Short Radius Curved Guardrail at Side Roads and Entrances

Occasionally, designers encounter situations where an intersecting side road or entrance is located so close to a side obstacle, even a minimum length MASH TL-3 steel beam guardrail installation is not possible. This most occurs often at bridge ends. A short radius curved guardrail installation may accommodate this situation.

> The short radius curved guardrail design has not passed either NCHRP Report 350 or MASH at test level 3 (TL-3); therefore, it should be used only as a last resort. Designers should first investigate other options.

With the curved guardrail design, the guardrail turns and follows the intersecting road, then terminates a given distance down that road. At the intersection, the guardrail is curved and breakaway posts (referred to as controlled releasing terminal (CRT) posts) are installed so that a colliding vehicle will not decelerate too rapidly. The curved guardrail design normally shields the obstacle, yet does not pose a significant obstacle in itself.

Figure 1 illustrates a sample short radius curved guardrail design used at a bridge end near an entrance.

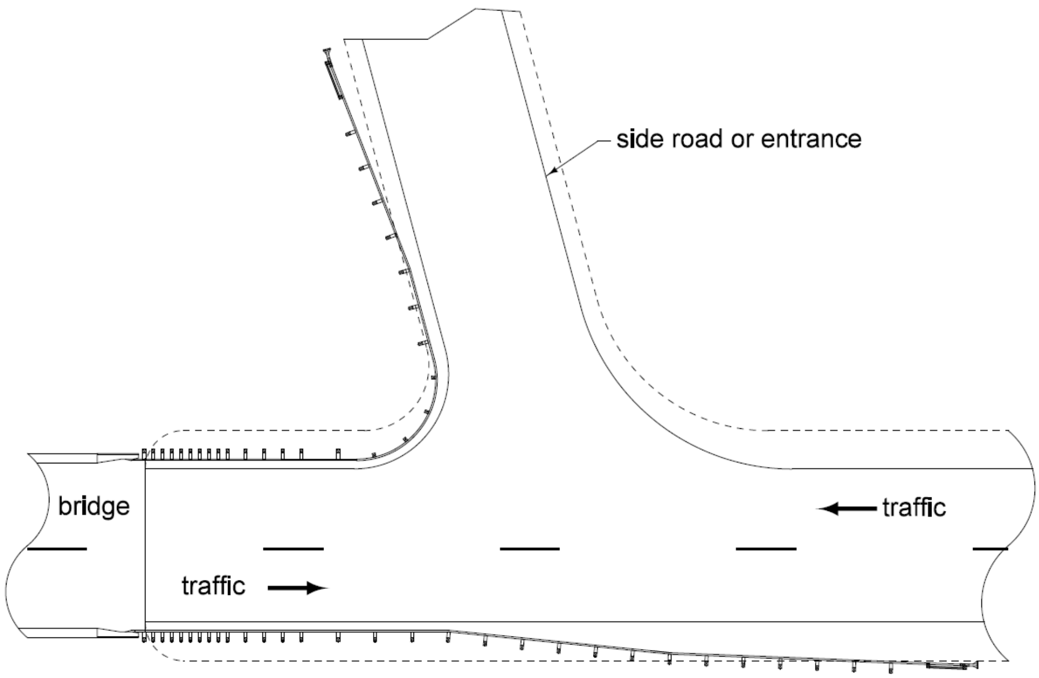

Figure 1: Short radius curved guardrail at an entrance.

The Roadside Safety Engineer has construction details for the short radius curved guardrail design. The end treatment used depends on the function of the side road. Use Standard Road Plan BA-205 or BA-206 for high speed side roads such as highways. Standard Road Plan BA-203 may be used for low speed side roads such as private entrances.

Design Considerations for Short Radius Curved Guardrail

Designers will need to keep several things in mind when designing a short radius curved guardrail installation:

- Installations placed at side roads and entrances can create nuisance hit problems for turning traffic, e.g. tractor trailers turning off of or onto side roads, or farm implements turning in to and out of field entrances. Designers should check turning patterns to ensure the guardrail installation does not significantly affect turning movements. Figure 2 shows the turning path for a single unit truck to negotiate the intersection in Figure 1.

