# SECTION A-3-TRAFFIC BARRIER INSTALLATION CRITERIA

## INTRODUCTION

Traffic Barriers should only be used where the result of striking a fixed object hazard or leaving the roadway would be more severe than the consequence of striking the barrier. Where guardrail needs are indicated by warrants see the current AASHTO Roadside Design Guide. The roadway should be examined to determine the feasibility of adjusting site features so that the barrier will not be required (i.e. flattening a fill slope, removing a hazardous object, such as a drainage headwall, etc.) The initial cost to eliminate the guardrail may appear excessive; however, the fact that a barrier installation will require maintenance costs for many years should not be overlooked.

## GUARDRAIL WARRANTS

The determining warrants for Traffic Barriers on VDOT projects are (1) Embankment Heights (see below) and (2) Fixed and Hazardous Objects Within the Clear Zone (see TABLE A-3-1M).

| SYSTEM CLASSIFICATION | | TRAFFIC VOLUMES | FILLS OVER 2.3 m | FILLS OVER 4.6 m | AT OBVIOUS NEEDS SUCH AS BRIDGES, LARGE END WALLS, PARALLEL WATER HAZARDS, ETC., AND FILLS WHERE RECOMMENDED DURING FIELD INSPECTION |
|---|---|---|---|---|---|
| INTERSTATE - PRIMARY AND ARTERIAL | FILLS WITHOUT RECOVERABLE AREAS | ALL | Ö | | Ö |
| | FILLS WITH RECOVERABLE AREAS | | | | Ö |
| SECONDARY AND FRONTAGE ROADS | | ADT OVER 1000 | Ö | | Ö |
| | | ADT 1000 - 250 | | *Ö | Ö |
| | | ADT LESS THAN 250 | | | Ö |
| URBAN | | ALL | | | Ö |

* Exception - Bristol, Salem, and Staunton Districts. Traffic barriers are to be provided only at obvious needs such as bridges, large endwalls, parallel water hazards, etc., and fills where recommended at field inspection.

When fill slopes are 3:1 or flatter, a barrier is not required unless there are hazardous obstacles within the clear zone limits. This may include the clear runout area if the fill slope is between 3:1 and 4:1 (see Fig. A-2-4M).

## DETERMINING WARRANTS FOR ROADSIDE BARRIERS

| Fixed and Hazardous Objects Within The Clear Zone | Guardrail Required | |
|---|---|---|
| | YES | NO |
| 1. Sign Support (ground mounted):<br>(A) Post of breakaway design (a) | | X |
| (B) Post not meeting breakaway criteria (b)(c)(d) | X | |
| 2. Lighting/Signal Poles and Towers<br>(A) Breakaway design | | X |
| (B) Not meeting breakaway design (b)(c)(g)(h) | X | |
| 3. Bridge parapet ends, piers and abutments at underpasses | X | |
| 4. Retaining walls and culvert headwalls | X | |
| 5. Trees with a diameter of 100 mm or greater (e) | X | |
| 6. Utility Poles (f) | | X |
| 7. Above ground utilities (telephone pedestals, etc.) (i) | X | |
| 8. Rough rock cuts and large boulders | X | |
| 9. Streams or permanent bodies of water more than 0.6 m deep (h) | X | |

NOTES

(a) Multiple post installations where the spacing between posts is less than the minimum spacing required for breakaway shall be replaced or shielded by guardrail.
(b) Every effort should be made to convert non-breakaway to breakaway.
(c) Where these devices exist and cannot be converted to breakaway, relocated or removed, the choice of guardrail should be in accordance with the deflection shown in Table A-3-2M.
(d) Wood posts larger than 150 mm x 200 mm nominal size do not meet the breakaway requirements even if drilled.
(e) Every effort should be made to remove the tree rather than shield it with guardrail.
(f) Guardrail will not normally be used to shield a line of utility poles. However, where guardrails are used in front of utility poles for other reasons, the choice of guardrail should be in accordance with the deflection shown in Table A-3-2M.
(g) Pedestal poles, except for those used for power supply, should be converted to breakaway standards where possible.
(h) A field review and evaluation should be made to determine if guardrail is suitable for protecting motorists from these roadside hazards.
(i) Consideration should be given to placing utilities underground.

TABLE A-3-1M

## BARRIER TYPE SELECTION

When it has been determined that a barrier is required, a determination must be made as to the type of barrier that is to be used. Although the process is complicated by the number of variables and the lack of objective criteria, there are guidelines that can be used in making a barrier system selection. In general, the most desirable system is one that offers the lowest accident severity at the least cost and is consistent with the given constraints. The Standard GR-8 Weak Post System is to be used only when speeds are ≤ 70 km/h.

The AASHTO Roadside Design Guide presents eight items which must be considered before a system selection is made. In taking all eight items into account, the deflection, strength, and safety requirements should never be compromised. Table A-3-2M groups the Standard types of guardrail by three systems: flexible, semi-rigid and rigid. The table includes barrier height, maximum dynamic deflection, minimum offset from hazardous object, post spacing, and typical terminal treatment for each Standard. The Road and Bridge Standards provide transition designs for use in various situations.

