Chapter 1610

1610.01  Introduction

WSDOT uses traffic barriers to reduce the overall severity of crashes. Consideration is given as to whether a barrier is preferable to the recovery area it may replace. In some cases, installation of a traffic barrier may result in more crashes as it presents an object that can be struck. Barriers are designed so that such encounters might be less severe and not lead to secondary or tertiary crashes. However, traffic barriers are not guaranteed to redirect an impacting vehicle without resulting injury to its occupants or triggering additional crashes. Barrier performance is affected by the characteristics of the vehicles that collide with them. Different vehicles will react differently given the characteristics and dynamics of the crash. Therefore, vehicles will be decelerated and redirected differently given the size, weight and direction of force imparted from the vehicle to the barrier.

Barriers are not placed with the assumption that the system will restrain or redirect all vehicles in all conditions. It is recognized that the designer cannot design a system that will address every potential crash situation. Instead, barriers are placed with the assumption that, under typical crash conditions, they might decrease the potential for excessive vehicular deceleration or excessive vehicle redirection when compared to the location without the barrier.

Traffic barriers do not prevent crashes or injuries from occurring. They often lower the potential severity for crash outcomes. Consequently, barriers should not be used unless a reduced crash severity potential is likely. No matter how well a barrier system is designed, optimal performance is dependent on drivers’ proper maintenance and operation of their vehicles and the proper use of passenger restraint systems. The ultimate choice of barrier type and placement should be made by gaining an understanding of site and traffic conditions, having a
thorough understanding of and applying the criteria presented in Chapters 1600 and 1610, and using engineering judgment.

Barrier systems and vehicle fleets continue to evolve. The choice of a barrier is based on the characteristics of today’s vehicle fleet and testing criteria, not on speculative assumptions of future vehicle designs. This continuum of change does not allow engineers to predict the future with any degree of certainty. Consequently, engineering decisions need to be made based on the most reliable and current information.

Engineers are constantly striving to develop more effective design features to improve highway safety. However, economics, asset management and maintenance needs, and feasibility do not permit the deployment of new designs as soon as they become available on the market or are invented by a manufacturer. Further, most new designs only make marginal changes to systems and do not imply that old designs are unsafe or need modification.

Solutions may consider crash frequency and severity. As discussed previously, performance of the system relies on the interaction of the vehicle, driver, and system design at any given location. Additionally, the ability to safely access, maintain and operate over time is incorporated into the final barrier decision.

When barriers are crash-tested, it is impossible to replicate the innumerable variations in highway conditions under which the barrier applications occur. Therefore, barriers are crash-tested under standardized conditions. These standard conditions were previously documented in National Cooperative Highway Research Program (NCHRP) Reports 230 and 350. These guidelines have been updated and are now presented in the AASHTO publication, Manual for Assessing Safety Hardware (MASH).

As roadside safety hardware changes occur on the highway system they will use MASH crash testing criteria instead of NCHRP Report 350. To learn more about WSDOT’s plan for implementing MASH-compliant hardware see the following website: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.01(1) Site Constraints

Site constraints play a major role in decisions regarding guardrail selection and placement. Depending on the location, these constraints may include (but are not limited to) environmental considerations, topographic challenges, restricted right-of-way, geologic concerns or conflicts with other infrastructure to name just a few. Document barrier location decisions, including any constraints encountered that influenced those decisions. A decision to install barrier using criteria outside the guidance provided in this chapter requires a Design Analysis (See Chapter 300).

1610.02 Barrier Impacts

Engineering judgment is required in determining the appropriate placement of barrier systems, therefore consider the location of the system and the possible impacts the barrier may have to other highway objectives.

1610.02(1) Assessing Impacts to Stormwater and Wetlands

The presence of stormwater facilities or wetlands influence the choice and use of barrier systems. For example, the placement of concrete barrier may increase the amount of
impervious surface, which could then result in retrofit or reconstruction of the existing retention/detention systems and environmental impact requirements and studies. Assess whether concrete barrier or beam guardrail placement will cause the need for an evaluation by the HQ Environmental Services Office. Conduct this evaluation early in the project’s development process to allow adequate time for discussion of options.

1610.02(2) Assessing Impacts to Wildlife

The placement of concrete barriers in locations where wildlife frequently cross the highway can influence wildlife-vehicle crash potential. When wildlife encounters physical barriers that are difficult to see beyond or cross, such as concrete barriers, they often stop or move parallel to those barriers, increasing their time on the highway and their exposure.

Traffic-related wildlife mortality may play a role in the decline of some species listed under the Endangered Species Act. To address wildlife concerns, see Exhibit 1610-1 to assess whether barrier placement needs to have an evaluation by the HQ Environmental Services Office to determine its effect on wildlife. Conduct this evaluation early in the project development process to allow adequate time for discussion of options.

Exhibit 1610-1 Concrete Barrier Placement Guidance: Assessing Impacts to Wildlife
1610.03 General Barrier Design Considerations

See Chapter 1105 Design Element Selection for guidance regarding required design elements for the various different project types (programs and subprograms).

Chapter 1120 identifies those elements and features to be evaluated and potentially addressed during the course of a Preservation project.

Follow the guidance in this chapter for any project that introduces new barrier onto the roadside (including median section) and follow the guidance in Chapter 1600 for removal of barrier that is not needed. Slope flattening is recommended when the crash reduction benefit justifies the additional cost to eliminate the need for barrier.

When selecting a barrier, consider the barrier system’s deflection characteristics, cost, maintainability and impacts to traffic flow during repair. Barriers are categorized as flexible, semi-rigid, or rigid depending on their deflection characteristics. (See Exhibit 1610-3). Barrier types include:

- Beam Guardrail
- Cable Barrier
- Concrete Barrier
- Bridge Traffic Barrier
- Other Barriers

Since non-rigid systems typically sustain more damage during an impact, consider the amount of traffic exposure maintenance crews might incur with the more frequent need for repairs.

The costs for procuring and maintaining the barrier system are important factors when considering what system to install. Considerations may include:

- Consultation with the Area Maintenance Superintendent to identify needs or recommendations.
- Drainage, alignment, and drifting snow or sand are considerations that can influence the selection of barrier type. Beam guardrail and concrete barrier can contribute to snow drifts. Consider long-term maintenance costs associated with snow removal at locations prone to snow drifting. Cable barrier is not an obstruction to drifting snow.
- Analysis of potential reduction of sight distance due to barrier selection and placement.
- Additional widening and earthwork requirements. With some systems, such as concrete barrier and beam guardrail, the need for additional shoulder widening or slope flattening is common. Selection of these types of barriers may require substantial environmental permitting or roadway reconstruction. Permits issued under the SEPA and NEPA processes may lead to the use of a barrier design, such as cable barrier, which has fewer potential environmental impacts and costs.
- For concrete barrier systems:
  - Lower maintenance costs than for other barrier types.
  - Deterioration due to weather and vehicle impacts is less than most other barrier systems.
  - Unanchored precast concrete barrier can usually be realigned or repaired after a vehicle impact. However, heavy equipment may be necessary to reposition or
replace barrier segments. Therefore, in medians, consider the shoulder width and the traffic volume when determining the acceptability of unanchored precast concrete barrier versus rigid concrete barrier. See Exhibit 1610-3 for deflection area requirements.

Consider the following for existing barrier systems:

- Install, replace, or modify transitions as discussed in 1610.04(6) Transitions and Connections.
- When installing new terminals, extend the guardrail to meet the length-of-need criteria found in 1610.03(5).
- When replacing damaged terminals, consider extending the guardrail to meet the length of need criteria in 1610.03(5)
- When the end of a barrier has been terminated with a small mound of earth, remove and replace with a terminal as described in 1610.06(3).
- Special use or aesthetic barriers may be used on designated Scenic Byway and Heritage Tour routes if funding, permits, and approvals can be arranged (see 1610.08).
- Design Manual Chapter 1120 identifies specific requirements to be addressed for a Preservation project. For other projects, address barrier runs that include:
  - W-beam guardrail with 12-foot 6-inch post spacing, or no blockouts, or both.
  - W-beam guardrail on concrete posts.
  - Cable barrier on wood or concrete posts.
  - Half-moon or C-shaped rail elements.

1610.03(1) Barrier Placement Considerations

Proper installation of a barrier system is required for the system to perform similar to the crash tests that resulted in its acceptance for use on our highways. Maximize the distance between the barrier and the travelled way.

See Chapter 1239 for minimum lateral clearance requirements.

