4.1 INTRODUCTION

Practical Design is a strategy to deliver focused benefits for the State’s transportation system while working with the realities of a fiscally constrained environment. This strategy requires project teams to use more engineering judgment to make cost effective system improvements. Understanding of the cross sections elements contained herein will allow the practitioner to make sound decisions in keeping the project within scope and budget.

The cross section elements of the roadway are as important as the alignments of the roadway and can have as much effect on the traveling vehicles. Corresponding care must be given to the cross section elements to assure safe operation of the facility.

Projects that are not intended to modernize the roadway, thus leaving the existing widths and alignments, still can make significant improvements to the overall safety of the facility by addressing the cross sectional elements discussed in this chapter.

Also included in this chapter are miscellaneous roadway features. These elements, while unique, require special attention when adding them to the overall roadway facility.
4.2 CROSS SECTION

4.2.1 ROADWAY

The Standard Roadbed Sections (Figures 5-1, 5-2, 7-1) and the ODOT 4R/New Standards (Tables 5-2, 6-1 through 6-5, 7-1, and 7-2) give the dimensions to be used for the design of new facilities or the modernization of existing facilities. These include shoulders, travel lanes, and medians. Frontage roads shall be designed in accordance with the anticipated traffic and their location.

When the distance computed for the lateral support of the surfacing material is a fractional distance, the lateral support slope distance is rounded up to the nearest foot.

In cases of very rugged terrain and where grading costs are high, consideration should be given to using steeper slopes or curb sections for lateral support. The use of either must be approved by the State Traffic-Roadway Engineer. Curbs should be avoided on rural highways.

When the slope at the edge of the surfacing material is 1:6 and continuous sections of guard rail are required, consideration may be given to reducing the surfacing material slope to a minimum of 1:3 behind the guard rail to minimize impacts on the total horizontal width. This may apply in the case of railway encroachments, high fill, or very high cost right of way.

4.2.2 CROSS SLOPE

The rate of cross slope is an important element in cross section design and is complicated by two contradictory controls. A reasonably steep lateral slope is desirable to quickly remove surface water and thus reduce hydroplaning of the vehicles. On the other hand, steep cross slope is undesirable because of the tendency of vehicles to drift toward the low edge of the traveled way. Cross slopes up to and including 2 percent are barely perceptible in terms of vehicle steering. However, cross slopes steeper than 2 percent are noticeable and require a conscious effort in steering. Steep cross slopes increase the susceptibility to lateral skidding when vehicles brake on icy or wet pavements or when stops are made on dry pavement under emergency conditions.

For state highways, the cross slope standard is 2 percent. This allows a balance between surface drainage and vehicle steering effort. The central crown line will not have a total rollover or cross slope change of over 4 percent without approval by the State Traffic-Roadway Engineer.

On facilities with 3 or more lanes inclined in the same direction, each successive pair of lanes outward from the first two lanes may increase the cross slope by 0.5 percent.
For non-modernization projects correcting poor cross slope can be an inexpensive safety feature to add to the project. Project ends are typical locations for compromised cross slope transitions unless enough length is used for the transition. Freeway sections that transition between a single cross slope and crown cross slope can be problematic if the transition is too abrupt. Vehicles with high centers of gravity can unexpectedly be caused to sway from side to side when traveling at high speed and control of the vehicle may be difficult to maintain. These tangent transitions need to be addressed similarly to the superelevation run out of a horizontal curve.

### 4.2.3 SAFETY EDGE

Lane departure crashes in which a vehicle departs from its lane and crashes with another vehicle, rolls over, or hits a fixed object represent from 60 to 80 percent of rural Oregon crashes. In 2007, fixed object crashes accounted for 70 percent of the rural crashes with an additional 10 percent involving overturned vehicles. This translates to 80 percent of the crashes being these two types and accounts for 90 percent of the fatal crashes and 90 percent of the injury crashes. These numbers have remained consistent for a number of years not only in Oregon but in states with a large number of miles on rural roads.

Safety Edge is a countermeasure developed to address potential problems with tire rubbing along the edge of pavement. When a vehicle's tires drop off the edge of the paved surface the driver tends to oversteer in the attempt to return the vehicle onto the paved surface. Safety Edge provides a sloped edge surface to assist the vehicle in returning to the paved surface without oversteering.

On paving projects with shoulder widths of 6 feet or less and new pavement thickness of two inches or more, Safety Edge will be included in the project and shown on the typical sections. Details for Safety Edge are shown on Oregon Standard Drawing RD610.

Roadside features can impede the paving operation and successful construction of the Safety Edge. These features commonly are guardrail, mailboxes, approaches, intersections and deep roadside ditches. Consecutive features may require Safety Edge to be omitted for portions of the project due to constructability issues.

### 4.2.4 CURBS AND THEIR LOCATION

When curbs are used on any freeway, expressway or rural highways they should be mountable. Only the low profile mountable curb has been approved for freeway application. The low profile mountable curb, mountable curb, and mountable curb and gutter are the mountable curb types approved for other locations. Full shoulder width shall be provided and paved to the same depth as the main roadway.

Where a standard curb is introduced, it should be curved away from the edge of the travel lane on the end of the curbed section approached by traffic. It need not be curved away where traffic
leaves the curbed section. When curbs are used on highways with narrow shoulders, the beginning of a curb on the right shall be offset a minimum of 6 feet. On the left, the offset shall not be less than 3 feet greater than the normal curb offset (Figure 8-22).

Where roadway grades are 0.5 to 0.3 percent, monolithic curb and gutter design (either curb and gutter, or mountable curb and gutter types) shall be used. The monolithic curb and gutter design is the most hydraulically efficient curb design. As such, this design type is required when the grades are flat to increase the efficiency of removing water from the road surface. On grades greater than 0.5 percent, low profile mountable curb, standard curb, or mountable curb may be used. Refer to ODOT Standard Drawings RD700 and RD701.

Consideration of the impact to bicycles needs to be given when using monolithic curb and gutter. The gutter forms a grade break where typically there is a change of surface materials. Bicyclists tend not to ride on the gutter material. A minimum bike lane width of 5 feet and the use of a monolithic curb and gutter system need careful evaluation with regard to the competing needs of all users.

Although curbs are typically installed in urban areas, there may be instances where curbs are not installed due to water quality reasons. The Senior Hydraulics Engineer should be contacted for discussion on curbs and water quality issues.

4.2.5 ROADSIDE BARRIERS

Where right side roadside barriers are used, the standard right shoulder width will be increased to provide a 2 foot shy distance. This applies to all divided arterial locations, freeway (including ramps), or non-freeway. Studies show that drivers tend to leave extra room on the right side of the vehicle when near a vertical obstruction. The shy distance or “E” allows a horizontal distance for the driver to shy away from the vertical obstruction. When the right hand shoulder is 12 feet or greater, the 2 foot “E” is not required, since a 12 foot right side shoulder is adequate to park a disabled vehicle and drivers do not tend to require extra width when vertical obstructions are 12 feet or more horizontally from the traveled way. The 2 foot shy distance applies to both concrete barrier and guardrail.

The 2 foot “E” is not added to the left side shoulder except under the following conditions:

1. On freeways only, when the standard shoulder is 10 feet. (This occurs on 6 lane minimum facilities). The minimum edge line to edge line distance in this configuration is 26 feet.

2. Four lane mainline section of all roadway types using concrete median barrier when the left side shoulders (6 feet or less) of the opposing lanes is separated by only barrier. Shoulders that are 6 feet in width require an edge line to edge line distance of 18 feet in this configuration.

This standard does not require the additional 2 foot “E” for the left shoulder at spot roadside barrier locations such as bridges and interchange areas unless the above criteria is met.
Interchange ramps with left side roadside barriers do not require the 2 foot “E” on the left side.

For more information on roadside barrier design and location refer to Section 4.6.

4.2.6 ROADSIDE TREES

The following is intended to provide for the placement of street trees at the discretion of project teams where the criteria are met. If street trees are to be placed in a location where any of the criteria are not met, a design exception is required. (See Section 4.3 for the placement of trees in the median.)

Standard criteria to allow roadside trees:

1. Design speed of 45 mph or less.
2. Trees located behind a positive (physical) delineation, i.e. curb.
3. The section is urban, suburban or a rural to suburban transition zone.
4. Trees may be located in the planter strip between the curb and sidewalk where the posted speed is 35 mph or less and there is a standard shoulder or on-street parking.
5. A minimum clear height of 10 feet from the pavement to the bottom of the branches not overhanging the roadway. This requirement allows for clear height of pedestrian use on sidewalks and allows sight distances to be clear. If the limbs overhang the roadway, a minimum clear height of 16 feet must be provided to prevent high loads from striking the branches.
6. When the design speed is 45 mph or less and if the shoulder is nonstandard, or if there is no on-street parking, trees should be located such that there is at least 6 feet from the edge of travel to the trunk of the tree at maturity.

7. Where the posted speed is greater than 35 mph, trees should be located behind the sidewalk or at least 6 feet beyond the curb to the trunk of the tree at maturity.

8. If there is no positive delineation such as a curb, or if the design speed is greater than 45 mph, trees should only be located beyond the clear zone recommended in the AASHTO "Roadside Design Guide - 2011".

9. Trees may only be placed within the Intersection Sight Distance Triangle (ISD) such that at least 50 percent of an approaching AASHTO defined “P-vehicle” remains visible at all times and at all approaches when the tree reaches maturity. Fifty percent visibility is measured against what would otherwise be visible if there were no sight obstructions from trees, street furniture, utility poles, vertical curves, etc. For example, if 25 percent of the vehicle is hidden behind a vertical curve, street trees could only block an additional 25 percent of the vehicle. If 50 percent or more of the vehicle were hidden behind a vertical curve, it would not be appropriate to further reduce visibility by planting trees.

10. Consideration must also be given to pedestrians and bicyclists visibility at intersections when selecting tree species and placement. Nearer to the intersection increases the importance of clear visibility lines for drivers to see all users.

