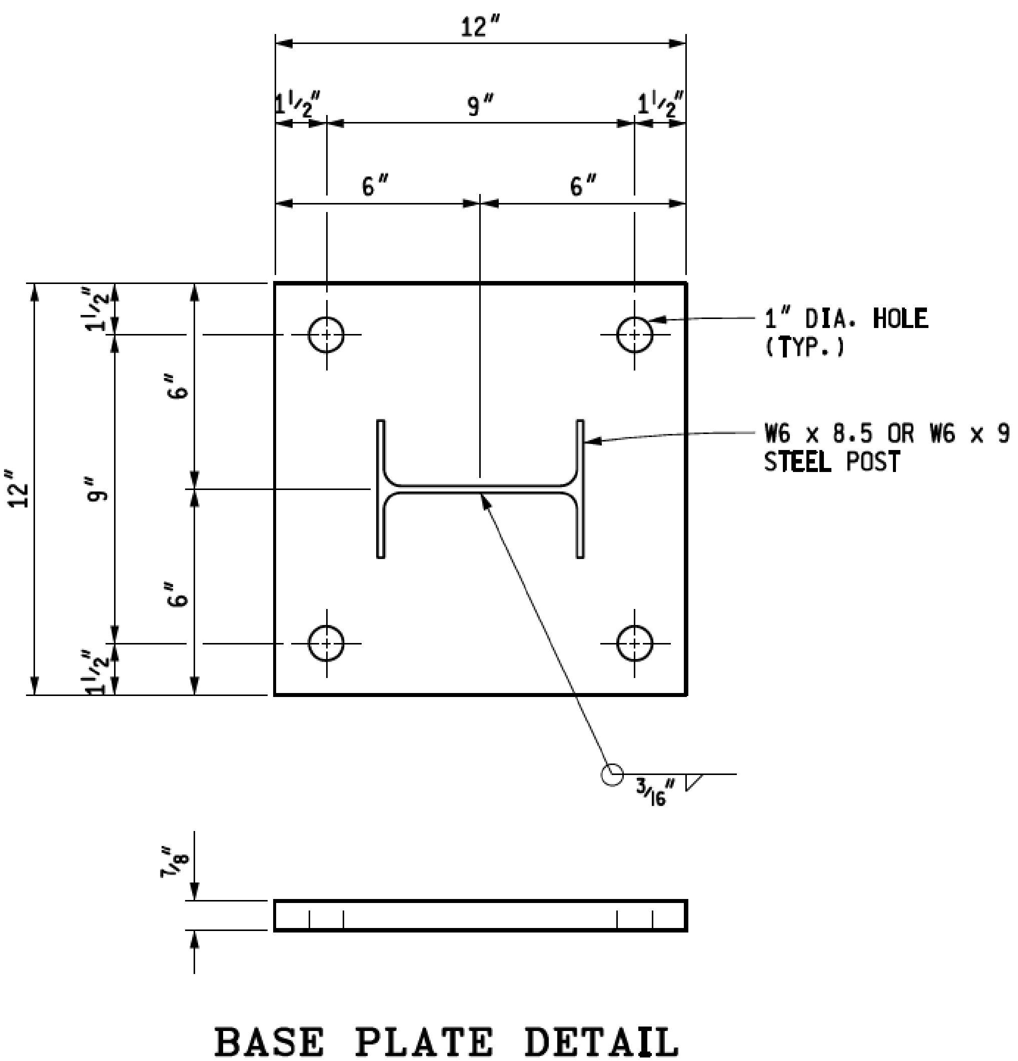
SECTION A - A

ALTERNATE CONSTRUCTION METHOD

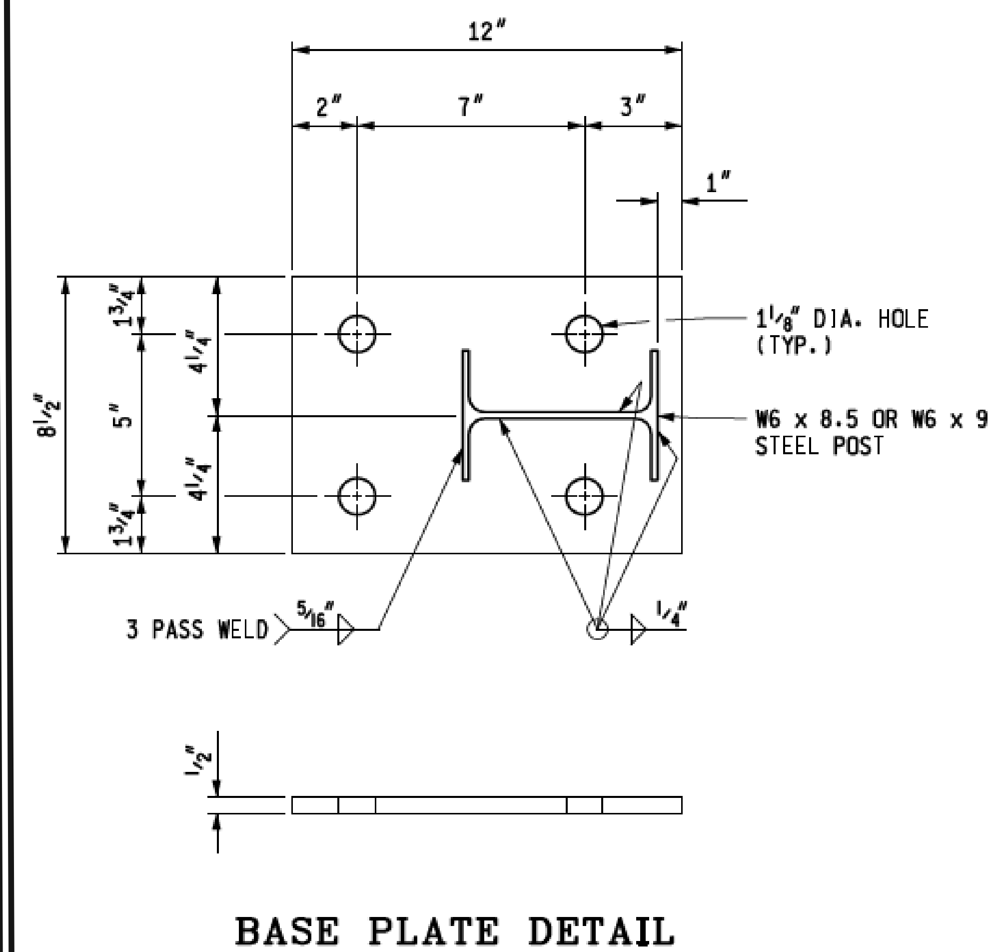


BASE PLATE DETAIL

Latest Version



Earlier Versions



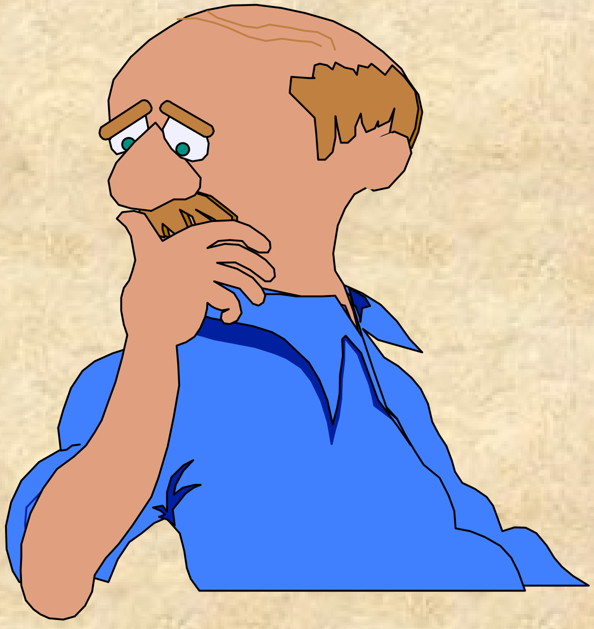
Same post type (W6x8.5 or W6x9), but different base plate and welding requirements

Barrier
End Treatments

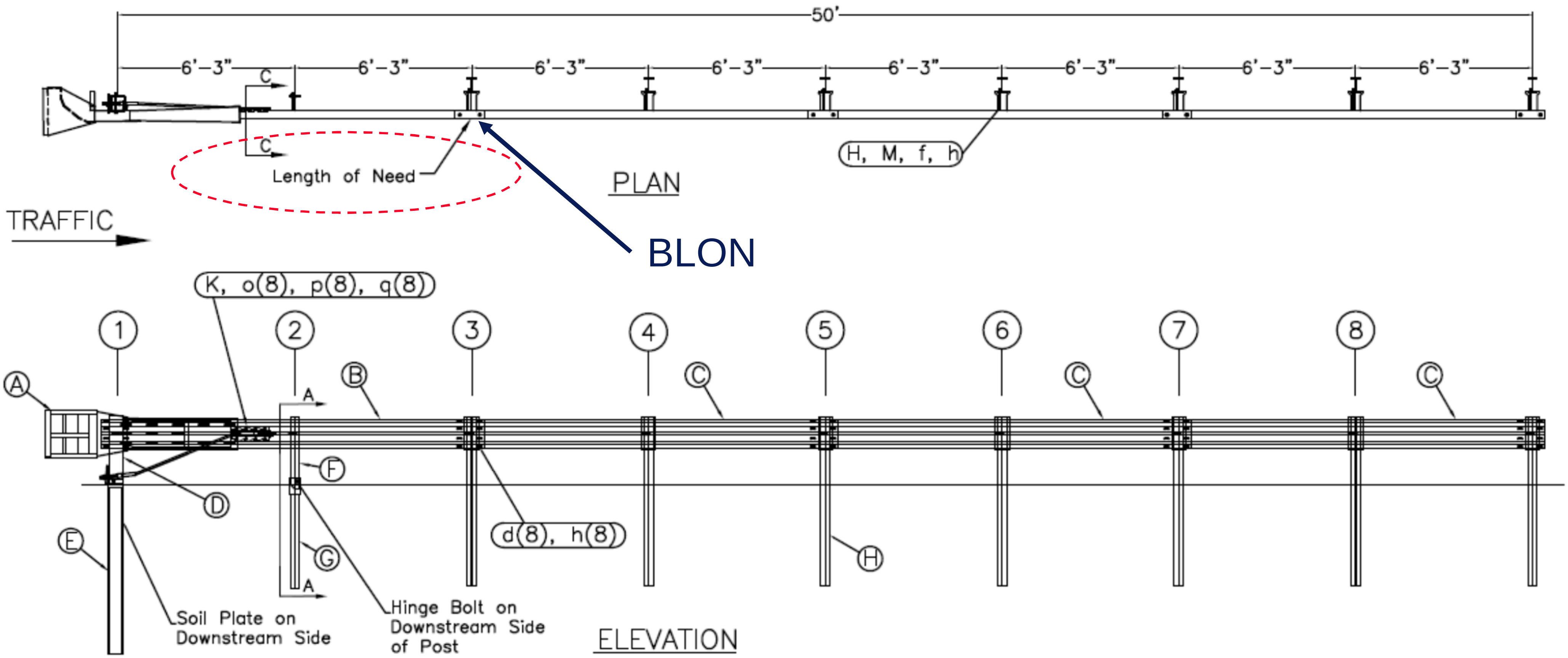
Guardrail Terminals

- Gating

- Non-Gating



Example of Gating Guardrail Terminals



Beginning Length of Need Point (BLON)

Point where terminal is capable of redirecting a vehicle

Gating Terminal

Gating Terminals

Section 7.01.25.E of RDM

- The area behind and beyond the terminal should be traversable and free of fixed objects

- A 20' x 75' (minimum) runout area beyond and parallel to the terminal should be provided


20’
75’

MDOT MASH Compliant Guardrail Approach Terminals

Type 2M (Tangent) Approach Terminals

- Soft-Stop
- MSKT
- MAX-Tension
- NGT (Next Generation Terminal) ***

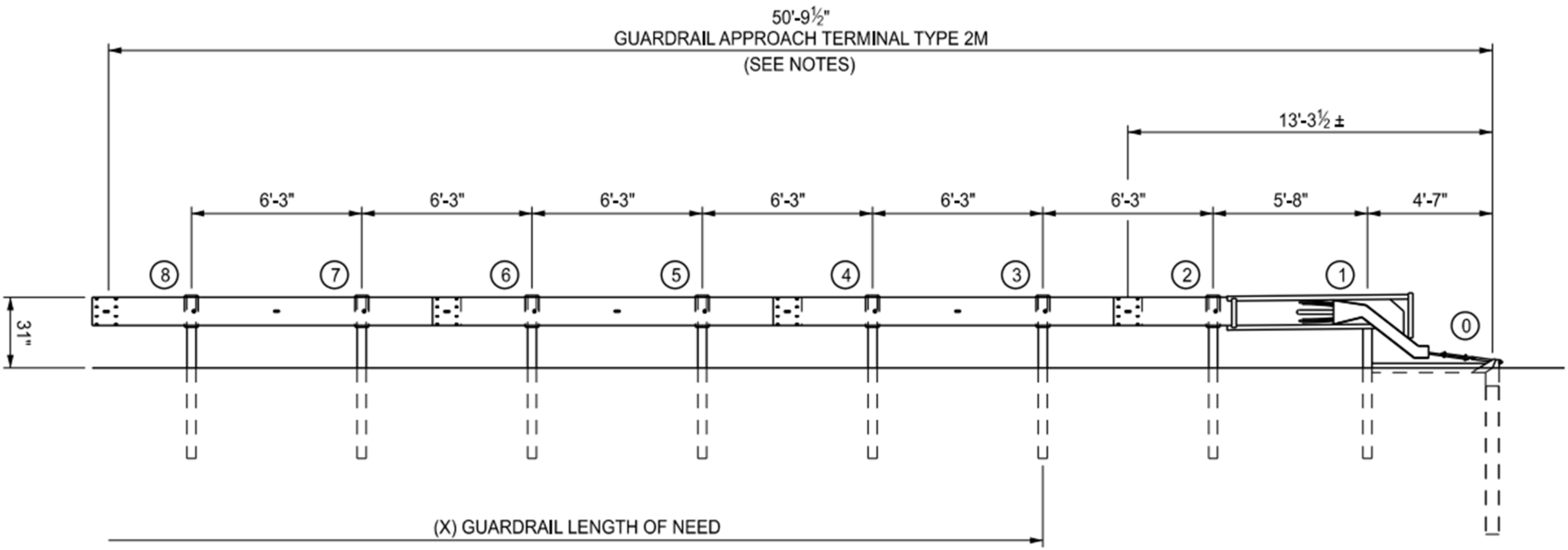
*** IMPLEMENTATION IN PROGRESS. Currently not shown in Standard Plan R-62 Series.

- Beginning Length of Need (BLON) varies by terminal

<u>USED FOR MAJORITY OF NEW SINGLE-SIDED GUARDRAIL APPROACH TERMINAL INSTALLATIONS</u>

MASH Compliant Guardrail Terminals

Soft-Stop



MDOT Standard Plan R-62-Series

MASH Compliant Guardrail Terminals

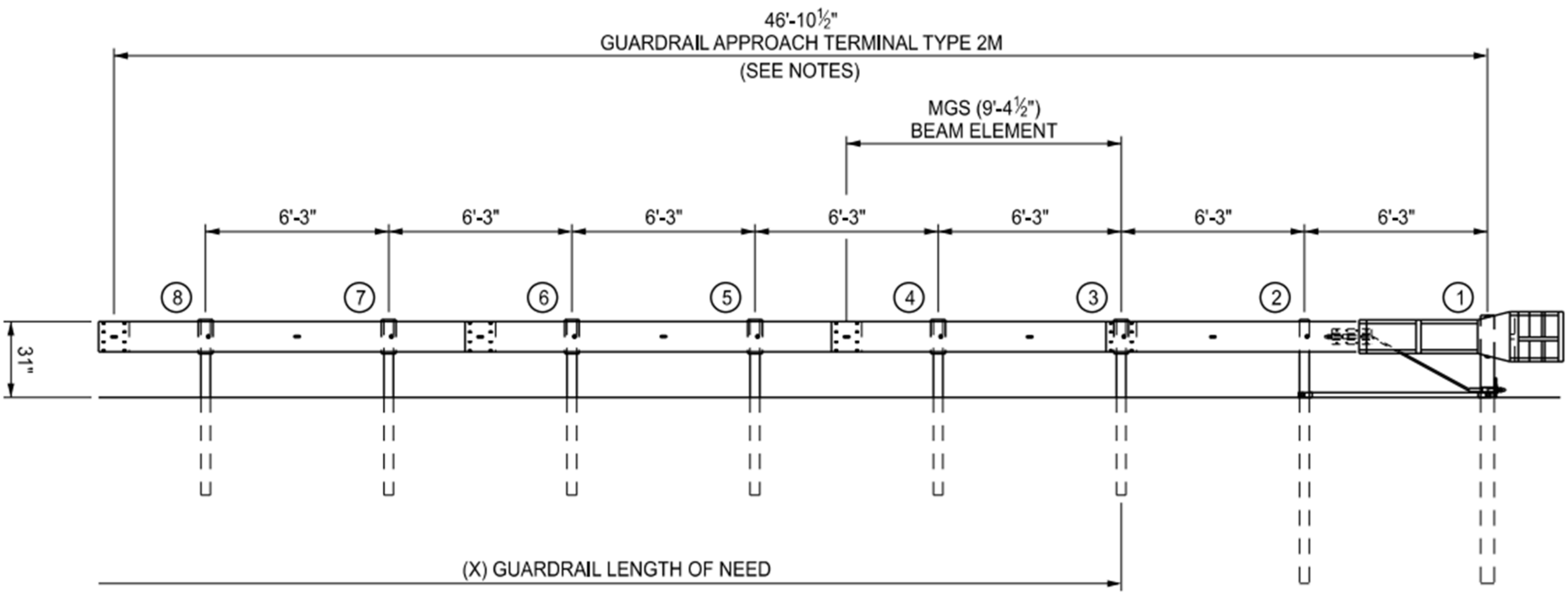
Source: Road Systems

MSKT (Road Systems, Inc.)


SKT
NCHRP 350 Compliant


MSKT
MASH Compliant
SKT
Source: Road Systems

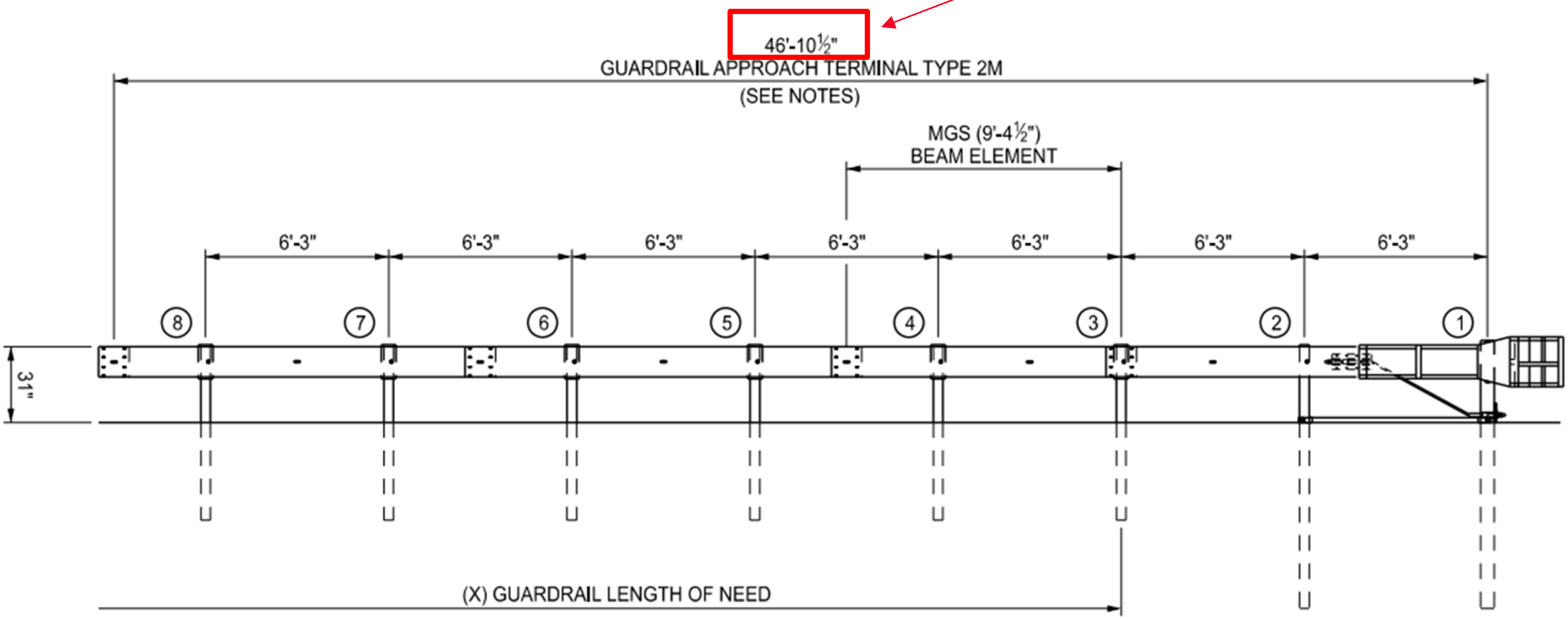
MSKT



MDOT Standard Plan R-62-Series

MSKT

59′-4½" in
earlier versions
of R-62 Series



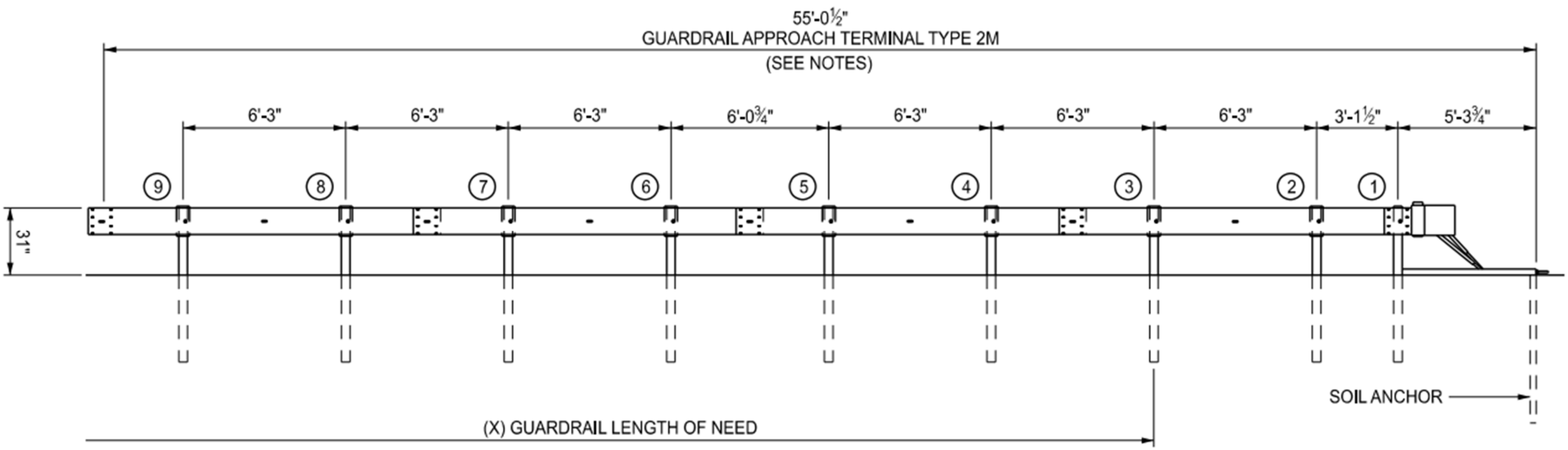
MDOT Standard Plan R-62-Series

MASH Compliant Guardrail Terminals

[*MAX-Tension (Lindsay Transportation Solutions)*]

Source: Safe Technologies Inc.

Max-Tension



MDOT Standard Plan R-62-Series

Max-Tension Crash Test Small Car (MASH, TL-3)

Max-Tension Crash Test
Pickup Truck (MASH, TL-3)

MASH Compliant Guardrail Terminals

Source: NextGen Safety, LLC

NGT (Next Generation Terminal)
(NextGen Safety, LLC)

**** COMING SOON! CURRENTLY NOT SHOWN IN STANDARD PLAN R-62 SERIES! ****

MDOT
MASH Compliant
Guardrail Approach Terminals

Type 3M (Double-Sided) Approach Terminals

- MATT
- MAX-Tension Median

➢ Beginning Length of Need (BLON) varies by terminal

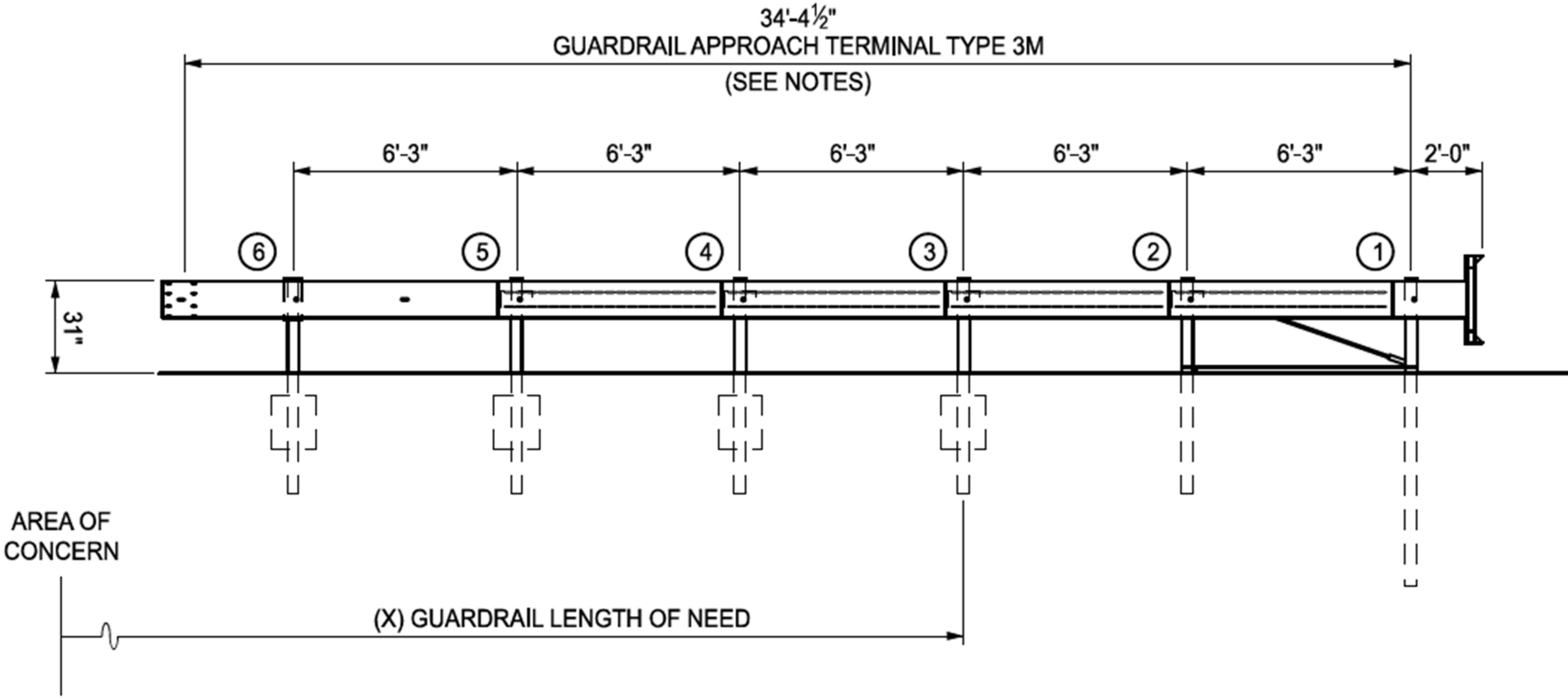
USED FOR NEW DOUBLE-SIDED GUARDRAIL APPROACH TERMINAL INSTALLATIONS

MATT
(Median Attenuating TREND Terminal)

- MASH, TL-3 compliant
- Standard Plan R-63 Series

Source: Valtir

MATT

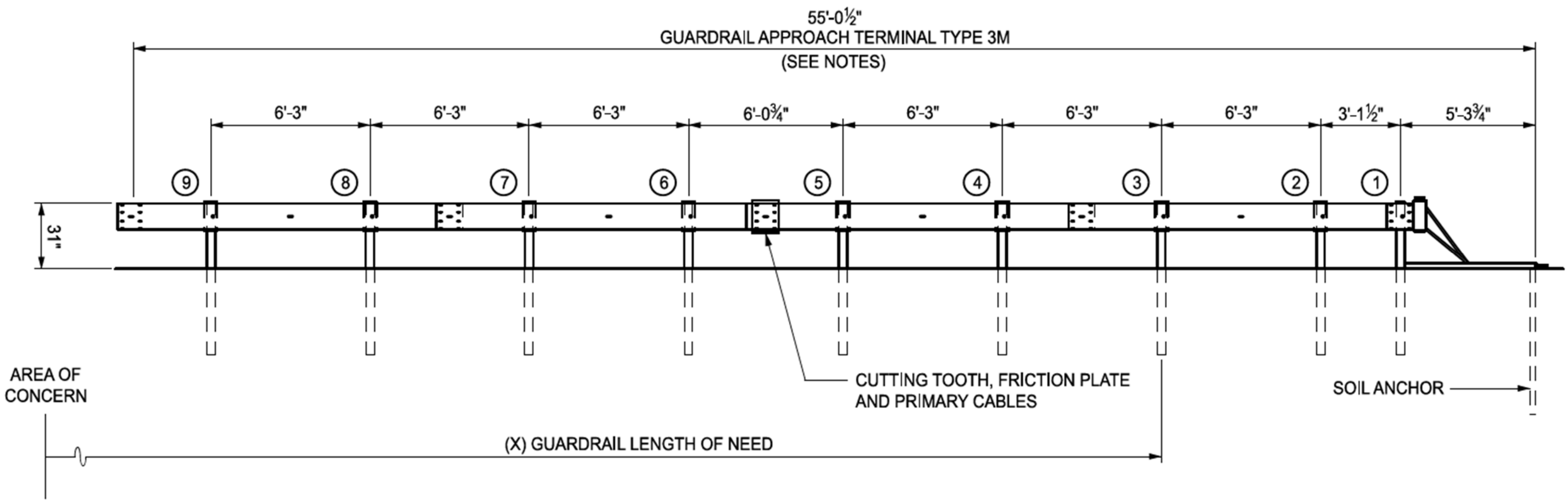


MDOT Standard Plan R-63-Series

MAX-Tension Median

- MASH, TL-3 compliant
- Standard Plan R-63 Series

MAX-Tension Median



MDOT Standard Plan R-63-Series

MDOT
NCHRP 350 Compliant
Guardrail Approach Terminals

Type 1B or 1T (Flared) Approach Terminals

- SRT
- FLEAT

  - Beginning Length of Need (BLON) starts 12’-6” from nose

USED VERY RARELY IN NEW GUARDRAIL INSTALLATIONS !

CONSULT WITH GEOMETRIC DESIGN UNIT BEFORE USING.

SRT (Slotted Rail Terminal)

FLEAT (Flared Energy Absorbing Terminal)

MDOT NCHRP 350 Compliant Guardrail Approach Terminals

Type 2B or 2T (Parallel) Approach Terminals

- **ET**
- **SKT**

  - **Beginning Length of Need (BLON) starts 12'-6" from nose**

<u>NOT USED FOR NEW GUARDRAIL INSTALLATIONS !</u>

ET (Extruder Terminal)

SKT (Sequential Kinking Terminal)

MDOT
NCHRP 350 Compliant
Guardrail Approach Terminals

Type 3B or 3T (Double-Sided) Approach Terminals

- CAT (Standard Plan R-63 Series)
- FLEAT-MT (Standard Plan R-63 Series)
- All Type 3 Terminals are gating
  - BLON varies by terminal

NOT USED FOR NEW GUARDRAIL INSTALLATIONS !

CAT
(Crash Cushion Attenuation Terminal)

FLEAT-MT
(Median Terminal)

MDOT
Guardrail Approach Terminals

Type 4 (Buried in Backslope)

- Non-proprietary
- Special Detail 24
- Non-Gating Terminal

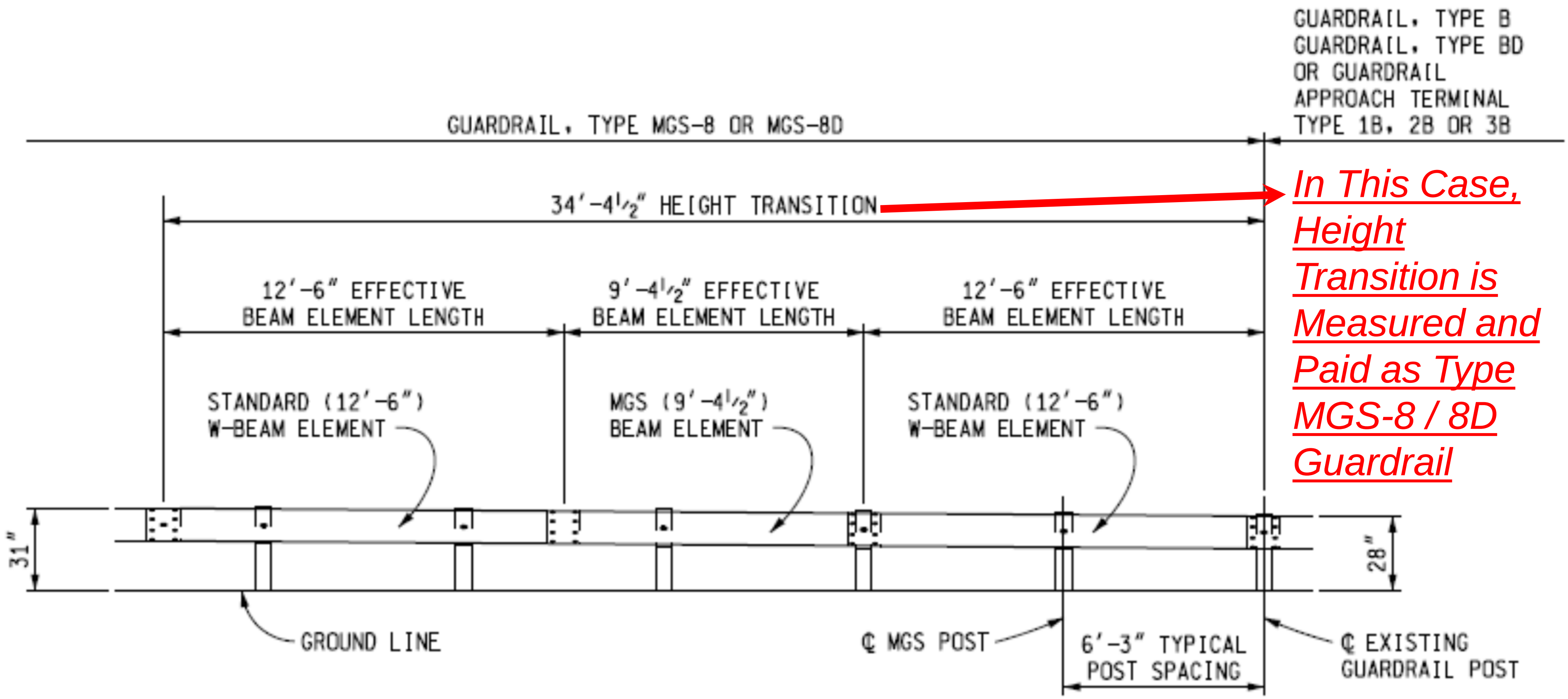
➢ CAN BE USED FOR NEW GUARDRAIL INSTALLATIONS

➢ RECOMMENDED WHEN CONDITIONS ALLOW ITS USE

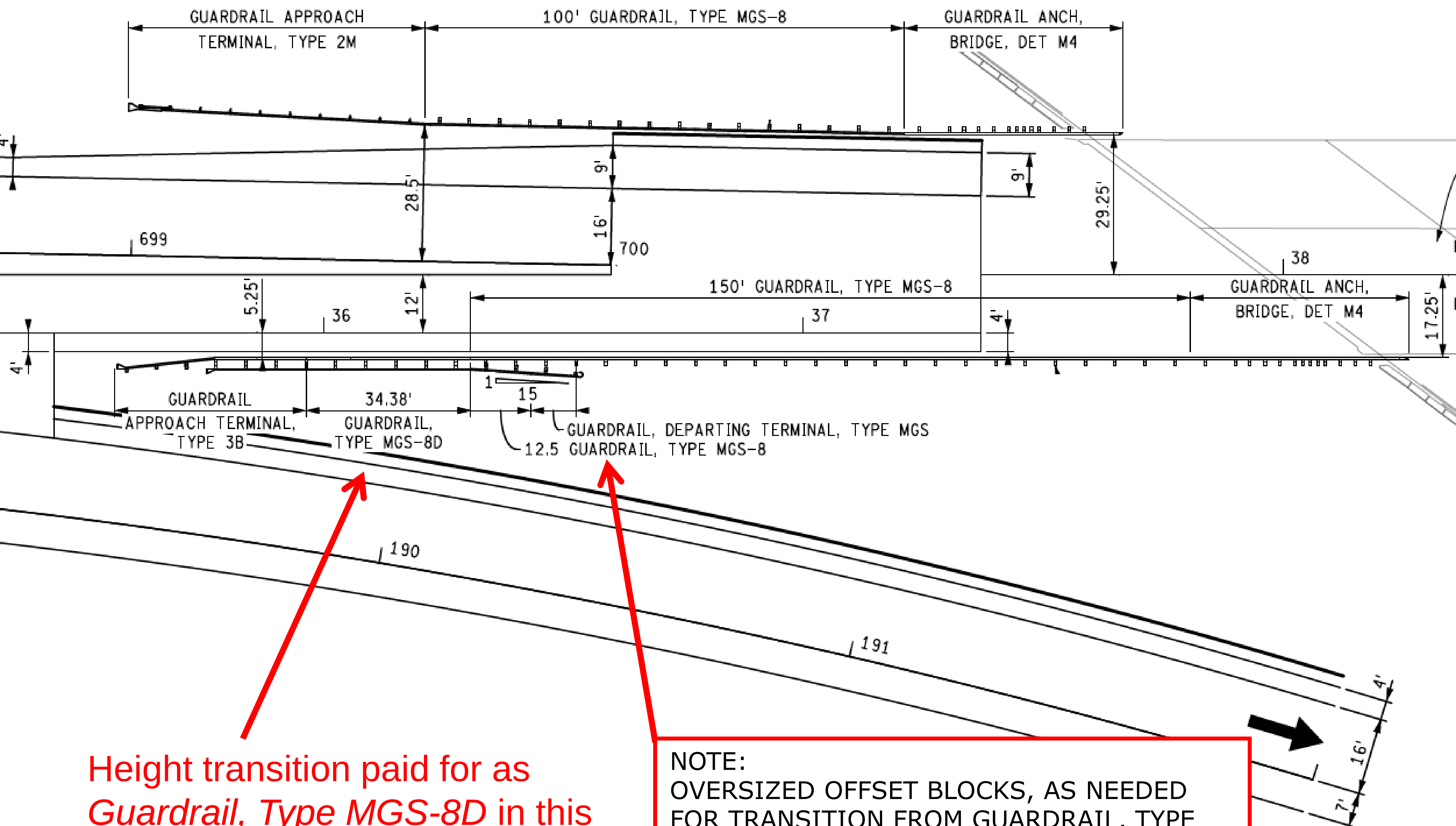
Buried in Backslope

Transition: MGS-8/8D to Type B or Guardrail Approach Terminals 1B/3B

MDOT Standard Plan R-60-Series



ELEVATION SHOWING POST SPACING CONNECTING GUARDRAIL, TYPE MGS-8 OR MGS-8D TO GUARDRAIL, TYPE B, GUARDRAIL, TYPE BD, OR GUARDRAIL APPROACH TERMINAL TYPE 1B, 2B, OR 3B

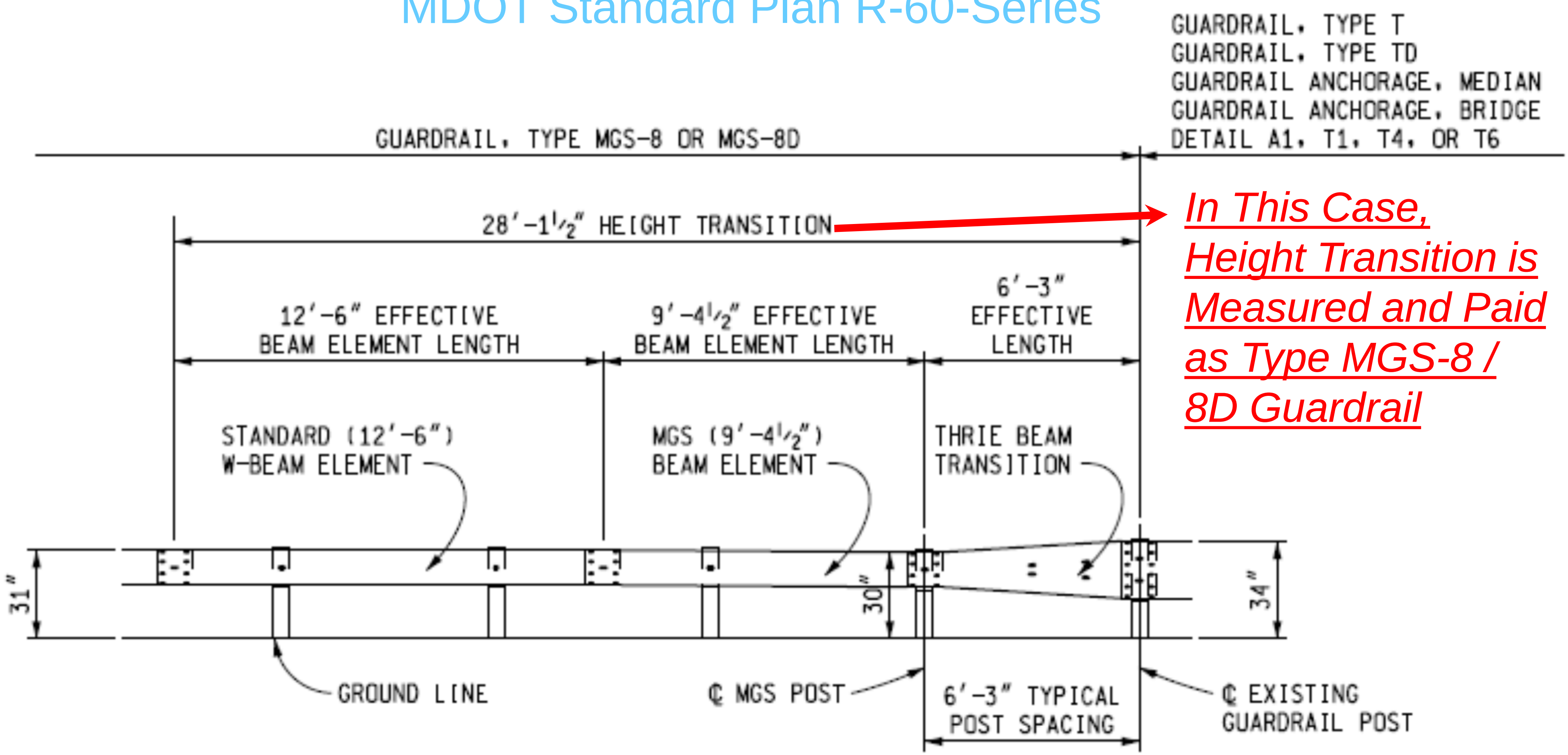


Height transition paid for as *Guardrail, Type MGS-8D* in this example.

NOTE:
OVERSIZED OFFSET BLOCKS, AS NEEDED FOR TRANSITION FROM GUARDRAIL, TYPE MGS-8D TO TYPE, MGS-8, ARE INCLUDED IN THE PAY ITEM GUARDRAIL, TYPE MGS-8.

Transition: MGS-8/8D to Type T/TD or Guardrail Bridge/Median Anchorages

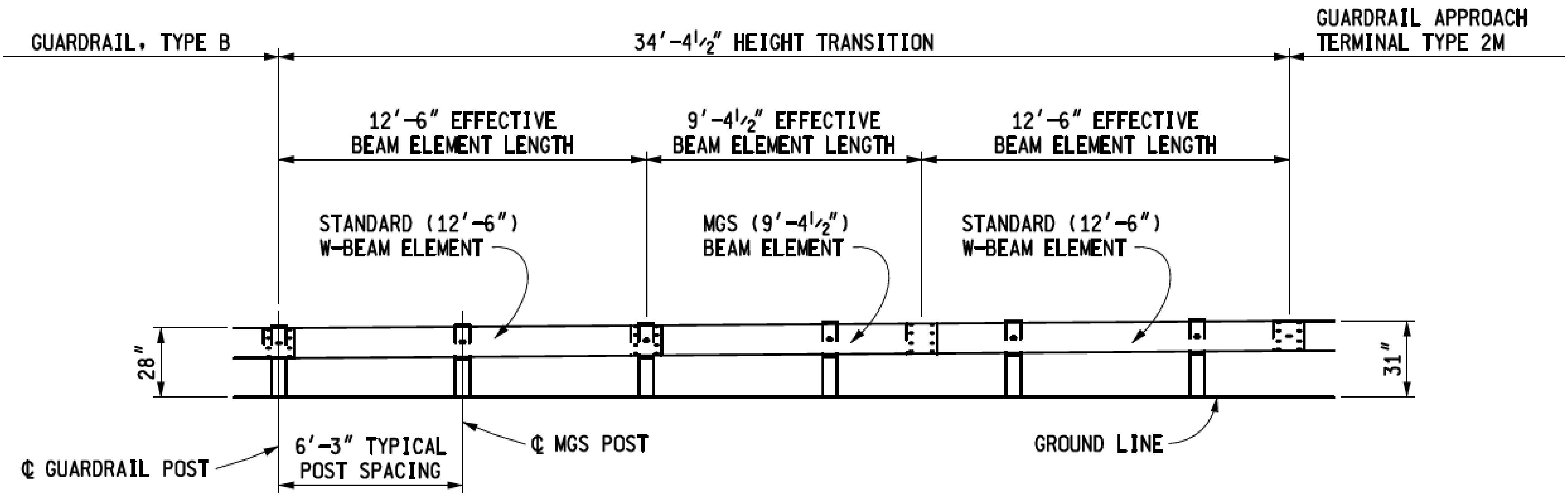
MDOT Standard Plan R-60-Series



ELEVATION SHOWING POST SPACING CONNECTING GUARDRAIL, TYPE MGS-8 OR MGS-8D TO GUARDRAIL, TYPE T, GUARDRAIL, TYPE TD, GUARDRAIL ANCHORAGE, MEDIAN, GUARDRAIL ANCHORAGE, BRIDGE DETAIL A1, T1, T4 OR T6

Transition: Type B to Guardrail Approach Terminal 2M

MDOT Standard Plan R-60-Series

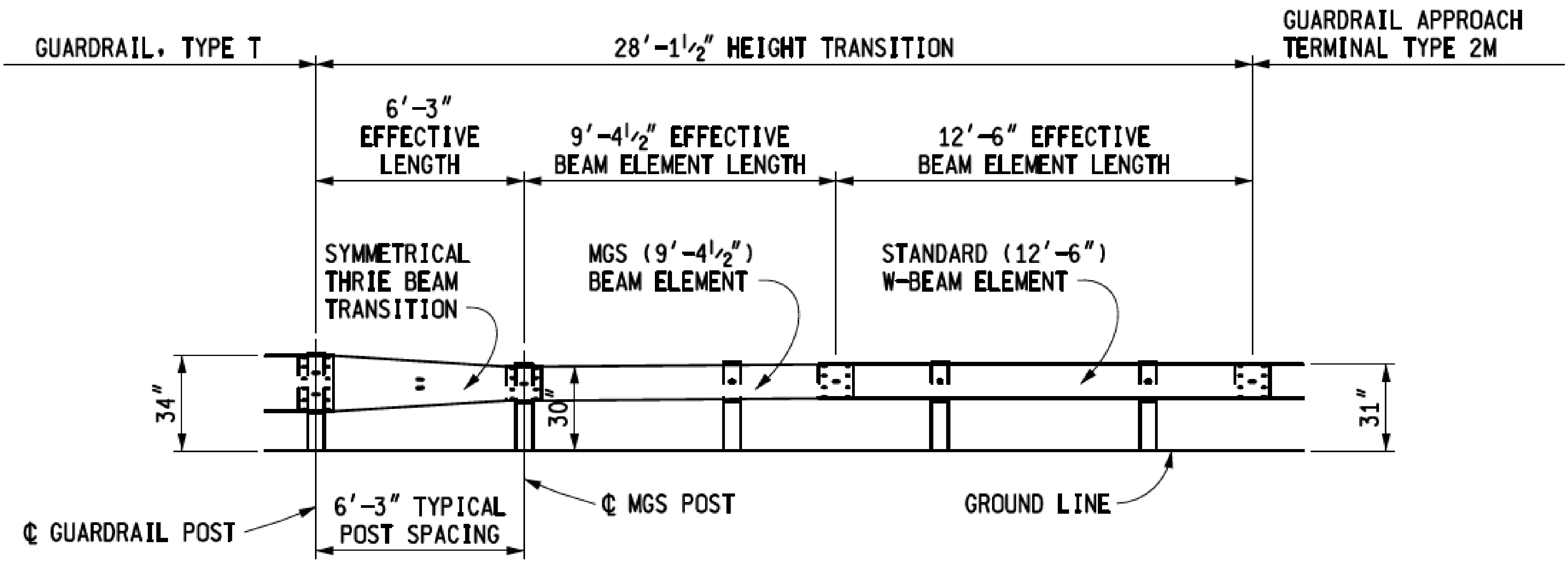


ELEVATION SHOWING TRANSITION DETAIL FOR CONNECTING GUARDRAIL, TYPE B TO GUARDRAIL APPROACH TERMINAL TYPE 2M

NOTE: 34'-4½" Height Transition Included as Part of Guardrail Approach Terminal, Type 2M pay item, as defined in Guardrail Approach Terminal, Type 2M FUSP.

Transition: Type T to Guardrail Approach Terminal 2M

MDOT Standard Plan R-60-Series



ELEVATION SHOWING TRANSITION DETAIL FOR CONNECTING
GUARDRAIL, TYPE T TO
GUARDRAIL APPROACH TERMINAL TYPE 2M

NOTE: 28'-1½" Height Transition Included as Part of Guardrail Approach Terminal, Type 2M pay item, as defined in Guardrail Approach Terminal, Type 2M FUSP.

Payment for Height Transitions When Connecting Guardrail Approach Terminal, Type 2M to Guardrail Types B or T

MDOT FUSP 20SP-807F

d. **Measurement and Payment.** The completed work, as described, will be measured and paid for at the contract unit price using the pay items defined in section 807 of the Standard Specifications for Construction. Payment for guardrail approach terminal installation includes constructing a guardrail approach terminal of specified length per Standard Plan R-62 Series and, when required, a transition section per Standard Plan R-60 Series for connecting guardrail approach terminal to guardrail Type B or Type T.

- Transition Included as Part of *Guardrail Approach Terminal, Type 2M* Pay Item

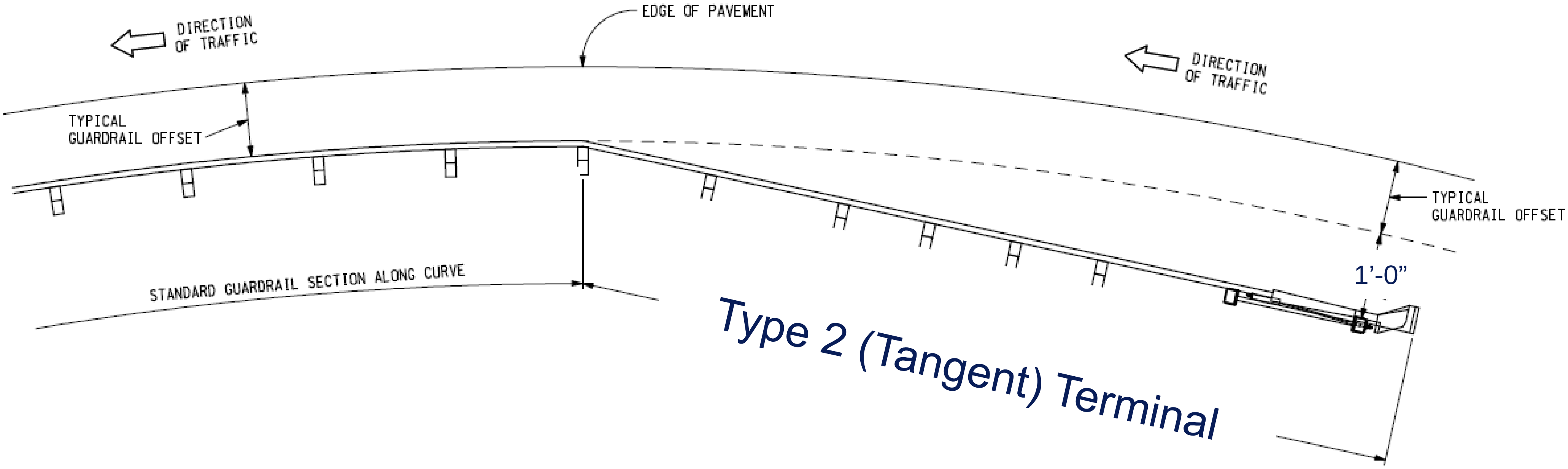
Guardrail Terminal Action Plan

- Use Type 2M guardrail approach terminals for all new installations and upgrades on MDOT trunkline projects, unless deemed unfeasible due to site-specific conditions
  - Use of NCHRP 350 compliant Type 1 (flared) terminals will be permitted on a case-by-case basis
    - Consult with the MDOT Geometric Design Unit, Design Division for assistance

May be difficult to install Type 2 (tangent) approach terminal in this case

- Consult with MDOT Geometric Design Unit, Design Division

Possible Solution
Type 2 (Tangent) Terminal Along Inside of Curve



Guardrail Terminal Action Plan

- On trunkline projects, only use Type 1B and 1T guardrail approach terminals when absolutely necessary.
  - Consult with the Geometric Design Unit.
- It will be necessary to obtain project-specific special details, and develop a special provision, in order to use Type 1B or 1T guardrail approach terminals on a project.

Guardrail Terminal Action Plan

- Use the Type 2M guardrail terminal *frequently used special provision (FUSP)* and *Standard Plan R-62 Series* when specifying Type 2M guardrail approach terminals
  - Per the FUSP, manufacturers will be required to provide an electronic copy of detailed drawings, installation manuals, and maintenance manuals for each type of terminal being provided.

Guardrail Terminal Action Plan

- Use the Type 3M guardrail terminal *frequently used special provision (FUSP)* and *Standard Plan R-63 Series* when specifying Type 3M guardrail approach terminals
  - Per the FUSP, manufacturers will be required to provide an electronic copy of detailed drawings, installation manuals, and maintenance manuals for each type of terminal being provided.

Guardrail Terminal Action Plan

- Continue using Buried-in Backslope or Type 4 terminals (Special Detail 24 Series).

Departing Terminals

- Detailed in MDOT Standard Plan R-66 Series

Important Note:

- Departing terminals may not be placed within approaching traffic's clear zone
  - Not designed to withstand a head-on impact
  - Comparable to blunt end

Departing Terminals

- Type B Departing Terminals are used for terminating Type B guardrail (i.e., W-Beam Guardrail)
- Type T Departing Terminals are used for terminating Type T guardrail (i.e., Thrie-Beam Guardrail)
- Terminal is <u>not</u> flared
- It has a semi-circular end shoe
- Last post does <u>not</u> have an offset block
- No ground strut

Departing Terminals

- Type MGS Departing Terminals are used for terminating Type MGS-8 guardrail
- Terminal is <u>not</u> flared
- It has a semi-circular end shoe
- Last post does <u>not</u> have an offset block
- No ground strut

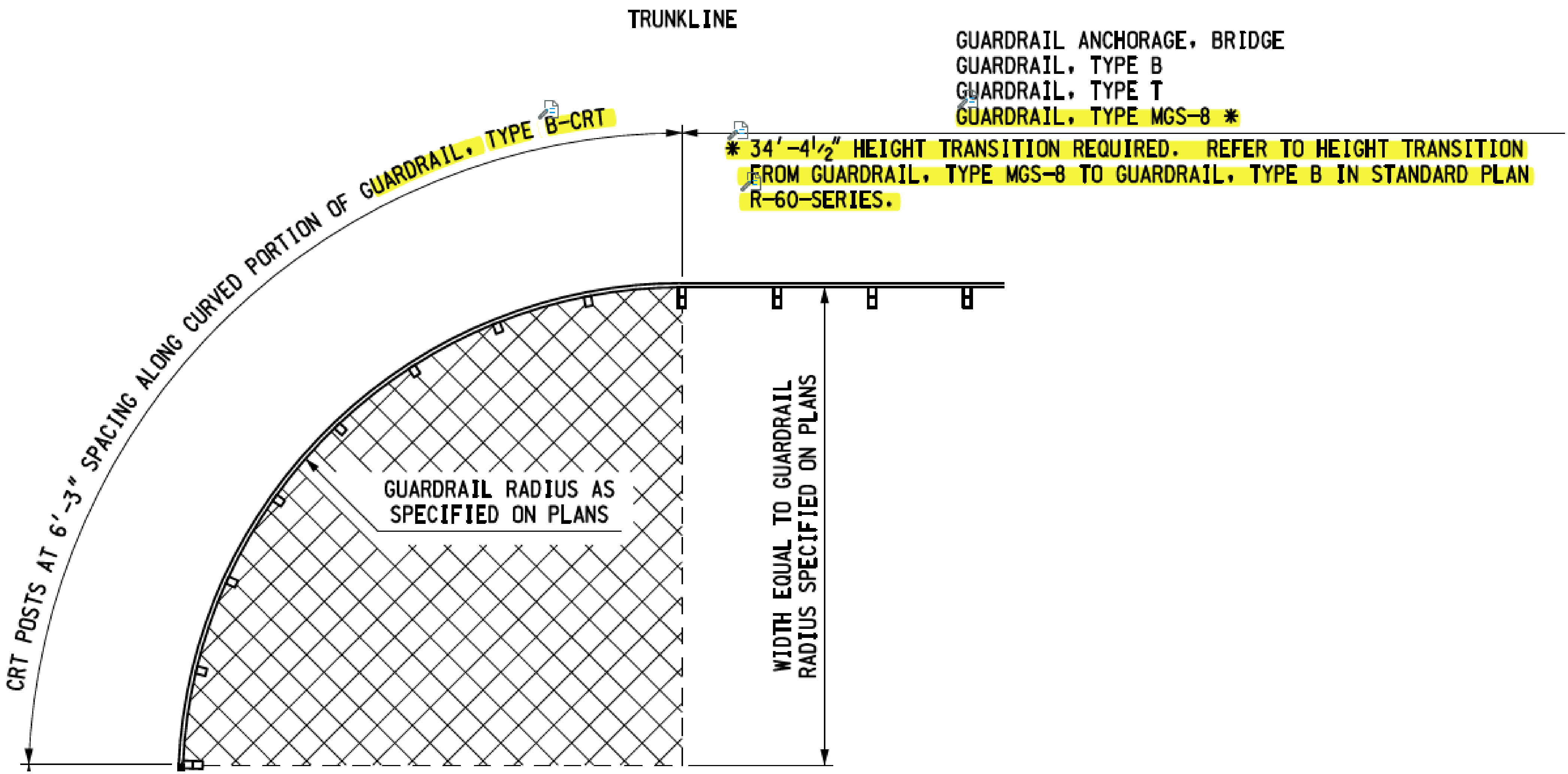
Curved Guardrail

Curved Guardrail

Key Features:

- Used primarily when there is guardrail at intersections (e.g., driveways, freeway ramps, side streets, etc.).
- Guardrail can be terminated at the end of the curve with either an approach terminal or departing terminal.
- Guardrail may continue to run parallel to intersecting roadway beyond curved portion.
    - ***MDOT Special Detail 21***

Use Type B-CRT guardrail along curved section when using Special Detail 21

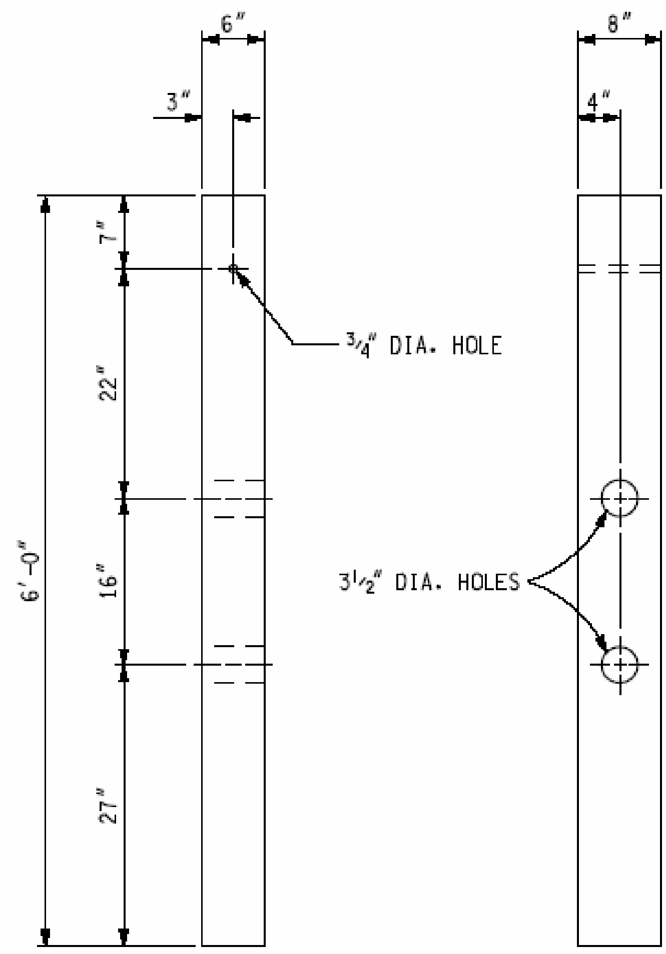


Curved Type B-CRT Guardrail Pay Items

Pay Item	**Pay Unit**
Guardrail, Curved, Type B-CRT	Foot
Guardrail, Curved, Temp, Type B-CRT	Foot

- Defined in Frequently Used Special Provision (FUSP) 20SP-807H
- Clearly identifies when Special Detail 21 is applicable
  - Curved Type B guardrail pay item was used previously

Use CRT Posts Along Curved Portion of Special Detail 21



CONTROLLED RELEASING TERMINAL POST
(CRT)

Curved Guardrail

NOTE:
FOR DRIVEWAYS, IF R.O.W. ALLOWS, USE DEPARTING END TERMINAL. (SEE STANDARD PLAN R-66-SERIES) IF R.O.W. IS LIMITED SUCH THAT A TYPICAL DEPARTING END TERMINAL CANNOT BE FIT IN, DRILL 8 HOLES IN THE CURVED BEAM GUARDRAIL TO ACCOMODATE AN ANCHOR PLATE AND INSTALL A CABLE ANCHOR SIMILAR TO THAT OF THE DEPARTING END TERMINAL ON STANDARD PLAN R-66-SERIES. THIS WILL BE PAID FOR AS GUARDRAIL, DEPARTING TERMINAL.