### Table A-3-2M - Typical Barrier/Guardrail Selection and Placement

| SYSTEM | STANDARD | MINIMUM BARRIER HEIGHT | MAXIMUM DYNAMIC DEFLECTION (a) | MINIMUM OFFSET FROM HAZARD (c) | POST SPACING | DIVIDED ROADWAY OR ONE-WAY TRAFFIC | | UNDIVIDED ROADWAY OR TWO-WAY TRAFFIC | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | RUN-ON TERMINAL TREATMENT | RUN-OFF TERMINAL TREATMENT (d) | RUN-ON TERMINAL TREATMENT | RUN-OFF TERMINAL TREATMENT |
| FLEXIBLE (WEAK POST OR CABLE) | GR-3 | 685 | 3.3 | 3.3 | 4.9 | GR-3 | GR-3 | GR-3 | GR-3 |
| | GR-8(l) | 760 | 2.1 | 2.1 | 3.81 | GR-6, 7 ,9 (h) | GR-8,Ty.II | GR-6, 7 ,9 (e) (h) | GR-6, 7 ,9 (e) (h) |
| | GR-8A | 760 | 1.5 | 1.5 | 1.905 | GR-6, 7, 9 (h) | GR-8,Ty.II | GR-6, 7 ,9 (e) (h) | GR-6, 7 ,9 (e) (h) |
| | GR-8B | 760 | 1.2 | 1.2 | 0.952 | GR-6, 7, 9 (h) | GR-8,Ty.II | GR-6, 7 ,9 (e) (h) | GR-6, 7 ,9 (e) (h) |
| | GR-8C | 760 | 1.4 | 1.4 | 1.27 | GR-6, 7, 9 (h) | GR-8,Ty.II | GR-6, 7 ,9 (e) (h) | GR-6, 7 ,9 (e) (h) |
| | MB-5 (f) | 760 | 2.1 | 2.1 | 8.81 | IMPACT ATT. | IMPACT ATT. | N/A | N/A |
| | MB-5 (f) | 760 | 1.5 | 1.5 | 1.905 | IMPACT ATT. | IMPACT ATT. | N/A | N/A |
| | MB-5 (f) | 760 | 1.2 | 1.2 | 0.952 | IMPACT ATT. | IMPACT ATT. | N/A | N/A |
| SEMI-RIGID (STRONG POST) | GR-2 | 685 | 0.9 | 0.9 | 1.905 | GR-6,7,9 (h) | W BEAM END SECTION | GR-6,7,9 (h) | GR-6,7,9 (h) |
| | GR-2A | 685 | 0.6 (b) | 0.6 (b) | 0.952 | GR-6,7,9 (h) | | GR-6,7,9 (h) | GR-6,7,9 (h) |
| | MB-3 (g) | 685 | 0.9 | 0.9 | 1.905 | IMPACT ATT. | IMPACT ATT. | N/A | N/A |
| RIGID (CONCRETE BARRIER) | MB-7D,7E, 7F,12A,12B, & 12C (k) | 810 | 0' | 0' | N/A | IMPACT ATTENUATOR (i) | N/A | IMPACT ATTENUATOR (i) | IMPACT ATTENUATOR (i) |

NOTES:

(a) The deflection zone of all rail systems must be totally clear of any obstacles in order to assure that the rail will perform as tested.

(b) No test data available.

(c) Minimum offset from back of post to hazardous object.

(d) The noted terminal treatments apply when the terminal is installed outside the clear zone for opposing traffic. If a run-off terminal is installed within the clear zone of opposing traffic, see note "e".

(e) Transition from weak post system to terminal must be provided in accordance with St'd. GR-INS drawings to protect opposing traffic from impacting the opposite end of the terminal when it falls within clear zone.

(f) For use in wide flat medians (>9 m).

(g) For use in narrow medians (approximately 3 m - 9 m).

(h) If more than a 60 m extension of standard guardrail is necessary to tie into the slope with a St'd. GR-6 use a St'd. GR-7 or GR-9 terminal. For St'd. GR-6 installations, St'd. GR-2 must be installed from the terminal to the beginning of the flare before introducing St'd. GR-8.

(i) Concrete turned down terminals may be used for locations outside clear zone.

(k) For use in medians 0 - 9 m wide.

(l) GR-8 is not acceptable on projects with design speeds greater than 70 km/h.

## GUARDRAIL INSTALLATION IN URBAN SETTINGS

In Urban settings with speeds of 70 km/h or less that include curb or curb and gutter, the use of guardrail is not recommended. Standard CG-2 or CG-6 (150 mm high curb) is usually used for speeds of 70 km/h or less in urban and suburban areas and is referred to as "barrier curb" because it has a 150 mm vertical face and is intended to discourage motorists from deliberately leaving the roadway. Even when CG-3 or CG-7 (100 mm high mountable curb) is used in Urban settings, it is impractical to install guardrail in an attempt to protect pedestrians walking along sidewalks due to the lack of accessibility caused when placing guardrail and terminals adjacent to accessible routes.

