

## SECTION 8

### **GUIDELINES FOR GUIDE RAIL DESIGN AND MEDIAN BARRIERS**

#### **8-01 INTRODUCTION**

These guidelines are based on the *1988 AASHTO Roadside Design Guide*.

The information in this section is intended to serve as guidelines which will assist the designer in determining conditions which warrant the installation of guide rail and the dimensional characteristics of the installations. Also, this section contains information to serve as guidelines to assist the designer in determining conditions which warrant the installation of median barrier.

It is important that application of these guidelines be made in conjunction with engineering judgement and thorough evaluation of site conditions so that a proper solution is arrived at.

It should be emphasized that guide rail should not be installed indiscriminately. Every effort should be made to eliminate the obstruction for which the guide rail is being considered.

In some cases, another type of traffic barrier might be a better choice than guide rail. For example, obstructions in gores can often be more effectively shielded with a crash cushion. The designer should consider such alternatives and choose the most suitable solution based on safety requirements, economic limitations, maintenance, and aesthetic considerations.

#### **8-02 GUIDE RAIL WARRANTS**

##### **8-02.1 General**

Guide rail is considered a longitudinal barrier whose primary functions are to prevent penetration and to safely redirect an errant vehicle away from a roadside or median hazard.

##### **8-02.2 How Warrants are Determined**

An obstruction's physical characteristics and its location within the clear zone are the basic factors to be considered in determining if guide rail is warranted.

Although a wide range of roadside conditions are covered below, special cases will arise for which there is no clear choice as to whether or not guide rail is warranted. Such cases must be evaluated on an individual basis, and, in the final analysis must usually be solved by engineering judgement.

In the absence of pertinent criteria, a cost effective analysis could be used to evaluate guide rail needs.

##### **8-02.3 Clear Zone**

Clear zone is defined as the area, starting at the edge of the travelled way, available for safe use by errant vehicles.

The width of the clear zone ( $L_c$ ) varies with the speed, roadside slope and horizontal roadway alignment. The design speed should be used when determining the clear zone. The posted speed plus 5 mph may be used when determining the clear zone width on existing highways when no design speed is available.

Figure 8-A contains the suggested range of clear zone distances on tangent sections of roadway based on selected traffic volumes, speed and roadside slopes. Clear zones may be limited to 30 feet for practicality and to provide a consistent roadway section if previous experience with similar projects or designs indicates satisfactory performance. According to the *Roadside Design Guide*; the designer may provide clear zone distances greater than 30 feet as indicated in Figure 8-A, where such occurrences are indicated by accident history.

Figure 8-B contains examples of determining clear zone distances. More examples and further explanation are contained in the *Roadside Design Guide*.

Horizontal alignment does affect the clear zone width. Therefore, clear zone widths on the outside of horizontal curves should be adjusted as shown in Figure 8-C.

#### **8-02.4 Warrants**

A warranting obstruction is defined as a nontraversable roadside or a fixed object which is located within the clear zone and whose physical characteristics are such that injuries resulting from an impact with the obstruction would probably be more severe than injuries resulting from an impact with guide rail.

##### **1. Nontraversable Roadside**

Examples of a nontraversable roadside which may warrant guide rail are: rough rock cuts; large boulders; streams or permanent bodies of water more than 2 feet in depth; roadside ditches with slopes steeper than 1:1 and depths greater than 2 feet; embankment slopes and slopes in cut sections as described below.

##### **a. Embankment (Fill) Slopes**

A critical slope is one in which a vehicle is likely to overturn. Slopes steeper than 3:1 generally fall into this category. If a slope steeper than 3:1 begins closer to the traveled way than the suggested clear zone distance, guide rail might be warranted if it is not practical to flatten the slope.

Guide rail warrants for critical slopes are shown below:

<u>Critical Embankment (fill) Slopes</u>	<u>Maximum Height Without Guide Rail</u>
1 1/2:1	3'-0"
2:1	6'-0"
2 1/2:1	9'-0"

A non-recoverable slope is defined as one that is traversable but the vehicle can be expected to travel to the bottom of the slope before steering recovery can be obtained. Embankments between 3:1 and 4:1 generally fall into this category. Fixed objects should not be constructed or located along such slopes that begin closer to the traveled way than the suggested clear zone distance. A clear runoff area at the base of these slopes is desirable, see Figure 8-B for an example. The designer should, therefore, evaluate each site before providing 3:1 slopes without guide rail.

When flattening existing slopes to remove guide rail, the proposed side slopes should be recoverable, that is, 4:1 or flatter. Where embankment slopes are being constructed, the designer should investigate the feasibility of providing a recoverable slope in lieu of a critical slope with guide rail. Rounding should be provided at slope breaks; see Figures 5-C, 5-H and 5-I.

b. Slopes in Cut Sections

Slopes in cut sections should not ordinarily be shielded with guide rail. However, their potential hazard should be recognized.