The illustration below is only a sample of a shadow diagram. Because of the many variables, shadow diagrams must be drawn on a case-by-case basis. Note that ISD applies equally to all
approaches and shall be determined by a design professional. Refer to the AASHTO “A Policy on Geometric Design of Highways and Streets - 2011” for the procedure to determine ISD.

If the above criteria are met, then the combined effect of the following factors should be considered to determine if street trees are appropriate:

- **Access control** – When the number of approaches is reduced, a greater area is generally available for trees. If there are frequent approaches, it may not be possible to provide trees and at the same time provide adequate visibility at road approaches.

- **Crash history** – Trees should not be placed where there is a history of run-off-the-road accidents or a high potential for such accidents.

- **Environmental value** – Aesthetics, air quality, etc.

- **Clear zone guidelines** – Recognize that if trees are located within the clear zone recommended in the AASHTO “Roadside Design Guide - 2011”, they pose a hazard to errant vehicles.

- **Traffic calming** – Tall trees may have a slowing effect on drivers as they provide a tall vertical element on the side of their field of vision.

- **Horizontal alignment** – Run-off-the-road accidents occur more frequently on curves. Trees should not be placed in high-crash locations.

- **Vertical alignment** – If visibility is already compromised due to a poor vertical alignment, street trees may compound the problem.

- **Shy distance to tree** – A minimum of 6 feet from the edge of travel to the trunk of the tree is desirable, when the design speed is 45 mph or less.

- **Signing** – Landscaping plans should show the location of all signs ensuring that trees do not interfere with visibility.

- **Other roadway uses** – Trees need to coexist with utilities, miscellaneous street furniture, etc.
- **Transportation system plans and city ordinances** – Roadside trees are often identified as desirable or required within cities or urban unincorporated areas.

If street trees are included in a project, an appropriate species needs to be selected taking into consideration the dimensions of the tree at maturity, the planter width required to support the root system, etc. Contact the Geo-Environmental section for further information.

### 4.2.7 DITCHES

Figures 5-1, 5-2, and 7-1, outline the typical ditch section for rural highways, and urban and rural freeways. These typical sections create a standard roadside ditch flow-line that is 0.5 feet below the subgrade elevation. The peak discharge, longitudinal slope, and ground cover for each ditch affect the ditch capacity. On steep slopes shear stresses on the ditch bottom should be evaluated to assure the ditch does not erode. The discharge contributing to ditches runs off from areas from within the right of way, but this area is often small compared to runoff from outside the right of way. Evaluate each ditch for significant flows from off-site.

The standard traversable ditch should be used on all projects unless the calculated peak flows indicate insufficient capacity or instability. A ditch is considered traversable when the sum of the horizontal components of the ditch fore slope and the ditch back slope is equal to or greater than 10. When the design speed is greater than 45 mph, the designer needs to give stronger consideration to the configuration of the ditch. Contacting the fore slope of the ditch with the rear bumper can cause the vehicle to roll, and contacting the back slope the ditch with the front bumper can cause an excessive deceleration of the vehicle.

The use of a flat bottom ditch may be appropriate in locations to satisfy water quality treatment requirements. Flat bottom ditches are recommended to be at least 4 feet wide at the ditch bottom with standard surfacing slopes. The 4 foot wide bottom typically allows a vehicle to safely traverse the ditch. Flat bottom ditches may also be appropriate in open freeway medians. Additional information on ditches is provided in Section 10.5.

### 4.2.8 EARTHWORK

When the standard sections do not provide for stable slopes and roadbed, a special design is necessary. The design shall be based on soil tests and other factors and must have the approval of the Geotechnical Engineer.

Care in the design of individual cuts and fills must be used when varying the rate of the slope due to height variations in order to avoid unsightly, irregular faces.

Table 4-1 below provides guidance for additional width for fill sections where there is a concern for the stability of slopes.
Table 4-1: Additional Embankment Widening on High Fills

<table>
<thead>
<tr>
<th>Fill Height (Feet)</th>
<th>Widening of Subgrade as Appropriate, Each Side of Centerline (Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>No Widening</td>
</tr>
<tr>
<td>20-30</td>
<td>1</td>
</tr>
<tr>
<td>30-40</td>
<td>2</td>
</tr>
<tr>
<td>40-50</td>
<td>3</td>
</tr>
<tr>
<td>Over 50</td>
<td>4</td>
</tr>
</tbody>
</table>

Fill height is to be considered as the difference in elevation between the subgrade shoulder and the adjacent toe of slope.

4.2.9 **ROUNDING CUTBANKS**

Cut slopes shall be designed to blend in with the surrounding terrain. This is accomplished by rounding the top of the cutbanks as shown on Figure 4-1, also as specified in the Oregon Standard Specifications for Highway Construction (Section 00330). The rounding limits also have an impact on right of way requirements.
Figure 4-1: Rounding Of Cutbanks

SLOPE Rounding

ASCENDING SECTION

DESCENDING SECTION

DETAIL "A"

DETAIL "B"

TABLE A *

<table>
<thead>
<tr>
<th>E</th>
<th>1-1</th>
<th>1-1.5</th>
<th>1-2</th>
<th>1-3</th>
<th>1-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
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<td>AREA</td>
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<td>AREA</td>
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<td>(ft)</td>
<td>(ft)</td>
<td>(ft)</td>
<td>(ft)</td>
<td>(ft)</td>
<td>(ft)</td>
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<tr>
<td>4</td>
<td>1.56</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.75</td>
<td>12</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>2.00</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.25</td>
<td>15</td>
<td>1.42</td>
<td>9</td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

GENERAL NOTES FOR ALL DETAILS:

1. Extend slope rounding 10' or to right of way line, whichever is less. Use the same X dimension on both sides of slope break point.

2. Table A values are only for slope rounding with an X dimension of 10'.

STATE OF OREGON
DEPARTMENT OF TRANSPORTATION
ROADWAY ENGINEERING UNIT
SLOPE Rounding
HIGHWAY DESIGN MANUAL
4.3 MEDIAN DESIGN (NON-FREeway)

4.3.1 GENERAL

Highway medians are important design elements that can significantly impact the safety, function, and/or efficiency of a highway. Highway medians provide separation of opposing traffic streams, separation of turning and through traffic, safety buffer and recovery area, positive longitudinal guidance, and positive control of turning movements. Some median designs improve pedestrian crossings by providing a refuge for pedestrians crossing, minimizing the exposure time to traffic and reducing the crossing distance. Other benefits may include enhanced aesthetics and reduced headlight glare. This section will discuss the design elements and standards for various median treatments on roadways other than freeways. Freeway median design is covered in Chapter 5.

Medians can be either traversable or non-traversable designs. Traversable medians are those which do not physically prevent vehicles from crossing or entering the median. These include Continuous Two Way Left Turn Lanes (CTWLTLs) and painted medians. A non-traversable median is designed to discourage or prevent vehicles from crossing the median except at designated locations. Examples of non-traversable medians include raised curb, concrete barrier, or depressed medians. Designers need to be aware that medians striped with “double-double yellow lines with transverse markings” are physically traversable but specifically illegal to cross.

Where ever a raised median or concrete barrier is being considered for installation where it did not exist previously, considerations of access management criteria and freight mobility must be followed. Access management criteria found in ORS 374.305 to 374.330 must be included in the design. Highway designs must follow the procedure and guidelines for the implementation of ORS 366.215, “Creation of state highways; reduction in vehicle carrying capacity” to ensure freight mobility issues have been addressed.

4.3.2 CONTINUOUS TWO WAY LEFT TURN LANES

Continuous Two Way Left Turn Lanes (CTWLTLs) are often used in urban areas to provide full movement access to adjacent properties and roadways while minimizing impacts of left turning vehicles on through traffic. CTWLTLs are a reasonable tool to improve system safety and efficiency for roadways with low to moderate traffic volumes and speeds. CTWLTLs should generally not be used on roadways with any of the following conditions:

1. Traffic volumes over 28,000 vehicles a day
2. Speeds of 45 mph or more and with multiple, closely spaced accesses.
Under these types of conditions, the preferred median treatment is a non-traversable median that controls left turn movements. CTWLTLs can be considered in high volume and/or high speed locations when the access points are all located on one side of the highway or are spaced at least 1000 feet apart when the access points are on opposite sides of the highway. On roadways with existing CTWLTLs, the existing median should not be converted to a painted median until all private accesses have been removed; this is generally only true on limited access highways.

While CTWLTLs are generally a good safety technique to use, the designer needs to be aware of potential competing use of the CTWLTLs for making either a two stage left turn or at overlapping left turns access locations. Both of these conflicts place vehicles in a potential head-on configuration.

Continuous left turn lanes should be considered only on roadways where:

1. Access to adjacent properties is desired and not otherwise precluded.
2. Left turning vehicles stopped in travel lanes may present an unexpected obstacle.
3. Left turning vehicles significantly reduce roadway capacity.
4. Property access points are clearly defined and the safety of pedestrian traffic is given the highest priority.
5. Passing opportunities on two-lane roadways are not appreciably reduced.

When the use of a continuous left turn lane is deemed appropriate, the following design features should be considered.

1. The volume of left turning vehicles should not exceed the available storage nor create a high conflict potential in the turn lane.
2. The continuous left turn lane should not extend through a railroad crossing or signalized intersection.
3. Horizontal and vertical alignment should be considered in the design of the continuous left turn lane to maximize sight distance.
4. The design of the continuous left turn lane and other median treatments should be consistent within a given highway section.
5. Care should be given to avoid overlapping left turns. This may require relocating or offsetting approach points. Consideration should also be given to restricting the approaches to “right-in / right-out” configuration to mitigate overlapping left turns.

