Curved W-Beam Guardrail Installations at Minor Roadway Intersections

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Some projects require the bridge approach railing to be on a radius and is shown on a Rail Layout Plan. The steel tubes and the double nested thrie beam of the bridge approach railing can be shop bent to a radius. However, two portions of the bridge approach railing ***cannot*** be bent to a radius: **connection plate (2'-5 1/8" section)** and **thrie-beam to w-beam transition section (6'-3")**.
See email "Steel Bridge Approach Railing" e-mail from Angela Hubbard, see attached.

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1. **PURPOSE**. To transmit information on two different operational designs of curved guardrail for radii between 8½ and 35 feet, as well as a specialized application of an 8½ foot radius curved guardrail. These new designs have been successfully crash tested and are acceptable for new construction, as well as for improving safety at existing sites. These designs are most appropriate for use on low volume highways.

2. **BACKGROUND**

   a. Often roads or driveways intersect a highway close to the end of a bridge or other immovable, restrictive features of the highway. To shield both the end of the bridge and the steep embankment, a strong post W-beam guardrailcurved around the radius is typically used. Often, these installations have not been effective when the curved section of the barrier has been hit at higher speeds. A vehicle which impacts the barrier under such conditions will generally vault over or penetrate the guardrail; or, in the event that the vehicle is contained by the guardrail, the resulting decelerating forces often exceed the recommended limits for occupant safety. In many of these situations, it is not practical to change the site conditions by relocating the intersecting roadway further away from the bridge end in order to allow room for a standard approach guardrail. It was, therefore, necessary to develop a curved guardrail installation which would substantially improve the safety at these sites.

   b. A cooperative research program between the Washington State Department of Transportation and the Federal Highway Administration was undertaken to design improved curved guardrail approaches and transitions. Subsequently, Yuma County in Arizona tested and developed a stiffer 8½-foot radius curved guardrail for sites where canals or other features such as drainage are close to the guardrail. Both systems are intended primarily for use on lower-speed through roadways intersected by low-speed, low-volume roads, driveways, or maintenance rights-of-way.

3. **SUMMARY**

   a. This information can be used to enhance highway safety in certain locations where it is desirable to use curved strong post guardrail sections. This information is appropriate for use in new construction and for improving or upgrading existing curved guardrail installations.

   b. The curved sections have been successfully crash tested within the performance limits detailed in this Technical Advisory. Crash tests also indicated that these sections have limitations and should not be used in situations which vary excessively from the conditions (such as grading, layout, or vehicle speed) under which these successful crash test results were obtained.

   c. Adherence to detail is important. Guardrail section layout and construction details such as rates of curvature, use of breakaway Controlled Releasing Terminal (CRT) posts, adequate deflection zone behind curved guardrail and appropriate end anchorages are elements which can critically affect performance.

   d. The recommended designs and details listed below are shown in the attached drawings **[SEE PRINTED COPY OF TA FOR DRAWINGS - FIGURES 1, 2, 3a, 3b AND 4]**:

      (1) Figure 1: Curved W-Beam Guardrail Installation for an 8½-foot radius.

(2) Figure 2: Curved W-Beam Guardrail Installation for a 35-foot radius.

(3) Figure 3a: Special Anchor Details.

(4) Figure 3b: Special Anchor Details.

(5) Figure 4: Yuma County, AZ, Curved W-Beam Guardrail Installation for an 8½-foot radius.

4. **RECOMMENDATIONS**

a. The curved guardrail designs detailed in this Technical Advisory should be considered for use in new construction projects as appropriate. Existing curved guardrail installations may also be replaced or upgraded as the opportunity becomes available.

b. These curved guardrail designs are for radii of 8½ feet and 35 feet. Crash test results and technical experience indicate that this system will also perform satisfactorily with other intermediate radii as noted in the table on Figure 1. Situations which require a curved guardrail installation which falls beyond this range of radii should be designed individually and not subjectedto a "make it fit" misapplication of these details.

5. **RELATED TECHNICAL INFORMATION**

a. The following details are essential to proper system performance in the field:

(1) Breakaway CRT posts are used within the curved "nose" of the guardrail installation. Wood blockouts are not used on the CRT posts. The W-beam rail in the curved area is attached directly to the CRT post with a button-head bolt which has no washer. This is done to have the posts break away in the curved nose area and thus separate from the rail. This minimizes rotation of the rail during impact and minimizes the likelihood that a vehicle will vault over the guardrail upon impact.

