

Class Exercise #5

Calculations and Notes

- 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

Approach End (South End)

- There are two hazards that warrant shielding:
 - o Steel Pole
 - o Steep embankment
- Must design guardrail to shield both hazards (i.e., design for the worst case scenario).

SOLUTION TO CLASS EXERCISE #5 - SE (Embank.)

GUARDRAIL WORKSHEET		(REV. 7-2017)
FOR APPROACH TERMINALS ON R-61-SERIES AND R-62-SERIES		
ROUTE <u>Rural Road (Exercise #5)</u>	CONTROL SECTION <u>99999</u>	JOB # <u>EXAMPLE</u>
DESIGNED BY <u>ABC</u>	DATE <u>00/01/18</u>	CHECKED BY <u>XYZ</u> DATE <u>00/01/18</u>
APPROX. STATION OR M.P. <u>171+29</u>	DESCRIPTION <u>Class Exercise #5</u>	
		GUARDRAIL RUN # <u>SE (Embank.)</u>
IF STATIONING IS NOT AVAILABLE, LOCATE TO NEAREST FIXED OBJECT		

NOTE: TYPE 1 TERMINAL ILLUSTRATED

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

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

$$X = \frac{L_H - (L_2 + d)}{\left(\frac{\text{No Flare or Type 2 Terminals}}{L_R}\right) \frac{L_H}{L_R}}$$

$$Z = (X - L_1 - 25) \left(\frac{b}{a}\right) + L_2$$

$$Z = L_2 \text{ (For Type 2 Terminals)}$$

LENGTH OF NEED $X = 184.38'$	DESIGN ADT <u>8,700 vpd</u>
RUNOUT LENGTH (7.01.19) $L_R = 250'$	DESIGN SPEED <u>60 mph</u>
GUARDRAIL TAPER RATE (R-59-SERIES) $\frac{b}{a} = 0$	APPROACH SLOPE <u>1:6</u>
E.O.P. TO FACE OF BARRIER (DESIGNED) $L_2 = 8.4'$	
CLEAR ZONE (7.01.11) $L_C = 32'$	$L_1 = \text{N/A}$ 5' MIN.)
E.O.P. TO ROADSIDE FEATURE (MEASURED) $L_3 = \text{N/A}$	$L_3 = 8'$ SHY LINE (7.01.18)
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... $d = 0$	STATION AT A <u>N/A</u>
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED) ... $L_H = 32'$	STATION AT B <u>***</u>
LATERAL OFFSET AT END OF FLARE $Z = 8.4'$	

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

SHEET 1 OF 2

PROPOSED TREATMENT

CALCULATIONS OR NOTES

***** Calculations and notes shown on the following sheets *****

PAY ITEMS

*** Ft * Guardrail, Type **MGS-8**

____ Ea Guardrail Anchorage, Bridge, Det ____

____ Ft Bridge Railing, Thrie Beam Retrofit

*** Ea Guardrail Approach Terminal, Type **2M**

____ 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 1	TYPE 2
GUARDRAIL TYPE B	25'	37.5'
GUARDRAIL TYPE T	31.25'	43.75'
GUARDRAIL TYPE MGS-8**	N/A	34.3'

PAY LENGTHS MUST BE DIVISIBLE BY 12.5'.
ROUND TO NEXT HIGHEST RAIL LENGTH, EXCEPT
WHEN ATTACHING GUARDRAIL APPROACH TERMINAL
TYPES 1B AND 2B, RESPECTIVELY, TO GUARDRAIL,
TYPE MGS-8.

**** NOTE:**
DEDUCTION VALUE PROVIDED FOR GUARDRAIL,
TYPE MGS-8 IS ONLY APPLICABLE WHEN USING A
MASH-COMPLIANT GUARDRAIL APPROACH TERMINAL
(I.E., GUARDRAIL APPROACH TERMINAL, TYPE 2M).
USE DEDUCTIONS VALUES FOR GUARDRAIL APPROACH
TERMINAL TYPES 1B AND 2B, RESPECTIVELY, WHEN
ATTACHING NCHRP 350-COMPLIANT GUARDRAIL
APPROACH TERMINALS (I.E., GUARDRAIL APPROACH
TERMINAL TYPES 1B AND 2B, RESPECTIVELY) TO
TYPE MGS-8 GUARDRAIL.