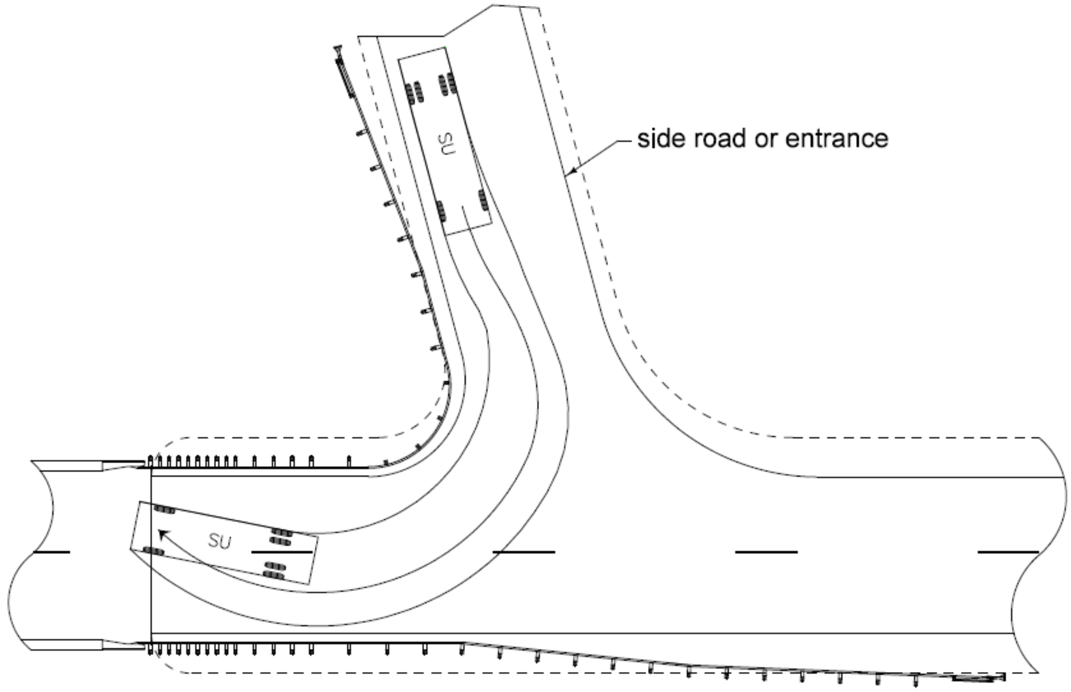

Figure 2: Turning path at an entrance.

- Installations placed at side roads and entrances can create sight distance issues, especially if the side road or entrance is at or near the crest of a vertical curve. Designers will want to study both plan and profile views when examining the effects a guardrail installation may have on sight distance.

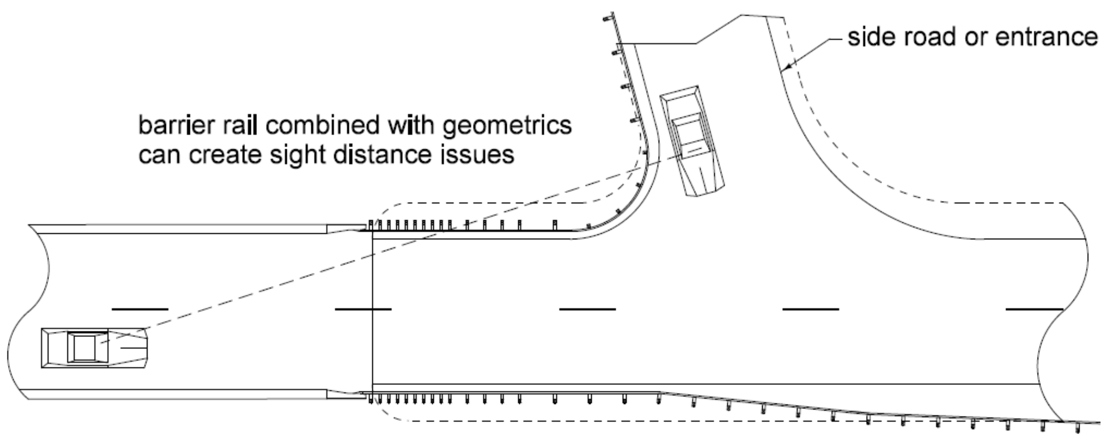

Figure 3: Examining sight distance for an entrance with short radius curved guardrail installation.

- The curved area of the installation has CRT posts. This area of the installation will pocket vehicles rather than redirect them, see Figure 4 below.