(2) For the 8½-foot radius layout (Figure 1), the guardrail is not bolted to the one CRT post at the center of the curved nose area. This allows the center post to easily separate from the guardrail upon impact, and facilitates guardrail deflection without having this bolt ripping or snagging the W-beam rail section.

(3) A flat approach to the curved guardrail installation is necessary in order to ensure proper performance of the system. The slope in front of the installation should not exceed 15:1. If the installation is on a superelevated section, analysis should be performed in order to evaluate the potential for vaulting of an errant vehicle.

(4) The embankment slope should break at least 2 feet behind the post (so that the post will have adequate bearing strength when hit). It is desirable that the embankment slopes behind the guardrail not be steeper than 2:1. Successful crash tests were done on installations with 2:1 slopes behind the guardrail.

(5) Considerable deflection of the W-beam guardrail can be expected with higher speed impacts on the curved guardrail portion of the installation. Therefore, the area behind the curved portion of the guardrail, shown as the cross-hatched areas on Figures 1, 2 and 4, must be kept free of fixedobjects.

b. These curved guardrail installations are not appropriate for use in all situations. To avoid misapplication, the designer should be aware of the following limitations:

(1) When used in close proximity to a bridge with a rigid bridge rail, these design layouts require an adequate space between the curved guardrail installation and the bridge end (approximately 25 feet) to place a crashworthy W-beam transition from the W-beam guardrail to a rigid bridge rail.

(2) Since the special end anchor shown in Figures 3A and 3B has not been crash tested as a guardrail terminal, its use should be limited to low-speed, low-volume facilities with a stop condition such as intersecting driveways or service-type roadways. For most intersecting public highways, the curved guardrail installation should be either terminated along the intersecting roadway with an acceptable terminal system, or connected to an existing guardrail system.

(3) The special end anchor system was developed for use when it is necessary to end the guardrail system immediately after the curved section. This end anchor uses many components from the breakaway cable terminal design. It also includes another cable to connect the steel foundation of the next-to-last post to the end post anchoring cable system. One novel feature incorporated is a pivoting pipe section which isplaced over the end post and improves rail performance by allowing it to swivel as it is deflected by a car. This special end anchor is not a crashworthy terminal for high speed highways. Therefore, as stated previously, its use should be limited to driveways or service roadways.

(4) In the high speed crash tests, some heavy debris was observed flying about in the area behind the impact. Judgment must be used when installing these sections where people are likely to be present in the area behind the curved section.

c. Curved guardrail installations of the Washington State design having radii of 8½ feet and 35 feet were successfully crash tested, but it should be noted that the 35-foot radius installation did not perform adequately when impacted at 60 MPH by a large vehicle (4740 lbs.). Satisfactory results were obtained for the 35-foot radius installation when a test was performed at a reduced speed of 50 MPH with the large vehicle. Two intermediate radii (17 feet and 25½ feet) are provided in Figure 1. Installations having a different radius between 8½ feet and 35 feet must be specially detailed so as to use only full lengths of W-beam rail, and to shop bend only full sections of rail. Any such intermediate radius designs must incorporate all other critical details and post types and locations as shown on the attached Figures 1 and 2 in order to be considered acceptable.

(1) It is important to note that the Yuma County design shown in Figure 4 was successfully crash tested at 50 mph. Radii larger than 8½ feet should not be used without further testing.

(2) All of the attached designs are based on an intersection angle of 90 degrees. If field conditions vary excessively from 90 degrees, it will be necessary to specially detail a curved guardrail section so that the curved rails will fit the intersection geometry, and that only full sections of W-beam rail will be shop bent for installation.

d. The attached drawings **[SEE PRINTED COPY OF TA FOR DRAWINGS]**, in a format suitable for use on the Intergraph CAD system, are available from the Federal Highway Administration, Office of Engineering, Geometric and Roadside Design Branch, HNG-14, 400 Seventh Street, S.W., Washington, D.C. 20590.

/s/
Thomas O. Willett, Director
Office of Engineering

/s/
R. Clarke Bennett, Director
Office of Highway Safety

Attachments

[SEE PRINTED COPY OF TA FOR ATTACHMENTS - FIGURES 1, 2, 3a, 3b AND 4]

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