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I. Introduction

These guidelines are based on the Roadside Design Guide, AASHTO, 4th Edition, 2011. This Design Guide will govern where it differs from the Roadside Design Guide. The information in Section II is intended to serve as guidelines that will assist the designer in determining conditions that warrant the installation of roadside barriers and the dimensional characteristics of the installations. Section IV contains information to serve as guidelines to assist the designer in determining conditions that warrant the installation of a median barrier. Appendix B contains Decision Trees for warrants, roadside barrier selection, and end treatment selection which may provide additional guidance for some situations. If Decision Trees are used, the designer shall determine if they are applicable to the design location based on the information provided in this Design Guide.

There are circumstances where site conditions do not permit standard installation details to be used and a reasonable balance between competing safety considerations is needed. For example, roadways in the vicinity of bus terminals and parking garages, along urban street facilities, and other locations may incorporate unique conditions where these guidelines might not be deemed applicable. It is important that application of this Design Guide be made in conjunction with engineering judgment to arrive at a reasonable solution.

In some cases, another type of traffic barrier may be more effective than roadside barrier. For example, obstructions in gores can often be more effectively shielded with an impact attenuator. The designer should consider such alternatives and choose the most suitable solution based on safety requirements, economic limitations, maintenance, and aesthetic considerations.

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

These guidelines are applicable to new installations on roadways within the jurisdiction of The Port Authority of New York & New Jersey (hereafter referred to as “Port Authority”). Where repairs to existing guide rail include upgrading to current standards, the entire run of guideway should be upgraded where practical. The design of roadside barrier and median barriers outside the jurisdiction of the Port Authority shall be in accordance with the standards and guidelines of the agency having jurisdiction.

II. Roadside Barriers

A. Roadside Barrier Warrants

The primary functions of guide rail and concrete barrier are to prevent penetration and to safely redirect an errant vehicle away from an obstruction on either side of the traveled way. An obstruction’s physical characteristics and its location within the clear zone are the basic factors to be considered in determining if a roadside barrier is warranted. Although some wide ranges of roadside conditions are covered below, special cases will arise for which there is no clear choice about whether or not a roadside barrier is warranted. Such cases must be evaluated on an individual basis and, in the final analysis, must usually be solved by engineering judgment. As a guide for roadside barrier warrants, a Decision Tree is provided in Appendix B, Exhibit B-1, “Roadside Barrier Warrants”.

1. Clear Zone

Clear zone is defined as the unobstructed, traversable area provided beyond the edge of the through traveled way for the recovery of errant vehicles. The clear zone includes shoulders, bike lanes, and auxiliary lanes, except those auxiliary lanes that function like through lanes. The width of the clear zone varies with the design speed, roadside slope and horizontal roadway alignment. If the design speed is known, then it should be used to determine the clear zone. Otherwise, the design speed may be estimated by adding 5 MPH to the posted speed. Higher design speeds may be warranted based on engineering judgment.

Table 1 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, AASHTO, 4th Edition, 2011, the designer may provide clear zone distances greater than 30 feet as indicated in Table 1, where such occurrences are indicated by crash history.

Figure 1 contains an example of determining clear zone distance on a foreslope. This figure depicts a clear zone distance reaching a non-recoverable parallel foreslope and the subsequent clear runout area that may be provided at the toe of the non-recoverable slope to provide a suggested adjusted clear zone distance. More examples and further explanation are contained in the Roadside Design Guide, AASHTO, 4th Edition, 2011.
Table 1

<table>
<thead>
<tr>
<th>Design Speed</th>
<th>Design ADT</th>
<th>Foreslopes (Fill)</th>
<th>Backslopes (Cut)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1V:6H or flatter</td>
<td>1V:6H to 1V:4H</td>
</tr>
<tr>
<td><strong>40 mph</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 750</td>
<td>7 - 10</td>
<td>7 - 10</td>
<td>**</td>
</tr>
<tr>
<td>750 – 1500</td>
<td>10 - 12</td>
<td>12 - 14</td>
<td>**</td>
</tr>
<tr>
<td>1500 – 6000</td>
<td>12 – 16</td>
<td>14 - 16</td>
<td>**</td>
</tr>
<tr>
<td>over 6000</td>
<td>14 - 18</td>
<td>16 - 18</td>
<td>**</td>
</tr>
<tr>
<td><strong>45 – 50 mph</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 750</td>
<td>10 - 12</td>
<td>12 - 14</td>
<td>**</td>
</tr>
<tr>
<td>750 – 1500</td>
<td>14 – 16</td>
<td>16 - 20</td>
<td>**</td>
</tr>
<tr>
<td>1500 – 6000</td>
<td>16 – 18</td>
<td>20 - 26</td>
<td>**</td>
</tr>
<tr>
<td>over 6000</td>
<td>20 – 24</td>
<td>22 - 24</td>
<td>**</td>
</tr>
<tr>
<td><strong>55 mph</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 750</td>
<td>12 – 14</td>
<td>14 - 18</td>
<td>**</td>
</tr>
<tr>
<td>750 – 1500</td>
<td>16 – 18</td>
<td>20 - 24</td>
<td>**</td>
</tr>
<tr>
<td>1500 – 6000</td>
<td>20 – 22</td>
<td>24 - 30</td>
<td>**</td>
</tr>
<tr>
<td>over 6000</td>
<td>22 – 24</td>
<td>26 - 32*</td>
<td>**</td>
</tr>
<tr>
<td><strong>60 mph</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 750</td>
<td>16 – 18</td>
<td>20 - 24</td>
<td>**</td>
</tr>
<tr>
<td>750 – 1500</td>
<td>20 – 24</td>
<td>24 - 32*</td>
<td>**</td>
</tr>
<tr>
<td>1500 – 6000</td>
<td>26 – 30</td>
<td>32 - 40*</td>
<td>**</td>
</tr>
<tr>
<td>over 6000</td>
<td>30 – 32*</td>
<td>36 - 44*</td>
<td>**</td>
</tr>
<tr>
<td><strong>65 – 70 mph</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 750</td>
<td>18 – 20</td>
<td>20 - 26</td>
<td>**</td>
</tr>
</tbody>
</table>

* When a site specific investigation indicates a high probability of continuing crashes, or when such occurrences are indicated by crash history, the designer may provide clear zone distances greater than the clear zone shown in Table 1. Clear zones may be limited to several factors, the foreslope parameters that may enter into determining a maximum desirable recovery area are illustrated in Figure 1.

** Because recovery is less likely on the unshielded, traversable 1V:3H slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the traveled way may be expected to occur beyond the toe of slope. Determination of the width of the recovery areas at the toe of slope should take into consideration right-of-way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of slope. While the application may be limited to several factors, the foreslope parameters that may enter into determining a maximum desirable recovery area are illustrated in Figure 1.

** Because recovery is less likely on the unshielded, traversable 1V:3H slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the traveled way may be expected to occur beyond the toe of slope. Determination of the width of the recovery areas at the toe of slope should take into consideration right-of-way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of slope. While the application may be limited to several factors, the foreslope parameters that may enter into determining a maximum desirable recovery area are illustrated in Figure 1.


Horizontal alignment can affect the clear zone width. Clear zone widths on the outside of horizontal curves should be adjusted by multiplying the clear zone values in Table 1 by the Curve Correction Factor shown in Table 2. The Curve Correction Factor applies to the outside of the curve only. Adjustment is not required for radii flatter than 2950 feet or for design speeds less than 40 MPH.

