Session 5: Guardrail Design and Site-specific Installation Considerations
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Guardrail Design and Site-specific Installation Considerations

Course Topics

- Session 4 – Testing Requirements and Performance Characteristics of Common Terminals and Crash Cushions
- Session 5 – Guardrail Design and Site-specific Installation Considerations

Session 5 Learning Outcomes

At the end of this session, you will be able to:

- Define barrier Length of Need (LON) and explain its basis
- Evaluate field installations
- Apply a field procedure to check Length of Need
- Describe the basic principles of an optimal barrier installation under different scenarios.
Length of Need (LON) Definition

The length of barrier needed in advance of the primary hazard to intercept and redirect the path of an encroaching vehicle.

Length of Need (LON) Theory

$\theta = \text{Angle of Departure (variable)}$

$L_R = \text{Runout Length}$

$\text{HAZARD}$

$\text{Edge of Traveled Way}$
### Runout Lengths - AASHTO

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

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Runout Length ($L_R$) Given Traffic Volume (ADT) (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Over 10,000</td>
</tr>
<tr>
<td>80</td>
<td>470</td>
</tr>
<tr>
<td>70</td>
<td>360</td>
</tr>
<tr>
<td>60</td>
<td>300</td>
</tr>
<tr>
<td>50</td>
<td>230</td>
</tr>
<tr>
<td>40</td>
<td>160</td>
</tr>
<tr>
<td>30</td>
<td>110</td>
</tr>
</tbody>
</table>

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

### Length of Need - AASHTO

- Calculating the length of need ($X$) for straight or nearly straight sections of roadway:
  - For **flared** guardrail installations:
    \[
    X = \frac{L_A + (b/a) (L_1) - L_2}{(b/a) + (L_A/L_R)}
    \]
  - For **parallel** guardrail installations:
    \[
    X = \frac{L_A - L_2}{L_A/L_R}
    \]

LON Design for Approach Barrier Layout

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

Length of Need on a Horizontal Curve

Ref: AASHTO Roadside Design Guide, 4th Edition, Figure 5.48, Pg. 5-59
Session 5: Guardrail Design and Site-specific Installation Considerations
Step 1: Identify the Area to be Shielded

Step 2: Define the Point of Departure
Step 3: Intersect the Hypotenuse

\[ X = \text{Length of Need (LON) of Barrier} \]

\[ L_A \]

\[ L_R \]

Quick Field Check of LON

1. Stand on roadway edgeline opposite the upstream edge of the hazard.
2. Pace upstream along edgeline appropriate runout length (based on speed of roadway and traffic volume).
3. Turn and look at far lateral edge of hazard.
4. If planned (or existing) guardrail run intercepts this line of sight, it satisfies basic design length of need.
5. Check for “secondary” hazards that could be economically shielded by extending barrier.
6. Check for better terminal location by extending barrier a short distance.
Guardrail Placement ($L_2$)

Place as far from outside edge of traffic lane as practical (without affecting performance)
Principle 1: Deflection Distance

Adequate room must be left behind the barrier to allow for lateral deflection in an impact.

- If the barrier is shielding a fixed object, the distance between the barrier and the object should be sufficient to avoid the vehicle impacting or snagging on the object.
- Note that large trucks may roll or tip and need more room for lateral deflection.

**Deflection Distance**

Barrier to Hazard Distance Is Critical Element
Deflection Distance

3 foot min. back of post to face of object for 6'-3" post spacing

Less than 3 foot but greater than 1 foot use Stiffened Section

Less than 1 foot use Concrete

Ref: Caltrans Traffic Manual, Section 7-03.5
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Deflection Distance

Principle 2: Soil Backing For Fill Locations
Soil Backing Recommendation

1. Slope can be as steep as 2H:1V with 2-ft. backing in strong soil with 6 ft. posts.

2. Backing can be less than 2 ft. with 2H:1V slope in strong soil with 7 ft. posts.

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – FIGURE 5.33, Pg. 5-41

Principle 3: Flare Rate
Flare Rate

*Flared barriers* are those that are not parallel to the edge of the traveled way. They are used to:

- Locate terminals farther from the roadway.
- Lessen driver reaction to a roadside obstacle.
- Transition from barrier to an obstacle nearer the roadway (bridge parapet or railing).
- Reduce total length of rail needed.
- Reduce nuisance hits.

