CHAPTER 4
BARRIER DESIGN AND PLACEMENT

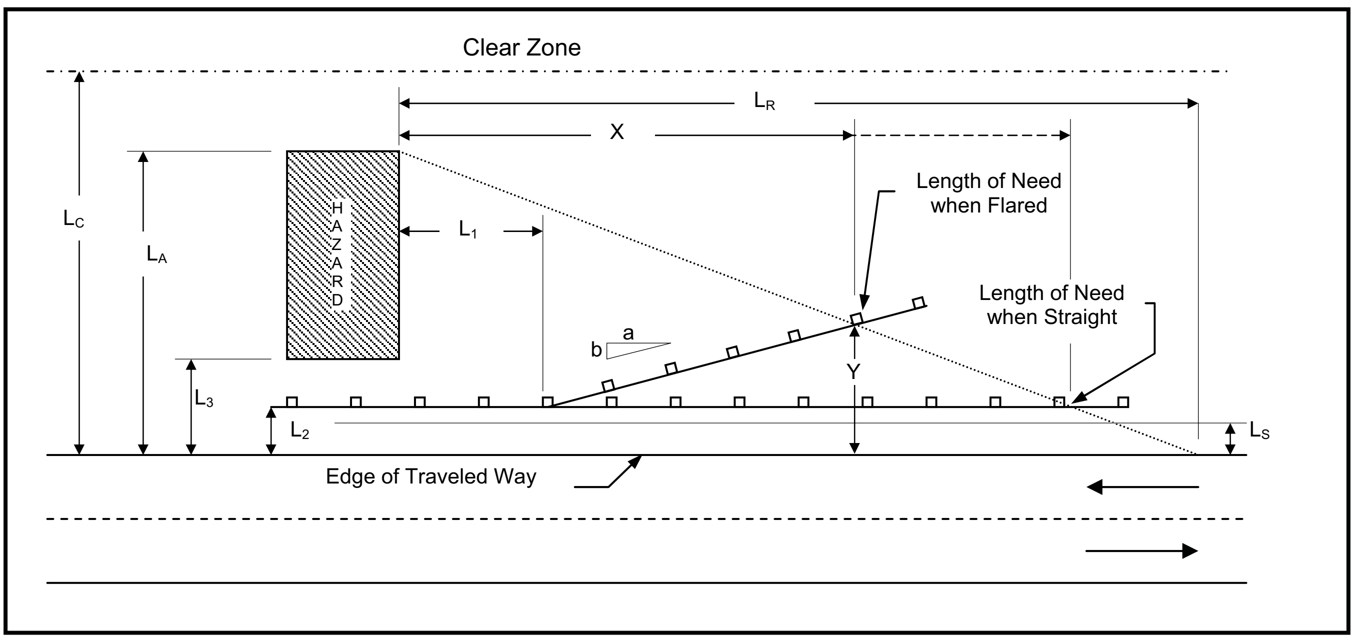
4.1 OVERVIEW OF THE AASHTO ROADSIDE DESIGN GUIDE DESIGN PROCESS

Chapter 5 of the AASHTO *Roadside Design Guide* (*RDG*) contains roadside barrier layout and design guidance. It is important to understand the philosophy behind the design process presented in the *RDG*. If a vehicle leaves the roadway at approximately 10 degrees in the vicinity of the upstream end of a roadside barrier and the driver then attempts to correct and return to the pavement, the vehicle could be traveling parallel and behind the barrier. This design process is intended to allow sufficient room for a vehicle to come to a stop before striking the hazard if it should get into this situation. An important part of the layout process is to allow a clear zone behind the barrier upstream of the hazard. This is also an important concept to remember in the construction and maintenance of the roadway.

4.1.1 Design Variables

Figure 4.1 shows the variables that are considered in the *RDG* design process.

Figure 4.1: Barrier Design Variables



The variables used in the design process are defined below:

- L_A is the lateral distance from the edge of the traveled way to the back of the hazard.

- L_C is the clear zone width, measured from the edge of the traveled way. L_C serves as a check on L_A. It is not necessary to shield a hazard beyond the clear zone, so L_A does not have to be greater than L_C.

- L_3 is the lateral distance from the edge of the traveled way to the front edge of the hazard.

- L_2 is the offset of the roadside barrier, measured from the edge of the traveled way to the front face of the barrier. The designer must select the barrier offset. Factors to consider in selecting L_2 are listed in Section 4.1.2.

- L_R is the runout length, measured longitudinally from the upstream extent of the hazard along the edge of pavement. L_R is the stopping distance off the pavement. L_R values are found in Table 4.1.

- L_S is the shy line offset. Rigid objects such as roadside barriers close to the pavement tend to intimidate drivers, causing them to slow down or shift positions. This may result in a loss in capacity that can be a concern for high volume roads. Although it is preferable to locate barriers at or beyond the shy line offset, it is seldom an important factor for low volume conditions. Shy line values are found in Table 4.2.