Slopes in cut section of 2:1 or flatter may be considered traversable and, as the cut slope steepens, the chance of rollover increases. Where feasible, slopes steeper than 2:1 should be flattened. If there is a warranting obstruction on the cut slope, the following apply:

- (1) Guide rail should be installed if the warranting obstruction is on a slope flatter than 0.7:1 and is within the clear zone width specified in section 8-02.3
- (2) Guide rail should be installed if the warranting obstruction is on a slope of 0.7:1 or steeper and is less than 6 feet (measured along the slope) from the toe of slope and is within the clear zone width specified in section 8-02.3.
- (3) Guide rail is not required if the warranting obstruction is on a slope of 0.7:1 or steeper and is 6 feet or more (measured along the slope) from the toe of slope.

c. Drainage Features

Ditches should be designed to be traversable. Where feasible, existing ditches should be reconstructed so as to be traversable.

Figures 8-R and 8-S show criteria for preferred cross sections for ditches. According to the *1988 AASHTO Roadside Design Guide* :

"Cross sections which fall in the shaded region of each of the figures are considered to have traversable cross sections.

Superseded

Ditch sections which fall outside the shaded region are considered less desirable and their use should be limited where high-angle encroachments can be expected, such as the outside of relatively sharp curves. Ditch sections outside the shaded region may be acceptable for projects having one or more of the following characteristics : restrictive right-of-way, rugged terrain, resurfacing, restoration or rehabilitation (3R) construction projects, or on low volume or low speed roads and streets, particularly if the ditch bottom and back slopes are free of any fixed objects.

If practical, ditches with cross sections outside the shaded regions and located in vulnerable areas may be re-shaped and converted to a closed system (culvert or pipe), or in some cases, shielded by a traffic barrier."

## 2. Fixed Objects

Examples of fixed objects which may warrant guide rail are: overhead sign supports, traffic signals and luminaires supports of nonbreakaway design; concrete pedestals extending more than 4 inches above the ground; bridge piers, abutments and ends of parapets and railings; wood poles or posts with a cross-sectional area greater than 50 square inches; and drainage structures.

Overhead sign supports should be located as close to right-of-way line as practical. Guide rail protection for all overhead sign supports should be provided regardless of location beyond the clear zone. This will limit severe implications resulting from impacts to the sign support.

### a. Trees

Trees, 6 inches in diameter, are considered fixed objects. However, trees are not considered a warranting obstruction for guide rail since guide rail is not installed solely for the purpose of shielding trees. The following guidance is provided for the treatment of trees within the clear zone:

- (1) On freeways and interstate routes, trees shall not be located within the clear zone.
- (2) Although it is desirable to provide a clear zone free of trees on land service roads, it is likely that situations will be encountered where removal of trees within the clear zone cannot be accomplished. For instance, the aesthetic appeal of the trees may cause local opposition to their removal, the trees may not be within the ROW, or removal of the trees may not be environmentally acceptable.

In some cases it may be appropriate to plant replacement trees outside the clear zone so that the removal of trees in close proximity to the roadway may be accomplished without severe public criticism.

Factors such as accident experience, traffic volume, speed, clearance from the traveled way and roadway geometry should be evaluated when determining whether it is appropriate to leave trees within the clear zone.

Sick and diseased trees that are beyond reasonable repair, along with dead trees, trees that cause sight distance problems and trees with a significant accident history shall be removed regardless of public criticism. Also, trees that will be harmed beyond reasonable repair due to construction shall be removed (ie: new curb that destroys the main root system). The Bureau of Landscape should be consulted for the tree's physical assessment.

Trees that have grown in behind guide rail, which are less than four feet from the back of rail element, shall be removed regardless of size. Trees, scrubs and overhanging branches shall be removed where they block or obscure horizontal sight distance whether they are behind guide rail or not. Undesirable branches shall be removed up to a height of 16 feet. The following areas should be checked for sight distance problems:

- (1) Along the inside of horizontal curves (mainline, ramps and jughandles)
- (2) Ramp and jughandle entrances and exits.
- (3) Within the sight triangle at intersections.
- (4) Sign obstructions.