Length of Need (X) – South End: Embankment

$$X = \frac{32 - 8.4}{\left(\frac{32}{250}\right)} = 184.38' \text{ (measured from 1:3 point; Sta. 171+29)}$$

$$\begin{aligned} \text{BLON}_{\text{min., embankment}} &= (171+29) - 184.38 \\ &= \text{Sta. 169} + 44.62 \end{aligned}$$

SOLUTION TO CLASS EXERCISE #5 - SE (Pole)

GUARDRAIL WORKSHEET		(REV. 7-2017)
FOR APPROACH TERMINALS ON R-61-SERIES AND R-62-SERIES		
ROUTE <u>Rural Road (Exercise #5)</u>	CONTROL SECTION <u>99999</u>	JOB # <u>EXAMPLE</u>
DESIGNED BY <u>ABC</u>	DATE <u>00/01/18</u>	CHECKED BY <u>XYZ</u> DATE <u>00/01/18</u>
APPROX. STATION OR M.P. <u>171+29</u>	DESCRIPTION <u>Class Exercise #5</u>	
		GUARDRAIL RUN # <u>SE (Pole)</u>
IF STATIONING IS NOT AVAILABLE, LOCATE TO NEAREST FIXED OBJECT		

NOTE: TYPE 1 TERMINAL ILLUSTRATED

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

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

$$X = \frac{L_H - (L_2 + d)}{\left(\frac{\text{No Flare or Type 2 Terminals}}{L_R}\right) \frac{L_H}{L_R}}$$

$$Z = (X - L_1 - 25) \left(\frac{b}{a}\right) + L_2$$

$$Z = L_2 \text{ (For Type 2 Terminals)}$$

LENGTH OF NEED X = <u>130'</u>	DESIGN ADT <u>8,700 vpd</u>
RUNOUT LENGTH (7.01.19) LR = <u>250'</u>	DESIGN SPEED <u>60 mph</u>
GUARDRAIL TAPER RATE (R-59-SERIES) $\frac{b}{a}$ = <u>0</u>	APPROACH SLOPE <u>1:6</u>
E.O.P. TO FACE OF BARRIER (DESIGNED) L2 = <u>8.4'</u>	
CLEAR ZONE (7.01.11) LC = <u>32'</u>	L1 = <u>N/A</u> 5' MIN.)
E.O.P. TO ROADSIDE FEATURE (MEASURED) L3 = <u>N/A</u>	LS = <u>8'</u> SHY LINE (7.01.18)
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d = <u>0</u>	STATION AT A <u>N/A</u>
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED) . LH = <u>17.5'</u>	STATION AT B <u>***</u>
LATERAL OFFSET AT END OF FLARE Z = <u>8.4'</u>	

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

PROPOSED TREATMENT

CALCULATIONS OR NOTES

***** Calculations and notes shown on the following sheets *****

PAY ITEMS

*** Ft * Guardrail, Type **MGS-8**

____ Ea Guardrail Anchorage, Bridge, Det ____

____ Ft Bridge Railing, Thrie Beam Retrofit

*** Ea Guardrail Approach Terminal, Type **2M**

____ 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 1	TYPE 2
GUARDRAIL TYPE B	25'	37.5'
GUARDRAIL TYPE T	31.25'	43.75'
GUARDRAIL TYPE MGS-8**	N/A	34.3'

PAY LENGTHS MUST BE DIVISIBLE BY 12.5'.
ROUND TO NEXT HIGHEST RAIL LENGTH, EXCEPT
WHEN ATTACHING GUARDRAIL APPROACH TERMINAL
TYPES 1B AND 2B, RESPECTIVELY, TO GUARDRAIL,
TYPE MGS-8.

