Chapter 7

CROSS SECTION ELEMENTS

SOUTH CAROLINA ROADWAY DESIGN MANUAL

February 2021

SPACER PAGE

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Chapter 7
CROSS SECTION ELEMENTS

The highway cross section will establish the basic operational and safety features for the facility, and it will have a significant impact on the project cost, especially for right of way. Chapters 14 through 18 contain typical sections and design criteria for cross sections of local roads and streets, collectors, arterials and freeways. This chapter provides guidance in the design of cross section elements, including the roadway section (e.g., travel lanes, shoulders, auxiliary lanes, passing lanes, curbing), roadside elements, medians, TWLTL, and bridge and underpass cross sections.

7.1 DEFINITIONS/NOMENCLATURE

Figures 7.1-A, 7.1-B, 7.1-C and 7.1-D provide the basic nomenclature for cross section elements for freeways, rural highways, urban streets with curb and gutter, and urban streets with valley gutters, respectively. The following definitions apply to the highway cross section:

1. Auxiliary Lane. The portion of the roadway adjoining the through traveled way for purposes supplementary to through traffic movement including parking, speed change, turning, storage for turning, weaving or truck climbing.

2. Backslope. The side slope created by the connection of the ditch bottom or shelf, upward and outward, to the natural ground.

3. Back Lip. The portion of a valley gutter section beyond the gutter.

4. Buffer. Where used, the area or strip between the roadway and a sidewalk.

5. Catch Curb. The curb type used where the adjacent travel lane or shoulder drains towards the curb and gutter.

6. Cross Slope. The slope in the cross section view of the travel lanes, expressed as a percent or ratio based on the change in horizontal compared to the change in vertical.

7. Depressed Median. A median that is lower in elevation than the traveled way and designed to carry a certain portion of the roadway runoff.

8. Divided Highway. A roadway that has separate traveled ways, usually with a depressed, raised or CMB median for traffic in opposite directions.

9. Fill Slopes. Slopes extending outward and downward from the shoulder hinge point to intersect the natural ground line.

10. Flush Median. A paved median that is essentially level with the surface of the adjacent traveled way.

11. Foreslope. This is the side slope in a cut section created by connecting the shoulder to the ditch hinge point, downward and outward.

12. Hinge Point. The point where the height of fill and depth of cut are determined. For fills, the point is located at the intersection of the shoulder and the fill slope. For cuts, the hinge point is located at the toe of the backslope.

13. Median Slope. The slope in the cross section view of a median beyond the shoulder, expressed as a ratio of the change in horizontal to the change in vertical.

14. Roadway. The combination of the traveled way, both shoulders and/or gutters, and any auxiliary lanes on the mainline highway. Traveled ways separated by a depressed median have two or more roadways.

15. Shelf. On curbed facilities, the relatively flat area located between the back of the curb and the break for the fill or backslopes.

16. Shoulder. The portion of the roadway contiguous to the traveled way for the accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses. On sections with curb and gutter, the shoulder includes the gutter.

17. Shoulder Slope. The slope in the cross section view of the shoulders, expressed as a percent or ratio.

18. Sidewalk. The portion of a street or highway right-of-way, beyond the curb or edge of roadway pavement, which is intended for use by pedestrians.

19. Slope Offset. On curbed facilities with sidewalks, the distance between the back of the sidewalk and the break for the fill slope or backslope.

20. Sloping Curb. A longitudinal element placed at the roadway edge for delineation, to control drainage, to control access, etc. Sloping curbs have a height of 6 inches or less with a face no steeper than 1 horizontal (H) to 3 vertical (V).