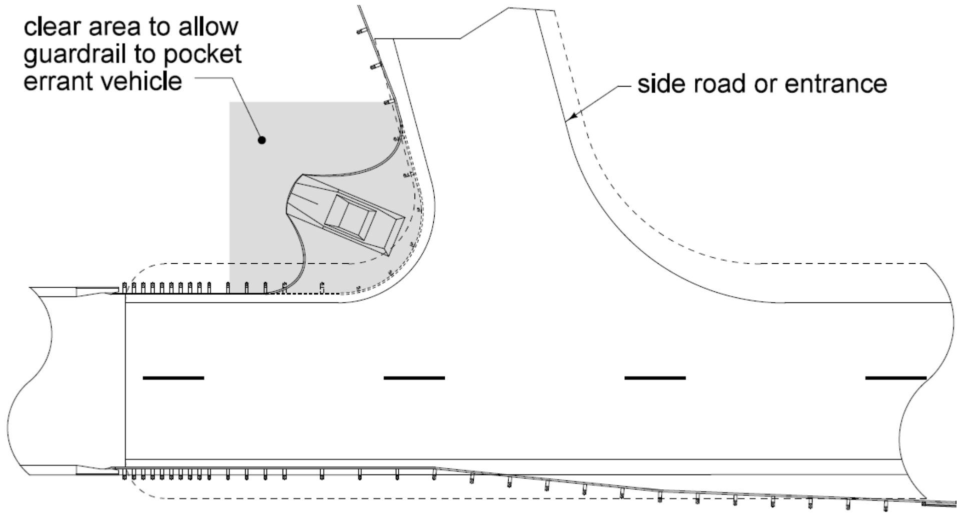

Figure 4: Clear area to allow for pocketing vehicle.

A clear area with a foreslope no steeper than 2:1 needs to be behind the curved guardrail to account for this. A 15:1 or flatter slope should be maintained to 4 feet behind the posts before breaking over to a steeper foreslope. Additionally, the curved portion of the installation must consist of 12.5 foot sections of guardrail, so the length of the curved portion must be in 12.5 foot multiples. The radius of the curved portion must be between 8.5 feet and 35 feet.

- Depending on the intersecting side road or entrance, additional guardrail may need to be placed upstream of the entrance. Transverse slopes steeper than 6:1 should be protected if they cannot be flattened. Drainage structures associated with the side road or entrance may need to be protected if they pose a snagging potential. BA-203 may be used at the trailing end of the installation if it is located outside of the clear zone for opposing traffic; otherwise, use BA-205. See Figure 5 below.

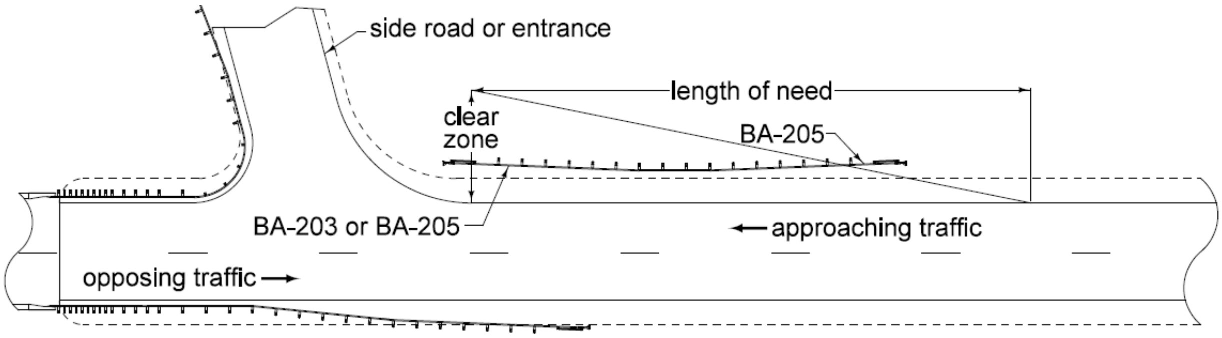

Figure 5: Additional upstream guardrail to protect transverse slope.

Determining the Radius of the Short Radius Curved Guardrail

If a short radius curved guardrail design is chosen, the radius of the required curved guardrail must be determined. It's a bit of an iterative process. Figure 6 shows the variables involved.