CTWLTL’s Design Standards

1. The width of a CTWLTL shall be 14 feet where the design speed is 55 mph or less. For design speeds of 60 mph or greater, the width shall be 16 feet.
2. The striping of CTWLTLs shall be in conformance with ODOT’s Traffic Line Manual.
3. Where CTWLTLs are widened at intersections to provide for double left turn lanes, the width should be 26 feet when the design speed is 55 mph or less and 28 feet when the design speed is 60 mph or greater. Figure 8-21 provide more detail on CTWLTLs.

4.3.3 PAINTED MEDIANS

Painted medians are generally narrower than CTWLTLs. This type of median is typically 6 feet to 10 feet in width and utilizes double solid yellow lines to define the median area. Painted medians are intended to prohibit vehicles crossing the median or using it as a CTWLTL. This type of median control may be used on moderate volume and speed highways in rural areas. In these situations, the painted median is often used as a precursor to installing a non-traversable median such as a concrete barrier. In urban areas however, this median treatment should be used carefully. For new applications this treatment should be limited to urban areas where no adjacent property approach exists and intersection spacing is very long, one-half mile or longer. Generally these conditions will only be present on limited access highways. The major concern is that the painted median will be used as a CTWLTL and may increase accident experience due to the narrow width.

4.3.4 NON-TRAVERSABLE MEDIANS

4.3.4.1 RAISED MEDIANS

By law, all proposals to install raised or depressed barriers on two-lane segments of state highways requires collaboration specifically with representatives of the freight industry and automobile users and may include representatives of local government and other transportation stakeholders, as appropriate (See ORS 374.326).

Raised medians are the preferred type of median treatment for most Statewide NHS and some Regional highways (See Oregon Highway Plan, Appendix D for Highway Classification information). Raised medians should also be considered on other highway classifications where the safety and operational benefits are significant and where improved pedestrian crossing opportunities are desired. Refer to the Median Policy from the Oregon Highway Plan for more information on raised median locations. Raised medians can be designed with either curbs or concrete barriers. Curbed raised median designs are the preferred treatment in urban areas as they are often more aesthetic than the concrete barrier and provide pedestrian crossing opportunities. However, the concrete barrier may be a more appropriate treatment in rural areas with high speeds or where right of way is constrained. Most of the design elements of this chapter apply to either type of median design. The remainder of this section will describe design standards and guidelines for both types of raised medians. In addition, raised curbed medians are described as two sub-sets. Full width medians refer to the curb to curb dimensions of the median between intersections or over long distances. A median traffic separator is that portion of the median that defines left turn channelization areas.
4.3.4.2 RAISED MEDIAN DESIGN STANDARDS

A. MEDIAN WIDTH

(Note: median widths include the raised portions only and do not include shy distance or left side shoulder).

The width of raised medians is variable between intersections. Factors such as pedestrian accommodation, landscaping, and right of way control median widths.

1. The minimum median traffic separator width at intersections is 4 feet when pedestrians are not to be accommodated in the median and the design speed of 55 mph. For design speeds below 55 mph, the median traffic separator can be reduced to 2 feet in constrained locations. However, because of the improved visibility, a median traffic separator width of 4 feet is preferred even when the design speed is less than 55 mph.

2. When crossing more than 6 lanes or 6 lanes and a 20-degree skew angle or more, the medians and median traffic separators must be designed to accommodate pedestrians mid-way across an intersection. The number of lanes includes turn and through lanes. Changes in the median traffic separator will impact the overall median width.

3. When pedestrians are to be accommodated mid-way, the median or median traffic separator width shall be as follows:

<table>
<thead>
<tr>
<th>Design Hour Ped. Volume</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 100</td>
<td>6 feet</td>
</tr>
<tr>
<td>≥ 101</td>
<td>8 feet</td>
</tr>
</tbody>
</table>

4. Where left turns are not accommodated over a significant length, one-half mile or longer, the minimum raised curb median width should be no narrower than 6 feet. Where left turn accommodation is provided at intersections the minimum median width shall be that necessary to provide a 4 foot median traffic separator, a 12 foot left turn lane and the appropriate shy distance for opposing traffic. (See Table 4-2 for shy distance requirements.) The intent is to minimize the hour glass effect of widening the median at intersections and narrowing between.

5. Where intersection spacing is relatively short, left turn bays often become back to back in nature. It is desirable to have some full width median between the left turn bays. The full width median allows for better visibility of the driver and also allows a place to install signing. Figure 4-2 shows an example of a full width median. The desirable full width median section should be as follows:

<table>
<thead>
<tr>
<th>Design Speed</th>
<th>Length of Full Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 30 mph</td>
<td>65 feet</td>
</tr>
<tr>
<td>35 mph</td>
<td>100 feet</td>
</tr>
<tr>
<td>45 mph</td>
<td>130 feet</td>
</tr>
<tr>
<td>≥ 50 mph</td>
<td>165 feet</td>
</tr>
</tbody>
</table>
Whenever barriers, such as curbs, are introduced into the roadscape it is desirable to provide a buffer space. This buffer helps improve safety of the users, traffic flow, and operational efficiency. This buffer is often referred to as “E” or Shy Distance. Table 4-2 establishes the shy distance requirements from raised medians. This table is not to be used for determining the shy distance for expressways (See Table 6-1 and Table 7-1). The table also applies to left side shy distance for other conditions such as curbed sections on one-way roadways.

When raised curb or concrete barrier medians are not continuous, an additional 1 foot of shy distance should be added to the values above. Table 4-2 is used in place of the direction given in Section 4.2.4.

Table 4-2: Left Side Shy Distance

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Shy Distance (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Curb</td>
</tr>
<tr>
<td></td>
<td>12 ft Lane</td>
</tr>
<tr>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>35</td>
<td>2</td>
</tr>
<tr>
<td>45</td>
<td>2</td>
</tr>
<tr>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>55+</td>
<td>3</td>
</tr>
</tbody>
</table>
C. SIGHT DISTANCE

Sight distance at both unsignalized and signalized intersections is critical to provide a safe and efficient median opening. It is desirable to provide intersection sight distance at all median openings. However, in many situations, this is not practical. The designer is encouraged to provide the highest level of sight distance practical. Sight distance is covered in more detail in Section 3.2.

D. LANDSCAPING ACCOMMODATION

Landscaping is an important feature to raised curb medians. Landscaping enhances the visibility of the median as well as the aesthetics. Two major concerns with landscaping are sight distance and maintenance. Sight distance concerns are crucial at both signalized and unsignalized intersections. The maintenance concerns include the amount of maintenance, median access, and cost. However, not all landscape techniques are labor intensive. Many types of vegetation are considered native and require almost no special care. In addition, landscaping features such as paving blocks, bricks, rocks, or other materials are relatively maintenance free. The following are important design elements to consider when landscaping medians:

1. It is desirable to provide a vertical element within the median to increase visibility. Vegetation or mounding of earth, blocks, or bricks should extend 8 inches above the top of curb height. However, to ensure sight distance lines are preserved, vegetation or mounding should not extend higher than 24 inches above the pavement surface within the functional area of intersections. Sight distance must also be preserved where pedestrian crossings are provided mid-block.

2. The minimum median width to accommodate landscaping is 6 feet. Care should be taken to not use landscaping that impairs sight distance. There should also be a planting setback. The use of trees in a raised median are typically not recommended and should only be considered in urban situations where the design criteria shown in (5) below can be met.

3. Sideslopes within the median for mounding shall be no steeper than 1:3 and preferably flatter.

4. A planting set back of 1 foot to 2 feet should be considered where median width allows. The planter strip should be structural to support maintenance equipment. This could minimize the maintenance requirements or ease maintenance operations, such as mowing.

5. Consider using planter boxes rather than continuous vegetation to reduce maintenance. Planter boxes are also effective treatments for improving median visibility. Planter boxes may either be flush or raised. Raised planter boxes should be 6 inches or less above the curb height.
E. CRITERIA FOR INCLUDING MEDIAN TREES IN ROADWAY PROJECTS

The following is intended to provide for the placement of median trees at the discretion of project teams where the criteria are met. If median trees are to be placed in a location where any of the criteria are not met, a design exception is required.

Standard criteria to allow median trees:

1. Posted speed of 35 mph or less
2. Trees located behind a positive (physical) delineation (i.e. curbed – raised median).
3. The section is urban, suburban or in a rural to suburban transition zone.
4. A minimum clear height of 10’ from the pavement to the bottom of the branches. If the limbs overhang the roadway, a minimum clear height of 16’ must be provided.
5. A minimum median width of 8’ from curb to curb.
6. Trees may only be placed within the Intersection Sight Distance Triangle (ISD) such that at least 50% of an approaching AASHTO defined “P-vehicle” remains visible at all times when the tree reaches maturity. 50% visibility is measured against what would otherwise be visible if there were no sight obstructions from trees, street furniture, utility poles, vertical curves, etc. For example, if 25% of the vehicle is hidden behind a vertical curve, median trees could only block an addition 25% of the vehicle – If 50% or more of the vehicle were hidden behind a vertical curve, it would not be appropriate to further reduce visibility by planting trees. Note that ISD applies equally to all approaches & should be determined by a design professional.

If the above criteria are met, then the combined effect of the following factors should be considered to determine if median trees are appropriate:

- **Access Control** – When the number of median openings is reduced, a greater area is generally available for trees. If there are frequent openings, it may not be possible to
provide trees and at the same time provide adequate visibility between left turning vehicles, oncoming traffic, and other roadway users.

- **Crash history** – Trees should not be placed where there is a history of run-off-the-road accidents or a high potential for such accidents.

- **Pedestrian use** - where the median is expected to provide a refuge for crossing pedestrians, there should be frequent open areas where visibility is good. Trees can hide the pedestrian or cause the driver to believe there is a pedestrian crossing, thus taking emergency action.

- **Environmental value** - aesthetics, air quality, etc.

- **Clear zone guidelines** – recognize that median trees are generally within the clear zone recommended in the AASHTO “Roadside Design Guide - 2011” and pose a hazard to errant vehicles.