Table 2

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Curve Correction Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>1.1</td>
</tr>
<tr>
<td>45</td>
<td>1.1</td>
</tr>
<tr>
<td>50</td>
<td>1.2</td>
</tr>
<tr>
<td>55</td>
<td>1.2</td>
</tr>
<tr>
<td>60</td>
<td>1.2</td>
</tr>
<tr>
<td>65</td>
<td>1.2</td>
</tr>
<tr>
<td>70</td>
<td>1.3</td>
</tr>
</tbody>
</table>


2. Warranting Obstructions

A warranting obstruction is defined as a non-traversable roadside or a fixed object 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 a roadside barrier.

a. Non-traversable Roadside

Examples of a non-traversable roadside that may warrant a roadside barrier are: rough rock cuts, large boulders, streams or permanent bodies of water more than 2 feet in depth, roadside channels with slopes steeper than 1V:1H and depths greater than 2 feet, embankment slopes and slopes in cut sections as described in the following:

i. Embankment (Fill) Slopes

A critical slope is one in which a vehicle is likely to overturn. Slopes steeper than 1V:3H generally fall into this category. If a slope steeper than 1V:3H begins closer to the traveled way than the suggested clear zone distance, roadside barrier might be warranted if it is not practical to flatten the slope. Roadside barrier warrants for critical slopes are shown in Table 3.
Table 3
Critical Slope Warrants

<table>
<thead>
<tr>
<th>Critical Embankment (Fill) Slopes</th>
<th>Maximum Height without a Roadside Barrier (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1V:1½H</td>
<td>3</td>
</tr>
<tr>
<td>1V:2H</td>
<td>6</td>
</tr>
<tr>
<td>1V:2½H</td>
<td>9</td>
</tr>
</tbody>
</table>

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 1V:3H and 1V:4H 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 runout area at the base of these slopes is desirable as shown in Figure 1. A minimum of 10 feet of runout area should be provided if practicable. The designer should, therefore, evaluate each site before providing 1V:3H slopes without a roadside barrier.

When flattening existing slopes to remove a roadside barrier, the proposed side slopes should be recoverable, that is, 1V:4H or flatter. Where embankment slopes are being constructed, the designer should investigate the feasibility of providing a recoverable slope instead of a critical slope with a roadside barrier. Rounding should be provided at slope breaks.

**ii. Slopes in Cut Sections**

Slopes in cut sections should not ordinarily be shielded with a roadside barrier. However, there may be obstructions on the slope that warrant shielding, such as bridge piers, retaining walls, trees, rocks, etc. that may cause excessive vehicle snagging rather than permit relatively smooth redirection.

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

- A roadside barrier should be installed if the warranting obstruction is on a slope flatter than 1V:0.7H and is within the clear zone width specified in Table 1 for a 1V:3H slope.
- A roadside barrier should be installed if the warranting obstruction is on a slope of 1V:0.7H or steeper and is less than 6 feet (measured along the slope) from the toe of the slope and is within the clear zone width specified in Table 1 for a 1V:3H slope.
- A roadside barrier is not required if the warranting obstruction is on a slope of 1V:0.7H or steeper and is 6 feet or more (measured along the slope) from the toe of the slope.

**iii. Drainage Features**

Channels should be designed to be traversable. Where feasible, existing channels should be reconstructed to be traversable. See Section 3.2.4 of the Roadside Design Guide, AASHTO, 4th Edition, 2011, for further guidance.

**b. Fixed Objects**

Examples of fixed objects that may warrant a roadside barrier are: non-breakaway sign supports, traffic signals and lighting poles of non-breakaway 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 (except as modified by Section II.A.2, “Utility Poles”), and drainage structures.

Fixed objects shall not be located less than the minimum offset from the back of the rail element shown in Table 4.

In no case, on new or upgraded roadside barrier installations, shall breakaway or non-breakaway sign supports, highway lighting, trees, utility poles, fire hydrants, and mailboxes remain in front of the roadside barrier.

Signs with breakaway supports may be placed in front of guide rail only if they are located in the median. Desirably, allow 7 feet between the face of barrier and the nearest sign post. If possible, relocate the sign behind the guide rail or place single post signs inside W-beam or modified thrie beam dual faced guide rail (between the two rail elements).
i. Trees

Trees, 4 inches in diameter or greater, are considered fixed objects. However, trees are not considered a warranting obstruction for a roadside barrier since barrier are not installed solely for shielding trees. The following guidance is provided for the treatment of existing trees within the clear zone:

On limited access highways, trees shall not be located within the clear zone. Although it is desirable to provide a clear zone free of trees on access permitted 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 right-of-way, 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 public criticism.

Factors such as crash 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 crash history shall be removed regardless of public criticism. Also, trees that will be harmed beyond reasonable repair due to construction shall be removed (i.e. new curb that destroys the main root system).

Trees that have grown behind guide rail located less than the minimum offset from the back of the rail element shown in Table 4 shall be removed regardless of size. Trees, shrubs and overhanging branches shall be removed where they block or obscure horizontal sight distance whether they are behind a roadside barrier or not. As a minimum, branches overhanging the roadway shall be removed up to a height of 16 feet. Trees and shrubs within the roadside recovery area (Figure 3) at the approach to guide rail terminals should be removed. The following areas should be checked for sight distance problems due to vegetative interference:

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

ii. Utility Poles

Although utility poles have a cross-sectional area greater than 50 square inches (8 inches diameter), they should not be handled the same as other warranting obstructions. 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 current utility accommodation regulations (NJAC 16:25 for New Jersey locations and NYCRR Title 17 Part 131 for New York State locations).

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.

On existing highways, any utility pole that has been struck three times or more within three 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 instead of a roadside barrier.

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 one that does not meet AASHTO standards given the design speed, radius and cross slope.

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 to 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 conform to the minimum offsets from the back of the rail element shown in Table 4. However as a minimum, the face of the pole shall be no closer than 1 foot 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 when a pole will be located directly behind a post, the face of the pole should be no closer than 6 inches from the back of the post.

Utility poles shall not be located within the 75 foot by 20 foot shaded recovery area shown in Figure 3. Also, utility poles should not be located closer than 25 feet in advance of a flared or tangent guide rail terminal.

iii. Lighting Poles

Desirably all lighting poles should be breakaway. However, where lighting poles cannot be made breakaway, they should be located as far from the traveled way as practical. Unless there is an accident history, a roadside barrier should not be installed to shield a non-breakaway lighting pole. The preferred alternate would be to convert the lighting pole to a breakaway design.

In no case, shall breakaway or non-breakaway lighting poles on new or upgraded guide rail installations remain in front of the guide rail. The placement of lighting poles behind the guide rail shall conform to the minimum offsets from the back of the rail element shown in Table 4.
iv. Traffic Signal Poles

Traffic signal poles should be located as far from the traveled way as practical on high speed roadways. Aluminum signal poles should be located a minimum of 32” from face of curb or edge of pavement to the center of the pole. Steel signal poles should be located a minimum of 10 feet from the edge of pavement wherever possible.

Traffic signal poles on new or upgraded guide rail installations shall not remain in front of the guide rail. Where traffic signal poles are installed behind guide rail, they shall conform to the minimum offsets from the back of the rail element shown in Table 4.

v. Sign Supports

In no case, on new or upgraded guide rail installations, shall breakaway or non-breakaway sign supports remain in front of guide rail.

Where sign supports for overhead signs and non-breakaway ground mounted sign supports are installed behind guide rail, they shall conform to the minimum offsets from the back of the rail element shown in Table 4.

Roadside barrier protection for overhead sign supports may be considered for locations beyond the clear zone based on engineering judgment.

vi. Fire Hydrants

Since fire hydrants do not meet the current AASHTO definition for breakaway design, they fall into the category of fixed objects and should be treated similar to utility poles.

Locate the hydrants as far from the traveled way as practical. In no case shall fire hydrants be located in front of the guide rail. However, the hydrants must be located 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 to permit connection to be made over the guide rail. Usually, the connection may be a maximum of 3 feet 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, a flared guide rail terminal, tangent guide rail terminal or anchorage must be provided in accordance with Section II.E. The location of hydrants behind guide rail shall conform to the minimum offsets from the back of the rail element shown in Table 4.

vii. Pedestrians

Roadside barrier may be used where there is a reasonable possibility of an errant vehicle encroaching into an unprotected area used by pedestrians. The basis for assessing the needs should be the crash history of the immediate area and the specifics for the cause of the crashes. There may be times when no causative factor can be isolated, and sound engineering judgment must be applied. Roadside barrier should not interfere with pedestrian crossings or pedestrian access along terminal frontage.

At locations where existing guide rail and the PVI (top of the slope) of a steep fill slope are both located directly behind a pedestrian sidewalk area and 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 length of a guide rail end terminal.