1610.03(1)(a) Placement on a Slope

Slopes may affect barrier placement. Considerations for barrier placement on a slope include:

- For slopes that are 10:1 or flatter, concrete barrier, beam guardrail or cable barrier can be installed anywhere beyond the edge of shoulder. See Exhibit 1610-2.
- For additional placement guidance see 1610.05(1) for cable barrier, see 1610.04(2) for beam guardrail, and see 1610.06 for concrete barrier.
1610.03(1)(b) Placement in Median Locations

Considerations for barrier placement in a median include:

- Address the design deflection characteristics of the barrier to avoid placement of barrier where the design deflection extends into oncoming traffic.

- Narrow medians provide little space for any maintenance activities, including repair or repositioning of the barrier. Installing barriers in medians that provide less than 8 feet from the edge of the traveled way to the face of the barrier will likely require temporarily closing the adjacent lane during maintenance activities. This will impact the travelling public and impact maintenance staff, and maintenance staff should be consulted. See Chapter 301 Design and Maintenance Coordination.

- At locations where the roadways are on independent alignments and there is a difference in elevation between the roadways, the slope from the upper roadway might be steeper than 6H:1V. In these locations, position the median barrier along the upper roadway and provide deflection and offset distance as discussed previously. Barrier is generally not needed along the lower roadway except where there are fixed features in the median.

- In wider medians, the selection and placement of barrier might depend on the slopes in the median. At locations where the median slopes are relatively flat (10H:1V or flatter), unrestrained precast concrete barrier, beam guardrail, and cable barrier can be used depending on the available deflection distance. At these locations, position the barrier as close to the center of the median as possible so that the recovery distance can be maximized for both directions. There may be a need to offset the barrier from the flow line to avoid impacts to the drainage flow.

- In general, cable barrier is recommended with medians that are 30 feet or wider. However, cable barrier may be appropriate for narrower medians if adequate deflection distance exists.

- When W-beam barrier is placed in a median as a countermeasure for cross-median crashes, design the barrier to be struck from either direction of travel. For example, the installation of beam guardrail might be double-sided (Type 31-DS).

- For additional placement guidance see 1610.05(1) for cable barrier, see 1610.04(2) for beam guardrail, and see 1610.06 for concrete barrier.
Chapter 1610  Traffic Barriers

1610.03(2)  Sight Distance

When selecting and placing a barrier system, consider the possible impact the barrier type and height may have on sight distance. In some cases, barriers may restrict the sight distances of road users entering the roadway, such as from road approaches, intersections, and other locations. In these cases, the barrier may need to be adjusted to meet the sight distance requirements at these locations.

1610.03(3)  Barrier Deflections

Expect all barriers, except rigid barriers (such as concrete bridge rails, barrier integral to retaining walls, or embedded cast-in-place barriers), to deflect when hit by an errant vehicle. The amount of deflection is primarily dependent on the stiffness of the system. However, vehicle speed, angle of impact, and weight of the vehicle also affect the amount of barrier deflection. For flexible and semi-rigid roadside barriers, the deflection distance is designed to prevent the impacting vehicle from striking the object being shielded. For unrestrained rigid systems (unanchored precast concrete barrier), the deflection distance is designed to help prevent the barrier from being knocked over the side of a drop-off or steep fill slope (2H:1V or steeper).

In median installations, design systems such that the anticipated deflection will not enter the lane of opposing traffic. When evaluating new barrier installations, consider whether impacts would require significant traffic closures to accomplish maintenance. Use a rigid system where deflection cannot be accommodated, such as in narrow medians or at the edge of bridge decks or other vertical drop-off areas. Runs of rigid concrete barrier can be cast in place or extruded with appropriate footings.

In some locations, where deflection distance is limited, anchor precast concrete barrier. Unless the anchoring system has been designed to function as a fully rigid barrier, some movement can be expected and repairs may be more expensive. Use of an anchored or other deflecting barrier on top of a retaining wall without deflection distance provided requires approval from the HQ Design Office. See 1610.06 for more information on concrete barrier.

Refer to Exhibit 1610-3 for barrier deflection design values when selecting a longitudinal barrier. The deflection values for cable and beam guardrail are minimum distances, measured between the face of the barrier to the fixed feature. The deflection values for unanchored concrete barrier are minimum distances, measured from the back edge of the barrier to the fixed feature, drop-off or slope break.
### Exhibit 1610-3 Longitudinal Barrier Deflection

<table>
<thead>
<tr>
<th>Barrier Type</th>
<th>System Type</th>
<th>Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-tension cable barrier</td>
<td>Flexible</td>
<td>12 ft [1]</td>
</tr>
<tr>
<td>Beam guardrail, Types 1, 1a, 2, 10, and 31</td>
<td>Semi-rigid</td>
<td>3 ft (face of barrier to object)</td>
</tr>
<tr>
<td>Two-sided W-beam guardrail, Types 3, 4,</td>
<td>Semi-rigid</td>
<td>2 ft (nearest face of barrier to object)</td>
</tr>
<tr>
<td>and 31-DS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent concrete barrier, unanchored</td>
<td>Rigid Unrestrained</td>
<td>3 ft [2] (back of barrier to object)</td>
</tr>
<tr>
<td>Temporary concrete barrier, unanchored</td>
<td>Rigid Unrestrained</td>
<td>2 ft [3] (back of barrier to object)</td>
</tr>
<tr>
<td>Precast concrete barrier, anchored</td>
<td>Rigid Anchored</td>
<td>6 inches</td>
</tr>
<tr>
<td>Rigid concrete barrier</td>
<td>Rigid</td>
<td>No deflection</td>
</tr>
</tbody>
</table>

**Notes:**

[1] See 1610.05(2)

[2] When placed in front of a 2H:1V or flatter fill slope, the deflection distance can be reduced to 2 feet.

[3] When used as temporary bridge rail, anchor all barrier within 3 feet of a drop-off.

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### 1610.03(4) Flare Rate

A roadside barrier is considered flared when it is not parallel to the edge of the traveled way.

Flare the ends of longitudinal barriers where site constraints allow (see 1610.01(1)). The four functions of a flare are to:

- Maximize the distance between the barrier (and its terminal) and the travelled way.
- Reduce the length of need.
- Redirect an errant vehicle.
- Minimize a driver’s reaction to the introduction of an object near the traveled way.

Keeping flare rates as flat as site constraints allow preserves the barrier’s redirectional performance and minimizes the angle of impact. It has also been shown that an object (or barrier) close to the traveled way might cause a driver to shift laterally, slow down, or both. The flare reduces this reaction by gradually introducing the barrier so the driver does not perceive the barrier as an object to be avoided. The flare rates in Exhibit 1610-4 are intended to satisfy the four functions listed above. Flares that are more gradual may be used. Flare rates are offset parallel to the edge of the traveled way. Transition sections are not flared.

Situations exist where hardware installations may have barrier flare rates different than shown in Exhibit 1610-4. If a Standard Plan for a barrier installation shows a different flare rate than is shown in Exhibit 1610-4, the flare rate shown on the Standard Plan can be used.
Exhibit 1610-4 Longitudinal Barrier Flare Rates

<table>
<thead>
<tr>
<th>Posted Speed (mph)</th>
<th>Rigid &amp; Rigid Anchored System</th>
<th>Unrestrained Rigid System</th>
<th>Semi-rigid</th>
</tr>
</thead>
<tbody>
<tr>
<td>65–70</td>
<td>20:1</td>
<td>18:1</td>
<td>15:1</td>
</tr>
<tr>
<td>60</td>
<td>18:1</td>
<td>16:1</td>
<td>14:1</td>
</tr>
<tr>
<td>55</td>
<td>16:1</td>
<td>14:1</td>
<td>12:1</td>
</tr>
<tr>
<td>50</td>
<td>14:1</td>
<td>12:1</td>
<td>11:1</td>
</tr>
<tr>
<td>45</td>
<td>12:1</td>
<td>11:1</td>
<td>10:1</td>
</tr>
<tr>
<td>40 or below</td>
<td>11:1</td>
<td>10:1</td>
<td>9:1</td>
</tr>
</tbody>
</table>

1610.03(5) Length of Need

Length of need refers to the total length of longitudinal barrier needed to shield a fixed feature.

In many cases, there may be a portion of the traffic barrier installation that is not redirective in capability. For instance, if a run of concrete barrier is terminated with an impact attenuator, there will likely be a section of the impact attenuator that is not redirective (see Chapter 1620 for more information). Therefore, in most cases, the Length of Need does not equal (i.e., it is shorter than) the actual physical length of the traffic barrier installation required to achieve that length of need.

Length of need is dependent on the location and geometrics of the object, direction(s) of traffic, posted speed, motor vehicle traffic volume, and type and location of traffic barrier.

