NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Tech Brief

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Buried-In-Cut End Treatment (BIC)

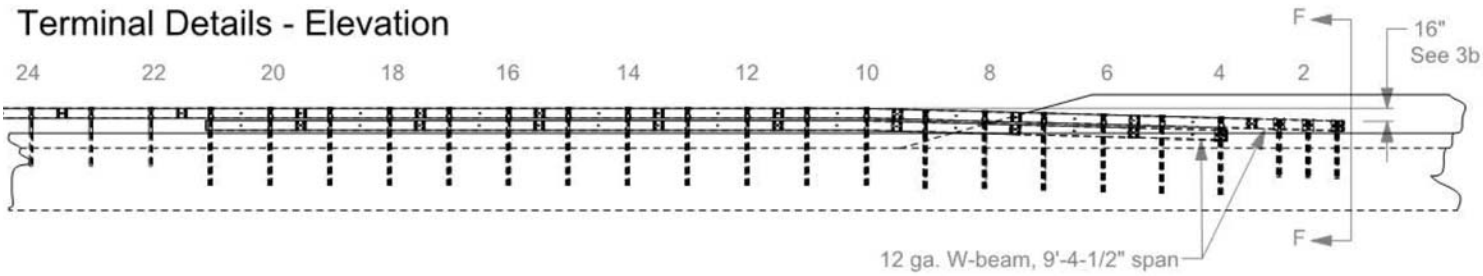
CATEGORY: Design, Construction and Maintenance

ISSUE: The Buried-In-Cut (BIC) is a generic system, where a w-beam guardrail can be terminated by burying the end of the rail element into the backslope. This type of anchor eliminates the possibility of an end-on impact with the barrier end and, when properly designed and constructed, minimizes the likelihood of a vehicle intruding behind the barrier and reaching the shielded area of concern. Therefore, it should be the terminal of choice at locations where it can be appropriately applied. The system, using a double rail over a 4:1 foreslope, has been successfully tested under several TL-3 impacts to be used with the MGS 31" guardrail system (Texas A&M Transportation Institute {TTI}, Report No. 608431-01-1&2, October 2018). A technical determination has been made by TTI that the single rail BIC, over a 10:1 or flatter foreslope, is also MASH compliant (as it is simply standard guardrail).

OBJECTIVE: To provide information on the BIC to design engineers, installers, inspectors, and maintenance personnel working with w-beam terminals.

METHODOLOGY: This Technical Brief will describe the BIC characteristics and identify the design features essential for expected barrier performance.

BASIC DESIGN: The buried-in-cut design uses standard 12-gauge w-beam guardrail with splices mid-span between the posts. The BLON is at the point where the installation crosses the toe of the backslope. The BIC can be either a double rail or a single rail design, depending on the steepness of the foreslope. For the double rail design, 8-ft long posts are used as soon as the rails are stacked; the top rail is blocked out while the bottom (rub) rail does not use a blockout. For the single rail design, standard 6-ft posts with blockouts are used throughout.



KEY DESIGN FEATURES:

- Slopes in front of ditch bottom:

  1. For slopes steeper than 10:1, keep the height of the w-beam rail constant relative to the roadway grade until the barrier crosses the toe of the backslope; add a w-beam rubrail when the distance between the bottom of the w-beam rail and the ground exceeds ~19" and is increasing (if the height of the top rail would become greater than 46", hold 46" constant until the rail crosses the toe of the backslope).

  2. For slopes 10:1 or flatter, measure the height of the rail from the ground directly beneath the face of the rail.

- Flare Rate: Reference the AASHTO Roadside Design Guide (RDG) Table 5.9, appropriate for the design speed of the highway until the toe of the backslope is reached.

- Length of need (LON): There are three situations that address determination of LON for the BIC

  1. For a nearly vertical backslope, the natural slope effectively becomes an extension of the barrier face; anchor as soon as possible – typically with a rock anchor; there is no "classical" LON determination as it is essentially a continuous barrier.

  2. For the normal steep backslope, the effective barrier (to BLON) must be brought to a sufficient distance in advance of the beginning of the area of concern such that a vehicle which passed behind the non-effective part of the rail (or upstream of the anchor) should have enough distance to be captured behind the rail upstream of the area of concern. Many states use 75' minimum for this distance (may be greater based on flare rate and offset from the normal parallel rail location to toe of backslope).

  3. For traversable and/or recoverable slopes (flatter than about 2.5:1), the BLON location must be determined by the state's normal LON procedure (such as using Runout Length L_R) with the back of area of concern being the clear zone used for the project's typical cross-section.

- Anchorage: Capable of developing the full tensile strength of the w-beam rail.

  1. For very steep backslopes, as stated above, the natural slope effectively becomes an extension of the barrier face; anchor as soon as possible – typically with a rock anchor.

  2. For the normal steep backslopes, the rail behind the toe of backslope is gently bent (8:1, then 6:1, then 4:1) into the backslope, keeping its height constant relative to the ditch bottom. The end of the anchor is to be a minimum of ONE foot under the natural groundline; if the 1' burial is achieved prior to reaching a maximum of 8' offset, the gentle bend may be flattened so as not to exceed the 1' burial; if 1' burial is not achieved by the maximum 8' offset, the entire length of the rail behind the toe of backslope may be lowered on a constant taper to achieve the 1' burial at the 8' offset. It is important that no (artificial) mounds are to be constructed in order to bury the end of the rail.

     The tested anchor used three steel posts in the last 6'-3" of top rail, each post with a steel plate attached and the rail connected using 4 standard spice bolts (a concrete block anchor has been used as an option in the past). The bottom rail for the double rail design is connected to the steel post (with similar plate) one rail panel short of the end.

EXAMPLE INSTALLATIONS

Photo A: Double Rail System - Foreslope is steeper than 10:1 and no steeper than 4:1. Top rail remains parallel to the road elevation (to a maximum of 46" height) so no override should occur. Once the top rail crosses the toe of the backslope (the BLON), the anchorage must be developed.

Photo B: Single Rail System - Foreslope MUST be 10:1 or flatter all the way to toe of backslope. If the backslope is flatter than 1:1, then the rail should be extended in front of the toe of backslope some distance (75') upstream of the area of concern before beginning the anchorage.

Photo C: Illustrates where the LON (minimum 75 ft. upstream of the area of concern criteria) was not met. A vehicle can potentially climb up the backslope, get behind the rail, and into the area of concern.