B. Roadside Barrier Types

Crashworthy roadside barriers are required on all roadways under the jurisdiction of the Port Authority. To assess the crashworthiness of roadside barriers, a series of standardized crash tests are required and are presented in NCHRP Report No. 350 and the Manual for Assessing Safety Hardware (MASH). These tests evaluate occupant risk, structural integrity of the barrier and post-impact behavior of the vehicle for a variety of vehicle weights, speeds and impact angles. Roadside barrier hardware that has been accepted under NCHRP Report 350 or MASH is appropriate for roadside barrier installations. As of January 1, 2011, all new roadside barrier designs require testing using MASH criteria. Barrier hardware previously approved under NCHRP Report No.350 does not require retesting. The test criteria for six test levels (TL-1 through TL-6) for roadside barriers have been impact tested and selection often requires consideration of the test

...
Table 4
Minimum Offset From the Back of the Guide Rail Element to the Obstruction

<table>
<thead>
<tr>
<th></th>
<th>Post Spacing</th>
<th>Minimum Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box Beam Guide Rail</td>
<td>6'</td>
<td>5'</td>
</tr>
<tr>
<td>W-Beam Guide Rail</td>
<td>6'-3&quot;</td>
<td>4'</td>
</tr>
<tr>
<td>Modified Thrie Beam Guide Rail</td>
<td>6'-3&quot;</td>
<td>2.5'</td>
</tr>
<tr>
<td>W-Beam Guide Rail or Modified Thrie Beam Guide Rail with double rail element</td>
<td>1'-6¾&quot;</td>
<td>1'</td>
</tr>
</tbody>
</table>

Details for the use of reduced post spacing and double rail element for W-beam guide rail or modified thrie beam guide rail are provided in the Traffic Engineering Standard Detail "Clearance From Back Of Rail". Where W-beam guide rail or modified thrie beam guide rail is modified with reduced post spacing or double rail elements, no portion of the modified guide rail shall be within the length of a crashworthy guide rail end terminal.

Concrete barrier may be placed less than 1 foot from the back of the barrier to the obstruction, but an offset of 3.5 feet from the front edge of the barrier (edge of pavement) to the obstruction is desirable since high profile vehicles have a tendency to lean when striking a concrete barrier at high speeds and steep angles.

1. Box Beam Guide Rail
Box beam guide rail is considered a weak post semi-rigid system and had passed NCHRP 350 test criteria for TL-3. A minimum 125 foot length of box beam guide rail is necessary for the system to develop its deflection resistance. Box beam guide rail is preferred for aesthetic reasons at the central terminal areas of airports. Minimum offsets from the back of the rail element to the obstruction are shown in Table 4.

2. W-Beam Guide Rail
W-beam guide rail is considered a strong post semi-rigid system and had passed NCHRP 350 test criteria for TL-3. A minimum 62.5 foot length of W-beam guide rail is necessary for the system to develop its deflection resistance. Rub rail may be required when W-beam guide rail is installed flush with curb as noted in Section II.C.3. Minimum offsets from the back of the rail element to the obstruction are shown in Table 4.

3. Modified Thrie Beam Guide Rail
Modified thrie beam guide rail is considered a strong post semi-rigid system and had passed NCHRP 350 test criteria for TL-4. A minimum 62.5 foot length of modified thrie beam guide rail is necessary for the system to develop its deflection resistance. Modified thrie beam guide rail may be considered when a wider rail element is desired due to a high volume of large vehicles. Thrie beam rail element is also used for transitioning W-beam guide rail to a concrete parapet attachment. A similar rail element is used on some impact attenuators. Minimum offsets from the back of the rail element to the obstruction are shown in Table 4.

4. Concrete Barrier
Concrete barrier curb types for use by the Port Authority as roadside barriers are:
- 32" Concrete Barrier Curb (meets NCHRP 350 TL-4 criteria)
- 42" Concrete Barrier Curb (meets NCHRP 350 TL-5 criteria)
- 42" Concrete Barrier Single Slope (meets NCHRP 350 TL-5 criteria)

Roadside concrete barriers can be half section or full section barriers. Where half section barrier is used, steel posts or earth backfill is required behind the barrier as shown in Traffic Engineering Standard Detail "Clearance From Back Of Rail". Where W-beam guide rail or modified thrie beam guide rail is modified with reduced post spacing or double rail elements, no portion of the modified guide rail shall be within the length of a crashworthy guide rail end terminal.

C. Design Criteria
1. Without Curb or Raised Berm in Front of Guide Rail
To the extent possible, guide rail should be located as far as possible from the traveled way to provide a recovery area for errant vehicles and to provide adequate sight distance along horizontal curves and at intersections.

On limited access highways, the front face of the guide rail may be placed any distance from the edge of pavement, however, an offset of 4 feet or more is preferred. Where possible, the offset should comply with the shy line offset distance from the traveled way as shown in Table 5.

On access permitted highways where there is a sidewalk or a sidewalk area used by pedestrians, the front face of the guide rail should desirably be 7 feet or more from the edge of pavement so that the sidewalk area is between the roadway and the guide rail. Where this offset is not possible, the guide rail should be installed flush with the edge of pavement.

On access permitted highways where there is no sidewalk and the border area is not used by pedestrians, the front face of the guide rail may be placed any distance from the edge of pavement, however, an offset of 4 feet or more is preferred. Where possible, the offset should comply with the shy line offset distance from the traveled way as shown in Table 5.
way as shown in Table 5. As a guide for guide rail selection where there is no curb or raised berm, a Decision Tree is provided in Appendix B, Exhibit B-2, “Roadside Barrier Selection for Roadways without Curb”.

2. Curb or Raised Berm in Front of Guide Rail

Curb or raised berm in front of guide rail should be avoided. On projects that involve upgrading existing highways, where there is a 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 re-graded at 1V:10H.

Where guide rail is installed flush with the face of curb, the mounting height is measured from the top of curb. For all other offsets, the mounting height is measured from the existing ground at the face of the guide rail.

On new installations of curb, mountable (sloping face) curb is required at design speeds of 55 MPH or greater and it is the preferred option at lower speeds. Examples of sloping face curbs are provided in NCHRP Report 537 (Figure 1), and AASHTO’s A Policy on Geometric Design of Highways and Streets, 6th Edition (Figure 4-5). If there is existing non-mountable (vertical) curb where guide rail is being installed or upgraded, it may remain in place if the curb height and guide rail offset requirements listed below are satisfied. As a guide for guide rail selection where curb is present, a Decision Tree is provided in Appendix B, Exhibit B-3, “Roadside Barrier Selection for Roadways with Curb”.

For new installations of curb in front of guide rail, the following apply:

a. Highways With a Design Speed 55 MPH or greater:

Curb shall be mountable and no greater than 4 inches in height. For design speeds of 60 MPH or higher the sloping face of the curb shall be no steeper than 1V:3H. W-beam or modified thrie beam guide rail shall be installed flush with the face of the curb. Box beam guide rail shall not be used.

b. Highways With a Design Speed of 45 to 50 MPH:

Mountable curb is the preferred option, however, non-mountable curb is permitted. Curb height shall be no greater than 6 inches. Where curb height is greater than 4”, W-beam or modified thrie beam guide rail shall be installed flush with the face of the curb. Box beam guide rail shall not be used.

c. Highways With a Design Speed of 40 MPH or less:

Mountable curb is the preferred option, however, non-mountable curb is permitted. Curb height shall be no greater than 6 inches. W-beam, modified thrie beam or box beam guide rail should desirably be placed either flush with the face of the curb (6 inches from the face of curb for box beam) or 8 feet or more from the edge of pavement. If this is not practical, any offset is acceptable due to the reduced risk of vaulting at lower speeds.

3. Rub Rail

Where W-beam guide rail is constructed less than 3 feet from curb or a raised berm that is 4 inches or greater in overall height, rub rail is required.

When W-beam guide rail is set flush to the edge of pavement and there are short sections (i.e., less than 100 feet long at each location) of curb, 4 inches or less in height, rub rail is not required and the mounting height is measured from the edge of pavement throughout.

On all projects involving new W-beam guide rail or the upgrading of existing W-beam guide rail, every effort should be made to eliminate or reduce the use of rub rail. Acceptable methods for reducing or eliminating the need for rub rail include: providing a sufficient offset, removing or revising a raised berm, providing a design without curb, and eliminating the existing curb where economically feasible.

4. Concept of Shy Line

A highly desirable characteristic of any roadway is a uniform clearance from the outside edge of the outermost travel lane to the roadside barrier. Wherever possible, it is desirable to place the roadside barrier at a distance beyond which it will not be perceived as a threat by the driver. This distance from the edge of traveled way to the face of the roadside barrier is the shy line offset which varies for different design speeds as shown in Table 5. Shy-line offset distance is seldom a controlling criterion for barrier placement. As long as the barrier is located beyond the perceived shoulder of a roadway, it will have minimum impact on driver speed or lane position.