When designing a barrier for a fill slope (see Chapter 1600), the length of need begins at the point where the need for barrier is recommended. For fixed objects and water, Exhibit 1610-5 shows design parameters for determining the needed length of a barrier for both adjacent and opposing traffic on relatively straight sections of highway.

When barrier is to be installed on the outside of a horizontal curve, the length of need can be determined graphically as shown in Exhibit 1610-7. For installations on the inside of a curve, determine the length of need as though it were straight. Also, consider the flare rate, barrier deflection, and barrier end treatment to be used.

When beam guardrail is placed in a median, consider the potential for impact from opposing traffic when conducting a length of need analysis. When guardrail is placed on either side of objects in the median, consider whether the trailing end of each run of guardrail will shield the leading end of the opposing guardrail. Shield the leading end when it is within the Design Clear Zone of opposing traffic (see Exhibit 1610-8). This is also a consideration when objects are placed in the outer separations between the main line and collector-distributors.

Before the actual length of need is determined, establish the lateral distance between the proposed barrier installation and the object shielded. Provide a distance that is greater than or equal to the anticipated deflection of the longitudinal barrier. (See Exhibit 1610-3 for barrier deflections.) Place the barrier as far from the edge of the traveled way as possible while maintaining the deflection distance.
If the end of the length of need is near an adequate cut slope, extend the barrier and embed it in the slope (see 1610.04(5)). Avoid gaps of 300 feet or less. Short gaps are acceptable when the barrier is terminated in a cut slope. If the end of the length of need is near the end of an existing barrier, it is recommended that the barriers be connected to form a continuous barrier. Consider maintenance access issues when determining whether or not to connect barriers.
Exhibit 1610-5 Barrier Length of Need on Tangent Sections

Note: For supporting length of need equation factors, see Exhibit 1610-6
Exhibit 1610-6 Barrier Length of Need

<table>
<thead>
<tr>
<th>Posted Speed (mph)</th>
<th>Over 10,000</th>
<th>5,000 to 10,000</th>
<th>1,000 to 4,999</th>
<th>Under 1,000</th>
<th>Rigid &amp; Rigid Anchored Barrier</th>
<th>Rigid Unrestrained Barrier</th>
<th>Semi-rigid Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>LR (ft)</td>
<td>LR (ft)</td>
<td>LR (ft)</td>
<td>LR (ft)</td>
<td>F</td>
<td>F</td>
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<td>70</td>
<td>360</td>
<td>330</td>
<td>290</td>
<td>20</td>
<td>18</td>
<td>15</td>
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</tr>
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<td>65</td>
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<td>250</td>
<td>20</td>
<td>18</td>
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<td>80</td>
<td>11</td>
<td>10</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

L1 = Length of barrier parallel to roadway from adjacent-side fixed feature to beginning of barrier flare. This is used if a portion of the barrier cannot be flared (such as a bridge rail and the transition).

L2 = Distance from adjacent edge of traveled way to portion of barrier parallel to roadway.

L4 = Length of barrier parallel to roadway from opposite-side fixed feature to beginning of barrier flare.

L5 = Distance from centerline of roadway to portion of barrier parallel to roadway. Note: If the fixed feature is outside the Design Clear Zone when measured from the centerline, it may only be necessary to provide a crash-tested end treatment for the barrier.

LH1 = Distance from outside edge of traveled way to back side of adjacent-side fixed feature. Note: If a fixed feature extends past the Design Clear Zone, the Design Clear Zone can be used as LH1.

LH2 = Distance from centerline of roadway to back side of opposite-side fixed feature. Note: If a fixed feature extends past the Design Clear Zone, the Design Clear Zone can be used as LH2.

LR = Runout length, measured parallel to roadway.

X1 = Length of need for barrier to shield an adjacent-side fixed feature.

X2 = Length of need for barrier to shield an opposite-side fixed feature.

F = Flare rate value.

Y = Offset distance needed at the beginning of the length of need.

Different end treatments need different offsets:

- For the SRT 350 and FLEAT 350, use Y = 1.8 feet.
- For evaluating existing BCTs, use Y = 1.8 feet.
- For the FLEAT TL-2, use Y = 0.8 feet.
- No offset is needed for the non-flared terminals or impact attenuator systems. Use Y = 0.
Exhibit 1610-7 Barrier Length of Need on Curves

Notes:

- This is a graphical method for determining the length of need for barrier on the outside of a curve.
- On a scale drawing, draw a tangent from the curve to the back of the fixed feature. Compare T to LR from Exhibit 1610-6 and use the shorter value.
- If using LR, follow Exhibits 1610-5 and 6.
- If using T, draw the intersecting barrier run to scale and measure the length of need.

Exhibit 1610-8 W-Beam Guardrail Trailing End Placement for Divided Highways
1610.03(6) Barrier Delineation

Refer to Chapter 1030 for barrier delineation requirements.

1610.04 Beam Guardrail

Strong post W-beam guardrail and thrie beam guardrail are semi-rigid barriers used predominantly on roadsides. They have limited application as median barrier. A strong-post W-beam (commonly referred to as W-Beam) guardrail system is the most common type of guardrail system used. The design uses wood or steel posts, rail, and blockouts to support the rail away from the post. The system resists a vehicle impact through a combination of the tensile and flexural stiffness of the rail and the bending or shearing resistance of the post.

Installed incorrectly, strong post W-beam guardrail can cause vehicle snagging or spearing. This can be avoided by lapping the rail splices in the direction of traffic (as shown in the Standard Plans), by using crash-tested end treatments, and by blocking the rail away from the posts.

Beam guardrail systems are shown in the Standard Plans.

1610.04(1) Beam Guardrail Systems

1610.04(1)(a) Type 31 Beam Guardrail

Use Type 31 guardrail for new runs. The Type 31 system uses many of the same components as the old WSDOT Type 1 system. The main differences are that the blockouts extend 12 inches from the posts, the rail height is 31 inches from the ground to the top of the rail, and the rail elements are spliced between posts.

Type 31 guardrail offers tolerance for future HMA overlays. The system allows a 3-inch tolerance from 31 inches to 28 inches without adjustment of the rail element.

Type 31 guardrail is available double-sided, which can be used in medians.

1610.04(1)(b) (Old) Type 1 Beam Guardrail

Previous WSDOT standard practice was to install W-beam guardrail at a rail height of 27 to 28 inches, and is referred to as “Type 1” guardrail. WSDOT is phasing out the use of Type 1 guardrail. Do not use Type 1 guardrail for new installations. For more information on (Old) Beam Guardrail Type 1, see: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

Existing runs of Type 1 guardrail are acceptable to leave in place. If an existing run of Type 1 guardrail requires extending, use the Beam Guardrail Type 31 to Beam Guardrail Type 1 Adaptor shown in the Standard Plans, and complete the guardrail extension using Type 31 guardrail.

1610.04(1)(c) Other Guardrail Types

W-beam guardrail Type 2 and Type 3 have a height of 30 inches and utilize a rubrail. A rubrail is a structural steel channel added below the W-beam rail and is used in these specific designs to reduce vehicle snagging on the post. Existing runs of Type 2 or Type 3 guardrail are acceptable to leave in place. If the existing run of Type 2 or 3 requires extending contact WSDOT Design Office to identify appropriate extension methods.
Type 4 guardrail is a double-sided version of the Type 1 guardrail system. For new installation, use the Type 31 double-sided W-beam guardrail instead of Type 4 guardrail. Existing runs of Type 4 guardrail are acceptable to leave in place. If the existing run of Type 4 requires extending contact WSDOT Design Office to identify appropriate extension methods to transition to the Type 31 double-sided system.

Type 10 and Type 11 are thrie-beam guardrail systems. Existing runs of Type 10 or 11 guardrail are acceptable to leave in place. If an existing run of Type 10 or Type 11 guardrail requires extending, contact the WSDOT Design Office to discuss options.

Weak post W-beam guardrail (Type 20) and thrie beam guardrail (Type 21) are flexible barrier systems primarily used in conjunction with a Service Level 1 bridge rail system for bridges with timber decks. These systems use weak steel posts. For information on Type 20 and Type 21 guardrail see: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.04(2)  Beam Guardrail Placement

There a number of considerations regarding guardrail placement. These include:

- During the project development processes, consult with maintenance staff to help identify guardrail runs that may need to be modified.

- When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced by 4 inches to accommodate the 12-inch blockout. A Design Analysis is not required for the reduced shoulder width. If the remaining shoulder width is 4 feet or less, see Chapter 1030 for barrier delineation guidance.