- If the barrier is placed on a flare, the flare is described as a: b in the *RDG*. Placing a barrier on a flare is a design decision. Benefits are that less barrier is needed (improving both safety and costing less) and the end treatment is moved further away from traffic. The ability to include a flare is usually limited by the site terrain. Slopes in front of a barrier should be 1V: 10H or flatter, which is often difficult to achieve. The flare a: b is in the standard section of the barrier and is not related to any flare that may be required for an end treatment. End treatments must be laid out from the projection of the barrier at the point of beginning of the end treatment. If a barrier is laid out on the maximum flare, it may be necessary to exceed the maximum flare because an additional flare for the end treatment is introduced. It is acceptable to exceed the maximum flare rate for this purpose. When possible, very flat flare rates should be used when the barrier is located within the shy line offset. Chapter 5 of the *RDG* has more detail on suggested flare rates in this case.

- If a flare in the standard section is used, L_1 is the tangent length of the barrier and defines the beginning point of the flare, measured from the upstream limit of the hazard. L_1 is a design tool that allows the flare point to be reactive to specific site requirements. The only requirement for L_1 is that a flare should not begin within a transition section.

4.1.2 Considerations for Selecting L_2

The designer determines the barrier offset, L_2, taking into consideration a number of issues. Table 4.1 lists these considerations, in order of importance.

Figure 4.2: Considerations for Selecting L_2 In Order of Importance

a. Available hazard offset
b. Slopes in front of the barrier
c. Presence of curbs
d. Soil Support Behind the Barrier
e. Available Shoulder
f. Shy Line Offset
g. Location

Each of these considerations is discussed below:

- **Available Hazard Offset.** Tables 3.2, 3.3 and 3.4 match appropriate barrier types with the available hazard offset. The hazard offset includes both the deflection distance and the depth of the barrier system. This criterion is not as important for hazards that go down, such as steep downward slopes, as for hazards that protrude upwards.

- **Slopes in Front of the Barrier.** Maintain a slope of 1V: 10H or flatter in front of the barrier. This should include any flare in the barrier and the approach to the end treatment. Conventional cable and some of the high-tension cable systems have been successfully tested on 1V: 6H slopes. Although the flatter slopes are preferable, it may be a reasonable trade-off to accept slopes as steep as 1V: 6H in front of barriers if the speeds are 40 km/h (25 mph) or lower.

- **Presence of Curbs.** Avoid placing barriers if curbs are present. Specific criteria include:

    1. It is preferable to not use barriers with curbs at speeds 80 km/h (50 mph) and higher. If necessary, the best location for the barrier is in front of the curb. If the curb is sloped and no higher than 100 mm (4 in) the barrier may be placed flush with the face of the curb. Do not place a wall-type

(CSS, PCG, or SMG) barrier on top of a curb. Remove the curb if necessary. A shoulder gutter design may be good option to a curb.

2. Avoid placing barriers with curb present at speeds 50 km/h (30 mph) to 70 km/h (45 mph). If necessary, the best location for the barrier is in front of the curb. If the curb is sloped and no higher than 150 mm (6 in) the barrier may be placed flush with the face of the curb. Do not place a wall-type (CSS, PCG, or SMG) barrier on top of a curb. Remove the curb if possible. A shoulder gutter design may be good option to a curb.
3. It is acceptable to place curbs in line with the face of a barrier at speeds 40 km/h (25 mph) and lower.

- **Soil Support Behind the Barrier Post.** For strong post systems, ensure that at least 0.6 m (2 ft) are present from behind the posts to a slope hinge. At speeds 50 km/h (30 mph) and lower this criterion can be reduced to 0.3 m (1 ft). This criterion ensures the soil support necessary for the posts to resist deflection. This is not an important issue for either rigid or flexible systems. If this criterion cannot be achieved, 2.1 m (7 ft)-long posts or halved post spacing can be used to mitigate the loss of soil support. If this criterion cannot be achieved, then the strong post system will deflect more than indicated in Chapter 3 and Appendix B.

- **Available Shoulder.** If possible, the full shoulder should be provided plus at least 0.6 m (2 ft). This allows the shoulder to function as designed and allows a vehicle to park on the shoulder and occupants to exit out the passenger door.

- **Shy Line Offset.** The shy line offset, as discussed earlier, should be provided if possible. This is not usually an important issue on low volume roads.

- **Location.** Locate the barrier as far from the road as possible, taking into consideration all the above criteria. The further away from the edge of the traveled way, the more recovery area is available for errant vehicles and there is less barrier to build and maintain.

4.1.3 Design Criteria Tables

Tables 4.1, 4.2 and 4.3 list criteria that are used in the AASHTO *RDG* design method.

Table 4.1: Suggested Runout Lengths, L_R

Design Speed		Traffic Volume (ADT)							
		Over 6000 vpd		2000 – 6000 vpd		800 – 2000 vpd		Under 800 vpd	
		Runout Length L_R		Runout Length L_R		Runout Length L_R		Runout Length L_R	
Km/h	mph	m	ft	m	ft	m	ft	m	ft
40	25	40	125	35	115	30	100	27	90
30	20	30	100	27	90	24	80	20	70

* See the AASHTO *Roadside Design Guide* for design speeds 50 km/h (30 mph) and higher.

Table 4.2: Suggested Shy Line Offset Values

Design Speed		Shy Line Offset, L_S	
km/h	mph	m	ft
40	25	0.8	2.5
30	20	0.6	2.0

* See the AASHTO *Roadside Design Guide* for design speeds 50 km/h (30 mph) and higher.