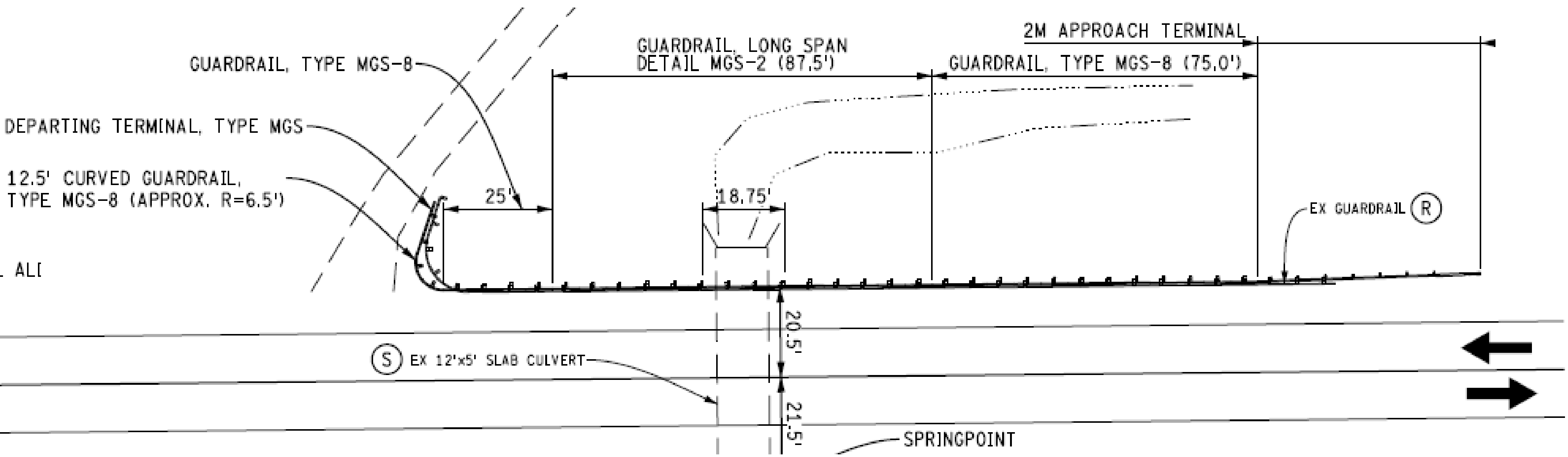
- Always use an approach terminal or departing terminal, as appropriate, to terminate curved guardrail
- Never use a terminal end shoe by itself
  - Common mistake

Purpose of Cable Assembly

Curved Guardrail

NOTE:

- Not all curved guardrail installations are constructed per Special Detail 21.



- In the example above, curved Type MGS-8 guardrail was correctly specified.
    - Not constructed according to Special Detail 21.

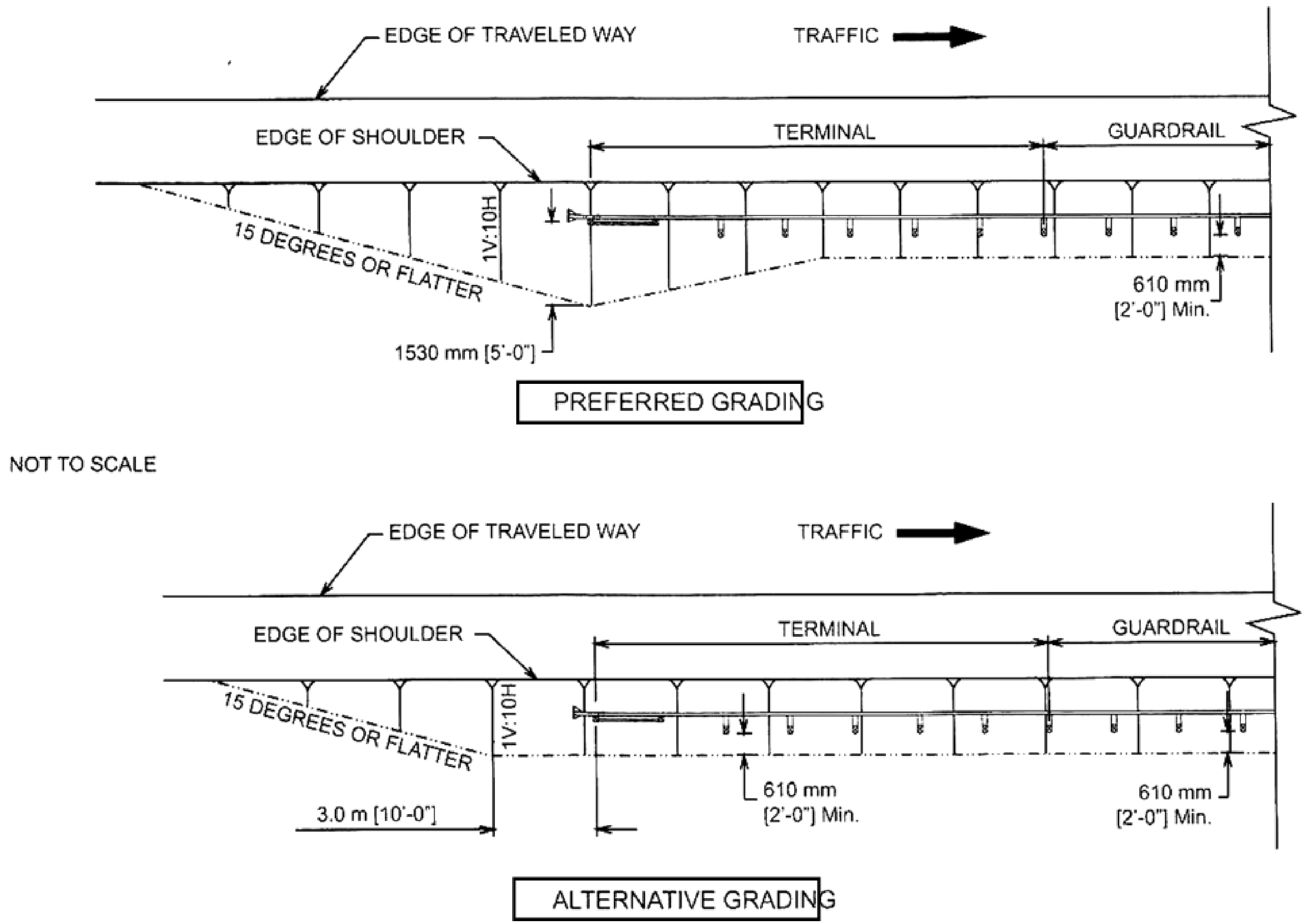
Grading

1:10 slope or flatter at least 2'-0" feet behind guardrail posts and tapering toward road in advance of terminal

<u>Note, this applies to ALL guardrail approach terminals</u>

<u>Designers must ensure grading quantities are included!</u>

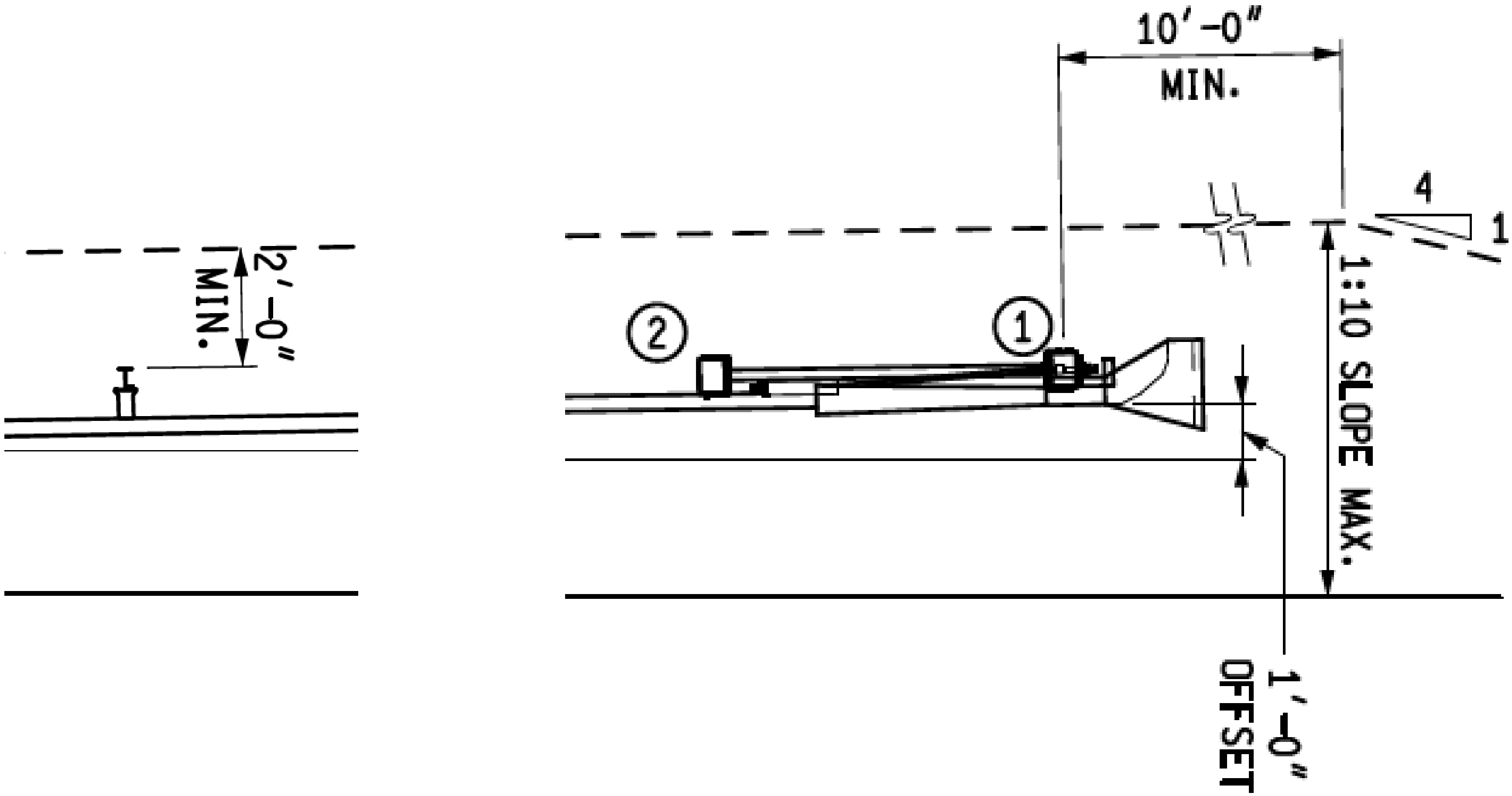
AASHTO Roadside Design Guide Terminal Grading Recommendations



Source: MSKT Installation Manual

Guardrail Approach Terminal, Type 2M Grading Requirements

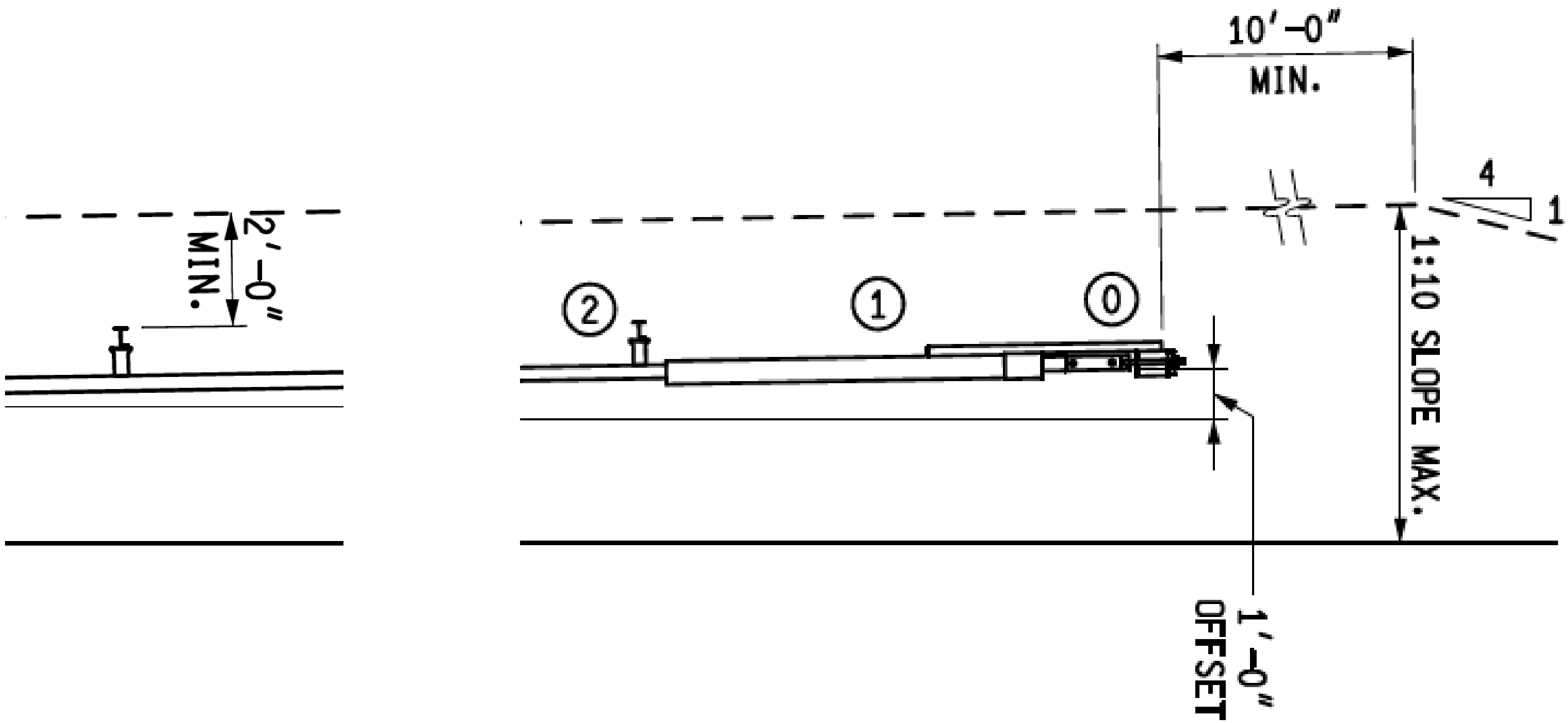
MDOT Standard Plan R-62 Series



MSKT

Guardrail Approach Terminal, Type 2M Grading Requirements

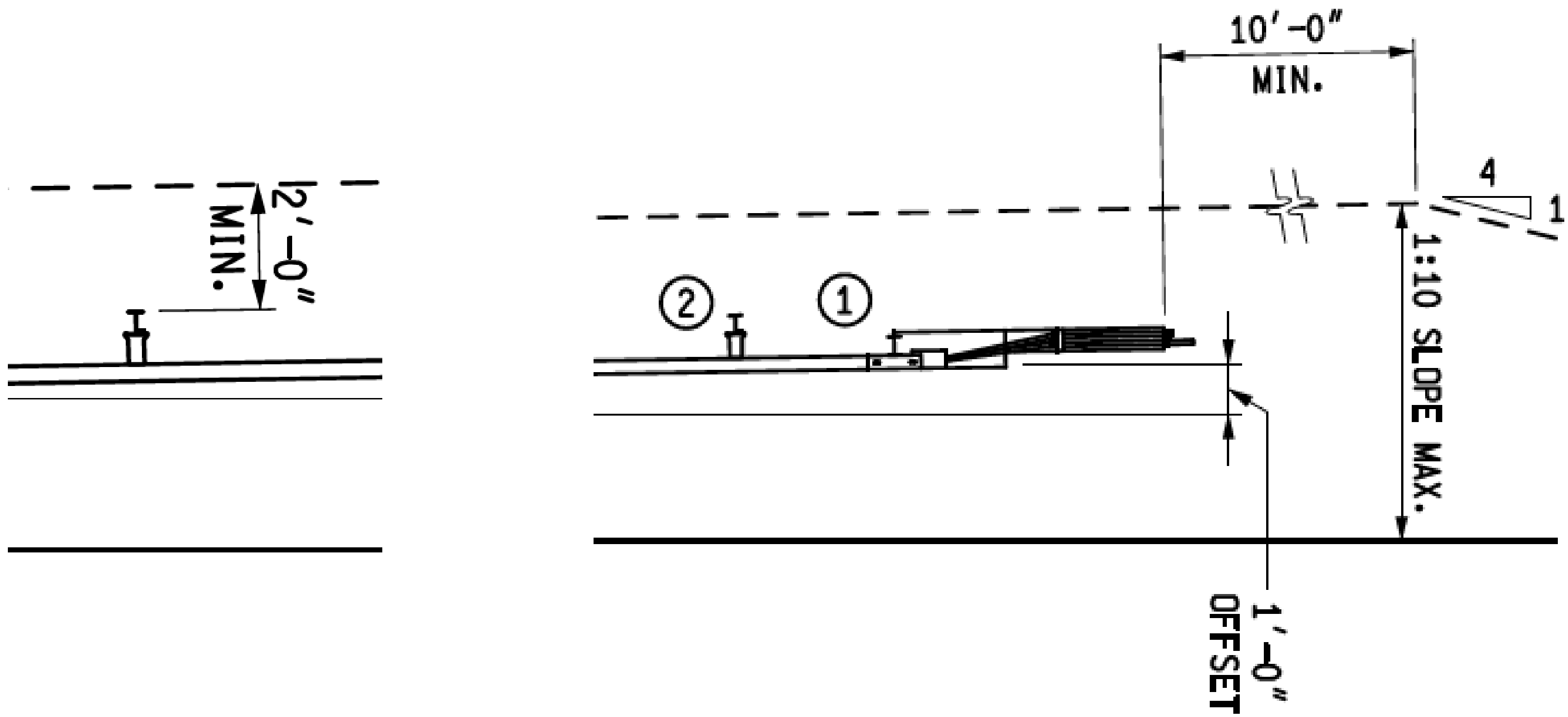
MDOT Standard Plan R-62 Series



Soft-Stop

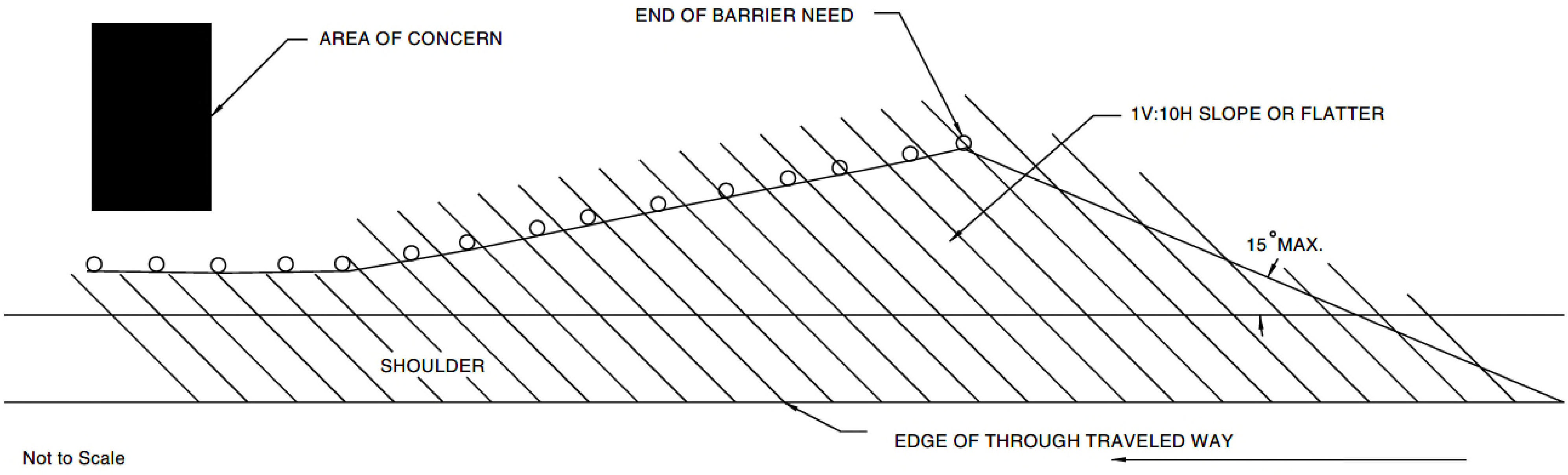
Guardrail Approach Terminal, Type 2M
Grading Requirements

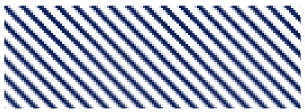
MDOT Standard Plan R-62 Series



Max-Tension

Preferred Grading
In Vicinity of
Flared Guardrail and Terminal





= 1:10 or flatter

Grading Quantities and Pay Items

- Ensure earthwork and slope restoration pay items and quantities are included for all necessary grading associated with guardrail installations

- Standard guardrail pay items only include shoulder/berm grading to provide drainage
  - This is very minor and does not cover significant slope regrading and other required slope work

Lack of Grading

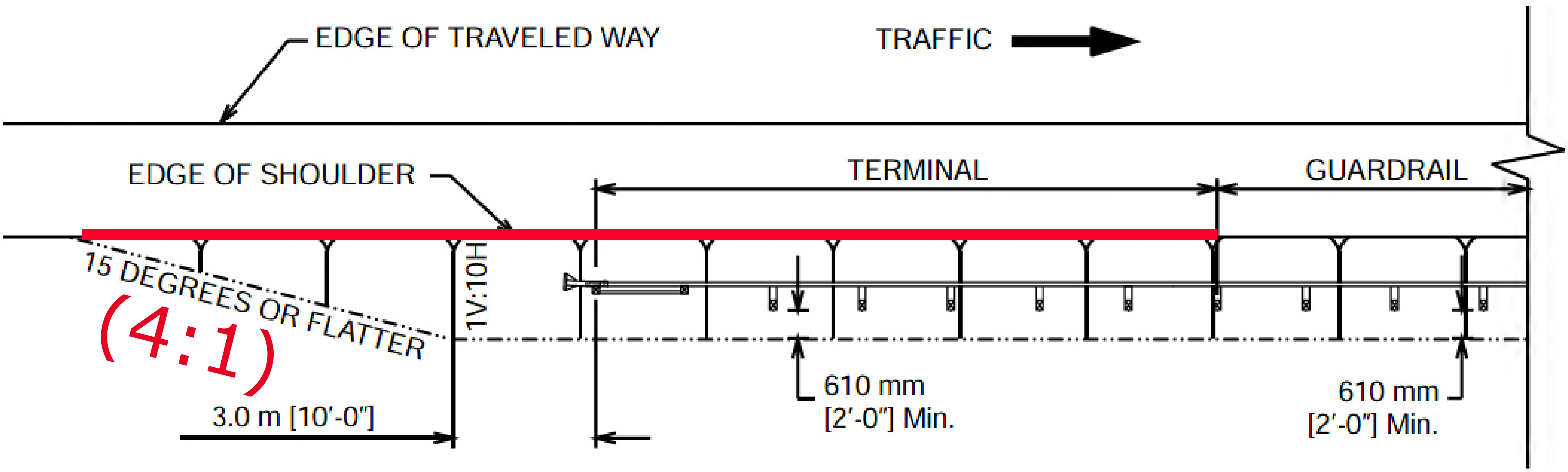
Poor/Improper Grading

Hinge Point Too Close to Approach Terminal Posts
(Should be at least 2'-0" Behind Posts)

Curb in Vicinity of Guardrail Approach Terminal

- Try to avoid placing curbs adjacent to guardrail terminals if possible. But if a curb is necessary:
  - Use Type D curb or valley gutter adjacent to terminal
  - Transition from high profile curb to Type D or valley gutter in advance of approach terminal
  - Transition should occur at or in advance of grading transition

Low-Profile Curb Placement Recommendation

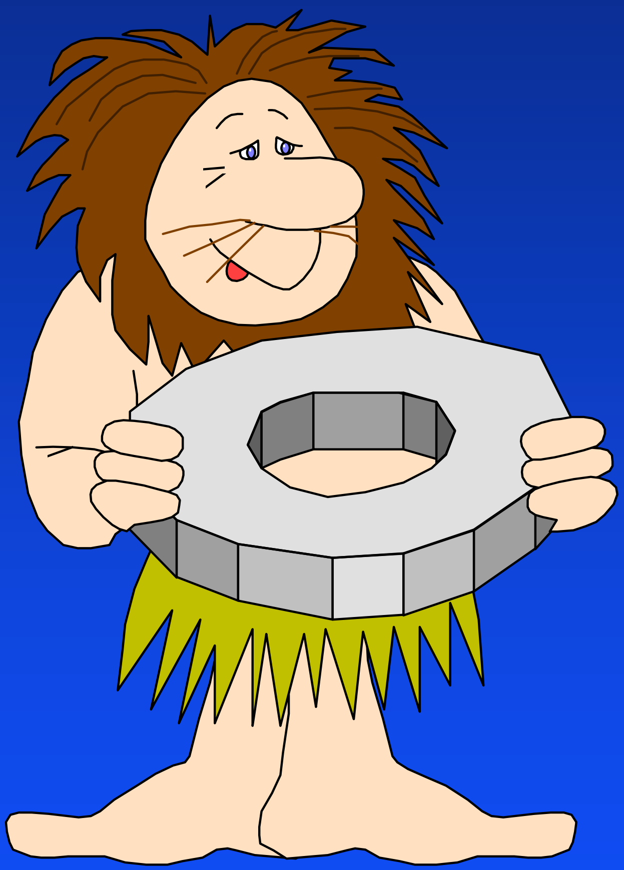


Low-Profile Curb / No Curb Recommended

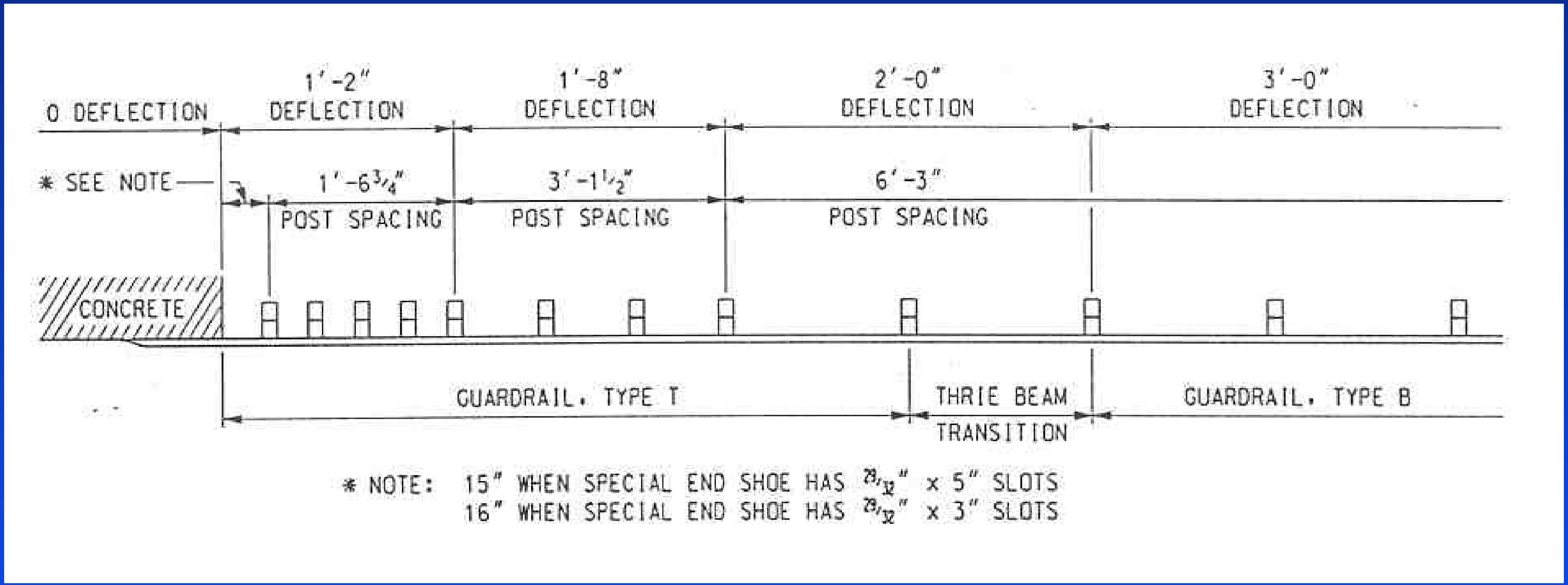
Guardrail
Anchorages and Transitions

Anchorages & Transitions

- Adequate Connection
- Block Outs as Specified
- Adequate Length
- *Gradually Increase Stiffness*



Guardrail Strength Transition

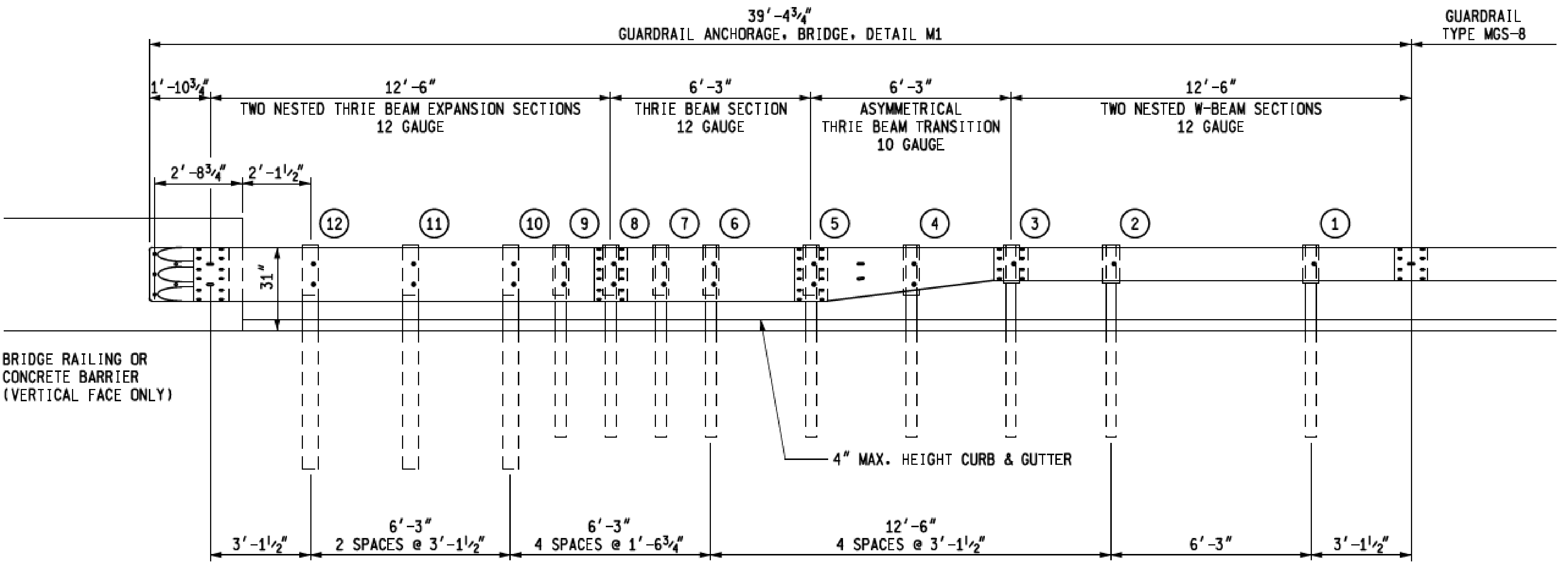


- Typical transition from guardrail to concrete
- Must have gradual change in stiffness
  - Avoid sudden and extreme changes in stiffness

M-Series Guardrail Anchorages

MDOT Standard Plan R-67-Series

- There are nine different M-Series anchorages
  - Determined by designer and defined in guardrail anchorage pay item
  - Function of guardrail type attached to anchorage and concrete barrier type
- However, T-Series anchorages will be used for anchoring to existing concrete safety-shape railings (e.g., Type 4 and Type 5 Bridge Railings)



MDOT Approved Guardrail Transitions

- Guardrail Anchorage Bridge Detail M-1
- Guardrail Anchorage Bridge Detail M-2
- Guardrail Anchorage Bridge Detail M-3

MASH-Compliant Anchorages

Detailed in MDOT Standard Plan R-67 Series

MDOT Approved Guardrail Transitions

- Guardrail Anchorage Bridge Detail M-4
- Guardrail Anchorage Bridge Detail M-5
- Guardrail Anchorage Bridge Detail M-6

MASH-Compliant Anchorages

Detailed in MDOT Standard Plan R-67 Series

MDOT Approved Guardrail Transitions

- Guardrail Anchorage Bridge Detail M-7
- Guardrail Anchorage Bridge Detail M-8
- Guardrail Anchorage Bridge Detail M-9

MASH-Compliant Anchorages

Detailed in MDOT Standard Plan R-67 Series

MDOT Approved Guardrail Transitions

- Guardrail Anchorage Bridge Detail T-1
- Guardrail Anchorage Bridge Detail T-2
- Guardrail Anchorage Bridge Detail T-3

Detailed in MDOT Standard Plan R-67-SD

NOTES: Only Used for Connecting to Safety-Shape Barriers

➢ T-series anchorages are NCHRP 350 Compliant

MDOT Approved Guardrail Transitions

- Guardrail Anchorage Bridge Detail T-4
- Guardrail Anchorage Bridge Detail T-5

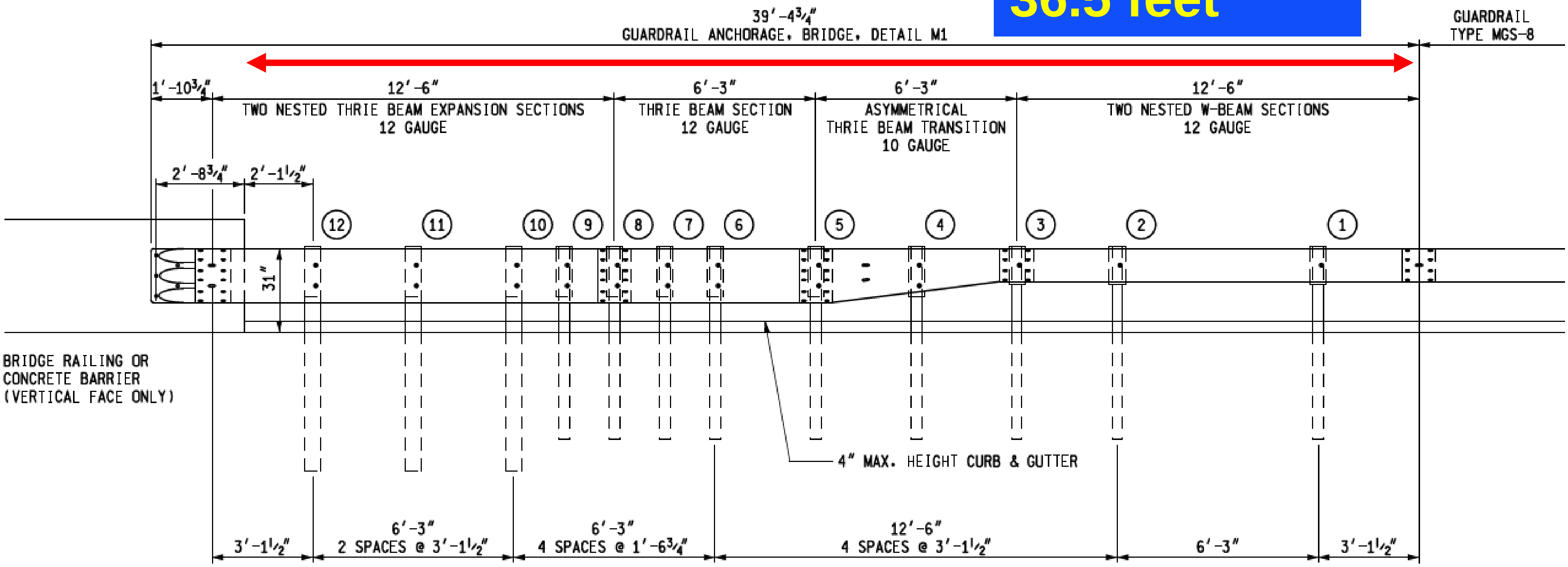
Detailed in MDOT Standard Plan R-67-SD

NOTES: Only Used for Connecting to Safety-Shape Barriers

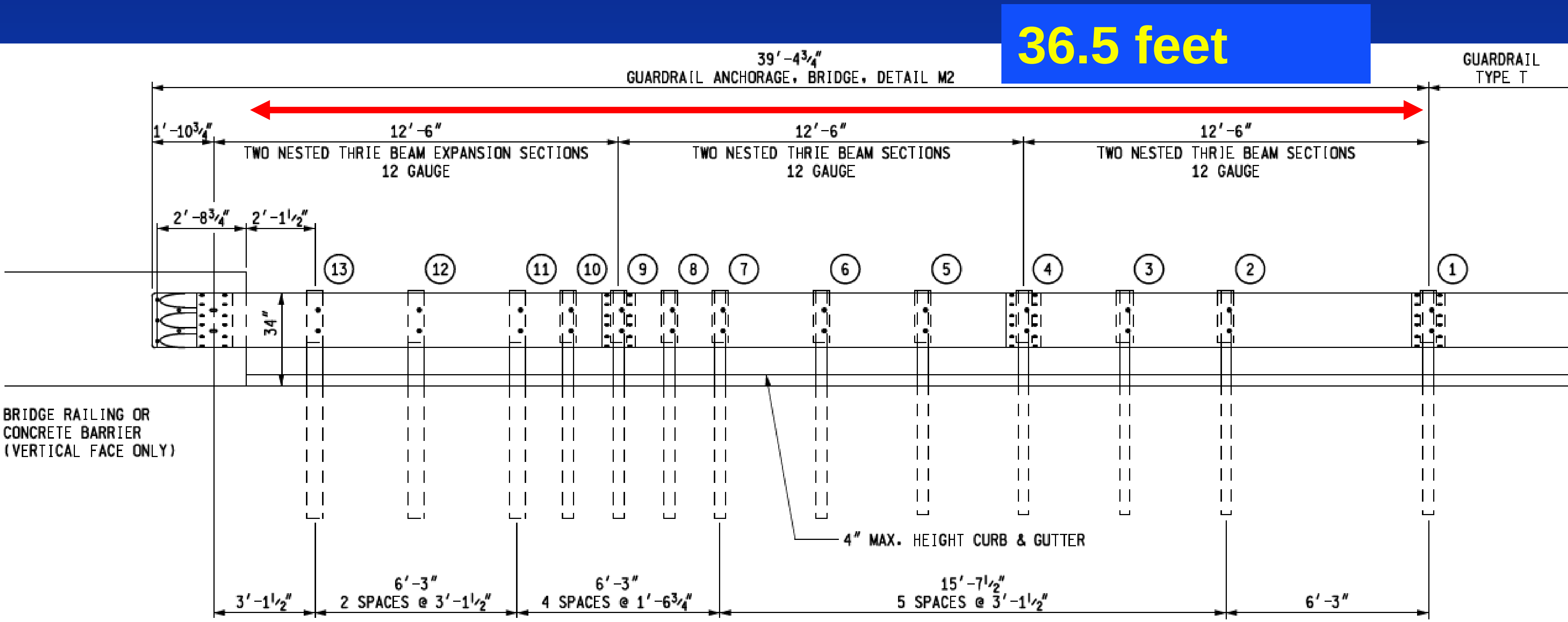
- T-series anchorages are NCHRP 350 Compliant

Detail M-1 (Sheet 1; R-67-G)

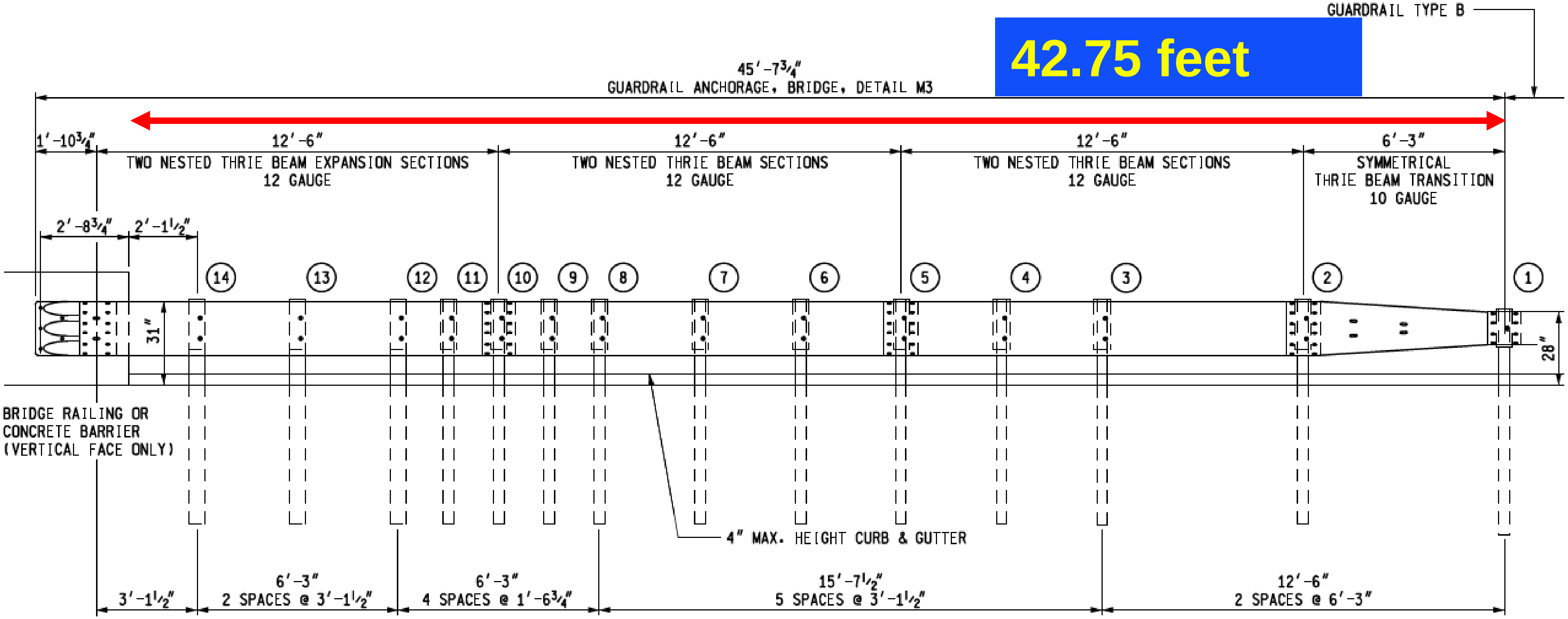
36.5 feet



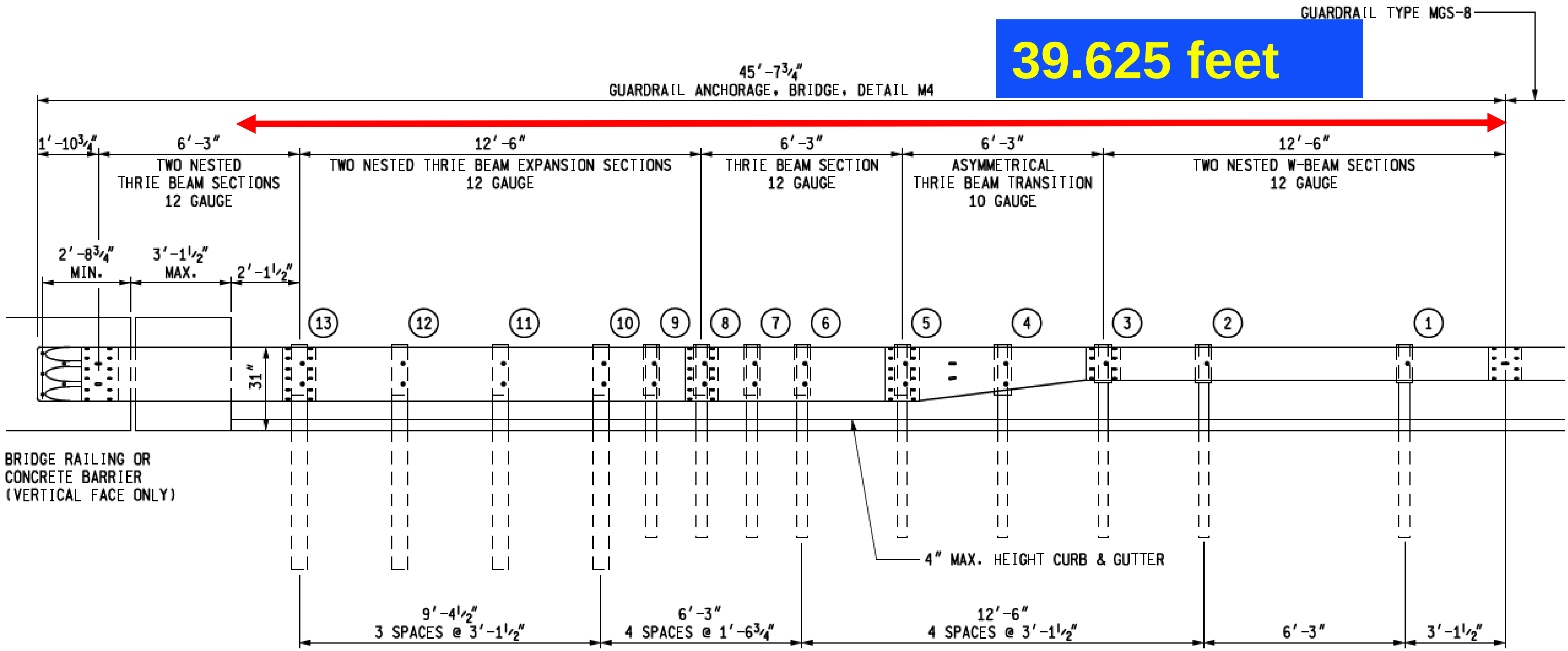
Detail M-2 (Sheet 2; R-67-G)



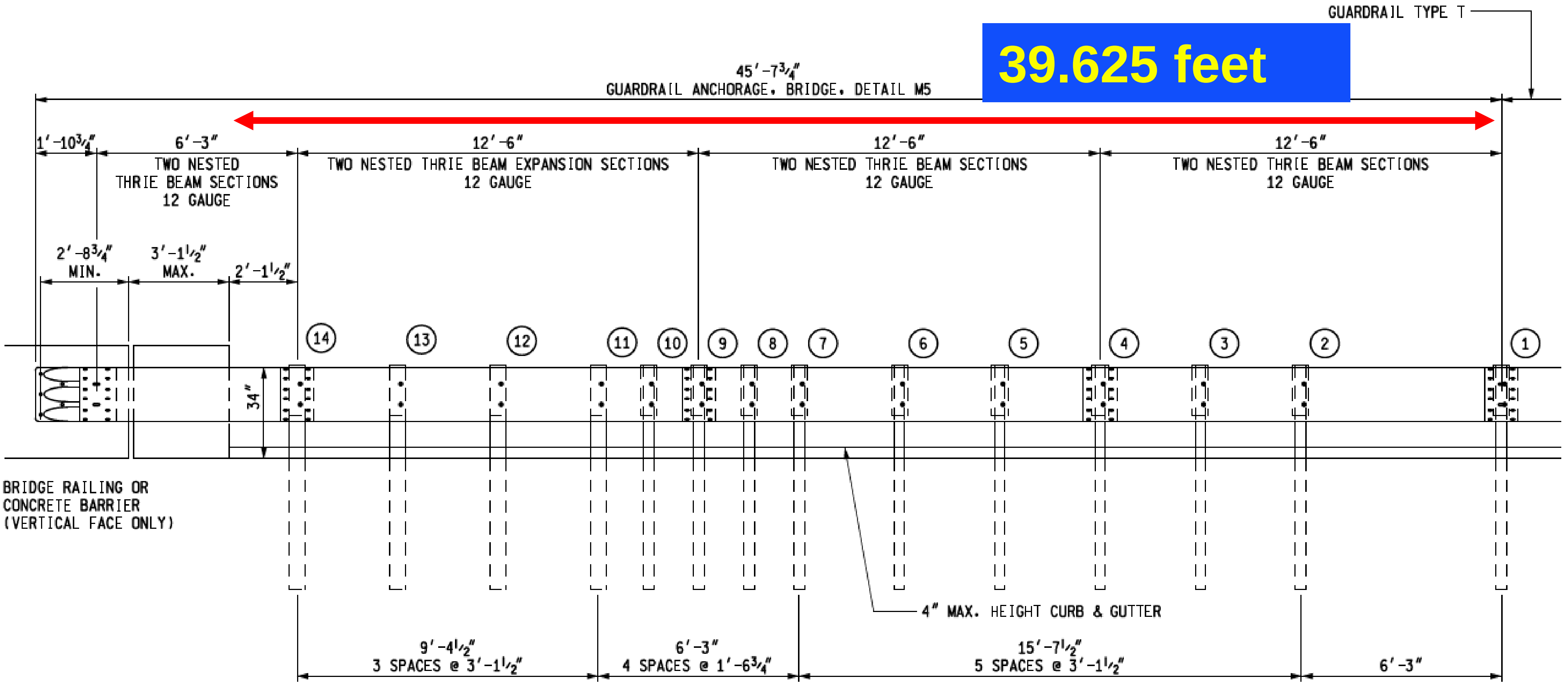
Detail M-3 (Sheet 3; R-67-G)



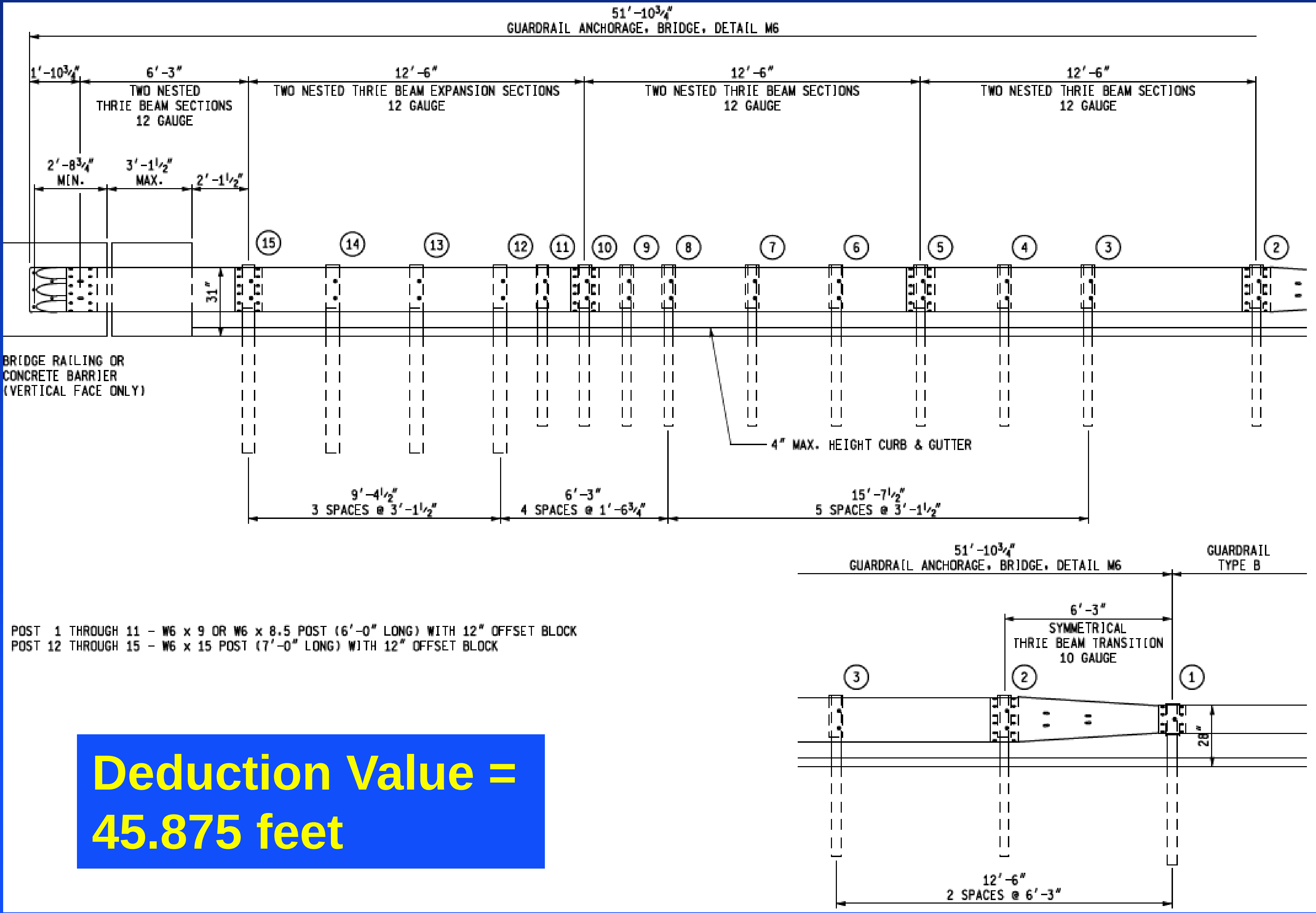
Detail M-4 (Sheet 4; R-67-G)



Detail M-5 (Sheet 5; R-67-G)

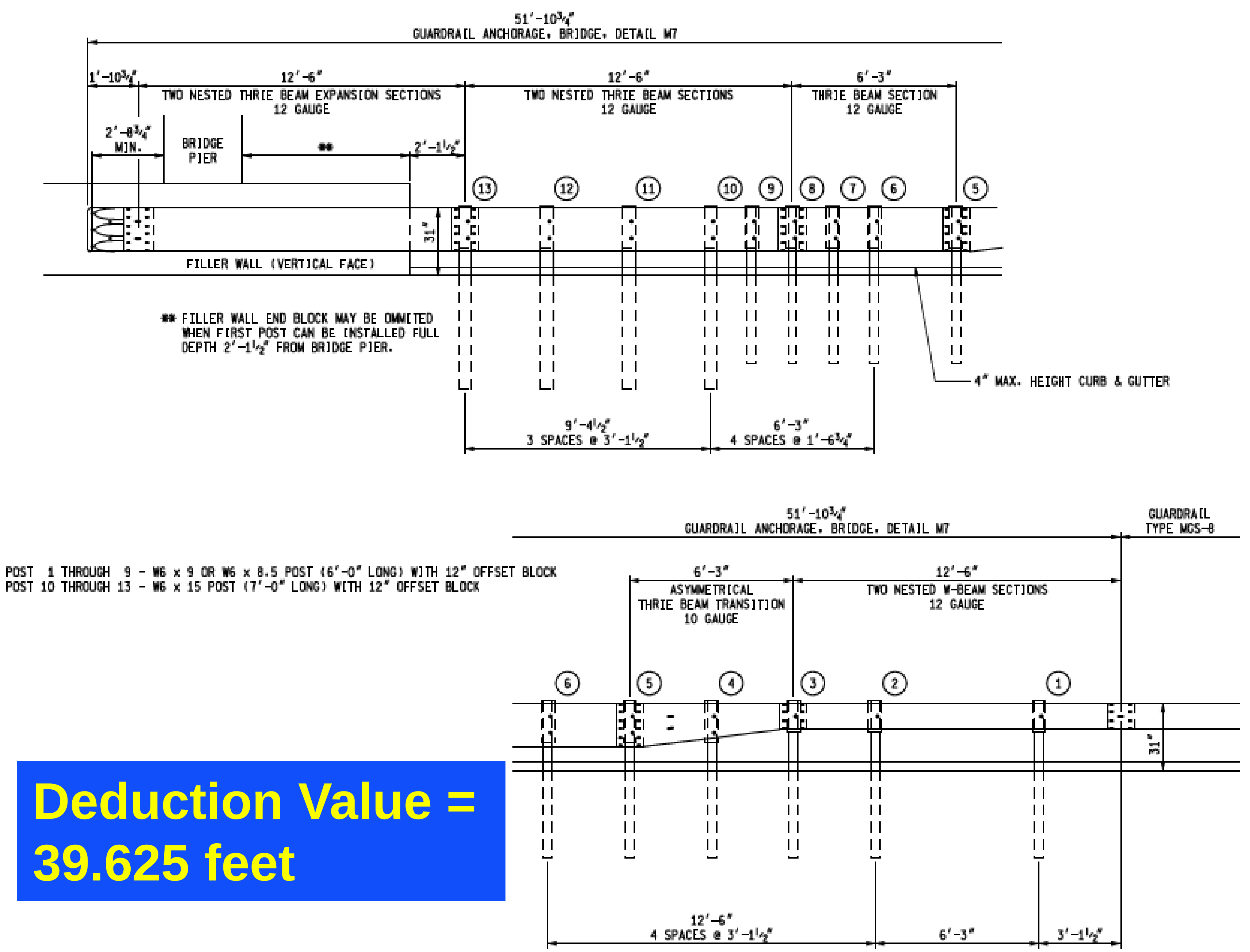


Detail M-6 (Sheet 6; R-67-G)



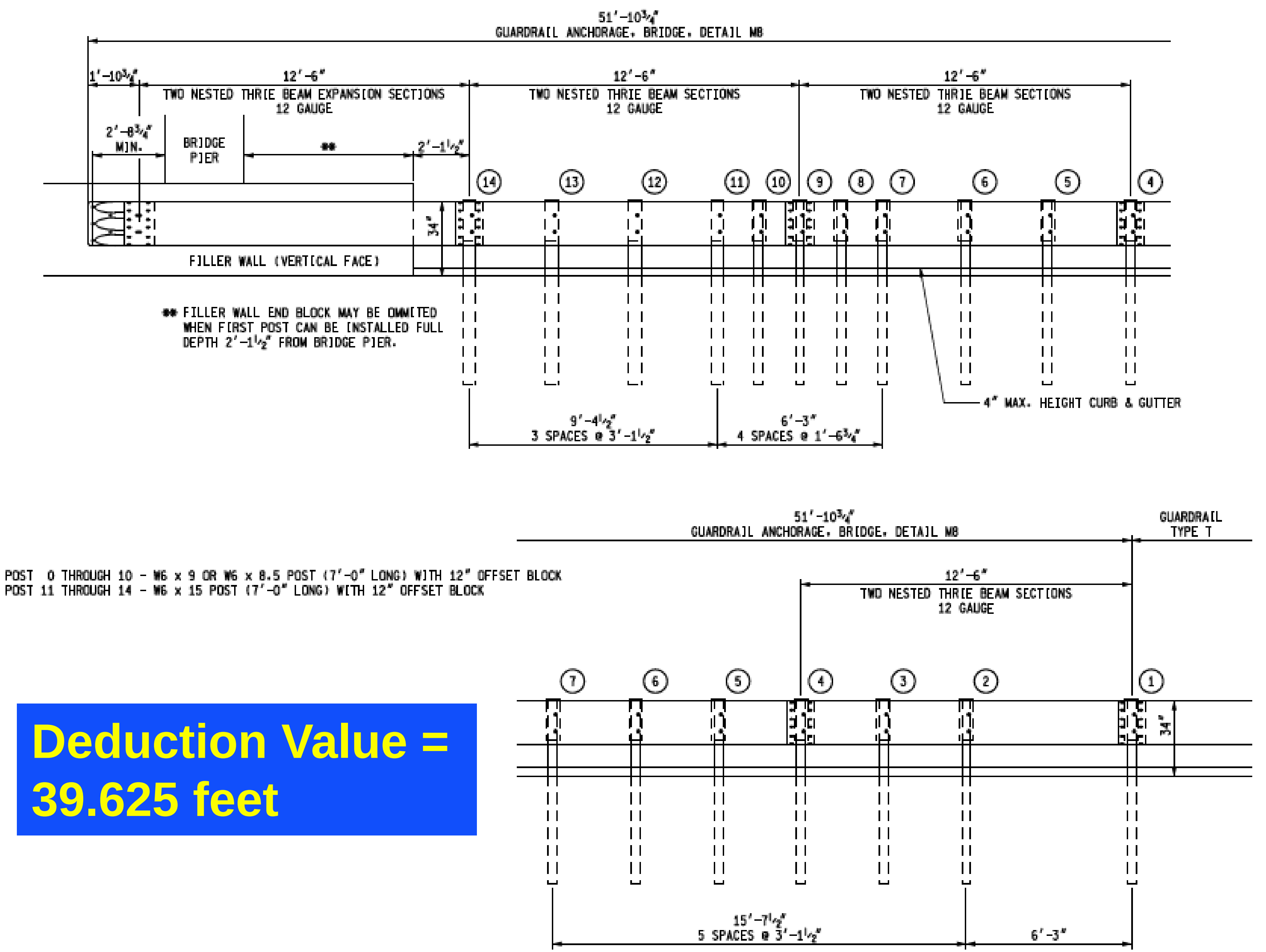
Deduction Value = 45.875 feet

Detail M-7 (Sheet 7; R-67-G)



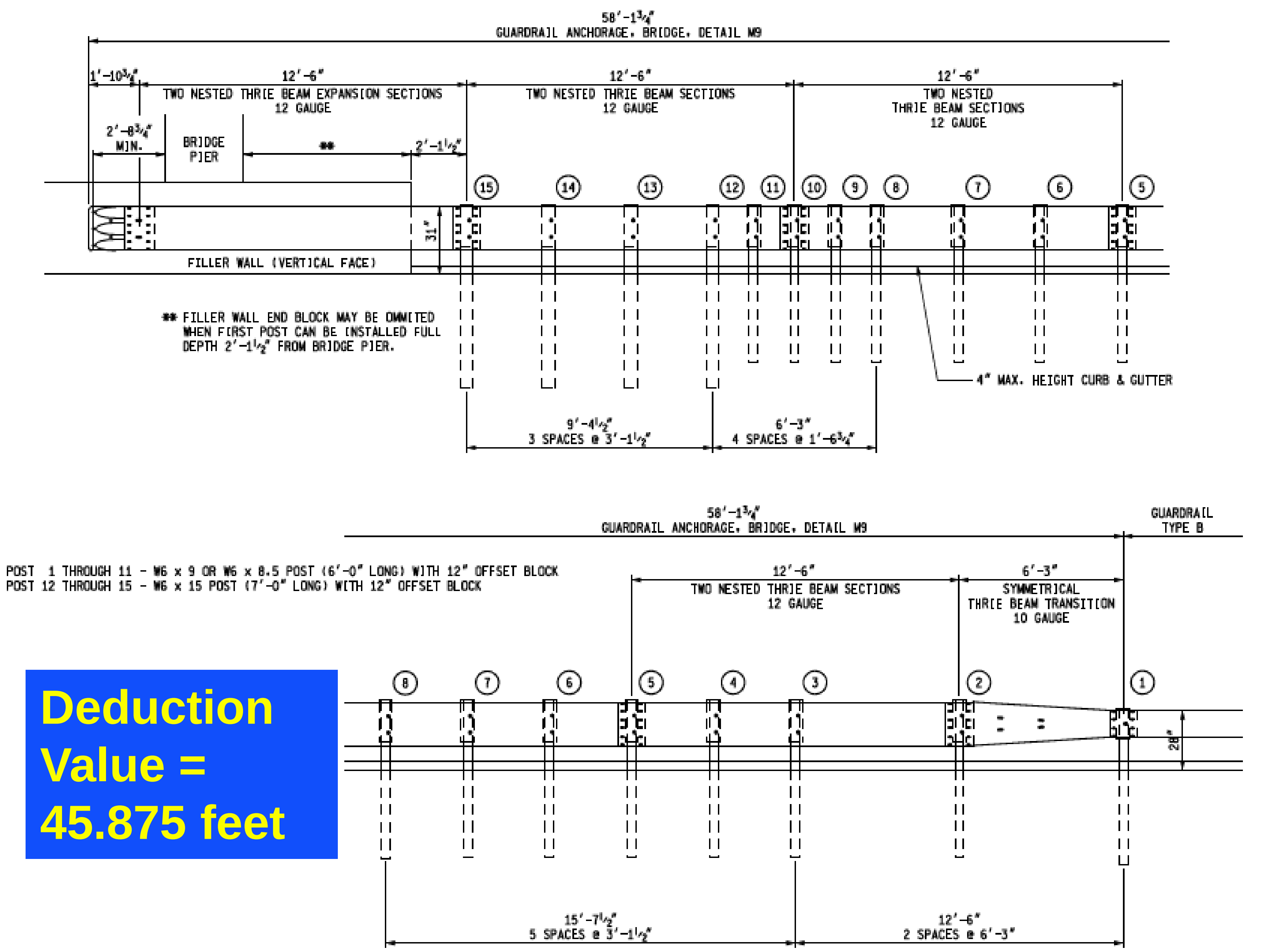
Deduction Value = 39.625 feet

Detail M-8 (Sheet 8; R-67-G)