**** NOTE:**
DEDUCTION VALUE PROVIDED FOR GUARDRAIL,
TYPE MGS-8 IS ONLY APPLICABLE WHEN USING A
MASH-COMPLIANT GUARDRAIL APPROACH TERMINAL
(I.E., GUARDRAIL APPROACH TERMINAL, TYPE 2M).
USE DEDUCTIONS VALUES FOR GUARDRAIL APPROACH
TERMINAL TYPES 1B AND 2B, RESPECTIVELY, WHEN
ATTACHING NCHRP 350-COMPLIANT GUARDRAIL
APPROACH TERMINALS (I.E., GUARDRAIL APPROACH
TERMINAL TYPES 1B AND 2B, RESPECTIVELY) TO
TYPE MGS-8 GUARDRAIL.

Length of Need (X) – South End: Pole

$$X = \frac{17.5 - 8.4}{\left(\frac{17.5}{250}\right)} = 130' \text{ (measured from Sta. 170+91)}$$

$$\begin{aligned} \text{BLON}_{\text{min., pole}} &= (170+91) - 130 \\ &= \text{Sta. 169} + 61 \end{aligned}$$

$\text{BLON}_{\text{embankment}}$ is further south than $\text{BLON}_{\text{pole}}$, so guardrail run will be based on $\text{BLON}_{\text{embankment}}$.

Departing End (North End)

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

SOLUTION TO CLASS EXERCISE #5 - NORTH END

GUARDRAIL WORKSHEET		(REV. 7-2017)
FOR APPROACH TERMINALS ON R-61-SERIES AND R-62-SERIES		
ROUTE <u>Rural Road (Exercise #5)</u>	CONTROL SECTION <u>99999</u>	JOB # <u>EXAMPLE</u>
DESIGNED BY <u>ABC</u>	DATE <u>00/01/18</u>	CHECKED BY <u>XYZ</u> DATE <u>00/01/18</u>
APPROX. STATION OR M.P. <u>171+29</u>	DESCRIPTION <u>Class Exercise #5 - North</u>	
	GUARDRAIL RUN # <u>North End</u>	
IF STATIONING IS NOT AVAILABLE, LOCATE TO NEAREST FIXED OBJECT		

NOTE: TYPE 1 TERMINAL ILLUSTRATED

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

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

$$X = \frac{L_H - (L_2 + d)}{\left(\frac{\text{No Flare or Type 2 Terminals}}{L_R}\right) \frac{L_H}{L_R}}$$

$$Z = (X - L_i - 25) \left(\frac{b}{a}\right) + L_2$$

$$Z = L_2 \text{ (For Type 2 Terminals)}$$

LENGTH OF NEED X = <u>90.63'</u>	DESIGN ADT <u>8,700 vpd</u>
RUNOUT LENGTH (7.01.19) LR = <u>250'</u>	DESIGN SPEED <u>60 mph</u>
GUARDRAIL TAPER RATE (R-59-SERIES) $\frac{b}{a}$ = <u>0</u>	APPROACH SLOPE <u>1:6</u>
E.O.P. TO FACE OF BARRIER (DESIGNED) L2 = <u>20.4'</u>	
CLEAR ZONE (7.01.11) LC = <u>32'</u>	$L_i = \frac{\text{N/A}}{5' \text{ MIN. }}$
E.O.P. TO ROADSIDE FEATURE (MEASURED) L3 = <u>16'</u>	$L_s = \frac{8'}{\text{SHY LINE (7.01.18)}}$
EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE ... d = <u>0</u>	STATION AT A <u>N/A</u>
LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED) . LH = <u>32'</u>	STATION AT B <u>***</u>
LATERAL OFFSET AT END OF FLARE Z = <u>8.4'</u>	

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

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TERMINAL TYPES 1B AND 2B, RESPECTIVELY) TO
TYPE MGS-8 GUARDRAIL.

