Identifying and addressing ALL hazards at a location that warrant shielding, as well as addressing secondary obstacles.

There are many locations where the designer focused on the most obvious severe hazard and missed other significant hazard(s) in the same area. Two of the most common examples of this are: shielding right side bridge piers and leaving the 2:1 transverse slope of the bridge embankment unshielded; and shielding the end of bridge rails and leaving the crossed feature unshielded and also possibly the 2:1 parallel fill slope of the overpass if present. The later situation is shown in Photo E, where there is also a sign support added to the mix; a LON calculation needs to be done for each of the hazards that meet barrier warrants to determine the beginning of the barrier to shield ALL.

Although the area between the beginning of the terminal and the upstream face of the shielded hazard(s) is supposed to be free of any other hazards, there are occasions where another feature that would normally not be shielded (such as a utility pole) is present. The installation shown in Photo F effectively shields the downstream drainage structure and waterway, but the terminal will generally not significantly slow an impacting vehicle before it reaches the utility pole. In this case, the desirable treatment would be to remove/mitigate the secondary feature. However, if that is not feasible, then the guardrail should probably have been extended back upstream to provide 75 feet of distance from the beginning of the terminal to this secondary feature (if the feature were a hazard warranting shielding by itself, a second determination of LON for that hazard would be calculated and the farthest extent of guardrail upstream for all the warranting hazards would control).

The installation shown in Photo G illustrates a common issue – what is (are) the warranting hazard(s). The primary purpose of this guardrail is to shield the bridge ends, but the trees lining the roadway also present a concern. If the bridge rail were not existent, would the trees be shielded? If the answer is yes, then the wrong hazard was selected and the barrier would need to be extended to adequately shield the trees. If the answer is no, then the decision as to where to end the guardrail is arbitrary but at least the length determined by a LON calculation for the warranting hazard (in this case the drainage area) AND to use a TBT Type I (Tangent) terminal.

E

F

G

November 2021

Selection and Grading of Guardrail Terminals

CATEGORY: Design/Inspection

ISSUE: Guardrail terminals have generally been tested for crashworthiness on flat ground under specific impact conditions. However, many of the sites where these terminals are actually installed differ considerably from the crash-tested conditions. What steps can designers take to select the appropriate terminals and to provide the best chance for desired performance under less than ideal field conditions?

OBJECTIVES: Provide guidelines that:

- Can be used for terminal selection once the run of guardrail barrier has been properly laid out during design
- Provide the designer with guidance for the proper site preparation and required grading for a terminal
- Emphasize the need to identify and appropriately treat ALL obstacles at the location that meet barrier warrants
- Enable field personnel to recognize site conditions that can lead to unsatisfactory terminal performance

METHODOLOGY: There are three common deficiencies that are seen repeated throughout the country that can affect the desired outcome when barrier is terminated in the field. These are:

- Grading at and around the terminals,
- Terminal selection and barrier length of need, and
- Identifying and shielding ALL obstacles at a location that warrant shielding, as well as addressing secondary obstacles.

Each of these will be addressed in this Technical Brief to help assist IDOT staff in both the selection of an appropriate terminal, its location, and the provision for proper grading.

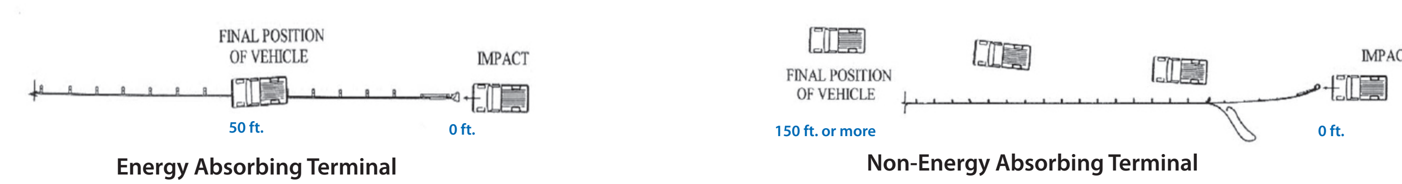

Figure 1: Pickup Truck Trajectories by Terminal Type (zero degree or very shallow angle head-on impact)

Illinois Department of Transportation

American Road & Transportation Builders Association

KLS Engineering

U.S. Department of Transportation Federal Highway Administration

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EXPECTED RESULTS:

Provides designers with guidance for selecting appropriate terminal type based on site conditions, and for providing proper grading around an terminal.