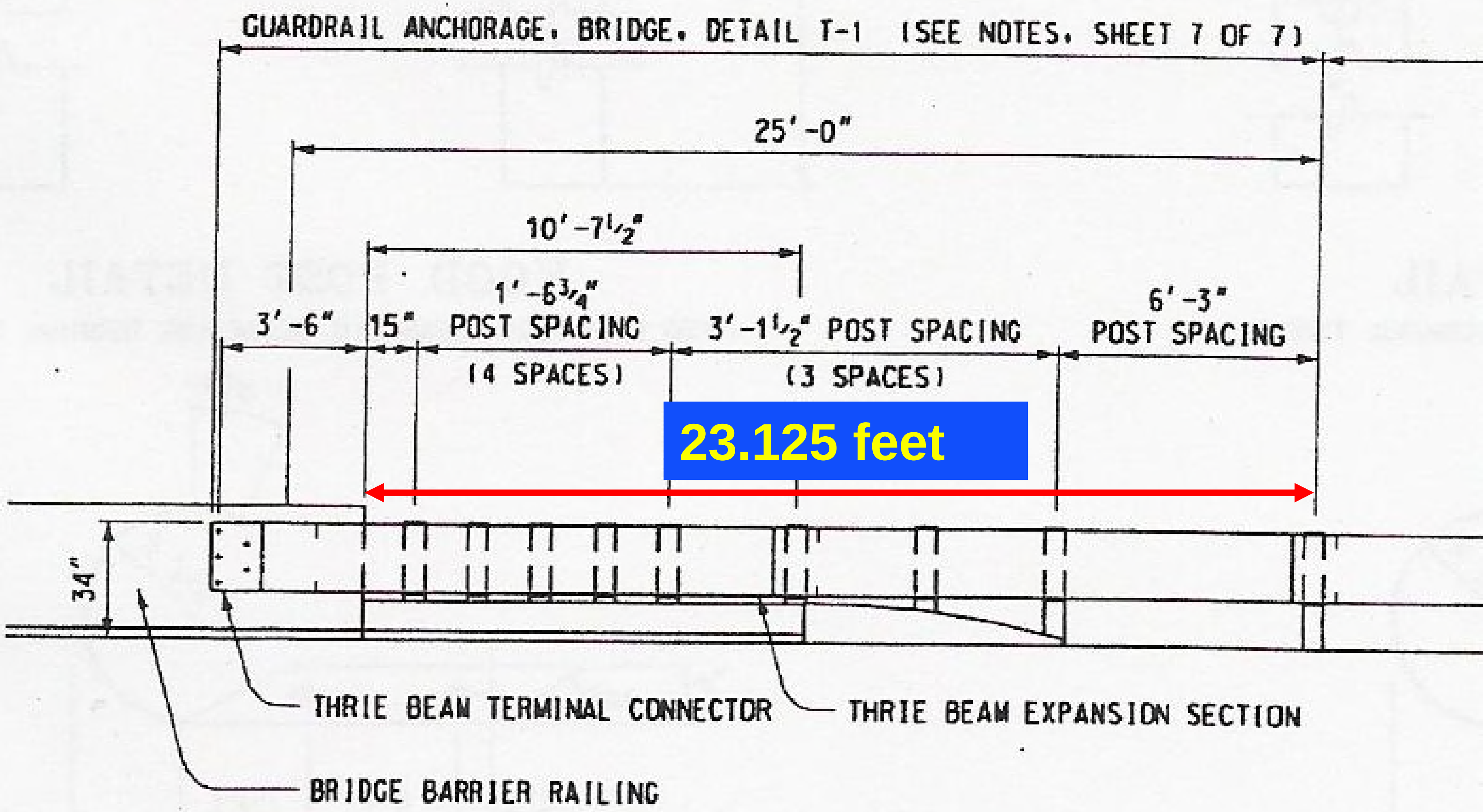
Deduction Value = 39.625 feet

Detail M-9 (Sheet 9; R-67-G)

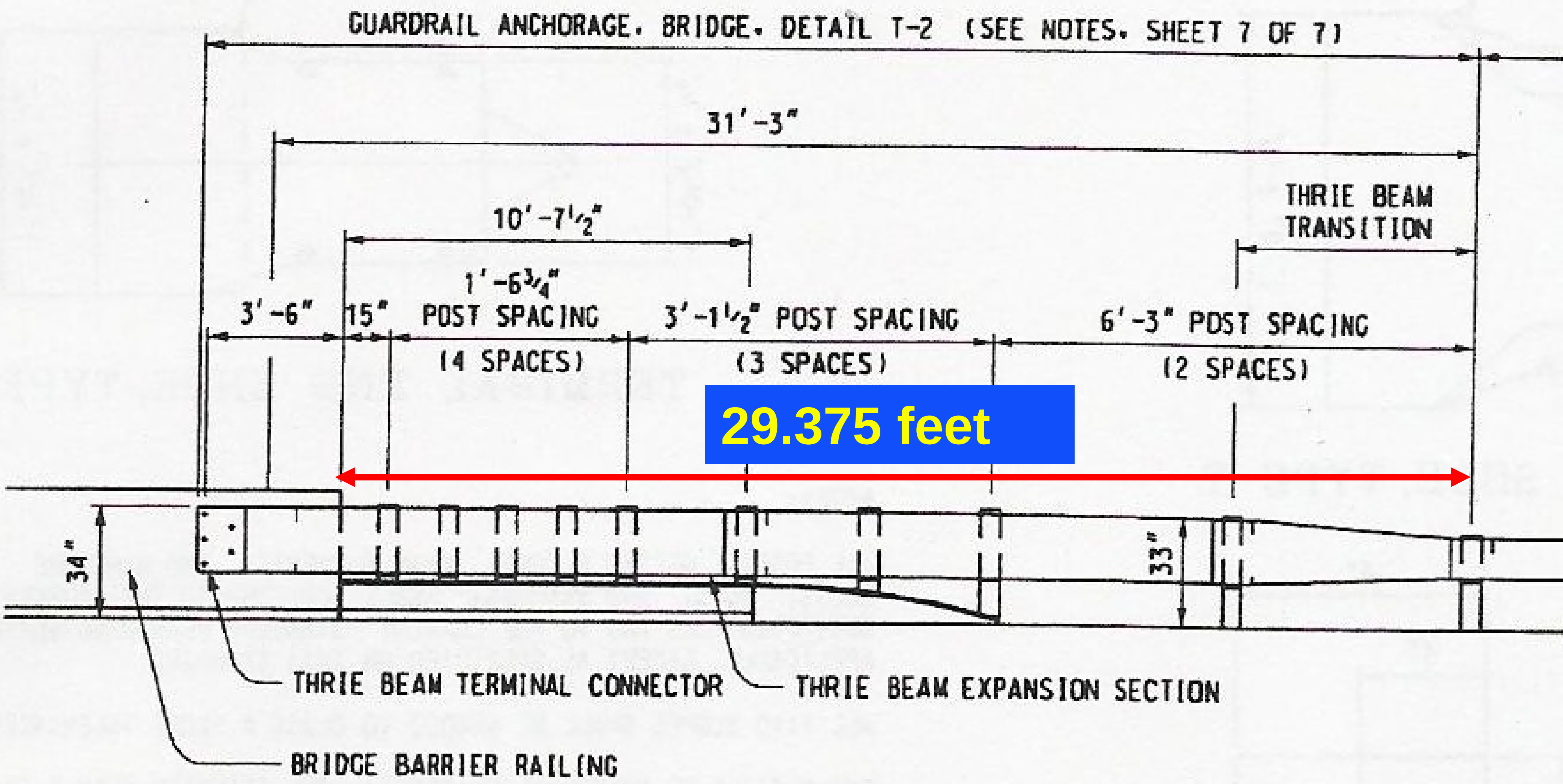


Deduction Value = 45.875 feet

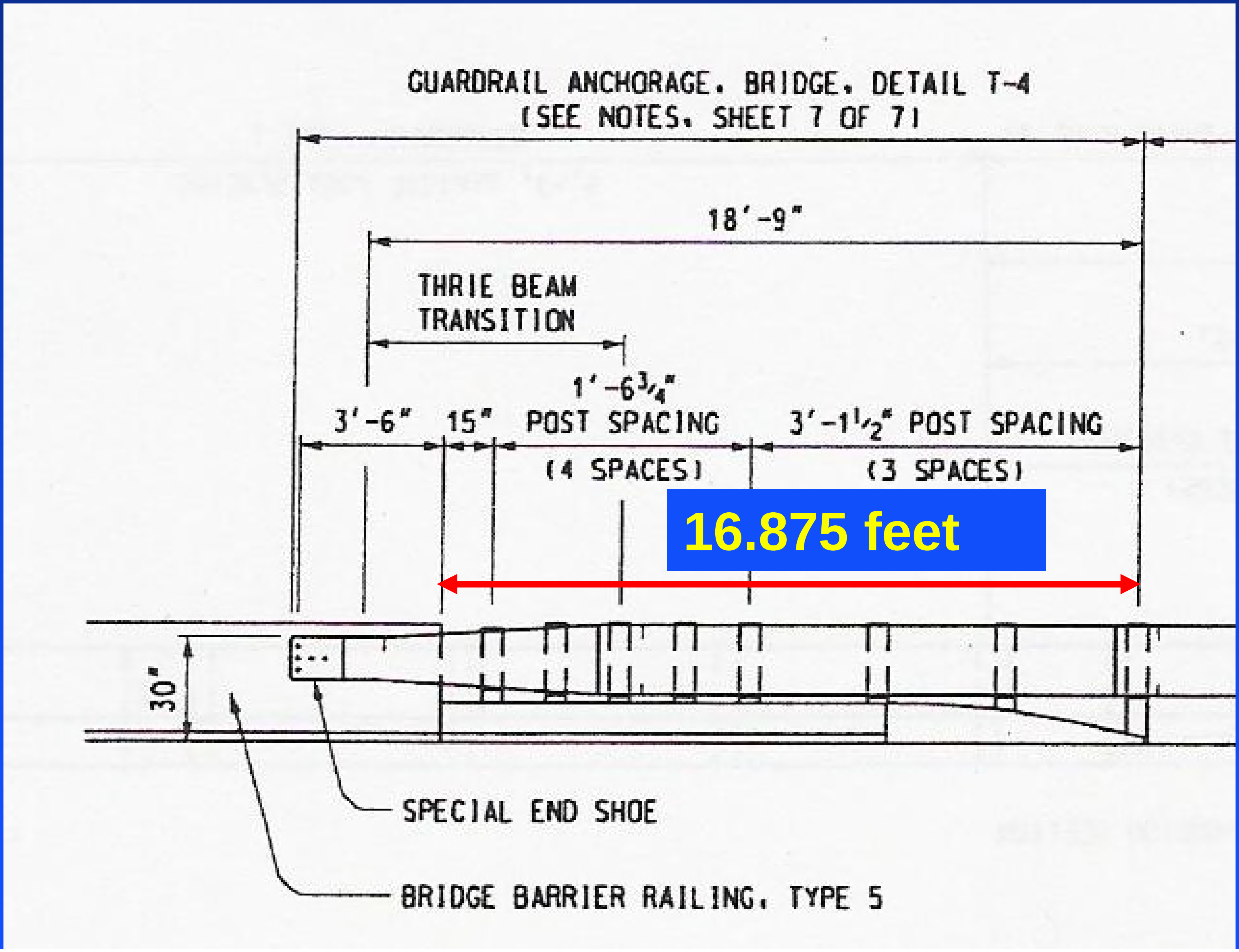
Detail T-1 (Sheet 1; R-67-SD)



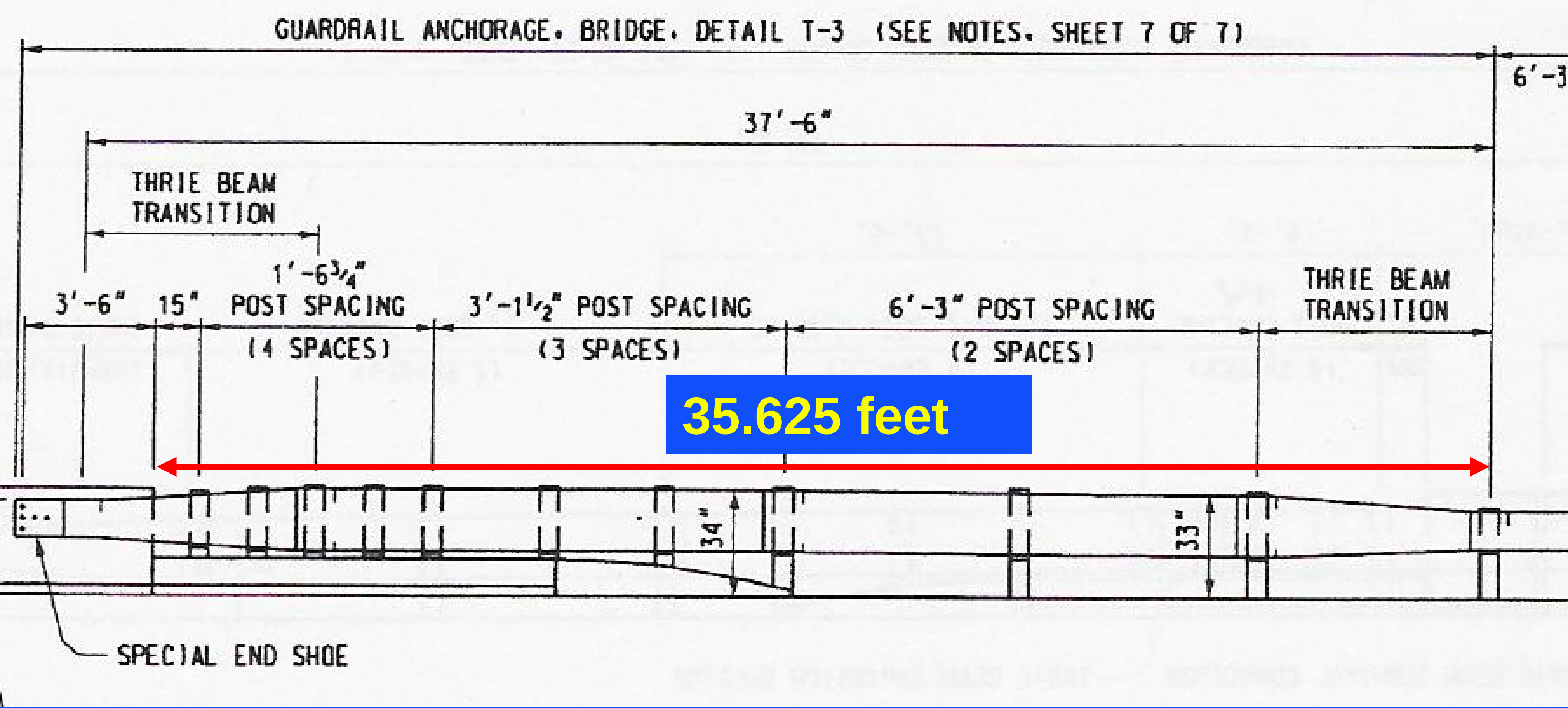
Detail T-2 (Sheet 1; R-67-SD)



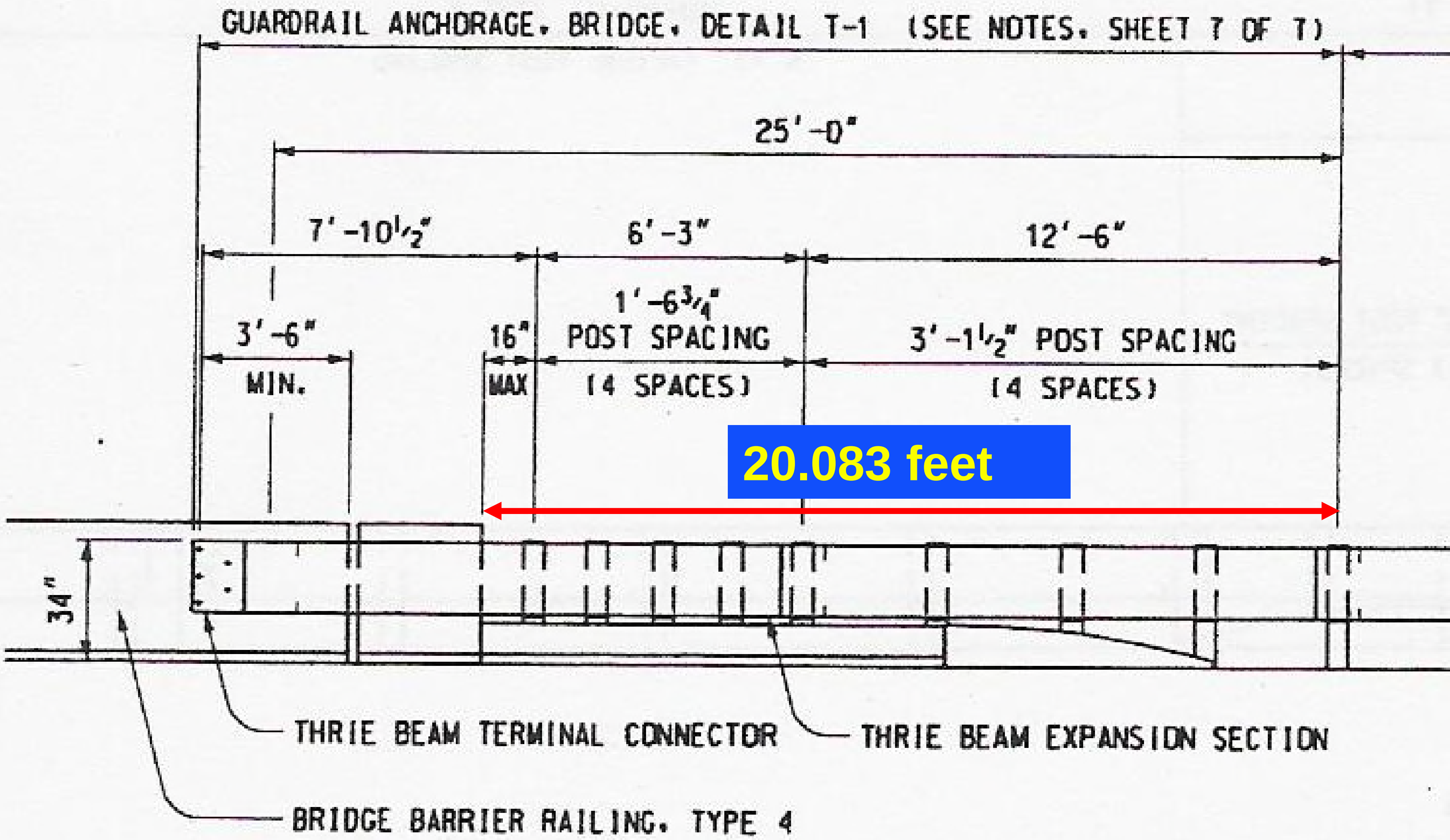
Detail T-4 (Sheet 2; R-67-SD)



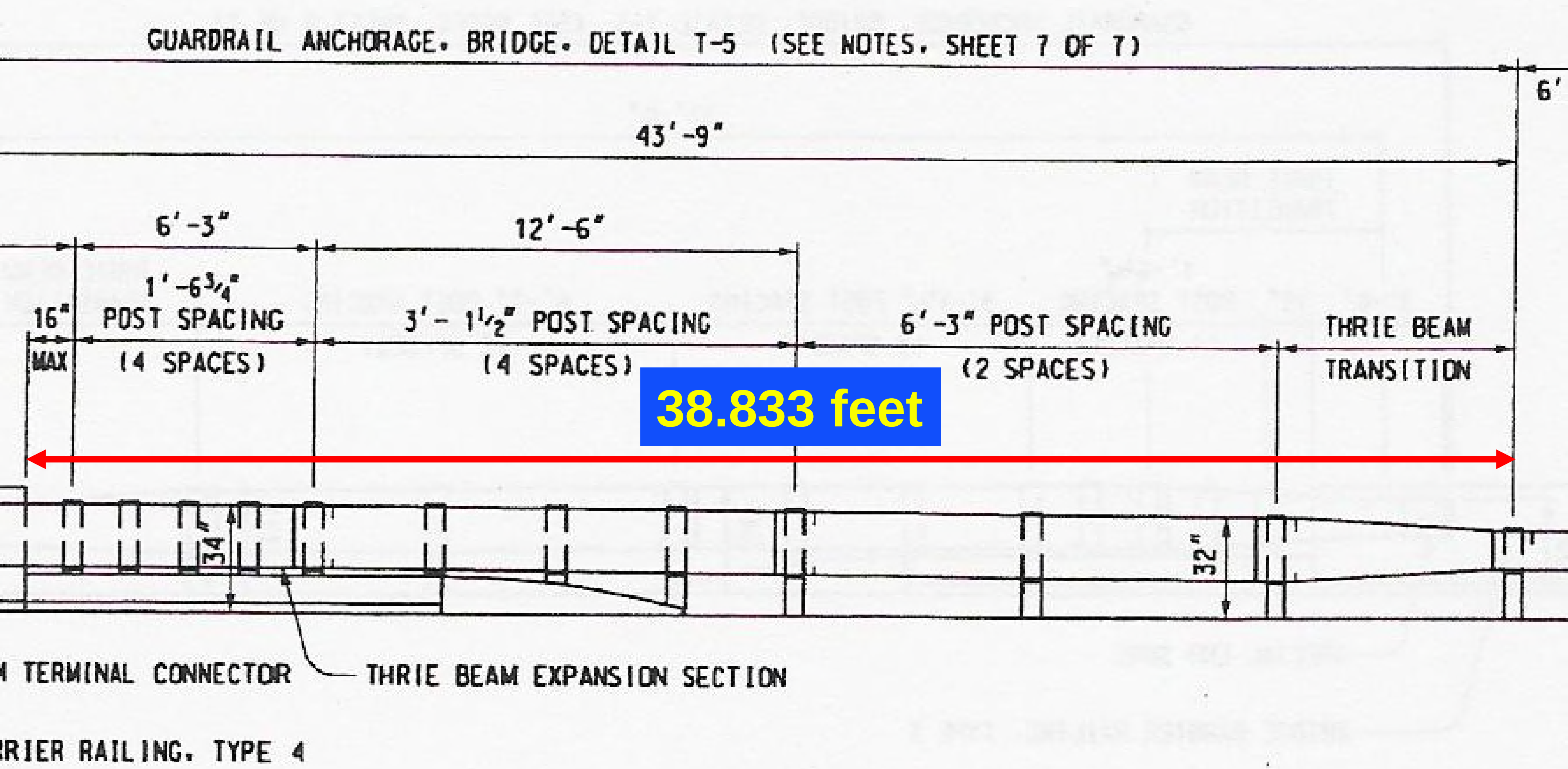
Detail T-3 (Sheet 2; R-67-SD)



Detail T-1 (Sheet 3; R-67-SD)



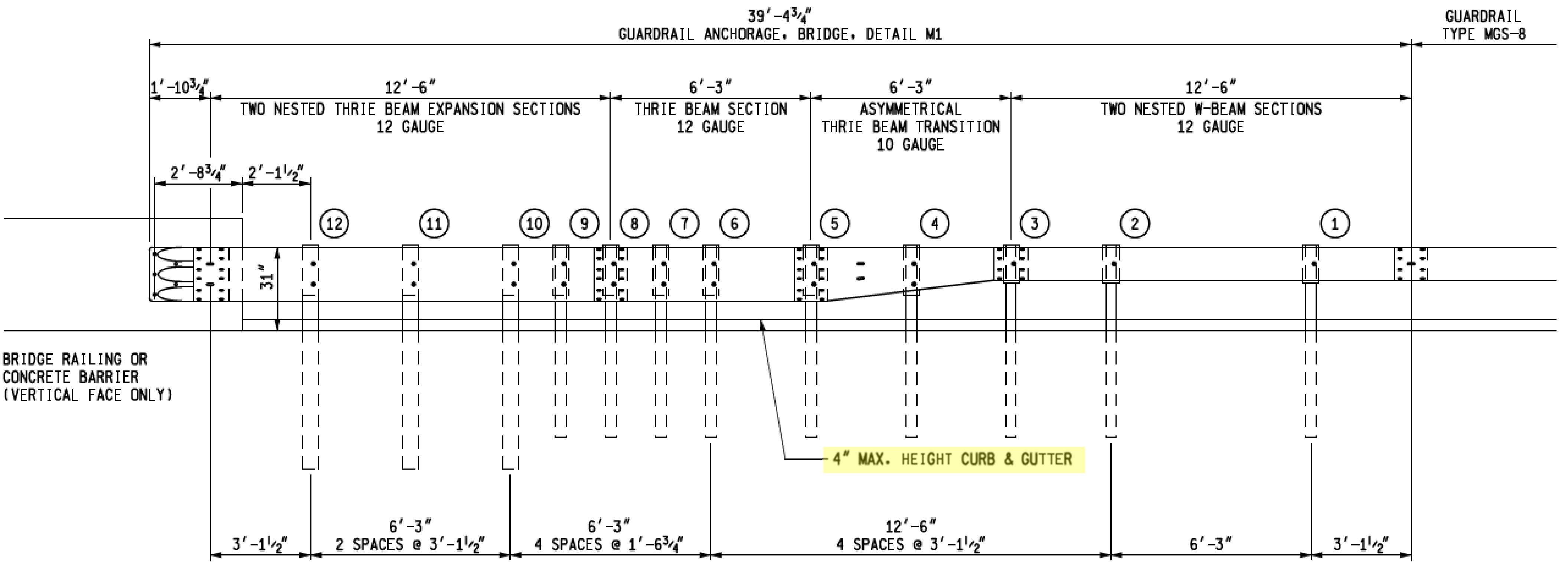
Detail T-5 (Sheet 3; R-67-SD)



M-Series Guardrail Anchorages

MDOT Standard Plan R-67-Series

- May Be Installed With or Without Curb & Gutter
- However, curb height cannot exceed 4” !!
    - Refer to Curb & Gutter Details from Standard Plan R-32 Series
    - Bridge Approach Curb & Gutter, Details 5 through 7



T-Series Guardrail Anchorages

MDOT Standard Plan R-67-SD

- Curb & Gutter Required with Safety-Shape Barrier
- Maximum curb height is 12” !!
  - Refer to Curb & Gutter Details from **Standard Plan R-32-SD**
  - Bridge Approach Curb & Gutter, Details 1 through 3

MDOT Approved
Guardrail Transitions
Standard Plan B-22 and B-23 Series

- Guardrail Anchorage, Bridge, Detail A-3
- Guardrail Anchorage, Bridge, Detail A-4
- Guardrail Anchorage, Bridge, Detail A-5

MDOT Approved Guardrail Transitions

Standard Plan B-22 and B-23 Series

- May be constructed with or without curb
- 4” max curb height !!

MDOT Approved Guardrail Transitions

- Guardrail Anchorage, Median
- Used to connect double-sided guardrail to concrete barrier

Detailed in MDOT Standard Plan R-71 Series

NCHRP 350 Compliant

Barrier  Design

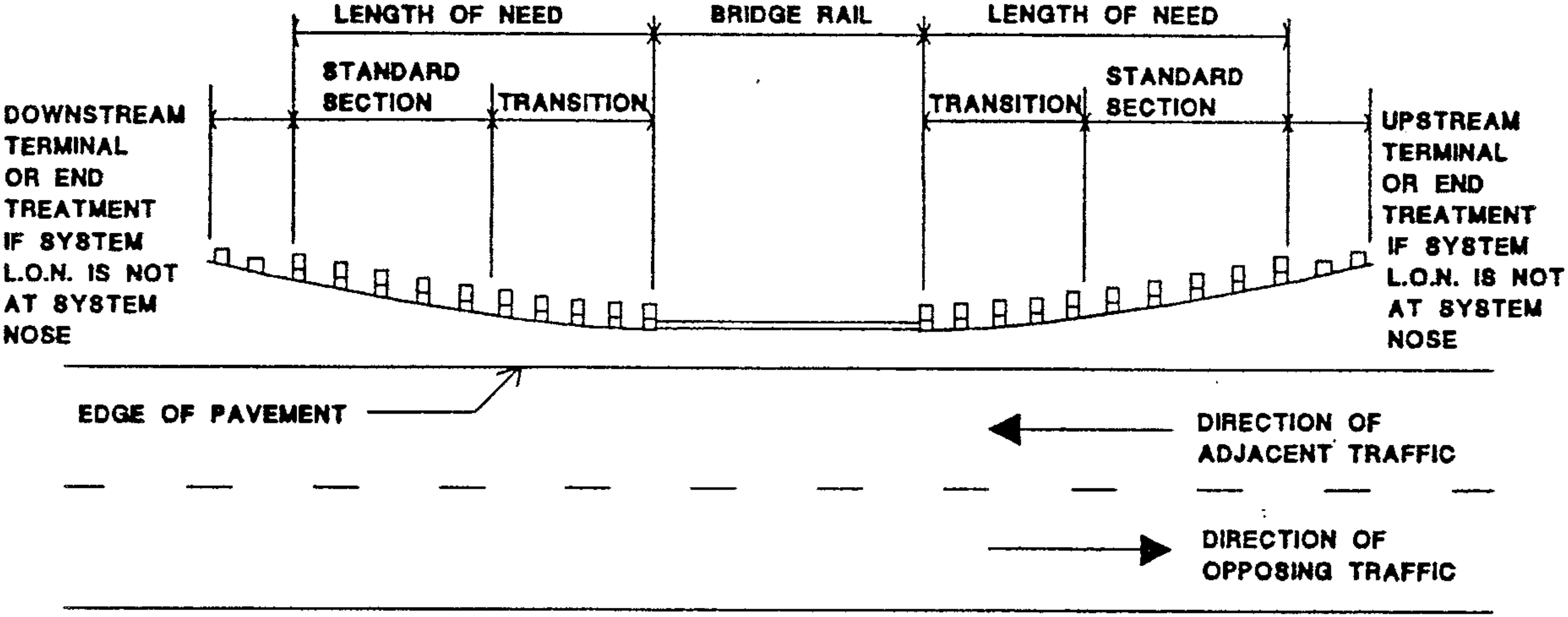
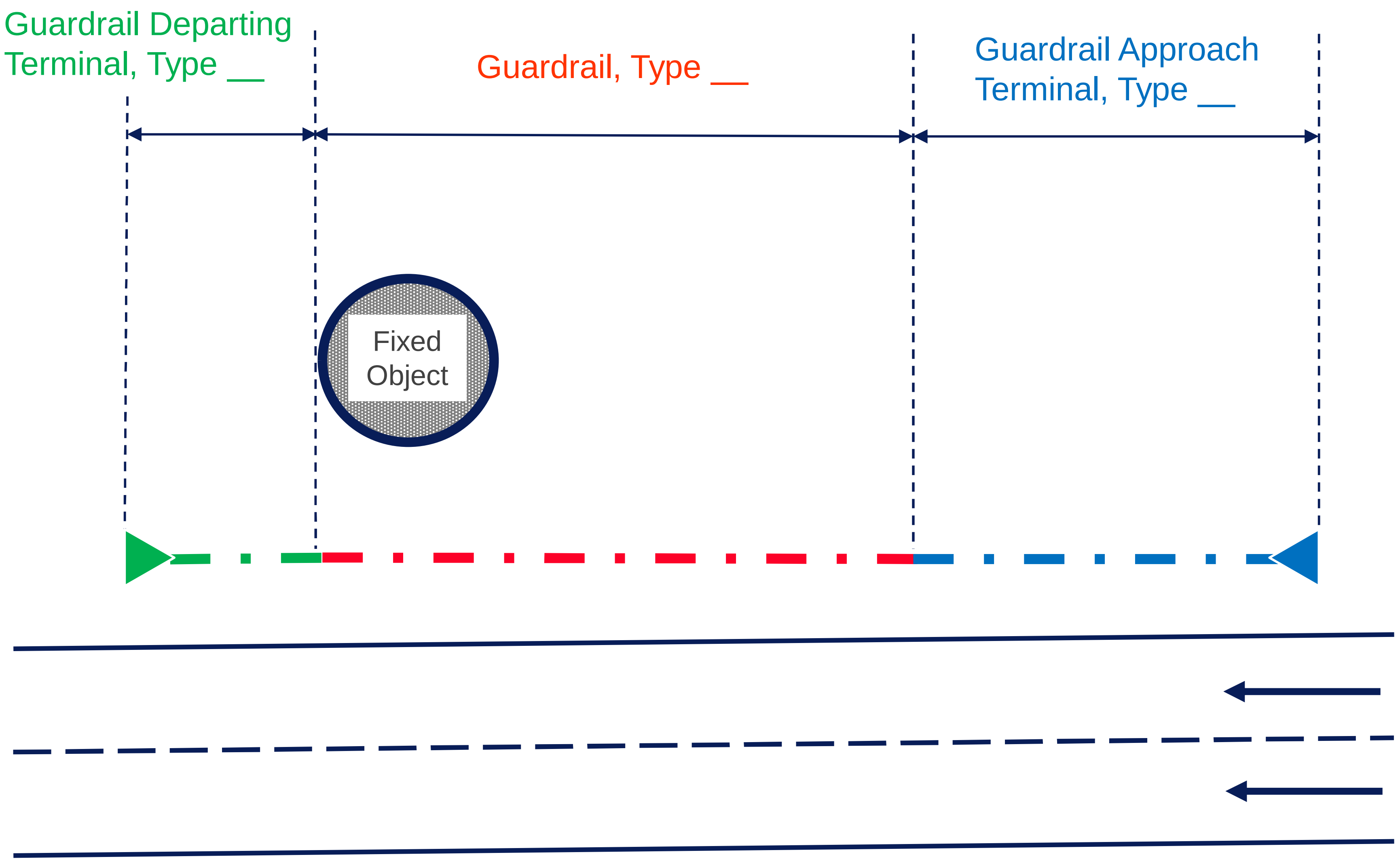


Figure 2.6.1 - Roadside barrier elements

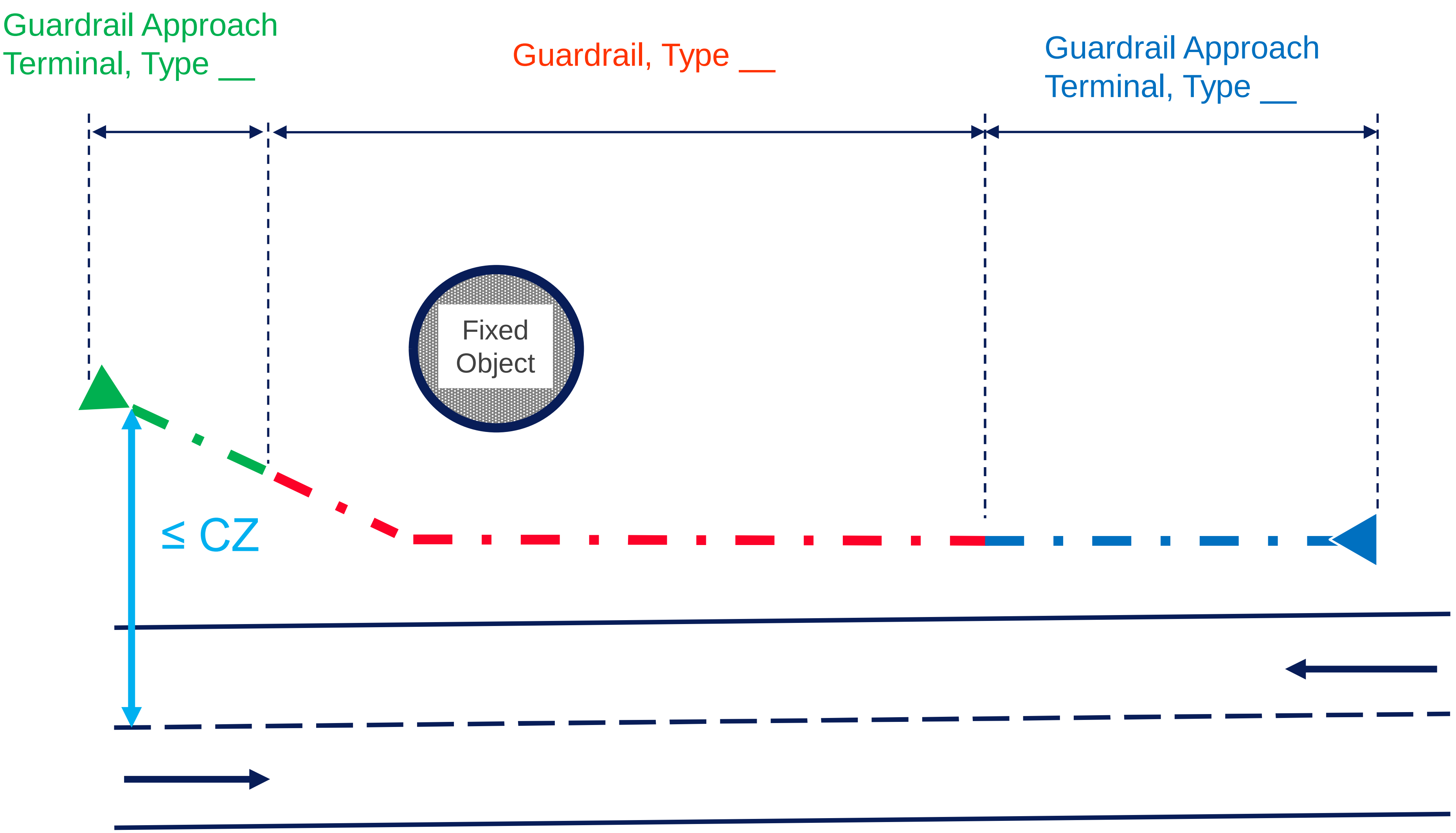
Guardrail Terminal Selection

One-Way Traffic



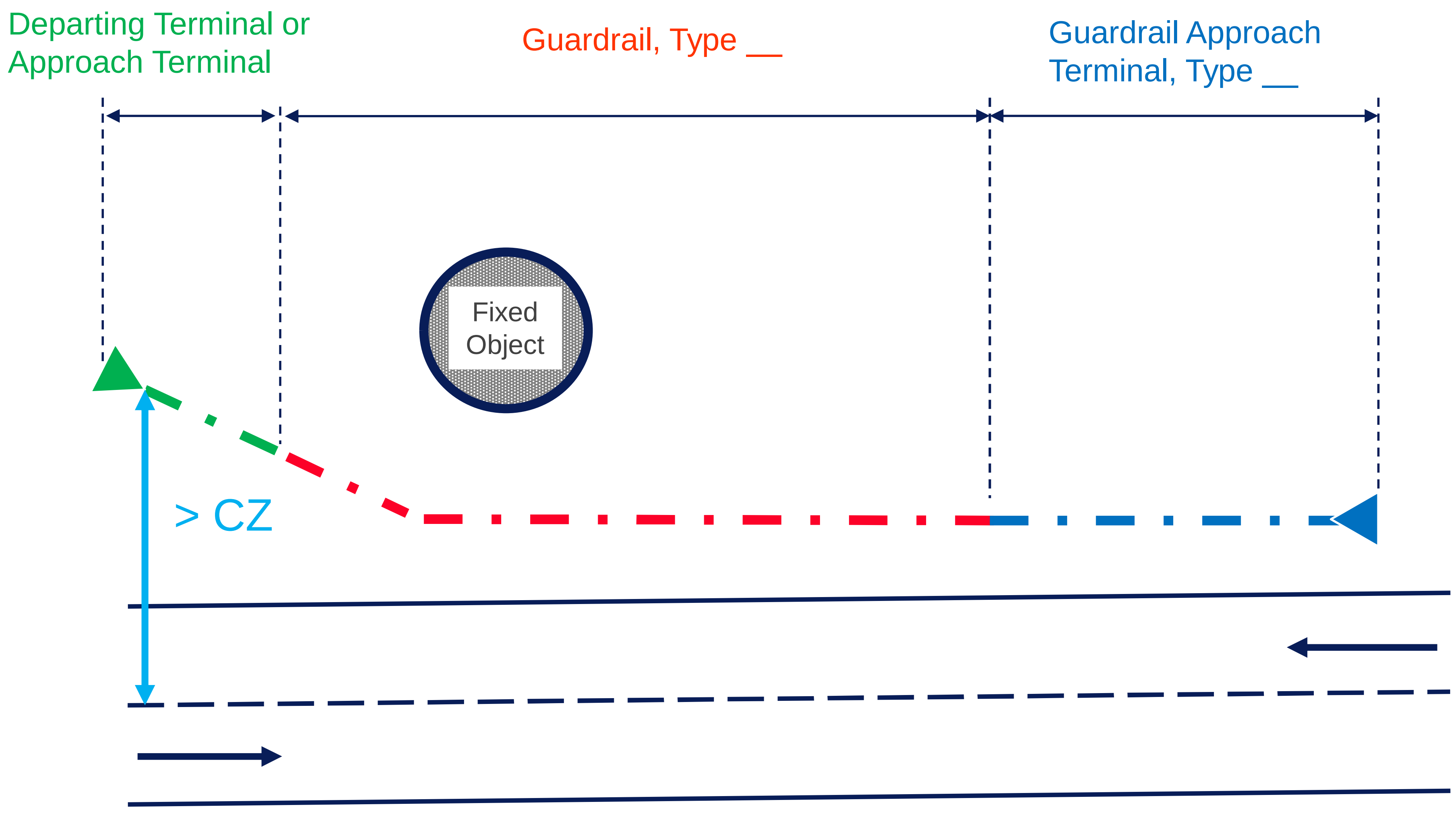
Guardrail Terminal Selection

Two-Way Traffic

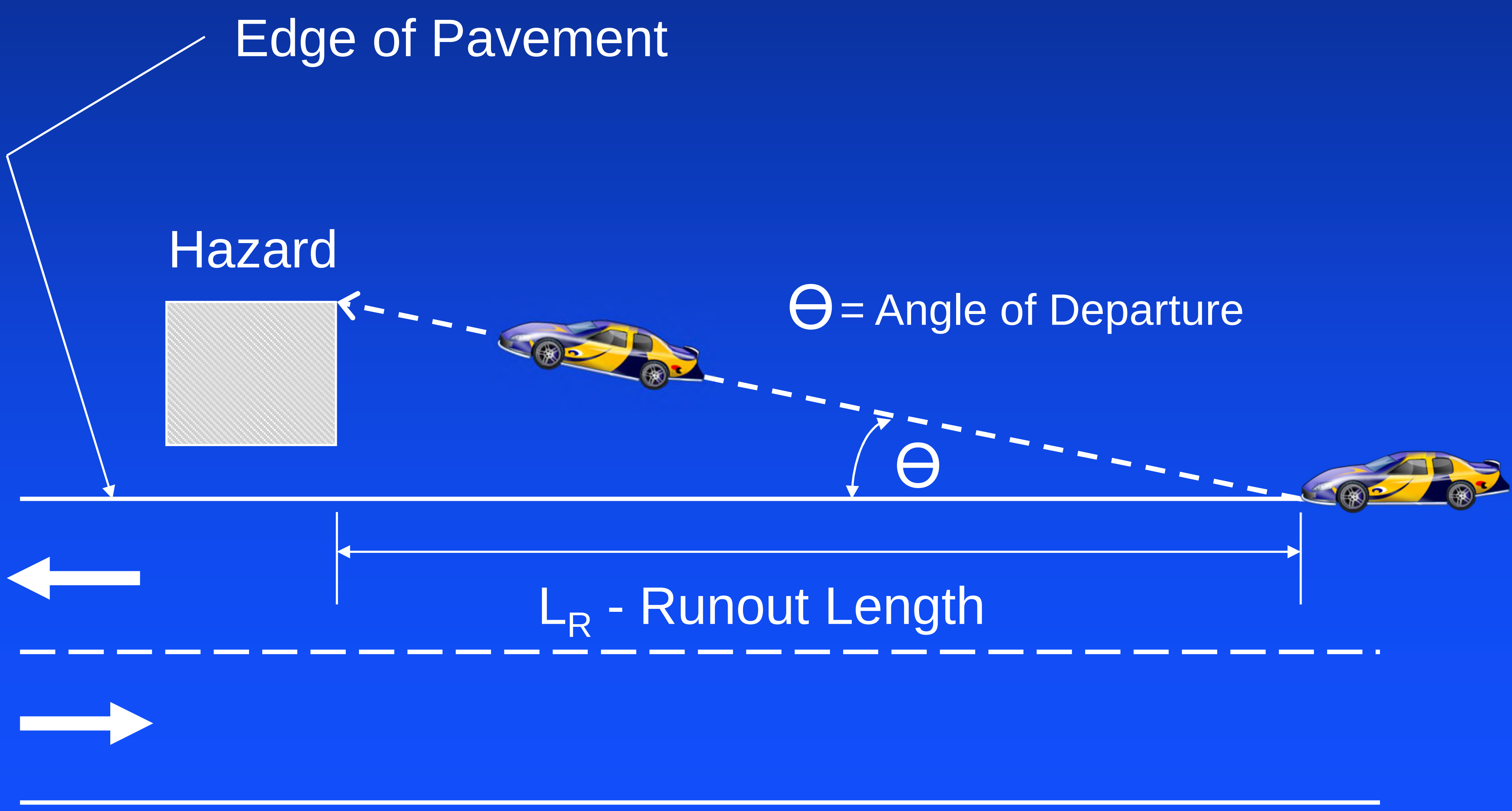


Guardrail Terminal Selection

Two-Way Traffic



Runout Length

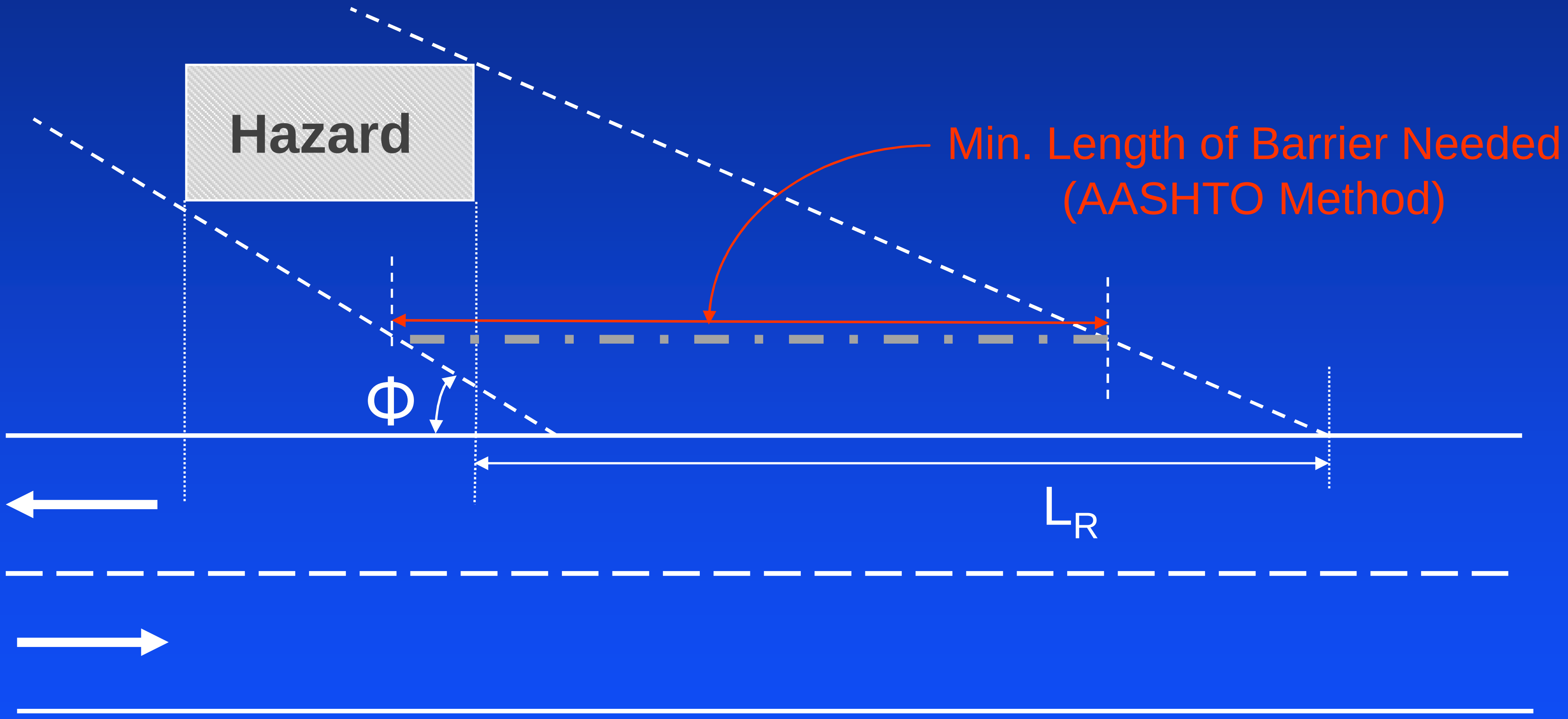


Runout Length

	Traffic Volume (ADT) veh/day			
	Over 10,000	Over 5,000-10,000	1000-5000	Under 1000
Design Speed (mph)	Runout Length L_R (ft)	Runout Length L_R (ft)	Runout Length L_R (ft)	Runout Length L_R (ft)
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

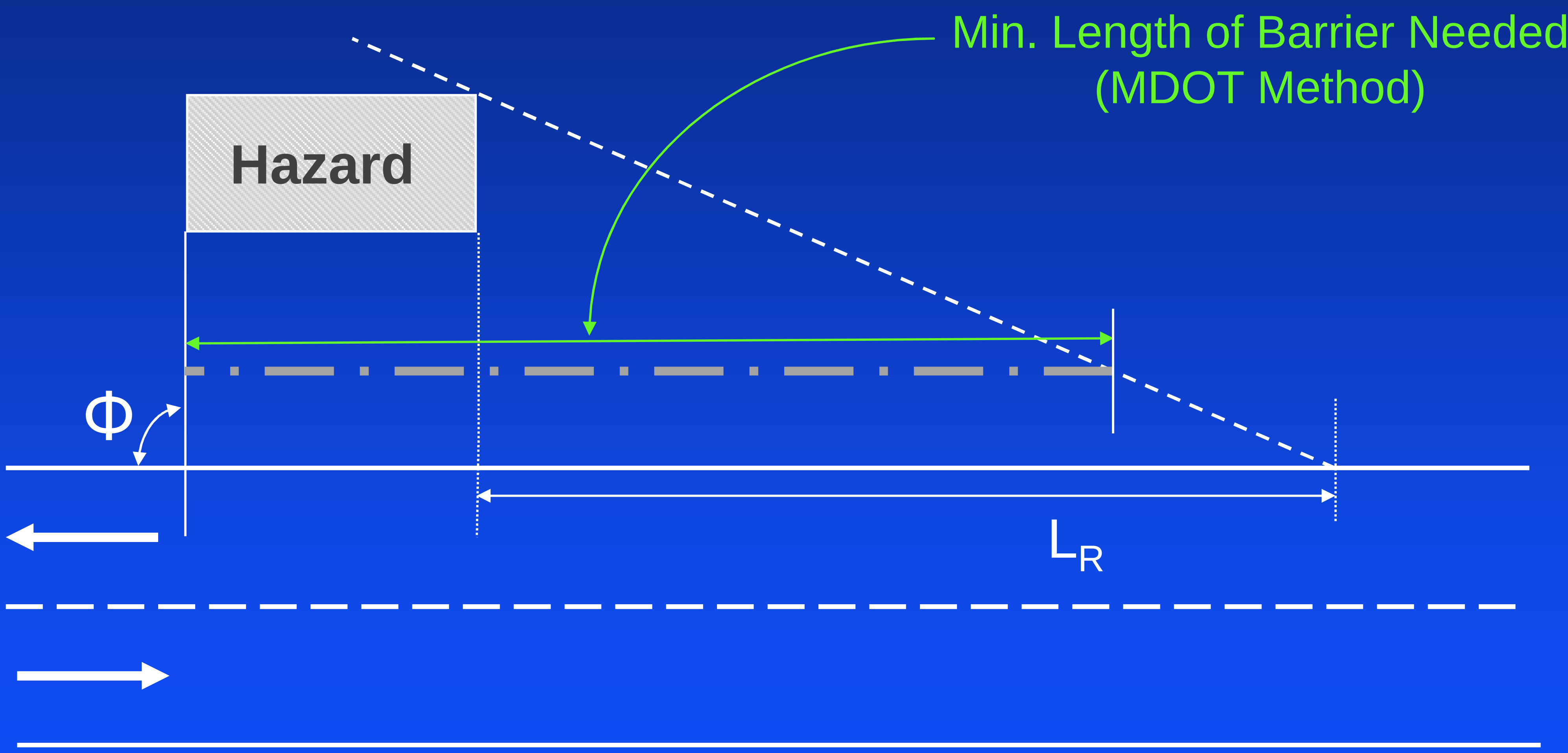
- RDM – Section 7.01.19
- Runout length is a function of *design speed* and *traffic volume*
- Interpolation is recommended for intermediate design speeds
  - Example: DS = 75 mph & ADT = 12,000: L_r = 415’

Minimum Length of Barrier Needed



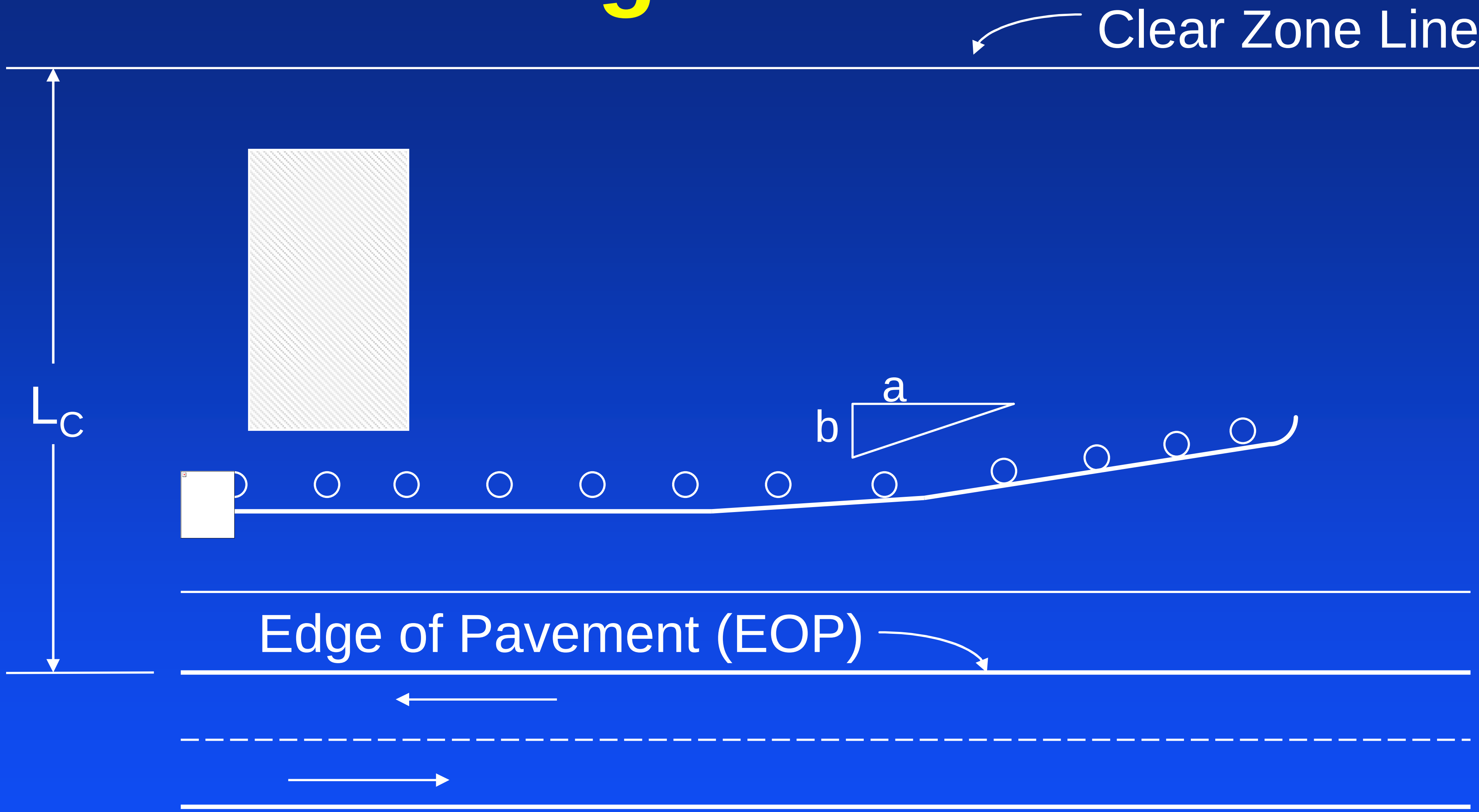
AASHTO Method: Φ typically varies between 25^o and 90^o

Minimum Length of Barrier Needed



MDOT's Current Method: $\Phi = 90^o$

Design Factors

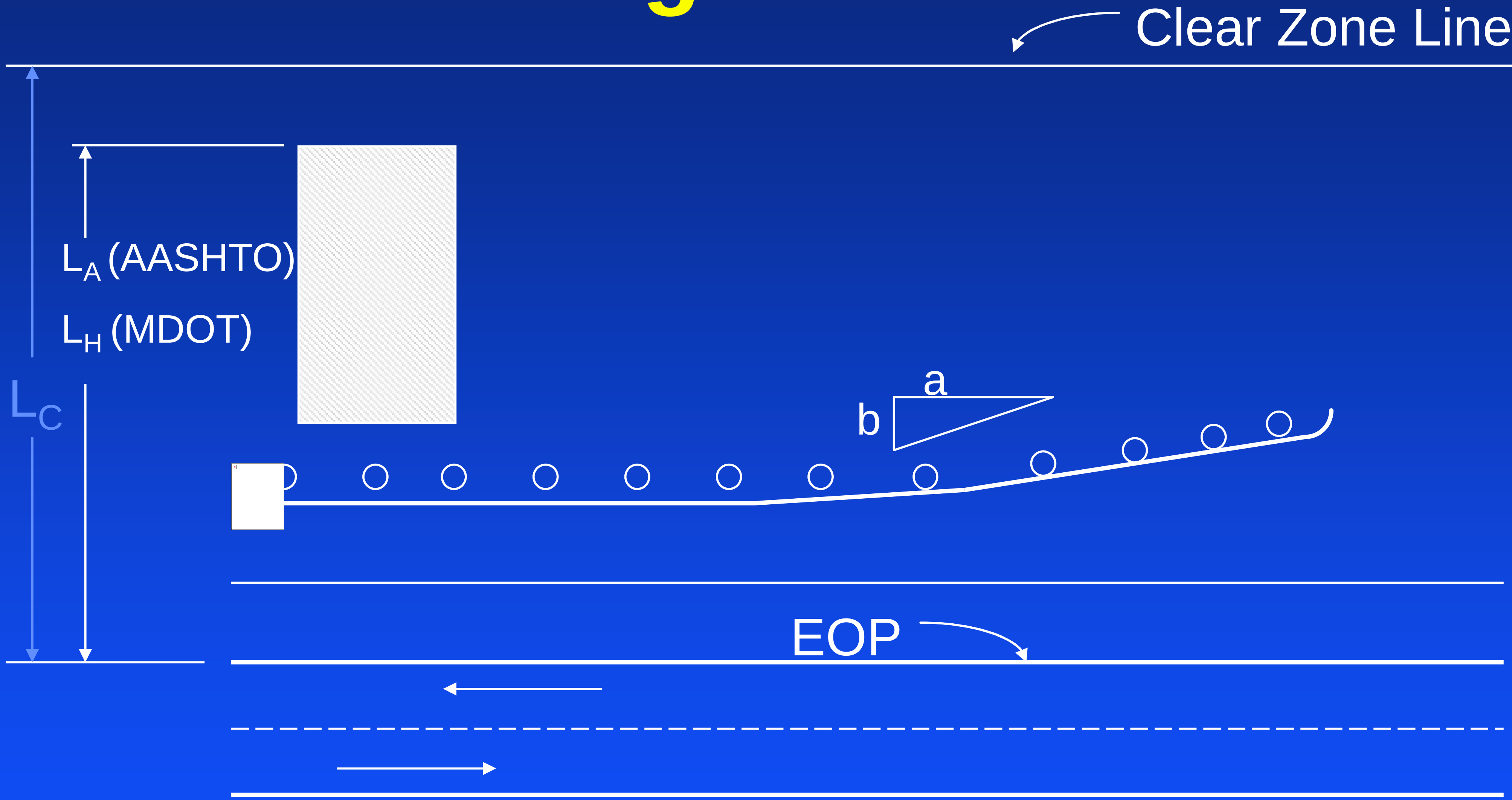


Note: Edge of Pavement (a.k.a. Edge of Metal)

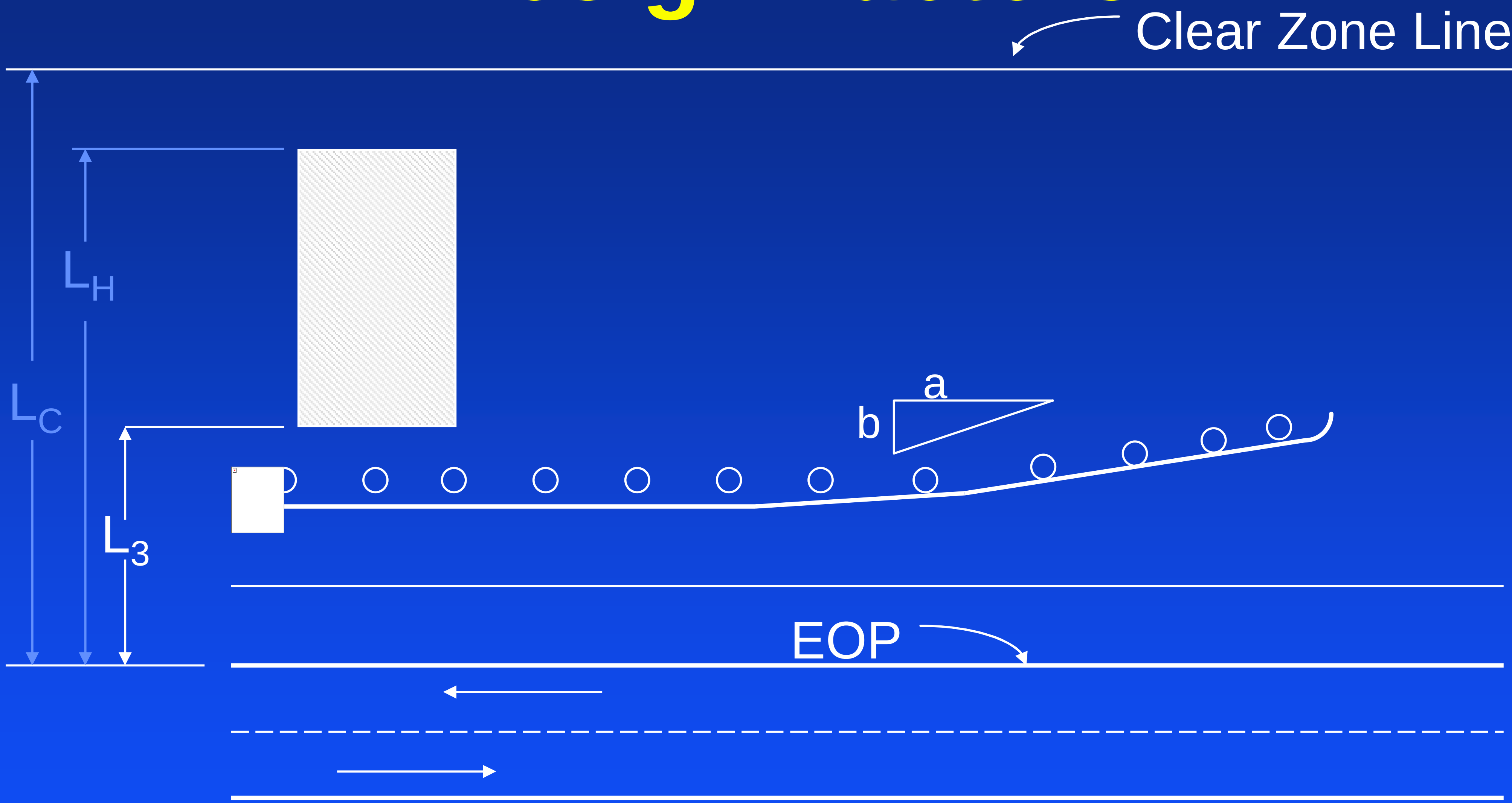
CLEAR ZONE DISTANCES
(IN FEET FROM EDGE OF DRIVING LANE)