Table 4.3: Suggested Maximum Flare Rates

Design Speed		Rigid Barriers	Semi-Rigid Barriers
km/h	mph		
40	25	7:1	6:1
30	20	7:1	6:1

* See the AASHTO *Roadside Design Guide* for design speeds 50 km/h (30 mph) and higher.

4.1.4 Length of Need Determination

The length of need, or distance upstream from the hazard necessary to adequately shield the hazard, is determined by the following formula:

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

If there is no flare, the formula simplifies to:

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

The lateral offset of the end of the length of need is determined by the following formula:

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

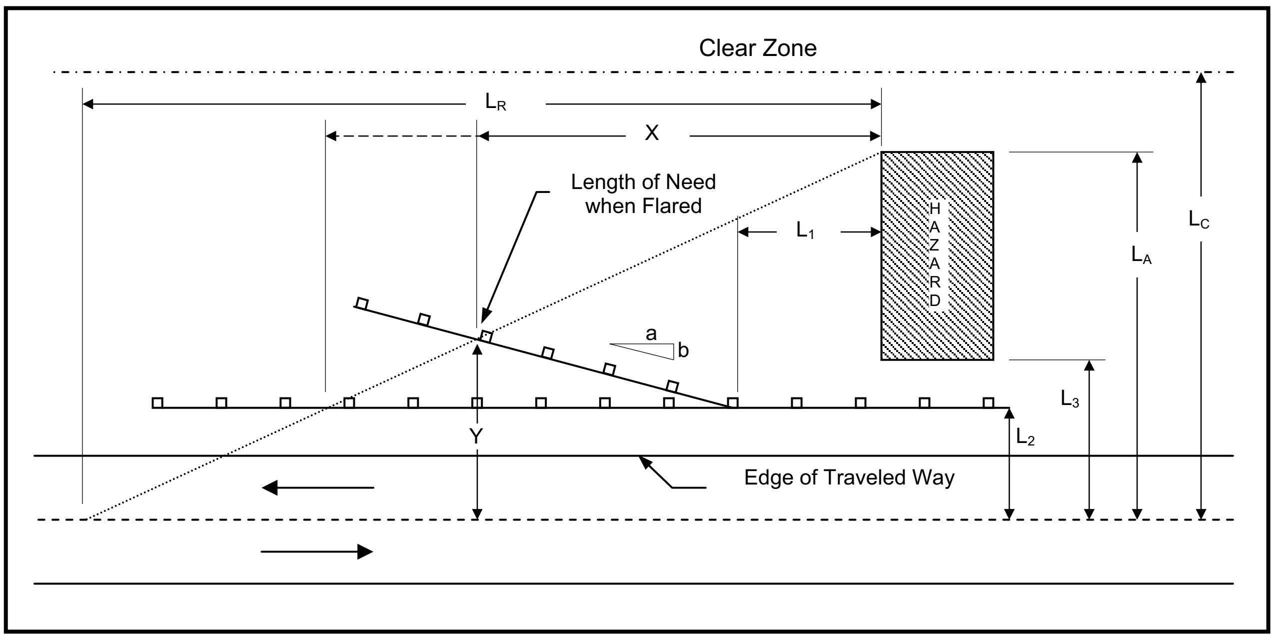
If there is no flare in the barrier, then Y is equal to L_2.

4.1.5 Opposing Traffic Length of Need

If the hazard is within the opposing traffic clear zone on a two-lane/ two-way road, a downstream length of need should be provided. The edge of pavement in this case is the centerline, as shown in Figure 4.3 (Figure 5.27 of the *RDG*). Usually, however, the hazard is outside the opposing traffic clear zone on low volume and low speed roads.

If the hazard is outside the opposing traffic clear zone but the barrier is within the clear zone, then a crashworthy end treatment should be used on the downstream end. If the barrier is also outside the opposing traffic clear zone, an end treatment is not required but should be considered. In general, features installed on the roadside for safety purposes should be safe for all foreseeable conditions. The relatively small investment for a crashworthy end could prove to be very worthwhile.