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Shy Line Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Speed (mph)</td>
<td>Shy Line Offset (feet)</td>
</tr>
<tr>
<td>60</td>
<td>8.0</td>
</tr>
<tr>
<td>55</td>
<td>7.0</td>
</tr>
<tr>
<td>50</td>
<td>6.5</td>
</tr>
<tr>
<td>45</td>
<td>6.0</td>
</tr>
<tr>
<td>40</td>
<td>5.0</td>
</tr>
<tr>
<td>30</td>
<td>4.0</td>
</tr>
</tbody>
</table>

5. At Fixed Objects
Where guide rail is used to shield an isolated obstruction, guide rail should be located as far from the traveled way as possible to minimize the probability of impact. The distance from the back of the rail element of guide rail to the obstruction must comply with the criteria in Table 4.

6. On Bridges
Safetywalks range in width from 1.5 feet to less than 4 feet. On existing structures with safetywalks, where it is not feasible to remove the safetywalk and provide a concrete, barrier-shaped parapet, the guide rail shall be carried across the structure along the edge of pavement. However, on ramps where the design speed is 40 mph or less and the safetywalk is 2.5 feet 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 does not meet NCHRP 350 or MASH crash test criteria.

Where the roadway approaching a structure has curbs or berms, the guide rail mounting height on the structure should be measured from the top of curb and rub rail is required. However, on long structures, the guide rail mounting height may be measured from the edge of pavement provided the face of guide rail is flush with the curb face. In this case, rub rail will not be required.

The guide rail mounting height should be measured from the edge of pavement on those structures where the approach roadway has no curb or raised berm 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 edge of pavement, rub rail is not required.

Where there is a difference in the offset to the approach guide rail and the offset to the bridge parapet, the approach guide rail should be flared at 15:1 or flatter prior to the standard guide rail transition to the bridge parapet.

Attachment of guide rail to bridges and structures shall be in accordance with the Port Authority’s Traffic Engineering Standard Details, revised or modified Standard Details or Special Details. The designer shall specify at each location on the construction plans whether the attachment is Type “A” or “B”, and which of the Traffic Engineering Standard Details is applicable.

Attachment of guide rail to sidewalk on bridges shall be in accordance with Traffic Engineering Standard Detail “Guide Rail Attachment to Sidewalk on Structure”.

Where there is considerable pedestrian traffic, W-beam guide rail may be set flush to the curb face to physically separate pedestrians from vehicular traffic if feasible (see Section II.A.2, “Pedestrians”).

7. On Embankments
Where guide rail is located at the top of an embankment slope, posts should be a minimum of 2 feet from the PVI to the back of the post as shown in Figure 2.

![Figure 2 – Minimum Offset from Back of Post to PVI](image)

When less than 2 feet is provided, the following post lengths for W-beam or modified thrie beam guide rail, shown in Table 6, should be used. Box beam guide rail should not be used where less than 2 feet is provided.

<table>
<thead>
<tr>
<th>Embankment Slopes</th>
<th>Additional Post Length (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatter Than 1V:6H</td>
<td>No Change</td>
</tr>
<tr>
<td>1V:6H to 1V:4H</td>
<td>1</td>
</tr>
<tr>
<td>1V:4H to 1V:2H</td>
<td>2</td>
</tr>
<tr>
<td>Steeper Than 1V:2H</td>
<td>4</td>
</tr>
</tbody>
</table>

Guide rail should be placed on slopes 1V:10H or flatter where the rollover between the pavement slope and the embankment slope is not greater than 10 percent. Rollovers greater than 10 percent are prone to occur where super-elevation slopes in the opposite direction of the embankment slope. Where this happens, install the W-beam or modified thrie beam guide rail flush to the edge of pavement. Box beam guide rail is not recommended under these conditions.

Proper grading in advance of, adjacent to, and behind the terminal is required to be sure the vehicle remains stable after hitting the terminal. The Standard Grading.
treatment shown in Traffic Engineering Standard Detail “Grading Treatment at Flared 
and Tangent Terminals” shall be used wherever practical. However, when upgrading 
existing guide rail sites or when there are site limitations at new guide rail locations, 
the Alternate Grading treatment may be used. 
Where guide rail is placed between the edge of pavement and sidewalk, a system 
with appropriate deflection characteristics should be selected in accordance with the 
information provided in Table 4.

D. Design Calculations

1. Roadside Recovery Area

Research has shown that over half of all fatal guide rail collisions involve a secondary 
event, either a second impact or a rollover. Many of these secondary events, e.g. 
trees, poles, and rollovers, typically carry a much higher fatality risk than guide rail 
impact. Therefore, a roadside recovery area void of fixed objects is required in 
advance, adjacent to, and behind the approach guide rail terminal. Figure 3 shows 
the required roadside recovery area that should be provided at flared and tangent 
guide rail terminals as shown in the cross hatched area.
The recovery area behind the guide rail in Figure 3 should extend 25 feet in advance 
of the guide rail terminal to the obstruction. However, where it is not practical to 
provide the desirable area, a minimum recovery area 75 feet long by 20 feet wide 
(shaded area) should be provided behind the guide rail.

Figure 3 – Roadside Recovery Area at Flared and Tangent Terminals
On roadways where the length of guide rail in advance of the obstruction is restricted 
due to the location of driveways, intersecting streets or other features, and the 
recovery area in advance of the guide rail terminal shown in Figure 3 cannot be 
provided, the recovery area should extend from the guide rail terminal to the 
obstruction. If the distance from the edge of traveled way to the back of the 
obstruction (Lr) extends beyond the clear zone or R.O.W. line, the recovery area 
should be limited to the clear zone or R.O.W. line, whichever is less. The location of 
utility poles should comply with the criteria in Section II.A.2, “Utility Poles”.
If the typical roadside in advance of the terminal does not have a 20 foot wide 
recovery area, the clear area behind the guide rail can be reduced if it is consistent 
with that available elsewhere along the roadway.

2. Approach Length of Need (L.O.N.)
a. General

The approach length of need (L.O.N.) is the minimum length of guide rail required 
in front of the warranting obstruction to shield it effectively. Table 7 provides 
Runout Lengths (Lr) for various design speeds and traffic volumes to be used with 
Length of Need calculations described in this Section.

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Traffic Volume (ADT)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Over 10,000 5,000 – 10,000</td>
</tr>
<tr>
<td>60</td>
<td>300 250 210 200</td>
</tr>
<tr>
<td>50</td>
<td>230 190 160 150</td>
</tr>
<tr>
<td>40</td>
<td>160 130 110 100</td>
</tr>
<tr>
<td>30</td>
<td>110 90 80 70</td>
</tr>
</tbody>
</table>


Figure 4 shows a typical Approach Length of Need design for flared and tangent 
terminals. The formulas shown below for calculating Length of Need apply to 
roadways with tangent horizontal alignment and where shoulder width and guide 
rail offset are consistent. On horizontal curves and/or where shoulder dimensions 
or guide rail offset vary, Length of Need should be determined graphically by 
drawing a line from the outside edge of the obstacle to a point on the edge of 
traveled way using the appropriate value of Lr. W-beam guide rail terminating 
with an end anchorage on the trailing end should extend a minimum 12.5 feet past the 
obstruction. Box beam guide rail should extend past the obstruction so that no part 
of the trailing end treatment is in front of the obstruction.
* The 12.5 foot minimum at the end terminal represents the point of redirection and applies to W-beam guide rail flared and tangent end terminals. For box beam tangent terminals, redirection occurs 17 feet from the approach end.

W-Beam Flare Terminal

\[
L_{ON} = \frac{L_R(L_H - L_2 - 2.7)}{L_H}
\]

W-Beam, Box Beam Tangent Terminal

\[
L_{ON} = \frac{L_R(L_H - L_2)}{L_H}
\]

If the obstruction extends beyond the clear zone, use the clear zone as \( L_C \), except if the obstruction is a critical slope.

If the roadway is curved or if the shoulder width or guide rail offset varies, layout to scale and obtain L.O.N. directly by scaling from the drawing using the appropriate value of \( L_R \).

The calculated L.O.N. should be rounded up to the nearest even multiple of element length based on the type of guide rail. This value plus the approach end length (12.5 feet for W-beam, 17 feet for box beam) should be equal to or greater than the roadside recovery length of 75 feet discussed in Section II.D, “Roadside Recovery Area”.