If clearing work is necessary within existing utility lines, the designer should request the utility company to perform regular trimming maintenance (at their cost) in the locations during the utility notification process. However, if clearing work is necessary where poles are to be relocated, then the utility company or the contractor shall be compensated for this work.

b. Utility Poles

Although utility poles have a cross-sectional area greater than 50 square inches (8" diameter.), they should not be handled the same as other warranting obstructions. It is questionable whether a safer roadside would result from installing guide rail for the sole purpose of shielding utility poles within the clear zone. Utility poles shall be located as close to the right of way line as practical. For the offset to the utility pole from the traveled way, the designer should refer to the *Utility Accommodation Regulation (NJAC 16:25)*, effective date August 9, 1993. For a quick and easy reference refer to the *NJDOT Design Criteria for Above Ground Utilities* dated January 26, 1995.

Desirably on projects where new right of way is to be purchased, sufficient right of way should be acquired to permit the placement of the poles beyond the clear zone.

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On existing highways, where the utility pole offset does not meet the Department standards (*Utility Accommodation Regulation (NJAC 16:25)*), the designer should prepare an accident analysis of existing pole locations to determine if the relocation of the utility poles further from the edge of through lane is warranted. Any utility pole which has been struck 3 times or more within 3 years, will require corrective action. Also, neighboring poles that have been struck a total of 3 or more times within 3 years will require corrective action. If corrective action is necessary, safety measures such as utility pole relocation and/or the improvement of the contributing roadway feature should be considered in lieu of guide rail.

Utility poles should not be placed in vulnerable locations, such as in gore areas, small islands or on the outside of sharp horizontal curves. For the purpose of these guidelines, a sharp horizontal curve is considered as any horizontal curve with a safe speed less than the posted speed.

In no case, shall utility poles on new or upgraded guide rail installations remain in front of the guide rail. The guide rail offset has preference over existing utility pole offsets where there is sufficient right of way. Therefore, where practical, do not place the guide rail closer to the road, instead, relocate the pole behind the guide rail. Guide rail is an obstruction in itself and should be placed as far from the traveled way as possible.

Where utility poles are placed behind guide rail, desirably the face of the pole should be four (4) feet or greater from the back of the rail. Where the offset is less than 4 feet, provide reduced post spacing and double rail element as per the *Standard Roadway Construction Details*. However as a minimum, the face of the pole shall be no closer than six (6) inches from the back of the rail.

It should be noted that spacing of guide rail posts at long runs of guide rail or at bridge installations may conflict with the spacing of the utility poles. In this case, the minimum pole offset where a conflict occurs should be no closer than eighteen (18) inches from the back of the rail, which equals six (6) inches from the back of the post.

Utility poles should not be located within the thirty seven and one half (37.5) feet parabolic flare of the eccentric loader terminal (ELT) and within the fifty (50) feet length of the extruder terminal (ET-2000), see Figure 8-D. Also, utility poles should be at least twenty five (25) feet or greater in advance of an ELT or an ET-2000.

c.. Fire Hydrants

Since fire hydrants do not meet the current AASHTO definition for breakaway design, they fall into the category of fixed objects that may warrant guide rail. The same reasoning applies here as was applicable to utility poles.

The acceptable solution is to locate the hydrants as far from the traveled way as possible. In no case shall fire hydrants be located in front of the guide rail. However, the hydrants must be located so as to be readily accessible at all times.



Where guide rail is required for some other reason and will be in front of a hydrant, the preferred treatment is to raise the hydrant so as to permit connection to be made over the guide rail. Usually, the connection may be a maximum of 36" above grade. It is the responsibility of the designer to confirm with the local Fire Department that such a treatment is acceptable. A less desirable treatment is to provide a short opening in the guide rail at the hydrant. Where an opening is provided, ELT's or an Anchorage must be provided in accordance with Section 8-03.2. The guide rail must be modified as per Section 8-03.1.3 when the offset to the face of hydrant from back of rail element is less than 4 ft.

d. Mailbox Supports

Limited accident data has shown that mailbox supports can contribute to the severity of an accident. The following guidelines should be followed on new construction, reconstruction and projects that involve resurfacing:

No more than two mailboxes may be mounted on a single support structure unless the support structure and mailbox arrangement have been shown to be safe by crash testing. Lightweight newspaper boxes may be mounted below the mailbox on the side of the mailbox support.

Mailbox supports shall not be set in concrete unless the support design has been shown to be safe by crash tests when so installed, see cantilever mailbox design in the *Standard Roadway Construction Details*.

A single 4-inch x 4-inch wooden post or 4 1/2-inch diameter wooden post or a metal post with a strength no greater than a 2-inch diameter standard strength steel pipe and embedded no more than 24 inches into the ground will be acceptable as a mailbox support, see the *Standard Roadway Construction Details*. A metal post shall not be fitted with an anchor plate, but it may have an anti-twist device that extends no more than 10 inches below the ground surface.

In areas where snow removal is a problem, a cantilever mailbox type support as shown in the *Standard Roadway Construction Details* may be permitted to allow snowplows to sweep under or near mailboxes without damage to their supports.