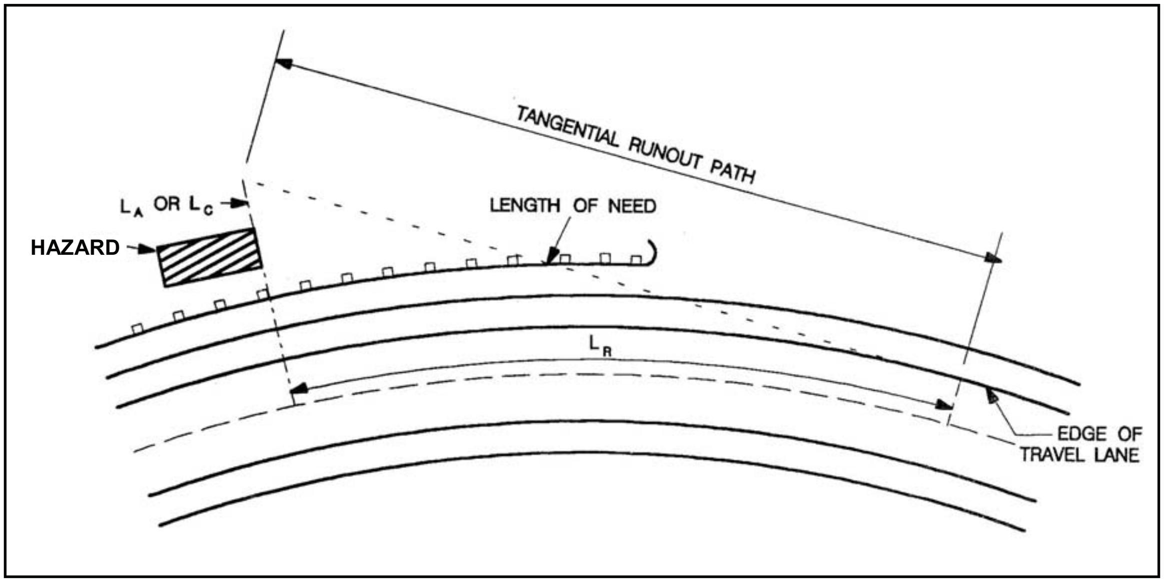
Figure 4.3: Opposing Traffic Length of Need



4.1.6 Length of Need on Horizontal Curves

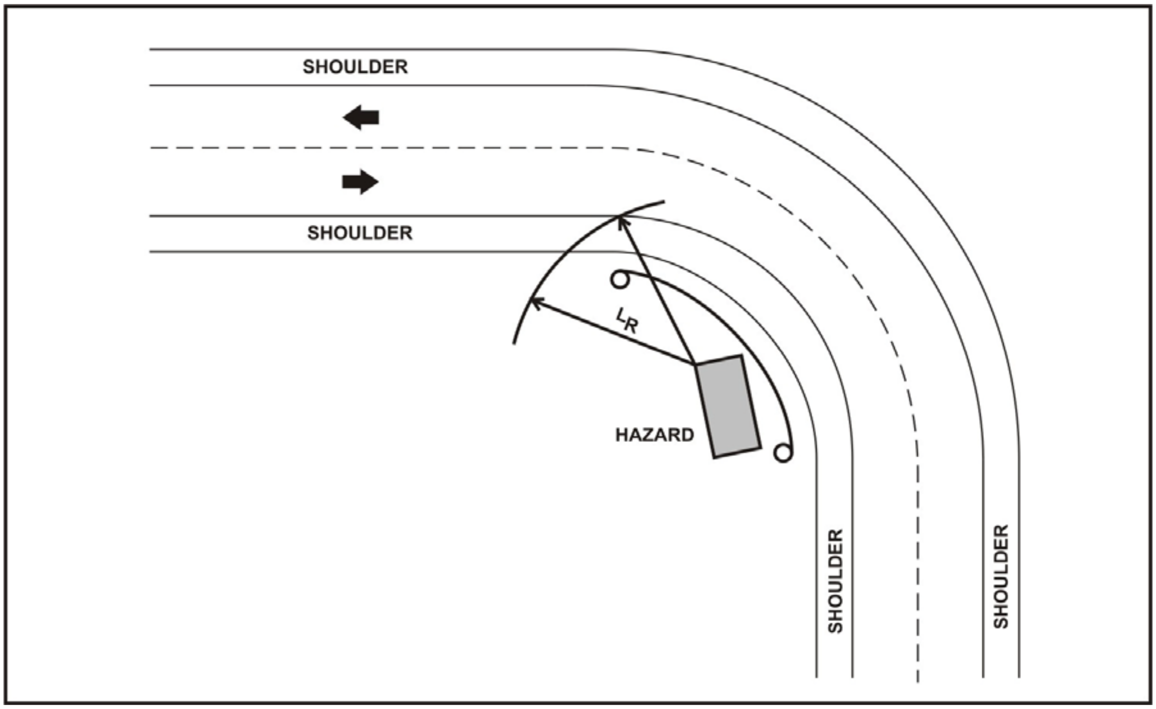
Figure 5.32 of the *RDG*, shown below as Figure 4.4, illustrates a graphic solution for a barrier length of need on the outside of a horizontal curve. The barrier length is a function of the distance it is located from the edge of the traveled way and can most readily be obtained graphically by scaling. Additional information concerning this procedure can be found in the *RDG* discussion accompanying Figure 5.32. Section 4.1.7 of this Guide discusses a graphic solution for length of need of a barrier on a tangent section of road.

Figure 4.4: Length of Need on the Outside of A Horizontal Curve



To determine the length of need on the inside of a horizontal curve, locate the point on the hazard closest to the roadway and draw an arc with a radius of L_R. Then draw a line from the center of the arc (the closest point to the roadway) to where the arc intersects the edge of traveled way. Barrier is then laid out to intersect this line. This process ensures that there will be at least L_R, or stopping distance, to the hazard if a vehicle should leave the roadway and get behind the barrier. This is illustrated in Figure 4.5.