- Keep the slope of the area between the edge of the shoulder and the face of the guardrail 10H:1V or flatter.

- On fill slopes 10:1 or flatter, beam guardrail can be placed anywhere outside of the shoulder.

- On fill slopes between 6H:1V and 10H:1V, place beam guardrail at the shoulder or at least 12 feet from the slope breakpoint (as shown in Exhibit 1610-9).

- Do not place beam guardrail on a fill slope steeper than 6H:1V

- On the high side of superelevated sections, place beam guardrail at the edge of shoulder prior to the slope breakpoint.

- For W-beam guardrail installed at or near the shoulder, 2 feet of shoulder widening behind the barrier is generally provided from the back of the post to the slope breakpoint of a fill slope (see Exhibit 1610-10, Case 2). If the slope is 2H:1V or flatter, this distance can be 2.5 feet measured from the face of the guardrail rather than the back of the post (see Exhibit 1610-10, Case 1).

- On projects where no roadway widening is proposed and site constraints prevent providing the 2-foot shoulder widening behind the barrier, long post installations are available as shown in Exhibit 1610-10, Cases 3, 4, 5, and 6. When installing guardrail where the roadway is to be widened or along new alignments, the use of Cases 5 and 6 requires a Design Analysis.
Exhibit 1610-9 Beam Guardrail Installation on 6:1 to 10:1 Slopes

Case A

See Exhibit 1610-10 for placement near slope breakpoint.

Case B

Locate guardrail at shoulder or at least 12' from the slope breakpoint.

Slopes 6H:1V to 10H:1V
Exhibit 1610-10 Beam Guardrail Post Installation

**Notes:**

- Use Cases 1 and 3 when there is a 2.5-foot or greater shoulder widening from face of guardrail to the slope breakpoint.
- Use Case 2 when there is a 4.0-foot or greater shoulder widening from the face of the guardrail to the slope breakpoint.
- Use Cases 4, 5, and 6 when there is less than a 2.5-foot shoulder widening from face of guardrail to the slope breakpoint.
- Cases shown do not apply to terminals, transition sections or anchors. Install terminals, transition sections and anchors per the *Standard Plans*.

**1610.04(3) W-Beam Barrier Height**

For Pavement Preservation (P1) projects see Chapter 1120.

For other projects with existing Type 1 guardrail runs under 26.5 inches, adjust or replace the rail to a height of 28 inches minimum to 30 inches maximum, or replace the run with the 31-inch high Type 31 beam guardrail.
If Type 1 Alternative W-beam guardrail is present, the rail element may be raised after each overlay. If Type 1 Alternative is not present, the blockout and rail element may be raised up to 4 inches. This requires field drilling a new hole in the guardrail post. See the Standard Plans.

1610.04(4) Additional Guidance

Additional guidance related to w-beam guardrail:

- Locations where crossroads and driveways cause gaps in the guardrail create situations requiring special consideration. Elimination of the need for the barrier is the preferred solution. At these locations, a barrier flare might be needed to provide sight distance.

- Rail washers on beam guardrail are not normally used. If rail washers are present, removal is not necessary. However, if the rail element is removed for any reason, do not reinstall rail washers. In areas where heavy snow accumulations are expected to cause the bolts to pull out, specify snowload post washers and rail washers in the contract documents (snowload post washers are used to help prevent the bolts from pulling through the posts, and snowload rail washers are used to help prevent the bolt head from pulling through the rail). In other installations, it is normal to have the rail pull loose from the bolt head when impacted. Do not use rail washers within the limits of a guardrail terminal except, for some models, at the end post when they are needed for anchorage of the rail.

- The use of curb in conjunction with beam guardrail is discouraged. If a curb is needed, the 3 inch-high curb is preferred. If necessary, the 4-inch-high extruded curb can be used behind the face of rail for any posted speed. The 6-inch-high extruded curb can be used at locations where the posted speed is 50 mph or below. When replacing extruded curb at locations where the posted speed is above 50 mph, use 3 inch-high or 4-inch-high curb. (See the Standard Plans for extruded curb designs.)

- When curb is used in conjunction with Type 31 W-beam guardrail, an acceptable option is to place up to a 6-inch-high extruded curb at a maximum 6 inch offset in front of the face of the rail at any posted speed. Contact the WSDOT Design Office for more information.

- Guardrail posts are expected to be able to rotate when the rail is impacted. The installation of strong post W-beam guardrail posts in rigid surfacing such as asphalt or concrete pavement involves specially designed post holes that will allow the posts to rotate. Contact the WSDOT Design Office for more information.

- For (Old) Guardrail Types 1, 2, 3, and 4, it is acceptable to use blockouts that extend the rail element from the post for a distance not to exceed 16 inches.

1610.04(5) Terminals and Anchors

A guardrail anchor is required at the end of a run of guardrail to develop tensile strength throughout its length. In addition, when the end of the guardrail is subject to head-on impacts, a crash-tested guardrail terminal is required (see the Standard Plans).

Replace guardrail terminals that do not have a crash-tested design with crash-tested guardrail terminals. Common features of systems that do not meet current crash-tested designs include:

- No cable anchor.
• A cable anchored into concrete in front of the first post.
• Second post not breakaway (CRT).
• Design A end section.
• Design C end sections may be left in place if the terminal is otherwise a crash-tested design —see the Standard Plans for end section details.
• Terminals with beam guardrail on both sides of the posts (two-sided).
• Buried guardrail terminals that slope down such that the guardrail height is reduced to less than 28 inches (measured in relation to a 10H:1V line extended from the breakpoint at edge of shoulder).

When the height of a terminal, as measured from the ground to the top of the rail element, will be affected by the project, adjust the terminal based upon the following criteria:

• If the height of the adjoining Type 1, 2, 3, or 4 guardrail will be reduced to less than 26.5 inches or increased to greater than 30 inches, adjust the height of the terminal to a minimum of 28 inches and a maximum of 30 inches. A terminal height of 30 inches is desirable to accommodate future overlays.

• If the height of the adjoining Type 31 guardrail will be reduced to less than 28 inches or increased to greater than 32 inches, adjust the height of the terminal to 31 inches.

When adjusting terminals that are equipped with CRT posts, the top-drilled holes in the posts need to remain at the surface of the ground.

One terminal that was used extensively on Washington’s highways was the Breakaway Cable Terminal (BCT). This system used a parabolic flare similar to the Slotted Rail Terminal (SRT) and a Type 1 anchor (Type 1 anchor posts are wood set in a steel tube or a concrete foundation). For guidance regarding BCT’s on Preservation projects see Chapter 1120. For non-Preservation projects replace BCTs with a currently approved terminal.

Information regarding (Old) Type 1 beam guardrail terminals can be found at: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.04(5)(a) Buried Terminal (BT) for Type 31 Beam Guardrail

A buried terminal is designed to terminate the guardrail by burying the end in a backslope. The BT is the preferred terminal because it eliminates the exposed end of the guardrail.

For new BT installations, use the Buried Terminal Type 2. Previously, another BT option (the Buried Terminal Type 1) was an available choice. For existing installations, it is acceptable to leave this option in service as long as height requirements and other design criteria is met. See the plan sheet at: www.wsdot.wa.gov/design/standards/plansheet.

The BT uses a Type 2 anchor to develop the tensile strength in the guardrail. The backslope needed to install a BT is to be 3H:1V or steeper and at least 4 feet in height above the roadway. The entire BT can be used within the length of need for backslopes of 1H:1V or steeper if the barrier remains at full height in relation to the roadway shoulder to the point where the barrier enters the backslope.

For backslopes between 1H:1V and 3H:1V, design the length of need beginning at the point where the W-beam remains at full height in relation to the roadway shoulder—usually
beginning at the point where the barrier crosses the ditch line. If the backslope is flatter than 1H:1V, provide a minimum 20-foot-wide by 75-foot-long clear area that is free of fixed features behind the barrier and between the beginning length of need point at the terminal end to the mitigated object to be protected.

Flare the guardrail to the foreslope/backslope intersection using a flare rate that meets the criteria in 1610.03(4). Provide a 4H:1V or flatter foreslope into the face of the guardrail and maintain the full guardrail height to the foreslope/backslope intersection in relation to a 10H:1V line extending from edge of shoulder breakpoint. (See the Standard Plans for details.)