When curbed sections do not include sidewalk or sidewalk space and hazards exist that warrant guardrail, St'd. GR-2 (Strong Post) guardrail (which includes a blockout) should be installed with the face of the rail aligned with the face of the curb. This decreases the possibility of an errant vehicle striking the curb before impacting the guardrail or from snagging the guardrail posts. St'd. GR-8 (Weak Post) guardrail should not be used adjacent to asphalt or concrete curb.

Sometimes hazards that need to be shielded exist on urban projects with sidewalk/sidewalk space. In situations like this, guardrail can be placed behind the sidewalk and in front of the hazard. Examples of such hazards are ponds, steep embankments, etc. When these situations arise, sound engineering judgment should be used in deciding whether/where to place the guardrail. If the hazard is within the clear zone, a barrier would be warranted. The hazards that are outside the clear zone are the items that require an engineering decision based on evaluation of all the elements within the design site.

## GUARDRAIL LOCATIONS ON FIELD INSPECTION PLANS

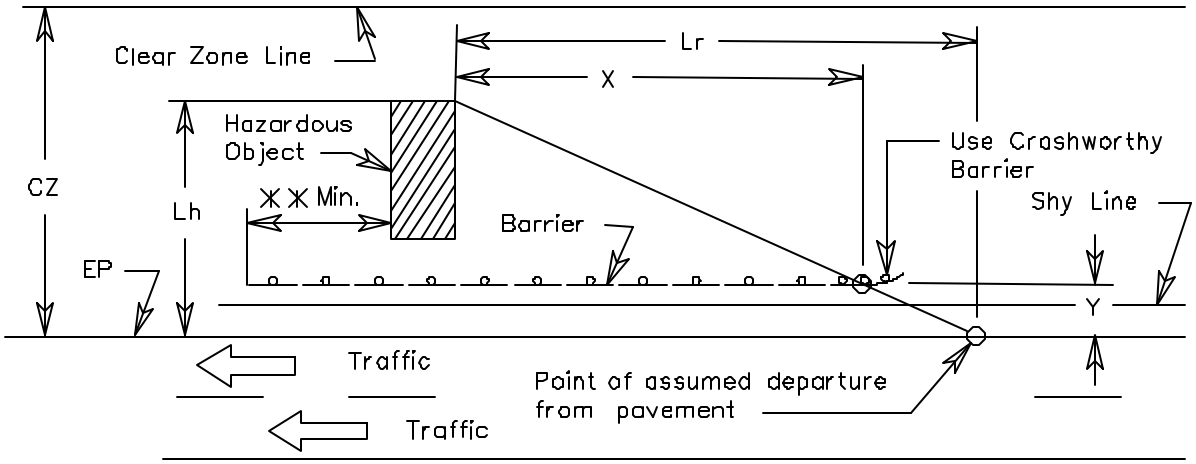
The approximate locations of barriers should be shown on field inspection plans and discussed at the field inspection. If the locations are not shown, the type, terminals, and placement should be generally discussed. Maintenance of areas protected by barriers should also be discussed at this time.

## DETERMINING LOCATION OF THE ENDS OF GUARDRAIL

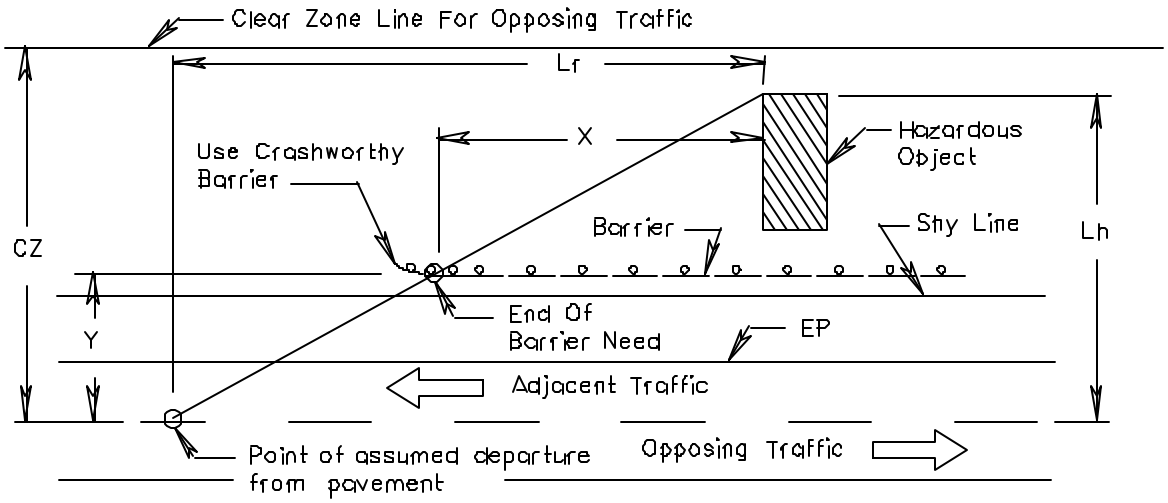
Figure A-3-1M and Table A-3-3M give a method to determine the location of the end of guardrail systems. Appropriate terminals shall be placed at this point.