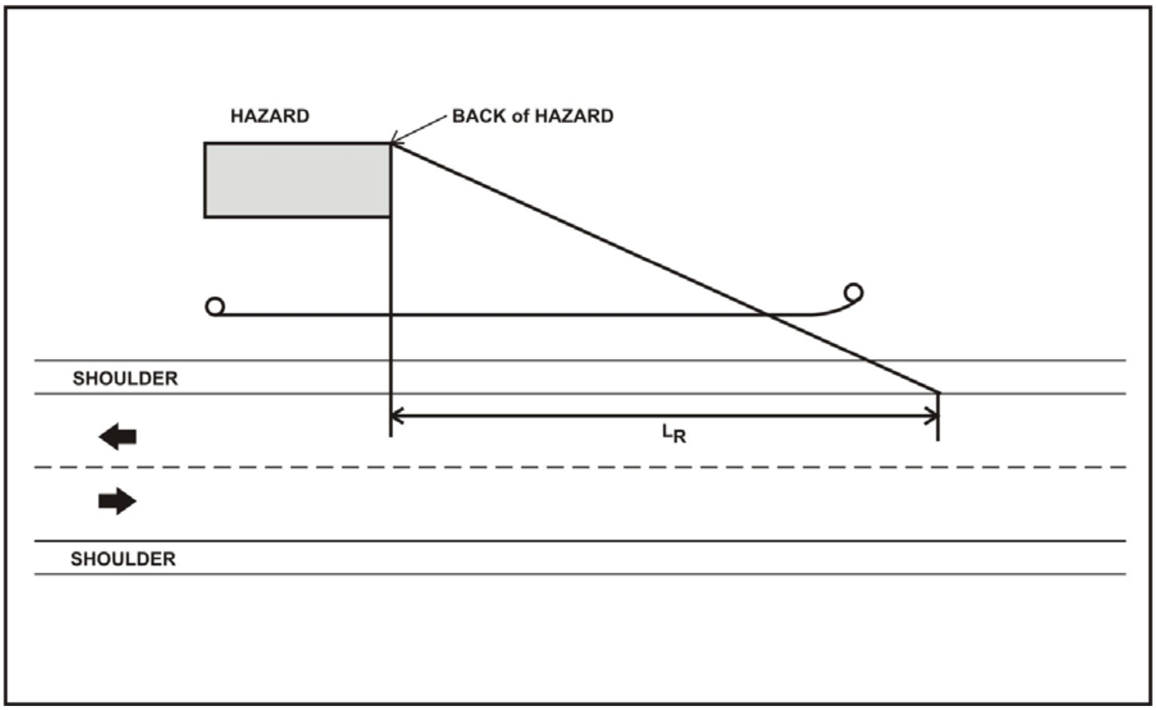
Figure 4.5: Length of Need on the Inside of a Horizontal Curve



4.1.7 Graphic Solution

The length of need on tangent sections can be determined graphically, as with horizontal curves. This involves laying out a sketch to scale of the roadway and hazard, then identifying a point of departure on the edge of the traveled way by measuring a distance L_R upstream of the hazard. A line is then drawn from that point to the back of the hazard or the clear zone, whichever is less distance from the edge of traveled way. Alternative barrier designs can now be laid out using different values for L_1, L_2 and with or without flares. This graphic process, shown in Figure 4.6, yields the same length of need as the formulae.

Figure 4.6: Graphic Solution for LON of a Tangent Section



4.1.8 Layout Requirements

The length of need, either by formula or graphical design, determines the approximate point at which the barrier must be able to resist penetration by a vehicle. Therefore, the gating portion of an end treatment must be outside this point. The length of need is normally measured to the third post of the end treatment. Standard sections of barrier should not be cut to meet this exact point. Designers should round up to the closest full length of barrier. For W-Beam guardrail, this would be 3.8 m (12 ft-6 in) and for SBT and SBL barriers, this is 3.0 m (10 ft).

4.2 ALTERNATE DESIGN PROCESS

The full length of need as provided by the AASHTO *RDG* design process is the preferred method to determine the length of need. However, it is frequently difficult to achieve this length on low volume and low speed roads because of either restrictive site conditions or because it is simply not economical. An alternate approach for low speed and low volume roads is based on intercepting a vehicle that leaves the roadway at approximately 10 degrees. The resulting length of need will not provide the stopping distance necessary for a vehicle that leaves upstream of the barrier end and gets behind the barrier in an attempt to regain control. Therefore, this process accepts some additional risk when compared to the AASHTO *RDG* process. However, the amount of additional risk may be relatively small on low speed and low volume roads, particularly for long barriers that are protecting area hazards.

The designer selects the barrier offset, or L_2, as described in Section 4.1.2. The length of need is calculated by the following formula, which provides shielding of the hazard for angles of departure of approximately 10 degrees:

$X = 6 (L_A – L_2)$

As with the AASHTO *RDG* procedure, the length of need is rounded up to the nearest length of barrier being used. The gating portion of the end treatment extends beyond this point. Table 4.4 should be useful for G4, G2, G9, and G9M barrier systems. Table 4.5 provides the same information for SBL and SBT barrier systems.