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

$$X = \frac{32 - 20.4}{\left(\frac{32}{250}\right)} = 90.63' \text{ (measured from 1:3 point; Sta. 178+84)}$$

Total Guardrail Length

$$\begin{aligned} \text{Min. Length} &= (178+84) - (171+29) + 184.38 + 90.63 - 2(34.3) \\ &= 961.41' \end{aligned}$$

$$\# \text{ of panels} = \frac{961.41}{12.5} = 76.91 \rightarrow \text{round up to 77 panels}$$

$$\therefore \text{Type MGS-8 Guardrail Length} = (12.5)(77) = \underline{962.5 \text{ feet}}$$

Reflectors

$$\# \text{ of reflectors} = \left(\frac{962.5}{50}\right) + 1 = 20.25 \rightarrow \text{round up to 21}$$

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

$$\therefore \# \text{ of reflectors} = 21 \times 2 = \underline{42 \text{ reflectors}}$$

Stations

- The difference between the minimum guardrail length and the actual guardrail length = $962.5 - 961.41 \approx 1.09'$
- The additional 1.09' of guardrail will be placed on the south (approach) end.

South (Approach) End

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

$$\text{Station } B_s = (171+29) - 184.38 - 1.09 + 34.3 = \underline{169+77.8}$$

Station $A_s \rightarrow$ N/A in this case

North (Departing) End

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

$$\text{Station } B_n = (178+84) + 90.63 - 34.3 \approx \underline{179+40.3}$$

Station $A_n \rightarrow$ N/A in this case

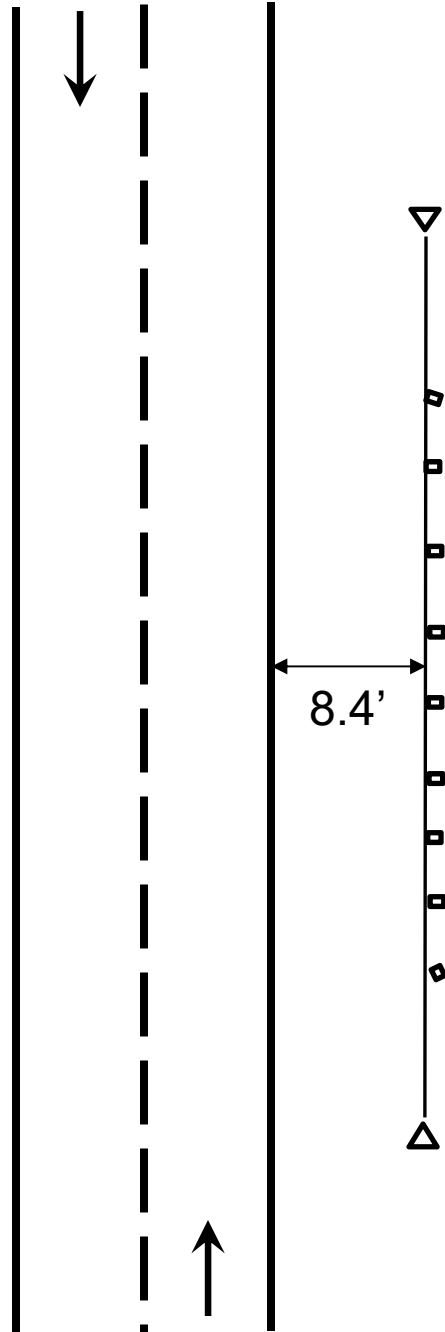
Check: Type MGS-8 Guardrail Length = Sta. B_n – Sta. B_s

$$962.5 \text{ feet} = (179+40.3) - (169+77.8)$$

$$962.5 \text{ feet} = 962.5 \text{ feet } \checkmark$$

Calculating Z

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



Type 2M Guardrail
Approach Terminal

179+40.3

Type MGS-8
Guardrail

169+77.8

Type 2M Guardrail
Approach Terminal

Quantities

962.5 Ft	Guardrail, Type MGS-8
2 Ea	Guardrail Approach Terminal, Type 2M
42 Ea	Guardrail Reflector