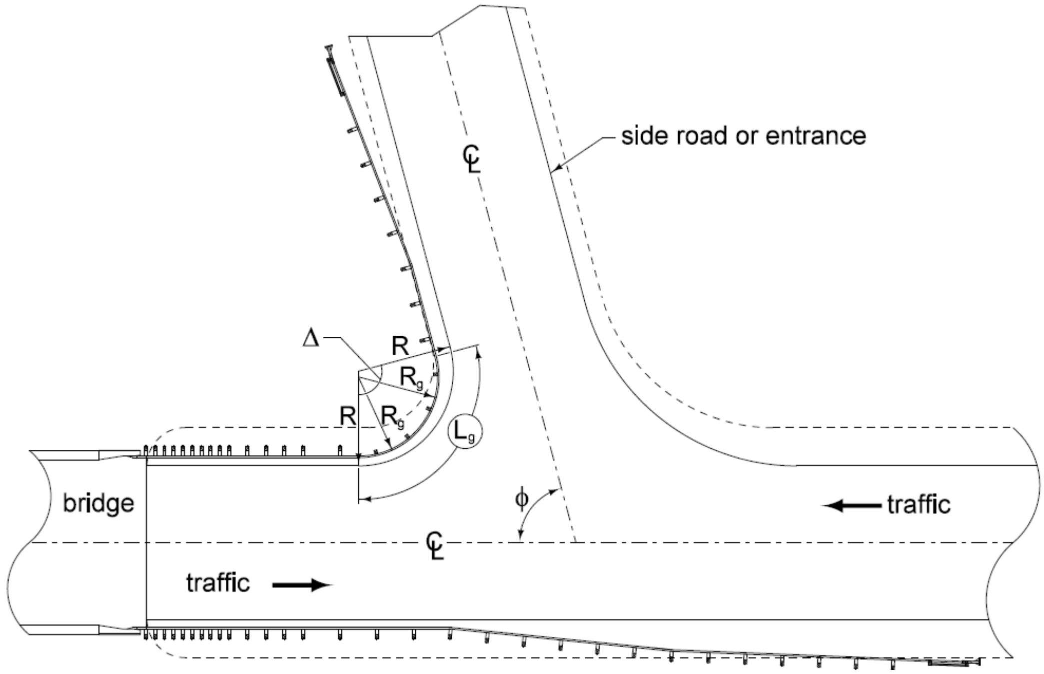

Figure 6: Variables involved with determining the radius of a short radius curved guardrail.

The process is as follows:

1. Determine the radius, R, and the angle of the curve, Δ, at the intersection. This information may be found in as-built plans. If plans aren't available, the intersection angle, ϕ, of the side road or entrance that intersects the main road will be required to approximate the Δ of the curve at the intersection. The radius will need to be determined from field measurements.

   Once ϕ is known, Δ is determined as:

   $$\Delta = 180° - \phi$$

2. Once the radius of the curve has been determined, choose a slightly smaller radius (3 to 5 feet smaller than the radius of the intersection curve, but between 8.5 feet and 35 feet), R_g, for the curved guardrail. From this, an approximation for the length of the curved guardrail is calculated as:

   $$L_g = \frac{\pi \times R_g \times \Delta}{180}$$

3. Guardrail used in the curved portion of the installation must be 12.5 foot sections, so the total length of curved guardrail must be divisible by 12.5 feet. Round L_g to the nearest multiple of 12.5 and calculate R_g:

   $$R_g = \frac{180 \times L_g}{\pi \times \Delta}$$

   If the new value of R_g is not smaller than the radius of the intersection curve, decrease L_g by 12.5 feet and recalculate R_g.

   Example:

   R = 35 feet and Δ = 75°. Try R_g = 30 feet

   $$L_g = \frac{\pi \times R_g \times \Delta}{180} = \frac{\pi \times 30 \times 75}{180} = 39.2 \text{ feet}$$

   37.5 feet is a multiple of 12.5 feet. Try L_g = 37.5 feet.

   $$R_g = \frac{180 \times L_g}{\pi \times \Delta} = \frac{180 \times 37.5}{\pi \times 75} = 28.65 \text{ feet.}$$

This is less than 30 feet, so start the design using R_g = 28.65 feet and L_g = 37.5 feet.

Example

A 20 foot wide granular low volume, low speed entrance is located close to a bridge. The entrance intersects the mainline at a 90° angle. The centerline of the entrance is approximately 68 feet from the end of the bridge rail end post. The mainline has a 6 foot shoulder which starts to blend into the entrance approximately 36 feet from the end of the bridge rail end post and blends in at about a 30 foot radius. A few trees are located within the clear zone by the bridge end, creating a secondary hazard needing protection in addition to the primary hazard of the bridge rail end post. A BA-201 with either a BA-205 or BA-206 will protect the secondary hazard, but places the head of the terminal in the middle of the entrance, as can be seen in Figure 7. A crash cushion won't protect the secondary hazard, nor will a TL-2 barrier transition section (BA-221) with a BA-225. A short radius curved guardrail design will be used.