- **Traffic calming** - tall trees may have a slowing effect on drivers as they provide a tall vertical element on the left side of their field of vision.

- **Horizontal alignment** – run-off-the-road accidents occur more frequently on curves. Trees should not be placed in high crash locations. See AASHTO’s Roadside Design Guide 2011 Table 3-2 for Horizontal Curve Adjustment Factors for clear zone widths.

- **Vertical alignment** – If visibility is already compromised due to a poor vertical alignment, median trees may compound the problem.

- **Shy distance to tree** – a minimum of 6’ from the edge of travel to the face of the tree is desirable.

- **Other Roadway uses** – Trees need to coexist with utilities, signs, misc. street furniture, etc. Need to consider future needs.

If median trees are included in a project, an appropriate species needs to be selected taking into consideration the dimensions of the tree at maturity, the median width required to support the root system, etc. **Trees should be of a type that remains small in trunk diameter, 4 inches or smaller.** Refer to the Roadside Development Manual for further information.
F. END TREATMENTS

Starting and ending raised median treatments can create conflict areas to roadway users and must be designed carefully. Raised median sections should be designed with logical starting and ending points within a given section of highway. Haphazardly placing small sections of raised median throughout a highway segment may offset any safety benefits and may actually increase the accident frequency over that anticipated without any median treatment. In urban situations it is preferred to have the median begin and end at an intersection. Rural areas may not allow this intersection approach. In these cases, the designer is to determine logical termini based upon the intended function of the median and roadside character of the highway. It is important to remember that raised medians are a barrier and can be a roadway hazard. End treatments are critical to ensure the appropriate and safe function of the raised median.

Concrete barriers generally require an impact attenuator to protect the ends. The type of attenuator used must conform to the ODOT approved materials list. AASHTO’s “Roadside Design Guide - 2011” can provide additional information regarding end treatment design for concrete barriers.
Raised curbed medians generally do not require any special end treatments but a squared off, blunt end style is an unacceptable end treatment. In high speed situations, design speeds over 45 mph, and where pedestrian accommodation in the median is not required, the curb line should be tapered to 2 inches in height. This tapered section should be accomplished over 15 feet. Standard Drawing RD706 provides additional detail for this tapered treatment.

Two other concerns about end treatments are pedestrian refuges and truck off-tracking. At signalized intersections, the preferred median treatment is to stop the raised median prior to the cross walk. Generally the pedestrian movement through a signalized intersection should be made in one stage. Pedestrian refuges create two stage crossings. At a signalized intersection, the refuge requires additional signal equipment and signal timing that needs to be considered prior to adding the refuge feature. The preferred design, when providing a pedestrian refuge for crossings at unsignalized intersections, is to utilize the cut-through option. This treatment requires a protective nose area that should be at least 13 square feet or more. The nose can be designed with either a semi-circle or half bullet type design. The semi-circle design type is only recommended for median traffic separator widths of 4 feet or less. Wider medians should utilize the half bullet type design to better facilitate truck turning movements. All end treatment designs need to consider the off-tracking characteristics of the appropriate design vehicle. The designer must use caution when providing a pedestrian refuge and using the half bullet type nose design. The half bullet design may reduce the available refuge for pedestrians. In some situations, the crossing may need to be moved back slightly to provide a full width refuge. This is especially prevalent where the nose must be moved back to provide for adequate truck turning movements. The transition approach to island area at the beginning and end of a raised median is the appropriate location for additional low cost warnings, such as rumble strips or painted chevrons. These additional warnings are not required at all locations. Figure 4-5 provides additional detail regarding end treatments for raised curb medians. For additional design specifics, see Chapter 8 Intersections.
G. ACCOMMODATING U-TURNS

The use of a raised median significantly reduces the opportunities for vehicles to make left turns. To facilitate traffic’s ability to reach destinations on the left side of the highway, U-turn opportunities need to be included with the design. The preferred approach is to provide U-turn capabilities at signalized median openings. This approach offers greater protection for the U-turning vehicles. The second option is to utilize an unsignalized median opening. This approach should be used in conjunction with a jug handle design. Executing a U-turn through the oncoming traffic lanes creates a greater exposure to the U-turning vehicle and through traffic and should be avoided in high volume or high-speed conditions. When accommodating U-turning vehicles, the designer needs to consider the following:

1. Speed of the highway
2. Volume of traffic opposing and executing the U-turn
3. The design vehicle to be accommodated
4. The adjacent roadside culture, and
5. The opportunity to use existing roadways to accommodate U-turn movements

A left turn lane shall always be included when accommodating U-turning vehicles. U-turn movements are never to be allowed out of a through travel lane. Section 2.6 provides additional information and illustrations for accommodating U-turns.
The Traffic-Roadway Section should be consulted when considering accommodating U-turns on state highways. U-turns must be located with respect to legal requirements [ORS 810.130(3), ORS 811.365, OAR 734-020-0025]. In addition, the State Traffic-Roadway Engineer must approve all U-turns at signalized intersections.

H. TYPE OF CURB

When using raised curb medians, the designer needs to determine the appropriate curb type. The preferred curb type is the mountable curb. Mountable curb is a design that provides some protection for pedestrians, landscaping, or other objects in the median, while also enhancing the aesthetics of the median. The use of low profile mountable curb also requires substantial mounding for visibility and safety. Standard curb can be substituted for mountable curb when desired by the project team when design speeds are less than or equal to 45 mph. The use of standard curb may also be appropriate for urban or urbanizing areas where the posted speed is 45 mph.
4.4 TRAFFIC CONTROL

Maintenance of traffic during construction must be included in the planning of all highway improvement projects. Develop a transportation management plan (TMP) for all projects to provide for the reasonable safe and effective movement of road users through a temporary traffic control zone while providing for a safe and effective work area. The TMP will consist of traffic control plans (TCP) and may include traffic operation and public information strategies. Strategies included in the TMP will vary based upon the expected work zone impacts and impacts beyond the immediate work zone area need to be considered to appropriately manage the transportation system.

The Traffic Control Plans Design Manual provides traffic control plan design standards, guidelines, policies, and procedures to be used in the development of TMP’s and TCP’s. The Traffic Control Plans Design Manual is based upon the Manual on Uniform Traffic Control Devices (MUTCD) and provides more specific guidance and policies to TCP designers.

The TCP Design Manual may not cover temporary traffic control strategies for all conditions encountered on the highway system. The temporary traffic control strategy selected for each project depends on type of highway, road user conditions, and duration of operation, physical constraints, and the relationship between the work and road users. Traffic control strategies should be agreed upon by the design team with assistance from technical experts. A TCP should include appropriate standard drawings, plan sheets, specifications, and an estimate.
4.5  CLEARANCES

4.5.1  VERTICAL CLEARANCE - HIGHWAYS

In 2007, Motor Carrier Transportation Division (MCTD) completed a study on the frequency of permitted loads that where over dimensional for height. Using this data it is determined that the actual measured height of bridges needs to be at least 17’ – 4”. MCTD also identified the routes that are of major significance for the mobility of high loads. These “High Routes” are primarily on the National Highway System (NHS), but there are portions that are on highways other than the NHS. Some of these routes are in rural portions of the state where there are no over passes, so high loads can move freely without physical restrictions. Some high routes require the use of detours, including “up and over” use of interchange ramps, for high vehicles to use the route. The Vertical Clearance Standards are minimum heights. The Vertical Clearance Standard is required for the full roadway width including shoulders for the through lanes, and to ramps and collector-distributor roadways in Interstate-to-Interstate interchanges. Future overlays of the highway are not included in the Vertical Clearance Standard and need to be considered when determining the clearance needed for new construction.

Vertical Clearance Standards are:

- 17”-4” on High Routes
- 17’-0” on NHS Non-High Routes
- 16’-0” on Non-NHS and Non-High Route
- For vertical clearance on Local Agency jurisdiction roadways, see Section 4.5.1.1

Proposed new construction that reduces vertical clearance shall require consultation with MCTD to ensure understanding of the impact of the proposed decrease to the user. All other projects, which result in final vertical clearances at or above the minimum vertical clearance, require notification of MCTD to ensure all vertical clearance inventories are current and updated for the appropriate routing of permit vehicles.

For projects other than new construction, no reduction of the existing vertical clearance below the minimum vertical clearance is allowed. No reduction in vertical clearance is allowed if the existing vertical height is currently below the minimum vertical clearance.

Projects that do not meet these Vertical Clearance Standards will need to apply for a Design Exception and will require consultation with MCTD. MCTD will then involve the industry stakeholders in the consultation process necessary to fully evaluate user impacts, project construction, and design options.

The lateral clearances shown in Figure 4-6 are to the face of rail and assume the barrier is warranted. The 19 feet-0 inch dimension does include off tracking. The design engineer may
determine that accommodation for off tracking is not required in tangent sections and may use a minimum dimension of 18 feet-0 inch.

In addition to ODOT vertical clearance standards, the FHWA has agreed that all exceptions to the AASHTO vertical clearance standard of 16 feet for the rural Interstate and the single routing in urban areas will be coordinated with the Military Traffic Management Command Transportation Engineering Agency (MTMCTEA) of the Department of Defense. Regardless of funding, this agreement applies whether it is a new construction project, a project that does not provide for correction of an existing nonstandard condition, or a project which creates a nonstandard condition at an existing structure.

Clearance requirements for transmission and communication lines vary considerably and must comply with the National Electrical Safety Code. Clearance information should be obtained from the State Utility Liaison.

See Appendix C for Oregon Vertical Clearance Standards High Route Highways Table and the High Route map.

4.5.1.1 VERTICAL CLEARANCES FOR LOCAL JURISDICTION ROADS

Local Jurisdiction roads that are part of the NHS are required to meet AASHTO standards for vertical clearance. Also, any project using federal funds on Local jurisdiction roads are required to meet AASHTO standards for vertical clearance. For new construction or reconstruction, provide 16 ft clearance over the entire roadway width (including travel lanes and paved shoulders). Existing clearances of 14 ft may be retained. In highly urbanized areas, a minimum clearance of 14 ft may be provided if there is an alternate route with 16 ft clearance, or if a local ordinance exists. Additional clearance should also be provided for future overlays of the under passing roadway.