1610.04(5)(b) Non-flared Terminals for Type 31 Beam Guardrail

If a buried terminal cannot be installed as described in 1610.04(5)(a), install a non-flared terminal. These systems use W-beam guardrail with a special end piece that fits over the end of the guardrail. When hit head on, the end piece is pushed over the rail, absorbing the energy of the impacting vehicle in the process. An anchor is included for developing the tensile strength of the guardrail. The length of need does not begin at the impact head, but will vary by system. Non-flared terminals may be provided for two different design levels that are based on the posted speed of the highway. For highways with a posted speed of 50 mph or above, use only a TL-3 (Test Level 3) product. For highways with a posted speed of 45 mph or below, either a TL-2 or a TL-3 product is acceptable. See the Standard Plans.

The availability and acceptance of these systems is expected to change rapidly over time. Refer to the Type 31 Beam Guardrail Terminals website for the latest information on availability or acceptance of different systems (see http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm).

Although non-flared terminals do not need to have an offset at the end, a flare is recommended so that the end piece does not protrude into the shoulder. See the Standard Plans.

Four feet of additional widening behind the terminal is needed at the end posts to properly anchor the systems (See the Standard Plans). When widening includes an embankment, properly placed and compacted fill material will be necessary for optimum terminal performance (see the Standard Specifications for embankment widening for guardrail).

For guardrail runs that are located more than 12 feet from the slope break (as shown in Exhibit 1610-9) no additional embankment widening is required at the terminal.

No snowload rail washers are allowed within the limits of these terminals.

WSDOT does not currently use a flared terminal system for the Type 31 guardrail system.

Note: Approved shop drawings for terminals can be found by accessing the following website: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.04(5)(c) Terminal Evolution Considerations

Some currently approved terminals have been in service for a number of years. During this time, there have been minor design changes. However, these minor changes have not changed the devices' approval status. Previous designs for these terminals may remain in place.

Note: If questions arise concerning the current approval status of a device, contact the HQ Design Office for clarification when replacement is being considered.
1610.04(5)(d) Anchors

A guardrail anchor is needed at the end of a run of guardrail to develop tensile strength throughout its length.

- Use the Type 10 anchor to develop the tensile strength of the guardrail on the end of Type 31 guardrail runs where a crash-tested terminal is not needed.

- A Type 2 anchor is used with the buried terminal.

For information on anchor types used in runs of (Old) Beam Guardrail Type 1, see: [http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm](http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm).

1610.04(6) Transitions and Connections

When there is an abrupt change from one barrier type to a more rigid barrier type, a vehicle hitting the more flexible barrier may be caught in the deflected barrier pocket and directed into the more rigid barrier. This is commonly referred to as “pocketing.” A transition stiffens the more flexible barrier by decreasing the post spacing, increasing the post size, and using stiffer beam elements to reduce the possibility of pocketing.

When connecting beam guardrail to a more rigid barrier or a structure use the transitions and connections that are shown in Exhibits 1610-12 and 1610-13 and detailed in the Standard Plans.

Type 21 transitions can be used on highways with all posted speeds to connect w-beam guardrail to single slope, safety shape or vertical concrete barriers.

Type 22 and Type 23 transitions are used to connect w-beam guardrail to thrie beam on bridges.

Type 24 transitions can be used on highways with a posted speed of 45 mph or less to connect w-beam guardrail to single slope, safety shape or vertical concrete barriers.

When connecting a Type 21 or Type 24 Transition to an existing vertical faced bridge rail with a low parapet, a special connection plate may be required. Coordinate with the WSDOT Bridge and Structures Office (BSO). The transition pay item includes the connection.

For information regarding transitions used with (Old) Type 1 guardrail see: [http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm](http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm).
### Exhibit 1610-11 Vacant

### Exhibit 1610-12 Guardrail Connections

<table>
<thead>
<tr>
<th>Condition</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrestrained concrete barrier</td>
<td>A</td>
</tr>
<tr>
<td>Rigid, rigid anchored, untapered safety shape bridge rails or barriers [1]</td>
<td>B</td>
</tr>
<tr>
<td>Bridge rails with curbs 9 inches or less in width</td>
<td>B</td>
</tr>
<tr>
<td>Bridge rails with curbs between 9 and 18 inches wide</td>
<td>C</td>
</tr>
<tr>
<td>Vertical walls, single slope, or tapered safety shape barrier [1]</td>
<td>D</td>
</tr>
</tbody>
</table>

**Note:**

[1] New single slope and safety shape bridge rails are designed with the toe of the barrier tapered so that it does not project past the face of the approach guardrail.
Exhibit 1610-13 Transitions and Connections

<table>
<thead>
<tr>
<th>Connecting Type 31 W-Beam Guardrail to:</th>
<th>Transition Type*</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge Rail [1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing Concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 in.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 in.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrie Beam at Face of Curb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approach End</td>
<td>23</td>
<td>n/a</td>
</tr>
<tr>
<td>Trailing End (two-way traffic only)</td>
<td>23</td>
<td>n/a</td>
</tr>
<tr>
<td>Thrie Beam at Bridge Rail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(curb exposed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approach End</td>
<td>22</td>
<td>n/a</td>
</tr>
<tr>
<td>Trailing End (two-way traffic only)</td>
<td>22</td>
<td>n/a</td>
</tr>
<tr>
<td>Concrete Barrier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unrestrained</td>
<td>21, 24 [3]</td>
<td>A</td>
</tr>
<tr>
<td>Rigid Structures such as Bridge Piers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>See Placement Cases 11A-31 through 11C-31</td>
<td>21, 24 [3]</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Connecting Thrie Beam Guardrail to:

| Bridge Rail or Concrete Barrier         | See the thrie beam transition in the Plan Sheet Library | Exhibit 1610-12 |

*Consult Section C of the Standard Plans for details on transition types.

Notes:


[2] When connecting a Type 21 or Type 24 Transition to an existing vertical faced bridge rail with a low parapet, a special connection plate may be required. Contact the WSDOT BSO for details.

[3] Transition Type 21 is acceptable for use on highways with all posted speeds. Transition Type 24 is acceptable for use on highways with posted speeds 45 mph or below.
1610.04(7) Guardrail Placement Cases

The Standard Plans contain placement cases that show beam guardrail elements needed for typical situations. For new installations, use the appropriate Type 31 placement option.

Information regarding placement cases for (Old) Type 1 beam guardrail can be found at http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

1610.04(7)(a) Beam Guardrail Type 31 Placements

- Case 1-31 is used where there is one-way traffic. It uses a crash-tested terminal on the approach end and a Type 10 anchor on the trailing end.
- Case 2-31 is used where there is two-way traffic. A crash-tested terminal is used on both ends.
- Case 3-31 is used at railroad signal supports on one-way or two-way roadways. A terminal is used on the approach end, but usually cannot be used on the trailing end because of its proximity to the railroad tracks. If there is a history of crossover collisions, consider additional protection such as an impact attenuator.
- Case 4-31 is used where guardrail on the approach to a bridge is to be shifted laterally to connect with the bridge rail. A terminal is used on the approach end and a transition is needed at the bridge end. Curves (bends) are shown in the guardrail to shift it to the bridge rail. However, the length of the curves are not critical. The criterion is to provide smooth curves that are not more abrupt than the allowable flare rate (see Exhibit 1610-4).
- Case 5-31 is a typical bridge approach where a terminal and a transition are needed.
- Case 10 (A-31, B-31, and C-31) is used at roadside fixed features (such as bridge piers) when 3 or more feet are available from the face of the guardrail to the feature. The approach end is the same for one-way or two-way traffic. Case 10A-31 is used with two-way traffic; therefore, a terminal is needed on the trailing end. Case 10B-31 is used for one-way traffic when there is no need to extend guardrail past the bridge pier and a Type 10 anchor is used to end the guardrail. Case 10C-31 is used for one-way traffic when the guardrail will extend for a distance past the bridge pier.
- Case 11 (A-31, B-31, and C-31) is used at roadside fixed features (such as bridge piers) when the guardrail is to be placed within 3 feet of the feature. Since there is no room for deflection, the rail in front of the feature is to be considered a rigid system and a transition is needed. The trailing end cases are the same as described for Case 10.
- Beam Guardrail Type 31 (12'6", 18'9", or 25' Span) is used when it is necessary to omit one, two, or three posts. This application is typically used when guardrail is installed over a shallow buried obstruction, such as drainage structures. This design may be used in other situations where there are no above ground objects located behind the guardrail and within the lateral deflection distance. Three CRT posts are provided on each end of the omitted post(s).
- Guardrail Placement Strong Post – Type 31 is the “Strong Post Intersection Design for Type 31 barrier” that provides a more rigid barrier. This design is used at crossroads or road approaches where a barrier is needed and where the length of need cannot be achieved using standard components such as standard longitudinal barrier runs, transitions, and terminals.
1610.05 High-Tension Cable Barrier

Cable barrier is a flexible barrier system that can be used on a roadside or as a median barrier. Early cable barrier designs centered around low-tension cable systems. With research and crash analysis of these systems, the designs evolved into high-tension cable systems. These high-tension cable systems are primarily used in medians and are preferred for many installations due in part to high benefit-to-cost ratios. Read about advantages for selecting a cable barrier system here:


There are a number of manufacturers of high-tension cable barrier systems. These systems have been designed using either three or four-cables fixed to metal posts placed at a fixed spacing. Each cable system has specially designed anchors placed at both ends of the barrier run to provide the proper tensioning in the cables. Currently, both three and four-cable high-tension cable barrier systems are installed along WSDOT state routes. See additional information about these approved cable barrier systems here:


Use four-cable high-tension cable barrier systems for all new installations.