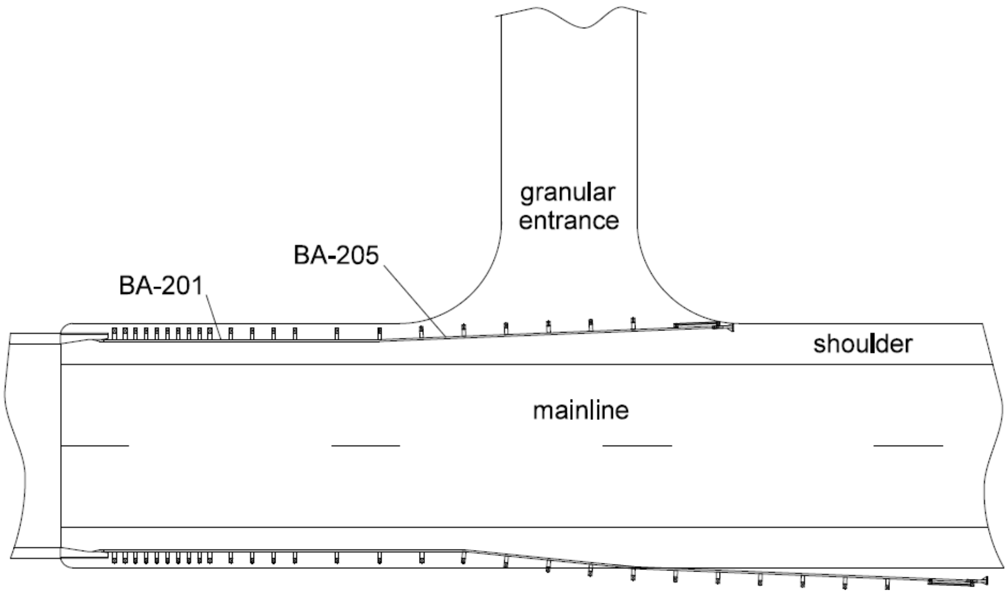

Figure 7: BA-201 with a BA-205.

The final design results ended up being:

- Along the mainline: a BA-201.
- Curved guardrail: L_g = 25 feet and R_g = 15.92 feet.
- Along the entrance: 12.5 feet of variable tangent with a BA-203 end treatment.

The final design is shown in Figure 8. A crest occurs on the bridge, so the installation won't create sight distance issues. A study of turning paths showed single unit trucks and tractor trailers will need to intrude into the opposing lane of traffic to make a right turn. Some minor grading needs to be done to provide a 15:1 slope out 4 feet beyond the posts of the curved guardrail; however, the foreslope will remain flatter than 2:1.

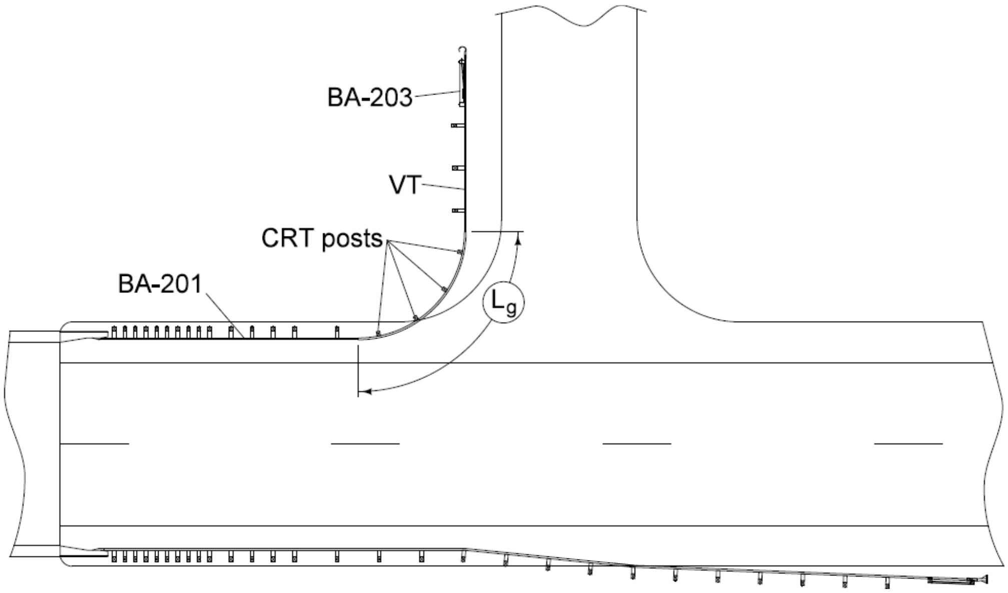

Figure 8: Final layout for example.

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