Grading at and around a terminal:

There are three grading areas identified around guardrail terminals: advance, adjacent, and run-out distance; these are shown on Figure 2, details taken from Standard 630301-09. A terminal struck by a stable vehicle, i.e., a vehicle that has its suspension neither compressed nor extended and has minimal roll, pitch, and yaw angles, will have the best chance of performing as designed.

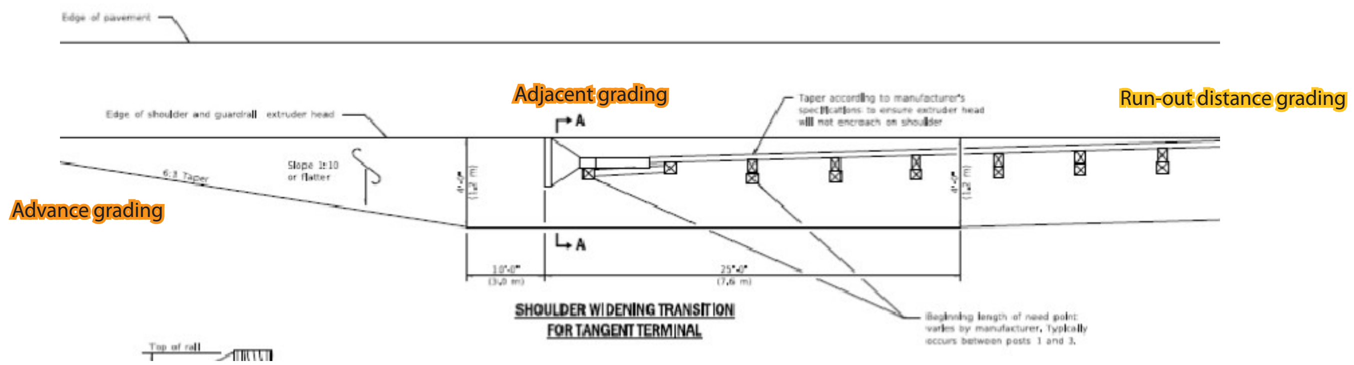


Figure 2: Shoulder Widening for Type 1 (Special) Guardrail Terminal

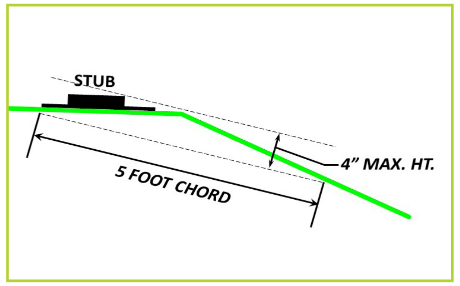
The "advance grading" consists of the space traversed by an errant motorist before the terminal is struck. This area should have slopes 10:1 or flatter to provide for the vehicle stability as it approaches the terminal. If a terminal "platform" is constructed, it should be smoothly blended into the existing roadside embankment so a motorist has an opportunity to return to the roadway without striking the terminal or losing control of the vehicle by dropping off the edge of the platform before impact. Sometimes grading platforms can be eliminated by extending the barrier a short distance to a flatter location. The grading shown in Photo A is very good (assuming the LON has been provided for all hazards that warrant shielding). The grading shown in Photo B shows where a "bubble" platform was provided, but failure to provide a traversable slope at the edge may have worsened the situation.

A

B

If the vehicle were to impact the end of a terminal with its left side, the right wheels would desirably be essentially level to minimize any pre-impact instability. The "adjacent grading" is the area immediately behind the terminal and extends the 10:1 approach slope a recommended 5' behind the back of post 1 as shown in the AASHTO RDG – Figure 8-3. In all cases, any hardware remaining after the vehicle passes through should not exceed the stub height criteria as shown in Sketch C (Reference AASHTO RDG - Figure 4.1 Breakaway stub height criteria).