The post-to-box attachment details should be of sufficient strength to prevent the box from separating from the post top if the installation is struck by a vehicle. The *Standard Roadway Construction Details* show acceptable attachment details.

The minimum spacing between the centers of support posts shall be three-fourths of the height of the posts above the ground line.

For more information on mail stop design and mailbox location, see *A Guide for Erecting Mailboxes on Highways*, AASHTO, May 24, 1984.

3. Pedestrians

Guide rail may be used where there is a reasonable possibility of an errant vehicle encroaching into an unprotected area used by pedestrians. Some examples are where a playground, school yard, or a public beach is adjacent to the right-of-way line. The basis for assessing the needs should be the accident experience of the immediate area and the specifics for the cause(s) of the accidents. There may be times when no causative factor can be isolated, and sound engineering judgement must be applied.

This policy is not intended to indiscriminately permit the installation of guide rail at every location where a request for guide rail has been received, but to offer some flexibility to the designer when unique circumstances occur.

There are locations where existing guide rail and the PVI (top of slope) of a steep slope are both located directly behind a pedestrian sidewalk area. If new guide rail is installed in front of the sidewalk area, the existing guide rail should either be left in place or the existing guide rail should be removed and a fence installed in its place. When guide rail is placed between the roadway and the sidewalk, a rail element may be attached to the back of the guide rail post so that pedestrians are shielded from the exposed back of post. The rail element, if added, shall not be located within the thirty seven and one half (37.5) feet parabolic flare of an ELT or within the fifty (50) feet length of an ET-2000.

**8-03 DIMENSIONAL CHARACTERISTICS**

**8-03.1 Clearance From the Traveled Way**

1. Without Curb or Raised Berm in Front of Guide Rail

A highly desirable characteristic of any roadway is a uniform clearance from the traveled way to the guide rail. It is desirable to place the guide rail at a distance beyond which it will not be perceived as a threat by the driver, see Figure 8-E, Table-1: Shy Line Offset. In general, the following offsets and slopes should be used:

- a. To the extent possible, guide rail should be located as far as possible away from the traveled way to provide a recovery area for errant vehicles and to provide adequate sight distance along horizontal curves and at intersections.
- b. On interstate highways and freeways, the front face of the guide rail should desirably be 4 feet or more from the outside edge of shoulder.
- c. On land service highways the front face of the guide rail should desirably be 7 feet or more from the outside edge of shoulder. Where the above offsets are not possible, the guide rail should be installed flush with the gutter line.

Where providing an offset of 7 feet or more, the designer is advised that additional right of way or slope easements may be necessary to construct the parabolic flare offset and/or provide the six foot flat area (10:1 minimum slope) adjacent to the Eccentric Loader Terminal (ELT) as shown in Figure 8-D. If the purchase of additional right of way is infeasible, an Extruder Terminal (ET-2000) should be provided at an offset of seven feet or more, in lieu of the ELT. If this is still infeasible, then the guide rail should be installed flush with the gutter line to permit the construction of the ELT with the parabolic flare offset and flat area.

- d. Where guide rail is located at the top of an embankment slope, the posts should be a minimum of 2 feet from the PVI to the center of the post. When less than 2 feet is provided, the following post lengths should be used:

<u>Embankment Slopes</u>	<u>Additional Post Length (feet)</u>
Flatter than 6:1	No Change
6:1 to 4:1	1'
3:1 to 2:1	2'
Steeper than 2:1	4'

- e. Guide rail shall be placed on slopes 10:1 or flatter provided the rollover between the shoulder slope and the embankment slope is not greater than 10%.
- f. Figure 8-D illustrates the slope treatment for embankment slopes at the ELT.

## 2. Curb or Raised Berm in Front of Guide Rail

Curb or a raised berm in front of guide rail should be avoided, see Section 5-06.2, Types of Curb.

On freeways and Interstate highways, new installations of vertical curb shall not be constructed. However, sloping curb may be constructed on urban freeways and urban Interstate highways but the overall curb height shall not exceed 4 inches. On land service highways, a design without curb or raised berm in front of guide rail should be provided where possible.

On projects which involve upgrading existing roadways, where there is curb or a raised berm in front of guide rail, removal or modification of the curb or raised berm should be the first consideration. If a raised berm in front of the guide rail cannot be removed, it shall be regraded at 10:1. Where curb in front of guide rail cannot be removed, seventy-five feet of curb in advance of and fifty feet beyond the front of an ELT or ET-2000 shall be no greater than 4 inches.