**Figure A-3-1M - Barrier Length of Need Determination**

Condition showing hazard for adjacent traffic




Condition showing hazard for opposing traffic




$$X = (1 - {}^{Y}/_{Lh})\ Lr$$

X = Length of Need
CZ = Clear Zone Width
Lh Max. = CZ
Lr = Runout length (See table A-3-3M)
LS = Shyline

** = 7.6 m for GR-2
= 3.8 m for GR-2A
= 7.6 m plus a Type II for GR-8
= 0.3 m for MB-7C

## TABLE A-3-3M
## DESIGN PARAMETERS FOR ROADSIDE BARRIER LAYOUT

| DESIGN SPEED (km/h) | DESIGN TRAFFIC VOLUME (ADT) | | | | ✳ SHY LINE (m) | FLARE RATE | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | BEYOND SHY LINE | | INSIDE SHY LINE |
| | OVER 6000 | 2000-6000 | 800-2000 | UNDER 800 | | GR-2, 3 & 8 MB-3 | MB-7D, 7E, 7F, 12A, 12B & 12C | ALL |
| | RUNOUT LENGTH Lr (m) | RUNOUT LENGTH Lr (m) | RUNOUT LENGTH Lr (m) | RUNOUT LENGTH Lr (m) | | | | |
| 110 | 145 | 135 | 120 | 110 | 2.8 | 15:1 | 20:1 | 30:1 |
| 100 | 130 | 120 | 105 | 100 | 2.4 | 14:1 | 18:1 | 26:1 |
| 80 | 100 | 90 | 80 | 75 | 2.0 | 11:1 | 14:1 | 21:1 |
| 60 | 70 | 60 | 55 | 50 | 1.4 | 8:1 | 10:1 | 16:1 |
| 50 | 50 | 50 | 45 | 40 | 1.1 | 7:1 | 8:1 | 13:1 |

✳ Shy line is measured from the adjacent edge of pavement and is a distance beyond which a roadside object will not be perceived as a threat by a driver. In other words, a driver will not react to an object beyond the shy line offset. If possible, the roadside barrier should be placed beyond the shy line offset.

## SLOPES FOR APPROACH BARRIERS

As a general rule, a roadside barrier should not be placed on an embankment if the slope of the embankment is steeper than 10:1; however, in special cases, such as "barn roof" ("recoverable area") slopes, it is acceptable to place semi-rigid barrier on slopes as steep as 6:1. When semi-rigid barrier is used on 6:1 slopes, a 3.0 m rounding should be included between the shoulder and slope. Where it is not feasible for the entire graded median in the area of the hazard to be on a 10:1 slope, an acceptable alternative is to provide the 10:1 slope between the edge of pavement and the approach barrier (See Fig. A-3-2M). A clear run-out path should also be provided behind the terminal.

When recoverable areas are less than 4.3 m in width and guardrail is required, the guardrail is to be placed on a fill with guardrail (W/GR) shoulder and the recoverable area is not to be provided. Although not encouraged, guardrail is permitted on 6:1 slopes if located beyond 3.6 m of the shoulder hinge point.

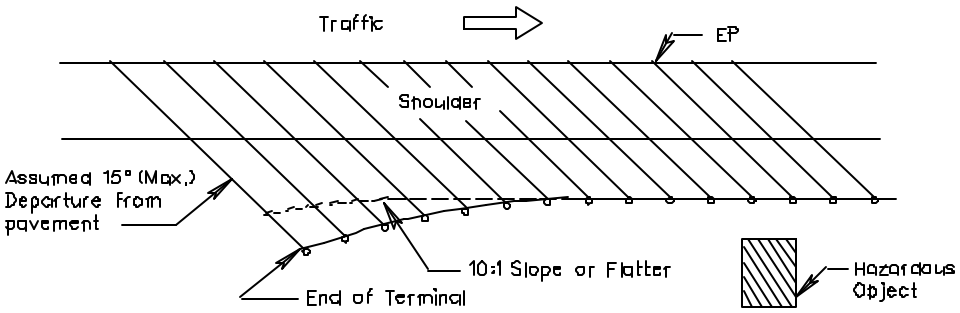



**Figure A-3-2M - Suggested Slopes For Approach Barriers**

## FIXED OBJECTS WITHIN DEFLECTION AREA

No fixed objects, regardless of their distances from the edge-of-pavement, will be allowed within the deflection zone of the guardrail system to assure that the barrier system will perform as designed. This will include overhead sign supports, walls, drainage structures, bridge piers, signal supports, utility poles, trees, etc. Additionally, the deflection zone must be free of breakaway signs, signals, and luminaire supports since their performance when struck by deflecting guardrail is unknown and untested. If a sign or luminaire support must remain within the deflection zone, it must be a breakaway design.