4.5.2 VERTICAL CLEARANCE – RAILROADS

The minimum railroad clearance to be provided on crossings shall conform to Oregon Administrative Rule (OAR) 741 and as shown in Figure 4-8. Additional clearance may be required and should be determined individually for each crossing. Information regarding additional clearance shall be obtained from the Railroad Liaison.

4.5.3 CLEAR ZONE

The AASHTO “Roadside Design Guide - 2011” is the most recent publication written to provide guidance in roadway design regarding roadside clearances. The AASHTO “Roadside Design Guide - 2011” gives procedures and tables to determine the correct clear zone distance for use in the placement of barrier, sign installation, guard rails, ditch location, and other roadside appurtenances. It provides the criteria for the placement or removal of any object which may
influence the trajectory of a vehicle which has left the travel lanes, either in a controlled or uncontrolled situation.

The AASHTO “Roadside Design Guide - 2011”, in chapter 10, gives additional assistance to designers with clear zone in the urban context. Understanding of the role delineation plays between the travel way and non-travel way along a highly urban environment gives the designer more options than before.

The clear zone is determined by several factors, including design speed, ADT, horizontal curvature, and embankment slope. Using tables given on the following pages and these four criteria for determination of clear zone distance, the distance required for vehicular recovery can be found. These distances are not absolute and the design options selected to mitigate the effect of roadside hazards require good engineering judgment in order to balance cost effectiveness with the expected increase in safety.

Keeping that in mind, the AASHTO “Roadside Design Guide - 2011” suggests the following options to be considered when evaluating a roadside hazard:

- Removing or redesigning the obstacle
- Relocating the obstacle
- Reduce impact severity by breakaway devices
- Redirection of vehicle by installation of barrier device
- Delineation of object

The clear zone distance can be determined by using Table 4-3 and Table 4-4 shown at the end of this section. These tables were taken from the AASHTO “Roadside Design Guide - 2011”. They are provided as a quick reference source for the experienced designer who is already familiar with the determination process. Table 4-3 is used to determine general clear zone distance. Table 4-4 is used for horizontal curve adjustments.

Care must be taken in arriving at the proper clear zone distance. Table 4-3 lists the different clear zone distances for cut and fill slopes. Many times multiple slopes have to be used to determine the appropriate clear zone distance. At times the roadway typical section will have both a front slope and back slope. When this occurs the procedure for determining the proper clear zone requires more than pulling a number from Table 4-3. Following is an example of the proper procedure for determining clear zone distance for a typical section that includes both a front slope and a back slope.

**Example:**

Design ADT: 7000
Design Speed: 60 mph
Recommended clear zone for 1:6 slope (fill): 30 to 32 feet from Table 4-3
Recommended clear zone for 1:4 slope (cut): 24 to 26 feet from Table 4-3
Discussion: Since the example is within the preferred channel cross section, Table 4-3 can be used to determine the clear zone. However, when the suggested clear zone exceeds the available recovery area for the foreslope, the backslope may be considered as additional available recovery area. The range for the suggested clear zone for the foreslope of 30 to 32 feet extends past the slope break into the backslope. Since the backslope has a suggested clear zone of 24 to 26 feet which is less than the foreslope the larger of the two values should be used. In addition, fixed objects should not be located near the center of the channel where the vehicle is likely to funnel. An appropriate clear zone range for this example is 30 to 32 feet.

For further information and more detailed procedures it is recommended all designers read the AASHTO “Roadside Design Guide - 2011”.

Design exceptions for clear zone on 4R projects are approved by the State Traffic-Roadway Engineer. Design Exceptions for clear zone on 3R projects are approved by the Region Roadway Manager using the design exception form shown in Chapter 14. The regional approved design exceptions are kept on file with the Region Roadway Manager.
ALL FREEWAY AND HIGHWAY CLEARANCES
(To be adjusted to provide minimum stopping sight distance when necessary)

- **h**: Minimum Vertical Clearance
- **m**: Distance from Edge of Traveled Way to Obstacle on Left
- **mb**: Distance from Edge of Traveled Way to Barrier on Left
- **Ls**: Left Shoulder
- **sb**: Distance from Edge of Traveled Way to Barrier on Right
- **Rs**: Right Shoulder
- **w**: Width of Traveled Way
- **s**: Distance from Edge of Traveled Way

NOTE: On two-lane, two-way highways, s and sb apply to shoulders on both sides of highway.
* When barrier is warranted.

<table>
<thead>
<tr>
<th>INTERSTATE FREEWAY</th>
<th>NON-INTERSTATE FREEWAY</th>
<th>ALL FREEWAY RAMPS</th>
<th>ALL OTHER HIGHWAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ONE LANE</td>
<td>TWO LANES</td>
</tr>
<tr>
<td>h</td>
<td></td>
<td>See Figure 4-6</td>
<td></td>
</tr>
<tr>
<td>w</td>
<td>12' Lanes</td>
<td>16'</td>
<td>24'</td>
</tr>
<tr>
<td>m</td>
<td>12' Lanes</td>
<td></td>
<td>12' Lanes</td>
</tr>
<tr>
<td>s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ls</td>
<td>Full Shoulder</td>
<td>4'</td>
<td>6'</td>
</tr>
<tr>
<td>Rs</td>
<td>Full Shoulder</td>
<td>6'</td>
<td>10'</td>
</tr>
</tbody>
</table>

### Footnotes

1. Where curb is introduced intermittently for drainage on interstate it shall be set back 2' from edge of shoulder at guardrail locations.

2. 10' on freeway to freeway ramps.

---

Figure 4-7: Freeway & Highway Clearances
Figure 4-8: Railroad Clearances
## Table 4-3: Clear Zone Distances

### CLEAR ZONE DISTANCES (ft.)

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Design ADT</th>
<th>Fill Slopes</th>
<th>Cut Slopes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1V:6H or flatter</td>
<td>1V:5H or 1V:4H</td>
</tr>
<tr>
<td>≤ 40</td>
<td>UNDER 750</td>
<td>7 - 10</td>
<td>7 - 10</td>
</tr>
<tr>
<td></td>
<td>750 - 1500</td>
<td>10 - 12</td>
<td>12 - 14</td>
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<tr>
<td></td>
<td>1500 - 6000</td>
<td>12 - 14</td>
<td>14 - 16</td>
</tr>
<tr>
<td></td>
<td>OVER 6000</td>
<td>14 - 16</td>
<td>16 - 18</td>
</tr>
<tr>
<td>45 - 50</td>
<td>UNDER 750</td>
<td>10 - 12</td>
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<td></td>
<td>750 - 1500</td>
<td>14 - 16</td>
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<td></td>
<td>OVER 6000</td>
<td>20 - 22</td>
<td>24 - 28</td>
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<tr>
<td>55</td>
<td>UNDER 750</td>
<td>12 - 14</td>
<td>14 - 18</td>
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<td></td>
<td>750 - 1500</td>
<td>16 - 18</td>
<td>20 - 24</td>
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<td>1500 - 6000</td>
<td>20 - 22</td>
<td>24 - 30</td>
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<td>OVER 6000</td>
<td>22 - 24</td>
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<td>60</td>
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<td>26 - 32</td>
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<td></td>
<td>1500 - 6000</td>
<td>26 - 30</td>
<td>32 - 40</td>
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<td>OVER 6000</td>
<td>30 - 32 a</td>
<td>36 - 44 a</td>
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<tr>
<td>65 - 70</td>
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<td>750 - 1500</td>
<td>24 - 26</td>
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<td></td>
<td>1500 - 6000</td>
<td>28 - 32 a</td>
<td>34 - 42 a</td>
</tr>
<tr>
<td></td>
<td>OVER 6000</td>
<td>30 - 34 a</td>
<td>38 - 46 a</td>
</tr>
</tbody>
</table>

Notes:

- a 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 this table. Clear zones may be limited to 30 ft for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

- b Because recovery is less likely on the unshielded traversable 1V:3H fill 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 shoulder may be expected to occur beyond the toe of slope. Determination of the width of the recovery area at the toe of slope should consider 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 by several factors, the foreslope parameters that may enter into determining a maximum desirable recovery area are illustrated in Table 4-4. A 10-ft recovery area at the toe of slope should be provided for all traversable, non-recoverable fill slopes.

- c For roadways with low volumes it may not be practical to apply even the minimum values found in this table. Refer to Chapter 12 in the AASHTO’s "Roadside Design Guide - 2011" for additional considerations for low-volume roadways and Chapter 10 for additional guidance for urban applications.

§ 4.5 - Clearances 4-30
Table 4-4: Horizontal Curve Adjustments

<table>
<thead>
<tr>
<th>Degree of Curvature</th>
<th>40</th>
<th>45</th>
<th>50</th>
<th>55</th>
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<th>70</th>
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<td>2°</td>
<td>1.1</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
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<td>2°30’</td>
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<td>1.1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>3°</td>
<td>1.1</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
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<td>3°30’</td>
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<td>1.4</td>
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<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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</tbody>
</table>

\[ CZ_c = (L_c) \times (K_{cz}) \]

Where:

\( CZ_c \) = Clear zone on outside of curvature, feet
\( L_c \) = Clear zone distance, feet (see Table 4-3)

AASHTO “Roadside Design Guide – 2011” Table 3-1

\( K_{cz} \) = Curve correction factor

Note: The clear-zone correction factor is applied to the outside of curves only. Corrections are typically made only to curves less than 2°.