The "run-out distance grading" refers to the area into which a vehicle may travel after impacting a terminal in advance of its re-direction point (or just missing the end). This area will normally be provided when the LON is provided. A field check should be made to determine if a run-out distance area exists. A minimal traversable area 75-feet long should be provided, and only tangent terminals should be used if the LON is not obtained. The width of this run-out distance grading area should be at least as wide as the roadside clear distance immediately upstream of the terminal.



C

Terminal selection and barrier length of need:

Terminals serve two functions: develop anchorage and prevent spearing/rolling by the rail element. There are three w-beam terminal types available in Illinois: buried in backslope, tangent energy absorbing systems, and flared (energy and non-energy absorbing) systems (see IDOT Qualified Products List at http://idot.illinois.gov/doing-business/material-approvals/metals/index.)

Buried-in-Backslope (BIB) terminals (Type 1B): generally considered to be the best way to end a guardrail. When properly designed and constructed, it provides full shielding of the identified hazard and eliminates the possibility of any end-on impact. It can be either a single rail (over flat ground) or stacked rails (NOT currently on IDOT standards). The backslope should be 3:1 or steeper, and the rail must be both kept high enough to capture the vehicle and extend upstream far enough (LON) to prevent any vehicle that gets behind it from reaching the hazard. In Photo D, the full rail height should have been extended back upstream (approx. 75'). (A generic technical brief on the BIB is available.)

D

Figure 1 on page 1 shows the relative trajectories of the heavy passenger vehicle impacting either a tangent (energy absorbing) terminal or a flared (non-energy absorbing) terminal, essentially head-on and at high speed (62 mph).

Energy absorbing terminals (Type 1), Tangent: have been shown to stop an impacting pick-up truck in about 50 feet when struck head-on and thus are suited to locations that do not have much traversable area behind the guardrail installation; however, they are also acceptable when the LON and full grading have been provided.

Non energy-absorbing terminals (Type 1), Flared: do not absorb/dissipate a vehicle's energy on impact; thus, they do not significantly reduce vehicle speed in end-on hits, regardless of angle. They should only be used (or left in place) when the Length of Need (LON) for the particular hazard(s) has (have) been obtained, and when the grading detailed on Standard 630301-09 is provided. Also, crash-testing has shown that the distance that the pickup truck travels after a head-on impact can be 150 feet or more.

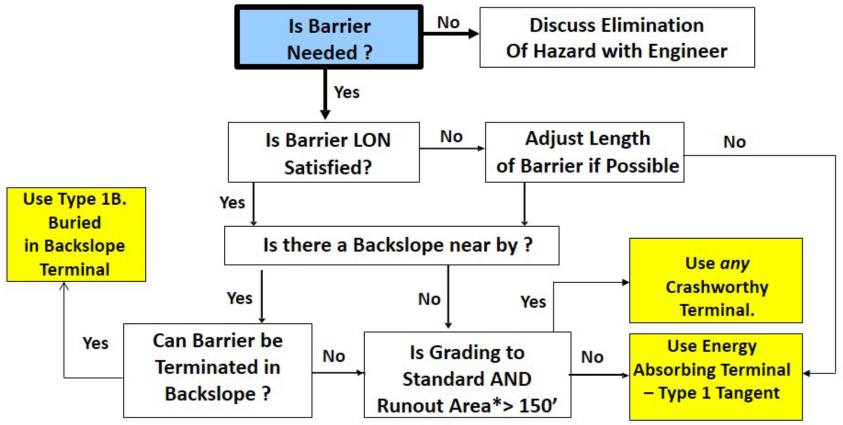


Figure 3: Terminal Selection Flowchart

Figure 3 is a suggested flowchart that can be used by a designer to select the most appropriate terminal for a specific location. Note that the starting point is to confirm that a barrier is actually needed. If so, then the appropriate length of need and grading should be verified.