The total length of a freestanding guide rail installation including approach and trailing end treatments should not be less than 87.5 feet for W-beam (based on the minimum roadside recovery area) and 125 feet for box beam (to develop its intended deflection resistance).

**Figure 4 – Approach Length of Need Calculation**

If the approach end of guide rail for opposing traffic is within the clear zone, a flared or tangent guide rail terminal shall be used as shown in **Figure 5**. The clear zone for the opposing traffic should also be adjusted for horizontal curvature (**Table 2**).

On two lane highways where passing is permitted, the clear zone shall be measured from the outside edge of the approaching traffic lane.

**Figure 5 – Length Of Need For Opposing Traffic**

* The 12.5 foot minimum at the end terminal represents the point of redirection and applies to W-beam guide rail end terminals. For box beam tangent terminals redirection occurs 17 feet from the approach end.

If guide rail is outside the clear zone \( L_C > L_2 \) or the roadway is divided with a non-traversable median, use a guide rail end anchorage.

If guide rail is within the clear zone, but the obstruction is beyond it \( L_2 > L_C \), use a flared or tangent end terminal.

If the obstruction is within the clear zone \( L_3 < L_C \), determine the required L.O.N. using the formulas in **Figure 4**.

\( L_2 \) shall be measured from the outside edge of the approaching traffic lane where passing is permitted for opposing traffic.

If there is a traversable median separating traffic, the median width should be included when determining \( L_2, L_3, \) and \( L_R \) for opposing traffic.
b. On Embankment Slopes

The approach L.O.N. on embankment (fill) slopes steeper than 1V:3H should be determined in accordance with Figure 6. 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 5 to determine the approach L.O.N. for opposing traffic on embankment slopes.

Note A
L_H is measured from the edge of traveled way to the toe of slope.

Note B
If a critical slope (steeper than 1V:3H) begins within the clear zone (L_C), guide rail is warranted.

Note C
If the distance from the back of the post to the PVI is less than 2 feet, use W-beam with additional post length (Table 6).

Note D
5 feet standard, 2 feet minimum as per Traffic Engineering Standard Detail “Grading Treatment at Flared and Tangent Terminals”.

Figure 6 – Approach Length Of Need For Critical Embankment Slopes

c. In a Cut Section

See Traffic Engineering Standard Detail “Guide Rail for Cuts” for an example of flaring W-beam guide rail in a cut section where criteria specified in Section II.E, “Buried Guide Rail Terminal” will permit a buried approach end. The Length of Need formula is shown in Figure 7. Recommended flare rates are shown in Table 8. Where this treatment is not possible, a standard flared or tangent end terminal should be used.

\[
L_1 = L_R - \left( \frac{L_0 L_1}{L_H} \right) = \frac{a}{b}(L_1 - L_2)
\]

\[
L_2 = \left( \frac{L_1 - L_2}{a/b} \right)
\]

\[
L.O.N. = L_1 + L_2
\]

If the obstruction extends beyond the clear zone, use the clear zone as L_H.

Flare rate (a/b) is obtained from Table 8. The shy line offset is the distance from the edge of traveled way to the face of the guide rail (L_2). See Traffic Engineering Standard Detail “Guide Rail for Cuts”.

Values of L_1 and L_2 should be rounded up to the nearest even multiple of element length (12.5 feet). L.O.N. should be equal to or greater than the roadside recovery length of 75 feet.

Figure 7 – W-Beam Approach Length Of Need for Buried Guide Rail Terminal

d. 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. Every effort should be made to keep the gore area clear of warranting obstructions. However, 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. Figure 8 shows a guide rail treatment example for gore areas.
3. Guide Rail Details

The dimensions and other characteristics of W-beam guide rail, box beam guide rail and modified thrie beam guide rail posts, rail elements, fasteners, etc., are shown in the Traffic Engineering Standard Details.

4. Other Design Considerations

Guide rail should not restrict sight distance. Sight distances should be checked when the 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 should be adjusted where feasible.

Wherever part of an existing guide rail run is lengthened, reset or upgraded, the entire run where practical shall be upgraded to current standards including the bridge attachments. Project limits should end outside the limits of a guide rail run where practical.

Gaps of 200 feet or less between individual guide rail installations should be avoided where possible.

For median W-beam guide rail treatment between parapets at adjacent bridges, use 3'-1½" post spacing and end anchorages as shown in Figure 9. Guide rail between parapets is not required if there is a concrete connecting wall 2.25 feet high or greater between parapets.

Where existing driveways are located within the length of need and cannot be relocated, appropriate end treatments should be used at the driveway opening as shown in Figure 10.

Proposed W-beam guide rail set flush with the curb line along intersection radius returns should be checked with a truck turning template. Existing W-beam guide rail along radius returns that experience truck overhang or oversteering crashes shall either be reset farther from the curb line or redesigned to provide a radius for a larger design vehicle.

Where concrete barrier is used as a roadside barrier it should be located flush with the edge of pavement. The minimum length of barrier should be the calculated length of need (L.O.N.) or the minimum roadside recovery area shown in Figure 3, whichever is greater. The approach end of concrete barrier shall be protected with an impact attenuator.

The preferred method for locating all end treatments on construction plans is to dimension from physical objects (i.e.; lateral offset from edge of road, longitudinal dimensions from utility pole). Another method is by station and offset.

The grading work necessary for the construction of the guide rail end treatments shall be shown on the construction plans. The grading shall conform to the Traffic Engineering Standard Details.

Transitions between the various guide rail types shall conform to the Traffic Engineering Standard Details.

The plans shall indicate the location of existing conduits or underground utilities or shall include a notation where there is a possibility of conflict in driving the guide rail posts. Where posts conflict with underground utilities, guide rail may be attached to concrete sidewalk as shown in Traffic Engineering Standard Detail "Guide Rail Attachment to Sidewalk on Structure".

In parking lots, guide rail is often used to delineate boundaries in addition to standard roadside barrier functions. In many cases, the guidelines contained herein may not apply. The designer should use this Design Guide and the Traffic Engineering Standard Details in conjunction with engineering judgment to determine the appropriate type of end treatment to be used.

While a TL-3 barrier is typically sufficient to shield a bridge pier within the clear zone, structural issues with the bridge may justify consideration of a higher test level barrier. AASHTO’s Load Resistance Factor Design Bridge Design Specifications (LRFD) recommends that bridge piers within 30 feet of the traveled way be designed to withstand a 600 kip impact load or be shielded with a 54 inch high barrier located 10 feet or less from the pier or a 42 inch high barrier located more than 10 feet from the pier. Implementation of these recommendations may not be appropriate for existing bridges that were not originally designed using these specifications. Additional information is provided in AASHTO’s Roadside Design Guide, 4th Edition (Section 5.5.2).
E. End Treatments

A crashworthy end treatment is considered essential if guide rail terminates within the clear zone. As a guide to the selection of end treatments, a Decision Tree is provided in Appendix B, Exhibit B-4, “Roadside Barrier End Treatments”. Where modified thrie beam is used, a W-beam to thrie beam transition section as shown in Figure 11 is required in advance of the W-beam end treatments.

1. W-Beam Flared Guide Rail Terminal

Flared guide rail terminals shall be used on the approach ends of W-beam guide rail and modified thrie beam guide rail installations terminating within the clear zone where feasible.

A 37.5 foot length straight flare shall be used with all flared W-beam guide rail terminal end treatments. This flare provides for an offset of 4 feet as shown in Traffic Engineering Standard Detail “Flared Guide Rail Terminal”. The approach end of a flared guide rail terminal shall be placed a minimum distance of 12.5 feet beyond the length of need.

A flared guide rail terminal shall not be installed behind a curb greater than 4 inches in height. Where there is an existing curb or proposed curb greater than 4 inches in height, 75 feet of the curb immediately in advance of and 50 feet beyond the front of a flared guide rail terminal shall be removed and replaced with sloping curb 4 inches or less in height (see Figure 12 and Figure 13).
Note 1 Where curb exists, curb height cannot be greater than 4 inches.

Note 2 See Traffic Engineering Standard Detail “Grading Treatment at Flared and Tangent Terminals” for grading treatment at end terminals.

Figure 12 – Flared or Tangent Guide Rail Terminal on Tangent Roadways

A roadside recovery area should be provided behind a flared guide rail terminal installation (see Section II.D, “Roadside Recovery Area”).

Rub rail, reduced post spacing, and double rail elements shall not be used within the 37.5 foot flare of a flared guide rail terminal.