Reference: AASHTO “Roadside Design Guide – 2011” Figure 3-2 and Table 3-2
4.6 GUARDRAIL AND CONCRETE BARRIER

4.6.1 GENERAL

This section provides information to the designer concerning guardrail and concrete barrier. Information on offsets, single slope barrier, cast in place, and slip form barrier is provided. The AASHTO “Roadside Design Guide - 2011” shall be used to determine guardrail and concrete barrier locations. Exceptions to this guide are to be approved by the State Traffic-Roadway Engineer. Standard Drawings in the RD400 series deal with guardrail while Standard Drawings in the RD500 series deal with concrete barrier. Barrier treatment in rural areas should consider impacts to animal crossings and the designer should contact the region environmental representative for assistance.

Regardless of the type of the barrier system used, when a median is proposed to be closed with a barrier system discussion with the Oregon State Police needs to occur to discuss cross over locations for emergency access.

Existing barrier systems used to mitigate lack of clear zone at a minimum shall meet NCHRP Report 230 crash testing criteria. No design exception will be granted to leave existing hardware that does not meet the minimum crash testing requirements on 3R and 4R projects.

4.6.2 BARRIER SYSTEMS ON RETAINING WALLS

Drop-offs greater than six feet in height at the top of retaining walls shall be protected with traffic barrier system. As a minimum, barrier located at the top of retaining walls on ODOT projects shall meet Test Level 3 (TL-3) requirements. A higher Test Level may be required for high speed freeways, expressways, and interstates where traffic includes a mix of trucks and heavy vehicles, or when unfavorable conditions justify a higher level of rail resistance. Barrier options for protection of retaining wall drop-offs include:

1. **Fixed Bridge Rail on Self Supporting (Moment) Slab**: This option consists of a Type “F” 32” Bridge rail (BR200) on a self supporting (moment) slab. The Type “F” 32” railing has been crash tested and satisfies TL-4 test criteria in AASHTO LRFD Chapter 13 Railings. The moment slab must be designed in accordance with AASHTO LRFD and ODOT Geotechnical Design Manual (GDM), and must be strong enough to resist the ultimate strength of the railing. The moment slab must also be designed to resist overturning and sliding by its own mass when subjected to a 10 kip static equivalent design load in accordance with AASHTO LRFD 11.10.10.2. ODOT also has a Type “F” 42” railing that has been crash tested and satisfies TL-5 criteria, but the static equivalent design load has not been determined.
2. **Anchored Precast Wide Base Median Railing:** Where TL-3 traffic railing is acceptable, anchored precast wide base median barrier (Oregon Standard Drawing, RD500) may be used when designed in accordance with AASHTO LRFD and the GDM. Anchored precast barriers shall be located at least 3.0 feet clear from the back of the wall face, and each precast section shall be anchored with four vertical anchors as shown on the “Median Installation” option on Oregon Standard Drawing RD515 and RD516.

3. **Guardrail:** Where TL-3 traffic railing is acceptable, standard guardrail (Oregon Standard Drawing RD400) may be used when designed in accordance with AASHTO LRFD and the GDM. Locate guardrail posts at least 3.0 ft clear from the back of the wall face, drive or place posts at least 5.0 ft below grade, and place at locations which do not conflict with retaining wall elements and components.

### 4.6.3 CONCRETE BARRIER AND BRIDGE COLUMNS

There are a couple of treatments for bridge column protection depending upon available shoulder width. When the design shoulder width is not encroached upon by placement of the concrete barrier, the concrete barrier should be placed as shown in Figure 4-9. For existing structures, the minimum clearance between the bridge column and barrier is 3 inches. For new structures, the normal clearance between the bridge column and barrier is 2 feet. The roadway designer should consult with the bridge designer to determine the appropriate clearances.

**Figure 4-9: Concrete Barrier Placement at Bridge Column**

When the design shoulder width is encroached upon by the placement of the concrete barrier, the designer should consult with the bridge designer to develop the best solution to protect the bridge columns.
4.6.4  TALL PRECAST CONCRETE BARRIER

The single slope barrier designed in 1992 as an innovative alternate barrier system has been replaced with the tall precast barrier. See Oregon Standard Drawings RD500 series. This 42 inch high safety shape is available only as precast, with segments 12.5 feet long, matching the length of ODOT’s standard precast barrier.

The tall barrier does not replace the standard, but it is to be used in the medians of interstates and on the State Highway Freight System where median barrier is justified or where existing barrier is to be replaced. The tall barrier is not to be used in the Columbia River Gorge National Scenic Area on Interstate 84. Standard concrete barrier can be used in the median in the Columbia River Gorge National Scenic Area.

Use the tall barrier on shoulders of any highway system as needed where adverse geometrics may occur such as curves with a degree of curvature greater than that specified in Tables 5-2 and 7-1 herein, or where severe consequences at specific locations might occur with penetration of a barrier by a heavy vehicle.

4.6.5  OVERLAYS AND CONCRETE MEDIAN BARRIER VERTICAL FACE

For relatively straight forward overlay projects, the 3 inch vertical face on concrete median and shoulder barrier may be utilized without adjustment of the barrier. The overlay shall not exceed the vertical face height.

Tapering of an overlay so the vertical face height will not be exceeded must be investigated to ensure that recommended slopes adjacent to the median barriers are not exceeded. Chapter 6 in the AASHTO’s “Roadside Design Guide - 2011” provides additional information on terrain effect and barrier placement.

4.6.6  CONCRETE BARRIER END TREATMENT

Any barrier end exposed to the flow of traffic must be protected in some manner. Impact attenuators are recommended by AASHTO. Burying ends in the cut slope is another approved method. Sloped ends may be used, but only when the design speed is less than 45 mph and the end is outside of the clear zone. In light of crash tests indicating potential launching hazards, earth mounds are not approved for use.

4.6.7  CONCRETE BARRIER UPGRADES

On 4R and 3R projects, barrier that does not meet NCHRP-Report 230 criteria must be replaced. This specifically is tongue and groove style barrier that is located in medians or locations where
the barrier backside is unsupported. Backside support can include a cut slopes or retaining wall. Backside support must be strong enough to prevent vehicle penetration of the system at the tongue and groove connection point. 1R projects must identify the presence of non-standard barrier types in the roadside inventory to ensure that a safety project will be scheduled to replace the barrier. 1R projects can include barrier replacement with other funding sources. No design exceptions will be given in the case of 4R or 3R projects.

4.6.8 GUARDRAIL UPGRADES

On projects where any portion of an existing run of guardrail is being reconstructed to current safety standards, the entire run of guardrail shall be brought up to current safety standards. This includes transitions to bridge rail, longitudinal runs of guardrail, and guardrail end terminals. Exception to these requirements is required by the State Traffic-Roadway Engineer. On 4R and 3R projects, guardrail and/or terminals that at a minimum, do not meet NCHRP-Report 230 criteria must be replaced. 1R projects must identify the presence of non-standard guardrail and/or terminal types in the roadside inventory to ensure that a safety project will be scheduled to replace those items. 1R projects can include guardrail and/or terminal replacement with other funding sources. No design exceptions will be given in the case of 4R or 3R projects for hardware that doesn’t meet the minimum requirements.

4.6.9 GUARDRAIL AND LENGTH OF NEED

On any project where guardrail or barrier is being proposed, the length of need calculation is required. This will assure that the fixed objects within the clear zone are shielded as intended. Chapter 5 in AASHTO’s “Roadside Design Guide - 2011” contains information and details on length of need calculations.

Designers need to understand where and what the length of need point is on the terminal. The critical impact point of the angled crash test is the length of need point. This is the point where a vehicle should begin to be redirected along the length of the barrier instead of passing through the barrier. For most W-beam terminals this is located at 12'-6" from the impact head unit. Any length of guardrail up stream from the length of need point is not included in the distance provided by the length of need calculation.

\[ X = \frac{L_A + \left( \frac{b}{a} \right) (L_1) - L_2}{\left( \frac{b}{a} \right) + \left( \frac{L_A}{L_R} \right)} \]

Example:

Given:  ADT = 7,500 vpd
       Speed = 50 mph
Select: \( \frac{b}{a} = 0 \) - non flared terminal

- \( L_A = \) Lateral Extent of Area of Concern – Designer selects 15 ft.
- \( L_R = \) Runout Length – 190 ft.

From table 5-10(b) page 5-50 AASHTO "Roadside Design Guide - 2011".

- \( L_1 = \) Tangent Length of Barrier upstream from the Area of Concern.
  
  If Barrier is installed with no flare, \( L_1 \) becomes zero.
  
  (See page 5-51 AASHTO "Roadside Design Guide - 2011")

- \( L_2 = \) Lateral Distance – 4 ft shoulder and 2 ft "E" distance = 6 ft.

Solution: For a parallel installation (i.e., no flare rate), the equation reduces to the following:

\[
X = \frac{L_A - L_2}{L_R}
\]

\[
X = \frac{15 - 6}{15/190} = \frac{9}{0.0789} = 114 \text{ ft.}
\]

### 4.6.10 GUARDRAIL TERMINALS

Guardrail terminals are protective systems that prevent errant vehicles from impacting hazards, by either gradually decelerating the vehicle to a stop when the terminal is hit head-on, or by redirecting the vehicle away from the hazard when struck on the side. These systems are connected to the ends of runs of guardrail and work in concert with the guardrail run to shield rigid objects or hazardous conditions that cannot be removed, or relocated, or break away.

Some terminals utilize W-Beam rail and breakaway timber posts, which are set in two steel foundation tubes for ease of replacement. Some end terminals utilize hinged breakaway steel posts. The rest of the breakaway posts are drilled. All systems establish the third post from the end as length-of-need point, referred to in the AASHTO "Roadside Design Guide - 2011".

Approved end terminals are listed in the Qualified Products List (QPL). Also available are terminals that are designed for a lower speed impact (under 45 mph) that are called Test Level 2 terminals. They are shortened versions of the standard terminals. With the competition as it is, all products undergo routine adjustments to design that make it impractical to list current models. The designer should refer to the QPL, as the QPL stays abreast with all changes and regularly posts updates.
4.6.11 DESIGN CRITERIA

The current line of terminals shows a common trait. They are all classified as gating terminals, meaning that, if hit other than head-on (angular impact) between the first and third post, the vehicle likely will gate (or break) through the device. These new systems are more collapsible than the devices ODOT used prior to NCHRP Report 350 testing.