1610.05(1) High-Tension Cable Barrier Placement

High-tension cable barrier can be placed in a median or along the roadside.

Note: Additional placement cases are shown in the WSDOT Standard Plans. For non-typical installations, such as double runs of cable barrier or median ditch cross sections that differ significantly from those shown, contact the HQ Design Office for guidance.

1610.05(1)(a) Median Applications

For typical cable barrier installations in a median, the following apply (see Exhibit 1610-14a):

- Install the cable barrier as far from the edge of traveled way as site constraints allow. Consider a minimum placement distance of 8 feet from the edge of traveled way to allow vehicles to use this area for refuge.
- Install cable barrier on slopes 6H:1V or flatter.
- There are approved high-tension cable barrier systems that can be placed on slopes as steep as 4H:1V. The use of these systems requires special placement considerations, contact the HQ Design Office for guidance.
- Provide an obstruction free zone within the cable barrier system’s lateral deflection distance (see 1610.05(2)).
- On tangent sections of a roadway where no ditch is present, consider installing the cable barrier in the middle of the median.
- Along horizontal curves, consider installing the cable barrier along the inside of the curve. Reduce the post spacing per manufacturer’s recommendations.
- Where a ditch is present, install cable barrier at the centerline of the ditch or within 1-foot of the ditch centerline.
• Avoid installing cable barrier within the range between 1-foot to 8-foot offset from the ditch centerline to avoid “under-riding” of vehicles that cross the ditch (see Exhibit 1610-14a).

• In some situations, it may be advantageous to terminate a run of cable barrier on one side of the median (to provide maintenance access to a feature, for example) and then begin an adjacent cable barrier run on the opposite side of the median. In this application, it is important to provide adequate cable barrier overlap distance between the two runs. For placement guidance, see Exhibit 1610-15.

• Narrow medians provide little space for maintenance crews to repair or reposition the barrier. Wherever site conditions permit, provide at least 14 feet of clearance from the adjacent lane edge to the face of the cable barrier.
Exhibit 1610-14a Median Cable Barrier Placement

Notes:

1. Cable barrier may be installed in the center of the ditch and from the ditch centerline a maximum of 1 foot (left or right).

2. Avoid installing cable barrier within a range of 1-foot to 8-foot offset from the ditch centerline.

3. Applies to slopes 6H:1V or flatter.

4. Provide an obstruction free zone within the cable barrier’s lateral deflection distance, see 1610.05(2)
1610.05(1)(b) Roadside Applications

For typical non-median roadside applications, the following apply (see Exhibit 1610-14b):

- Install the cable barrier as far from the edge of traveled way as site constraints allow.
- Consider a minimum placement distance of 8 feet from the edge of traveled way to allow vehicles to use this area for refuge.
- Install cable barrier on slopes 6H:1V or flatter
- There are approved high-tension cable barrier systems that can be placed on slopes as steep as 4H:1V. The use of these systems requires special placement considerations, contact the HQ Design Office for guidance.
- Along horizontal curves, consider installing along the inside of the curve. Reduce post spacing per manufacturer’s recommendations
- Provide an obstruction free zone within the cable barrier system’s lateral deflection distance, see 1610.05(2).

Exhibit 1610-14b Roadside Cable Barrier Placement

Notes:

- Provide an obstruction free zone within the cable barrier’s lateral deflection distance, see 1610.05(2)

1610.05(2) High-Tension Cable Barrier Lateral Deflection Distances

Depending on the high-tension cable barrier system, lateral deflection distances for each barrier system vary based upon the length of the barrier run, the spacing of the end anchors, and post spacing. Provide an obstruction free zone within the system’s lateral deflection distance for the following situations:

1. In the direction of travel (located in the median or along roadside), locate the cable barrier system so that there are no fixed objects within the limits of the cable barrier lateral deflection distance.
2. For opposing traffic (where present), locate the cable barrier to provide lateral deflection distance to prevent a vehicle’s encroachment into the opposite lane of travel.

Provide a minimum 12-feet for cable barrier lateral deflection distance and specify the minimum allowable lateral deflection distance in the contract documents in order for the contractor to select a cable barrier manufacturer that can meet the lateral deflection requirements.

**Note:** There are new high-tension cable barrier systems under development that may change selection and placement criteria. For example, newer systems may allow placement on steeper slopes or have reduced deflection distances. Contact the HQ Design Office for guidance.

### 1610.05(3) High-Tension Cable Barrier Height

A high-tension four-cable barrier system shall provide a height to the center of the top cable of not less than 35 inches and a height to the center of the bottom cable not greater than 19 inches. Previous testing of cable barrier systems has shown that providing cables within the ranges specified typically restrains a vehicle traversing the various slopes and reduces the possibility of the vehicle either overriding or under riding the cable barrier.

### 1610.05(4) High-Tension Cable Barrier Termination

Manufacturers of high-tension four-cable barrier systems provide designed anchors for the ends of cable barrier runs. Other alternatives to end a cable barrier include:

- It is possible to terminate high-tension cable barrier systems by connecting directly to beam guardrail runs (such as transitions to bridge rails) or to a separate cable barrier anchorage system. Review field conditions, check local maintenance personnel needs, and then specify the required connection option in the contract documents. If a separate anchorage system is used, refer to Exhibit 1610-15 for placement guidance.

- When cable barrier is connected to a more rigid barrier, a transition section is typically needed. Contact the HQ Design Office for further details.
Exhibit 1610-15 Cable Barrier Placement for Divided Highways

**Cable Barrier Median Overlap**

\[
BO = \frac{LH1 - L2}{(LH1/LR)} \quad \text{(Direction A shown)}
\]

**Note:**

Calculate barrier overlap (BO) from both directions of travel. Use the greatest value of BO obtained.

**Cable Barrier Overlap with Beam Guardrails**

**Notes:**

- The beam guardrail may need to be extended and flared to maintain adequate barrier overlap and shoulder width.
- Typical applications may be at either bridge transitions or where high-tension cable and beam guardrail systems end or begin.
- For supporting length of need equation factors, see Exhibit 1610-6.
1610.05(5) High-Tension Cable Barrier Curb Placement

Avoid the placement of curb in conjunction with high-tension cable barrier systems. Currently, there are no known acceptable cable barrier systems that have been successfully crash tested with this feature present.

1610.06 Concrete Barrier

Concrete barriers are identified as either rigid, rigid anchored, or unrestrained rigid systems. They are commonly used in medians and as shoulder barriers. These systems are stiffer than beam guardrail or cable barrier, and impacts with these barriers tend to be more severe. Consider the following when installing concrete barriers:

- For slopes 10H:1V or flatter, concrete barrier can be used anywhere outside of the shoulder.
- Do not use concrete barrier at locations where the foreslope into the face of the barrier is steeper than 10H:1V.
- Light standards mounted on top of precast concrete median barrier must not have breakaway features. (See the concrete barrier light standard section in the Standard Plans.)
- When considering concrete barrier use in areas where drainage and environmental issues (such as stormwater, wildlife, or endangered species) might be adversely impacted, contact the HQ Hydraulics Office and/or the appropriate environmental offices for guidance. Also, refer to 1610.02.

1610.06(1) Concrete Barrier Shapes

Concrete barriers use a single-slope or safety shape (New Jersey or F-Shape) to redirect vehicles while minimizing vehicle vaulting, rolling, and snagging. A comparison of these barrier shapes is shown in Exhibit 1610-16.

The single-slope barrier face is the recommended option for embedded rigid concrete barrier applications.

Exhibit 1610-16 Concrete Barrier Shapes
When the single-slope or F-Shape face is used on structures, and precast barrier is selected for use on the approaches, a cast-in-place transition section is needed so that no vertical edges of the barrier are exposed to oncoming traffic. For details on bridge rail designs, see the Bridge Design Manual.