Where a flared guide rail terminal is installed along a horizontal curve, see Figure 13.

The flared terminal currently approved for use on highways within the Port Authority’s jurisdiction is the Flared Energy Absorbing Terminal (FLEAT).

Note 1 To avoid installing the flared terminal within the roadway, the horizontal radius (R) must not be less than 175 feet where the approach guide rail offset (A) is flush with the edge of pavement on the outside of the curve. If the radius is less than 175 feet, the warranting obstruction should be relocated or the guide rail extended to a point where the radius is 175 feet or greater.

Note 2 Where curb exists, curb height cannot be greater than 4 inches.

Note 3 See Traffic Engineering Standard Detail “Grading Treatment at Flared and Tangent Terminals” for grading treatment at end terminals.

Figure 13 – W-Beam Flared Guide Rail Terminal on Horizontal Curves

2. W-Beam Tangent Guide Rail Terminal

At locations where it is not possible to construct a flared W-beam guide rail terminal with a 4 feet flared offset, a tangent terminal should be used. A 50 foot tangent terminal can be erected parallel to the roadway without needing a flare to function properly (see Traffic Engineering Standard Detail “Tangent Guide Rail Terminal”). The approach end of the tangent terminal shall be placed a minimum distance of 12.5 feet beyond the length of need.

Where the guide rail is installed flush with the edge of pavement, a tangent terminal shall be constructed with a 50:1 straight flare with the approach end of the terminal offset 1 foot from the edge of pavement.

A roadside recovery area should be provided behind a tangent guide rail terminal installation (see Section II.D, “Roadside Recovery Area”).

Where a tangent guide rail terminal is installed along a horizontal curve, see Figure 14.

A tangent guide rail terminal shall not be installed behind a curb greater than 4 inches in height. Where there is an existing curb or proposed curb greater than 4 inches in height, 75 feet of the curb immediately in advance of and 50 feet beyond the front of a
tangent guide rail terminal shall be removed and replaced with sloping curb 4 inches or less in height (see Figure 12 and Figure 14).

Rub rail, reduced post spacing, and double rail elements shall not be used within 50 feet from the end of a tangent terminal.

W-beam tangent terminals currently approved for use on highways within the Port Authority’s jurisdiction are the Beam Eating Steel Terminal (BEST), Extruder Terminal (ET-PLUS), and the Sequential Kinking Terminal (SKT-350).

Note 1 Desirably the end of the tangent terminal should be at the same offset as the approach guide rail.

Note 2 Where the horizontal radius (R) is flatter than 1250 feet and the approach guide rail offset (A) is flush with the edge of pavement, the end of the tangent terminal should be offset 1 foot from edge of pavement.

Note 3 Where the horizontal radius (R) is 625 feet or flatter but less than 1250 feet and the approach guide rail offset (A) is flush with the edge of pavement, the end of the tangent terminal should be offset 2 feet from edge of pavement.

Note 4 For other combinations of radii and offset, the designer should make sure the tangent terminal does not encroach into the roadway. In no case should the end of the tangent terminal be offset more than 2 feet greater than the approach guide rail offset.

Note 5 Where the approach guide rail offset (A) is flush with the edge of pavement, the end of the tangent terminal should be offset 1 foot minimum from edge of pavement.

Note 6 Where the approach guide rail is flush with the back of sidewalk, the offset to the end of the tangent terminal from the back of sidewalk should be in accordance with the offsets referenced in Notes 2, 3, 4, and 5 above.

Note 7 See Traffic Engineering Standard Detail “Grading Treatment at Flared and Tangent Terminals”.

Note 8 Where curb exists, curb height cannot be greater than 4 inches.

**Figure 14 - W-Beam or Box Beam Tangent Terminal on Horizontal Curves**

3. **W-beam Cable Release Terminal (C.R.T.)**

Where an intersection is located near an obstruction and there is insufficient length to construct a W-beam flared or tangent terminal, a Cable Release Terminal may be used as shown in Figure 15. The Clear Area behind the CRT shall be free of any obstructions and graded 1V:10H or flatter. If a raised berm in front of a CRT cannot be removed, it shall be regraded at 1V:10H or flatter. Where curb in front of the CRT cannot be removed, curb shall be no higher than 2 inches. This guide rail treatment should not be used where sidewalk is located behind the guide rail.

**Figure 15 – W-beam Cable Release Terminal (C.R.T.)**

4. **Box Beam Tangent Guide Rail Terminal**

A box beam tangent terminal shall be used on the approach ends of box beam guide rail. Where box beam guide rail is installed flush with the edge of pavement, the impact head of the box beam approach terminal shall be offset a minimum of 1 foot from the edge of pavement. A 50:1 or flatter flare shall be used to provide for the 1 foot minimum offset.

A roadside recovery area should be provided behind a box beam guide rail terminal installation (see Section II.D, “Roadside Recovery Area”). Where a box beam tangent terminal is installed along a horizontal curve, see Figure 14.
A tangent guide rail terminal shall not be installed behind a curb greater than 4 inches in height. Where there is an existing curb or proposed curb greater than 4 inches in height, 75 feet of the curb immediately in advance of and 50 feet beyond the front of a tangent guide rail terminal shall be removed and replaced with sloping curb 4 inches or less in height (see Figure 12 and Figure 14).

The approach end of a box beam tangent terminal shall be placed a minimum distance of 17 feet beyond the length of need.

Box beam tangent terminals approved for use are the 14 foot long Bursting Energy Absorbing Terminal (BEAT) or the 50 foot long Wyoming Box-Beam End Terminal (WYBET-350).

5. Guide Rail End Anchorage

A crashworthy end treatment is not required for:
- A trailing end of guide rail on a one-way roadway
- A trailing end of guide rail on a divided roadway with a non-traversable median
- An approach end of guide rail that is well beyond the clear zone or where an end hit is unlikely

When one of these conditions exists, the following applies:
- W-beam guide rail installations should be terminated with a Guide Rail End Anchorage.
- Box beam guide rail should be terminated with a Buried End, a Type I End Assembly, or a Type IIA End Assembly.

6. Buried Guide Rail Terminal

In cut sections where topography and R.O.W. will permit a buried end approach as shown in the Traffic Engineering Standard Detail “Guide Rail for Cuts”, the approach end of W-beam guide rail may be buried in the backslope. A straight flare should be used where the guide rail is buried in a cut slope. Table 8 shows the straight flare rate recommended for various speeds. The L.O.N. is measured from the point where the guide rail crosses the PVI of the foreslope and backslope to the obstruction being shielded as shown in Figure 7 but in no case shall the L.O.N. be less than 75 feet. The minimum roadside recovery area shown in Figure 3 should be traversable and free of fixed objects. The approach cross slope must be 1V:10H or flatter. Where this treatment is not possible, a standard flared or tangent terminal should be used.

### TABLE 8

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Shy Line Offset (feet)</th>
<th>Flare Rate Inside Shy Line</th>
<th>Flare Rate Beyond Shy Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>8.0</td>
<td>26:1</td>
<td>14:1</td>
</tr>
<tr>
<td>55</td>
<td>7.0</td>
<td>24:1</td>
<td>12:1</td>
</tr>
<tr>
<td>50</td>
<td>6.5</td>
<td>21:1</td>
<td>11:1</td>
</tr>
<tr>
<td>45</td>
<td>6.0</td>
<td>18:1</td>
<td>10:1</td>
</tr>
<tr>
<td>40</td>
<td>5.0</td>
<td>16:1</td>
<td>8:1</td>
</tr>
<tr>
<td>30</td>
<td>4.0</td>
<td>13:1</td>
<td>7:1</td>
</tr>
</tbody>
</table>


In cut sections where the border area slopes towards the roadway, the clearance to the bottom of the W-beam rail along the flared portion of the guide rail shall be maintained at 15 inches above the ground line.

In cut sections where the border area slopes away from the roadway, the height of the flared portion of the W-beam guide rail shall be constant relative to the normal guide rail offset until the guide rail is buried in the backslope. If the clearance from the ground to the bottom of W-beam rail exceeds 18 inches, a rub rail and 8 foot long posts shall be used throughout the portion where the clearance is 18 inches and greater.

The beginning of the flare and the location of the buried end post shall be indicated by station and offset on the construction plans.