Extensive crash-testing and data collection of guardrail terminals has led to the decision to modify four procedures, described below:

4.6.11.1 ENERGY- ABSORBING VS. NON ENERGY- ABSORBING

A very specific distinction has been made that, in general, an energy-absorbing terminal will capture a vehicle in a head-on impact better than a non energy-absorbing terminal can. This equates to fewer gating instances with energy-absorbing terminals. Energy-absorbing terminals are available with offsets from one foot to four feet. First preference will be to use an energy-absorbing terminal with the least possible flare so as to reduce impacts to right-of-way and wetlands. Avoid using a non-flared terminal where snow poles are commonly used or where snow pack routinely obscures the guardrail section. Non-flared terminals actually are installed with a one or two-foot offset, in order to ensure the extruder head is completely off of the normal edge of pavement. Standard Drawings are sorted by energy-absorbing and non energy-absorbing types. Non-Energy-absorbing terminals may be used on state highways providing the requirements of recovery areas (described below) are accounted for and can be field verified.

4.6.11.2 ESTABLISHMENT OF VARIABLE-SIZED RECOVERY AREAS

Since virtually all guardrail terminals gate, it is strongly recommended that a reasonable recovery area is provided behind each terminal. The designer should verify in order to provide, where potential exists without extensive grading, an area of the following dimensions:

<table>
<thead>
<tr>
<th>DESIGN SPEED (MPH)</th>
<th>WIDTH (FT.)</th>
<th>LENGTH (FT.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 +</td>
<td>20</td>
<td>75</td>
</tr>
<tr>
<td>35-45</td>
<td>18</td>
<td>50</td>
</tr>
<tr>
<td>&lt; 35</td>
<td>16</td>
<td>40</td>
</tr>
</tbody>
</table>

The recovery area shall have traversable slopes, no steeper than 1:3 ½. The area should be free of obstructions.
4.6.11.3  WIDEN POST TO HINGE-POINT DIMENSION

In order to create predictable outcome in actual crashes conditions that existed during the crash testing should be duplicated as closely as possible. This means that an adequate width of approach at the end post of terminals is essential. This is so an impacting vehicle will be in the same plane as the roadway surface and not dropping off the edge at the instant of impact. The dimension will now be 5 feet from the back of the end post to the hinge point. This change will show on appropriate Standard Drawings.

4.6.11.4  TERMINATING CONSTRUCTION OF THE 8-FOOT FLARE

The 8-foot flare was designed when it was preferred that the end be farther away from traffic so it would be difficult to hit head-on. It was a good concept because the old terminals were spearing hazards. Today, with the softer, more collapsible terminal heads it is actually preferable to hit the head rather than hit the rail element downstream of the head. The angle of impact downstream of the head is considered critical. The 8-foot flare has a higher angle of impact in the vicinity of the head than the 4-foot flare has. This higher angle lies beyond the intended range in which energy absorbing slider heads operate as designed, so gating conditions would be the norm rather than the exception. Other considerations are impact to right-of-way and to wetlands.

New 8-foot flares will not be constructed. Existing 8-foot flares may remain in place if a NCHRP Report 350 approved terminal is in place. If a non-standard terminal such as the Breakaway Cable Terminal (BCT) or a blunt end is discovered in place on an 8-foot flare that is exposed to on-coming traffic remove the old terminal and Type 2A rail back to where the parabolic flare departs the normal shoulder line, add Type 2A rail along the normal tangent until it is appropriate to start the new terminal. Keep in mind that the Length of Need (according to AASHTO’s “Roadside Design Guide - 2011”) might change. Smaller flares require more guardrail to meet required Length of Need. Each location needs Length of Need to be calculated individually.

4.6.12  CABLE BARRIER

Cable barrier can be used in medians and on outside shoulders. Though cable barrier has been successfully tested on a 1:4 slope, optimum performance can be achieved by placing on a transverse slope of 1:10 or flatter.

4.6.12.1  FOR MEDIAN USE

Cable barrier is very effective to use in medians as long as there is at least 8 feet deflection room on both sides of the barrier. The deflection limit is measured from the taut cable to each adjacent fog line. Having less than 8 feet of deflection requires a design exception.
Care must be taken on interstate highways and freight routes where truck mix tends to be higher than the norm, to account for the fact that no cable system has been tested against semi trucks. A semi truck can stretch cable many times more than the design-tested deflection, and will usually hold the cable at maximum deflection until the truck and cable are untangled from each other. The designer should account for extra deflection if there is a site-specific history of truck cross-over incidents. For extra measure of protection the designer should consider use of a NCHRP Test Level 4 system in cases like this.

Cable barrier use can be considered on Interstate Highways and designated Freight Routes with a median width of 30 feet without an increase in the post spacing. Cable barrier installations in median widths less than 30 feet require consultation with the Senior Roadside Design Engineer.

### 4.6.12.2 FOR SHOULDER USE

Cable barrier works well on shoulders as long as the designer ensures at least 8 feet deflection distance is provided between the cable barrier system and the face of any obstruction. As with median application, account for extra deflection if there is a site-specific history of truck run-off-road incidents.
4.7 DRAINAGE

4.7.1 GENERAL

Drainage facilities enable the carrying of water across the highway right of way and also provide a mechanism for removing storm water from the roadway itself. There are many types of drainage facilities including channels, bridges, culverts, curbs, gutters, and a variety of drains. Typically, the roadway designer designs roadside ditches, cut-off ditches, inlet spacing and locations, drainage systems for storm sewers pipes, 24 inches or less, culverts 48 inches or less, and outlet protection. The designer should work with the regional hydraulics engineer in determining drainage needs for projects with systems larger than described above, or when flood plains, bridge hydraulics, scour or bank protection, fish passage, detention, water quality, or temporary erosion control are involved. More discussion is provided on hydraulic issues in Sections 10.5 and 10.10. The Hydraulics Manual should be referred to when performing hydraulic designs.

4.7.2 LONGITUDINAL SLOPE

Experience has shown that the recommended minimum values of roadway longitudinal slope will provide safe, acceptable pavement drainage. A minimum longitudinal gradient can be more important for a curbed pavement than for an uncurbed pavement since the water is constrained by the curb. However, flat gradients on uncurbed pavements can lead to drainage problems if vegetation is allowed to build up along the pavement edge. Desirable gutter grades should not be less than 0.5 percent for curbed pavements with an absolute minimum of 0.3 percent. The designer should consult with the regional hydraulic engineer for potential solutions to flat longitudinal grades. Superelevation and/or widening transitions can create a gutter profile different from centerline profile. The design should carefully examine the gutter profile to prevent the formation of ponds potentially created by superelevation and widening transitions. Water cross flow in superelevation transitions need to be considered and inlet locations need to be carefully designed to catch excess flows. The cross flows can contribute to hydroplaning or be locations of ice.

4.7.3 SELECTION OF INLETS

The performance of inlets and cross slope has an impact on hydraulic capacity. In a past study, the performance of the CG-3 inlet was compared to the standard grated inlets. The efforts of the study provided the following results. The CG-3 inlet outperformed the CG-1 and G-1 inlets when the gutter grade were less than 1%. The CG-3 inlet provided about the same performance as the CG-2 and G-2 inlets when the gutter grade was less than 0.8%. When the gutter grade
exceeded 1%, bypass became a problem with CG-3 inlets and required close inlet spacing to control the bypass flow. In summary the study concluded that the CG-3 inlets are cost effective when the gutter grade is less than 1%.

4.7.4 STORMWATER MANAGEMENT

Most projects must address water quality and some projects must address flow control issues. ODOT’s water quality goal is to design and implement highway projects in a manner that manages project runoff to protect the beneficial uses of the receiving surface and ground waters, and to manage project runoff quantities and flows to protect the receiving water’s stream form, function, and stability.

The ODOT Hydraulics Manual provides design guidance for stormwater water quality and flow control (detention). Other manuals may be referenced such as Metro’s “Green Streets” on a project by project basis in urban environments.

Coordinate the design of stormwater water quality and flow control facilities with the region hydraulics engineer.
4.8  MISCELLANEOUS

4.8.1  FENCES

4.8.1.1  RIGHT OF WAY FENCE

There are two types of fence typically used as access control or right of way fences. A Type 1 fence is a barbed wire fence with 4 or 5 strands of barbed wire. A Type 2 fence uses a woven wire fabric with 3 strands of barbed wire above the woven wire fabric. When determining the type of fence to use, consideration for the type of livestock present may be a factor.

For all freeways, fence will be placed at the access control line. In other situations fencing shall be a consideration in the right of way agreement and installed when required by that agreement.

4.8.1.2  CHAIN LINK FENCE

The installation of chain link fence, located in clear zones, should be done without the use of the top rail. FHWA has reviewed the use of top rail installations and considers the use of top rail or pipe rail hazardous. They do not recommend using this type of support for chain link fences or pedestrian hand rails where they can be struck by an errant vehicle. In the event of a crash, the rails can penetrate the passenger compartment of vehicles. Chain link fences with top rails are particularly poor as vehicle impact on the fabric tends to pull the rail down onto the hood of the vehicle and into the windshield. Top rails, or other rigid horizontal rails or members, metal or wood, should not be used within the clear zone on projects.

4.8.1.3  SNOW CONTROL

On the Cascade and Siskiyou Mountain passes and east of the Cascades, drifting snow may be a serious problem. Snow fencing can eliminate the need for snow removal, lower pavement maintenance costs, and increase visibility and safety on the road. The following factors should be considered:

A. INVESTIGATION

The direction of the prevailing winter winds must be determined before effective measures can be taken to prevent snowdrift problems. Personal observations, interviews with persons familiar with the local winter conditions, including the ODOT maintenance foreman, and reviews of local records may be of value.
B. GRADE

Highway grades above the surrounding ground are much less subject to drifting because of wind action. A cut section of highway may act as a natural fence, impeding the steady flow of wind, resulting in snow being deposited on the roadway.