When it is impractical to locate these obstacles outside of the deflection zone of a particular type of guardrail (e.g., GR-8 = 2.1 m, GR-8B = 1.2 m), it will be necessary to strengthen the guardrail to decrease deflection or use a different type of guardrail or barrier which has less deflection so the object is shielded within the clear zone.

Methods of stiffening the rail include decreasing post spacing and double nesting of rail elements. Each stiffening method typically halves the deflection. The stiffening method should begin 5.4 m in advance of the hazard and continue at least to the end of the hazard. Plans fitting these criteria are to be submitted to the Engineering Services Section for review, approval, and details.

Table A-3-2M (Typical Barrier/Guardrail Selection and Placement) specifies the minimum offset distance required from "hazardous objects" to meet deflection requirements of the different types of barrier systems.

## FIXED OBJECT ATTACHMENT/TRANSITIONS POLICY

A transition section is needed where flexible (weak-post) roadside guardrail must join a rigid bridge railing, concrete barrier, retaining wall, etc. The transition design produces a gradual stiffening of the overall approach protection system so vehicular pocketing, snagging, or penetration can be reduced or avoided at any position along the transition. A transition is also needed when a GR-6, GR-7, or GR-9 terminal is used on the run-off end of a flexible (weak-post) guardrail system on undivided roadways with two-way traffic to protect opposing traffic from impacting the opposite end of the terminal. The Road and Bridge Standards include details on guardrail transitions.

A rub rail is provided in Standards GR-FOA-1, -2, and -4 to help prevent potential vehicular snagging at the immediate upstream end of the rigid bridge railing. The rub rail is not necessary on the Special Design GR-FOA-3 as it is attached to a flared terminal wall that has a transitioned face to prevent snagging. Special Design GR-FOA-3 will be retained for use only on bridges that have been designed with the flared terminal wall.

## ENTRANCES OR CONNECTIONS ADJACENT TO A BRIDGE

When entrances or connections cannot be relocated or eliminated and are located adjacent to a bridge on low-volume rural roads or in areas with dense entrance locations, it is necessary to install radial guardrail around the entrances or connections. Plans fittingthis criteria are to be submitted to the Engineering Services Section for review, approval and details.

## GUARDRAIL OVER CULVERT IN FILLS

Standard GR-10, Type I, II or III, is the preferred method of installing guardrail over culverts where fills are less than 1090 mm above the culvert top slab.

Type I is adaptable to culverts with a perpendicular width of 3.2 m or less. A 7.6 m section is used with the rail doubled and one post omitted. Type II is adaptable to culverts with a perpendicular width of 5.1 m. A length of 11.4 m is used with the rail doubled and two posts omitted. Type III is for use with a perpendicular width of 7 m. A length of 30.5 m is used with the rail doubled and three posts omitted.

In situations where the use of Standard GR-10 is not feasible, an allowable alternative may be the TEXAS T-6 (BGR-01) for speeds ≤ 70 km/h.

## SHORT GAPS

Short gaps between barrier installations should be avoided. When the areas of concern are less than 60 m apart, the barrier protection shall be made continuous.

## PONDS OR OTHER BODIES OF WATER

Barrier is to be constructed on all functional classifications at ponds or other bodies of water over 0.6 m in depth.

## TERMINAL REQUIREMENTS

Guardrail/barrier terminals are to be provided for all installations regardless of "Functional Classification". Terminals develop the necessary tension at the end of the system in order to redirect a vehicle and, if hit, minimize the damage to a vehicle and its occupants. The termini of guardrail/barrier must be designed and located so there are no exposed rail element ends within the clear zone that a vehicle could impact.

(1) Flexible (Weak Post or Cable) Guardrail Installations-

Cable guardrail should normally be used only on Limited Access projects that provide "Recoverable Areas" exceeding 4.3 m in width. Cable guardrail should be introduced when the height of fill slopes exceeds 6.0 m. This height is based on the hinge point between 6:1 slopes and 2:1 slopes. If the introduction of cable guardrail is in close proximity to an adequate cut section, it should be extended and terminated in the back slope of the cut ditch. (Use 15:1 transition for Design Speeds of 110 km/h or 13:1 transition for Design Speeds of 100 km/h or less). Standard GR-3 (Cable Guardrail) is terminated on both the run-on and run-off ends with an anchor assembly as detailed in St'd. GR-3.

When using GR-8 Weak Post Guardrail, the preferable run-on terminal is St'd. GR-6 which buries the end of the guardrail into a cut slope and anchors the terminal with a concrete block. This terminal treatment requires enough right of way to extend the guardrail a minimum of 3.8 m beyond the ditch line. The guardrail should terminate a minimum of 300 mm below the ground elevation of the backslope. The rail preceding the GR-6 terminal is to maintain a consistent height (760 mm) from the ground elevation to the top of the rail to prevent errant vehicles from impacting at an improper height. A total length of St'd. GR-8 Weak Post Guardrail based on the appropriate flare for the design speed shown on the standard drawing should be used adjacent to the St'd. GR-6 terminal. If more than a 60 m extension of St'd. GR-8 guardrail is necessary to tie into the slope with a Std. GR-6 terminal, it would not be cost effective. If the GR-8, Type II, terminal installation is not feasible, a St'd. GR-7 (Breakaway Cable Terminal) or GR-9 (Strong Post Alternate Breakaway Cable Terminal) including appropriate transitions should be used.