7. Existing Slotted Rail Terminals (SRT), Breakaway Cable Terminals (BCT), Eccentric Loader Terminals (ELT), Box Beam Buried End, Box Beam End Assembly Type I, Type II, or Type IIA Installed as an Approach End Treatment

Any existing SRT, BCT, ELT, Box Beam Buried End, or Box Beam End Assembly Type I, Type II or Type IIA installed as an approach end treatment shall be replaced with an approved end treatment in accordance with this Design Guide as follows:

- An SRT, BCT, ELT, Box Beam Buried End, or Box Beam End Assembly Type I, Type II or Type IIA that must be replaced due to crash damage shall be upgraded.
- An SRT, BCT, ELT, Box Beam Buried End, or Box Beam End Assembly Type I installed within the clear zone shall be replaced in conjunction with roadway
work in the same area. A Box Beam End Assembly Type II or Type IIA may remain in place if the guide rail is not being modified or upgraded. An SRT-350 can remain in place if the guide rail is not being modified or upgraded and it has a minimum adjacent recovery area 175 feet long.

8. Concrete Barrier End Treatment
Where the approach end of concrete barrier terminates within the clear zone, an impact attenuator shall be used.
When terminating the approach end of concrete median barrier beyond the clear zone where an end hit is unlikely, a tapered concrete end terminal may be used in lieu of an impact attenuator. The minimum length of a tapered concrete end terminal is 20 feet (30 to 40 feet desirable) and the height at the end of the taper should be no greater than 4 inches. Curb is not permitted in front of this end treatment.

III. Nonvegetative Surface Under Guide Rail
In order to reduce soil erosion and highway maintenance costs associated with spraying vegetation killer or trimming vegetation underneath guide rail, nonvegetative surfaces shall be applied underneath guide rail as shown in Table 9.

<table>
<thead>
<tr>
<th>Conditions Warranting Use of Nonvegetative Surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Guide rail</td>
</tr>
<tr>
<td>Where upgrading guide rail</td>
</tr>
<tr>
<td>Where regrading berms</td>
</tr>
<tr>
<td>Where resetting guide rail</td>
</tr>
<tr>
<td>New Guide rail</td>
</tr>
<tr>
<td>All cases</td>
</tr>
</tbody>
</table>

All nonvegetative surfaces require maintenance to spray emergent non-selective herbicide treatment for total control of vegetation on the nonvegetative surface area. The nonvegetative surface shall be constructed as shown in the Traffic Engineering Standard Details.

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

1. Limited Access Highways
The warrants for median barriers on high speed, access-controlled highways with traversable slopes 1V:10H or flatter are shown in Figure 16. When the need for a median barrier is determined to be optional from Figure 16, an evaluation of the cross median crash history should be made to determine if a median barrier is warranted regardless of the median width and volume. The warrant for a median barrier based on crash history should meet one of the following conditions. This criteria requires a minimum of three crashes occurring within a 5 year period.

- 0.50 cross median crashes per mile per year of any crash severity
- 0.12 fatal cross median crashes per mile per year

Research of cross median crashes indicates that crashes are more likely to occur within one mile of an interchange and this factor has been included as a median barrier warrant in Figure 16. Figure 16 depicts the relationship of low ADT’s to median widths less than 60 feet to determine if a median barrier is warranted. As presented in Figure 16, if the median width is 60 feet or less and the ADT is greater than 50,000 a median barrier is warranted. 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 within the optional areas of Figure 16, a median barrier is warranted only if there has been a history of cross-median crashes. Likewise, for relatively wide medians the probability of a vehicle crossing the median is also low. Thus, for median widths greater than 60 feet and within the optional area of Figure 16, a median barrier may or may not be warranted, again depending on the cross-median crash history.
2. Access Permitted Highways

Careful consideration should be given to the installation of median barriers on access permitted 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, crash history, alignment, sight distance, design speed, traffic volume and median width should be made before installation of median barriers on access permitted highways. Each location should be looked at on a case-by-case basis. If the crash history meets either of the conditions listed above for Interstate and freeways, a median barrier should be installed. For the clear zone for median cross over protection on access permitted highways, see Table 1.

B. Median Barrier Types

Median barriers approved for use are as follows:

- Box Beam Median Barrier (TL-3)
- Dual Faced W-Beam Guide Rail (TL-3)
- Dual Faced Modified Thrie Beam Guide Rail (TL-4)
- 32” Concrete Barrier Curb (TL-4)
- 42” Concrete Barrier Curb (TL-5)
- 42” Concrete Barrier Single Slope (TL-5)

Median barrier type, when warranted, is related to median width (distance between the edge of the traveled way of opposing lanes). Suggested median barrier types relative to the median width are shown in Table 10.

<table>
<thead>
<tr>
<th>Median Width vs. Median Barrier Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Width</td>
</tr>
<tr>
<td>12 feet or less</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>over 12 feet to 26 feet</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>greater than 26 feet</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
</tbody>
</table>
Where median guide rail is proposed, it is recommended to use dual faced modified thrie beam guide rail, in lieu of dual faced W-beam guide rail or box beam median barrier, where one of these conditions exist:

- There are 12 percent or more trucks in the project area
- The traffic volume is greater than 15,000 vehicles per lane (i.e., 4 lane section > 60,000 AADT)
- The horizontal radius of the roadway is less than 3000 feet
- There is a split profile with 1V:6H side slopes or steeper creating opposing roadways with different elevations
- When median guide rail is placed flush with the edge of an inside shoulder 5 feet or less in width

When modified thrie beam guide rail is to be installed in the median and there is existing beam guide rail or box beam guide rail in the median shielding obstructions, the existing beam guide rail or box beam guide rail shall be replaced with modified thrie beam guide rail.

42” Concrete Barrier Single Slope or 42” Concrete Barrier Curb should be used in lieu of 32” Concrete Barrier Curb when one of these conditions exists:

- There are 12 percent or more trucks in the project area
- The traffic volume is greater than 15,000 vehicles per lane (i.e., 4 lane section > 60,000 AADT).

Where barrier curb is used to shield an obstruction (bridge piers, abutments, sign bridges, etc.), a minimum offset of 3.5 feet from the front edge of the barrier (edge of pavement) to the face of the obstruction is desirable, since high profile vehicles have a tendency to lean when impacting barrier curb at a high speed (50 mph or greater) and angle (15 degrees) and may strike the obstruction behind it.

C. End Treatments

1. Concrete Barrier

Where the approach end of concrete barrier terminates within the clear zone, an impact attenuator shall be used.

When terminating the approach end of concrete median barrier beyond the clear zone where an end hit is unlikely, a tapered concrete end terminal is 20 feet (30 to 40 feet desirable) and the height at the end of the taper should be no greater than 4 inches.

At intersections where impact attenuators are used to protect the opening in concrete median barrier, the barrier opening width should be sufficient to accommodate the turning characteristics of the design vehicle.

2. Median Guide Rail

a. General

When terminating the approach end of dual faced W-beam guide rail, dual faced modified thrie beam guide rail, or box beam median barrier within the clear zone, a crashworthy end treatment shall be used.

A median guide rail end terminal shall be installed on relatively flat surfaces (8 percent or flatter slope). Use on raised islands or behind curbs is not recommended. If there is a cross slope of more than 8 percent at the end terminal location, a leveling pad must be used.

All curbs, islands, or elevated objects (delineators, signs) present at the end terminal site over 4 inches high should be removed. Curbs greater than 4 inches high should be removed a minimum of 75 feet in front of the end terminal system and as far back as the rear of the system, and replaced with sloping curb 4 inches or less in height.

b. Box Beam Median Barrier

A box beam tangent terminal shall be provided on the approach end of box beam median barrier within the clear zone. Box beam median barrier tangent terminals approved for use are the 32 foot long Bursting Energy Absorbing Terminal (BEAT-MT) or the 50 foot long Wyoming Box-Beam End Terminal (WYBET-350MB).

c. Dual Faced W-Beam or Dual Faced Modified Thrie Beam Guide Rail

A telescoping guide rail end terminal shall be used with dual faced W-beam or dual faced modified thrie beam guide rail within the median. Where dual faced modified thrie beam guide rail is used, a transition to dual faced W-beam guide rail is needed prior to termination with a telescoping guide rail end terminal. The end terminals permitted for use as a telescoping guide rail end terminal are the 31.25 foot long Crash Cushion Attenuating Terminal (CAT) and the 31.5 foot long Brakemaster 350. A minimum of 12.5 feet of dual faced W-beam guide rail is required behind the telescoping guide rail end terminal before flaring to single faced guide rail.