If curb (vertical curb and/or sloping curb) is present and cannot be removed, the following apply (along with Section 8-03.1: 1d, e and f):

a. Highways With a Posted Speed of More than 40 MPH:

On freeways and interstate highways where sufficient roadside width is available, guide rail should be placed 10 feet or more behind the gutter line. On land service roadways where there is a sidewalk or sidewalk area used by pedestrians, guide rail should be placed at 7 feet or more behind the gutter line. Where the above offsets are not possible, the guide rail should be installed flush with the gutter line.

Where providing an offset of 7 feet or more, the designer is advised that additional right of way or slope easements may be necessary to construct the parabolic flare offset and/or provide the six foot flat area (10:1 minimum slope) adjacent to the ELT as shown in Figure 8-D. If the purchase of additional right of way is infeasible, an Extruder Terminal (ET-2000) should be provided at an offset of seven feet or more, in lieu of the ELT. If this is still infeasible, then the guide rail should be installed flush with the gutter line to permit the construction of the ELT with the parabolic flare offset and flat area.

b. On Roadways With a Posted Speed of 40 MPH or Less:

Guide rail may be placed any distance behind the gutter line, but usually an offset of 4 feet or more (freeway or Interstate ramps), or 7 feet or more (land service roadways) should be used.

Where the "4 feet or more" and "7 feet or more" offsets are not possible, the guide rail should be installed in accordance with the previous discussion on parabolic flare offset and flat area (use "4 feet or more" instead of "7 feet or more" when addressing freeway or interstate ramps).

c. Rub Rail

When guide rail is constructed less than three (3) feet from a curb (vertical curb and/or sloping curb) or raised berm which is 4" or greater in overall height, the mounting height is measured from the top of curb and rub rail is required. Where guide rail is set flush to the gutter line and goes across short sections (ie: less than 100 feet long at each location) of curb, less than 4 inches in height; the mounting height may be measured from the gutter line, in which case, rub rail is not required.

On all projects involving new guide rail or the upgrading of existing guide rail, every effort should be given to the elimination or reduction in the use of rub rail.

Acceptable methods for reducing or eliminating the need for rub rail include: providing sufficient offsets, removing or revising earth berms, providing designs without curb, and eliminating existing curb where economically feasible.

Superseded

3. At Fixed Objects

Where guide rail is used to shield an isolated obstruction it is more important that the guide rail be located as far from the traveled way as possible so as to minimize the probability of impact. The distance from the back of the rail element to the face of obstruction should desirably be 4 feet or greater, see *Standard Roadway Construction Detail* CD-28.8. If less than 4 feet must be used, the guide rail system must be modified (See CD-28.4, 28.6 and 28.7).

4. On Bridges

a. Safety walks range in width from 1'-6" to less than 4 feet. On existing freeway and interstate structures with safety walks where it is not feasible to remove and provide a concrete barrier shaped parapet, the guide rail shall be carried across the structure along the gutter line. However, on existing freeway and Interstate ramps where the posted speed or advisory speed is 40 mph or less and the safety walk is 2'-6" or less in width, it is not necessary to carry guide rail across the structure since vaulting is not likely to occur. In this case, guide rail should only be provided across the structure if the parapet is not crashworthy.

b. When the roadway approaching a structure is curbed or bermed, the guide rail mounting height on the structure should be measured from the top of curb. However, the guide rail mounting height may be measured from the gutter line provided the face of guide rail is flush with the curb face.

The guide rail mounting height should be measured from the gutter line on those structures where the approach roadway is an umbrella section and the face of guide rail is set flush with the curb face on the structure.

Where guide rail is set flush with the curb face and the mounting height is measured from the gutter line, rub rail is not required.

c. When there is a difference in the offset to the approach guide rail and the offset to the bridge parapet, a transition flare of 15:1 should be used.

d. Attachment of guide rail to bridges and structures shall be in accordance with the Department's *Standard Roadway Construction Details*; revised or modified Standard Details; or Special Details.

e. Where there is considerable pedestrian traffic, the guide rail may be set flush to the curb face to physically separate pedestrians from vehicular traffic if feasible (see Section 8-02.4.3).

### **8-03.2 End Treatments**

#### **1. Eccentric Loader Terminal (ELT)**

- a. Eccentric Loader Terminals shall be used on the approach ends of beam guide rail installations terminating within the clear zone, unless covered by conditions noted in 8-03.2.2, 8-03.2.3 or 8.03.2.4. Also, if the approach end of guide rail for opposing traffic is within the clear zone, an ELT shall be used (see Figure 8-H).

A 37 foot 6 inch parabolic flare shall be used with all ELT end treatments. This parabolic flare provides for a flare offset of four feet, see *Standard Roadway Construction Details*. The ELT shall be placed a minimum distance of 12 feet 6 inches beyond the length of need.