DESIGN SPEED	DESIGN ADT	FILL SLOPES			CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3	1:3	1:4 TO 1:5	1:6 OR FLATTER
40 mph or Less	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 mph	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	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	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 mph	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 mph	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

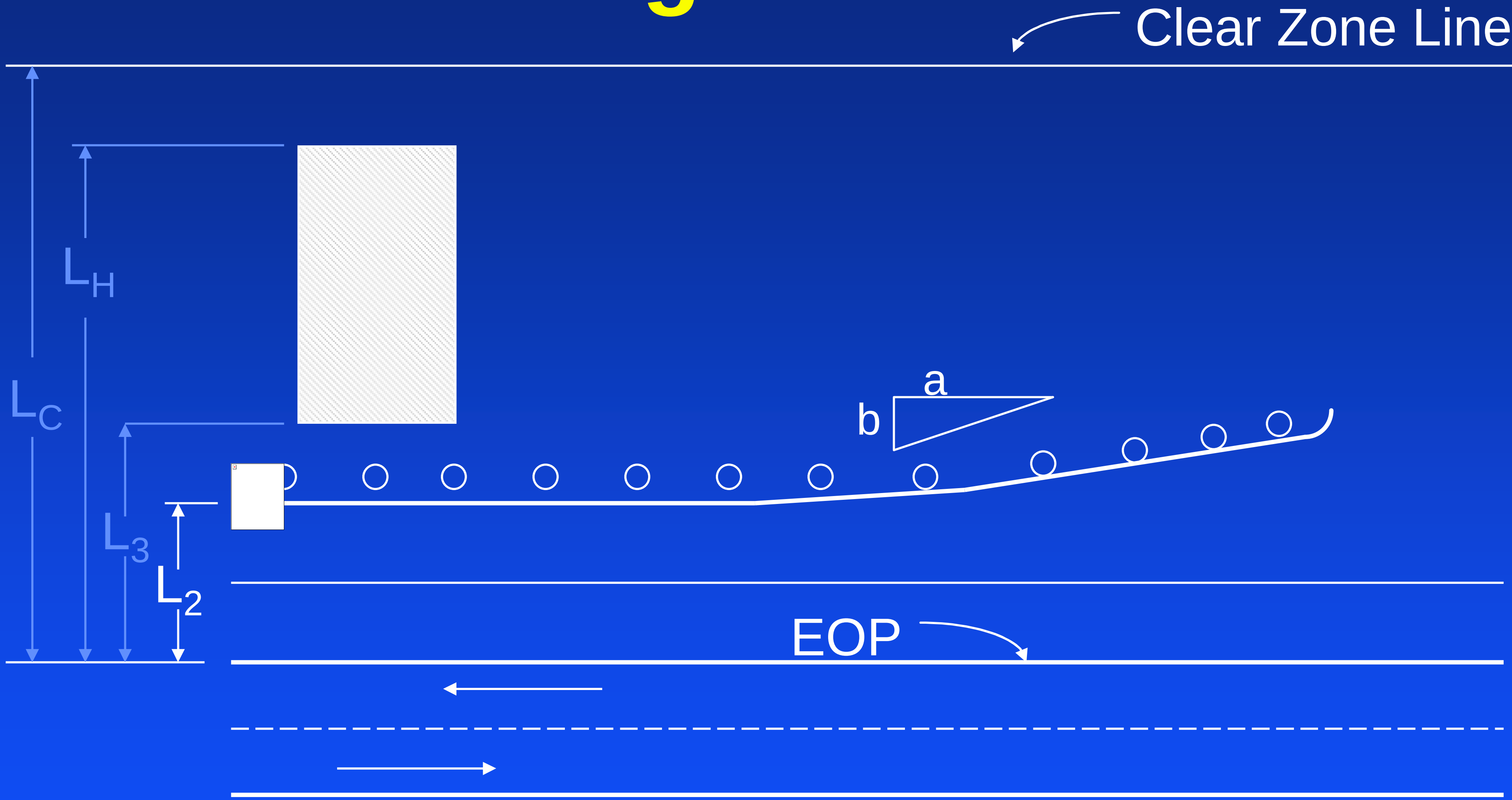
Design Factors



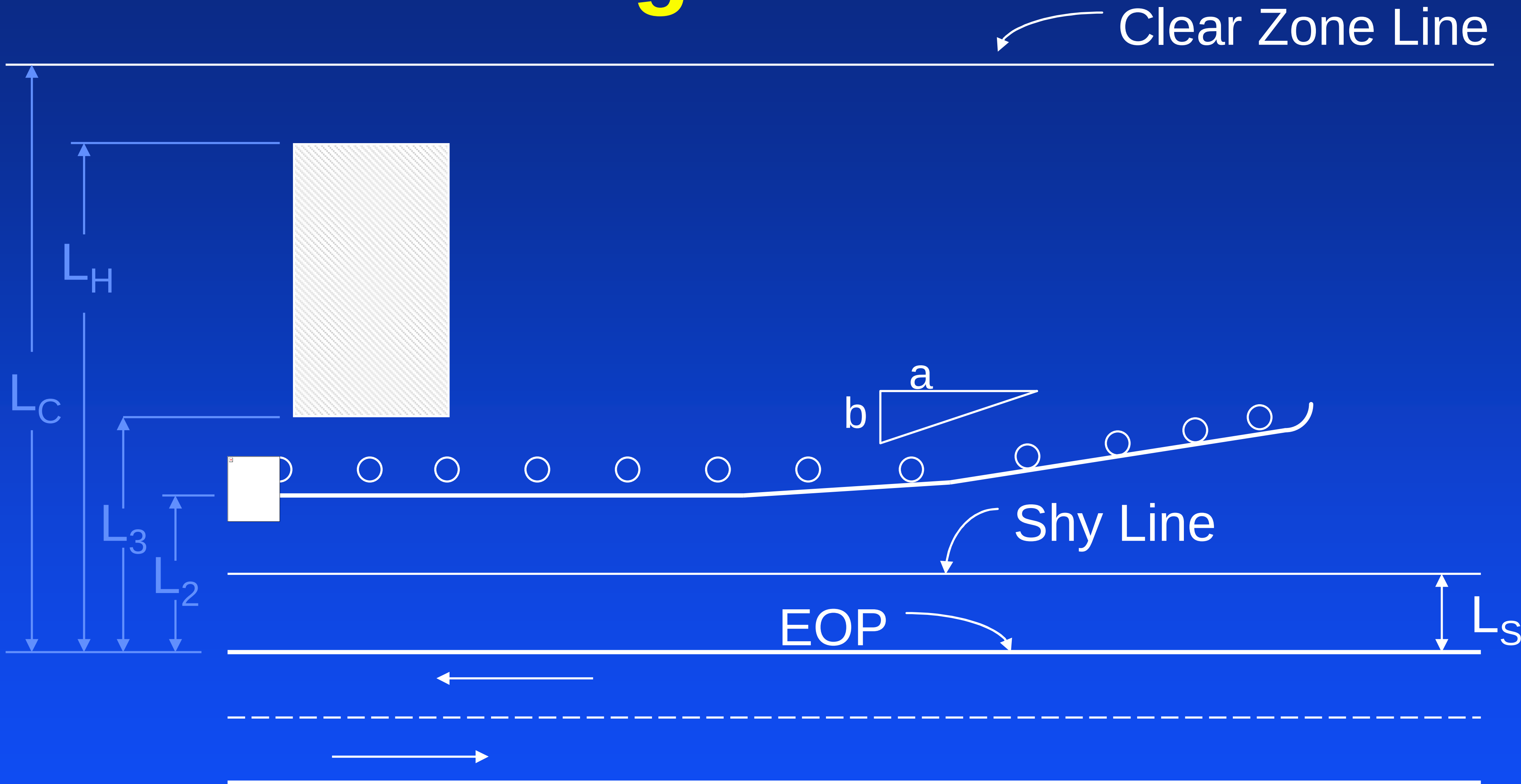
Design Factors



Design Factors



Design Factors

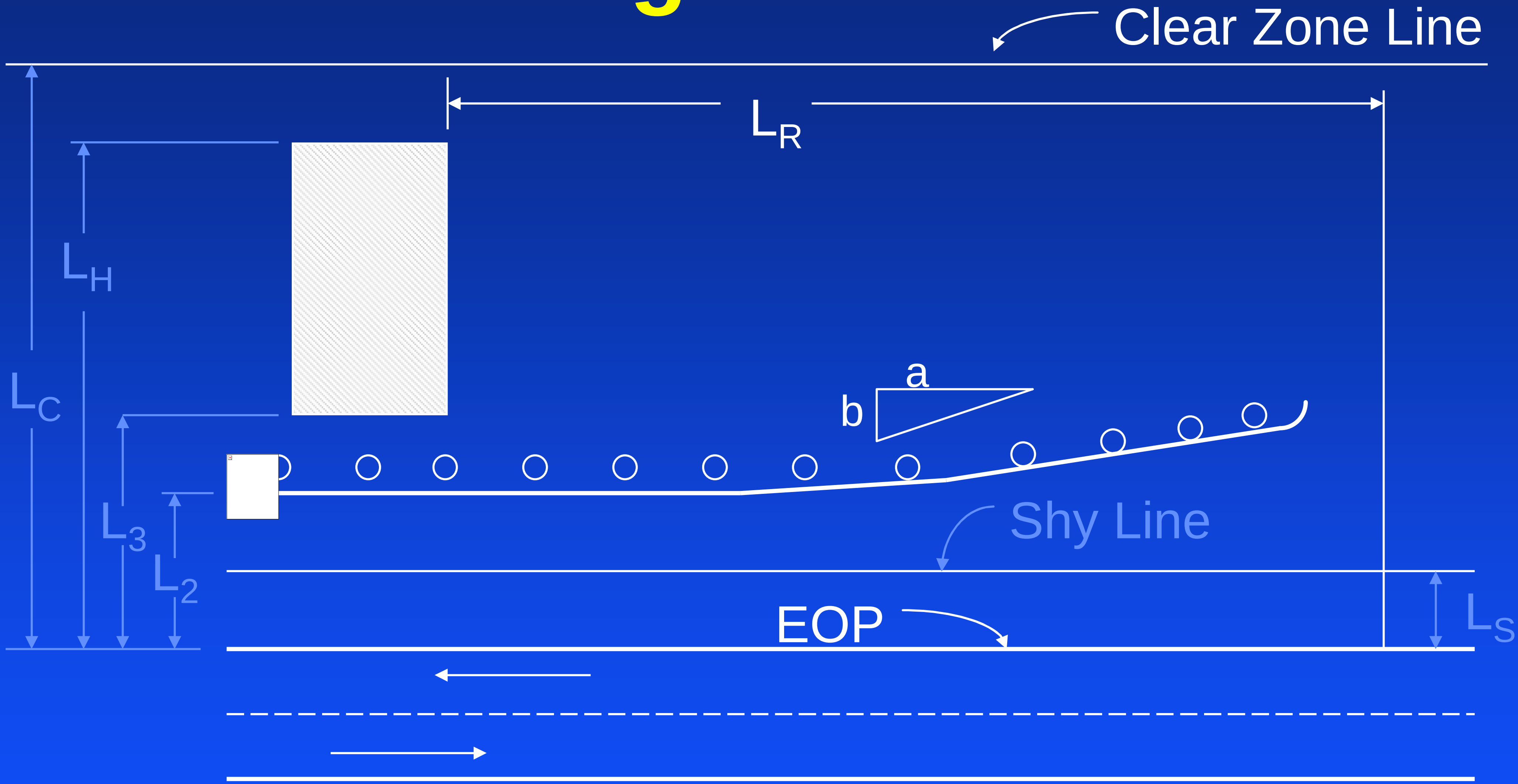


MDOT Shy Distance Table

Design Speed (mph)	Shy Line Offset (L_S) (ft)
80	12
75	10
70	9
60	8
55	7
50	6.5
45	6
40	5
30	4

RDM - Section 7.01.18

Design Factors

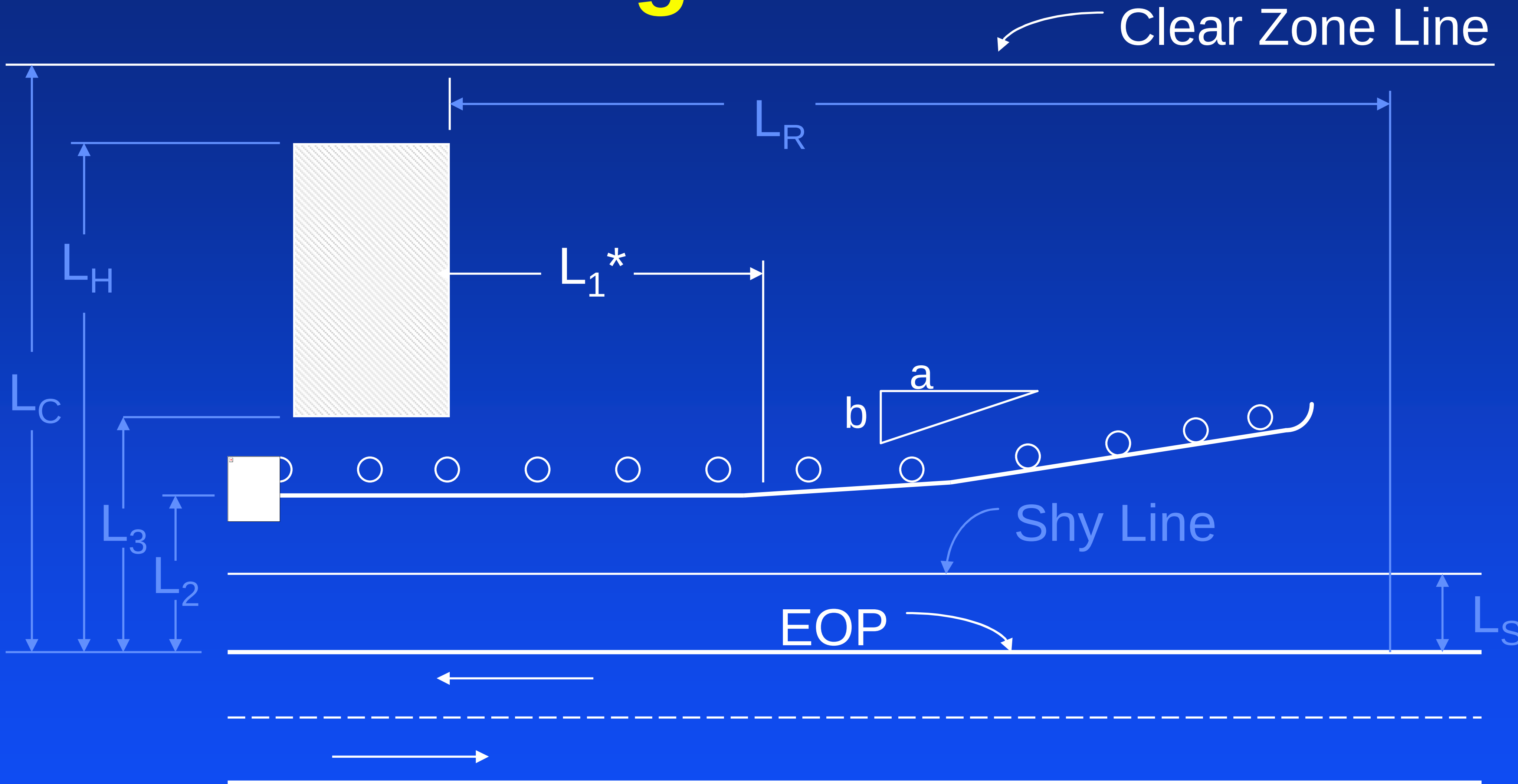


MDOT
Runout Length Table

	Traffic Volume (ADT) veh/day			
	Over 10,000	Over 5,000-10,000	1000-5000	Under 1000
Design Speed (mph)	Runout Length L_R (ft)	Runout Length L_R (ft)	Runout Length L_R (ft)	Runout Length L_R (ft)
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

RDM - Section 7.01.19

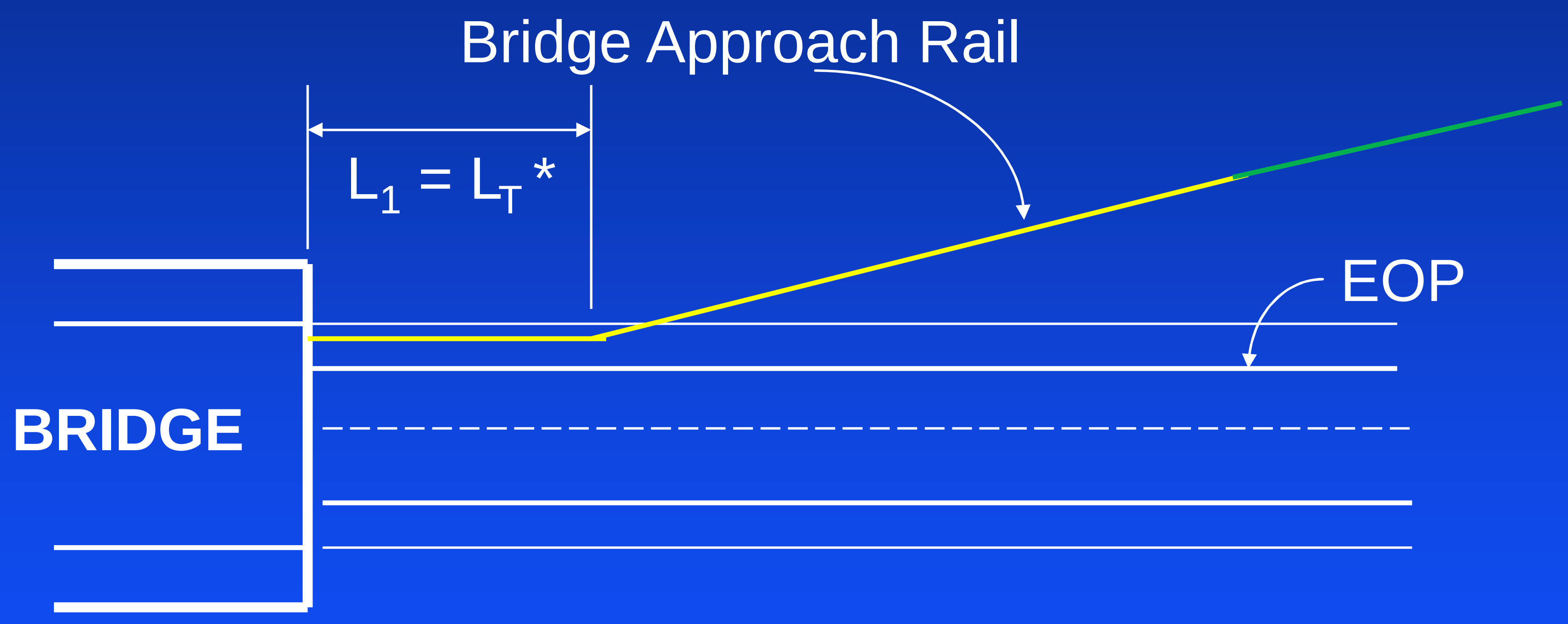
Design Factors



* MDOT Guardrail Worksheet specifies L_1 must be 25' min., but there are exceptions:

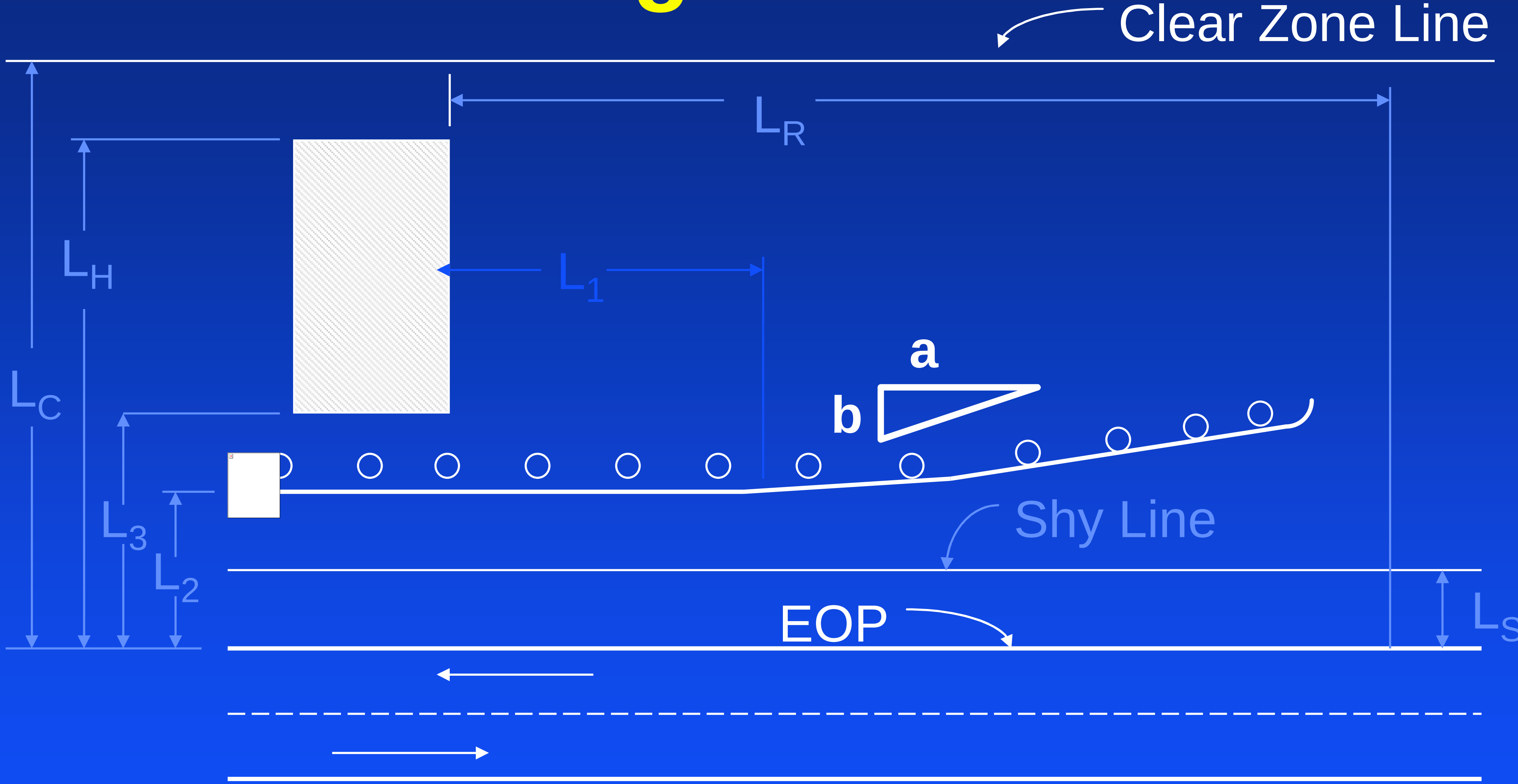
- Guardrail bridge anchorages
- Guardrail installations with a large offset between the hazard and the guardrail

Bridge Approach Rail



* Use $L_1 = L_T$ even when $L_T < 25'$

Design Factors



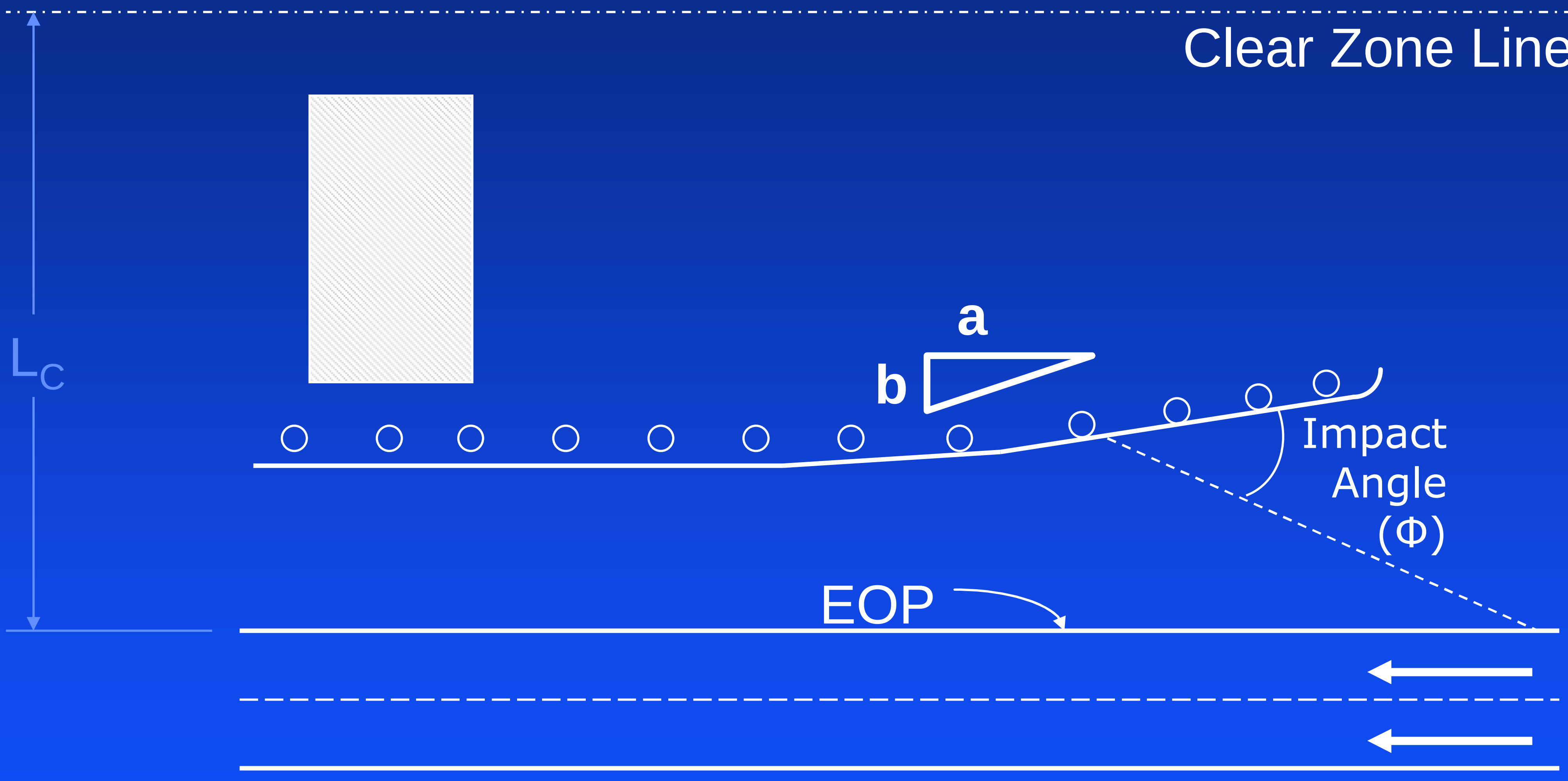
MDOT Flare Rates

Design Speed (mph)	Flare Rate (b/a) for	
	Concrete Barriers	Guardrail
70	1:20	1:15
60	1:18	1:14
55	1:16	1:12
50	1:14	1:11
45	1:12	1:10
40	1:10	1:8
30	1:8	1:7

RDM – Subsection 7.01.29.A

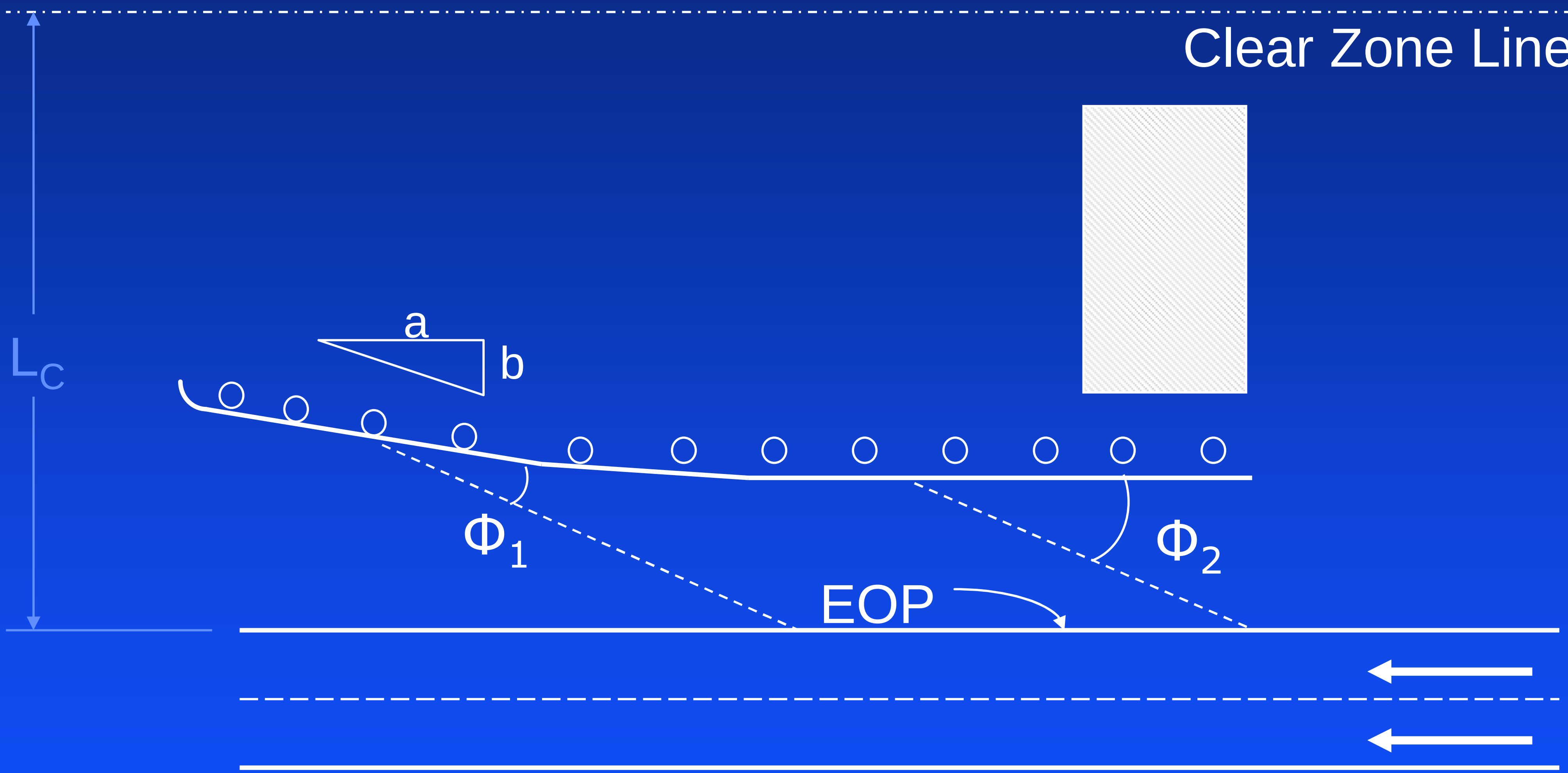
These are maximum flares rates for approach ends within clear zone.
Shallower flare rates are acceptable.

Approach End – One Way Traffic



<u>Flare Rate (b/a) Should Not Exceed Maximum In This Case</u>

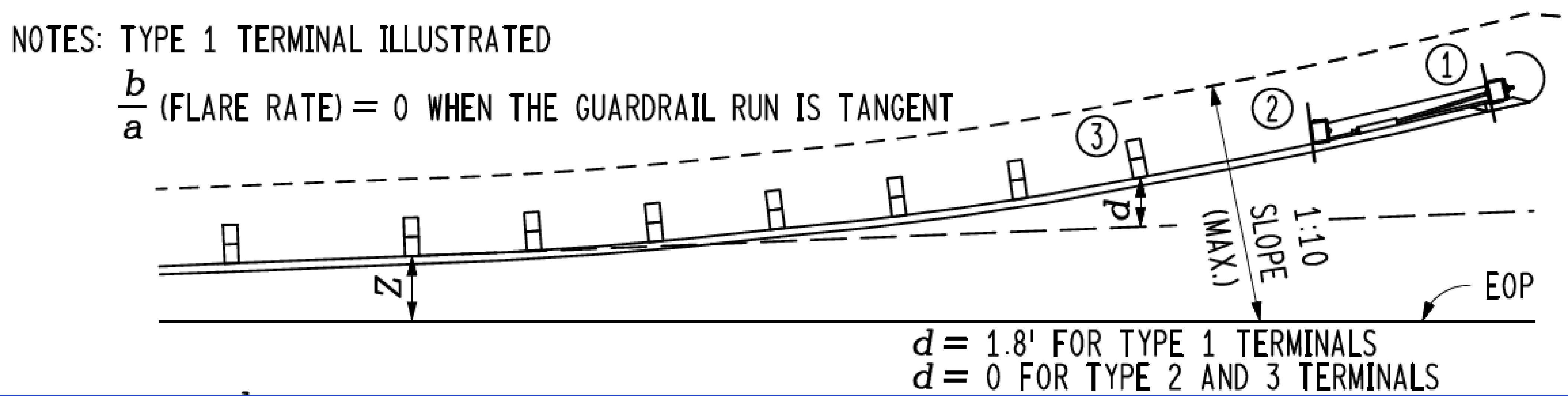
Departing End – One Way Traffic



Flare rate (b/a) may exceed recommended maximum,

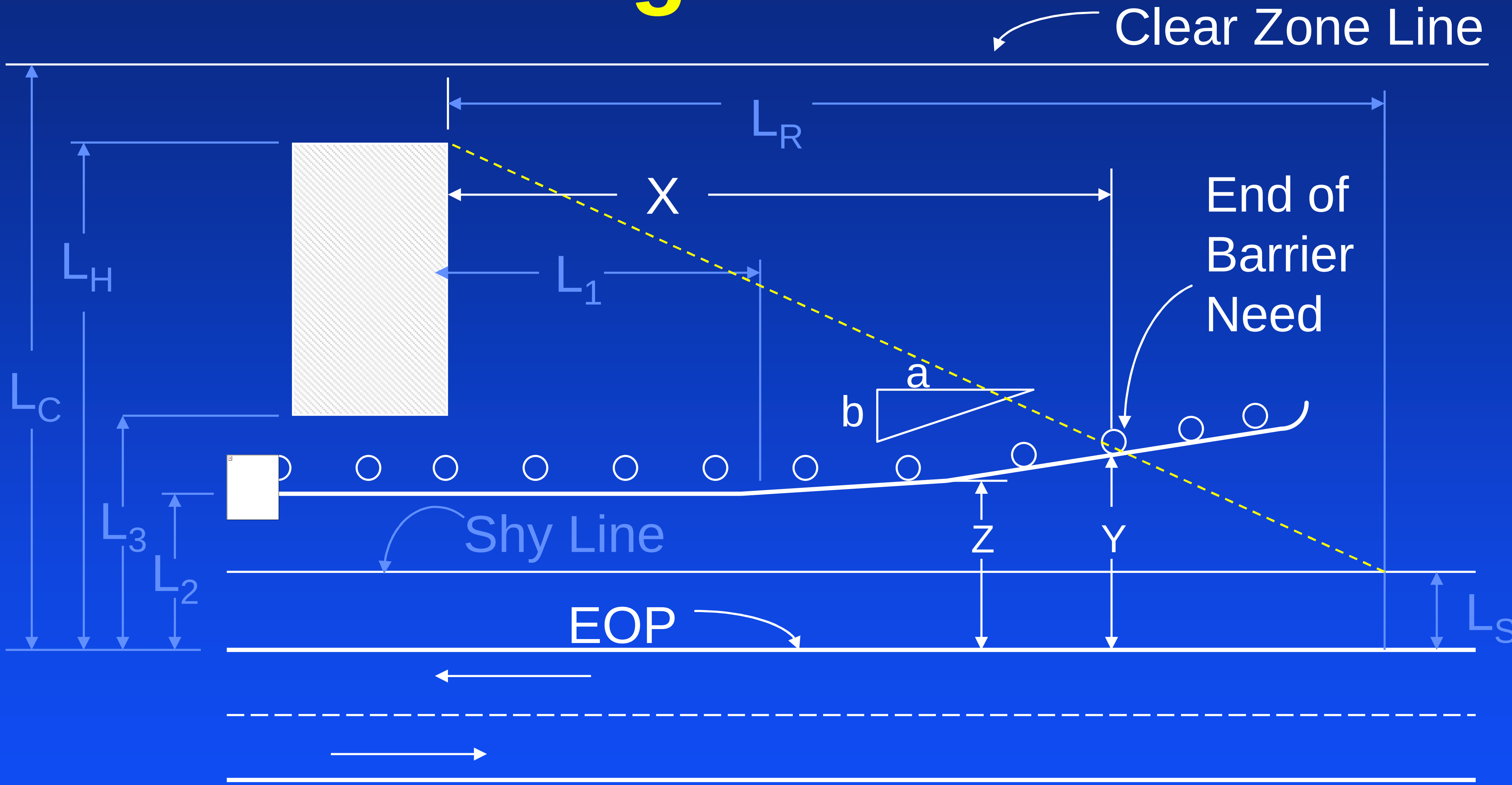
since Φ_1 is less than Φ_2

Design Factors

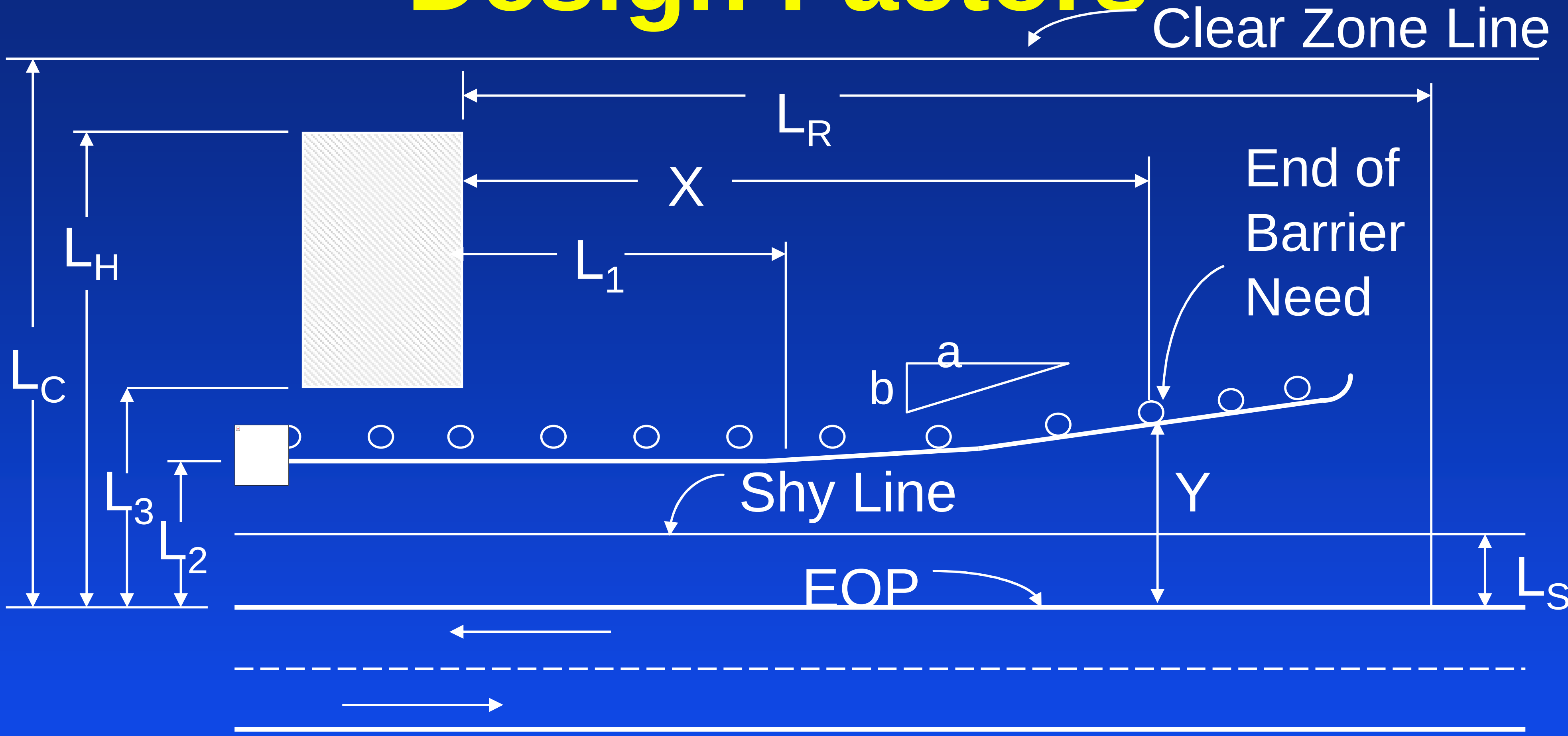


Note: d and Z are not described in the AASHTO RDG

Design Factors



Design Factors

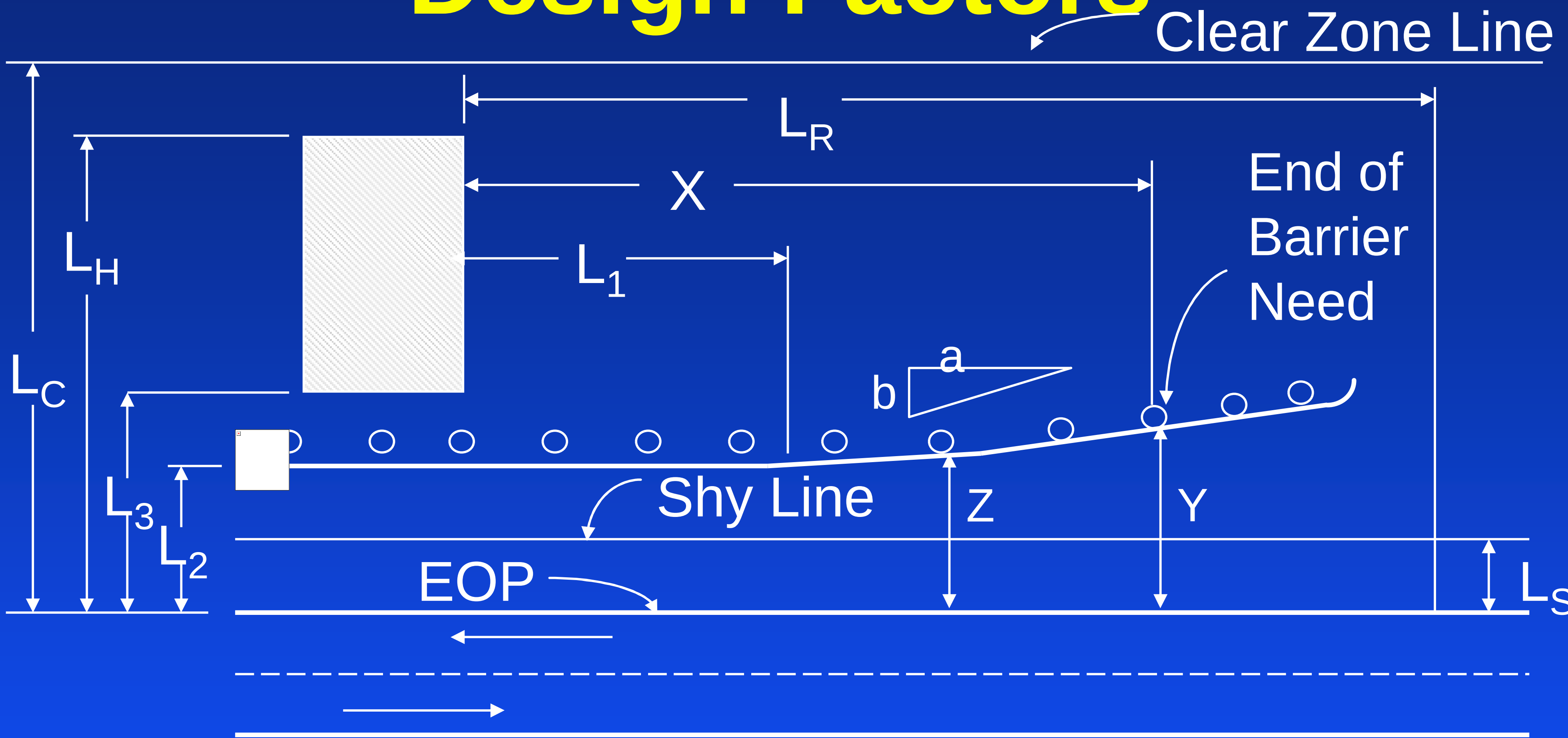


$$X = \frac{L_H + (b/a)(L_1) - (L_2 + d)}{(b/a) + (L_H/L_R)}$$

$$Y = L_H - (L_H/L_R)(X) + d$$

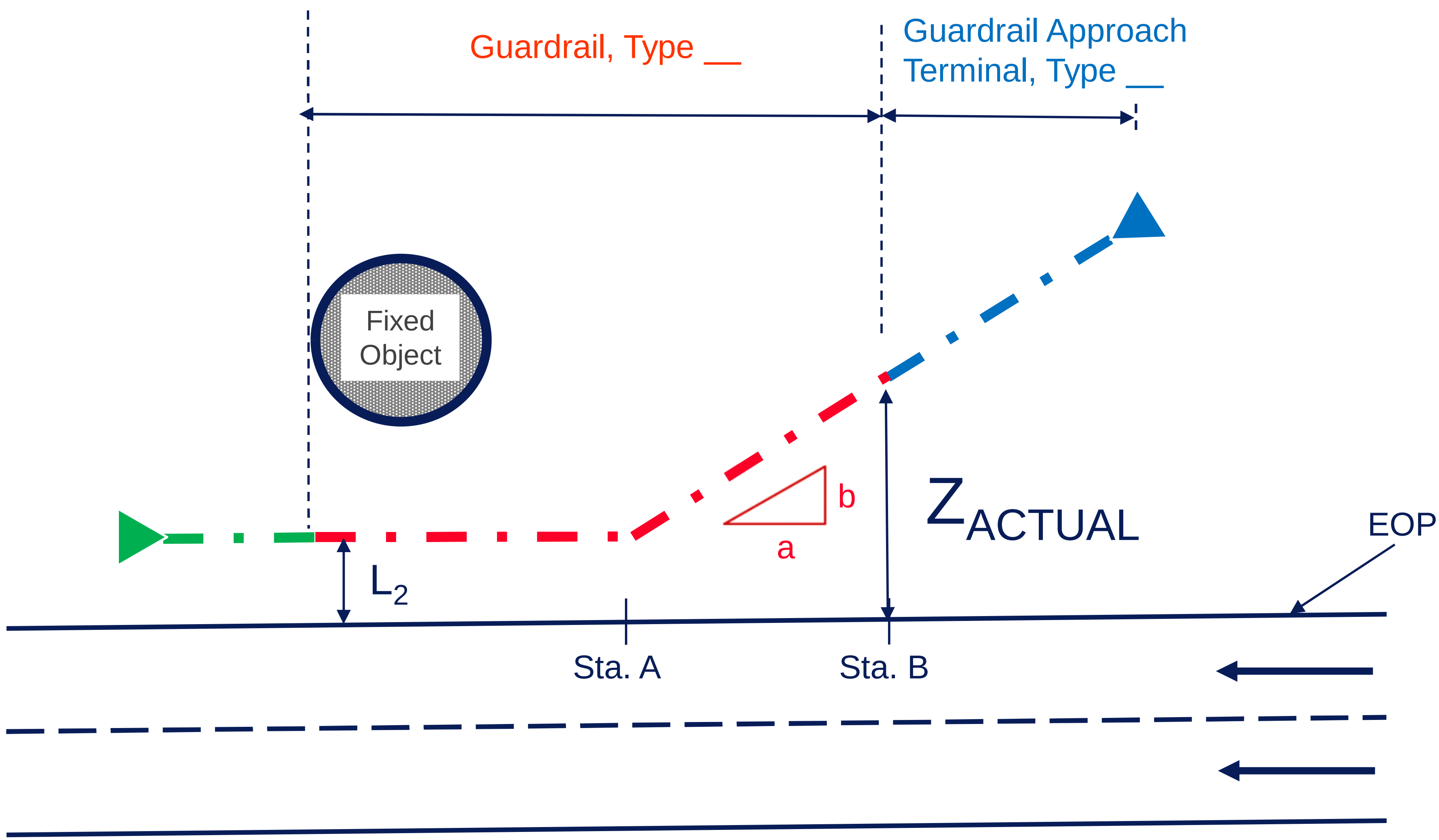
Note: Y is a term from the AASHTO RDG typically not used by MDOT.

Design Factors



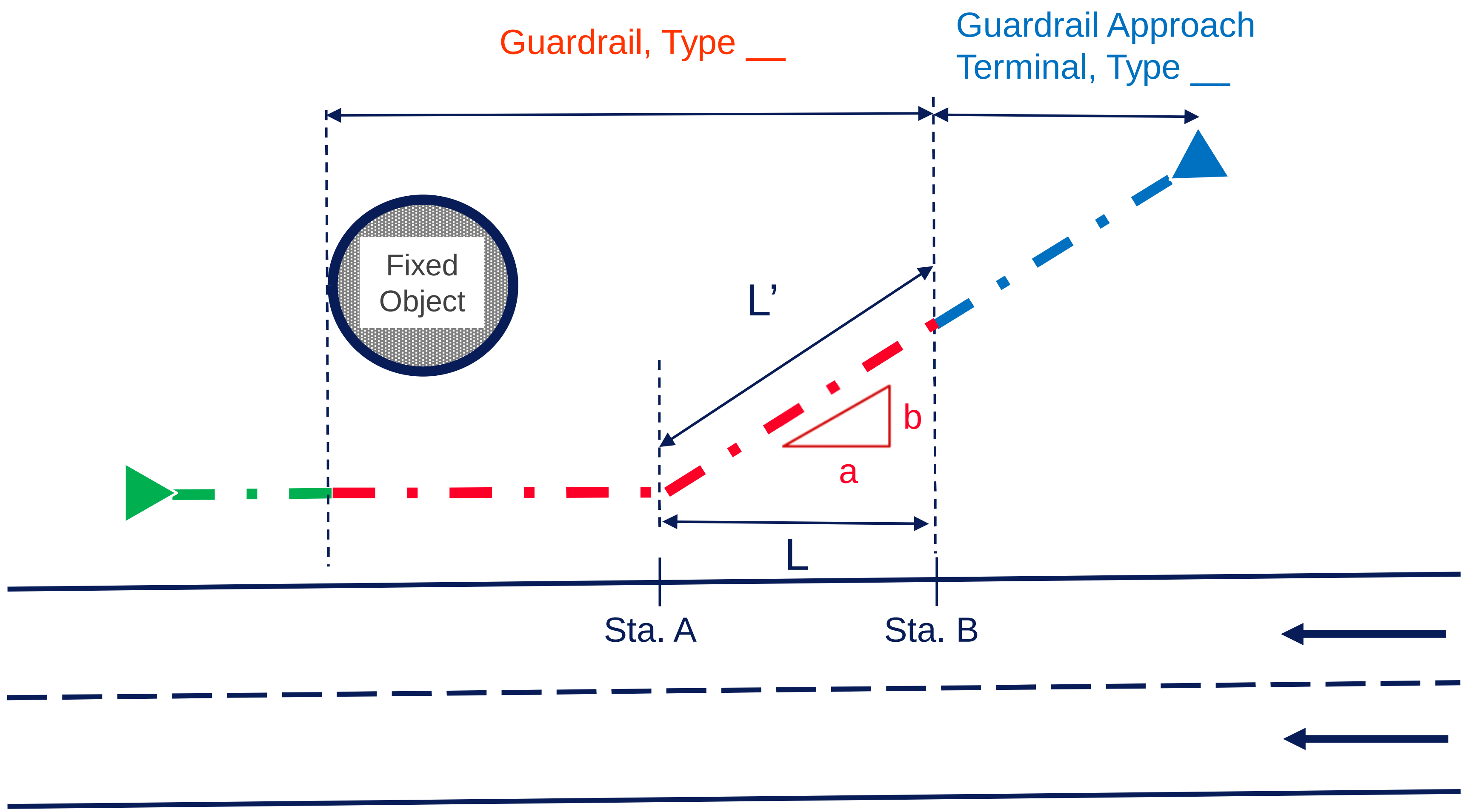
$$Z = L_2 + \left| (Sta._B - Sta._A) \right| \times (b/a)$$

Calculating Z



$$Z = L_2 + \left| (Sta._B - Sta._A) \right| \times (b/a)$$

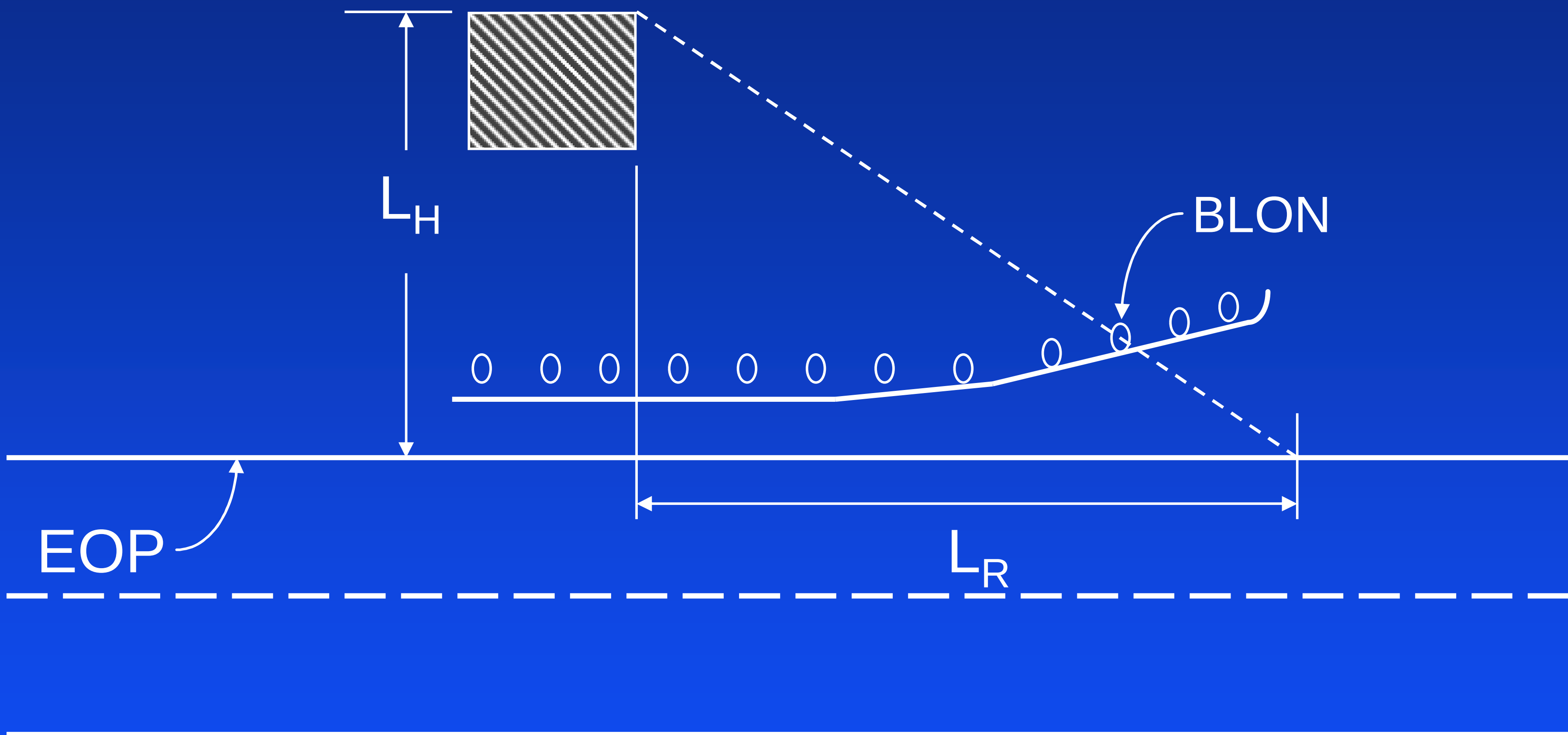
Calculating Stations A and B



Assume L ≈ L' for most guardrail applications

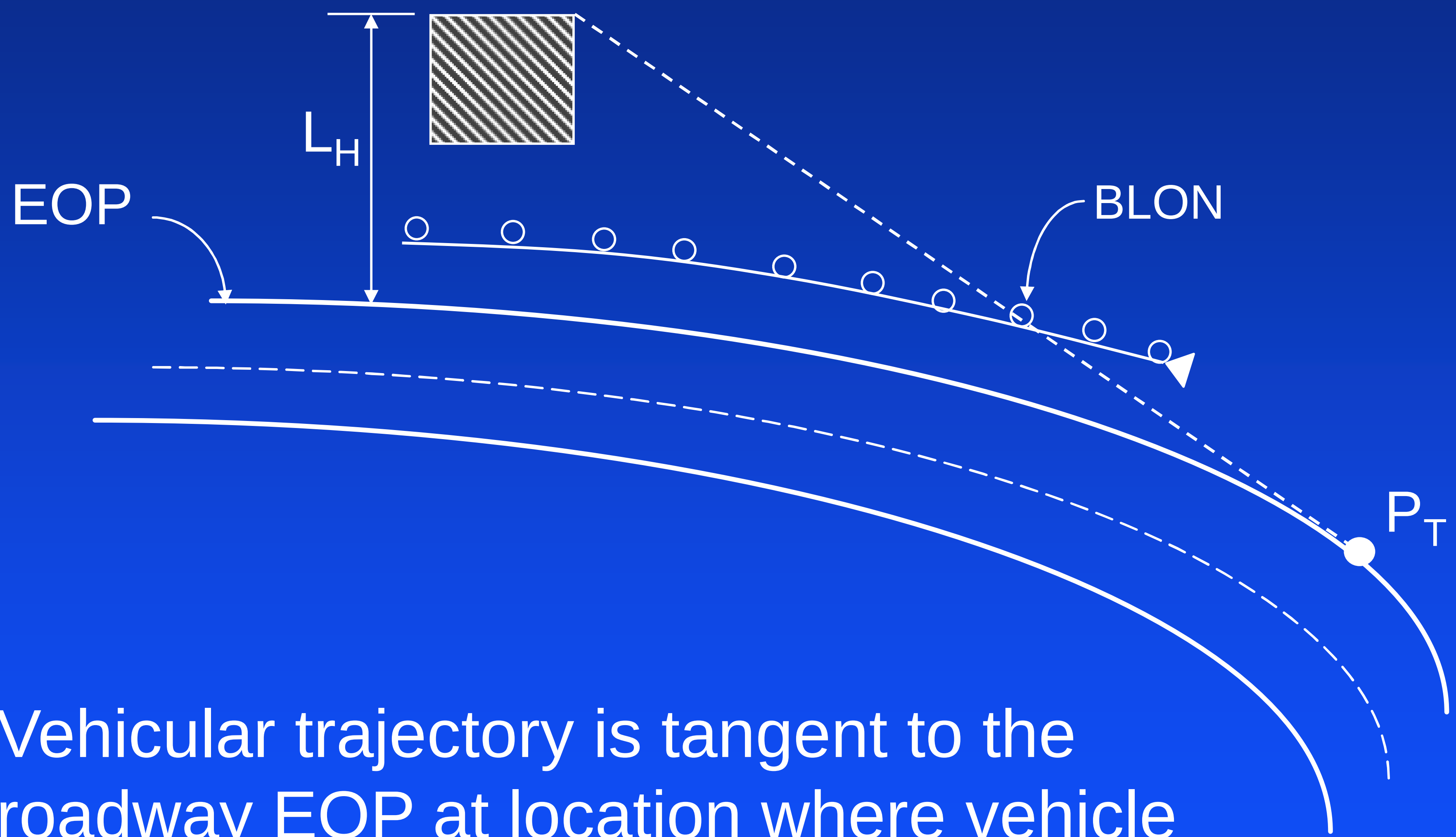
(unless dealing with extremely long flared sections)

Graphic Solution



Vehicular trajectory must intersect or be located in advance of
beginning length of need (BLON) point

Horizontal Curve Solution



- Vehicular trajectory is tangent to the roadway EOP at location where vehicle leaves the roadway (at location P_T)