Table 4.4: Alternate LON Design for W-Beam and Thrie-Beam Systems

Metric Units

$L_A – L_2$	Guardrail Lengths	LON (m)
1.2 m	2	7.6
1.5 m	3	11.4
1.8 m	3	11.6
2.0 m	4	15.2
2.4 m	4	15.2
2.7 m	5	19.1
3.0 m	5	19.1
3.7 m	6	22.9
4.3 m	7	26.7
4.9 m	8	30.5

U.S. Customary Units

$L_A – L_2$	Standard Barrier Lengths	LON (ft)
4 ft	2	25
5 ft	3	37 ½
6 ft	3	37 ½
7 ft	4	50
8 ft	4	50
9 ft	5	62 ½
10 ft	5	62 ½
12 ft	6	75
14 ft	7	87 ½
16 ft	8	100

Table 4.5: Alternate LON Design of Log and Timber Rail Systems

Metric Units

$L_A - L_2$	Standard Barrier Lengths	LON (m)
1.2 m	3	9.1
1.5 m	3	9.1
1.8 m	4	12.2
2.0 m	5	15.2
2.4 m	5	15.2
2.7 m	6	18.3
3.0 m	6	18.3
3.7 m	8	24.6
4.3 m	9	27.4
4.9 m	10	30.5

U.S. Customary Units

$L_A - L_2$	Standard Barrier Lengths	LON (ft)
4 ft	3	30
5 ft	3	30
6 ft	4	40
7 ft	5	50
8 ft	5	50
9 ft	6	60
10 ft	6	60
12 ft	8	80
14 ft	9	90
16 ft	10	100

4.3 COMMON DESIGN AND LAYOUT CHALLENGES

Site conditions commonly create problems in the design and layout of roadside barriers. Some common situations include the following:

- Multiple Hazards. Although a barrier may be placed to shield a specific hazard, the designer should be aware of other serious hazards present and provide adequate shielding for all. An example may be an approach to a bridge passing over a river. As the bridge approach increases in height, the side slopes become steeper than 3:1. In this case there are three hazards: the bridge rail end, the river and the steep foreslope. The barrier layout should provide appropriate shielding for all three.

- Intersecting Roads. Frequently intersecting roads interrupt a barrier. The Curved Rail Guardrail (CRG) was developed for this application. The CRG connects G4 barrier on the mainline to a barrier or appropriate end treatment on a side road or driveway. Details of the CRG are shown in Standard Drawings 617-21 and 627-22. An important feature of the CRG is the provision of the indicated clear zone behind the barrier. If the G4 barrier transitions to a bridge end on the mainline, the full transition section must be provided. If there is not room for a completed transition and the CRG as shown in the Standard Drawing, then the CRG is not an appropriate design to use and a crashworthy end or crash cushion must be used.

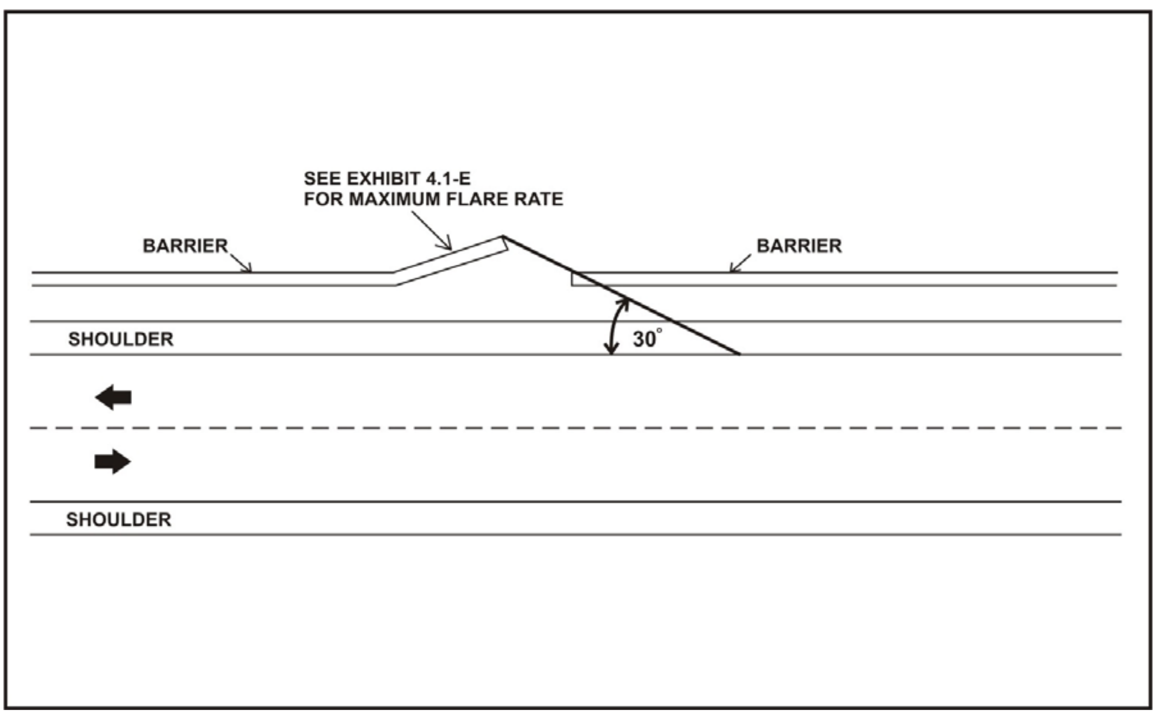
Figure 4.7: Curved Rail Guardrail

- End Treatment. The layout of a barrier must take into account the operating characteristics of the selected end treatment. The slopes in front of, immediately behind and approaching the end treatment must be relatively flat and unobstructed. Care must be taken not to create a hazardous slope in the construction of the platform necessary to provide these flat slopes. Frequently the only solution to this problem is to extend the barrier upstream to a point where the existing foreslopes are flat enough to install the end treatment properly. Because of the cost, long extensions may affect the barrier warrant. See Section 3.4 for a discussion on the grading requirements associated with end treatments.