21. Spill Curb. The curb type used where the adjacent travel lane or shoulder drains away from the curb and gutter.

22. Toe of Slope. The intersection of the fill slope or foreslope with the natural ground or ditch bottom.

23. Top of Slope (Cut). The intersection of the backslope with the natural ground.

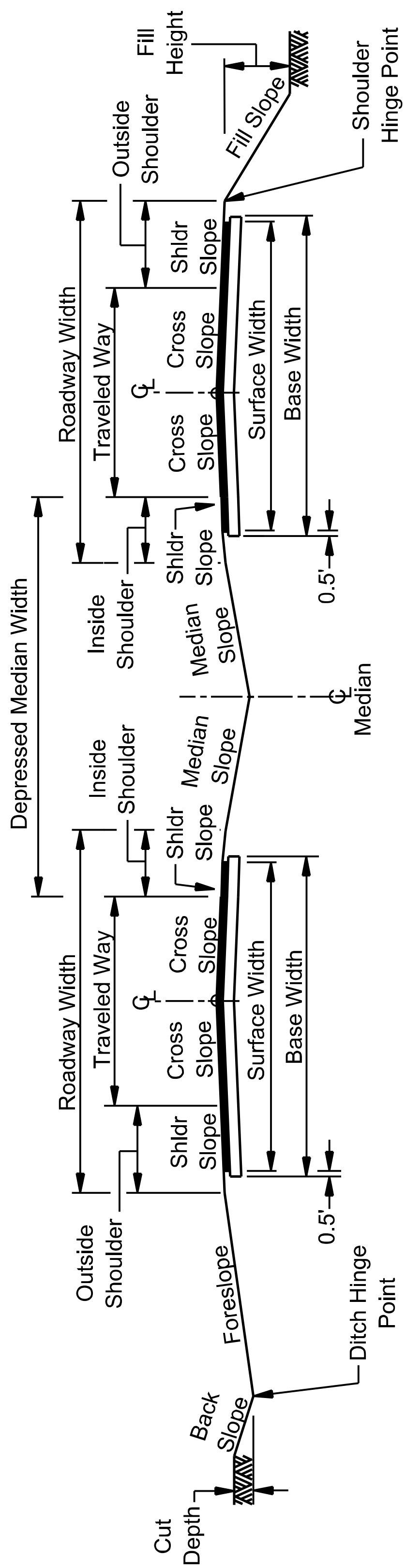
24. Traveled Way. The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

25. Two-Way-Left-Turn-Lane (TWLTL). An area within the flush median marked continuously along a street or highway to provide a deceleration and storage area, out of the through traffic stream, for vehicles traveling in either direction to use in making left turns into and out of access points.

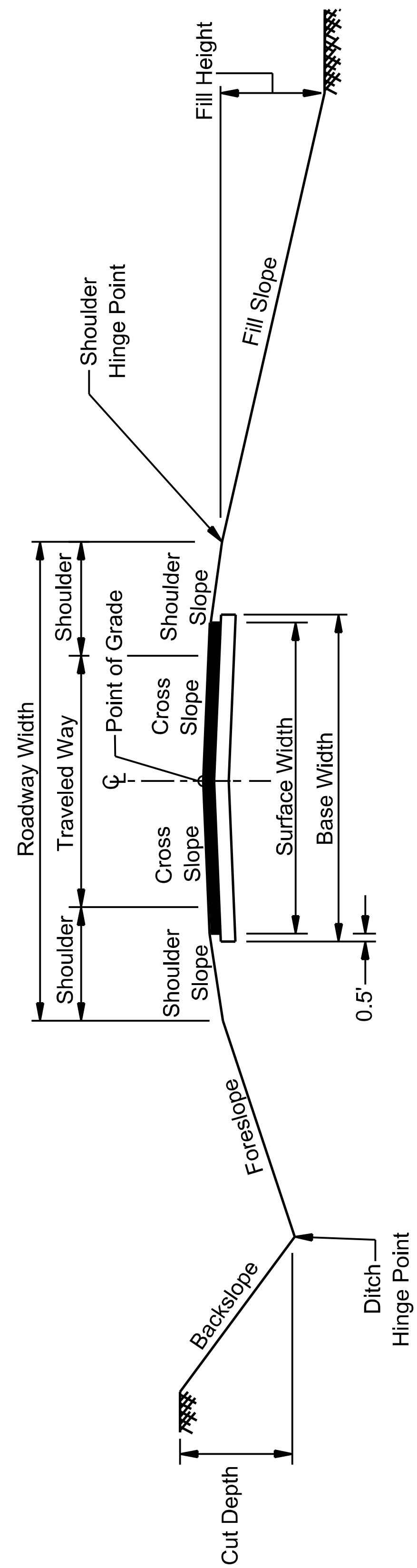
26. Undivided Highway. A roadway that does not have a physical barrier (e.g., depressed median, CMB median) between opposing traffic lanes.

27. Valley Gutter. A paved longitudinal element placed at the roadway edge to control drainage. The valley gutter is designed with a backslope of 10 percent and a width of 3 feet or greater.