- b. An ELT shall not be installed behind curb greater than 4 inches in height. Where there is existing curb or proposed curb greater than 4 inches in height, seventy-five (75) feet of curb immediately in advance of and fifty (50) feet beyond the front of an ELT shall be removed and replaced with 9" x 16" (4" face) white concrete vertical curb.
- c. A clear area shall be provided behind an ELT installation. The desired clear area is shown cross-hatched on Figure 8-D. Slopes in front of guide rail and 6 feet behind the ELT shall be graded at 10:1 or flatter, see Figure 8-D.
- d. Rub rail, reduced post spacings, and double rail elements shall not be used within the 37 feet 6 inch parabolic flare of an ELT.
- e. Where guide rail is installed along a horizontal curve, the post offsets for the parabolic flare is measured from a line tangent to the horizontal curve.

#### **2. Extruder Terminal (ET-2000)**

- a. At locations where it is not possible to construct an ELT with a four foot parabolic flare, an ET-2000 should be used. The ET-2000 is 50 feet long and is erected parallel to the roadway without needing a parabolic flare to function properly. The ET-2000 shall be placed a minimum distance of 12 feet 6 inches beyond the length of need.
- b. Where the guide rail is installed flush with the gutter line, the ET-2000 shall be constructed with a 50:1 straight flare for its entire length so that the guide rail extruder does not protrude into the roadway.
- c. Where the ET-2000 is installed along a horizontal curve, the ET-2000 shall be constructed tangent to the curve (straight), therefore its offset from the roadway may have to be adjusted so it does not protrude into the roadway.
- d. The curb requirements for the ELT in b. above is applicable to the ET-2000. The ET-2000 shall have a clear area six feet behind the ET-2000 for its entire length of 50 feet.

- e. Rub rail, reduced post spacings, and double rail elements shall not be used within 50 feet from the end of the ET-2000.

3. Beam Guide Rail Anchorage

- a. On a one-way roadway or a divided roadway with a nontraversable median, trailing ends of guide rail installations should be anchored with a Beam Guide Rail End Anchorage, as shown in *Standard Roadway Construction Detail* CD-29.2.
- b. In cut sections, the approach ends of guide rail installations should be anchored with a Beam Guide Rail In Line Anchorage and buried in the slope as shown in Figure 8-K and in the *Standard Roadway Construction Detail* CD-28.5 and CD-29.1. A straight flare should be used where the guide rail is buried in a cut slope. Table-1 of Figure 8-E shows the straight flare rate allowable for various speeds.
- c. In special cases, where the approach end of a guide rail installation is located so that an end hit is unlikely, the end may be anchored with a Beam Guide Rail End Anchorage as shown in *Standard Roadway Construction Detail* CD-29.2. One example would be where the approach end of a guide rail installation for opposing traffic is outside the clear zone, see Figure 8-H, Step 1.

4. Crash Cushion Attenuating Terminal (C.A.T.) or Brakemaster

- a. A C.A.T. or Brakemaster terminal shall be used when terminating dual face beam guide rail within a grass median, see Figure 8-I.
- b. A C.A.T. or Brakemaster shall be installed on relatively flat surfaces (8 percent or flatter slope). Use on raised islands or behind curbs is not recommended.

All curbs, islands, or elevated objects (delineators, signs) present at the C.A.T. or Brakemaster site and over 2 inches high should be removed. Curbs greater than 2 inches high should be removed a minimum of 75 feet in front of the C.A.T. or Brakemaster system and as far back as the rear of the system, and replaced with 2 inch high curb.

The Brakemaster and C.A.T. shall be installed on a four foot wide Non-Vegetative Surface, Bituminous Concrete. If there is a cross slope of more than 8 percent at the Brakemaster location, a leveling pad must be used.

- c. The C.A.T. is 31 feet 3 inches long (measured from centerline of first post to centerline of sixth post) and the Brakemaster is 31 feet 6 inches long (measured from centerline of anchor assembly to centerline of sixth post). A tail end attachment to dual-face beam guide rail is also required which is an additional 12 feet 6 inches.
- d. Since the C.A.T. and Breakmaster terminals are proprietary products, both shall be included in all contracts under the item name, Telescoping Guide Rail End Terminal, when an end terminal is required for dual face beam guide rail.



Superseded

5. Existing Breakaway Cable Terminals (BCT)

Existing BCT's shall be replaced with the crashworthy terminals discussed in Section 8-03.2 at the following locations:

- a. BCT's that must be replaced due to accident damage shall be upgraded with a crashworthy terminal other than a BCT.
- b. Any BCT installed within the clear zone without a 37 foot 6 inch parabolic flare (4 foot offset) shall be replaced in conjunction with regularly scheduled roadway work in the same area.