- Buried in Backslope Terminal. If a buried in backslope terminal is used, a length of need determination is not necessary because the end treatment prevents a vehicle from proceeding beyond the terminal. Therefore, the only design and layout issue with a barrier using this terminal is to extend the barrier to an appropriate burial point.

- Breaks in a Barrier. If a break in a barrier is needed for pedestrian or wildlife access, the exposed end of the barrier must have either an appropriate end treatment or must be shielded by the downstream end. A 30-degree angle is adequate to provide this shielding, as illustrated in Figure 4.8. This layout is only appropriate when the barrier is outside the opposing traffic clear zone. If the barrier is in the opposing traffic clear zone then crashworthy end treatments on both terminals is needed.

Figure 4.8: Break in Barrier



4.4 EXAMPLE PROBLEMS

The following are example applications of the barrier design process described in this chapter.

Problem 1. This problem is the same as Problem 1 discussed in Chapters 2 and 3.

Roadway data: A two-lane road, with 3.6 m (12 ft) lanes and 1.2 m (4 ft) paved shoulders. There is a tangent section and a 46 m (150 ft) long horizontal curve on a 240 m (800 ft) radius. The whole section is on a 3 percent downward grade.

Traffic data: 400 present ADT with a 3 percent annual growth factor. Design speed is 50 km/h (30 mph). On the tangent section actual speeds may exceed the design speed.

Hazard data: The hazard is a 1V: 2H foreslope 18 m (60 ft) high, offset 1.8 m (6 ft) from the edge of travel way on the outside of the horizontal curve. The slope is 150 m (500 ft) parallel to the road, including both the horizontal curve and the tangent section. There are some scattered trees and small boulders on the slope.

Other issues: Because of the remote location, barrier construction is expected to be costly. There are no crash data available. There are no aesthetic or environmental issues.

Previous Recommendations: A barrier is warranted on both the tangent and horizontal curve sections. The selected barrier system is G4.

Solution:

1. Select the barrier offset, L_2. Using the criteria listed in Section 4.1.2, the following considerations apply:

    a. Available hazard offset. The available hazard offset is 1.8 m (6 ft).
    b. Slopes in front of the barrier. The slope in front of the hazard is 1V: 10H or flatter, so this is not an issue.
    c. Curbs. No curbs are present.
    d. Soil Support Behind the Barrier. Because of the low speed, the barrier could be located so that the back of the barrier is 0.3 m (1 ft) from the slope break.
    e. Available Shoulder. The only way to achieve the criterion of the shoulder plus 0.6 m (2 ft) is to add additional fill to flatten the slope by approximately 0.6 m (2 ft), allowing the shoulder plus 0.6 m (2 ft), 0.3 m (1 ft) for the barrier depth and 0.6 m (1 ft) for soil support. Such widening is impractical in this case, so this criterion must be violated.
    f. Shy Line Offset. From Table 4.2 the desired shy line offset is 1.1 m (3.6 ft).

g. Locate as Far as Possible. In this case there is no flexibility to locate the barrier any further than the slope break.

Locating the barrier face 1.2 m (4 ft) from the edge of the traveled way will meet all the above criteria except the shoulder plus 0.6 m (2 ft). Violation of this criterion will have some negative impact on the usability of the shoulder but will not affect barrier performance.

2. A flare is not practical at this location because of the existing slopes.

3. Using the AASHTO *RDG* design method, the design variables are as follows:

- L_A is 38 m (126 ft).
- From Table 2.1, L_C is 2.0 m (7 ft). This is using the 1V: 4H slope upstream of the hazard. L_C will be used in the calculations.
- L_3 is 1.8 m (6 ft).
- The selected L_2 is 1.2 m (4 ft).
- From Table 4.1, L_R is 40 m (130 ft).

4. The length of need is (in metric units):

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

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

$$X = \frac{(40)(2.0 - 1.2)}{2.0}$$

$X = 16$ m

This rounds to 5 lengths of guardrail, or 19.0 m

The length of need is (in U.S. customary units):

$$X = \frac{(130)(7 - 4)}{7}$$

$X = 55.7$ ft

This rounds to 5 lengths of guardrail, or 62.5 ft.

5. The hazard is outside the clear zone for opposing traffic, so no length of need is necessary on the downstream end. Forty lengths of guardrail are needed to shield the hazard, or 152 m. The total guardrail length is: 152 + 19 m = 171 m. In U.S. customary units, the total guardrail length is 500 + 62.5 = 562.5 ft.