Length of Need – Approach End
Flared vs. Parallel

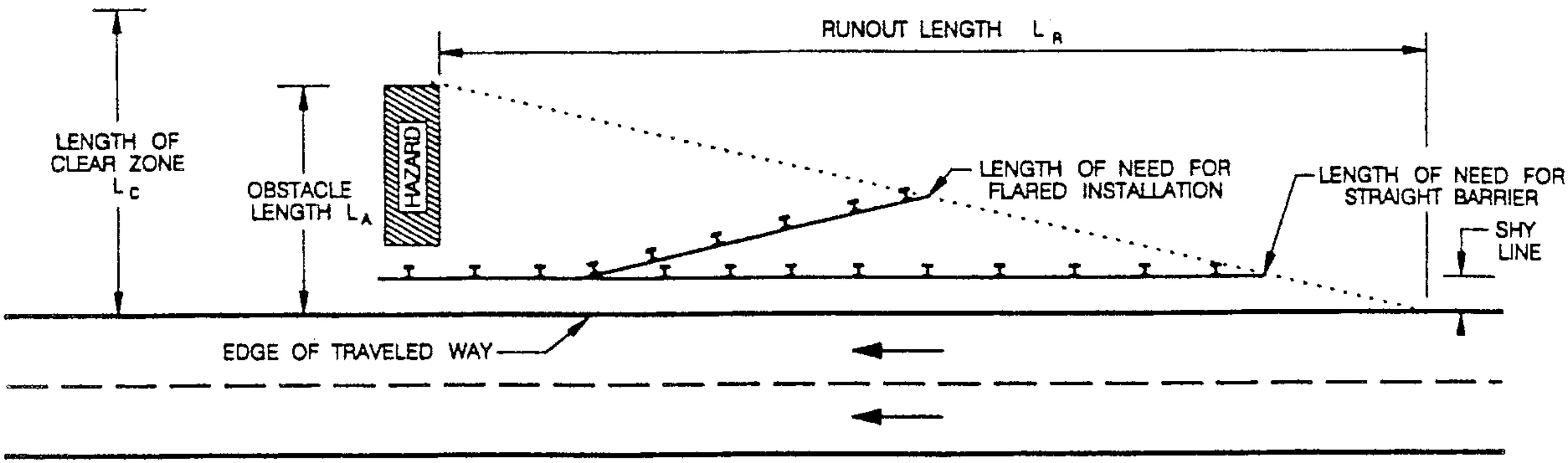
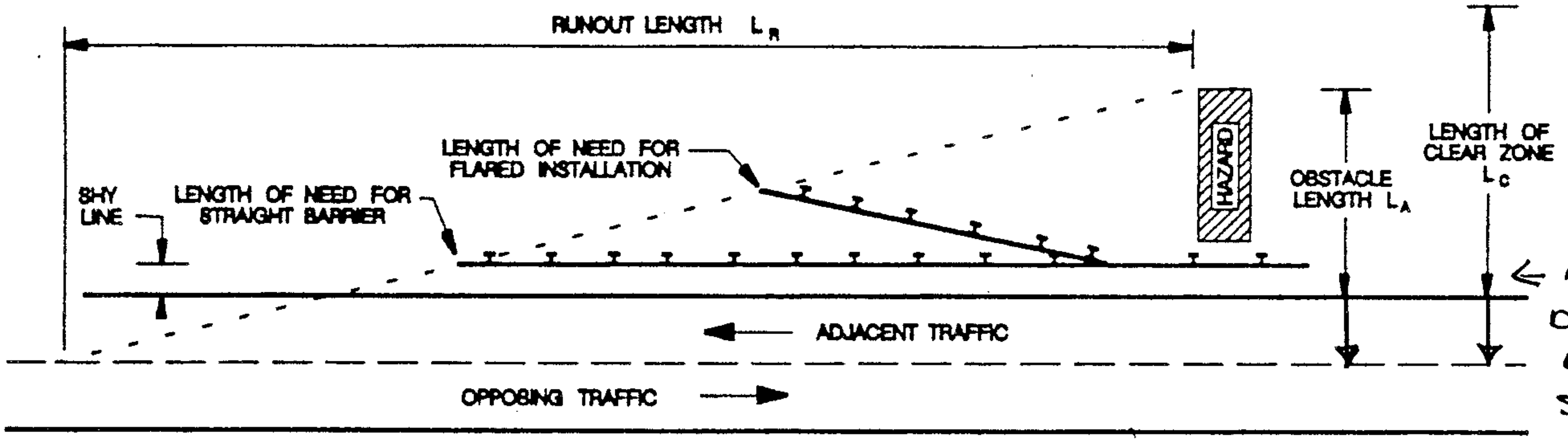


Figure 2.6.5 - Simplified representation of length of need

Flaring the guardrail reduces the length of need (X)

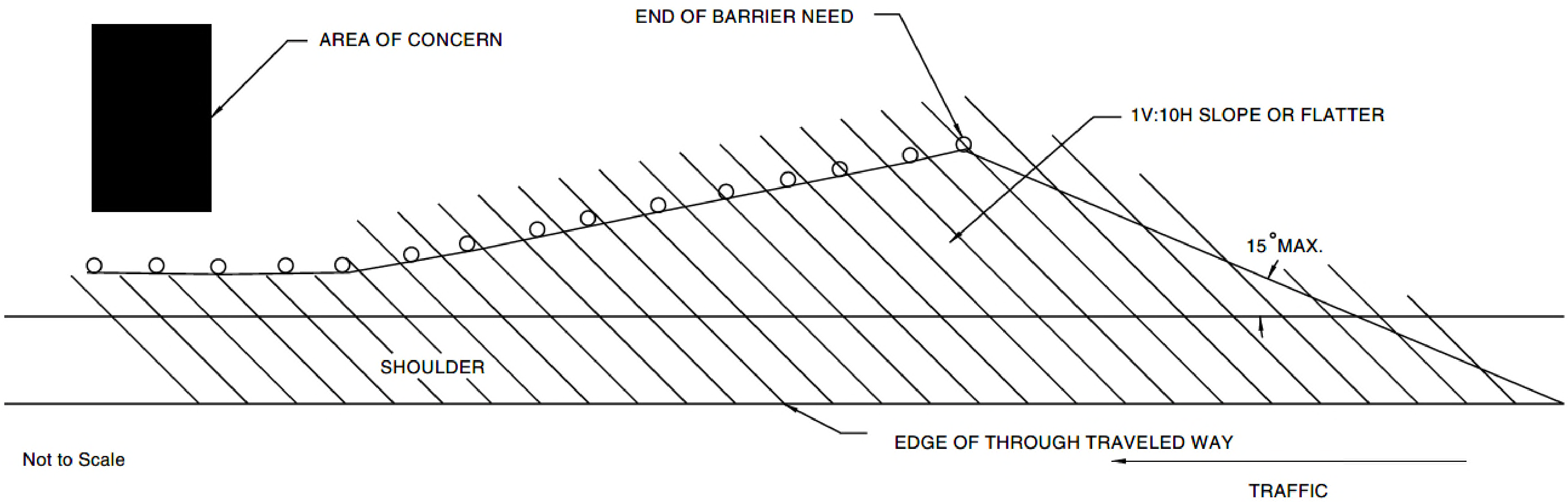
Length of Need – Departing End

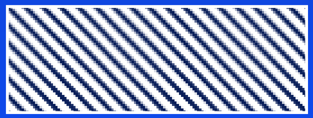
Flared vs. Parallel



Flaring the guardrail reduces the length of need (X)

Grading Requirements

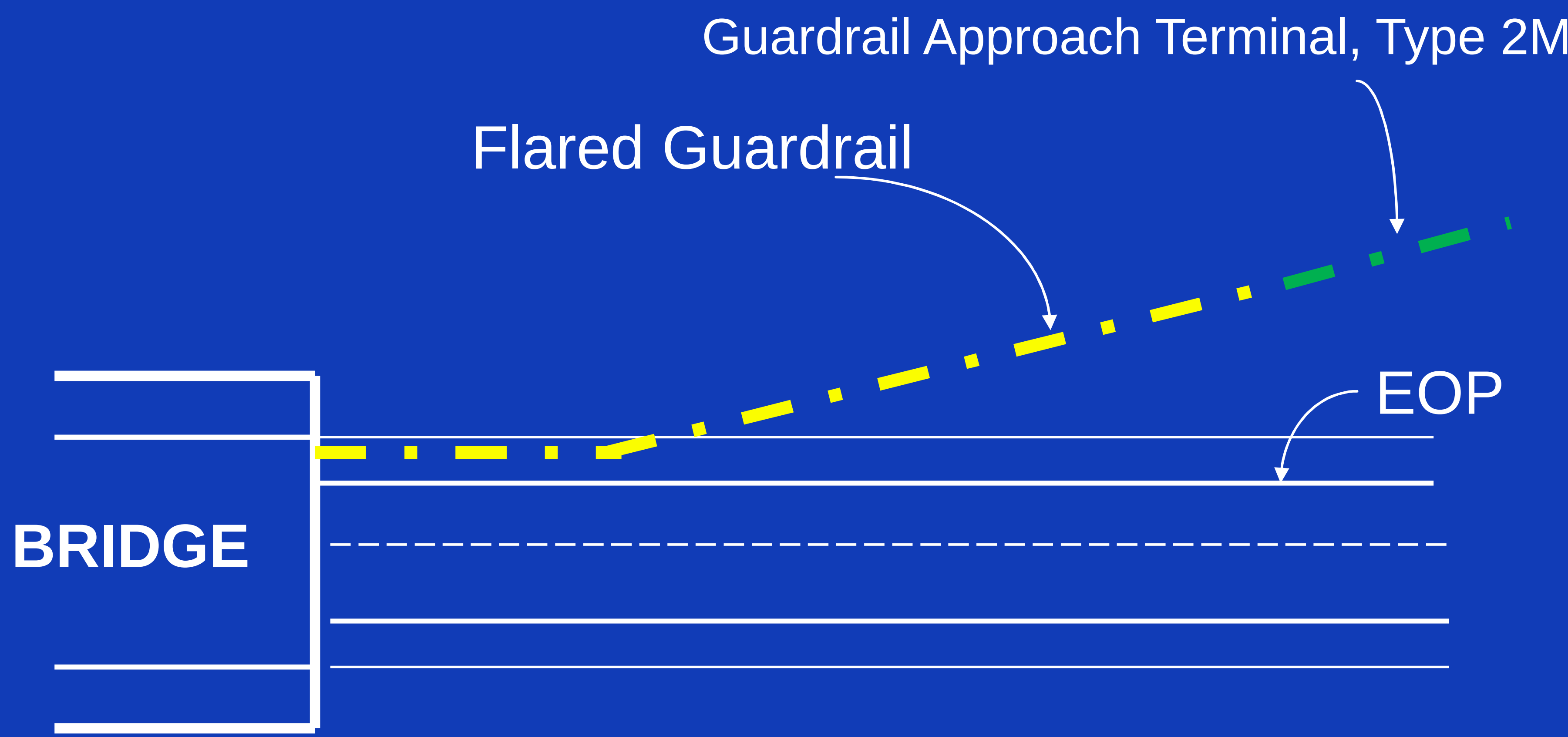




= 1:10 or flatter

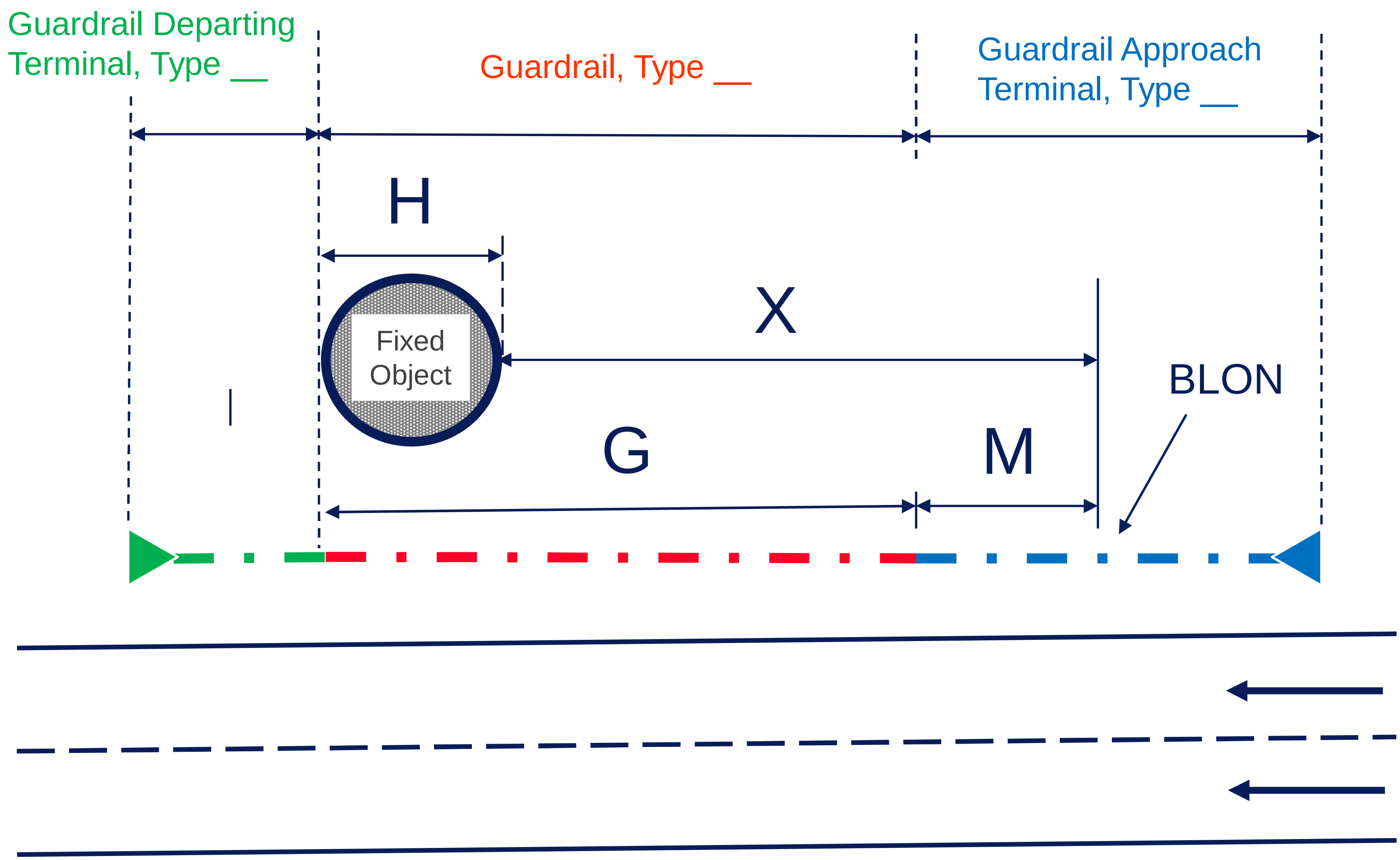
- Grading requirements for flared installations may be impractical or cost-prohibitive
- Decision to install flared or parallel guardrail run is <u>site-specific</u>

Can a Type 2 Terminal be Attached to Flared Guardrail?



Calculating Length of Guardrail

Freestanding Guardrail Shielding Fixed Object & One-Way Traffic



$$G^* = X - M + H$$

M (Deduction Value)

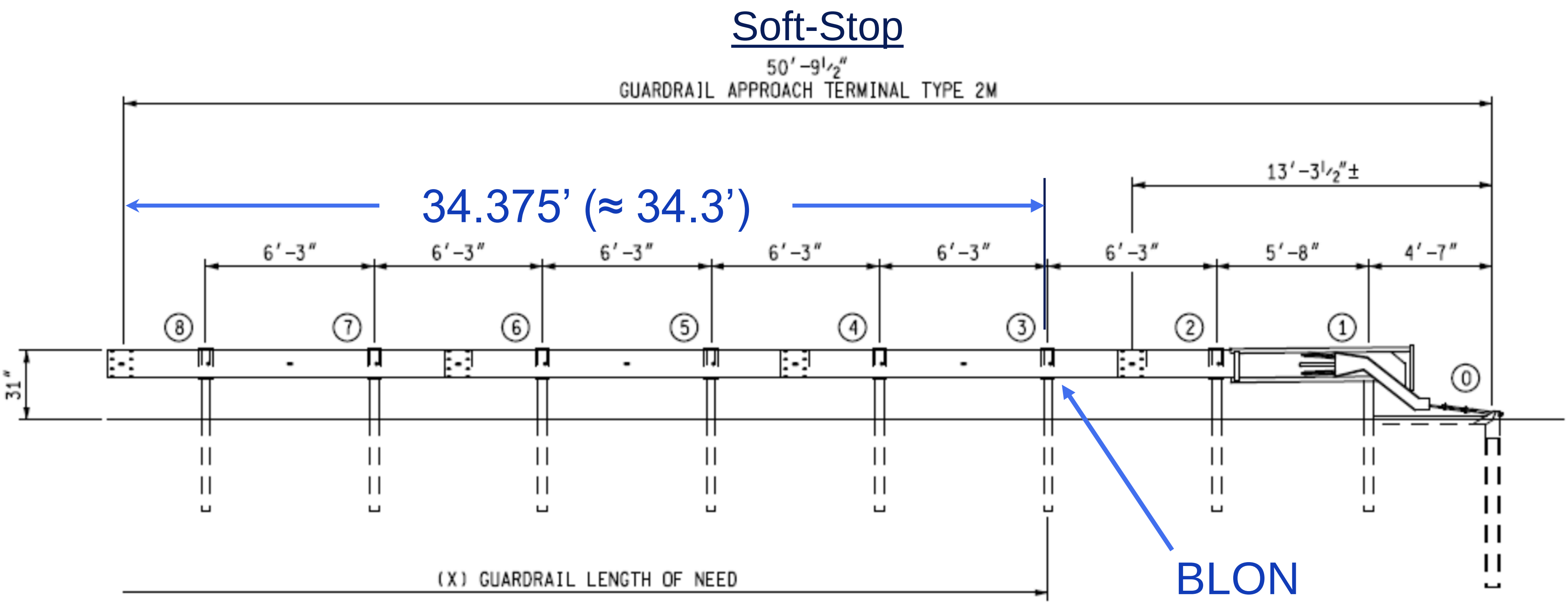
MDOT Guardrail Worksheet

DEDUCTION TABLE							
GUARDRAIL APPROACH TERMINAL TYPE							
1B	1T	2B	2T	2M	3B	3T	3M
25'	31.25'	37.5'	43.75'	34.3'	12.5'	31.25'	21.8'

Example:

For Type 2M terminals, use 34.3’ for the deduction value

Type 2M Terminal Deduction Value



- Currently, of the three Type 2M terminals in Standard Plan R-62 Series, Soft-Stop has the smallest deduction value (34.3')
- However, this will change when the NGT is adopted in Standard Plan R-62 Series
  - <u>Guardrail worksheet deduction value table will be revised</u>

Calculating Length of Guardrail

Freestanding Guardrail Shielding Fixed Object & One-Way Traffic

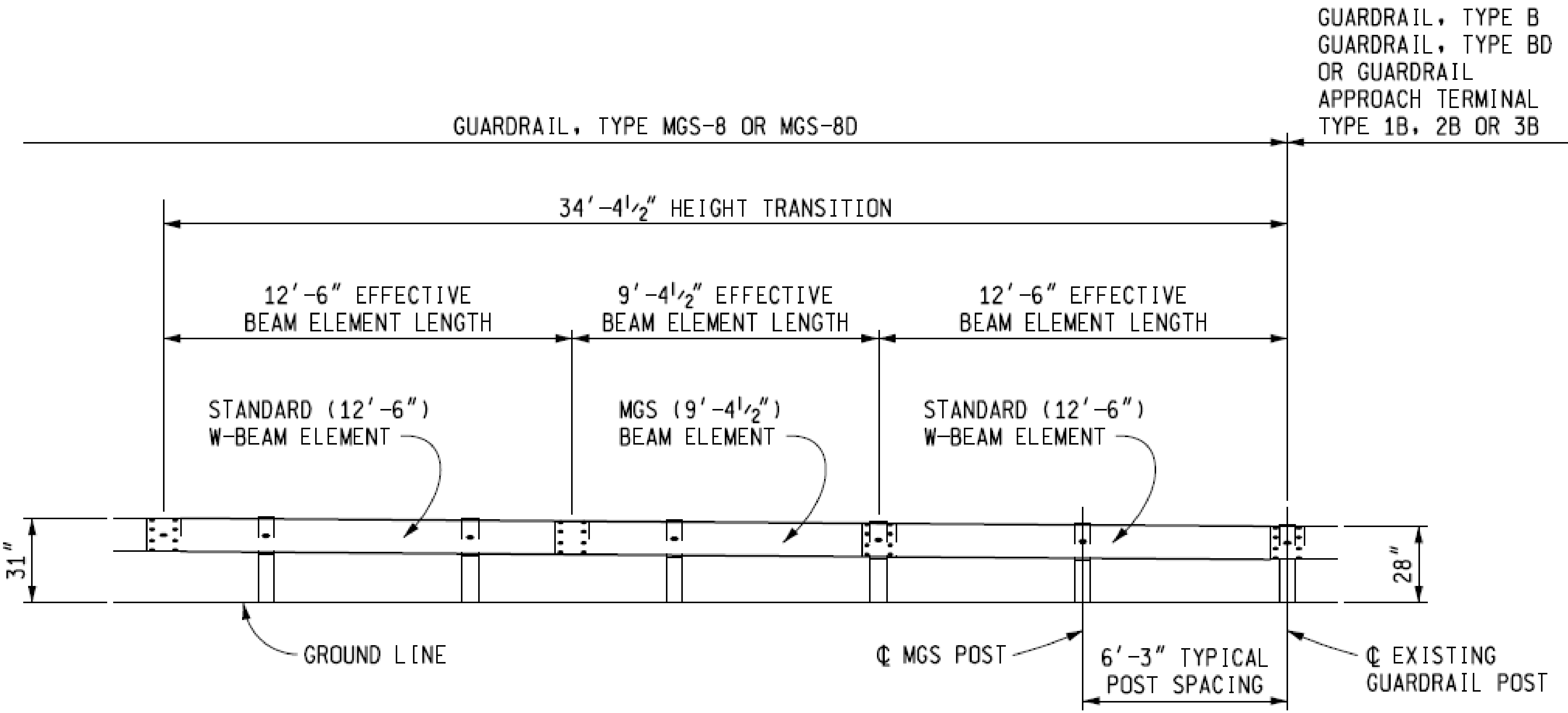
- H = fixed object width
- M = portion of approach terminal located within length of need
  - Deduction values from guardrail worksheet
- G = guardrail quantity

$$G^* = X - M + H$$

* Important Notes

- ➢ Always round up guardrail quantity based on whole number of guardrail panels
- ➢ With a freestanding run consisting of Type 2M approach terminals, Type MGS-8 guardrail, and/or Type MGS departing terminals, guardrail quantity will be divisible by 12.5’
- ➢ When interconnecting NCHRP 350 and MASH-compliant guardrail features, guardrail quantity might **not** be divisible by 12.5’
  - ❖ Examples: Type MGS-8 guardrail to Type B or Type T guardrail, or Type MGS-8 guardrail to NCHRP 350-compliant anchorages
  - ❖ Must take MGS (9’-4.5”) beam elements and thrie-beam transition panels into consideration when determining guardrail quantities

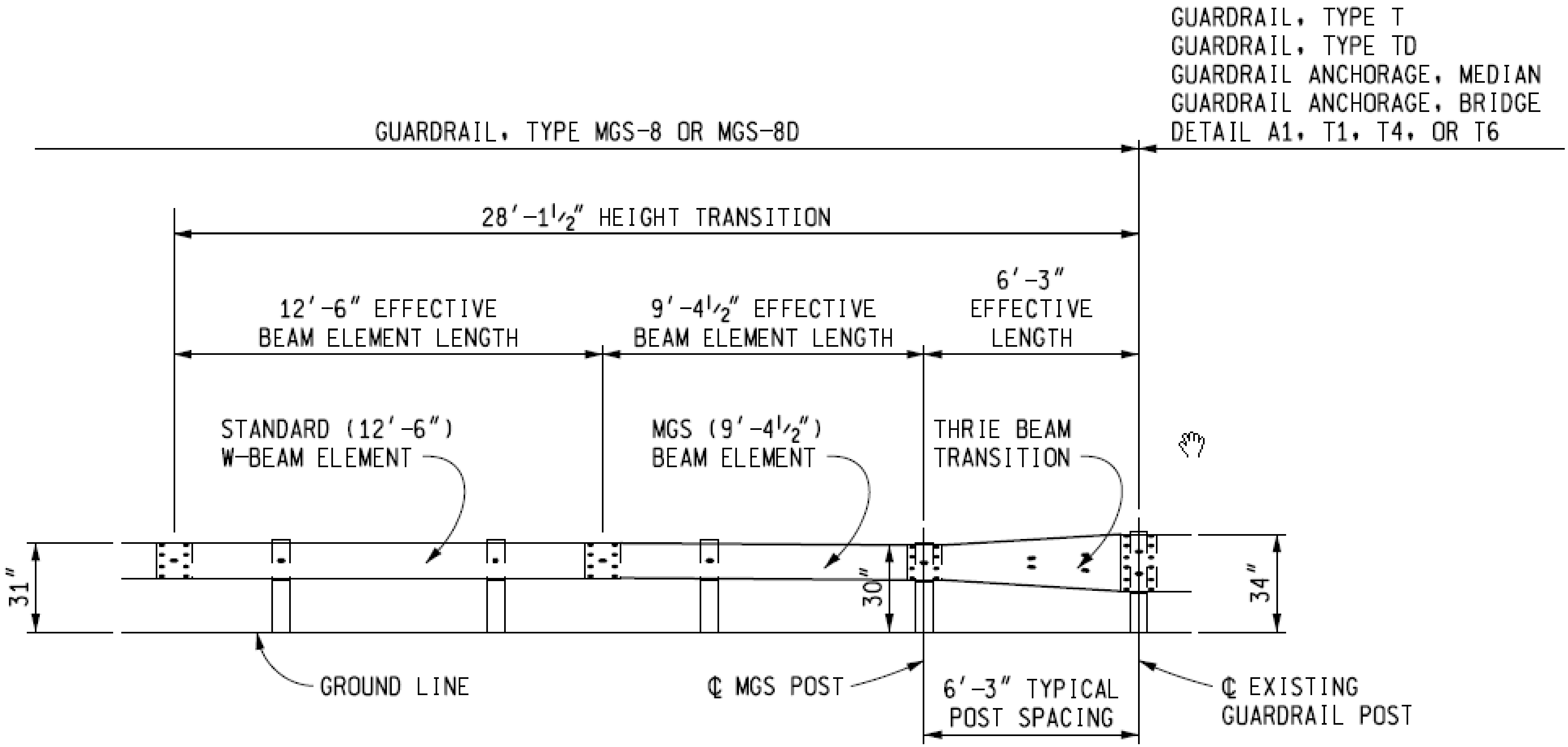
MDOT Standard Plan R-60-Series



ELEVATION SHOWING TRANSITION DETAIL FOR CONNECTING GUARDRAIL, TYPE MGS-8 OR MGS-8D TO GUARDRAIL, TYPE B, GUARDRAIL, TYPE BD, OR GUARDRAIL APPROACH TERMINAL TYPE 1B, 2B, OR 3B

Note: Transition is part of Guardrail, Type MGS-8 or MGS-8D

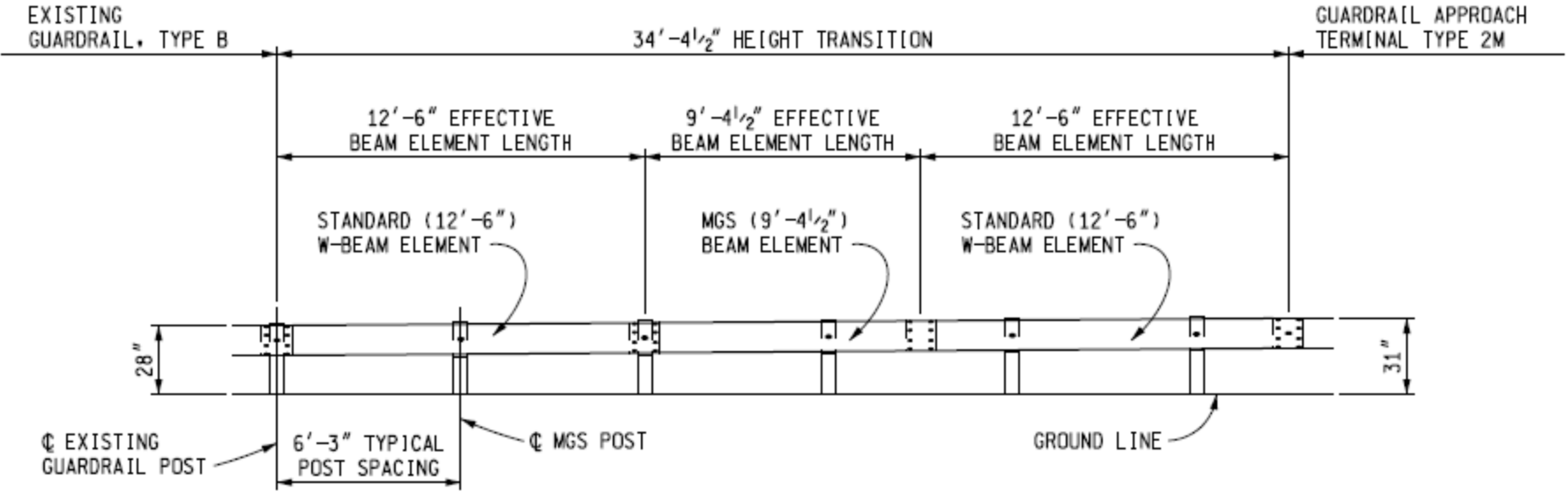
MDOT Standard Plan R-60-Series



ELEVATION SHOWING TRANSITION DETAIL FOR CONNECTING GUARDRAIL, TYPE MGS-8 OR MGS-8D TO GUARDRAIL, TYPE T, GUARDRAIL, TYPE TD, GUARDRAIL ANCHORAGE, MEDIAN, GUARDRAIL ANCHORAGE, BRIDGE DETAIL A1, T1, T4 OR T6

Note: Transition is part of Guardrail, Type MGS-8 or MGS-8D

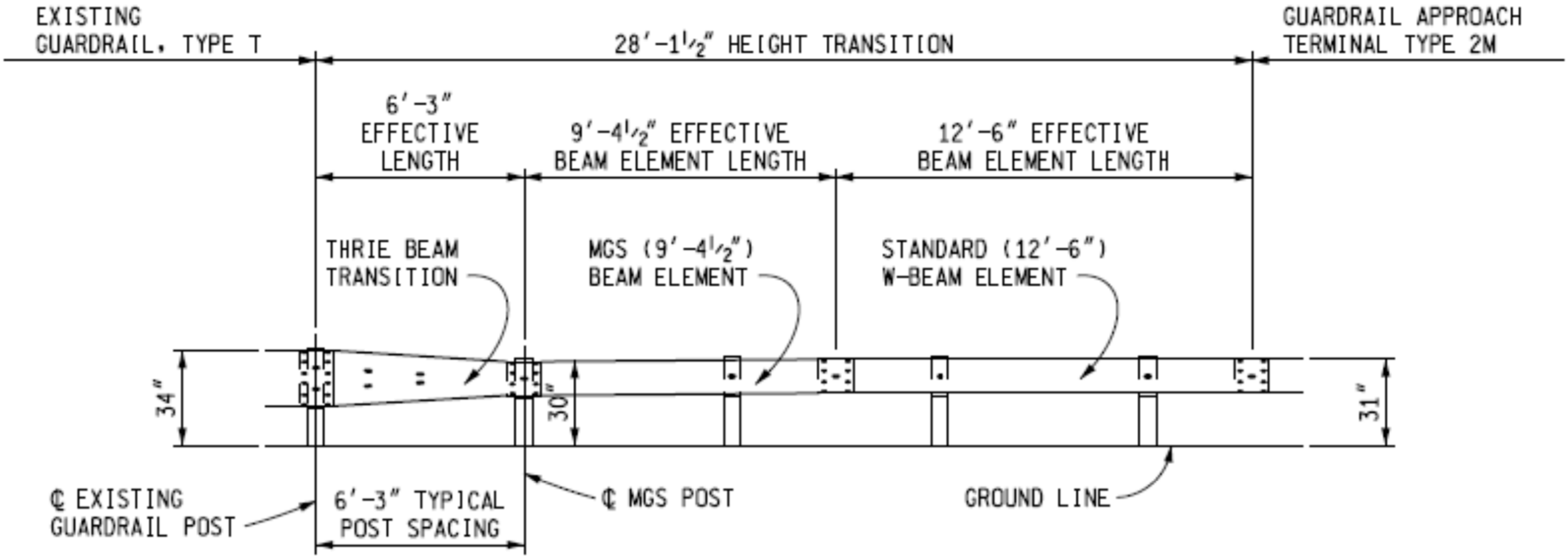
MDOT Standard Plan R-60-Series



ELEVATION SHOWING TRANSITION DETAIL FOR CONNECTING
GUARDRAIL, TYPE B TO
GUARDRAIL APPROACH TERMINAL TYPE 2M

Note: Transition is part of Guardrail Approach Terminal, Type 2M

MDOT Standard Plan R-60-Series

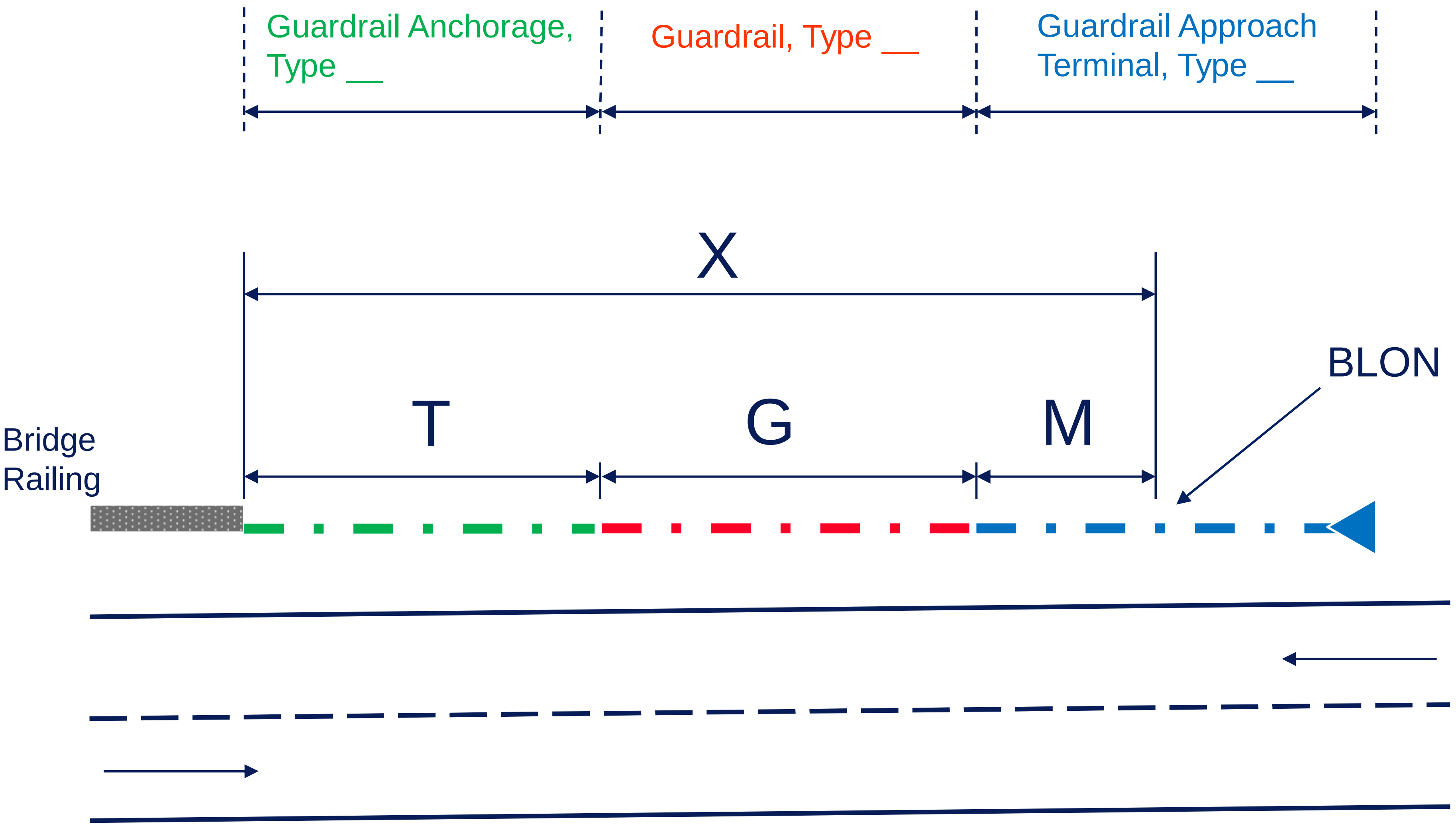


ELEVATION SHOWING TRANSITION DETAIL FOR CONNECTING
GUARDRAIL, TYPE T TO
GUARDRAIL APPROACH TERMINAL TYPE 2M

Note: Transition is part of <u>Guardrail Approach Terminal, Type 2M</u>

Calculating Length of Guardrail

Guardrail Anchored to Bridge Railing



$$G^* = X - M - T$$

Calculating Length of Guardrail

Guardrail Anchored to Bridge Railing

- T = transition length measured from edge of bridge railing/barrier (if applicable)
  - Do not deduct overall transition length
  - Deduction lengths for M-series and T-series anchorages provided in earlier slides
- M = portion of approach terminal located within length of need
  - Deduction values from guardrail worksheet
- G = guardrail quantity

$$G^* = X - M - T$$

* Important Notes

- ➢ Always round up guardrail quantity to the nearest whole number of guardrail panels
- ➢ Must take MGS (9'-4.5") beam elements and thrie-beam transition panels into consideration when determining guardrail quantities
  - ❖ Guardrail quantity may not be divisible by 12.5' in certain cases

Reflectors

- MDOT Standard Plan R-60 Series describes recommended reflector spacing
- *Do not install reflectors on approach terminals*

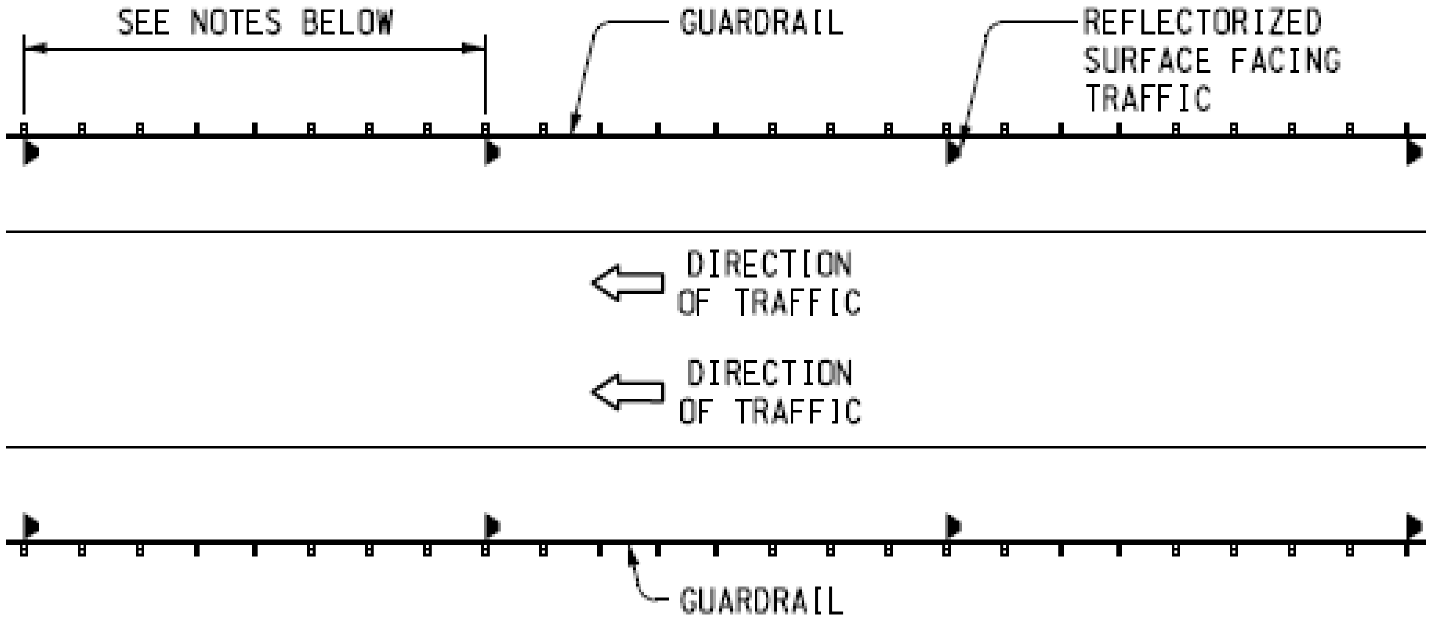
$$N_R = \left(\frac{\text{Guardrail Length*}}{\text{Reflector Spacing}} \right) + 1$$

N_R is always rounded up to nearest integer

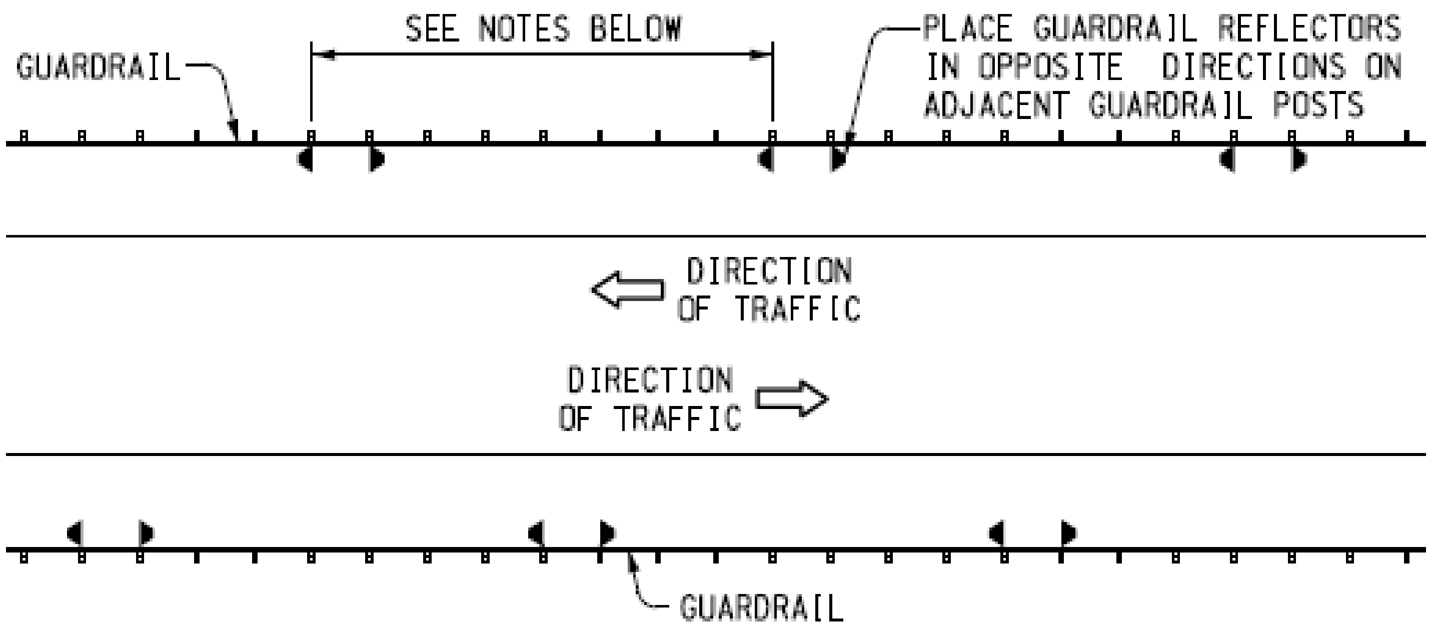
* Total Guardrail Length, including anchorages, but excluding approach terminals

Reflectors

- One-Way Roads:
  - Reflector quantity = N_R
- Two-Way Roads:
  - Reflector quantity = $2N_R$



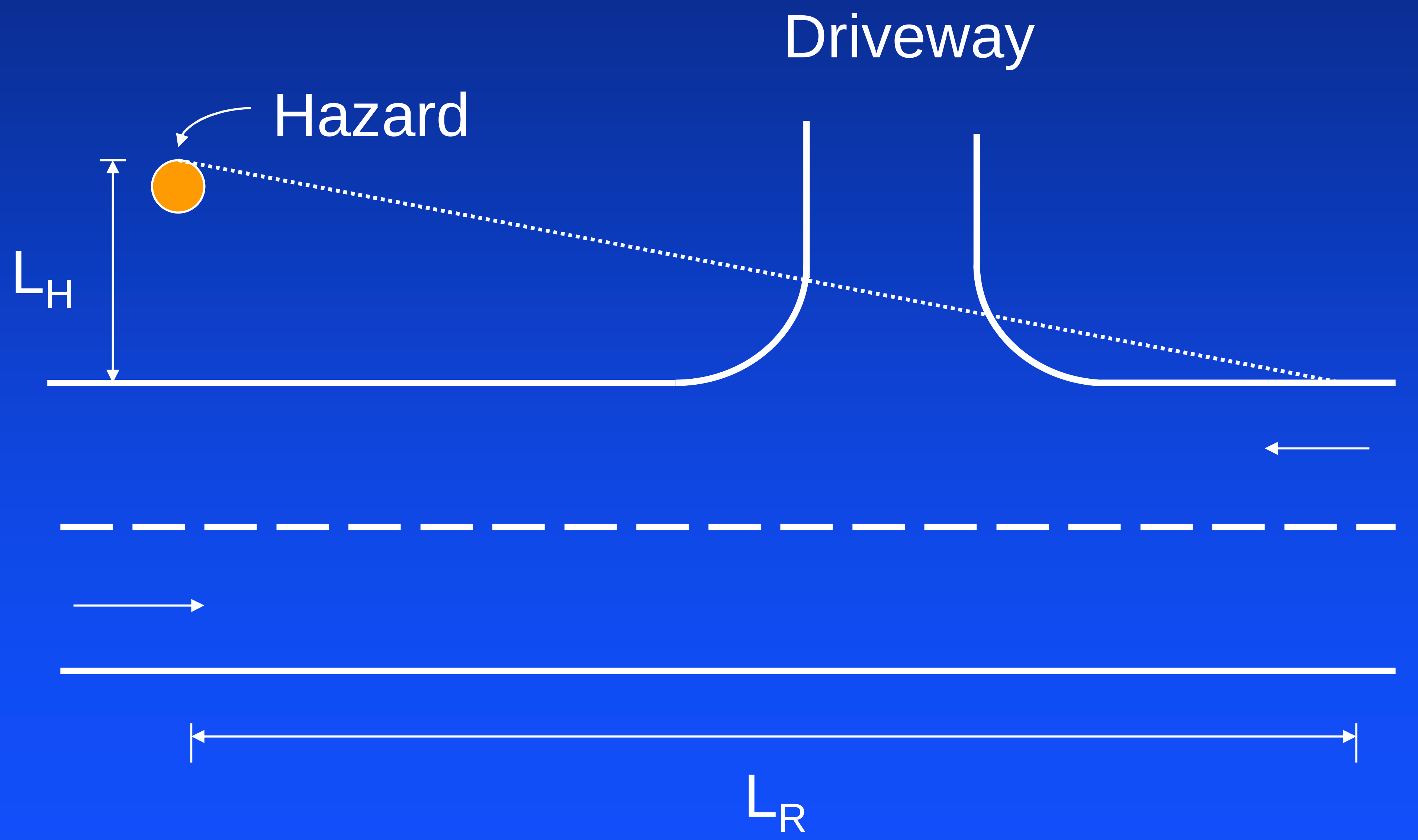
ONE-WAY TRAFFIC



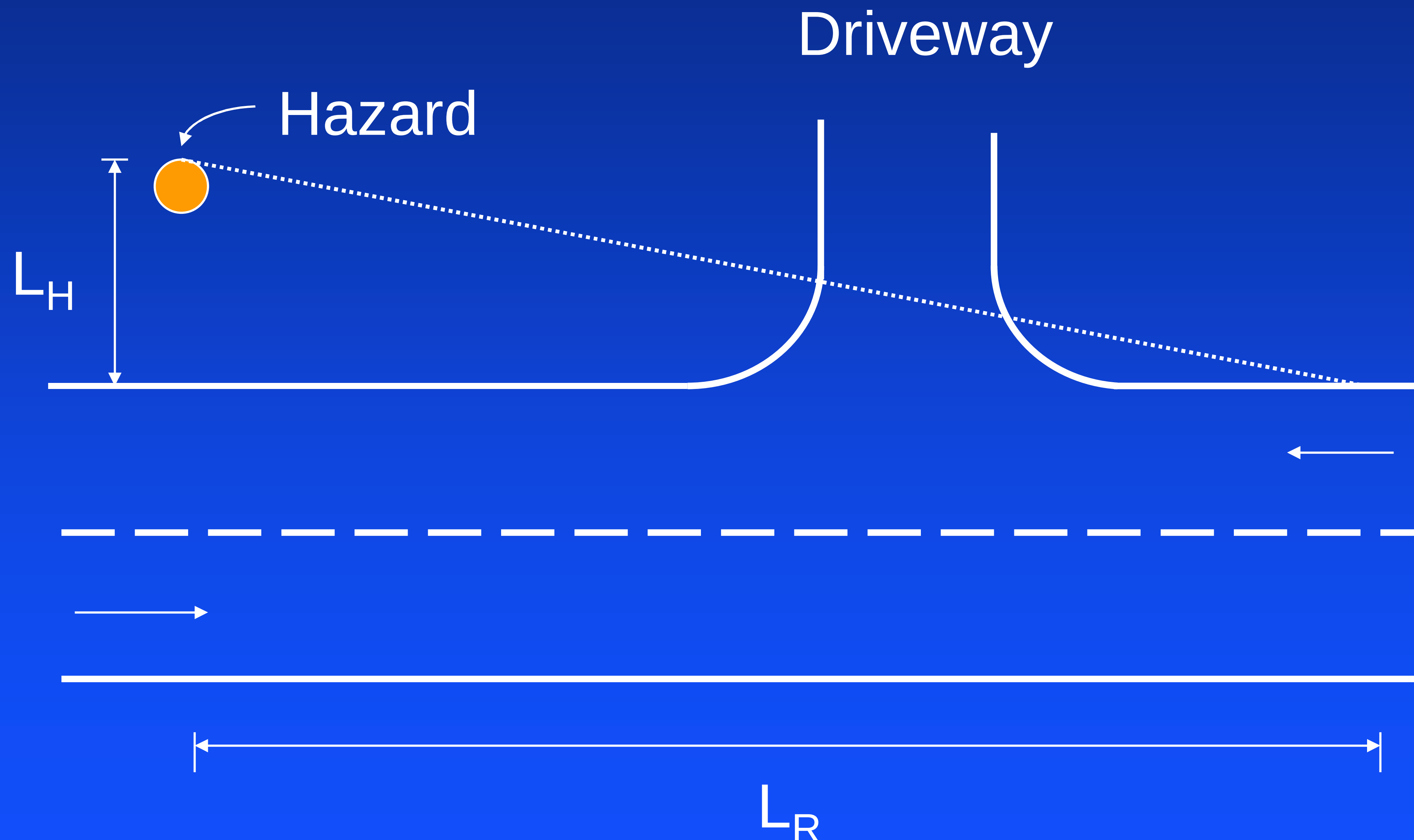
TWO-WAY TRAFFIC

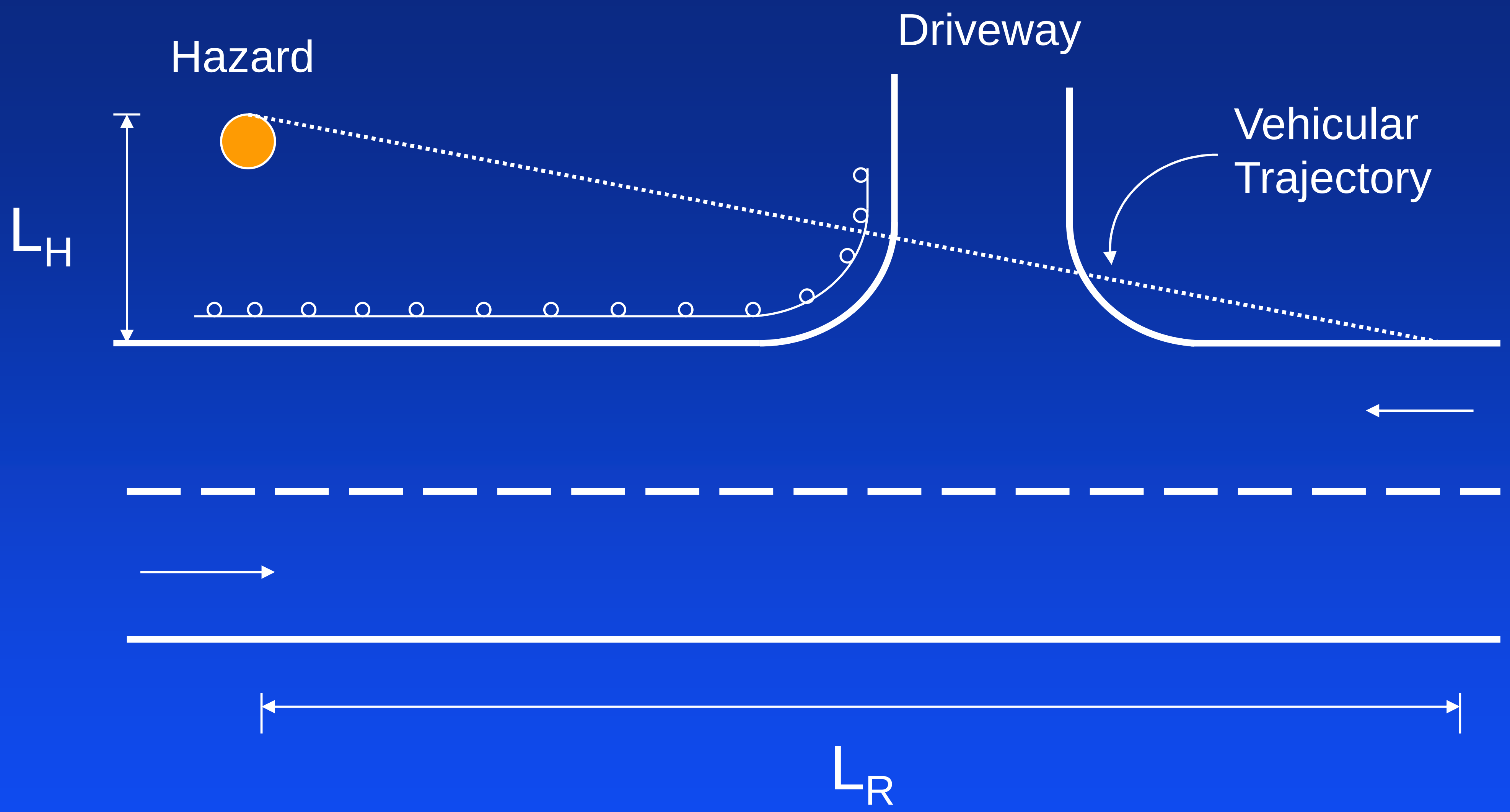
PLACEMENT OF GUARDRAIL REFLECTORS

Common Design Problem

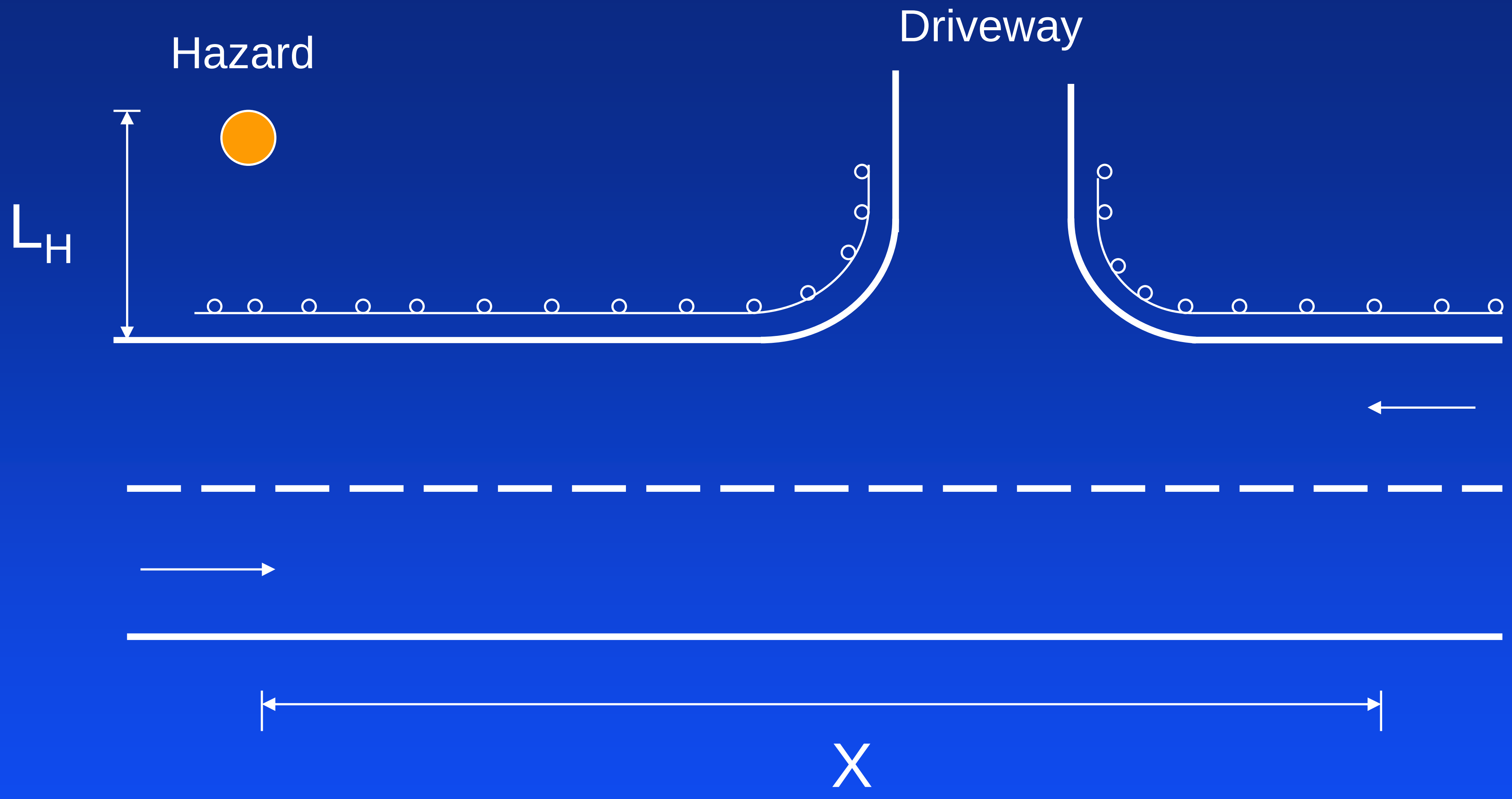


Described in Section 7.01.30.H of RDM

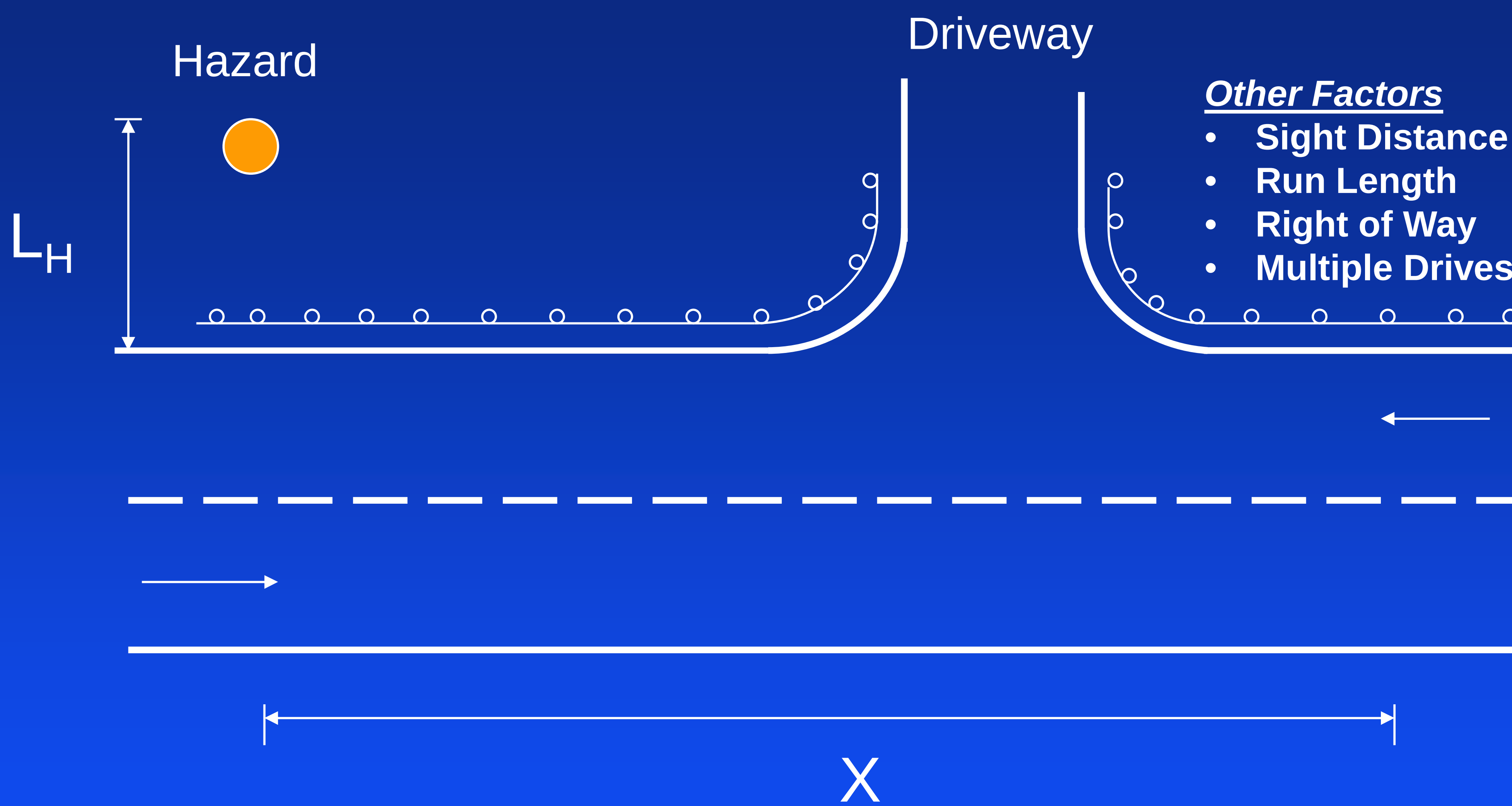




Ensure vehicular trajectory intersects curved or strong post guardrail (excluding first 12.5 feet of approach terminal or departing terminal)



Otherwise, consider continuing guardrail past intersecting driveway until LON is satisfied



<u>Other Factors</u>

- **Sight Distance**
- **Run Length**
- **Right of Way**
- **Multiple Drives**

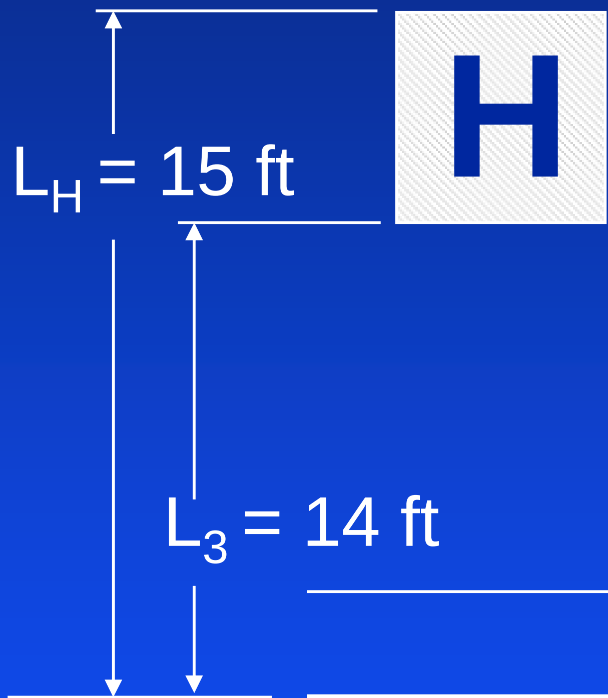
<u>However, designers must take other factors into consideration…design is site-specific!!</u>