For aesthetic reasons, avoid changes in the shape of the barrier face within a project or corridor.

The New Jersey shape and F-shape barriers are commonly referred to as “safety shapes.” The New Jersey shape and F-shape have an initial overall height of 32 inches. This height includes provision for up to a 3-inch future pavement overlay that can reduce the barrier height to 29 inches minimum.

As part of the implementation of MASH-compliant hardware WSDOT is transitioning from predominantly using New Jersey shape barrier (Type 2 barrier) for precast concrete barrier to using F-shape concrete barrier (Type F barrier) instead. For permanent installations of non-embedded precast concrete barrier F-shape (Type F) barrier is preferred. New Jersey shape (Type 2) barrier is still allowed.

For projects requiring variations of Type F barrier with no Standard Plan yet available, using Type 2 barrier instead is appropriate, or contact the HQ Design Office for more information.

To learn more about WSDOT’s plan for implementing MASH-compliant hardware see the following website: [http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm](http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm)

1610.06(1)(a) Safety Shape Barrier

Concrete Barrier Type F (see the Standard Plans) is a freestanding precast barrier that has the F-shape on both sides. It can be used for both median and shoulder installations. Unanchored units are connected with steel pins through metal loops. For permanent installation, this barrier is placed on a paved surface and a paved surface is provided beyond the barrier for deflection. See Exhibit 1610-3 for deflection requirements.

The New Jersey shape face is primarily used on precast concrete barrier. Concrete Barrier Type 2 (see the Standard Plans) is a freestanding precast barrier that has the New Jersey shape on two sides. It can be used for both median and shoulder installations. Unanchored units are connected with steel pins through wire rope loops. For permanent installation, this barrier is placed on a paved surface and a paved surface is provided beyond the barrier for deflection. See Exhibit 1610-3 for deflection requirements.

The cost of precast safety shape barrier is significantly less than the cost of the cast-in-place barriers. Therefore, consider the length of the barrier run and the deflection needs to determine whether transitioning to precast barrier is desirable. If precast safety shape barrier is used for the majority of a project, use the safety shape for small sections that need cast-in-place barrier, such as for a light standard section, see the Standard Plans for additional details for transitioning the barrier faces.

Concrete barrier Type 4 is a precast, single-faced New Jersey shape barrier. These units are not freestanding and are to be placed against a rigid structure or anchored to the pavement. If Type 4 barriers are used back to back, fill any gap between them to prevent tipping.

Precast barrier can be anchored where a more rigid barrier is needed. (Anchoring methods are shown in the Standard Plans.) Anchors Type 1 and Type 2 are for temporary installations on a rigid pavement. Type 3 anchors can be used in temporary or permanent installations on an
Asphalt pavement. Consult the WSDOT BSO for details when anchoring permanent precast concrete barrier to a rigid (Portland cement concrete) pavement.

Precast barrier used on the approach to bridge rail is to be connected to the bridge rail by installing loops embedded into the bridge rail with epoxy resin and as detailed in the Standard Plans.

Place unrestrained (unanchored) precast concrete barrier on slopes of 5% (20H:1V) or flatter where possible. The maximum slope for placement of concrete barrier is 10% (10H:1V).

In the past WSDOT used a Type 5 single-faced New Jersey shape for special applications, such as adjacent to bridge rails with similar shapes. The Type 5 barrier is seldom used by WSDOT. See the Plan Sheet Library for more information on Type 5 barrier:


1610.06(1)(b) Single-Slope Barrier

Single-slope barrier is available in various heights, as shown in the Standard Plans. Single-slope concrete barrier can be cast in place or precast. A primary benefit of using precast single-slope barrier is that it can be used as temporary barrier during construction and then reset into a permanent location. In temporary applications, the height of the single-slope barrier may also offer the added benefits of reducing headlight glare and providing reduced deflection characteristics over some other barrier types.

Single-slope barrier is considered a rigid system regardless of the construction method used provided the barrier is embedded a minimum of 3-inches in the roadway wearing surface on both sides. When precast single-slope barrier is installed on top of the roadway surface, it is considered a rigid unrestrained system and barrier deflection needs to be provided as shown in Exhibit 1610-3.

For new installations, the minimum height of single-slope barrier above the roadway is 2 feet 10 inches, which allows a 2-inch tolerance for future overlays. The minimum total height of the barrier section is 3 feet 6 inches (including embedment). This allows for use of the 3-foot-6-inch barrier between roadways with grade separations of up to 5 inches. A grade separation of up to 10 inches is allowed when using a 4-foot-6-inch high barrier section, as shown in the Standard Plans. The barrier is to have a depth of embedment equal to or greater than the grade separation. Contact the WSDOT BSO for grade separations greater than 10 inches.

1610.06(1)(c) High-Performance Concrete Barrier

High-Performance Concrete Barrier (HP Barrier) is a rigid barrier with a minimum height of 3-foot-6-inch above the roadway surface. This barrier is designed to function more effectively during heavy-vehicle crashes. This taller barrier may also offer the added benefits of reducing headlight glare and reducing noise in surrounding environments. WSDOT HP Barrier utilizes the single-slope shape. (See the Standard Plans for barrier details.)

Use HP Barrier in freeway medians of 22 feet or less. Also, use HP Barrier on Interstate or freeway routes where crash history suggests a need or where roadway geometrics increase the possibility of larger trucks hitting the barrier at a high angle (for example, on-ramps for freeway-to-freeway connections with sharp curvature in the alignment).
Consider the use of HP Barrier at other locations such as highways with narrow medians, near highly sensitive environmental areas, near densely populated areas, over or near mass transit facilities, or on vertically divided highways.

1610.06(1)(d)  Low-Profile Barrier

Low-profile barrier designs are available for median applications where the posted speed is 45 mph or below. These barriers are normally used in urban areas. They are typically 18 to 20 inches high and offer sight distance benefits. For barrier designs, terminals, and further details, contact the HQ Design Office.

1610.06(2)  Concrete Barrier Height

Overlays in front of safety shape concrete barriers can extend to the top of the lower, near-vertical face of the barrier before adjustment is necessary.

- Allow no less than 2-foot 5 inches from the pavement to the top of the safety shape barriers. Allow no less than 2-foot 8-inches from the pavement to the top of the single-slope barrier.

1610.06(3)  Concrete Barrier Terminals

Whenever possible, bury the blunt end of a concrete barrier run into the backslope of the roadway. If the end of a concrete barrier run cannot be buried in a backslope or terminated as described below, terminate the barrier using a guardrail terminal and transition or an impact attenuator (see Chapter 1620).

To bury the blunt end of the barrier into a backslope, the following conditions must be met:

- The backslope is 3H:1V or steeper
- The backslope extends minimum of 4 feet in height above the edge of shoulder
- Flare the concrete barrier into the backslope using a flare rate that meets the criteria in 1610.03(4)
- Provide a 10H:1V or flatter foreslope into the face of the barrier and maintain the full barrier height until the barrier intersects with the backslope. This might create the need to fill ditches and install culverts in front of the barrier face.

The 7-foot-long precast concrete barrier Type 2 and the 10- to 12-foot single-slope barrier terminal (precast or cast-in-place) may be used for the following conditions:

- Outside the Design Clear Zone.
- On the trailing end of the barrier when it is outside the Design Clear Zone for opposing traffic.
- On the trailing end of one-way traffic.
- Where the posted speed is 25 mph or below.

See the Standard Plans for barrier terminal details.
1610.07 Bridge Traffic Barriers

Bridge traffic barriers redirect errant vehicles and help to keep them from going over the side of the structure. (See the Bridge Design Manual for information regarding bridge barrier on new bridges and replacement bridge barrier on existing bridges).

When considering work on a bridge traffic barrier consult the WSDOT Bridge and Structures Office (BSO).

- The standard bridge traffic barrier is a 3 foot 6 inch single slope or F Shape traffic barrier.
- For corridor continuity, a 2 foot 10 inch single slope or 2 foot 8 inch F Shape traffic barrier may be used with a pedestrian railing attached to the top for a total height of 3 foot 6 inch height inches. This also meets requirements for worker fall protection.

Approach barriers, transitions, and connections are usually needed on all four corners of bridges carrying two-way traffic and on both corners of the approach end for one-way traffic. (See 1610.04(6) for guidance on transitions). A transition is available to connect the Type 2 concrete barrier (New Jersey shape) and the bridge barrier (F-Shape.) (See the Standard Plans for further details).