For run-off terminal treatment with St'd. GR-8 (weak post guardrail), the St'd. GR-8, Type II terminal is acceptable only for divided roadways or one-way traffic situations. When two-way traffic on an undivided facility would introduce the possibility of opposing traffic impacting an intended run-off terminal for another lane, a GR-6, 7, or GR-9 terminal must be used. Because the possibility would then exist for opposing traffic to impact the opposite end of the terminal, a transition (in accordance with the Road and Bridge Standards) must be used to join the St'd. GR-6, 7 or GR-9 terminal and the weak post guardrail system (GR-8) to minimize any possible impacts.

(2) Semi-Rigid (Strong Post) Guardrail Installations -

With Standard GR-2 (Strong Post Guardrail), the preferred run-on terminal treatment on divided and undivided roadways is to bury the end of the guardrail into a cut slope, using St'd. GR-6 terminal, even if the guardrail must be extended 60 m to accomplish this. If more than a 60 m extension of St'd. GR-2 (Strong Post Guardrail) is necessary to tie a St'd. GR-6 terminal into the back slope, cost-effectiveness would justify use of a St'd. GR-7 (Breakaway Cable Terminal) or GR-9 (Alternate Breakaway Cable Terminal). Run-off terminals for use with undivided roadways with two-way traffic are handled in the same manner. However, for the run-off terminal on a divided roadway or with one-way traffic, a W-Beam End Section treatment in accordance with St'd. GR-HDW details is sufficient to terminate the St'd. GR-2.

(3) Rigid (Concrete Barrier) Installations -

St'd. MB-7D, 7E, 7F, 12A, 12B and 12C Concrete Median Barriers are considered rigid installations, thus requiring special attention to the terminal treatment to minimize the hazard if impacted. For run-on treatment outside the clear zone and all run-off treatment, a concrete turned down terminal can be used to terminate concrete barrier.

A Standard Insertable Sheet is available in the CADD Insertable Sheet directory for a 3.6 m section of the turned down terminal. A special design Impact Attenuator must be requested for all sites within the clear zone where concrete median barrier must be terminated.

## TERMINAL INSTALLATION

(1) GR-8, Type II, Terminal Treatment Installation:

The St'd. GR-8, Type II, terminal is used only as a means of anchoring the run-off end of GR-8 (Weak Post) guardrail on divided or one-way roadways when installed outside the clear zone for opposing traffic. The guardrail is to be flush with the concrete anchor throughout the length of the anchor assembly in order for the installation to function properly without shearing the bolts.

(2) GR-6 Terminal Treatment Installation:

The St'd. GR-6 terminal is used as a means of terminating run-on or run-off ends of St'd. GR-2 or GR-8 guardrail on divided or undivided roadways by burying the end of the guardrail into the cut slope.

(3) GR-7 Breakaway Cable Terminal Installation:

When using the St'd. GR-7 terminals on standard shoulders,the 1.2 m flare as specified in the standard drawing or manufacturer' s specifications must be provided for the installation to function as tested. This is considered essential to proper performance for end-on impacts to eliminate the potential of spearing. In consideration of the 1.2 m flare requirement to construct the terminal treatment for St'd. GR-7, the shoulder in the terminal area must be widened sufficiently to accommodate site preparation for the terminal. The terminal should be located, or the barrier may need to be extended as needed, to provide a clear run-out path behind the terminal.

On bridge replacement projects and other projects (involving guardrail updates) on which existing shoulders are of insufficient width and for which there are no provisions for widening such shoulders, additional fill material is required to be placed to ensure that the flare can be correctly installed. Typical installation details are shown in StandardGR-SP with a tabulation of the applicable widths. (Projects with paved shoulders - Details are shown on Special Design Drawing No. 2154-A, Asphalt Paving Under Guardrail).

When this situation occurs for the GR-7 terminals on projects without normal grading operations, a pay item [Guardrail Terminal site preparation (GR- ) - Item Code 13349 with pay unit of Each] is to be used to cover the required embankment, benching and reseeding.

(A Special Provision Copied Note is available for use in contracts involving this pay item.)

New construction projects provide the necessary shoulder widening for the required guardrail terminals; therefore, the separate pay item for site preparation is not applicable.

(4) GR-9 Alternate Breakaway Cable Terminal Installation:

If the 1.2 m offset cannot be achieved to properly install the Standard GR-7 terminal, evaluate using a St'd. GR-9 or request a special design terminal treatment from the Engineering Services Section. The GR-9 terminal treatment should only be used after an analysis including additional right of way costs indicates it is more cost effective than providing the proper site preparation to install a St'd. GR-7 or to extend the guardrail (60 m maximum) to provide a St'd. GR-6 terminal. The estimated cost of the GR-9 terminal is $2000.