7682

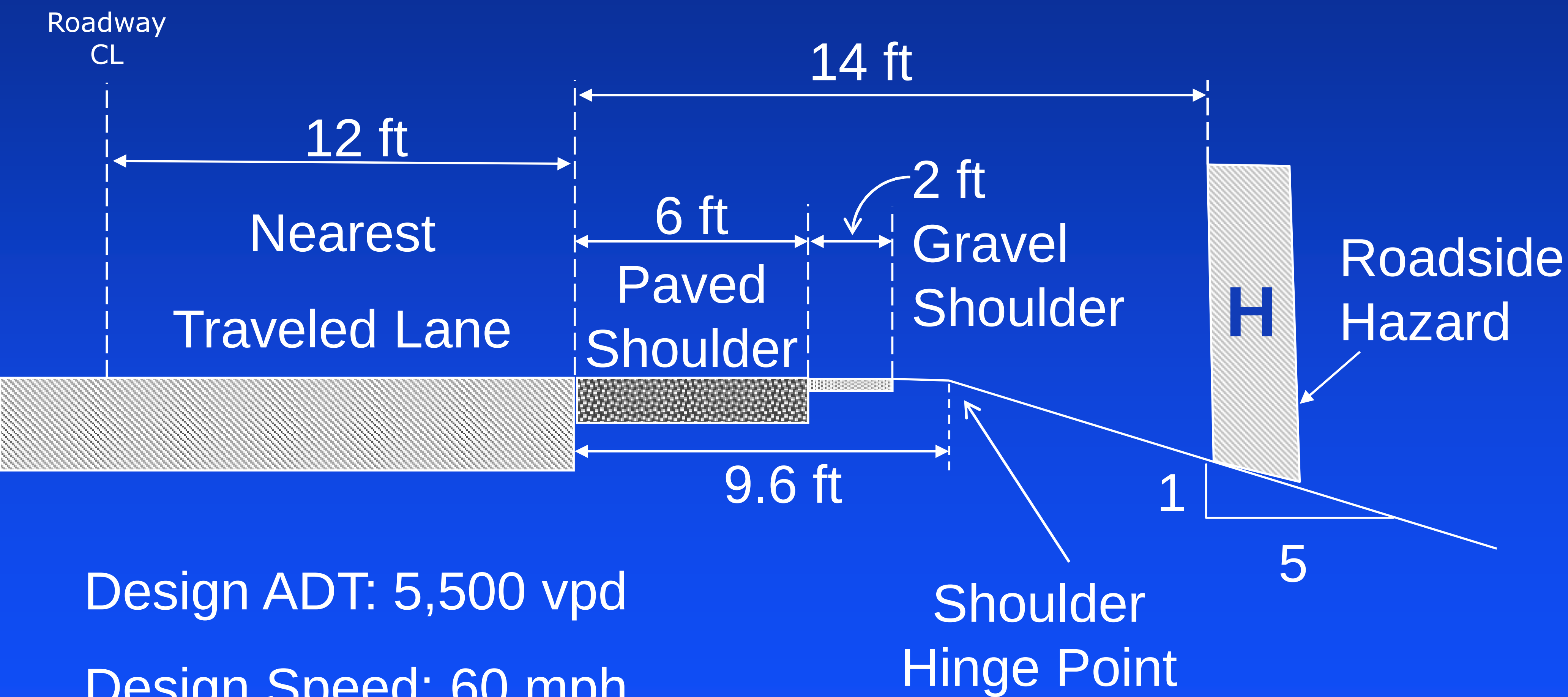

7670

Practice Example #1

- ADT: 5,500 vpd
- Design Speed: 60 mph
- Slope: 1:5, Fill
- Non-Freeway
- Flare guardrail where possible
- Two-lane, two-way road with 12’ lanes



Practice Example #1



Design ADT: 5,500 vpd

Design Speed: 60 mph

Non-Freeway

CLEAR ZONE DISTANCES
(IN FEET FROM EDGE OF DRIVING LANE)

DESIGN SPEED	DESIGN ADT	FILL SLOPES			CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3	1:3	1:4 TO 1:5	1:6 OR FLATTER
40 mph or Less	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 mph	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	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	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 mph	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 mph	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

Questions

- Which guardrail type should be used?
  - ✓ Type MGS-8
- Which terminal type should be used on the approach end of the guardrail run?
  - ✓ Guardrail Approach Terminal, Type 2M
  - ✓ Terminal within clear zone of approaching traffic
- Which terminal type should be used on the departing end of the guardrail run?
  - ✓ Guardrail Approach Terminal, Type 2M
  - ✓ Terminal within clear zone of opposing traffic

GUARDRAIL WORKSHEET

(REV. 02-2024)

FOR APPROACH TERMINALS ON R-61-SERIES, R-62-SERIES AND R-63-SERIES

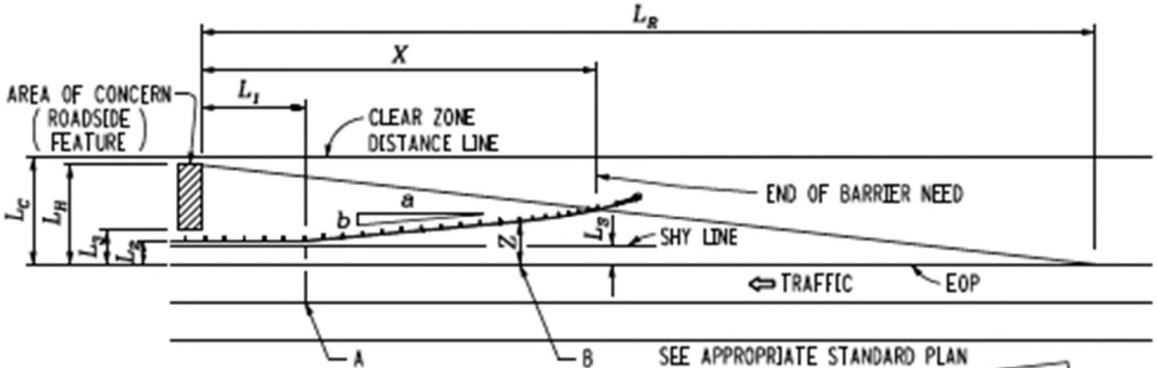
ROUTE ________ CONTROL SECTION ________ JOB # ________

DESIGNED BY ________ DATE ________ CHECKED BY ________ DATE ________

APPROX. STATION OR M.P. ________ DESCRIPTION ________

GUARDRAIL RUN # ________

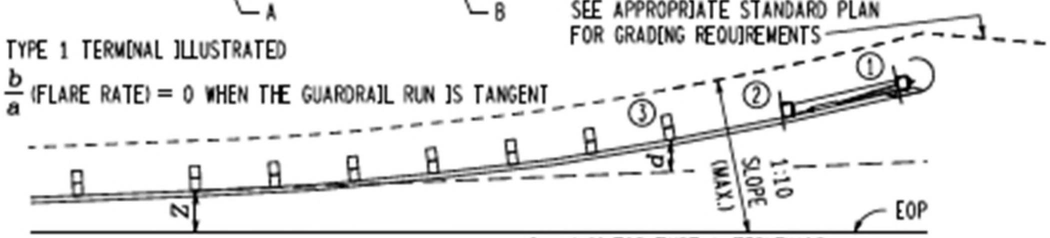
IF STATIONING IS NOT AVAILABLE, LOCATE TO NEAREST FIXED OBJECT



NOTES: TYPE 1 TERMINAL ILLUSTRATED

$\frac{b}{a}$ (FLARE RATE) = 0 WHEN THE GUARDRAIL RUN IS TANGENT

SEE APPROPRIATE STANDARD PLAN FOR GRADING REQUIREMENTS



d = 1.8' FOR TYPE 1 TERMINALS
d = 0 FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + \left(|S_B - S_A|\right)\left(\frac{b}{a}\right)$$

LENGTH OF NEED	X =	DESIGN ADT	
RUNOUT LENGTH (7.01.19)	L_R =	DESIGN SPEED	
GUARDRAIL TAPER RATE (7.01.29A)	$\frac{b}{a}$ =	APPROACH SLOPE	
E.O.P. TO FACE OF BARRIER (DESIGNED)	L_2 =		
CLEAR ZONE (7.01.11)	L_C =	L_1 =	(RECOMMENDED MINIMUM DISTANCE: 25' OR LENGTH OF GUARDRAIL BRIDGE ANCHORAGE MEASURED FROM BRIDGE RAIL ENDING, WHICHEVER IS GREATER)
E.O.P. TO ROADSIDE FEATURE (MEASURED)	L_3 =		
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE	d =		
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED)	L_H =		
LATERAL OFFSET AT END OF FLARE	Z =	L_S =	SHY LINE (7.01.18)
		STATION AT A (S_A)	
		STATION AT B (S_B)	

NOTE: DISTANCE OF OBJECT FROM BACK OF BARRIER MUST BE GREATER THAN THE MAXIMUM DEFLECTION (7.01.20)

$L_H \leq L_C$

REFER TO STANDARD PLAN R-59-SERIES AND DESIGN MANUAL SECTION 7.01.30 FOR GUARDRAIL AT EMBANKMENTS

(REV. 02-2024)

PROPOSED TREATMENT

CALCULATIONS OR NOTES

PAY ITEMS

____	Ft	* Guardrail, Type ____ , ____ inch Post
____	Ea	Guardrail Anch, Bridge, Det ____
____	Ft	Bridge Railing, Thrie Beam Retrofit
____	Ea	Guardrail Approach Terminal, Type ____
____	Ea	Guardrail Departing Terminal, Type ____
____	Ea	Guardrail Reflector
____	Cyd	Embankment, LM

* FOR THIS PAY ITEM, THE GUARDRAIL APPROACH TERMINAL, TYPE ____ PORTION OF LENGTH OF NEED (X) MUST BE DEDUCTED

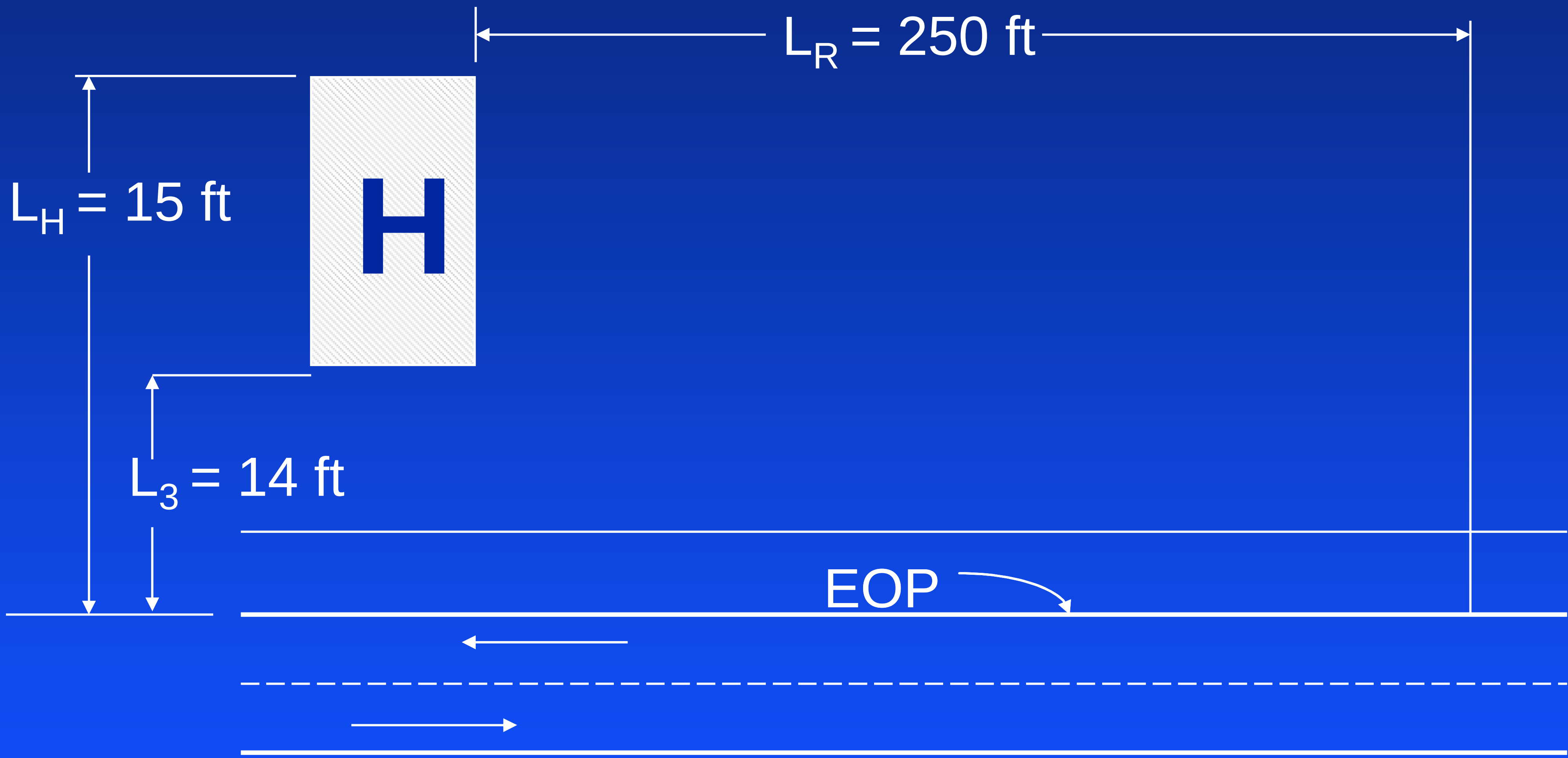
DEDUCTION TABLE							
GUARDRAIL APPROACH TERMINAL TYPE							
1B	1T	2B	2T	2M	3B	3T	3M
25'	31.25'	37.5'	43.75'	34.3'	12.5'	31.25'	21.8'

PAY LENGTHS MUST BE DIVISIBLE BY 12.5'. ROUND TO NEXT HIGHEST RAIL LENGTH, EXCEPT WHEN TYPE MGS-8 OR TYPE MGS-8D GUARDRAIL IS ATTACHED TO A GUARDRAIL FEATURE REQUIRING A HEIGHT TRANSITION (e.g., GUARDRAIL APPROACH TERMINAL TYPES 1B, 2B, OR 3B; A T-SERIES GUARDRAIL BRIDGE ANCHORAGE; etc.)

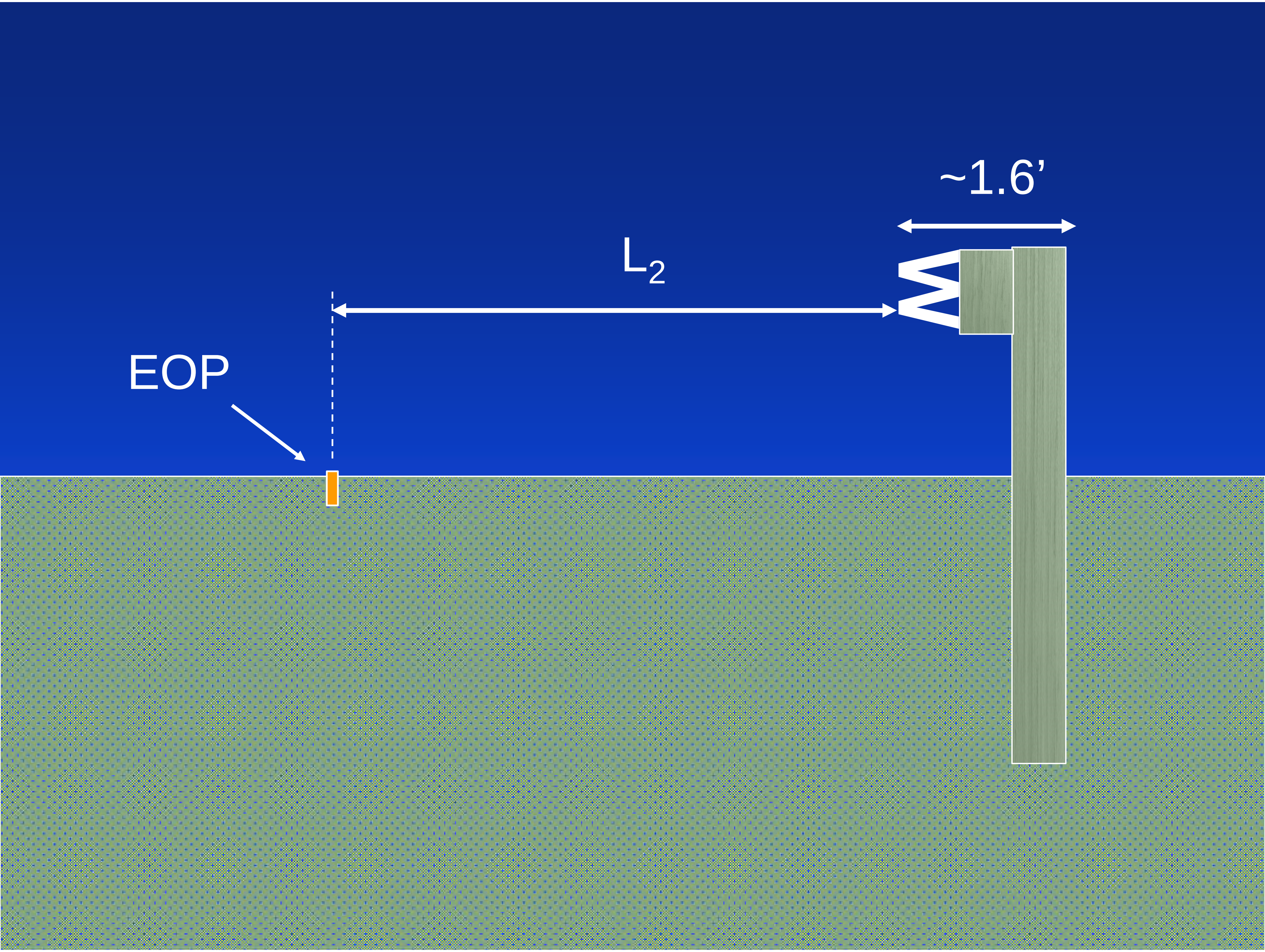
	Traffic Volume (ADT) veh/day			
	Over 10,000	Over 5,000-10,000	1000-5000	Under 1000
Design Speed (mph)	Runout Length L_R (ft)	Runout Length L_R (ft)	Runout Length L_R (ft)	Runout Length L_R (ft)
80	470	430	380	330
70	360	330	290	250
60	300	250	210	200
50	230	190	160	150
40	160	130	110	100
30	110	90	80	70

Design Speed (mph)	Shy Line Offset (L_S) (ft)
80	12
75	10
70	9
60	8
55	7
50	6.5
45	6
40	5
30	4

Practice Example #1



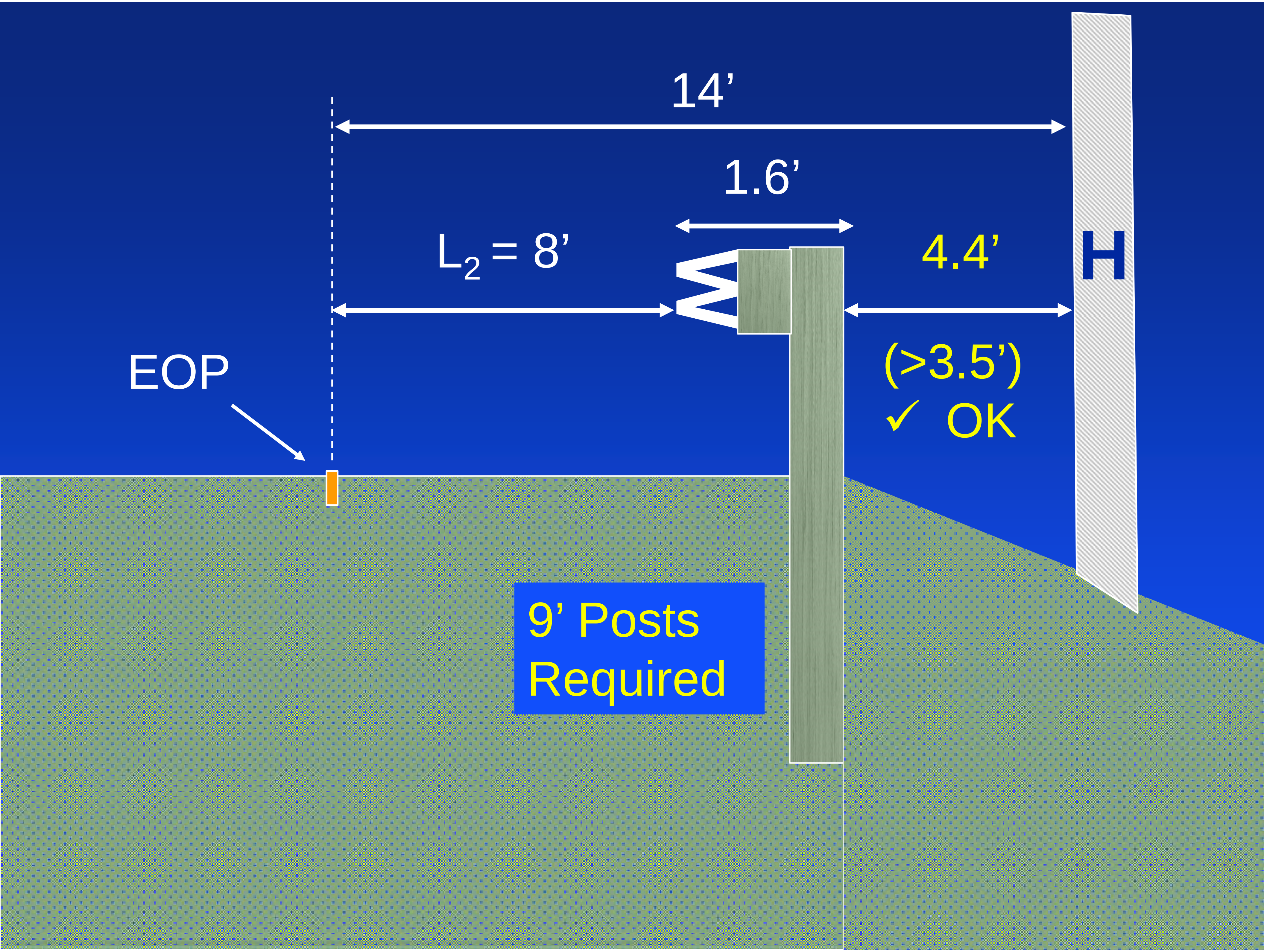
Shy distance for 60 mph = 8 ft
Clear Zone = 40 feet


~1.6'
L_2
EOP

MDOT
Guardrail Deflection Table

Guardrail	Post Spacing	Minimum Design Offset *
Type T	1'-6¾"	1'-2"
Type T	3'-1½"	1'-8"
Type T	6'-3"	2'-0"
Type B	1'-6¾"	1'-6"
Type B	3'-1½"	2'-0"
Type B	6'-3"	3'-0"
Type MGS-8	1'-6¾"	2'-5"
Type MGS-8	3'-1½"	2'-11"
Type MGS-8	6'-3"	3'-6"
Type MGS-8 Adjacent to Curb	6'-3"	4'-1"
Type MGS-8 Near Shoulder Hinge Point **	6'-3"	4'-1"

RDM - Section 7.01.20

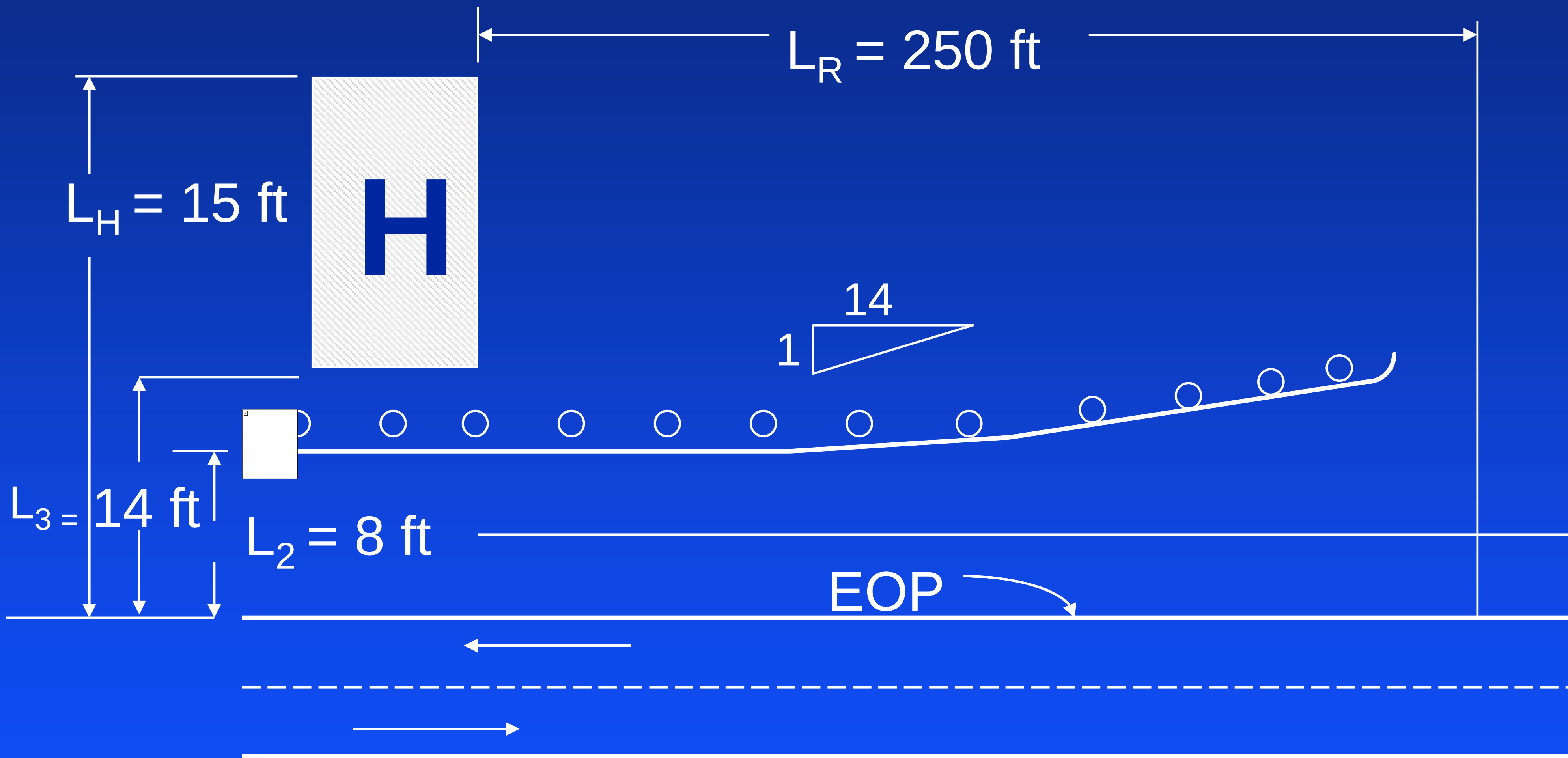

14’
1.6’
L_2 = 8’
4.4’
H
EOP
(>3.5’)
✓ OK
9’ Posts
Required

MDOT Flare Rate Table

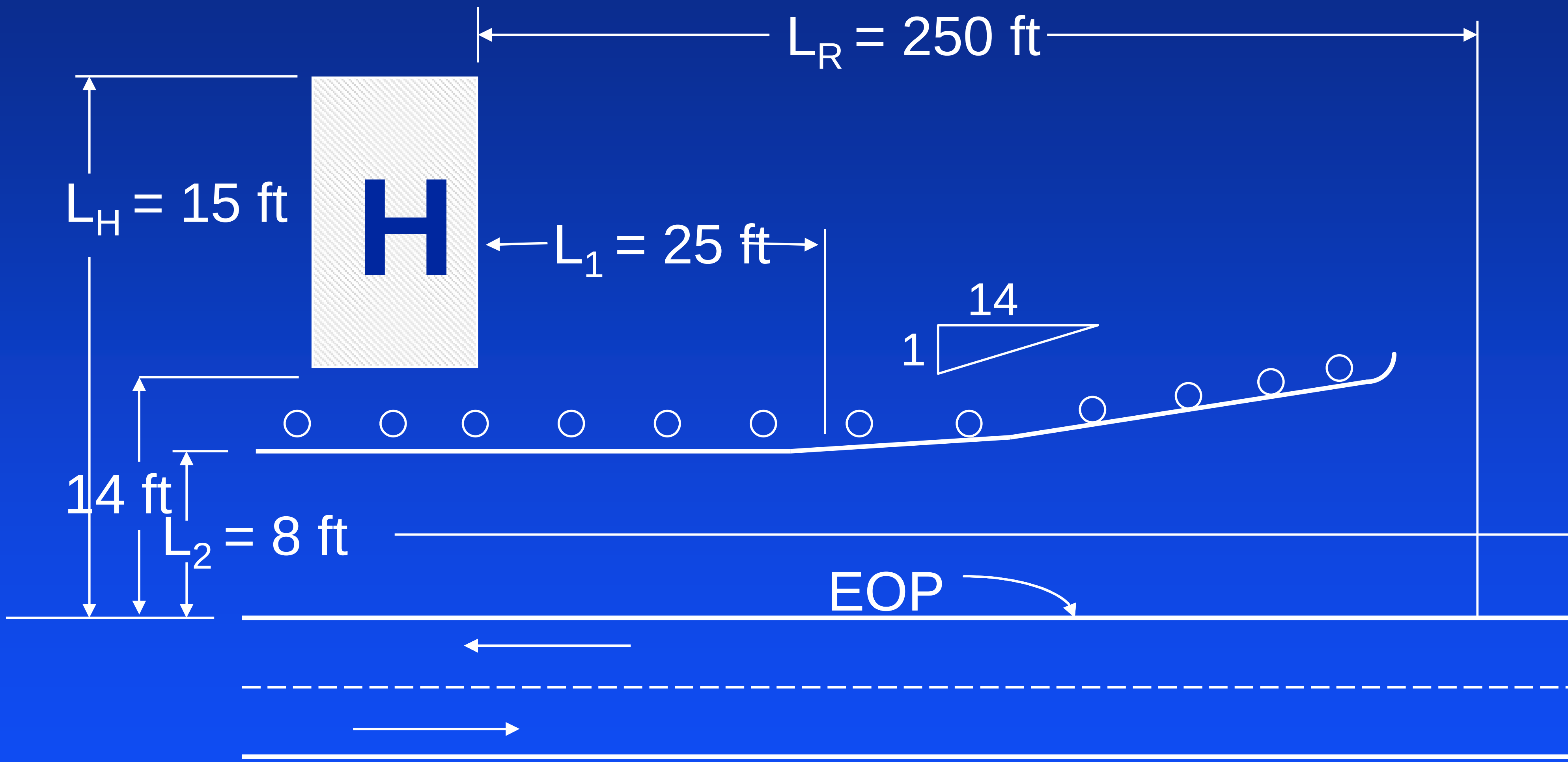
Design Speed (mph)	Flare Rate (b/a) for	
	Concrete Barriers	Guardrail
70	1:20	1:15
60	1:18	1:14
55	1:16	1:12
50	1:14	1:11
45	1:12	1:10
40	1:10	1:8
30	1:8	1:7

RDM – Subsection 7.01.29.A

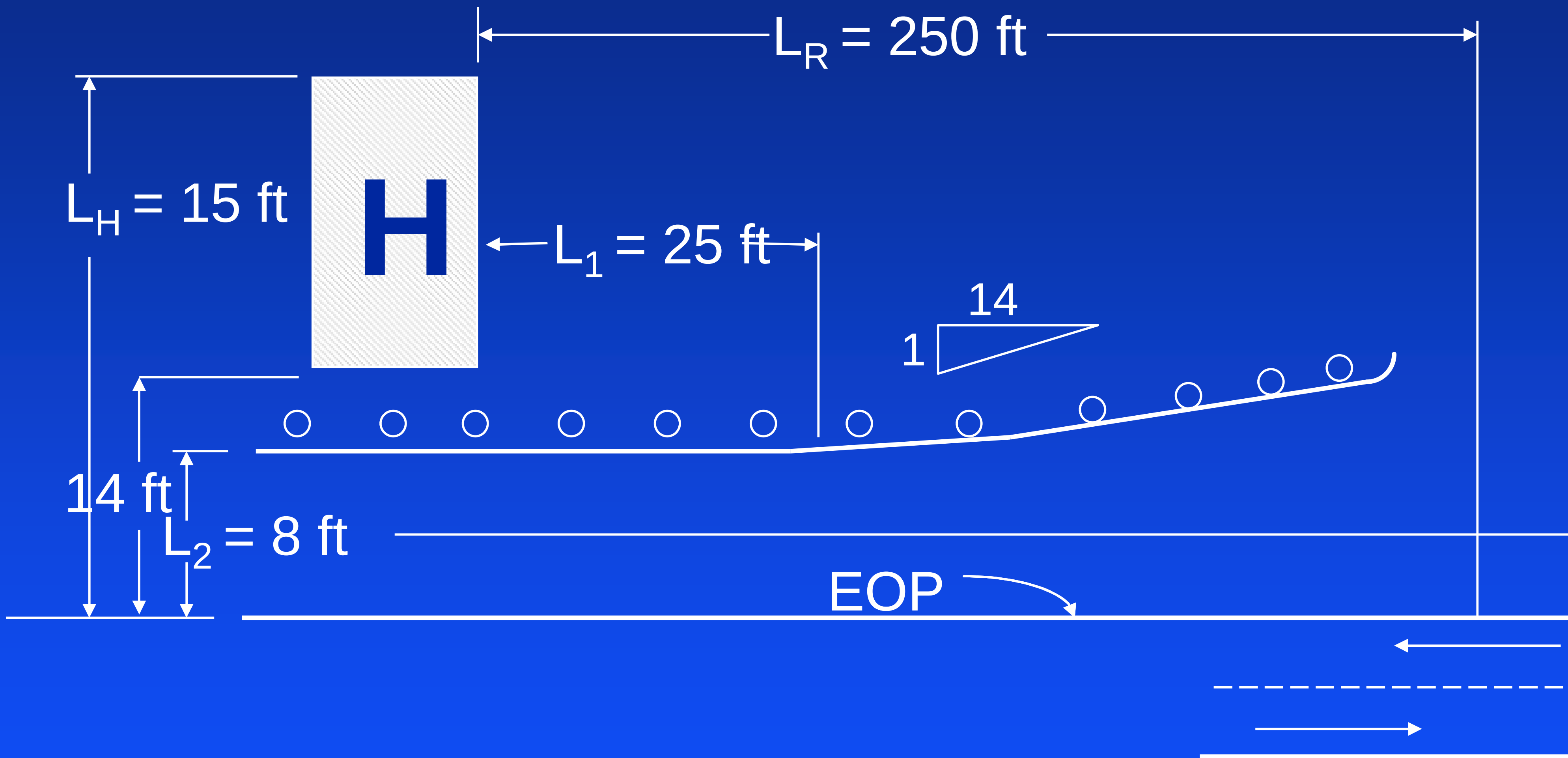
Practice Example #1



Practice Example #1

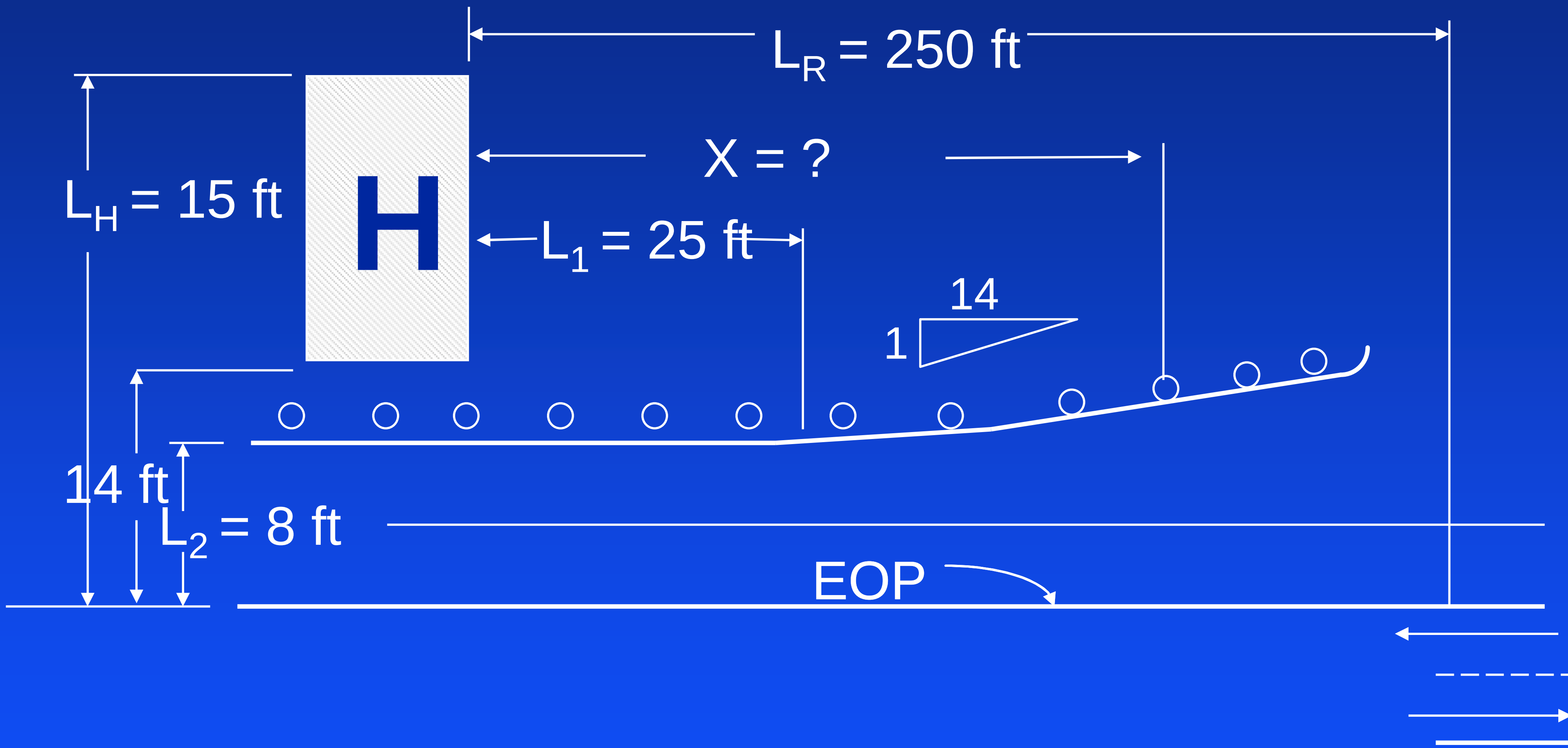


Practice Example #1



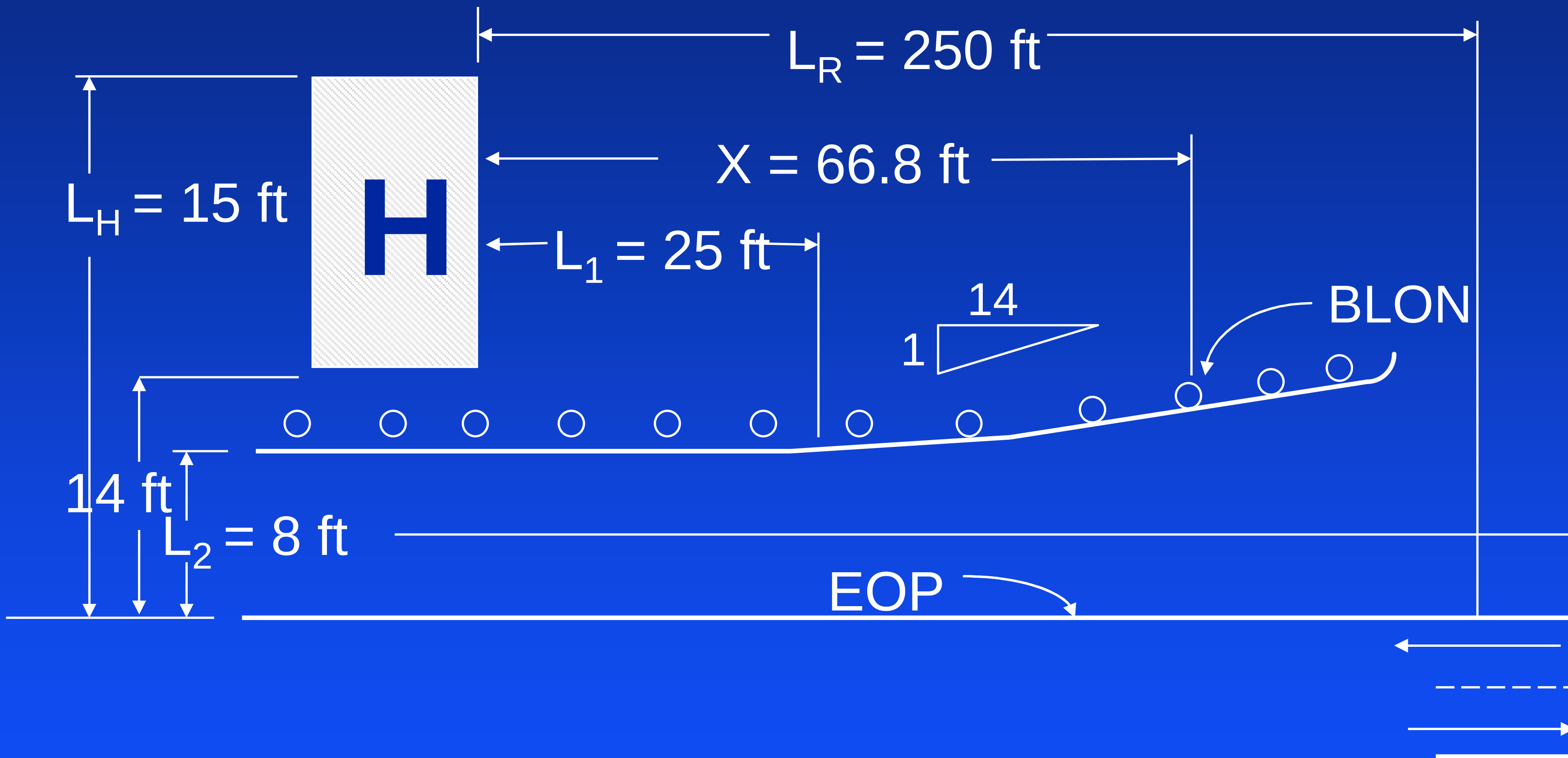
$$X = \frac{L_H + (b/a)(L_1) - (L_2 + d)}{(b/a) + (L_H/L_R)}$$

Practice Example #1



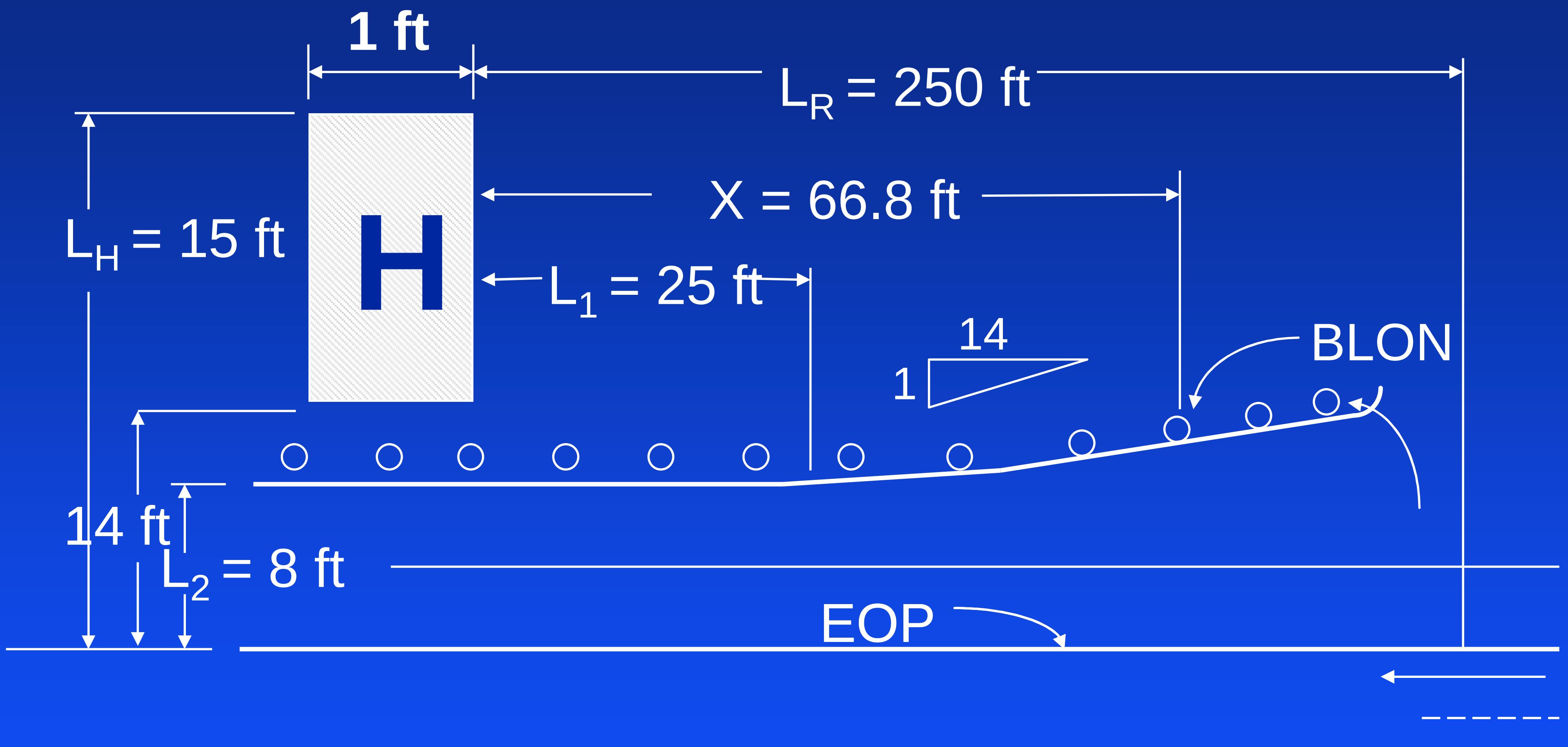
$$X = \frac{L_H + (b/a)(L_1) - (L_2 + d)}{(b/a) + (L_H/L_R)} = \frac{15 + (1/14)(25) - (8 + 0)}{(1/14) + (15/250)} = ?$$

Practice Example #1



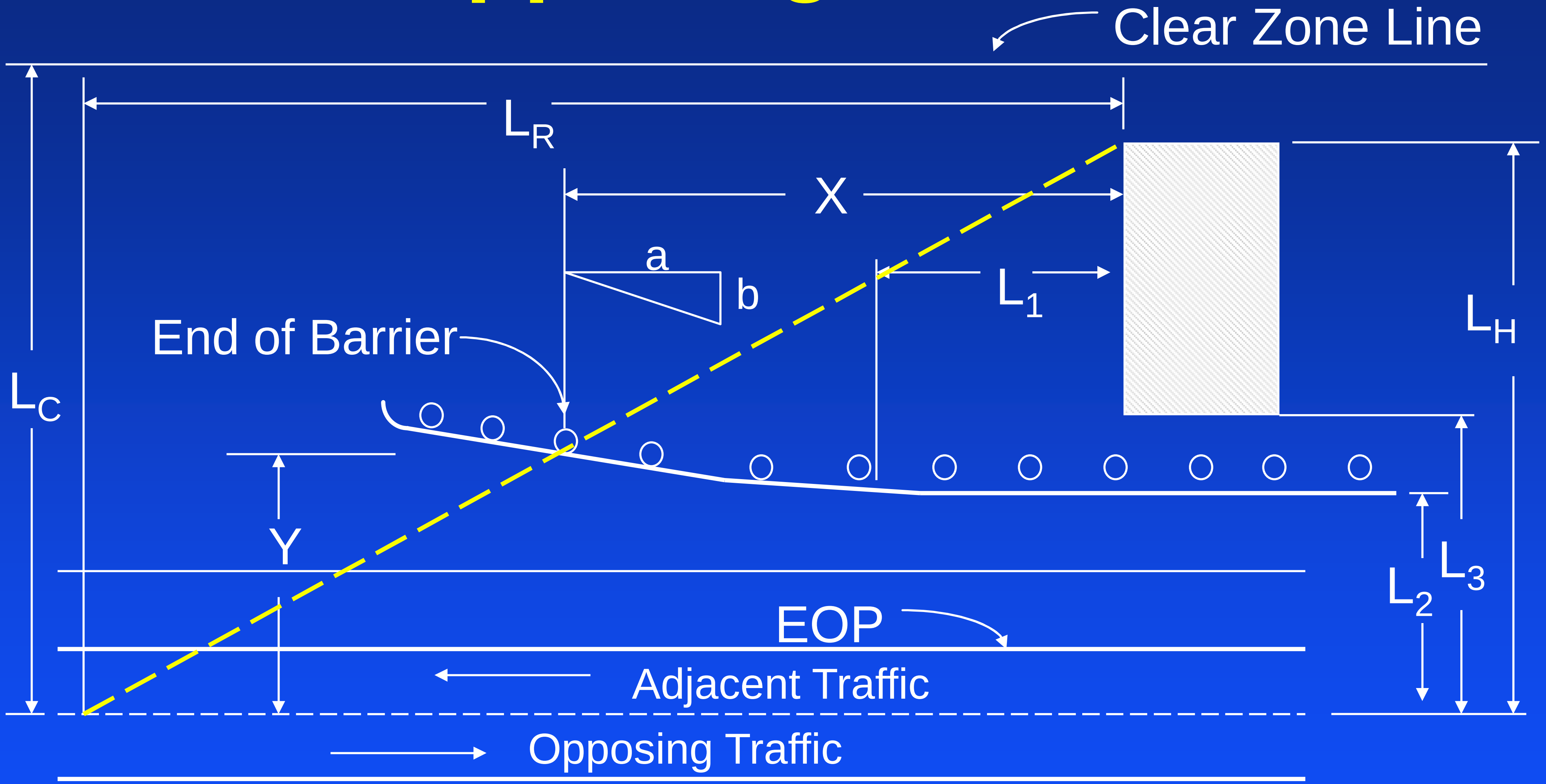
X = 66.8 ft

Practice Example #1



Total Length of Need = 66.8 + 1 + ??? = ??? ft

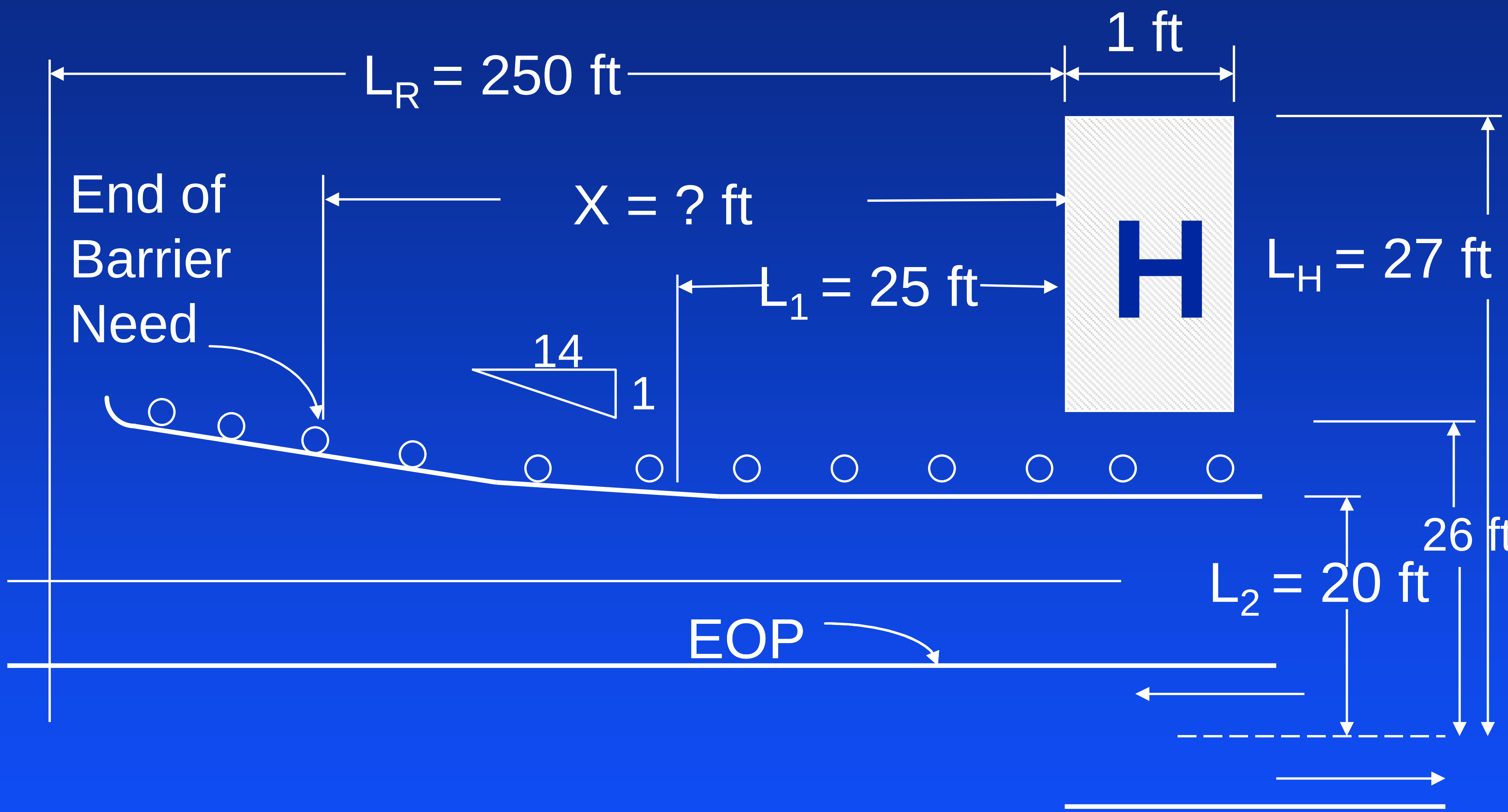
Opposing Traffic



12’ lanes

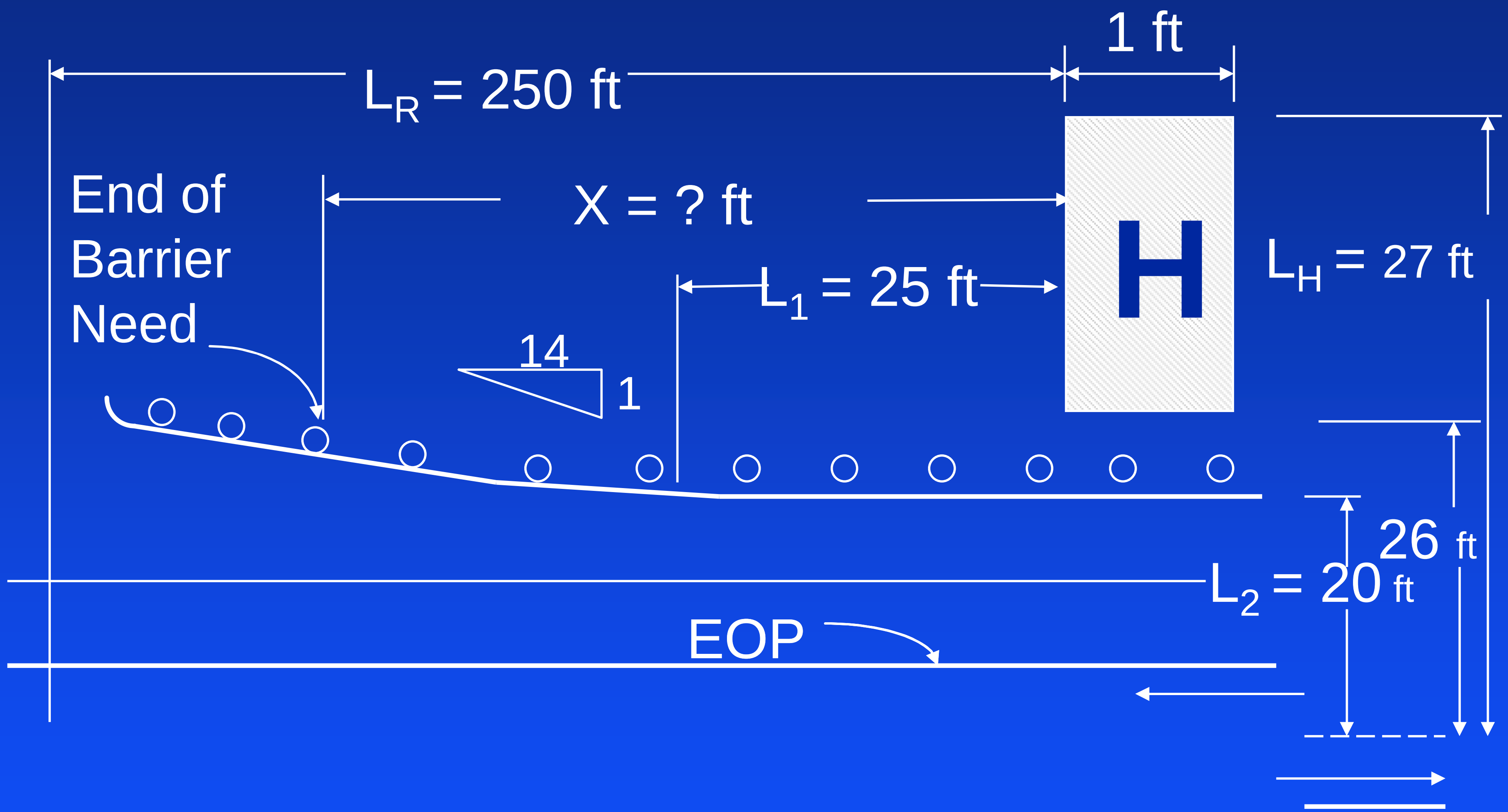
L_c = 40’

Practice Example #1



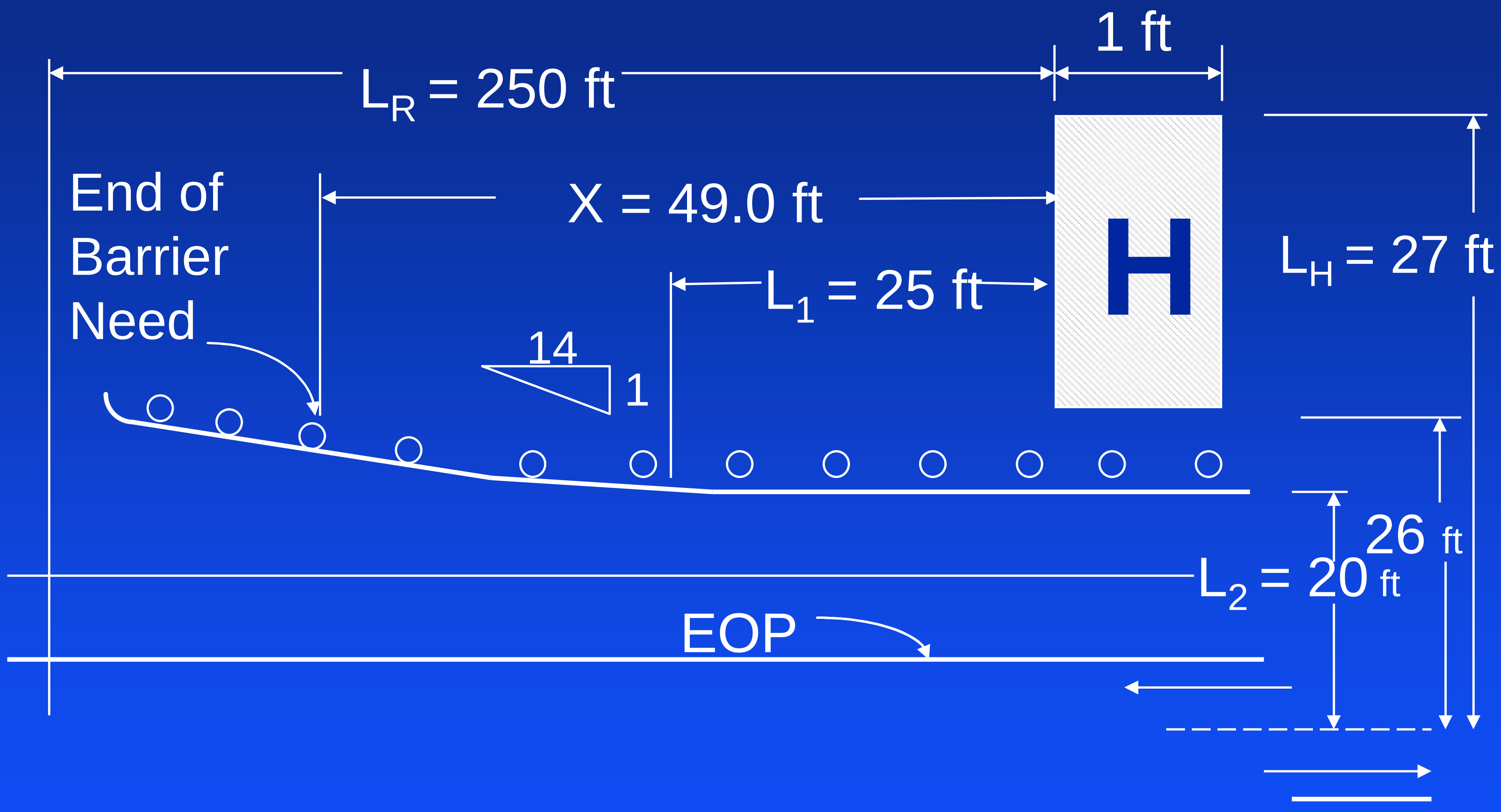
$$X = \frac{L_H + (b/a)(L_1) - (L_2 + d)}{(b/) + (L_H/L_R)}$$