Bridge railing attaches to the top of the bridge barrier. When bridge barrier is included in a project, the bridge rails, including crossroad bridge rail, are to be addressed. Consult the WSDOT BSO regarding bridge rail selection and design and for design of the connection to an existing bridge. Consider the following:

- Use an approved, NCHRP 350 or MASH crash-tested bridge traffic barrier on new bridges or bridges to be widened. The Bridge Design Manual provides examples of typical bridge rails. The BSO’s minimum crash test level for all state and interstate bridges is a TL-4.
- An existing bridge rail on a roadway with a posted speed of 30 mph or below may remain in place if it is not located on a bridge over a National Highway System (NHS) highway. When Type 7 bridge rail is present on a bridge over an NHS highway with a posted speed of 30 mph or below, it may remain in place regardless of the type of metal rail installed. Other bridge rails are to be evaluated for strength and geometrics. (See 1610.07(1) for guidance on retrofit techniques.)
- The Type 7 bridge rail is common. Type 7 bridge rails have a curb, a vertical-face parapet, and an aluminum top rail. The curb width and the type of aluminum top rail are factors in determining the adequacy of the Type 7 bridge rail, as shown in Exhibit 1610-17. Consult the WSDOT BSO for assistance in evaluating other bridge rails.

When considering an overlay on a bridge, consult the WSDOT BSO to verify the overlay depth can be placed on the bridge deck based on the type of traffic barrier. There may be instances where the height of the bridge barrier will not allow for the planned overlay depth without removal of existing pavement.
1610.07(1) **Bridge Barrier Retrofit**

If the bridge barrier system does not meet the criteria for strength and geometrics, modifications to improve its redirectional characteristics and its strength may be needed. Consult the WSDOT BSO to determine which retrofit method described below can be completed.

### 1610.07(1)(a) Concrete Safety Shape

Consult the WSDOT BSO to determine whether the existing bridge deck and other superstructure elements are of sufficient strength to accommodate this bridge barrier system and provide design details for the retrofit. Retrofitting with a new concrete bridge barrier is costly and requires authorization from Program Management when no widening is proposed.

### 1610.07(1)(b) Thrie Beam Retrofit

Retrofitting the bridge barrier with thrie beam is an economical way to improve the strength and redirectional performance of a bridge barrier. The thrie beam can be mounted to steel posts or the existing bridge barrier, depending on the structural adequacy of the bridge deck, the existing bridge barrier type, the width of curb (if any), and the curb-to-curb roadway width carried across the structure. Exhibit 1610-18 shows typical retrofit criteria.

Note that bridges designated as historical landmarks may not be candidates for thrie beam retrofitting. Contact the Environmental Services Office regarding bridge historical landmark status.

Consider the Service Level 1 (SL-1) system on bridges with wooden decks and for bridges with concrete decks that do not have the needed strength to accommodate the thrie beam system. Contact the WSDOT BSO for information needed for the design of the SL-1 system.

#### Exhibit 1610-17 Type 7 Bridge Rail Upgrade Criteria

<table>
<thead>
<tr>
<th>Aluminum Rail Type</th>
<th>Curb Width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9 Inches or Less</td>
</tr>
<tr>
<td>Type R, S, or SB</td>
<td>Bridge rail adequate</td>
</tr>
<tr>
<td>Type 1B or 1A</td>
<td>Bridge rail adequate</td>
</tr>
<tr>
<td>Other</td>
<td>Consult the WSDOT BSO</td>
</tr>
</tbody>
</table>

*When the curb width is greater than 9 inches, the aluminum rail be able to withstand a 5 kip load.
If a thrie beam retrofit results in reduction in sidewalk width ensure ADA compliance is addressed, see Chapter 1510.

Exhibit 1610-18 Thrie Beam Rail Retrofit Criteria

<table>
<thead>
<tr>
<th>Curb Width</th>
<th>Bridge Width</th>
<th>Concrete Bridge Deck</th>
<th>Wood Bridge Deck or Low-Strength Concrete Deck</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;18 inches</td>
<td>&lt; 28 ft (curb to curb)</td>
<td>Thrie beam mounted to existing bridge rail [2] and blocked out to the face of curb. Height = 32 inches.</td>
<td>Thrie beam mounted to steel posts [2] at the face of curb. Height = 32 inches</td>
</tr>
</tbody>
</table>
| >18 inches | > 28 ft (curb to curb) | Thrie beam mounted to steel posts [2] at the face of curb. [1] Height = 32 inches. | • Service Level 1 Bridge Rail. [2]  
• Height = 32 inches.  
• Curb or wheel guard needs to be removed. |

Notes:

[1] To maximize available curb/sidewalk width for pedestrian use, thrie beam may be mounted to the bridge rail at a height of 35 inches.
[2] Contact the WSDOT BSO for design details on bridge rail retrofit projects.
1610.08 Other Barriers

1610.08(1) Redirectional Landform

Redirectional landforms, also referred to as earth berms, were formerly installed to help mitigate crashes with fixed objects located in depressed medians and at roadsides. They were constructed of materials that provided support for a traversing vehicle. With slopes in the range of 2H:1V to 3H:1V, they were intended to redirect errant vehicles. The use of redirectional landforms has been discontinued. Where redirectional landforms currently exist as mitigation for a fixed object, provide alternative means of mitigation of the fixed object, such as remove, relocate, upgrade with crash-tested systems, or shield with barrier. Landforms may be used to provide a smooth surface at the base of a rock cut slope.

1610.08(2) Aesthetic Barrier Treatment

When designing a barrier for use on a Scenic Byway, consider barriers that are consistent with the recommendations in the associated corridor management plan (if one is available). Contact the region or HQ Landscape Architect Office to determine whether the project is on such a designated route. Low-cost options may be feasible, such as weathering agents, stains, colorants, or coatings applied to galvanized steel beam guardrail and its components. Higher-cost options, such as steel-backed timber rail and stone guardwalls, might necessitate a partnering effort to fund the additional costs. Grants might be available for this purpose if the need is identified early in the project definition phase.

1610.08(3) Steel-Backed Timber Guardrail

Steel-backed timber guardrails consist of a timber rail with a steel plate attached to the back to increase its tensile strength. There are several variations of this system that have passed crash tests. The nonproprietary systems use a beam with a rectangular cross section that is supported by either wood or steel posts.

A proprietary (patented) system, called the Ironwood Guardrail, is also available. This system uses a beam with a round cross section and is supported by steel posts with a wood covering to give the appearance of an all-wood system from the roadway. The incorporation of the Ironwood Guardrail will need to be documented. Consult with the Assistant State Design Engineer to determine what justification (proprietary or a public interest finding) will be required.

The most desirable method of terminating the steel-backed timber guardrail is to bury the end in a backslope, as described in 1610.04(5). When this type of terminal is not possible, use of the barrier is limited to highways with a posted speed of 45 mph or below. On these lower-speed highways, the barriers can be flared away from the traveled way as described in 1610.03(4) and terminated in a berm outside the Design Clear Zone.

For details on these systems, contact the HQ Design Office.

1610.08(4) Stone Guardwalls

Stone guardwalls function like rigid concrete barriers but have the appearance of natural stone. These walls can be constructed of stone masonry over a reinforced concrete core wall or of simulated stone concrete. These types of barriers are designed to have a limited textured
projection of the stones to help aid in the redirection characteristics of the barrier. The most
desirable method of terminating this barrier is to bury the end in a backslope, as described in
1610.06(3). When this type of terminal is not possible, use of the barrier is limited to highways
with a posted speed of 45 mph or below. On these lower-speed highways, the barrier can be
flared away from the traveled way and terminated in a berm outside the Design Clear Zone.

For details on these systems, contact the HQ Design Office.

1610.08(5) Dragnet

The Dragnet Vehicle Arresting Barrier consists of chain link or fiber net that is attached to energy
absorbing units. When a vehicle hits the system, the Dragnet brings the vehicle to a controlled
stop with limited damage. Possible uses for this device include the following:

- Reversible lane entrances and exits
- Railroad crossings
- Truck escape ramps (instead of arrester beds—see Chapter 1270)
- T-intersections
- Work zones
- Swing span bridges

Coordinate with the HQ Design Office for design details.

1610.09 References

1610.09(1) Design Guidance


Bridge Design Manual LRFD, M 23-50, WSDOT


Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Traffic Manual, M 51-02, WSDOT

1610.09(2) Supporting Information

Manual for Assessing Safety Hardware (MASH), AASHTO, 2009

NCHRP 350, TRB, 1993

Determining Length of Need. This e-learning course for WSDOT employees covers the “Length of
Need,” which is a calculation of how much longitudinal barrier is necessary to shield objects on
the roadside. Request this training via the web-based Learning Management System.