The GR-9 terminal is intended solely for use on the end of a w-beam installation with no flare. The guardrail is anchored in a manner similar to the standard breakaway cable terminal and redirects side-impacting vehicles. For an "end-on" hit, the terminal essentially flattens and slides backward, absorbing crash energy.

The total length of the terminal is 15.2 m. The length of need begins 3.8 m from the first post. The maximum deflection for the terminal along the length of need is 1.2 m. For GR-9 installations used to terminate GR-8 (weak post guardrail), an additional 15.2 m transition of St'd. GR-2 (wood posts only) is required.

(5) W-Beam End Section Installation:

For run-off treatment on a divided or one-way roadway, St'd. GR-2 (Strong Post) guardrail can be terminated with a W-Beam End Section in accordance with the Standard GR-HDW details as long as the installation is outside the clear zone for opposing traffic. The "flared" or "rounded" treatment may be used if installed outside the clear zone for opposing traffic. Payment is length of St'd. GR-2 guardrail.

## IMPACT ATTENUATORS (CRASH CUSHIONS)

During the preliminary design stages for new construction and for rehabilitation or reconstruction of existing highways, the need for and space requirements of crash cushions to shield non-removable fixed objects should be considered. This will ensure compatibility with the final design and the crash cushion that is to be installed. Since these devices are expensive to install and maintain, the hazard must be studied to determine if elimination is possible or its inherent hazard potential can be economically reduced to tolerable limits by less drastic safety treatments, such as guardrail, breakaway supports, set-back, safety shape, etc. Present procedure requires that the proposed site be selected by the roadway designer and reviewed by the Special Design section for the type of crash cushion to be used. When requesting the review and installation details from the Special Design section, submit a print of the plans with a transmittal slip giving the project number, activity number, roadway design speed and advertisement date. In no case will attenuation devices be designed for placement behind curbed locations. For additional data, refer to the AASHTO's Roadside Design Guide.

In 1993 the National Cooperative Highway Research Program (NCHRP) published NCHRP Report 350. As a result of that report the FHWA issued a requirement that all permanent safety hardware systems included in Federal Aid projects after August 1998 meet NCHRP 350. VDOT extended that requirement to include state funded projects as well.

Devices subjected to traffic speeds greater than 70 km/h must meet NCHRP 350 Test Level 3.

Devices subjected to traffic speeds of 70 km/h and less must meet NCHRP 350 Test Level 2.

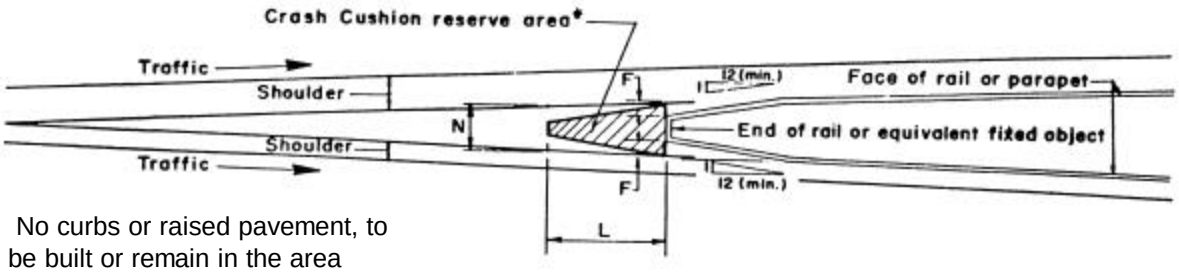
For a list of approved devices see Instructional and Informational Memorandum LD-(D)222.

Fixed roadside hazards vary in size and shape, and in the degree of danger they present. The traffic passing by varies as well in volume, speed and density. For thesereasons a selection from various types of crash cushions can be designed to meet the special requirements of a particular hazard site.

Figure A-3-3M suggests the area that should be made available for crash cushion installation. Although it depicts a gore location, the same recommendations will generally apply to other types of fixed object hazards that require shielding. The unrestricted conditions represent the minimum dimensions for all locations except for those sites where it can be demonstrated that the increased costs for obtaining these dimensions (as opposed to those for restricted conditions) will be unreasonable. The preferred condition dimensions should be considered optimum. The space provided by these dimensions will seldom be fully used by a crash cushion. These dimensions are recommended so there will be additional space available should experience dictate the need for a device capable of slowing larger vehicles than originally considered or for producing lower deceleration forces. In the meantime, the unoccupied space provides valuable motorist recovery area. Site conditions may dictate the type of attenuator needed. For example, fixed objects such as barrier ends which are less than 1 meter wide should be shielded by a narrow crash cushion. Similarly, wide hazards, e.g., those greater than 4.9 meters, can be effectively shielded best a wide impact attenuator or approved sand barrier arrays.