Practice Example #1



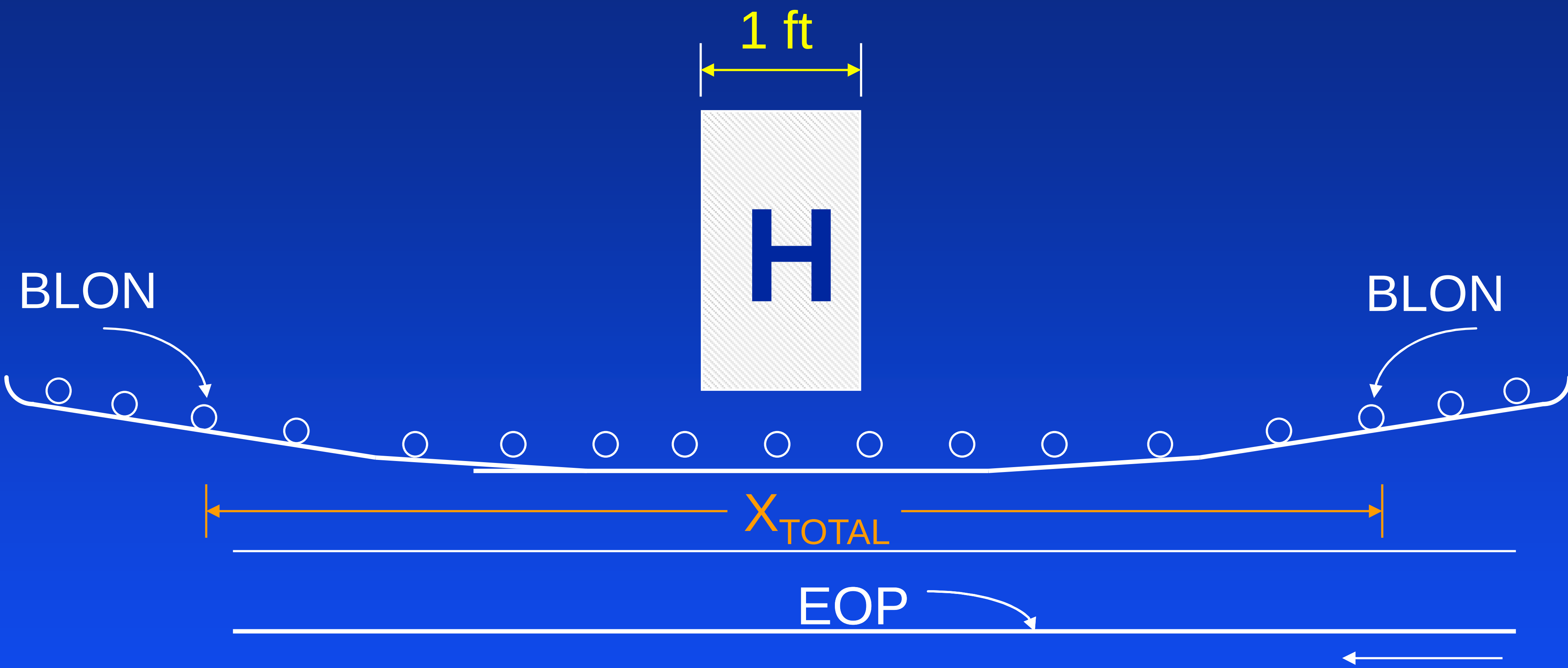
$$X = \frac{L_H + (b/a)(L_1) - (L_2 + d)}{(b/a) + (L_H/L_R)} = \frac{27 + (1/14)(25) - (20 + 0)}{(1/14) + (27/250)} = ?$$

Practice Example #1



X = 49.0 ft

Practice Example #1

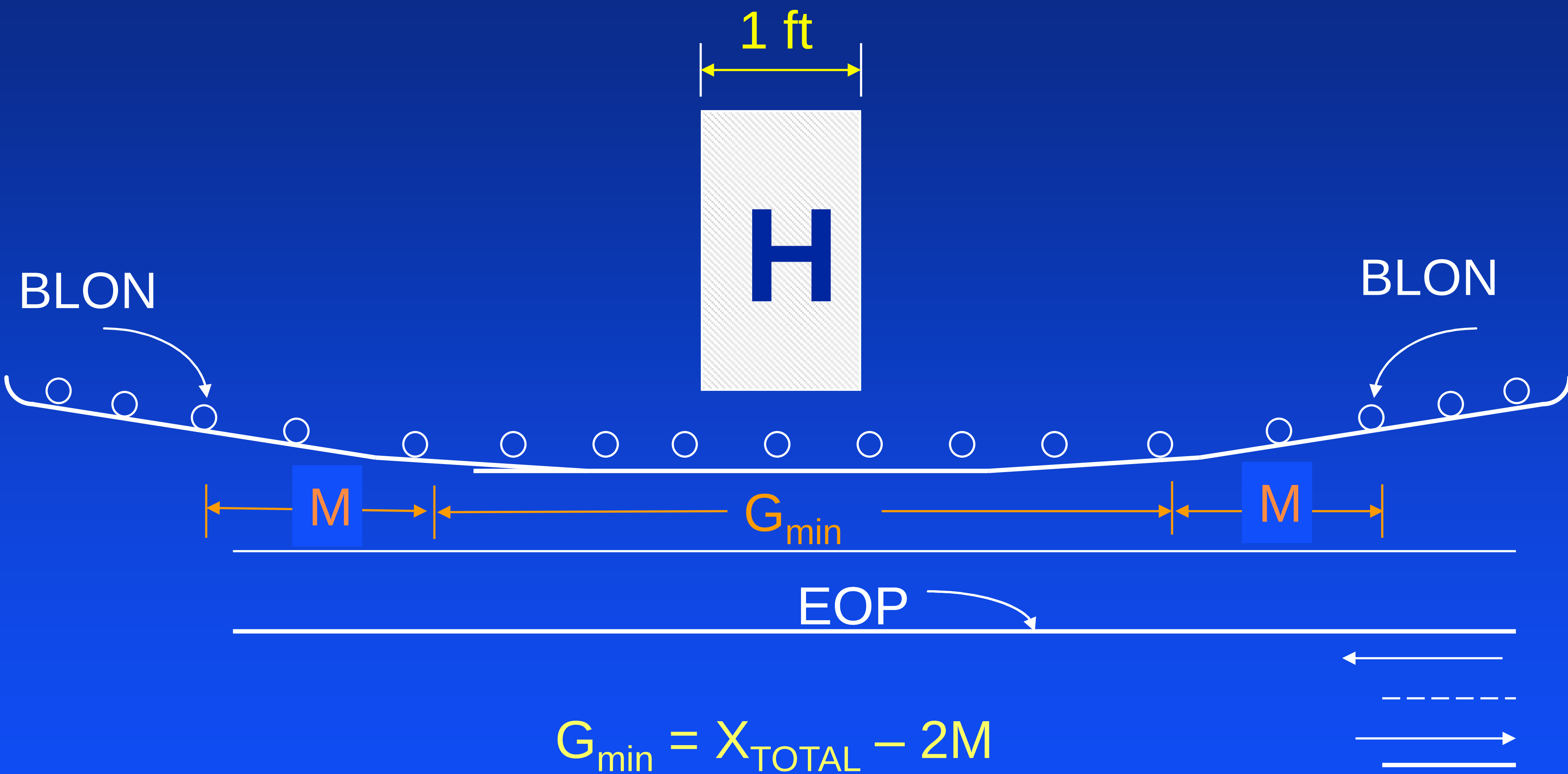


X_{TOTAL} = 66.8 + 1 + 49.0 = **<u>116.8 ft</u>**

Deduction Value
Type 2M Approach Terminal
MDOT Guardrail Worksheet

DEDUCTION TABLE							
GUARDRAIL APPROACH TERMINAL TYPE							
1B	1T	2B	2T	2M	3B	3T	3M
25'	31.25'	37.5'	43.75'	34.3'	12.5'	31.25'	21.8'

Practice Example #1



$$G_{min} = X_{TOTAL} - 2M$$

$$G_{min} = 116.8 - 2(34.3)$$

$$G_{min} = 48.2 \text{ ft}$$

Calculating Guardrail Quantity

Number of Guardrail Panels

- Type MGS-8 guardrail connected to Type 2M approach terminals
- Guardrail quantity is divisible by 12.5 (i.e., whole number of 12.5’ panels)

$$\frac{G_{min}}{12.5} = \frac{48.2}{12.5} = 3.86 \longrightarrow 4 \text{ panels}$$

Type MGS-8 Guardrail Length = (12.5)(4) = 50 ft

Reflectors

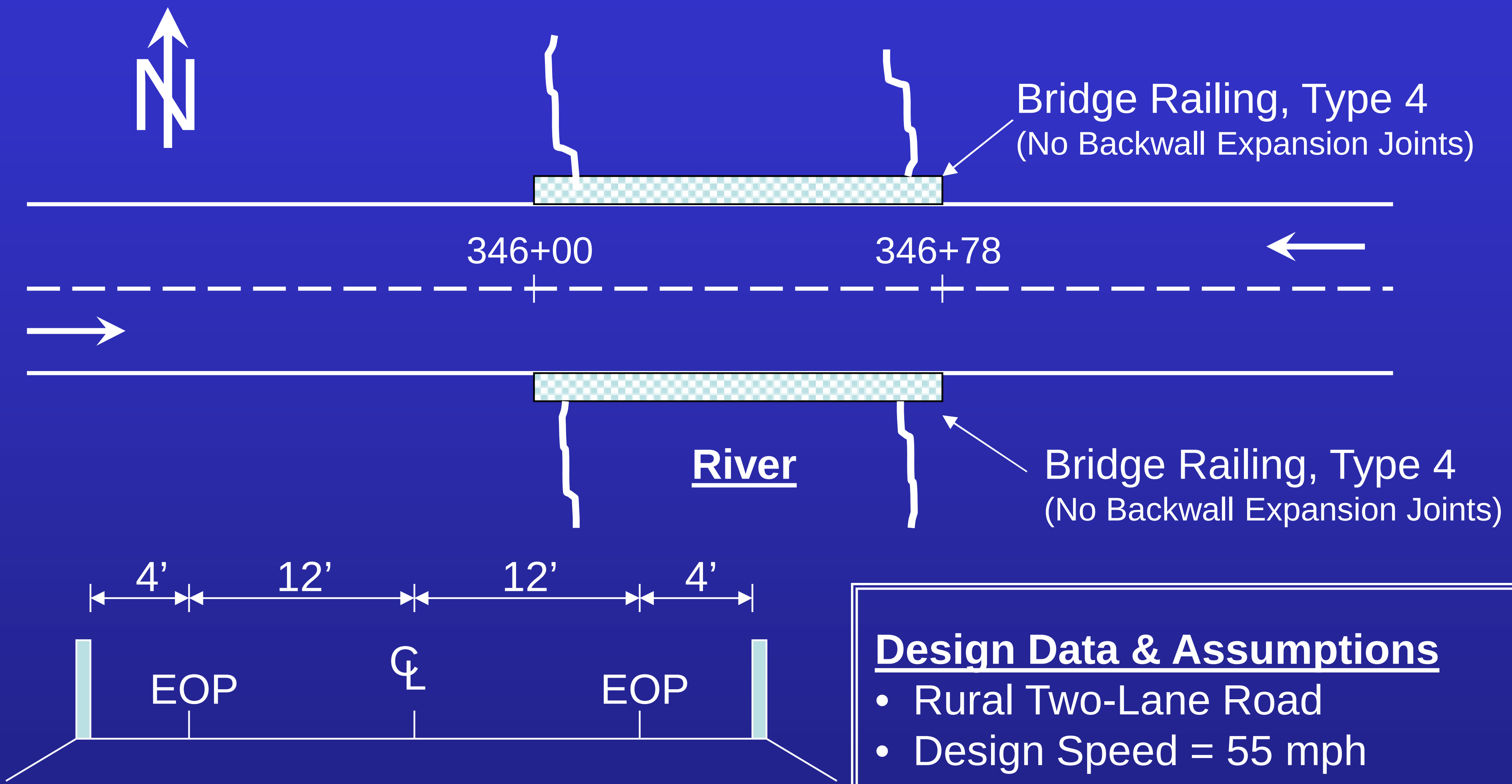
- *Do not install reflectors on approach terminals*

$$N_R = \left(\frac{50}{50}\right) + 1 = 2 \longrightarrow 2$$

Since this is a two-way road, number of reflectors is $2N_R$:

Number of Reflectors = 2(2) = 4

Practice Example #2



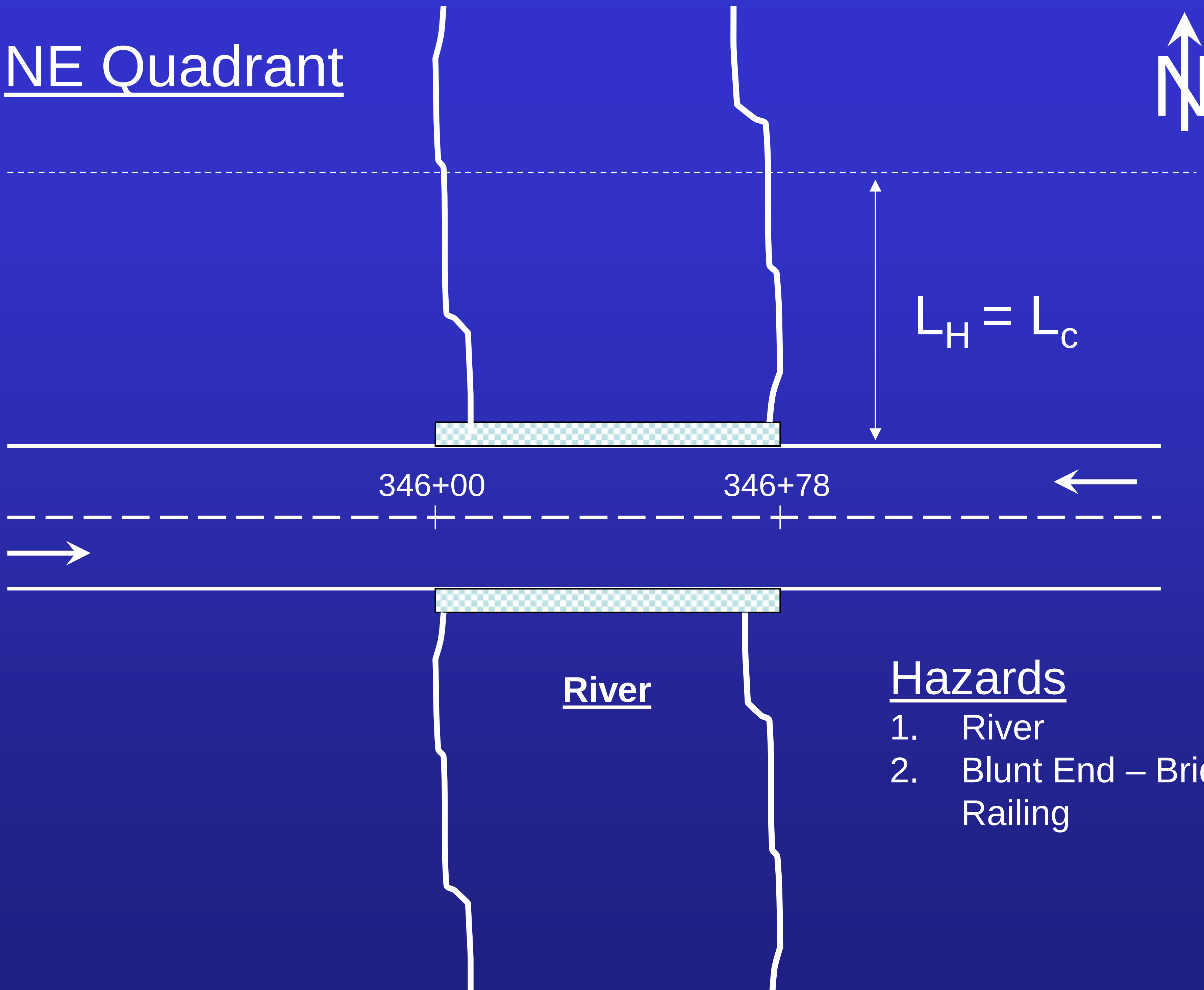
Assignment – NE & NW Quadrants Only

1. Identify all roadside hazards.
2. Determine if guardrail is needed.
3. If necessary, design guardrail and calculate quantities using guardrail worksheet.

Design Data & Assumptions

- Rural Two-Lane Road
- Design Speed = 55 mph
- ADT = 5,000 vpd
- River is 6' deep
- 1:5 Slope in advance of bridge ends
- Flare guardrail where possible

NE Quadrant

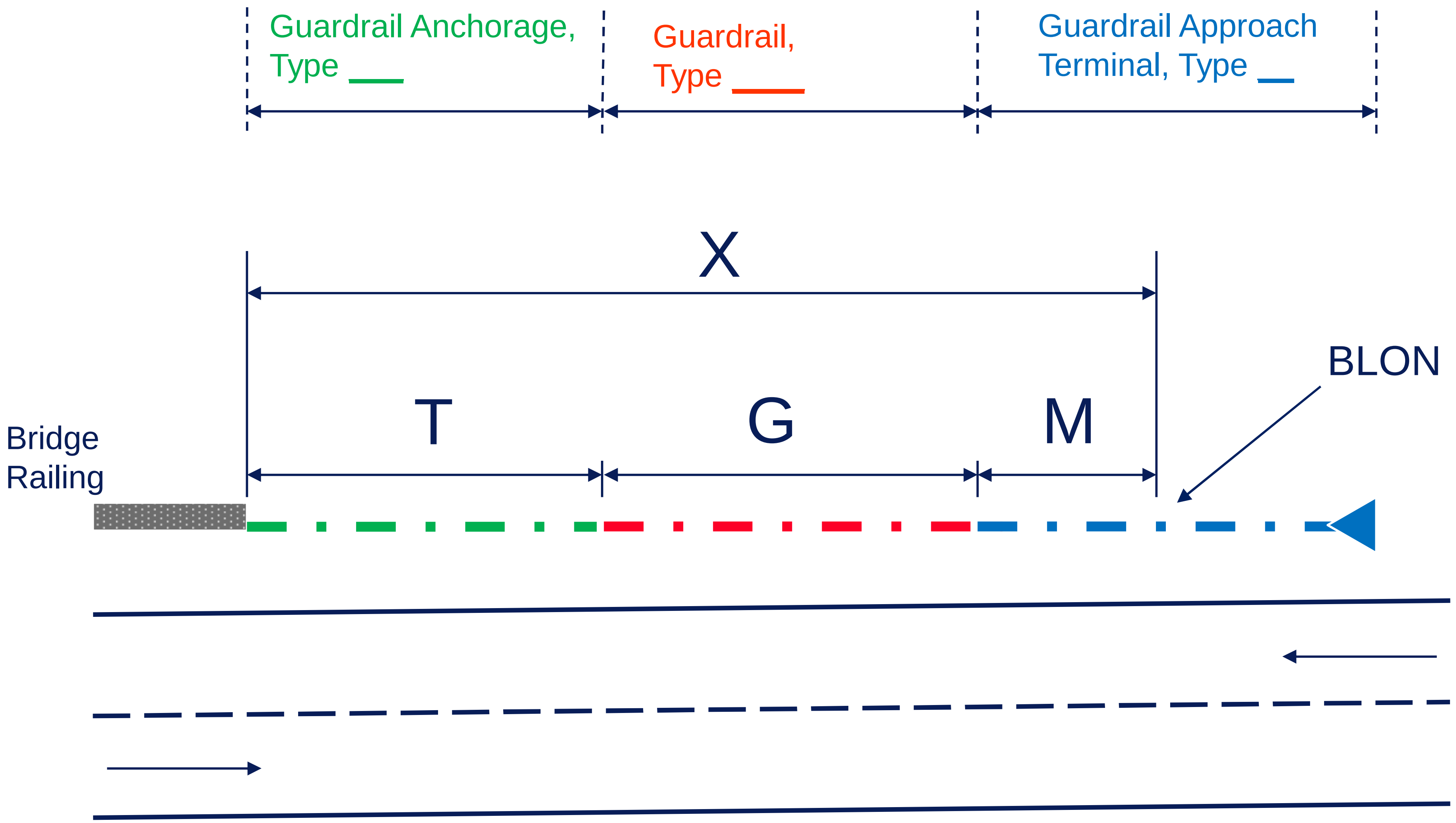


Hazards

1. River
2. Blunt End – Bridge Railing

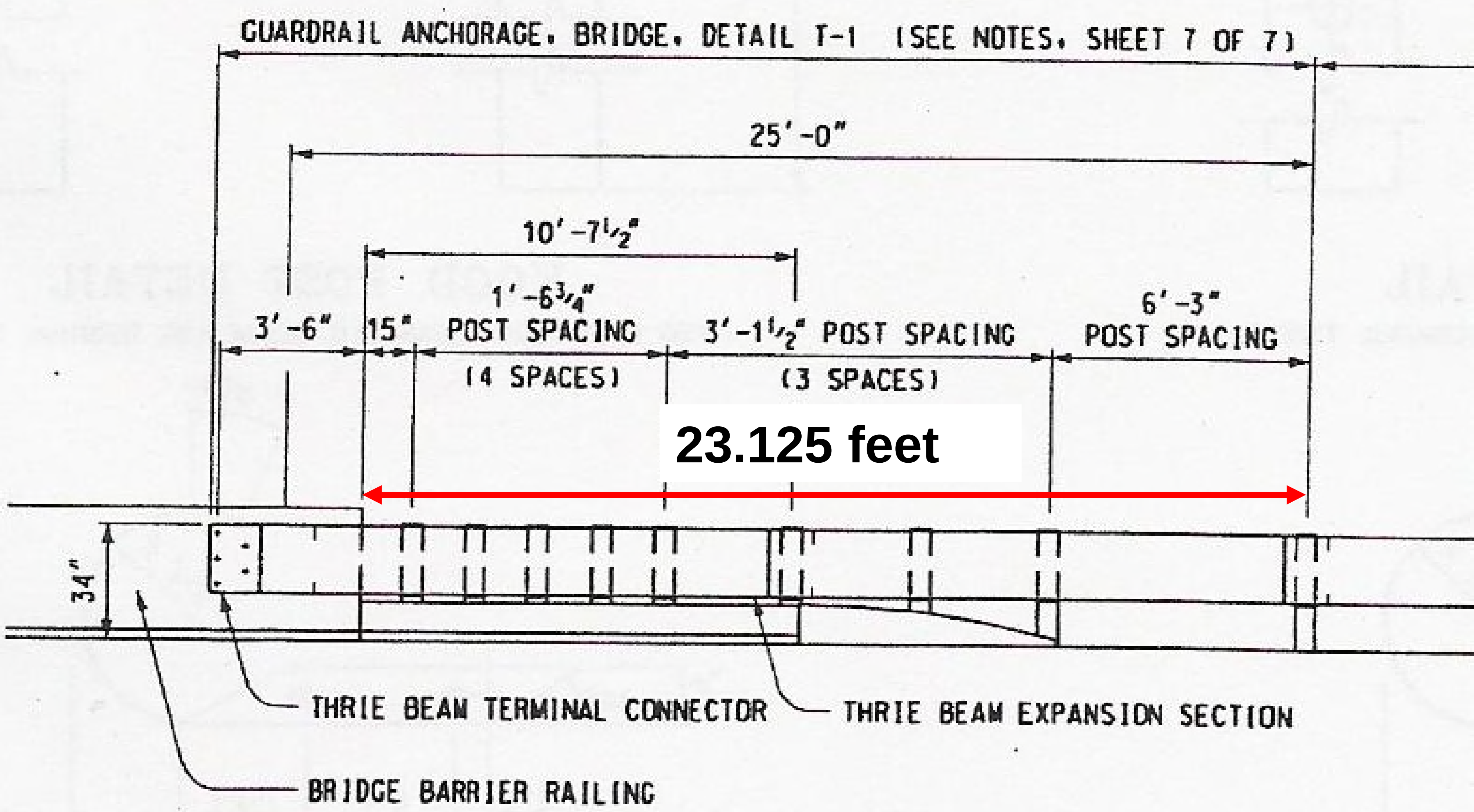
Determining Guardrail Components

Guardrail Anchored to Bridge Railing



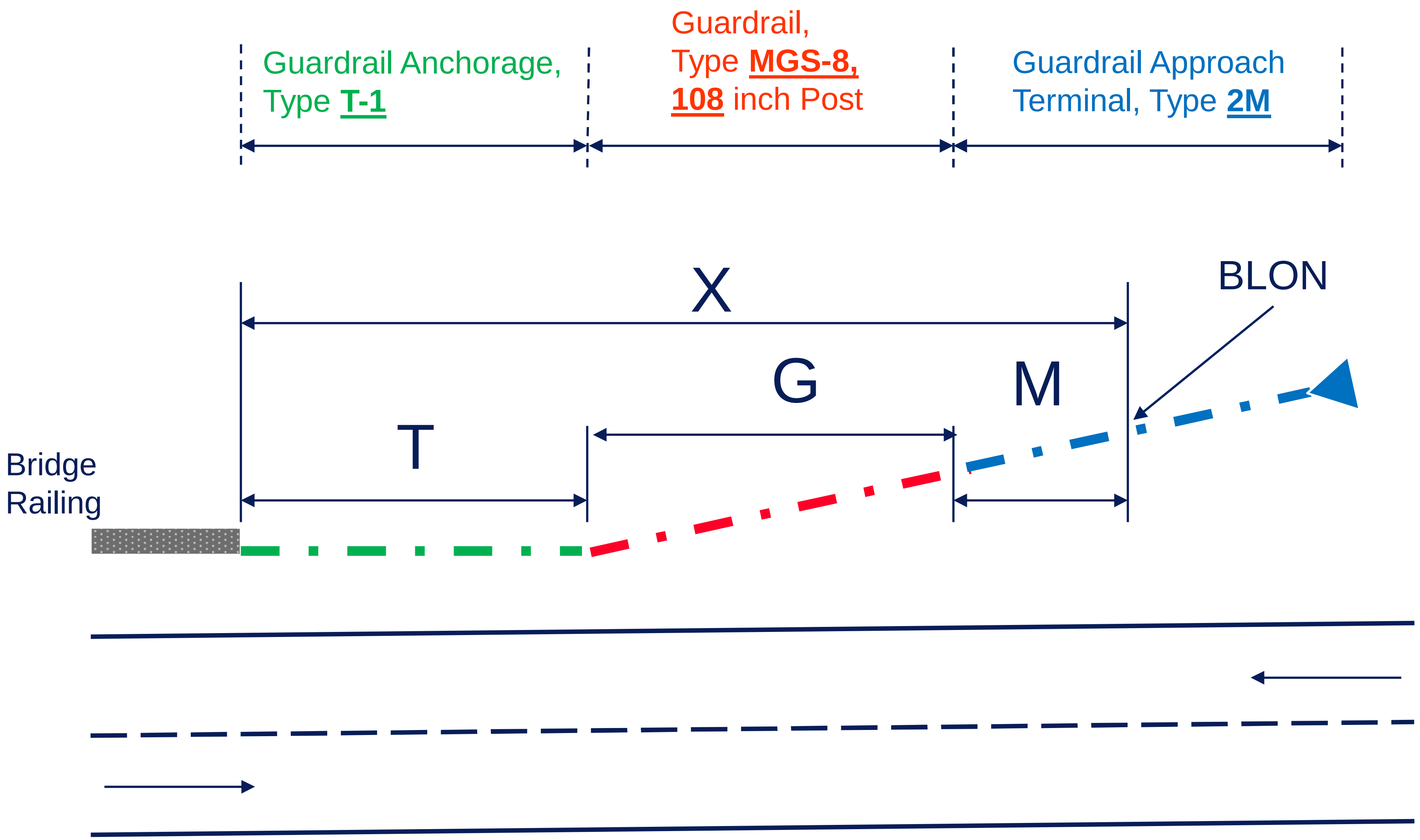
$$G^* = X - M - T$$

Detail T-1 (Sheet 1 of R-67-SD)



Determining Guardrail Components

Guardrail Anchored to Bridge Railing



$$G^* = X - M - T$$

GUARDRAIL WORKSHEET

(REV. 02-2024)

FOR APPROACH TERMINALS ON R-61-SERIES, R-62-SERIES AND R-63-SERIES

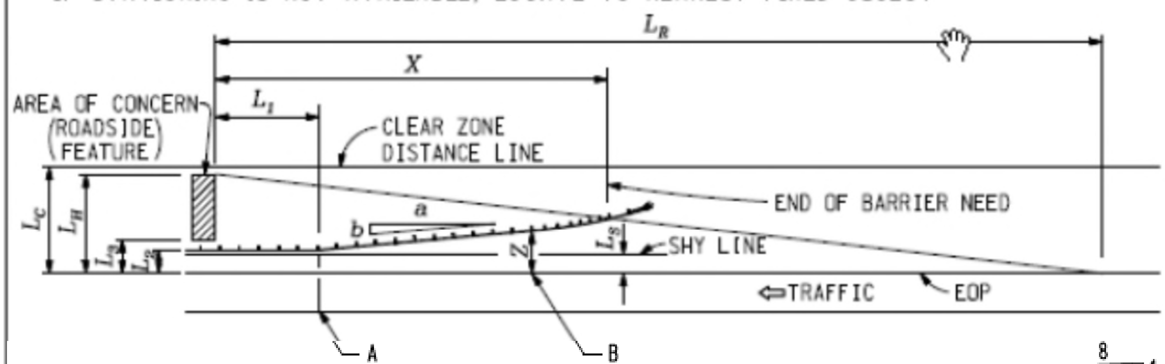
ROUTE . Practice Example #2 CONTROL SECTION 99999 JOB # EXAMPLE

DESIGNED BY ABC DATE 00/01/18 CHECKED BY XYZ DATE 00/01/18

APPROX. STATION OR M.P 346+78 DESCRIPTION Practice Example #2

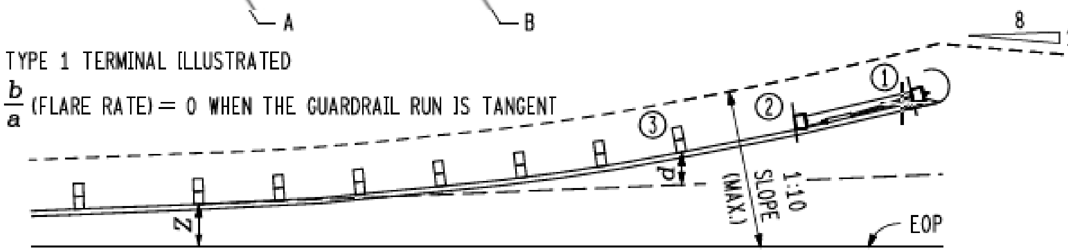
GUARDRAIL RUN # NE Quad

IF STATIONING IS NOT AVAILABLE, LOCATE TO NEAREST FIXED OBJECT



NOTES: TYPE 1 TERMINAL ILLUSTRATED

$\frac{b}{a}$ (FLARE RATE) = 0 WHEN THE GUARDRAIL RUN IS TANGENT



d = 1.8' FOR TYPE 1 TERMINALS
d = 0 FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + \left(|S_B - S_A|\right)\left(\frac{b}{a}\right)$$

LENGTH OF NEED .... X = 113.76'
RUNOUT LENGTH (7.01.19) .... L_R = 185'
GUARDRAIL TAPER RATE (R-59-SERIES) .... $\frac{b}{a}$ = 1/12
E.O.P. TO FACE OF BARRIER (DESIGNED) .... L_2 = 4'
CLEAR ZONE (7.01.11) .... L_C = 30'
E.O.P. TO ROADSIDE FEATURE (MEASURED) .... L_3 = 4'
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d = 0
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED). L_H = 30'
LATERAL OFFSET AT END OF FLARE .... Z = 9.47' **

DESIGN ADT 5,000 vpd
DESIGN SPEED 55 mph
APPROACH SLOPE 1:5

L_1 = 23.125' ' MIN.)
L_S = 7' SHY LINE (7.01.18)
STATION AT A 347+01.1
STATION AT B 347+66.8

NOTE: DISTANCE OF OBJECT FROM BACK OF BARRIER MUST BE GREATER THAN THE MAXIMUM DEFLECTION (7.01.20)

$L_H \leq L_C$

REFER TO STANDARD PLAN R-59-SERIES AND DESIGN MANUAL SECTION 7.01.30 FOR GUARDRAIL AT EMBANKMENTS

** Refer to Calculations and Notes

$d =$ 1.8' FOR TYPE 1 TERMINALS
$d =$ 0 FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + \left(\left|S_B - S_A\right|\right)\left(\frac{b}{a}\right)$$

LENGTH OF NEED .... X =	113.76'	DESIGN ADT	5,000 vpd
RUNOUT LENGTH (7.01.19) .... L_R =	185'	DESIGN SPEED	55 mph
GUARDRAIL TAPER RATE (R-59-SERIES) .... $\frac{b}{a}$ =	1/12	APPROACH SLOPE	1:5
E.O.P. TO FACE OF BARRIER (DESIGNED) .... L_2 =	4'		
CLEAR ZONE (7.01.11) .... L_C =	30'	L_1 = 23.125' ' MIN.)	
E.O.P. TO ROADSIDE FEATURE (MEASURED) .... L_3 =	4'	L_S = 7' SHY LINE (7.01.18)	
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d =	0	STATION AT A	347+01.1
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED). . L_H =	30'	STATION AT B	347+66.8
LATERAL OFFSET AT END OF FLARE .... Z =	9.47' **		

MDOT
Runout Length Table

	Traffic Volume (ADT) veh/day			
	Over 10,000	Over 5,000-10,000	1000-5000	Under 1000
Design Speed (mph)	Runout Length L_R (ft)	Runout Length L_R (ft)	Runout Length L_R (ft)	Runout Length L_R (ft)
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

RDM - Section 7.01.19

** Must interpolate in this case to obtain L_R

d = 1.8' FOR TYPE 1 TERMINALS
d = 0 FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + \left(\left|S_B - S_A\right|\right)\left(\frac{b}{a}\right)$$

LENGTH OF NEED .... X = 113.76'

RUNOUT LENGTH (7.01.19) .... L_R = 185'

GUARDRAIL TAPER RATE (7.01.29.A) .... $\frac{b}{a}$ = 1/12

E.O.P. TO FACE OF BARRIER (DESIGNED) .... L_2 = 4'

CLEAR ZONE (7.01.11) .... L_C = 30'

E.O.P. TO ROADSIDE FEATURE (MEASURED) .... L_3 = 4'

EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d = 0

LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED) . L_H = 30'

LATERAL OFFSET AT END OF FLARE .... Z = 9.47' **

DESIGN ADT 5,000 vpd

DESIGN SPEED 55 mph

APPROACH SLOPE 1:5

L_1 = 23.125' ' MIN.)

L_S = 7' SHY LINE (7.01.18)

STATION AT A 347+01.1

STATION AT B 347+66.8

MDOT Flare Rate Table

Design Speed (mph)	Flare Rate (b/a) for	
	Concrete Barriers	Guardrail
70	1:20	1:15
60	1:18	1:14
55	1:16	$\boxed{1:12}$
50	1:14	1:11
45	1:12	1:10
40	1:10	1:8
30	1:8	1:7

RDM – Subsection 7.01.29.A

$d = 1.8'$ FOR TYPE 1 TERMINALS
$d = 0$ FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + \left(\left|S_B - S_A\right|\right)\left(\frac{b}{a}\right)$$

LENGTH OF NEED .... X =	113.76'	DESIGN ADT	5,000 vpd
RUNOUT LENGTH (7.01.19) .... L_R =	185'	DESIGN SPEED	55 mph
GUARDRAIL TAPER RATE (R-59-SERIES) .... $\frac{b}{a}$ =	1/12	APPROACH SLOPE	1:5
E.O.P. TO FACE OF BARRIER (DESIGNED) .... L_2 =	4'		
CLEAR ZONE (7.01.11) .... L_C =	30'	L_1 =	23.125' ' MIN.)
E.O.P. TO ROADSIDE FEATURE (MEASURED) .... L_3 =	4'	L_S =	7' SHY LINE (7.01.18)
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d =	0	STATION AT A	347+01.1
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED) . L_H =	30'	STATION AT B	347+66.8
LATERAL OFFSET AT END OF FLARE .... Z =	9.47' **		

Used distance to face of bridge railing

$d =$ 1.8' FOR TYPE 1 TERMINALS
$d =$ 0 FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + \left(|S_B - S_A|\right)\left(\frac{b}{a}\right)$$

LENGTH OF NEED	X =	113.76'
RUNOUT LENGTH (7.01.19)	L_R =	185'
GUARDRAIL TAPER RATE (R-59-SERIES)	$\frac{b}{a}$ =	1/12
E.O.P. TO FACE OF BARRIER (DESIGNED)	L_2 =	4'
CLEAR ZONE (7.01.11)	L_C =	30'
E.O.P. TO ROADSIDE FEATURE (MEASURED)	L_3 =	4'
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE	d =	0
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED)	L_H =	30'
LATERAL OFFSET AT END OF FLARE	Z =	9.47' **

DESIGN ADT	5,000 vpd
DESIGN SPEED	55 mph
APPROACH SLOPE	1:5

L_1 = 23.125' ' MIN.)

L_S = 7' SHY LINE (7.01.18)

STATION AT A 347+01.1

STATION AT B 347+66.8

CLEAR ZONE DISTANCES
(IN FEET FROM EDGE OF DRIVING LANE)

DESIGN SPEED	DESIGN ADT	FILL SLOPES			CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3	1:3	1:4 TO 1:5	1:6 OR FLATTER
40 mph or Less	under 750	7 - 10	7 - 10	**	7 - 10	7 - 10	7 - 10
	750 - 1500	10 - 12	12 - 14	**	10 - 12	12 - 14	12 - 14
	1500 - 6000	12 - 14	14 - 16	**	12 - 14	14 - 16	14 - 16
	over 6000	14 - 16	16 - 18	**	14 - 16	16 - 18	16 - 18
45-50 mph	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	20 - 22	24 - 28	**	14 - 16	18 - 20	20 - 22
55 mph	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 mph	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 mph	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

* Where a site specific investigation indicates a high probability of continuing crashes, or such occurrences are indicated by crash history, the designer may provide clear zone distances greater than 30 feet as indicated. Clear zones may be limited to 30 feet for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

** Since recovery is less likely on the unshielded, traversable 1:3 slopes, fixed objects should not be present in the vicinity of the toe of these slopes.

$d = 1.8'$ FOR TYPE 1 TERMINALS
$d = 0$ FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + \left(\left|S_B - S_A\right|\right)\left(\frac{b}{a}\right)$$

LENGTH OF NEED X	= 113.76'	DESIGN ADT	5,000 vpd
RUNOUT LENGTH (7.01.19) .... L_R	= 185'	DESIGN SPEED	55 mph
GUARDRAIL TAPER RATE (R-59-SERIES) .... $\frac{b}{a}$	= 1/12	APPROACH SLOPE	1:5
E.O.P. TO FACE OF BARRIER (DESIGNED) .... L_2	= 4'		
CLEAR ZONE (7.01.11) .... L_C	= 30'	L_1 = 23.125' ' MIN.)	
E.O.P. TO ROADSIDE FEATURE (MEASURED) .... L_3	= 4'	L_S = 7'	SHY LINE (7.01.18)
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d	= 0	STATION AT A	347+01.1
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED). . L_H	= 30'	STATION AT B	347+66.8
LATERAL OFFSET AT END OF FLARE .... Z	= 9.47' **		

Used distance to face of bridge railing

d = 1.8' FOR TYPE 1 TERMINALS
d = 0 FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + (|S_B - S_A|)\left(\frac{b}{a}\right)$$

LENGTH OF NEED .... X =	113.76'	DESIGN ADT	5,000 vpd
RUNOUT LENGTH (7.01.19) .... L_R =	185'	DESIGN SPEED	55 mph
GUARDRAIL TAPER RATE (R-59-SERIES) .... $\frac{b}{a}$ =	1/12	APPROACH SLOPE	1:5
E.O.P. TO FACE OF BARRIER (DESIGNED) .... L_2 =	4'		
CLEAR ZONE (7.01.11) .... L_C =	30'	L_1 = 23.125' ' MIN.)	
E.O.P. TO ROADSIDE FEATURE (MEASURED) .... L_3 =	4'	L_S = 7' SHY LINE (7.01.18)	
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d =	0	STATION AT A	347+01.1
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED). . L_H =	30'	STATION AT B	347+66.8
LATERAL OFFSET AT END OF FLARE .... Z =	9.47' **		

Using a Type 2M approach terminal, so d=0

$d = 1.8'$ FOR TYPE 1 TERMINALS
$d = 0$ FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + \left(\left|S_B - S_A\right|\right)\left(\frac{b}{a}\right)$$

LENGTH OF NEED X	= 113.76'	DESIGN ADT	5,000 vpd
RUNOUT LENGTH (7.01.19) .... L_R	= 185'	DESIGN SPEED	55 mph
GUARDRAIL TAPER RATE (R-59-SERIES) .... $\frac{b}{a}$	= 1/12	APPROACH SLOPE	1:5
E.O.P. TO FACE OF BARRIER (DESIGNED) .... L_2	= 4'		
CLEAR ZONE (7.01.11) .... L_C	= 30'	L_1 = 23.125'	' MIN.)
E.O.P. TO ROADSIDE FEATURE (MEASURED) .... L_3	= 4'	L_S = 7'	SHY LINE (7.01.18)
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d	= 0	STATION AT A	347+01.1
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED) .. L_H	= 30'	STATION AT B	347+66.8
LATERAL OFFSET AT END OF FLARE .... Z	= 9.47' **		

$L_H = L_C$ in this case, since the river is the hazard and extends beyond the clear zone

$d = 1.8'$ FOR TYPE 1 TERMINALS
$d = 0$ FOR TYPE 2 AND 3 TERMINALS

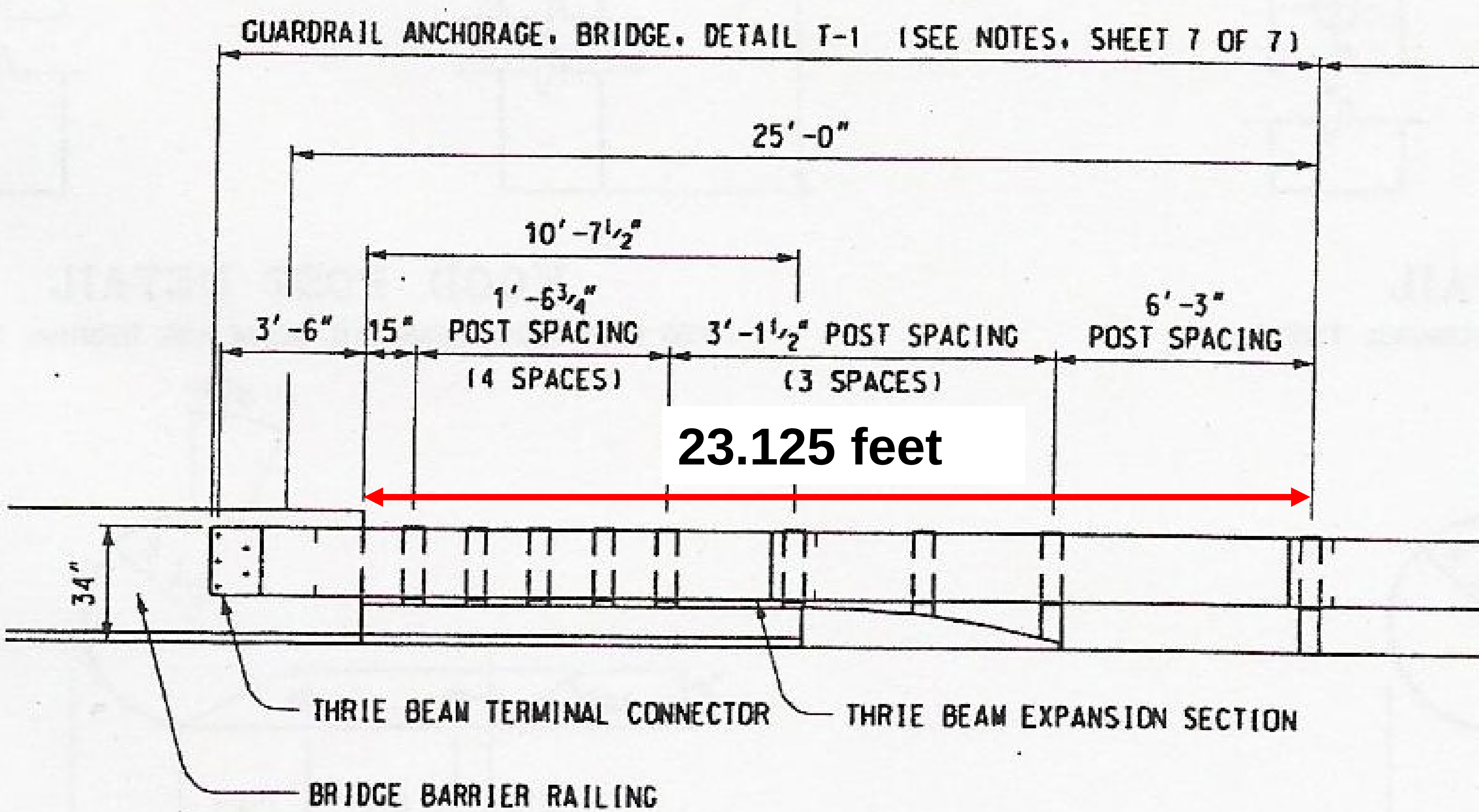
$$X = \frac{L_H + \left(\frac{b}{a}\right)(L_1) - (L_2 + d)}{\frac{b}{a} + \frac{L_H}{L_R}}$$

$$Z = L_2 + \left(\left|S_B - S_A\right|\right)\left(\frac{b}{a}\right)$$

LENGTH OF NEED X	= 113.76'	DESIGN ADT	5,000 vpd
RUNOUT LENGTH (7.01.19) .... L_R	= 185'	DESIGN SPEED	55 mph
GUARDRAIL TAPER RATE (R-59-SERIES) .... $\frac{b}{a}$	= 1/12	APPROACH SLOPE	1:5
E.O.P. TO FACE OF BARRIER (DESIGNED) .... L_2	= 4'		
CLEAR ZONE (7.01.11) .... L_C	= 30'	L_1 = 23.125'	(' MIN.)
E.O.P. TO ROADSIDE FEATURE (MEASURED) .... L_3	= 4'	L_S = 7'	SHY LINE (7.01.18)
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d	= 0	STATION AT A	347+01.1
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED). . L_H	= 30'	STATION AT B	347+66.8
LATERAL OFFSET AT END OF FLARE .... Z	= 9.47' **		

$L_1 < 25'$ in this case because $L_1 = L_T$
(exception to $L_1 = 25'$ min. rule)

Detail T-1 (Sheet 1 of R-67-Series)



$d =$ 1.8' FOR TYPE 1 TERMINALS
$d =$ 0 FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + \left(\left|S_B - S_A\right|\right)\left(\frac{b}{a}\right)$$

LENGTH OF NEED X	= 113.76'	DESIGN ADT	5,000 vpd
RUNOUT LENGTH (7.01.19) .... L_R	= 185'	DESIGN SPEED	55 mph
GUARDRAIL TAPER RATE (R-59-SERIES) .... $\frac{b}{a}$	= 1/12	APPROACH SLOPE	1:5
E.O.P. TO FACE OF BARRIER (DESIGNED) .... L_2	= 4'		
CLEAR ZONE (7.01.11) .... L_C	= 30'	L_1 = 23.125' ' MIN.)	
E.O.P. TO ROADSIDE FEATURE (MEASURED) .... L_3	= 4'	L_S = 7'	SHY LINE (7.01.18)
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d	= 0	STATION AT A	347+01.1
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED) .. L_H	= 30'	STATION AT B	347+66.8
LATERAL OFFSET AT END OF FLARE .... Z	= 9.47' **		

$L_2 < L_S$ in this case (i.e., guardrail within shy distance)

This is acceptable

Design Speed (mph)	Shy Line Offset (L_s) (ft)
80	12
75	10
70	9
60	8
55	$\boxed{7}$
50	6.5
45	6
40	5
30	4

$d = 1.8'$ FOR TYPE 1 TERMINALS
$d = 0$ FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + \left(\left|S_B - S_A\right|\right)\left(\frac{b}{a}\right)$$

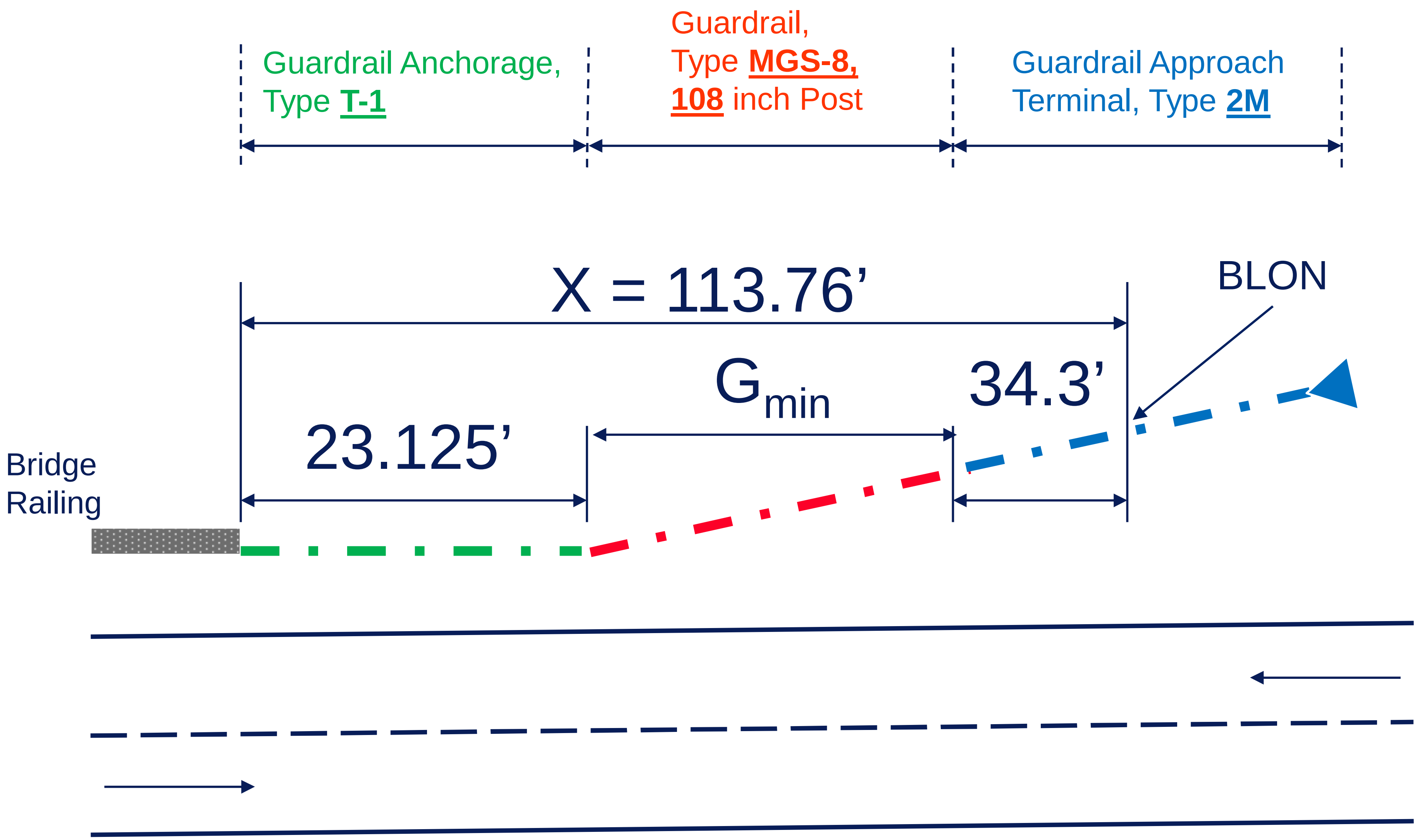
LENGTH OF NEED .... X =	113.76'	DESIGN ADT	5,000 vpd
RUNOUT LENGTH (7.01.19) .... L_R =	185'	DESIGN SPEED	55 mph
GUARDRAIL TAPER RATE (R-59-SERIES) .... $\frac{b}{a}$ =	1/12	APPROACH SLOPE	1:5
E.O.P. TO FACE OF BARRIER (DESIGNED) .... L_2 =	4'		
CLEAR ZONE (7.01.11) .... L_C =	30'	L_1 =	23.125' ' MIN.)
E.O.P. TO ROADSIDE FEATURE (MEASURED) .... L_3 =	4'	L_S =	7' SHY LINE (7.01.18)
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d =	0	STATION AT A	347+01.1
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED) . L_H =	30'	STATION AT B	347+66.8
LATERAL OFFSET AT END OF FLARE .... Z =	9.47' **		

$L_1 < 25'$ in this case because $L_1 = L_T$
(exception to $L_1 = 25'$ min. rule)

__Length of Need (X)__

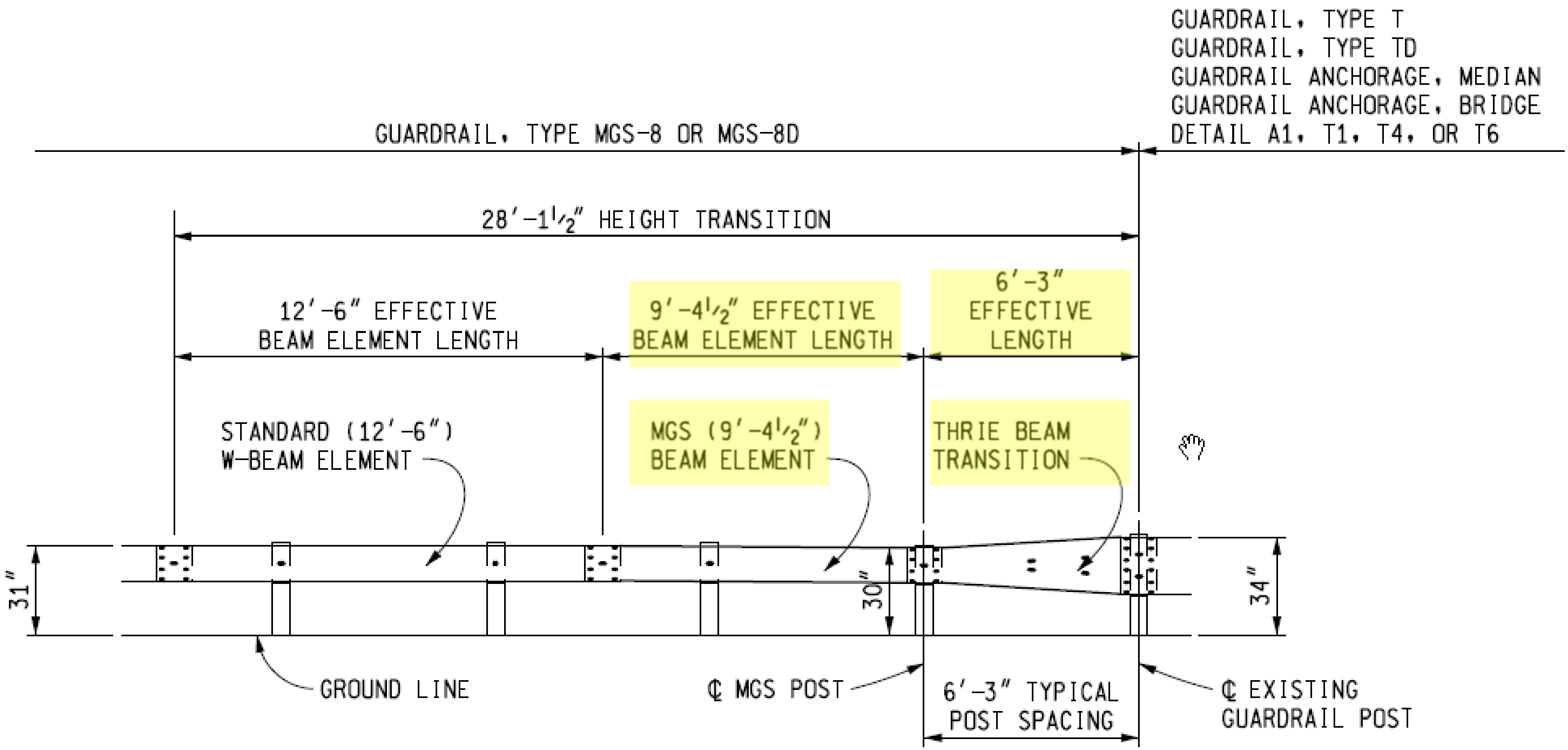
$$X = \frac{30 + \left(\frac{1}{12}\right) \times (23.125) - 4}{\left(\frac{1}{12}\right) + \left(\frac{30}{185}\right)} = 113.76'$$

Minimum Guardrail Length



$$G_{min} = 113.76' - 34.3' - 23.125' = 56.34'$$

However, the MGS (9'-4.5") beam element and thrie-beam transition panel must be considered due to T-1 anchorage



ELEVATION SHOWING TRANSITION DETAIL FOR CONNECTING GUARDRAIL, TYPE MGS-8 OR MGS-8D TO GUARDRAIL, TYPE T, GUARDRAIL, TYPE TD, GUARDRAIL ANCHORAGE, MEDIAN, GUARDRAIL ANCHORAGE, BRIDGE DETAIL A1, T1, T4 OR T6

$\therefore$ # of 12.5' panels = $\left(\frac{56.34-9.375-6.25}{12.5}\right)$ = 3.26 $\rightarrow$ 4 panels

Type MGS-8 guardrail length = (12.5)(4) + 9.375 + 6.25

= <u>65.625 feet</u>

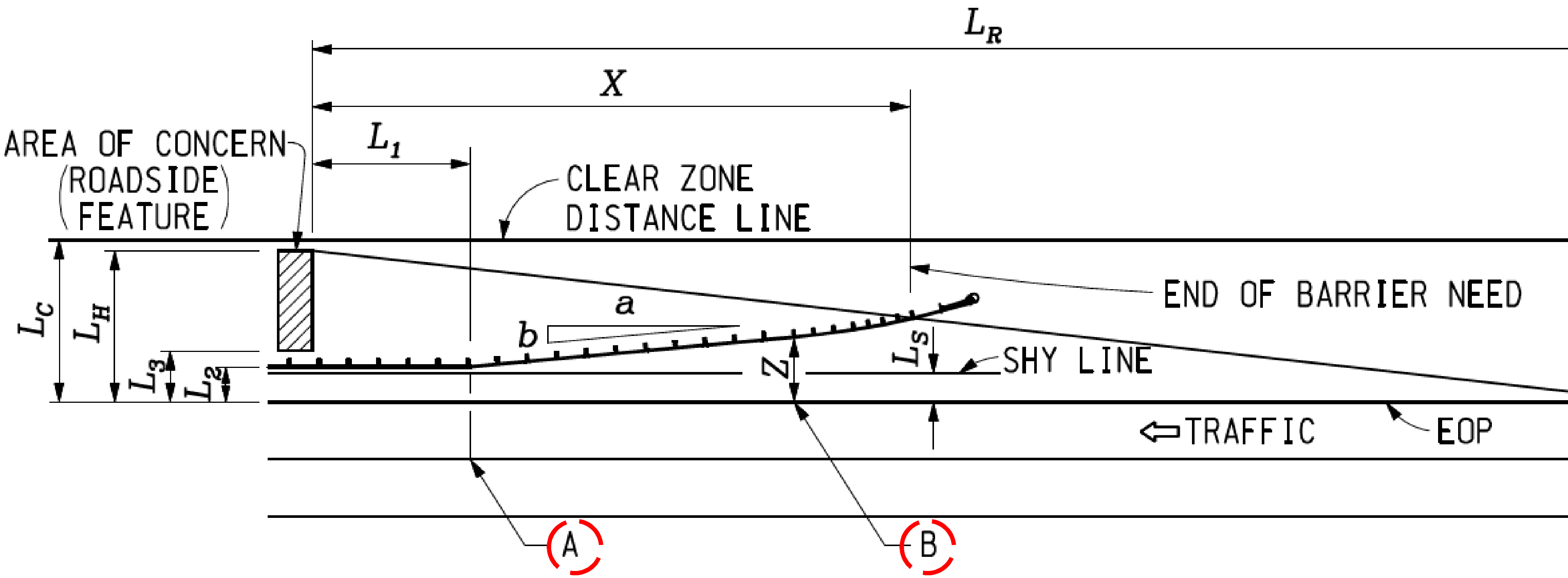
Reflectors

$$\# \text{ of reflectors} = \left(\frac{65.625 + 23.125}{50}\right) + 1 = 2.78 \rightarrow \text{ round up to } 3$$

**** But two-way roads require reflectors facing both sides ****

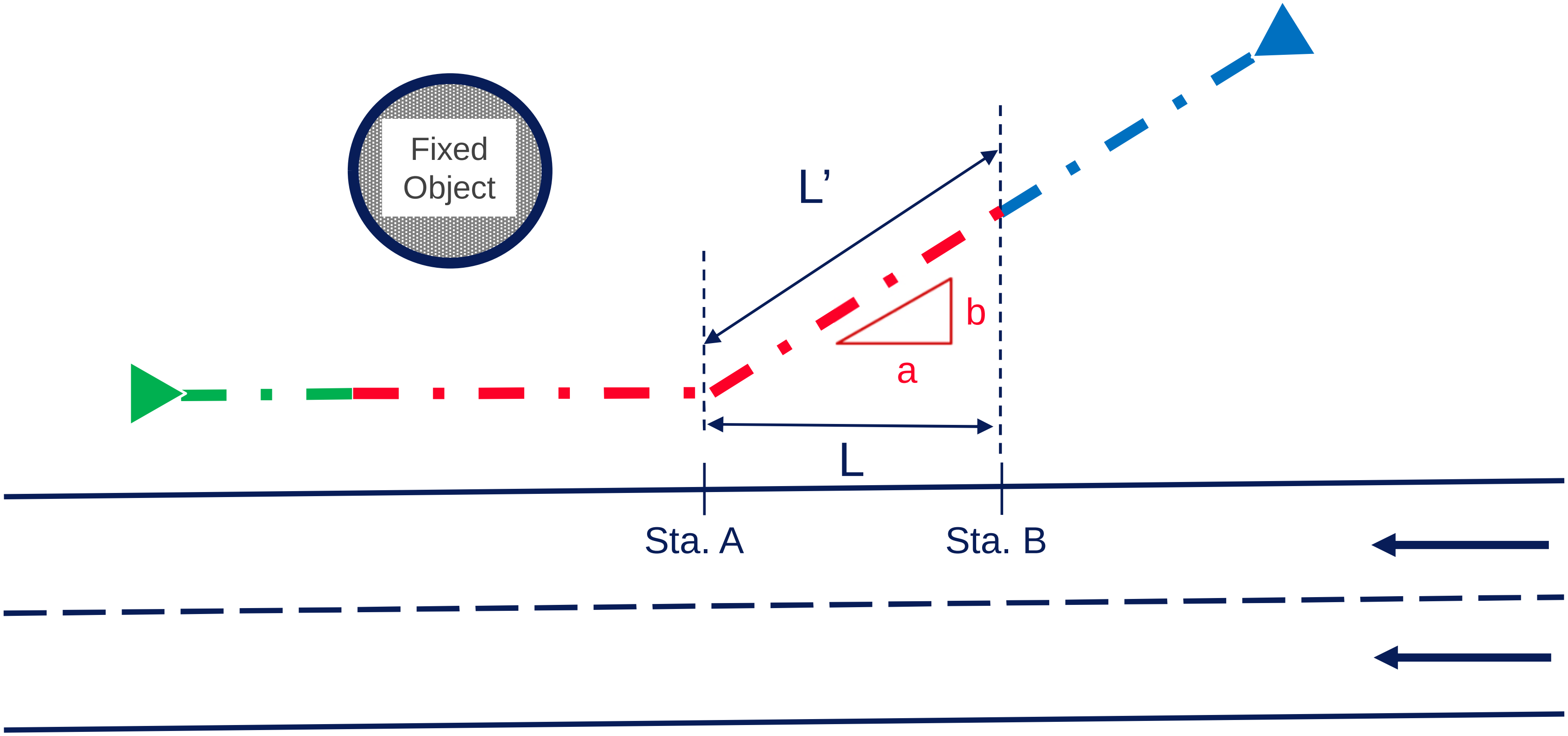
$\therefore$ # of reflectors = 3 x 2 = 6 reflectors

Stations A and B



Calculating Stations A and B

Does Flaring Affect the Calculations?