6. A tangent terminal would be most appropriate in this case because the existing slopes make it difficult to accommodate a flared terminal. The barrier is outside the opposing traffic clear zone, so a downstream terminal is not required but should be considered.

If the alternate design process is used, the length of need is:

$X = 6\ (L_A – L_2)$

$X = 6\ (2.0 – 1.2)$

$X = 4.8$ m

This rounds to 2 lengths of guardrail, or 7.6 m for the length of need.

In U.S. customary units:

$X = 6\ (L_A – L_2)$

$X = 6\ (7 – 4)$

$X = 18$ ft

This rounds to 2 lengths of guardrail, or 25 ft for the length of need. All other considerations are the same as the AASHTO *RDG* method.

If the site conditions make it difficult to install the four lengths of guardrail for the full length of need, it could be shortened to two sections. The shortened sections allow a larger degree of risk of a vehicle getting behind the upstream end of the barrier and not being able to come to a stop before hitting the hazardous slope.

Problem 2. This problem is the same as Problem 2 discussed in Chapters 2 and 3.

Roadway data: A two-lane road, with 3.6 m (11 ft) lanes and 0.4 m (2 ft) paved shoulders. This is a flat and tangent section. The roadway approaches a bridge across a river. On the approach the road leaves a cut section and approaches the bridge on a fill with 1V: 3H side slopes. It is 37 m (120 ft) from the cut section to the bridge. The slope break for the fill is 0.6 m (2 ft) from the edge of the shoulder. The fill is approximately 2.4 m (8 ft) high. On the far side a similar fill extends 60 m (200 ft) where the fill flattens to 1V: 4H. There are no pavement markings on the road or the bridge.

Traffic data: 1,100 present ADT with a 1 percent annual growth factor. Design speed is 70 km/h (45 mph).

Hazard data: A 9 m (30 ft)-wide bridge crosses a river with water depths of approximately 1.5 m (5 ft). The bridge rail is a vertical concrete wall.

Other issues: This roadway is in a park with serious aesthetic concerns.

Previous Recommendations: The clear zone is 11.9 m (39 ft). A barrier is warranted on both approaches near sides of the bridge. SBT is the selected barrier system.

Solution:

1. Select the barrier offset, L_2. Using the criteria listed in Section 4.1.2, the following considerations apply:

   a. Available hazard offset. The available hazard offset is 1.2 m (4 ft).
   b. Slopes in front of the barrier. The slope in front of the hazard is 1V: 10H or flatter, so this is not an issue.
   c. Curbs. No curbs are present.
   d. Soil Support Behind the Barrier. The SBT barrier is a strong post system so there should be 0.6 m (2 ft) behind the posts before a slope break. To meet this criterion the barrier offset should be 0.2 m (1 ft). If this is violated there will be more deflection in the barrier than anticipated.
   h. Available Shoulder. To meet this criterion, additional fill is necessary, which is unrealistic in this case.
   i. Shy Line Offset. From Table 4.2 the desired shy offset is line 2.3 m (4.1 ft). This criterion will also have to be violated.
   j. Location. In this case there is no flexibility to locate the barrier any further than the slope break.

   Locating the barrier face 0.6 m (2 ft) from the edge of the traveled way appears to be the most reasonable choice. This offset allows only 0.2 m (1 ft) behind the posts, which will result in more deflection in the system than planned. However, there are no protruding hazards near the barrier. This offset will also violate the shoulder plus 0.6 m (2 ft) and the shy line offset. Violation of these criteria will have some negative impact on the usability of the shoulder and traffic capacity but will not affect barrier performance.

2. A flare is not practical at this location because of the existing slopes.

3. Using the AASHTO *RDG* design method, the design variables are as follows:

   - From Chapter 2, L_C for this problem is 11.9 m (39 ft). L_C will be used for L_A in the calculations.
   - L_3 is 1.0 m (3 ft).
   - The selected L_2 is 0.6 m (2 ft).
   - From Table 4.1, L_R is 60 m (200 ft).

4. The length of need is (in metric units):

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

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

$$X = \frac{(60)(11.9 - 0.6)}{11.9}$$

$$X = 57.0 \text{ m}$$

   This rounds to 19 lengths of SBT rail, or 58 m

   The length of need in U.S. customary units:

$$X = \frac{(200)(39 - 2)}{39}$$

   X = 190 ft, which rounds to 19 lengths of SBT rail, or 190 ft.

5. Because of the higher speeds and traffic volumes, it was decided not to use the alternate design procedure.

6. The barrier should be flared back and buried in the cut section at approximately 130 ft from the bridge. Although this does not provide the length of need, the buried end prevents a vehicle from striking the river. Standard Drawing 617-61 requires that the turned-down terminal be flared back 0.6 m (2 ft), and that a flat area be provided 1.5 m (5 ft) beyond the back of the end. The additional fill required by this design would result in slopes steeper than 1V: 3H if it were constructed at the end of the length of need. Therefore, the barrier must be extended to the 1V: 4H slopes, 60 m [200 ft] away from the bridge. The flared end treatment is over a distance of 10 meters (30 ft), so the total barrier length is 70 m (230 ft).