D. Median Barrier Location

Roadside slopes between the traveled way and the median barrier can have a significant effect on the barrier’s impact performance. When a vehicle traverses a roadside slope in the median, the vehicle’s suspension system can be compressed or extended. As a result, a vehicle that traverses a roadside slope prior to impact with guide rail may go over or under the rail, or snag on the support posts. For concrete barrier curb, a vehicle could go over the barrier, or the barrier could impart an additional roll moment thus increasing the potential for vehicle rollover.
1. Concrete Barrier Curb and Concrete Barrier Single Slope

Concrete barrier curb is normally placed at or near the centerline of the median. The area between the traveled way and the concrete barrier curb should be paved and the slope should not exceed 10 percent.

2. Dual Faced W-Beam Guide Rail, Dual Faced Modified Thrie Beam Guide Rail, or Box Beam Median Barrier

a. Medians Without Curb or Raised Berm

In medians without curb or raised berm, dual faced W-beam, dual faced modified thrie beam, and box beam median guide rail should be placed a minimum of 6 feet from the centerline of the median swale when the median slopes are 1V:10H or flatter (Figure 17A). The centerline of the median swale is determined by the centerline of the median inlets.

For proposed guide rail installations on 1V:6H side slopes, dual faced W-beam or dual faced modified thrie beam guide rail should be installed a minimum of 2 feet in advance of the slope break with rub rail installed on the swale side of the barrier (Figure 17B).

For median slopes that are steeper than 1V:6H, W-beam, modified thrie beam, or box beam guide rail should be placed on both sides of the median a minimum of 2 feet in advance of the slope break (Figure 17C).

Where the median is on a split profile (opposing roadways constructed with different elevations) and the cross slope from the higher roadway is equal to or steeper than 1V:6H, dual faced W-beam or dual faced modified thrie beam guide rail should be placed on the high side of the median a minimum of 2 feet in advance of the slope break with the rub rail installed on the swale side of the barrier (Figure 17D).

Where there is insufficient width between the edge of shoulder and the slope break to provide the 2 foot offset, use W-beam or modified thrie beam guide rail and place the face of the barrier flush with the edge of shoulder using additional post lengths in accordance with Table 6.

b. Medians With Curb or Raised Berm

Dual faced W-beam guide rail, dual faced modified thrie beam, or box beam median barrier should not be used in medians with curb or raised berm. Where curb is required in the median on high speed roadways, the preferred treatment is to use concrete barrier curb or concrete barrier single slope in lieu of mountable or non-mountable curb.

* If the distance from the back of the post to the PVI is less than 2 feet, use W-beam with additional post length (Table 6).

Figure 17 – Median Guide Rail Placement
APPENDIX A

Test Level Matrices
<table>
<thead>
<tr>
<th>Test Level</th>
<th>NCHRP Report 350 Test Vehicle Designation and Type</th>
<th>Test Conditions</th>
<th>MASH Test Vehicle Designation and Type</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vehicle Weight kg (lbs.)</td>
<td>Speed km/h (mph)</td>
<td>Angle degrees</td>
<td>Vehicle Weight kg (lbs.)</td>
</tr>
<tr>
<td>1</td>
<td>820C (Passenger Car) 2,000P (Pickup Truck)</td>
<td>820 (1,800) 2,000 (4,400)</td>
<td>50 (31) 50 (31)</td>
<td>1,100C (Passenger Car) 2,270P (Pickup Truck)</td>
</tr>
<tr>
<td>2</td>
<td>820C (Passenger Car) 2000P (Pickup Truck)</td>
<td>820 (1,800) 2,000 (4,400)</td>
<td>70 (44) 70 (44)</td>
<td>1,100C (Passenger Car) 2,270P (Pickup Truck)</td>
</tr>
<tr>
<td>3</td>
<td>820C (Passenger Car) 2,000P (Pickup Truck)</td>
<td>820 (1,800) 2,000 (4,400)</td>
<td>100 (62) 100 (62)</td>
<td>1,100C (Passenger Car) 2,270P (Pickup Truck)</td>
</tr>
<tr>
<td>4</td>
<td>820C (Passenger Car) 2,000P (Pickup Truck) 8,000S (Single-Unit Truck)</td>
<td>820 (1,800) 2,000 (4,400) 8,000 (17,600)</td>
<td>80 (50) 80 (50)</td>
<td>1,100C (Passenger Car) 2,270P (Pickup Truck) 10,000S (Single-Unit Truck)</td>
</tr>
<tr>
<td>5</td>
<td>820C (Passenger Car) 2,000P (Pickup Truck) 36,000V (Tractor Trailer)</td>
<td>820 (1,800) 2,000 (4,400) 36,000 (80,000)</td>
<td>80 (50) 80 (50)</td>
<td>1,100C (Passenger Car) 2,270P (Pickup Truck) 36,000V (Tractor-Trailer)</td>
</tr>
<tr>
<td>6</td>
<td>820C (Passenger Car) 2,000P (Pickup Truck) 36,000T (Tractor-Tanker Trailer)</td>
<td>820 (1,800) 2,000 (4,400) 36,000 (80,000)</td>
<td>80 (50) 80 (50)</td>
<td>1,100C (Passenger Car) 2,270P (Pickup Truck) 36,000T (Tractor-Tanker Trailer)</td>
</tr>
</tbody>
</table>

Table A-1 – NCHRP Report 350 Crash Test Matrix for Longitudinal Barriers

Table A-2 – MASH Crash Test Matrix for Longitudinal Barriers

APPENDIX B

Decision Trees
Exhibit B-1 – Roadside Barrier Warrants

Is obstruction within clear zone
- yes
- no
  - no: Can obstruction be eliminated
  - yes: Can obstruction be relocated beyond clear zone

Is obstruction an overhead or cantilever sign support
- no: Can obstruction be made breakaway
- yes: Roadside barrier protection may be considered based on engineering judgment

Can roadway be realigned so that obstruction is outside of clear zone
- yes: Is obstruction within Port Authority jurisdiction
- no: Provide roadside barrier using standards of agency having jurisdiction

See Exhibit 2

Is obstruction located behind curb
- yes: See Exhibit 3
- no: Realign roadway
Note 1  See Table 4 in Design Guide for minimum offsets from back of rail element to the obstruction.

Note 2  Guide rail shall not be installed within the airport terminal frontage where it would interfere with pedestrian access.

Exhibit B-2 – Roadside Barrier Selection for Roadways without Curb
Note 1: Mountable curb only with a height no greater than 4 inches.
Note 2: Mountable curb preferred with a height no greater than 6 inches when guide rail is placed at the FOC, and no greater than 4 inches when installed 13 ft or greater from FOC.
Note 3: Mountable curb preferred with a height no greater than 6 inches.
Note 4: 13 ft. for guide rail offset plus 4 ft. from back of rail element to obstruction. See Table 4 in Design Guide for minimum offset from back of rail element to obstruction.
Note 5: 13 ft. for guide rail offset plus 1 ft. from back of rail element to obstruction. See Table 4 in Design Guide for minimum offset from back of rail element to obstruction.
Note 6: 8 ft. for guide rail offset plus 4 ft. from back of rail element to obstruction. See Table 4 in Design Guide for minimum offset from back of rail element to obstruction.
Note 7: 8 ft. for guide rail offset plus 1 ft. from back of rail element to obstruction. See Table 4 in Design Guide for minimum offset from back of rail element to obstruction.
Note 8: Install rub rail when w-beam guide rail is placed less than 3 ft. from the FOC.
Note 9: Guide rail shall not be installed within the airport terminal frontage where it would interfere with pedestrian access.
Note 10: If this offset is not practical, guide rail can be placed any distance from FOC. See Table 4 in Design Guide for minimum offset from back of rail element to obstruction.
Note 11: 6 inches for guide rail offset plus 4 ft. from back of rail element to obstruction. See Table 4 in Design Guide for minimum offset from back of rail element to obstruction.

LEGEND
CTA = Airport Central Terminal Area
FOC = Face of Curb

Exhibit B-3 – Roadside Barrier Selection for Roadways with Curb
Exhibit B-4 – Roadside Barrier End Treatments
APPENDIX C

Sample Drawings
APPENDIX D

Reference Publications


New York State Department of Transportation - *Highway Design Manual and New York State Standard Sheets, Latest Edition*


American Association of State Highway and Transportation Officials - *Manual for Assessing Safety Hardware (MASH), 2009*