Assume L ≈ L’ for most guardrail applications

(unless dealing with extremely long installations)

Stations

Station A = (346+78) + 23.125′ ≈ <u>347+01.1</u>

Station B = (346+78) + 23.125 + 65.625′ ≈ <u>347+66.8</u>

Calculating Z

$$Z = L_2 + (\text{Distance}_{B\text{-}A}) \times \left(\frac{b}{a}\right)$$

$$= 4 + (65.625) \times \left(\frac{1}{12}\right) = \underline{9.47'}$$

PAY ITEMS

65.625 Ft * Guardrail, Type MGS-8, 108 inch Post

1 Ea Guardrail Anchorage, Bridge, Det T-1

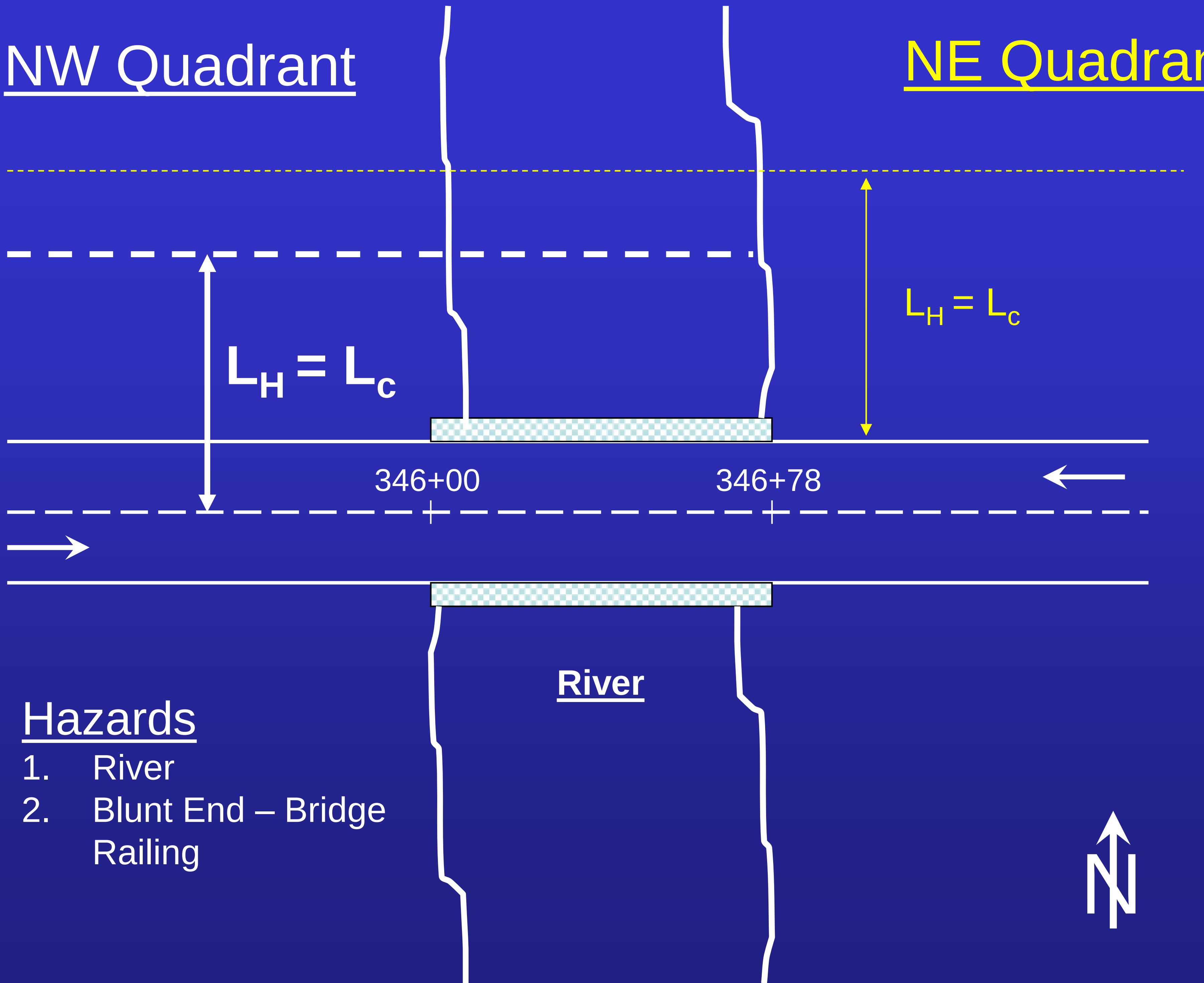
______ Ft Bridge Railing, Thrie Beam Retrofit

1 Ea Guardrail Approach Terminal, Type 2M

______ Ea Guardrail Departing Terminal, Type ___

6 Ea Guardrail Reflector

______ Cyd Embankment, LM



Hazards

1. River
2. Blunt End – Bridge Railing

$d = 1.8'$ FOR TYPE 1 TERMINALS
$d = 0$ FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + \left(\left|S_B - S_A\right|\right)\left(\frac{b}{a}\right)$$

LENGTH OF NEED .... X = 64.88'

RUNOUT LENGTH (7.01.19) .... L_R = 185'

GUARDRAIL TAPER RATE (R-59-SERIES) .... $\frac{b}{a}$ = 1/12

E.O.P. TO FACE OF BARRIER (DESIGNED) .... L_2 = 16'

CLEAR ZONE (7.01.11) .... L_C = 30'

E.O.P. TO ROADSIDE FEATURE (MEASURED) .... L_3 = 16'

EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d = 0

LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED) . L_H = 30'

LATERAL OFFSET AT END OF FLARE .... Z = 6.34' (measured from EOP)**
18.34' (measured from CL)**

DESIGN ADT 5,000 vpd

DESIGN SPEED 55 mph

APPROACH SLOPE 1:5

L_1 = 23.125' (5' MIN.)

L_S = 7' SHY LINE (7.01.18)

STATION AT A 345+76.9

STATION AT B 345+48.8

NOTE: DISTANCE OF OBJECT FROM BACK OF BARRIER MUST BE GREATER THAN THE MAXIMUM DEFLECTION (7.01.20)

$L_H \leq L_C$

** Refer to Calculations and Notes

REFER TO STANDARD PLAN R-59-SERIES AND DESIGN MANUAL SECTION 7.01.30 FOR GUARDRAIL AT EMBANKMENTS

<u>Length of Need (X)</u>

$$X = \frac{30 + \left(\frac{1}{12}\right) \times (23.125) - 16}{\left(\frac{1}{12}\right) + \left(\frac{30}{185}\right)} = 64.88'$$

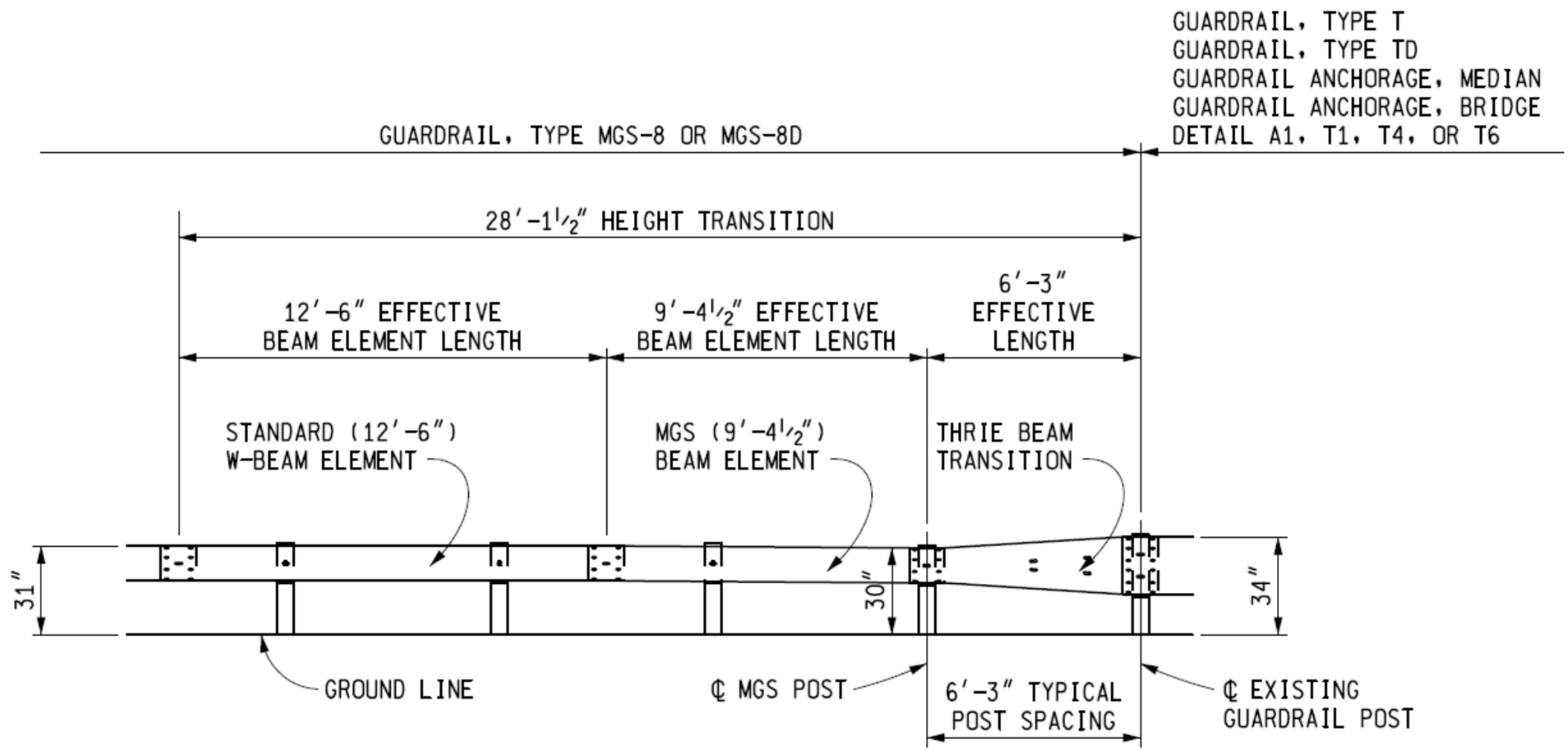
Guardrail Length

Using a Guardrail Approach Terminal, Type 2M with Guardrail, Type MGS-8 in this case

$\therefore$ Min. Guardrail Length = 64.88’ – 23.125’ – 34.3’ = 7.46’

However, in this case, the minimum length of Type MGS-8 between the T-1 anchorage and Type 2M approach terminal is 28'-1.5" due to the required height transition section; see MDOT Standard Plan R-60-Series.

∴ Type MGS-8 guardrail length = <u>28.125 feet</u>



Reflectors

$$\# \text{ of reflectors} = \left(\frac{28.125 + 23.125}{50}\right) + 1 = 2.02 \rightarrow \text{round up to } 3$$

**** But two-way roads require reflectors facing both sides ****

$\therefore$ # of reflectors = 3 x 2 = <u>6 reflectors</u>

PAY ITEMS

28.125 Ft * Guardrail, Type MGS-8, 108 inch Post

_1_ Ea Guardrail Anchorage, Bridge, Det T-1

_____ Ft Bridge Railing, Thrie Beam Retrofit

_1_ Ea Guardrail Approach Terminal, Type 2M

_____ Ea Guardrail Departing Terminal, Type __

_6_ Ea Guardrail Reflector

_____ Cyd Embankment, LM

Stations

Station A = (346+00) - 23.125′ ≈ <u>345+76.9</u>

Station B = (346+00) - 23.125 – 28.125′ ≈ <u>345+48.8</u>

Calculating Z

$$Z = L_2 + (\text{Distance}_{B\text{-}A}) \times \left(\frac{b}{a}\right)$$

$$= 16 + (28.125) \times \left(\frac{1}{12}\right) = \underline{18.34'} \text{ (measured from CL)}$$

or

$$= 4 + (28.125) \times \left(\frac{1}{12}\right) = \underline{6.34'} \text{ (measured from EOP)}$$

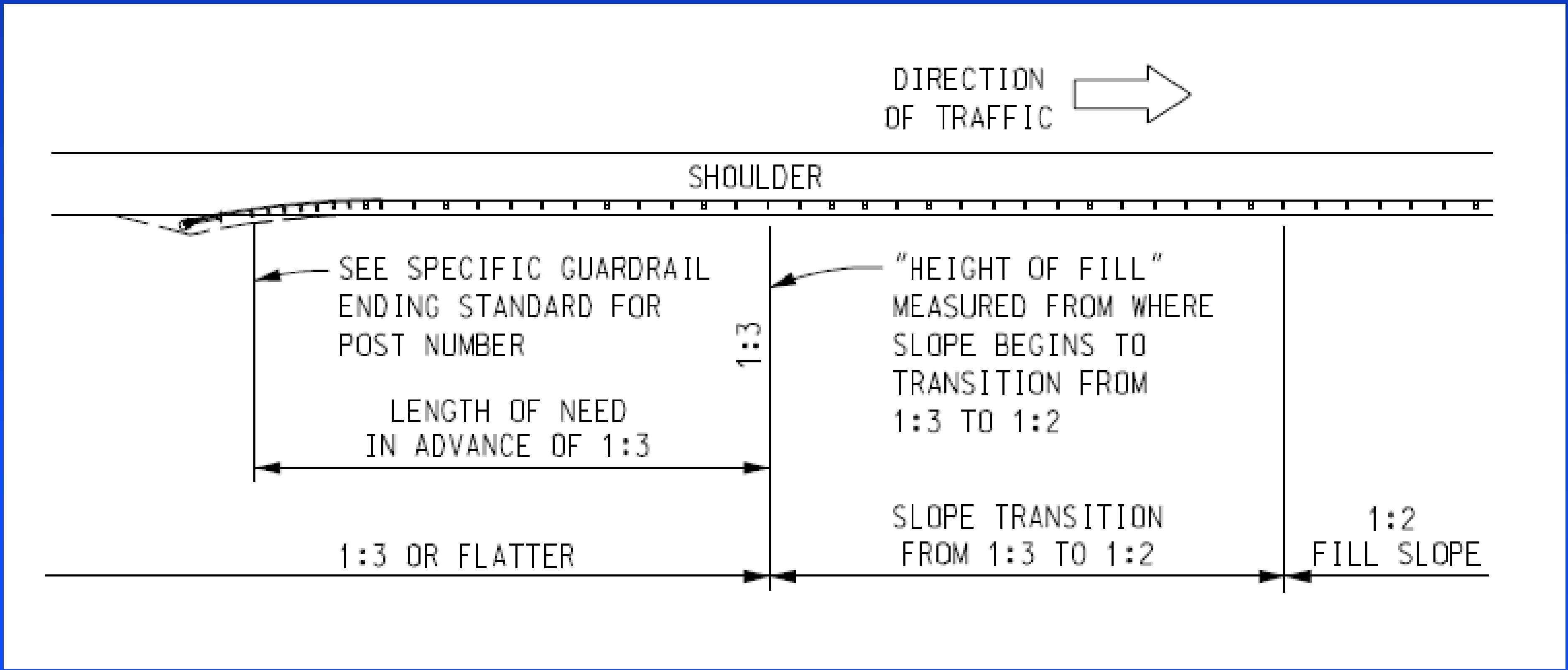
Guardrail Design
Shielding Embankments

Guardrail at Embankments

MDOT Method

Parallel Guardrail Installations

- Section 7.01.30F of RDM



Guardrail at Embankments

MDOT Method

Parallel Guardrail Installations

- Section 7.01.30F of RDM

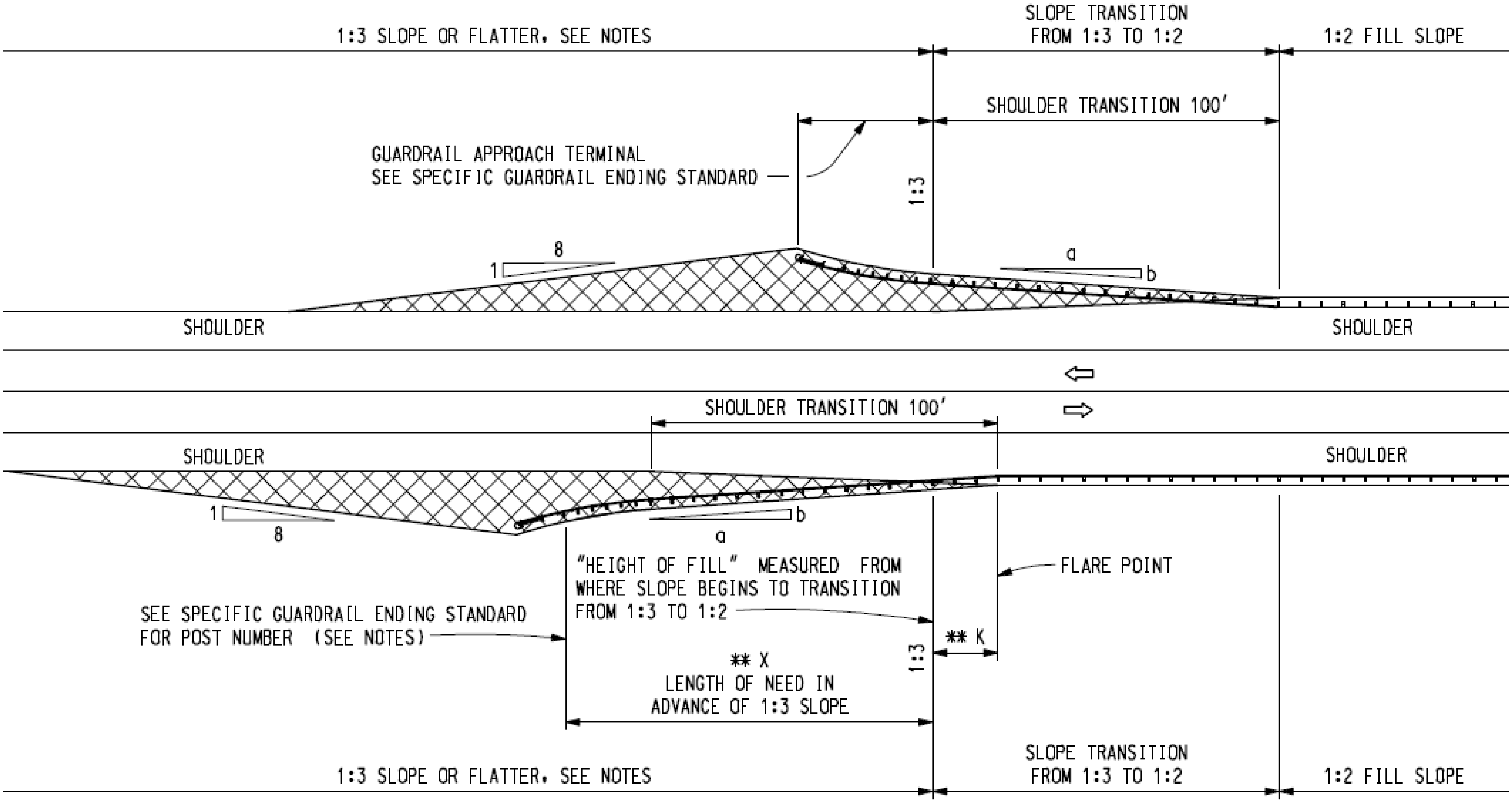
GUARDRAIL AT EMBANKMENTS (PARALLEL INSTALLATIONS)				
HEIGHT OF FILL AT 1:3 (ft)		LENGTH OF NEED IN ADVANCE OF 1:3 (ft)		
OVER	TO	70 mph	60 mph	50 mph
5	10	147	121	100
10	12	197	171	122
12	14	235	205	153
14	16	269	238	179
16	18	296	262	198
18	20	316	280	212
20	22	331	294	223
22	24	343	305	231
24	25	349	309	235

Guardrail at Embankments

MDOT Method

Flared Guardrail Installations

- Section 7.01.30E of RDM
- MDOT Standard Plan R-59 Series



** SEE CHART FOR THE "X" AND THE "K" DISTANCE. (SHEET 6 OF 6)

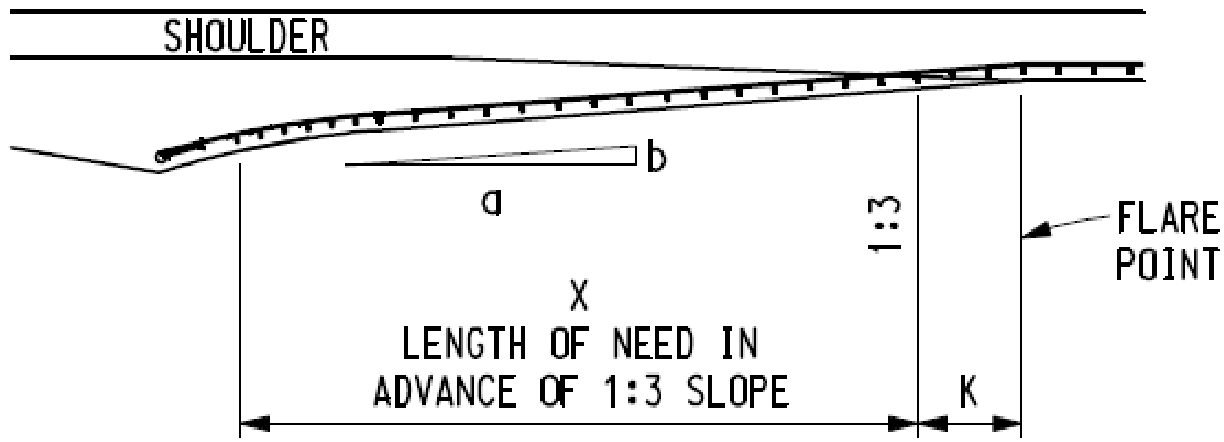
BEAM GUARDRAIL AT EMBANKMENTS - TWO-WAY ROADWAYS

LEGEND

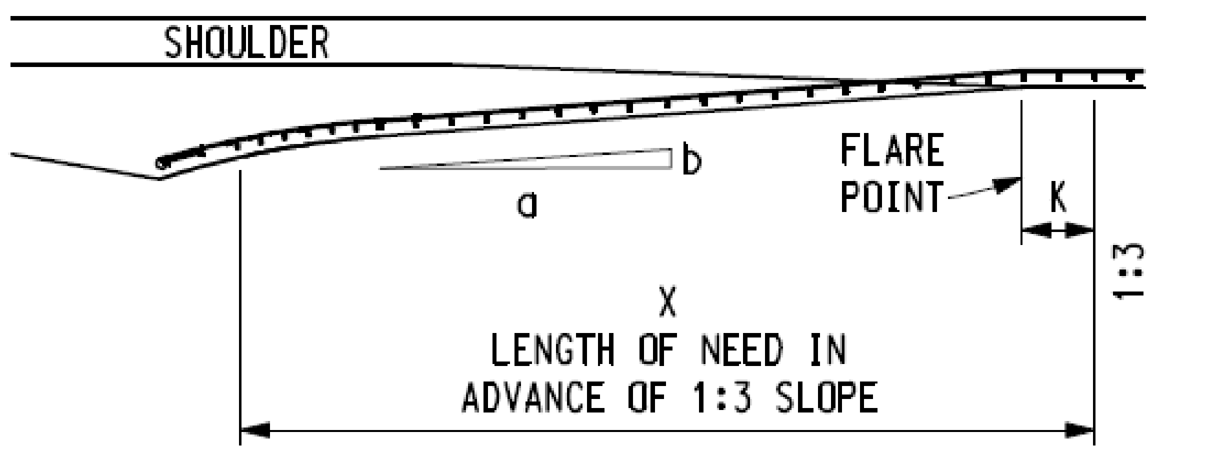
Cross-hatched	1:10 SLOPE BETWEEN SHOULDER LINE AND 2′-0″ BEHIND FACE OF POST.
Diagonal hatched	1:6 BERM

Standard Plan R-59-E
X & K Values

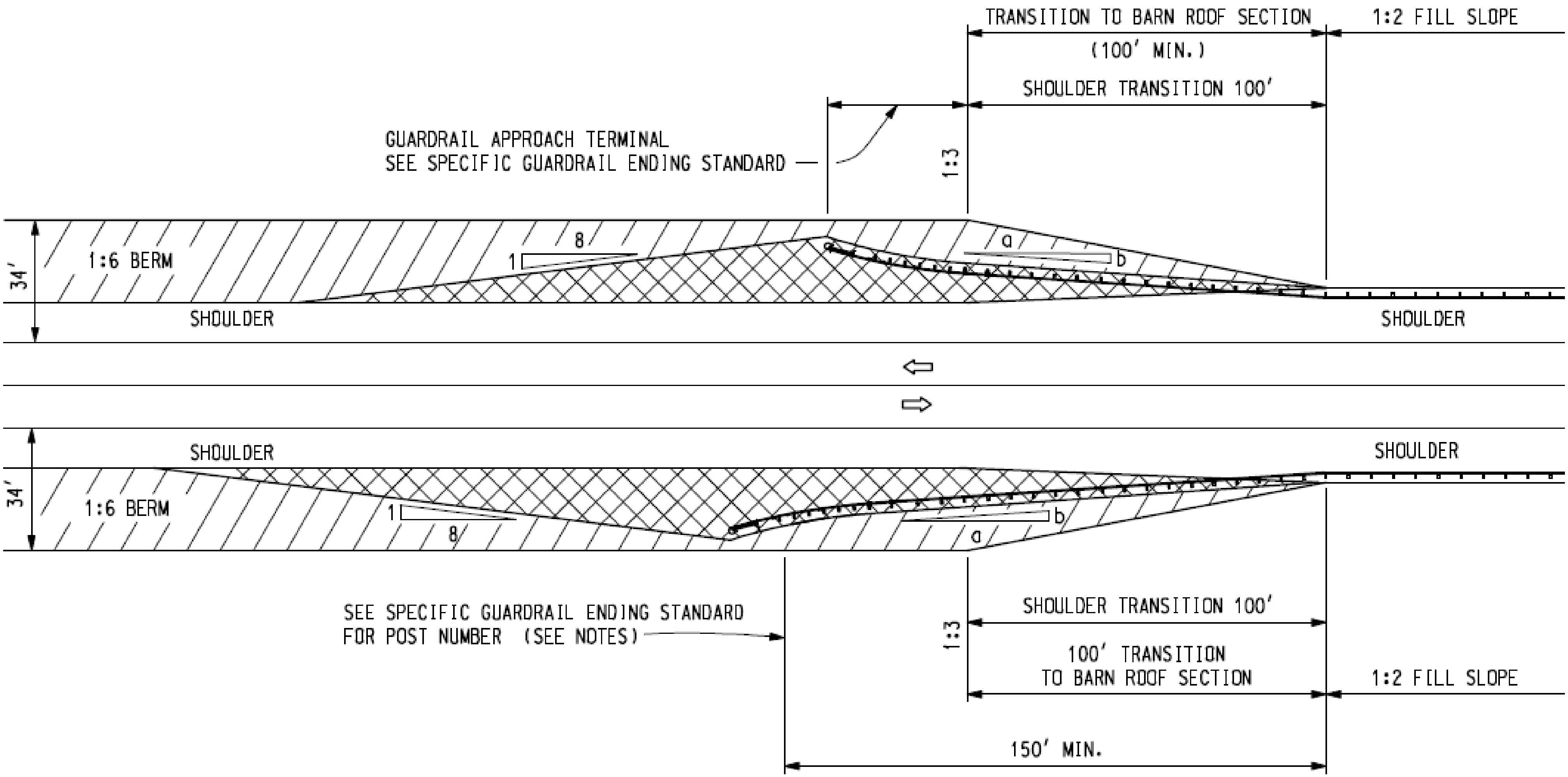
GUARDRAIL AT EMBANKMENTS (FLARED INSTALLATIONS, b/a)							
HEIGHT OF FILL AT 1:3 SLOPE (FEET)		70 MPH FLARE 1 : 15		60 MPH FLARE 1 : 14		50 MPH FLARE 1 : 11	
OVER	TO	X	K	X	K	X	K
5	10	100	37.5	100	12.5	100	0
10	12	100	37.5	100	12.5	100	0
12	14	100	37.5	100	12.5	100	0
14	16	113	24.5	110	2.5	100	0
16	18	155	−17.5	149	−36.5	101	−1
18	20	193	−55.5	182	−69.5	127	−27
20	22	223	−85.5	207	−94.5	148	−48
22	24	246	−108.5	227	−113.5	164	−64
24	25	256	−118.5	235	−122.5	171	−71



FOR POSITIVE "K" DISTANCES, BEGIN FLARE POINT BEYOND THE 1:3 SLOPE.

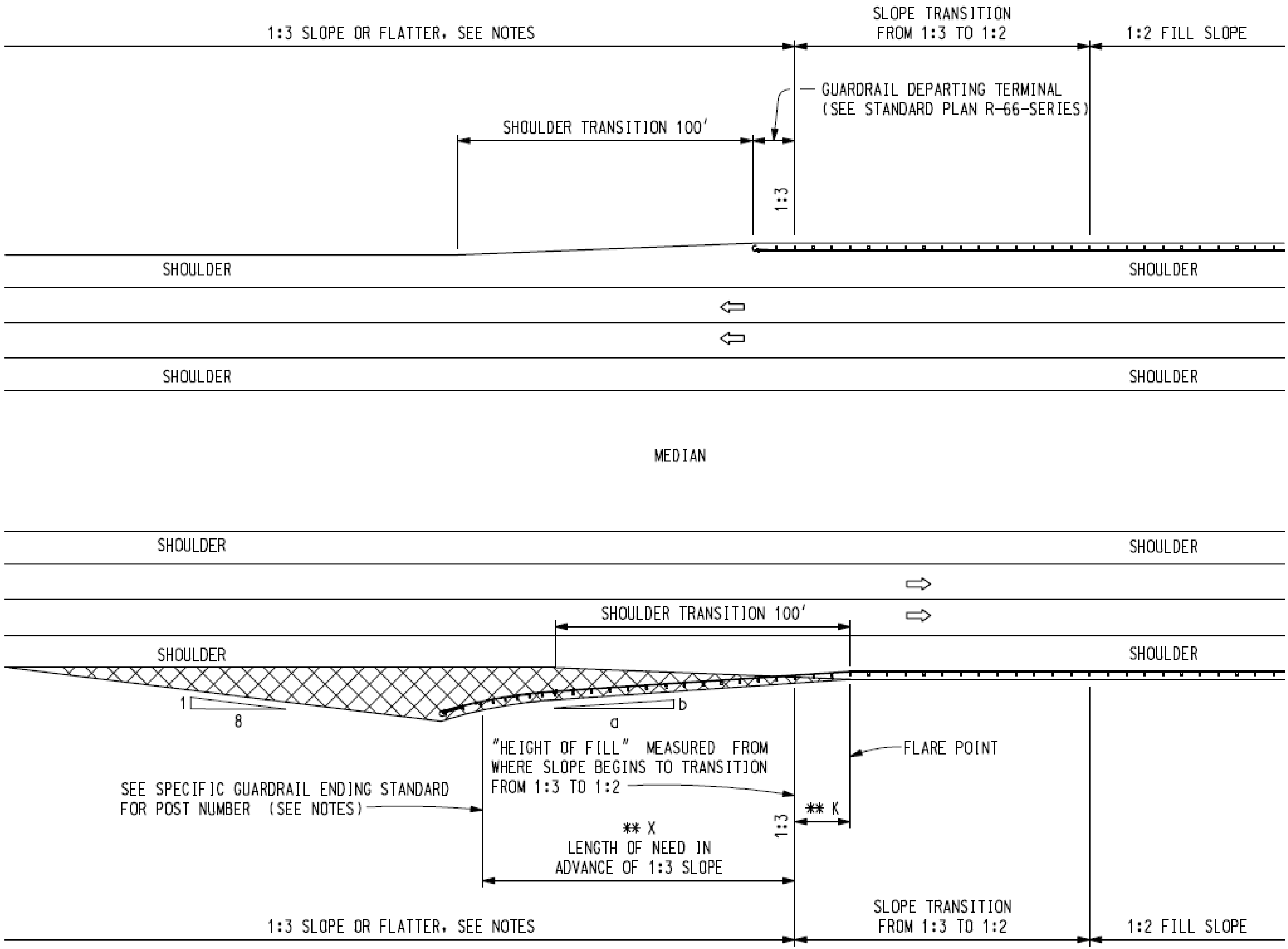


FOR NEGATIVE "K" DISTANCES, BEGIN FLARE POINT IN ADVANCE OF THE 1:3 SLOPE.



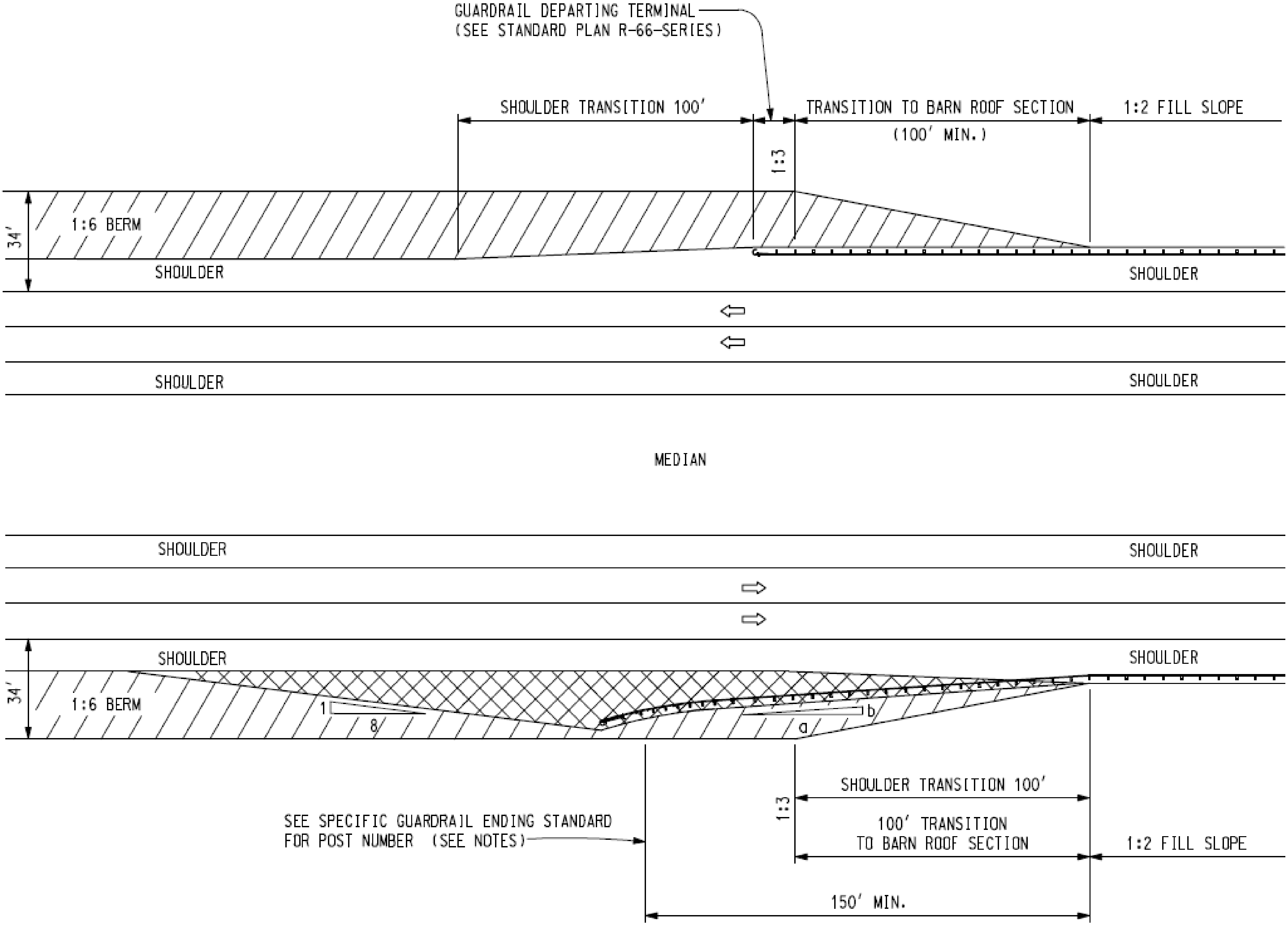
BEAM GUARDRAIL AT EMBANKMENTS - TWO-WAY ROADWAYS

(BARN ROOF SLOPE)



** SEE CHART FOR THE "X" AND THE "K" DISTANCE. (SHEET 6 OF 6)

BEAM GUARDRAIL AT EMBANKMENTS - DUAL ROADWAYS

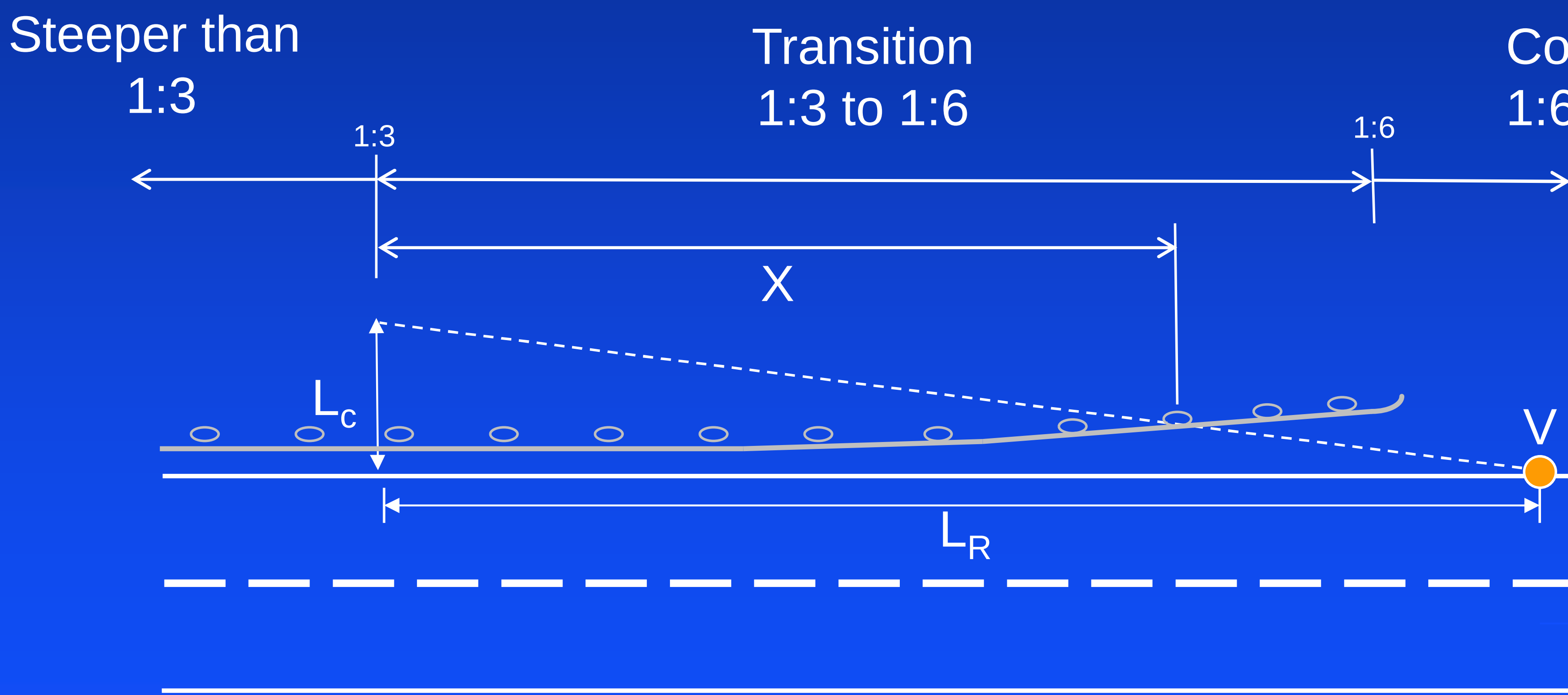


BEAM GUARDRAIL AT EMBANKMENTS - DUAL ROADWAYS

(BARN ROOF SLOPE)

Guardrail at Embankments

Calculation Method
(AASHTO RDG)



L_c is clear zone based on slope at *Point V*
(in this example, the slope would be a *1:6 Fill Slope*)

Guardrail at Embankments

Calculation Method

Methodology

- Step 1: Determine L_R
- Step 2: Determine L_c
  - In this case, L_H=L_c

Guardrail at Embankments

Calculation Method

Methodology

- Step 3: Determine Layout and Terminal
  - Flared or Parallel Guardrail

    If flared:

    - Determine flare rate (b/a)
    - Determine location where flare begins
  - Terminal Type:
    - Type 1 (Flared) or Type 2 (Parallel) Terminal

Guardrail at Embankments

Calculation Method

Methodology

- Step 4: Determine Guardrail Location (L_2)

Guardrail at Embankments

Calculation Method

Methodology

- Step 5: Use appropriate formula to calculate length of need (X) in advance of 1:3 point

Guardrail at Embankments

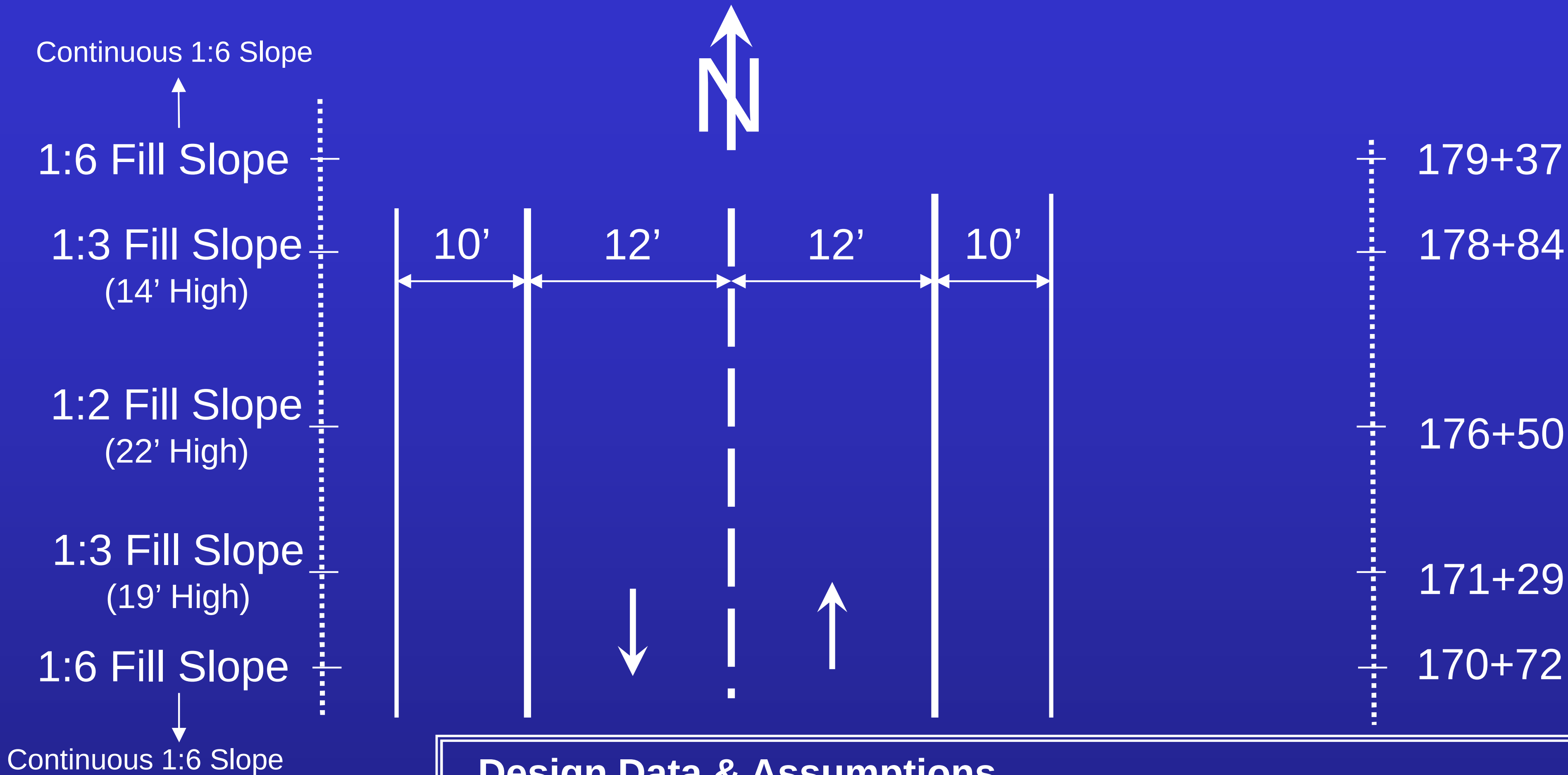
Calculation Method

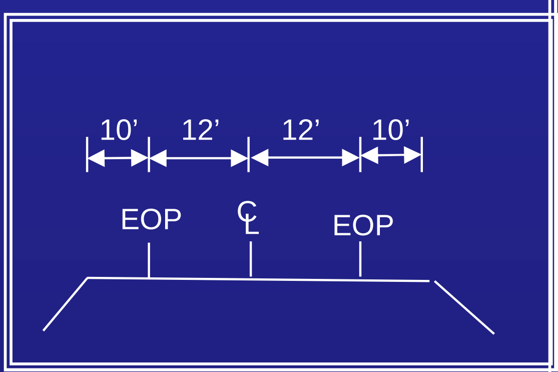
Methodology

- Step 5: Use appropriate formula to calculate length of need (X) in advance of 1:3 point

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

Practice Example #3

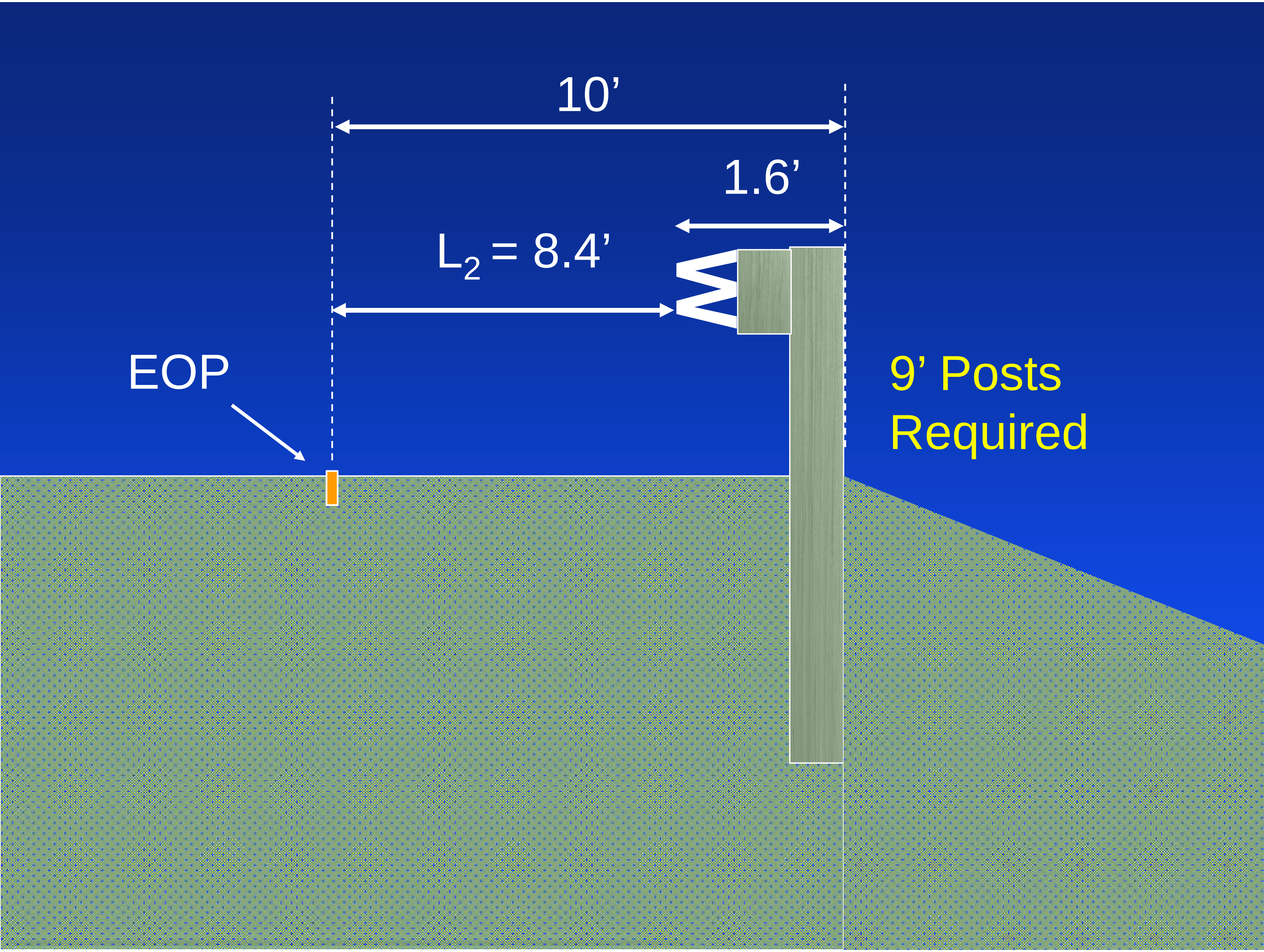




Design Data & Assumptions

- Rural Two-Lane Road
- Design Speed = 60 mph
- ADT = 8,700 vpd
- Parallel Installation (SB side; west side of road)
- Approach End: Use Chapter 7 - RDM to design guardrail
- Departing End: Use Calculation Method to design guardrail

- Type MGS-8 guardrail will be used
- Type 2M guardrail approach terminals will be used
- L_c = 32’ (1:6 slope at Sta. 168+79; 250’ (L_r) south of Sta. 171+29)
- Assume L_2 = 8.4’ (i.e., 10’-1.6’); requires use of 9’ posts


10’
1.6’
L2 = 8.4’
EOP
9’ Posts
Required

Approach End (North End)

Refer to Subsection 7.01.30.F of Michigan Road Design Manual

- Fill Height = 14’ at 1:3 Point (Sta. 178+84); Speed = 60 mph

∴ Length of Need in Advance of 1:3 = <u>205’</u>

GUARDRAIL AT EMBANKMENTS (PARALLEL INSTALLATIONS)				
HEIGHT OF FILL AT 1:3 (ft)		LENGTH OF NEED IN ADVANCE OF 1:3 (ft)		
OVER	TO	70 mph	60 mph	50 mph
5	10	147	121	100
10	12	197	171	122
12	14	235	205	153
14	16	269	238	179
16	18	296	262	198
18	20	316	280	212
20	22	331	294	223
22	24	343	305	231
24	25	349	309	235

<u>Departing End (South End)</u>

- Shoulder hinge point on west side of road is within northbound (NB) traffic's clear zone
  - Use guardrail worksheet to calculate length of need
- Guardrail ending on south end is within NB traffic's clear zone
  - Must use a crashworthy guardrail terminal (i.e., Type 2M guardrail approach terminal).

GUARDRAIL WORKSHEET

FOR APPROACH TERMINALS ON R-61-SERIES AND R-62-SERIES

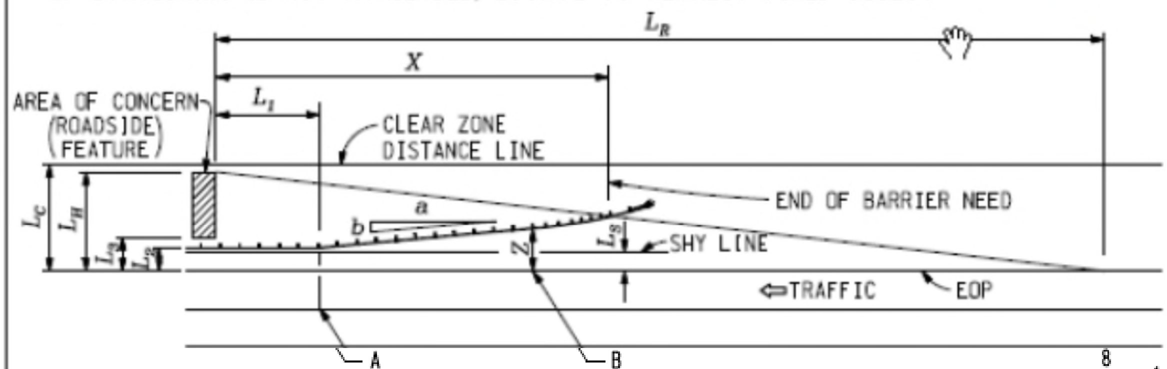
ROUTE Practice Example #3 CONTROL SECTION 99999 JOB # EXAMPLE

DESIGNED BY ABC DATE 00/01/18 CHECKED BY XYZ DATE 00/01/18

APPROX. STATION OR M.P. 171+29 DESCRIPTION Practice Example #3

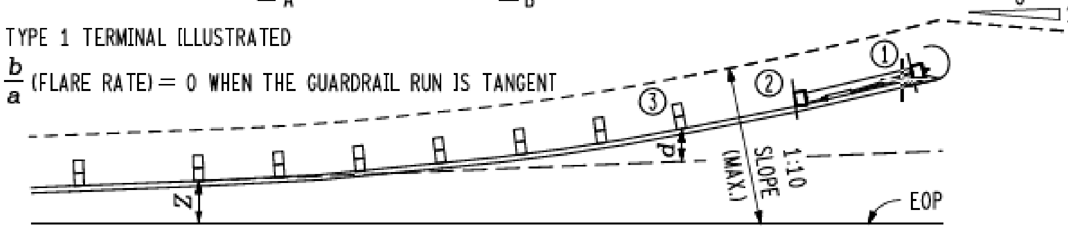
GUARDRAIL RUN # South End

IF STATIONING IS NOT AVAILABLE, LOCATE TO NEAREST FIXED OBJECT



NOTES: TYPE 1 TERMINAL ILLUSTRATED

$\frac{b}{a}$ (FLARE RATE) = 0 WHEN THE GUARDRAIL RUN IS TANGENT



d = 1.8' FOR TYPE 1 TERMINALS
d = 0 FOR TYPE 2 AND 3 TERMINALS

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

$$Z = L_2 + \left(|S_B - S_A|\right)\left(\frac{b}{a}\right)$$

LENGTH OF NEED .... X = 90.63'

RUNOUT LENGTH (7.01.19) .... L_R = 250'

GUARDRAIL TAPER RATE (R-59-SERIES) .... $\frac{b}{a}$ = 0

E.O.P. TO FACE OF BARRIER (DESIGNED) .... L_2 = 20.4'

CLEAR ZONE (7.01.11) .... L_C = 32'

E.O.P. TO ROADSIDE FEATURE (MEASURED) .... L_3 = 16'

EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d = 0

LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED). L_H = 32'

LATERAL OFFSET AT END OF FLARE .... Z = 8.4'

DESIGN ADT 8,700 vpd

DESIGN SPEED 60 mph

APPROACH SLOPE 1:6

L_1 = N/A

L_S = 8' . SHY LINE (7.01.18)

STATION AT A N/A

STATION AT B 170+72.7

NOTE: DISTANCE OF OBJECT FROM BACK OF BARRIER MUST BE GREATER THAN THE MAXIMUM DEFLECTION (7.01.20)

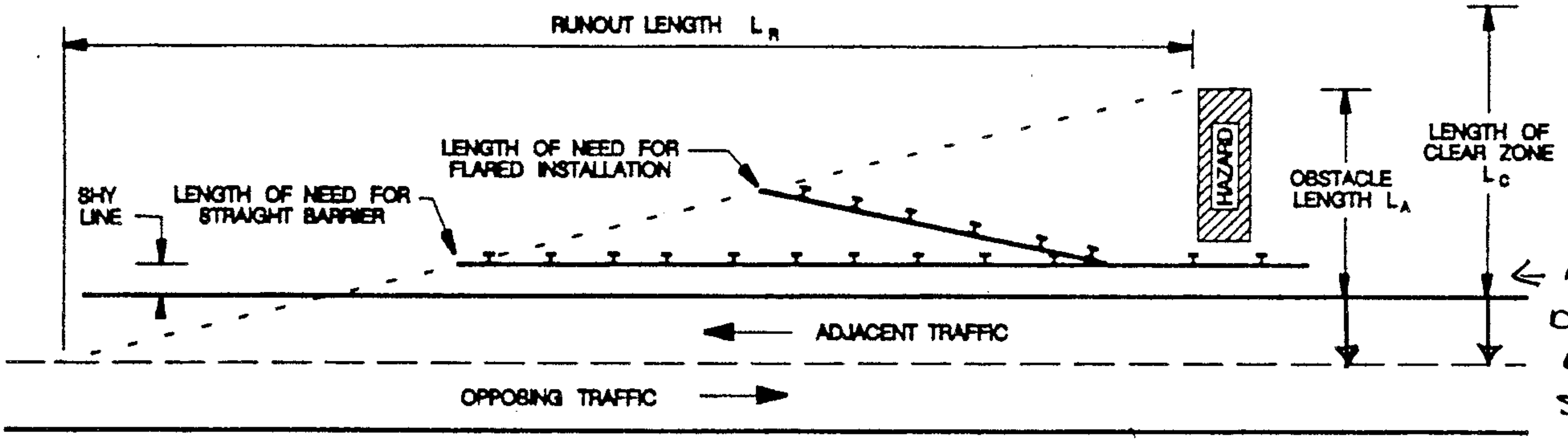
$L_H \leq L_C$

REFER TO STANDARD PLAN R-59-SERIES AND DESIGN MANUAL SECTION 7.01.30 FOR GUARDRAIL AT EMBANKMENTS

LENGTH OF NEED	X =	90.63'
RUNOUT LENGTH (7.01.19)	L_R =	250'
GUARDRAIL TAPER RATE (7.01.29.A)	$\frac{b}{a}$ =	0
E.O.P. TO FACE OF BARRIER (DESIGNED)	L_2 =	20.4'
CLEAR ZONE (7.01.11)	L_C =	32'
E.O.P. TO ROADSIDE FEATURE (MEASURED)	L_3 =	16'
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ...	d =	0
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED)..	L_H =	32'
LATERAL OFFSET AT END OF FLARE	Z =	8.4'

DESIGN ADT	8,700 vpd
DESIGN SPEED	60 mph
APPROACH SLOPE	1:6
L_1 =	N/A
L_S =	8'. SHY LINE (7.01.18)
STATION AT A	N/A
STATION AT B	170+72.7

Departing End



On two-lane, two-way roads, L_2, L_H, and L_C referenced from centerline on departing end

Length of Need (X) – South End (Using Guardrail Worksheet)

$$X = \frac{32 - 20.4}{\left(\frac{32}{250}\right)} = 90.63'$$ (measured from 1:3 point; Sta. 171+29)

Total Guardrail Length

Min. Length = (178+84) - (171+29) + 205 + 90.63 – 2(34.3)

= 982.03’

\# of panels = $\frac{982.03}{12.5}$ = 78.56 → round up to 79 panels

∴ Type MGS-8 Guardrail Length = (12.5)(79) = 987.5 feet

Reflectors

# of reflectors = $\left(\frac{987.5}{50}\right) + 1 = 20.75$ → round up to 21

***** But two-way roads require reflectors facing both sides *****

$\therefore$ # of reflectors = 21 x 2 = 42 reflectors

Stations

- The difference between the minimum guardrail length and the actual guardrail length = 987.5 – 982.03 ≈ 5.47’
- The additional 5.47’ of guardrail will be placed on the north (approach) end.

North (Approach) End

Station where approach terminal meets Type MGS-8 guardrail on the north (approach) end is:

$$\text{Station } B_n = (178{+}84) + 205 + 5.47 - 34.3 = \underline{180{+}60.2}$$

Station A_n → N/A in this case

South (Departing) End

Station where approach terminal meets Type MGS-8 guardrail on the south (departing) end is:

Station B_s = (171+29) - 90.63 + 34.3 ≈ 170+72.7

Station A_s → N/A in this case

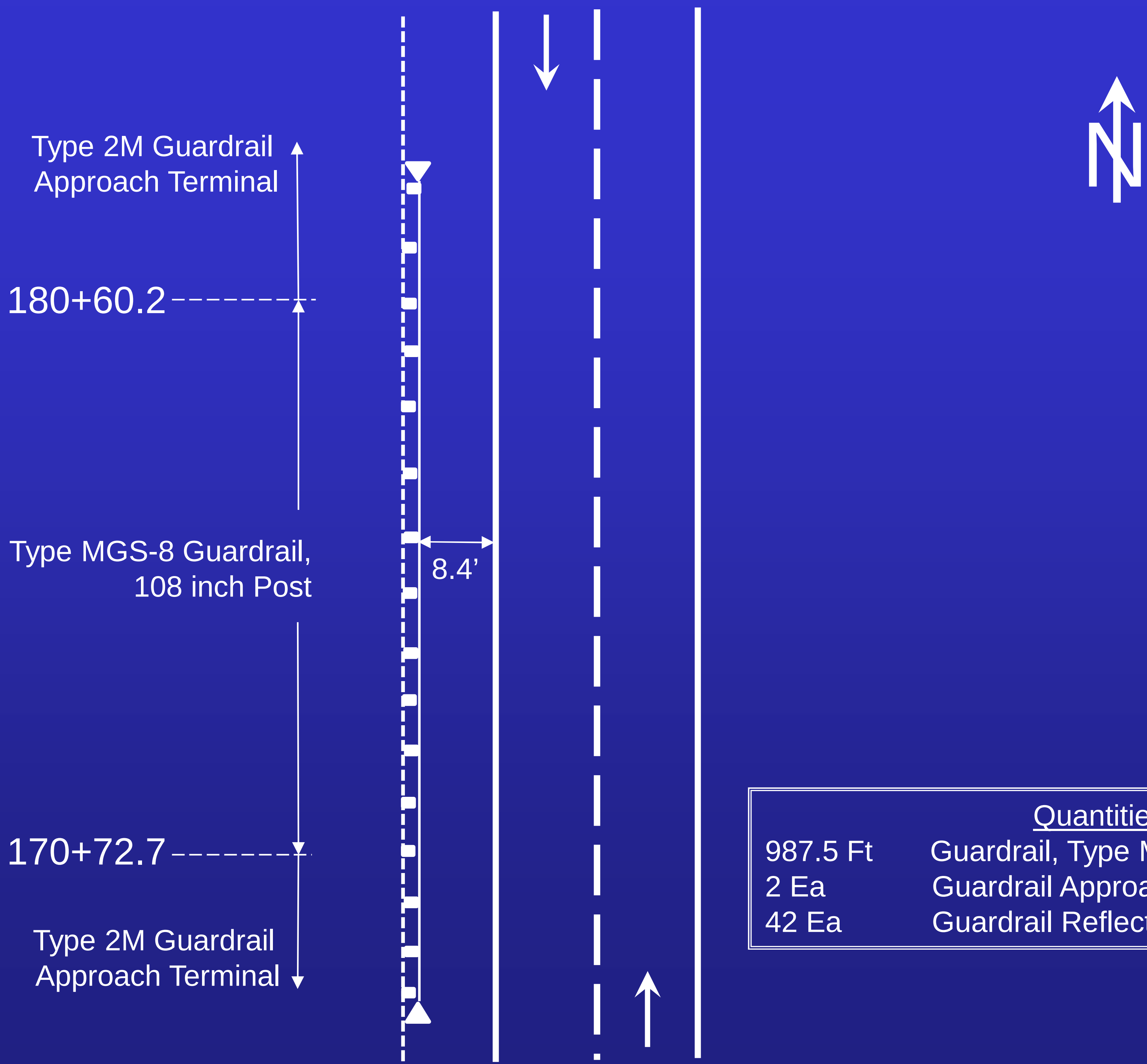
<u>Check:</u> Type MGS-8 Guardrail Length = Sta. B_n – Sta. B_s

987.5 feet = (180+60.2) – (170+72.7)

987.5 feet = 987.5 feet ✓

Calculating Z

$Z = \underline{8.4'}$ (measured from EOP)



Quantities

987.5 Ft	Guardrail, Type MGS-8, 108 inch Post
2 Ea	Guardrail Approach Terminal, Type 2M
42 Ea	Guardrail Reflector

Questions?

<u>Contact Information</u>

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