Where BCT's require replacement in a. and b. above, upgrade the entire run of guide rail that the BCT is attached to.

**8-03.3 Approach Length of Need**

The approach length of need (L.O.N.) is the minimum length of guide rail required in front of the warranting obstruction to shield the hazard effectively.

1. On Embankment Slopes

The approach L.O.N. on embankment (fill) slopes should be determined in accordance with Figures 8-E and 8-F. On a two-way, undivided highway or on a divided highway with a narrow traversable median, an "approach end " treatment may be required for both directions of traffic; see Figure 8-H to determine the approach L.O.N. for opposing traffic on embankment (fill) slopes.

The guide rail treatment for critical embankment slopes is shown in Figure 8-G.

Figure 8-I shall be used when determining the approach L.O.N. when terminating dual face beam guide rail within a grass median

2. In A Cut Section

See Figure 8-J for an example of determining L.O.N. in a cut section. Also, see Figure 8-K to determine the length required beyond the toe of slope to bury the guide rail.

3. At Driveways

If the existing driveway falls outside the L.O.N., design guide rail as shown in Figure 8-E.

Where existing driveways are located within the L.O.N., the designer's first consideration should be to relocate the driveway as far away from the warranting obstruction as the property line allows. If the relocated driveway falls outside the L.O.N., design guide rail as shown in Figure 8-E.

If a driveway cannot be relocated beyond the L.O.N., use treatments shown in Figures 8-L or 8-M. The Controlled Release Terminal (CRT) shown in Figure 8-M is the preferred design. Where the minimum functional length of the ELT in Figure 8-L is longer than the space available from the obstruction to the driveway or the right of way purchase is impractical for the CRT in Figure 8-M, consideration should be given to using a G.R.E.A.T. system.

Driveway openings sometimes fall within a continuous guide rail run. An example of a guide rail treatment at this location is shown in Figure 8-N.

4. At Gore Areas

It is desirable to provide a traversable and unobstructed gore area since the gore area may serve as a recovery area for errant vehicles. Urban areas, wetlands, parklands, etc. can put restrictions on this policy by placing warranting obstructions such as critical embankment slopes, parapets or abutments close to gore areas. The closer the obstruction to the gore area, the closer the L.O.N. to the gore area, therefore the more limited the guide rail treatment becomes. Figures 8-O and 8-P provide guide rail treatment examples for gore areas, starting from less restricted or open gore areas in Figure 8-O to more restricted or limited gore areas in Figure 8-P.

The preferred treatment for gore areas is no guide rail warrants at all.

**8-03.4 Guide Rail Details**

The dimensions and other characteristics of beam guide rail posts, rail elements, fasteners, etc. are shown in the *Standard Roadway Construction Details*.

**8-03.5 General Comments**

1. Guide rail should not restrict sight distance. Sight distances should be checked when guide rail is to be installed at intersections, ramp terminals, driveways, along sharply curving roadways, etc. If the sight distance is determined to be inadequate, the guide rail placement shall be adjusted.
2. Wherever part of an existing guide rail run is lengthened, reset or upgraded, then the entire run shall be upgraded to current standards including the bridge attachments. Also, always end a project outside the limits of a guide rail run.
3. Gaps of 200 feet or less between individual guide rail installations should be avoided where possible.
4. Guide rail should not be installed beyond the right-of-way unless easements or necessary rights-of-way are acquired.
5. For the guide rail treatment at adjacent bridges, see Standard Roadway Construction Detail CD-29.3. Guide rail between parapets is not required if there is a concrete connecting wall 2'-3" high (minimum) between parapets.

6. Proposed guide rail set flush with the curb line along intersection radius returns should be checked with a truck turning template. Existing guide rail along radius returns that experience truck overhang or oversteering accidents shall either be reset farther from the curb line or redesign the radius return for a larger design vehicle.

7. Thrie Beam

With the exception of guide rail transitions at bridges, Thrie beam should not be substituted for W-beam with rub rail unless there are extenuating circumstances and then only with the approval of the Bureau of Roadway Design Standards.

8. All approach end treatments (ELT, ET-2000, etc.) shall be located on the construction plans by station and offset. The applicable flare rate shall also be indicated.

9. Conduits

The plans shall indicate the location of existing conduits or shall include a notation where there is a possibility of conflict in driving the guide rail posts.

## **8-06 MEDIAN BARRIER**

A median barrier is a longitudinal system used to prevent an errant vehicle from crossing that portion of a divided highway separating travelled ways for traffic in opposite directions.

### **8-06.1 Warrants for Median Barriers**

1. Interstate and Freeways

Figure 8-Q presents the warrants for median barriers on high speed access controlled highways with traversable slopes 10:1 or flatter.