C. CROSS-SECTION

It may be possible to reduce or eliminate drifting snow problems by streamlining the roadbed. Steep slopes and obstructions to air movement cause snow drifts. Any flattening of the slopes will reduce the areas where snow is deposited on the road. Guardrail is particularly objectionable and wherever feasible should be eliminated by flattening fill slopes. In cut sections the intersection of the cut with natural ground should be back of a 1:6 slope measured from the edge of the shoulder. Widening the cross section through cuts may be desirable to provide for snow storage.

When considering the use of flat slopes for reducing snowdrift problems, the impacts on the safety and aesthetics of the highway should also be considered.

D. CONTROL WITH SNOW FENCES

Snow fences may be required where control cannot be obtained by other methods. It is necessary that any snow fence be properly located and placed. Snow fences are generally placed parallel to the roadway if the prevailing wind is within 25 degrees of being perpendicular to the roadway otherwise the snow fence is placed perpendicular to the prevailing wind direction and at a distance from the roadway centerline that is equal to 35 times the fence height. If a higher than required fence is used the distance from the roadway centerline can be reduced to 18 times the fence height. Snow fence placement depends on a study of conditions at the site, particularly the direction of prevailing winds. A snow fence, in order to function properly, must have an adequate distance behind it to allow for the piling of snow, called snow storage room. The fence itself impedes the wind flow, thereby creating a swirling action behind the fence resulting in the snow being deposited. Ordinarily snow fences should be placed so that the distance from the fence to the top of cut or bottom of fill is 10-15 times the height of the snow fence. If a snow fence is to close to a highway, or a cutbank exists without adequate snow storage room, it can be more of a problem than a solution. A minimum snow storage distance is based on the site conditions.

Two or more parallel rows of fences may be required, but these should be placed far enough apart so the resulting drifts do not overlap, generally 25 times the height of the fence between the snow fences allow non-overlapping snow drifts to form. Snow fences should not be placed any closer than 16 feet to right of way fences or natural parallel barriers.

E. CONTROL WITH LANDSCAPING

Trees and shrubs planted at the appropriate location may also provide a permanent and
effective type of snowdrift control. An ODOT roadside development professional should be contacted.

Additional information may be obtained from the ODOT Inspector’s Manual and the ODOT Maintenance Manual.

### 4.8.2 PASSING LANES

Passing lanes should be considered on two-lane arterials where it is not practical to achieve adequate passing sight distance or where increased traffic volumes have an adverse impact on the desired volume to capacity ratio. Ideally, passing lanes should be considered only in areas where the roadway can be widened on both sides to provide simultaneous passing opportunities for both directions.

The standard travel lane for a passing lane section is 12 feet. The desirable shoulder width should be 6 feet with a minimum of 4 feet. Consult the ODOT Bicycle-Pedestrian Facility Specialist for input on shoulder width. The minimum median width in a passing lane section (three or four lanes) shall be 2 feet.

If at all possible, passing lanes should be located where there are no approaches. If there are existing approaches, the type of approach is critical. Consideration of closing the approach should be given. It may be possible to allow a passing lane where there are single residential approaches or possible forest service type roads, but the approach to public/county roads and approaches that serve multiple trip generation opportunities are problematic in a passing lane section. There are expectations in a passing lane such that the drivers will only be focused on the through movement vehicles. Entering and exiting vehicles violate the driver expectations, for example a vehicle stopped in the left lane waiting to make a left turn. In cases where higher volume access points exist in a passing lane section, left turn lanes are strongly encouraged. The ending point and transition section of a passing lane is critical and these specific types of locations need to be avoided for ending the passing lane; the crest of a hill, on a horizontal curve, and locations that have the potential for a left turn.

Passing lanes should be clearly identified to prevent motorists from thinking they are entering a four lane section of roadway. The minimum length of a passing lane should be 1250 feet, plus tapers. The taper section at the end of a climbing lane should be computed by the following formula:

\[
L = WS
\]

(L=Length in feet, W=Width in feet, S=Posted Speed in mph).

The recommended length for the lane addition taper is half to two-thirds of the lane drop length. Optimum passing length is 1.25 miles. It is very important to have passing lanes long enough to allow the passing of vehicles but not too long as to make the added passing lane seem like an additional travel lane. The Transportation Planning Analysis Unit (TPAU) or the Region Traffic Engineer should be contacted to determine the appropriate length of passing lane.
Design considerations for providing passing lanes on two-lane highways are as follows:

1. Horizontal and vertical alignment should be designed to provide as much length as feasible with sight distance for safe passing.
2. To maximize safe operations, drivers should be able to clearly recognize both lane additions and lane drops.
3. For volumes approaching design capacity, the effect of lack of passing lanes in reducing capacity should be considered.
4. Where the traffic is slowed or capacity reduced because of trucks climbing long grades, construction of climbing lanes should be considered.
5. Where the passing opportunities provided by application of Items 1 and 4 are still inadequate, the construction of a four-lane highway should be considered. Inability to economically justify climbing lanes or multi-lanes may require that the roadway be designed for a much higher volume to capacity ratio.
6. Consider providing extensions to the passing lane section to allow slower vehicles the opportunity to attain free flow speed prior to merging. This reduces the speed differential between vehicles at the merge, improving safety and operations.

4.8.3 CLIMBING LANES

Climbing lanes are normally provided to prevent unreasonable reductions in operating speeds. Normally the combination of heavily loaded vehicles operating on long uphill grades results in the need for climbing lanes. A climbing lane section is not considered a three lane section but a two lane section with an additional lane for uphill slow moving vehicles. (See AASHTO’s “A Policy on Geometric Design of Highways and Streets - 2011”)

Where climbing lanes are warranted as specified in Table 7-2 ODOT 4R/New Standards, the location of the beginning and the end of the lane can be determined by the chart, "Truck Speed - Distance Curves", Figure 4-10. In using this chart for design purposes, vertical curves are not considered, and the speeds are taken from the chart assuming that the vehicle travels in a straight line from one point of grade intersection to the next. Vertical curves can be broken up into straight line segments if additional accuracy is desired. The taper section added at the beginning of a climbing lane should have a 25:1 ratio desirably, but not less than 165 feet in length. The taper section added at the end of a climbing lane should have a 50:1 ratio desirably, but not less than 300 feet in length.

Whenever climbing lanes are warranted, the feasibility of supplemental downhill passing lanes should be investigated. Both climbing lanes and downhill passing lanes shall be the same width as the travel lanes used for normal construction. The desirable adjacent shoulder width is 6 feet with a minimum of 4 feet. If the roadway has substantial bike use, consult the ODOT Bicycle-Pedestrian Facility Specialist for input on shoulder width. When climbing lanes are supplemented with downhill passing lanes, a 2 foot wide median shall be introduced. Four-lane
construction with appropriate shoulder and median widths should be substituted for climbing lanes wherever traffic is likely to approach or exceed capacity.

4.8.4 STOPPING LANES AT RR CROSSINGS

Additional stopping lanes for vehicles that must come to a stop at railroad at-grade crossings were formerly added routinely. In some cases stopping lanes are not justified. The following procedure is established to determine whether additional stopping lanes are justified.

The Project Leader is responsible to determine that an at-grade railroad crossing will exist within the project limits. The Project Leader notifies Region Traffic and requests an investigation. Region Traffic will conduct the investigation per the procedure outlined in the ODOT Traffic Manual.


Additional design guidance for Railroad Grade Crossings can be found on ODOT Standard Drawing No. RD445 when stopping lanes have been justified. More information about rail crossings can be found in Section 10.8.

4.8.5 STOCK AND EQUIPMENT PASSES

The standard stock pass shall be a pipe 90 inches in diameter or a box culvert with inside dimensions of 72 inches wide by 96 inches high. If the length is over 150 feet, a box culvert with inside dimensions of 96 inches by 96 inches shall be used. In some cases, smaller sizes may be feasible and may be used with the approval of the State Traffic-Roadway Engineer. In no case shall a stock pass be smaller than a pipe with 84 inch inside diameter. When a pipe is used for a stock pass, the invert should be paved. However, the pipe should not be asphalt coated. (The asphalt drips in hot weather and cattle will not use it.) Stock passes are to be at locations free from flow of surface water in order to comply with the DEQ regulations on water quality.

Various dimensions may be appropriate for equipment passes. A reinforced box culvert with inside dimensions of 120 inches by 120 inches will accommodate small farm machinery and small trucks. It may not be feasible to provide equipment passes for larger farm equipment.

4.8.6 RUMBLE STRIPS

Safety is a very important component of design and roadway departures and head-on crashes make up a significant portion of Oregon’s fatalities and serious injury crashes. Rumble strips are a relatively low cost engineering treatment designed to alert drivers of a lane departure through vibration and noise created when a vehicle’s tires contact the rumble strip. Rumble strips may be placed on the shoulders, between opposing travel lanes (centerline), or in the travel lanes (transverse). Rumble strips are considered a traffic control device and require the approval of
either the State Traffic-Roadway Engineer or Region Traffic Engineer depending on the application.

Guidelines have been established on when it may be necessary to install the rumble strips for safety reasons on state highways. Rumble strips are not normally installed on urban freeways and the accommodation of bicyclists and shoulder width should be considered along with maintenance activities. The ODOT Traffic Manual provides specific details to determine if a particular project should have rumble strips installed.
Figure 4-10: Truck Speed Distance Curve

Effect of length and grade on speed of average trucks on modern multilane highways. Based on trucks having a weight-power ratio of 200 lb./hp.

DISTANCE UPGRADE (1000 FT.)

NOTE: Refer to discussion on trucks, pages 3-127 & 3-130, AASHTO Geometric Design of Highways & Streets - 2011