Disadvantages of flared barriers:

- Flare *increases the maximum angle* at which the barrier can be hit.
- Flare *increases the probability* that a vehicle will be redirected into or across the roadway after an impact.
- Flared barriers *require more grading* to provide a flat area between the traveled way and the barrier.
Flare Rate Table

Table 5.7 Suggested flare rates for Barrier Design (U.S. Customary Units)

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Flare Rate for Barrier inside Shy Line</th>
<th>Flare Rate for Barrier beyond Shy Line</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rigid Barrier</td>
<td>Semi-Rigid Barrier</td>
</tr>
<tr>
<td>70</td>
<td>30:1</td>
<td>20:1</td>
</tr>
<tr>
<td>60</td>
<td>26:1</td>
<td>18:1</td>
</tr>
<tr>
<td>55</td>
<td>24:1</td>
<td>16:1</td>
</tr>
<tr>
<td>50</td>
<td>21:1</td>
<td>14:1</td>
</tr>
<tr>
<td>45</td>
<td>18:1</td>
<td>12:1</td>
</tr>
<tr>
<td>40</td>
<td>16:1</td>
<td>10:1</td>
</tr>
<tr>
<td>30</td>
<td>13:1</td>
<td>8:1</td>
</tr>
</tbody>
</table>

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – TABLE 5.9, Pg. 5-48

Flared W-Beam Guardrail Example
Principle 4: Slope in Front of Guardrail
Any barrier may be placed anywhere on a 10H:1V or flatter slope.

Cable Guardrail may be placed on slopes of 6H:1V or 4H:1V, but its location on these slopes is critical for minimizing penetrations.

On slopes steeper than 10H:1V but no steeper than 6H:1V, metal beam guardrail should be placed in compliance with Figure 5-38 (AASHTO RDG).
Recommended beam Guardrail placement on slopes

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – FIGURE 5.38, Pg. 5-47

Guardrail Height Measurement

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – FIGURE 5.39, Pg. 5-47
Guardrail Height Measurement

Ref: CALTRANS Standards

D = Distance, GB to face of rail
H = HEIGHT AT FACE OF RAIL FROM EXTENDED LINE, BASED ON D

- D = 0'-2'
  - H = 31" ±1" FOR MGS
  - H = 29" ±1" FOR MBGR

- D = 2'-4'

- D = 4'-8' See Note 4

- D = 8' or more

Slope within 8' of guardrail

Grade Break (GB)

Measure height from top of rail

Video Clip
Slope in Front of Guardrail

- MGS on 8H:1V slope

5-ft from Shoulder on 8H:1V Slope

Location of Cable in Swales

Video Clip
Terminal Grading

- Special grading requirements for Guardrail terminals:
  - Avoid installing terminals on or too near steep slopes.
  - Relatively flat terrain is required in front of terminals so that vehicles do not vault into the air or dive into the ground.
  - Modest slopes are used behind terminals to allow sufficient recovery areas for vehicles gating through the end treatment.
  - FHWA has guideline requirements for both tangent and flared terminals.
Terminal Grading

Ref: CALTRANS 2015 Standard Drawing A77Q1
Principle 5: Guardrail and Curbs

Curbs – may function to channelize traffic, to control drainage, improve delineation, control access, and reduce erosion.

Curbs are not adequate to prevent a vehicle from leaving the roadway; they are not a barrier.

Use of any guardrail/curb combination where high-speed, high-angle impacts are likely should be discouraged.
MGS with Curbs

- Can be up to 7” behind the face of vertical curbs:
  - For a 6” high vertical curb use a 12” blockout or
  - For a 4” high vertical curb with 8” blockouts
- Flush with a vertical or sloped curb no higher than 6”.
- 6 ft. beyond the curb
  (TL-2 only)

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Guardrail/Curb Recommendations

Best: Remove curb
May also: Limit curb height to 4” or stiffen guardrail by:
  - Adding rail to back of post
  - Adding a rubrail
  - Reducing the post spacing
  - Nesting rail elements
Curbs should not be used along High-Speed Roadways

Guardrail Placement at Intersections
A non-breakaway anchor should be used to add intermediate anchorage when there is an abrupt change in the alignment of the guardrail, such as when the guardrail is continued down an intersecting road or if there is an area of concern on the side slope that would cause a more severe collision than impacting the guardrail. If there is no area of concern on the side slope, then a breakaway anchor with drilled posts set in foundation should be used for intermediate anchorage.

Ref: CALTRANS Traffic Manual pg. 7-23

Ref: CALTRANS Construction Detail – Intermediate Assembly
Transportation Pooled Fund Program

Accepted at NCHRP Report 350 at TL-2
TxDOT MASH TL-3 Design

Short Radius at Intersecting roadways

Video Clip
If solid rock is encountered within 0” to 18” of the finished grade.

Drill a 21” dia. hole for steel post or 23” dia. hole for wood post, 24” into the rock.
Guardrail Placement in Paved Areas

• Any excess post length, after meeting these depths, may be field cut to ensure proper guardrail mounting height.

• Backfill with a cohesionless material.

Review Learning Outcomes

- Define barrier Length of Need (LON) and explain its basis
- Evaluate field installations
- Apply a field procedure to check Length of Need
- Describe the basic principles of an optimal barrier installation under different scenarios.