At low ADT's the probability of a vehicle crossing the median is relatively small. Thus, for ADT's less than 20,000 and median widths less than 20 feet, the median barrier is optional. Likewise, for relatively wide medians, the probability of a vehicle crossing the median is also relatively small. Thus, for median widths greater than 30 feet with ADT's below the warrant curve, and for widths greater than 50 feet, regardless of the ADT, the use of median barriers is optional unless there is a significant history of across-the-median accidents.

2. Land Service Highways

Careful consideration should be given to the installation of median barriers on land service highways or other highways with partial control of access. Problems are created at each intersection or median crossover because the median barrier must be terminated at these points.

An evaluation of the number of crossovers, accident history, alignment, sight distance, design speed, traffic volume and median width should be made before installation of median barriers on land service highways. Each location should be looked at on a case-by-case basis with the prevailing reason for its installation being the number of crossover accidents.

### 3. Median Barrier Type

Median barrier type, when warranted, is related to median width as shown below:

<u>Median Width</u>	<u>Median Barrier Type</u>
Up to 12 Feet:	Concrete Barrier Curb
13 to 26 Feet:	Concrete Barrier Curb (Preferred Treatment) or Dual Face Beam Guide Rail
Above 26 Feet:	Dual Face Beam Guide Rail

Where barrier curb is used to shield an obstruction (bridge piers, abutments, sign bridges, etc.), a minimum offset of 3.25 feet from the gutter line to the face of the obstruction shall be used, since high profile vehicles have a tendency to lean when impacting barrier curb at a high speed (60 mph or greater) and angle (25 degrees) and may strike the obstruction behind it, see Figure 5-K.

### 4. End Treatments

When terminating the approach end of dual face beam guide rail beyond the clear zone, an end anchorage with end section (buffer) is required as shown in the *Standard Roadway Construction Details* CD-27. When terminating the approach end of concrete barrier curb beyond the clear zone, a tapered concrete terminal section is required as shown in the *Standard Roadway Construction Detail* CD-21.4.

Where a median barrier terminates within the clear zone area on freeways and Interstate highways, a crashworthy end treatment shall be used. Acceptable methods of developing a crashworthy end treatment would be to use a crash cushion such as a Guide Rail Energy Absorbing Terminal (G.R.E.A.T.) system or an Adiem with concrete barrier curb; or use a Crash Cushion Attenuating Terminal (C.A.T.) or Breakmaster with dual face beam guide rail.

In the past, on land service highways, tapered concrete terminal sections have been provided where concrete barrier curb terminated at an intersection. Since pavement edge markings are not generally provided through intersections, there is no visual reference for the guidance of the driver through the intersection during adverse weather and visibility conditions. Therefore, at existing concrete barrier curb locations, a crashworthy end treatment may be appropriate on the concrete barrier curb end located on the outside of a horizontal curve with a radius of approximately 1000 feet or less. A dotted line may be used to extend markings as necessary through the intersection to guide vehicles making left-turn moves from the cross street or to guide vehicles in the high speed through lanes.

Superseded

On land service highways where the posted speed exceeds 40 mph (60 km/h), all concrete barrier curb that terminate within the clear zone on any roadway segment shall have the exposed concrete barrier curb end protected by a crash cushion at:

- a. New locations of concrete barrier curb.
- b. New locations of concrete barrier curb that are being installed to replace substandard height barrier curb.
- c. Existing locations of concrete barrier curb on a reconstruction project.
- d. A new, relocated or widened opening in existing barrier curb for emergency u-turns, pedestrian crossings, jughandles or intersections.

The introduction of new or existing median concrete barrier curb within the clear zone other than at intersections shall be protected with a crash cushion regardless of the posted speed.

See Figure 6P for treatment of concrete barrier curb at median openings.

On December 22, 1993, the Federal Highway Administration has taken the position that any project that includes existing or proposed tapered concrete terminal section within the clear zone, on any roadway segment where the posted speed exceeds 40 mph (60 km/h), for the locations previously discussed, without providing the protection of a crash cushion, will make the entire project ineligible for Federal-aid highway funds, except if proper documentation is provided in the Project Report. This documentation should be performed for all projects, regardless of funding.

## INSERT IN STANDARD SPECIFICATION 612.03

### CONSTRUCTION PROCEDURES

In an effort to provide a safe roadside area during construction, the following procedures are a guide to installing guide rail on existing highways. Consideration should be given to placing the following procedures in the supplemental specifications of each individual project:

1. **The installation shall be made in such a manner that no unprotected end is exposed to approaching traffic.**
2. New guide rail, **exposed to approaching traffic**, should be installed prior to the removal of the existing system to the maximum extent possible to provide some degree of protection for the warranting obstruction at all times.