| DESIGN SPEED ON MAINLINE | TEST LEVEL | DIMENSIONS FOR CRASH CUSHION RESERVE AREA (Meters) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | MINIMUM | | | | | | PREFERRED | | |
| | | RESTRICTED CONDITIONS | | | UNRESTRICTED CONDITIONS | | | | | |
| (km\h) | NCHRP 350 | N | L ** | F | N | L ** | F | N | L | F |
| 50 | TL-2 | 6 | 2.4 | .5 | 2.5 | .35 | 1 | 3.5 | 5.2 | 1.5 |
| 60 | | 6 | 3.6 | .5 | 2.5 | 5.5 | 1 | 3.5 | 7.6 | 1.5 |
| 70 | | 6 | 4.6 | .5 | 2.5 | 6.7 | 1 | 3.5 | 8.8 | 1.5 |
| 80 | TL-3 | 6 | 5.2 | .5 | 2.5 | 7.6 | 1 | 3.5 | 10.1 | 1.5 |
| 90 | | 6 | 6.7 | .5 | 2.5 | 10.7 | 1 | 3.5 | 13.4 | 1.5 |
| 100 | | 6 | 8.5 | .5 | 2.5 | 13.7 | 1 | 3.5 | 16.8 | 1.5 |
| 110 | | 6 | 10.7 | .5 | 2.5 | 16.8 | 1 | 3.5 | 21.3 | 1.5 |

** Note: For Low Maintenance Impact Attenuators, a minimum length (L) of 9.4 meters may be required. Check manufacturers' design details.




✳ No curbs or raised pavement, to be built or remain in the area surrounding or occupied by the crash cushion.

**Figure A-3-3M**

## BRIDGES

When the proposed design calls for the utilization of an existing bridge having the older type parapet walls or rails, an appropriate detail showing the "Recommended Method for Attaching Guardrail to Bridge Rails" is to be obtained from the Engineering Services Section for inclusion in plans. Prints of the existing bridge rail should accompany the request. The method of measurement and basis of payment is for "Special Design Guardrail Bridge Attachment, (B or Str. No.), Lump Sum" which price bid shall include all materials, labor, tools, equipment, and incidentals necessary to complete the work connecting all segments of railto one bridge.

When the use of guardrail on depressed medians is being planned to shield bridge piers, the designer should also consider the use of a Special Design Impact Attenuator Bull Nose Barrier. This design has been used for several years with excellent performance. The design utilizes a 1.5 m radius W-beam guardrail and wooden breakaway posts; therefore, a 3.0 m wide median would be the minimum. A similar design of the "Bull Nose Barrier" is shown in the AASHTO Roadside Design Guide. (Pay Item - Bull Nose Barrier-Each - Computer Est. No. 13601.) Installation layout details will be furnished by the Engineering Services Section for each Bull Nose Barrier location for inclusion in the plans. Bull nose barriers must not be used behind or on top of curbs or raised medians.

## SECONDARY PROJECTS

See Section A-1-Geometric Standards (Metric), GS-3, GS-4, GS-7 and GS-8 for additional widths to be added to the normal shoulders on secondary roads when guardrail is required.

## SAFETY/MAINTENANCE PROJECTS

When developing details for a Safety or Maintenance project, care must be taken to ensure proper barrier installation/maintenance/replacement to upgrade any outdated locations. There may be locations on a project where the guardrail has not been hit, but the installation may not be the safest that can currently be provided if an errant vehicle impacted the guardrail. Attention should be given to the following factors in evaluating these locations:

(1) Location of barrier:
- relative to hazard
- relative to pavement
- relative to shoulder break point
- relative to fixed objects (such as bridges); face of guardrail should be aligned with bridge rail, not closer to the roadway

(2) Type of guardrail used (Strong Post or Weak Post):
- no longer use Weak Post guardrail adjacent to curb
- cable guardrail normally used only on Limited Access facility with recoverable area exceeding 4.3 m
- sufficient space for maximum deflection for type used

(3) Terminals (need, type, proper installation, etc.):
- end treatment needed on both ends of a run of barrier
- terminals used with strong post guardrail
- terminals used for run-on treatment with weak post guardrail
- terminal treatment used as anchor for run-off end of weak post guardrail when not subject to two-way traffic
- proper flare, anchor, post placement for terminal to effectively decrease damage caused to impacting vehicle
- substandard terminals such as GR-5 (old turndown terminal), old standard GR-7 (those with 0.6 m diameter concrete footings for first two posts), etc., should be replaced with approved terminals.
- at bridges/walls, guardrail terminals should not be located closer to the roadway than the bridge rail or wall (fixed object attachment should be installed instead of separate units)

(4) Shoulder width and site preparation:
- provide sufficient width for site preparation
- provide additional fill if necessary for proper flare installation
- provide clear run-out area behind terminal installation

(5) Fixed object attachments:
- proper attachments to fixed objects (such as bridges/walls) to reduce possibility of snagging vehicles that impact the attachment
- align guardrail with face of bridge rail so that the end of the bridge with the fixed object attachment will not become an additional hazard
- include proper transition to gradually stiffen the overall approach

THIS PAGE INTENTIONALLY LEFT BLANK