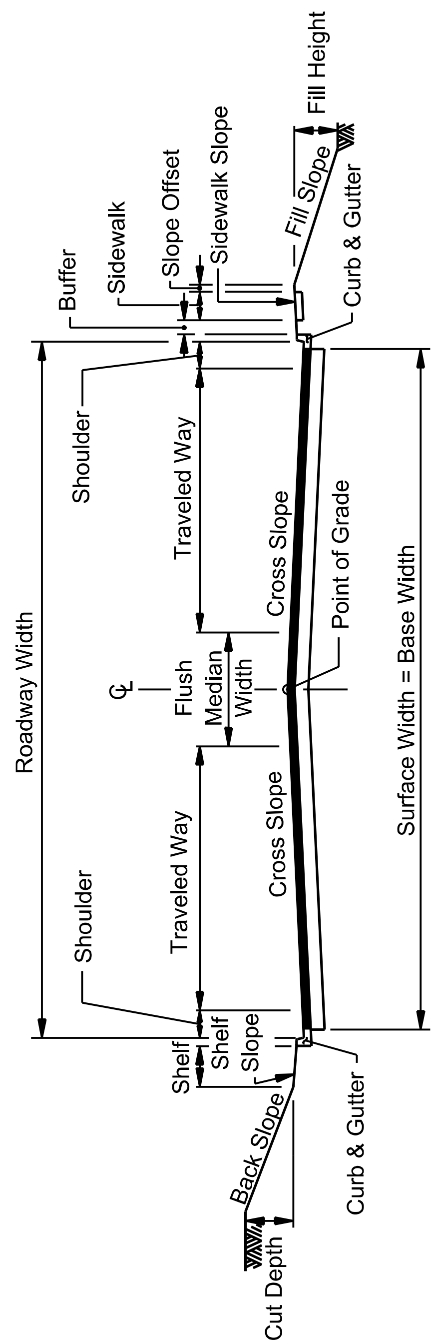
28. Vertical Curb. A longitudinal element, typically concrete, placed at the roadway edge for delineation, to control drainage, to control access, etc. Vertical curbs may range in height between 6 inches and 12 inches with a face no steeper than 1 horizontal (H) to 6 vertical (V).



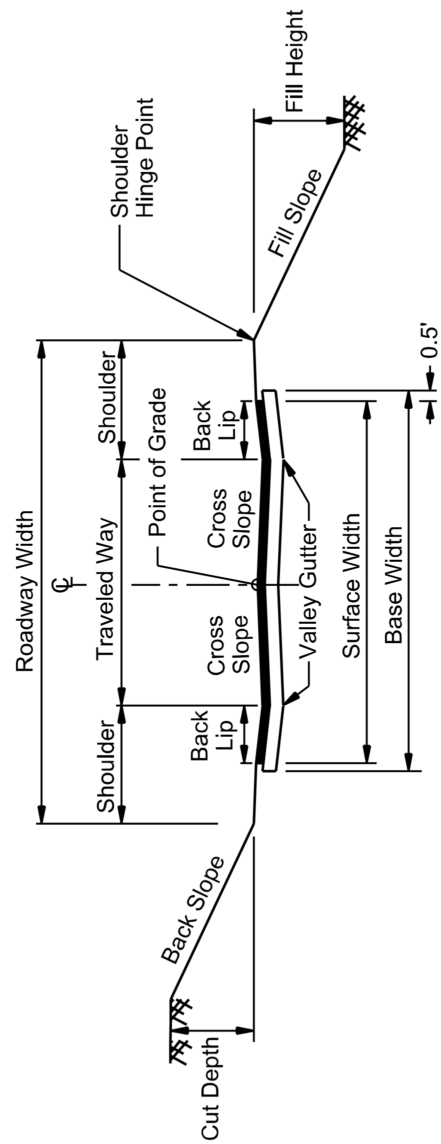
FREEWAY NOMENCLATURE
Figure 7.1-A



RURAL NOMENCLATURE
Figure 7.1-B



URBAN NOMENCLATURE
(Curb and Gutter)
Figure 7.1-C



URBAN NOMENCLATURE
(Valley Gutter)
Figure 7.1-D

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7.2 ROADWAY SECTION

7.2.1 Typical Cross Sections

Typical cross sections are graphical representations with dimensions showing the width, limits and slopes of the various cross sectional elements the designer uses for a particular project. Typical cross sections generally illustrate one side in a fill section and the other side in a cut section for both normal crown and superelevated sections. They generally detail the thickness, depth and layers of the pavement structural components. Typical cross sections for local roads and streets, collectors, arterials and freeways are presented in Chapters 14 through 17, respectively.

Chapters 14 through 18 provide the minimum criteria for lane widths, shoulder widths and other cross section elements.

7.2.2 Pavement Surface Type

For the selection of pavement type, the designer should consider the following factors:

- volume and composition of traffic,
- soil characteristics,
- weather,
- historical performance of various pavement types in the project area,
- energy conservation,
- availability of materials,
- costs, and
- life cycle costs.

Pavements are generally classified into one of three categories — high, intermediate and low. The selection of the appropriate pavement type for a particular road, street or highway is primarily based upon the anticipated volume and type of traffic. For more information on pavement selection, contact the Pavement Design Engineer. The Department uses the following pavement types:

1. High-Type Pavements. High-type pavements are classified as asphaltic concrete (flexible) or concrete (rigid). Use this pavement type wherever high volumes of traffic are expected. Adequate design and construction techniques should allow pavements to retain their cross sectional shape, smooth riding qualities, drain properly and maintain good skid-resistant properties throughout their expected service life. The primary objective in the selection, design and construction of high-type pavements is to ensure maximum performance. The proper design and construction avoids performing non-routine maintenance and the resultant interruption and annoyance to traffic operations; as well as, the associated increased cost to the responsible governmental entity and the highway user.

2. Intermediate-Type Pavements. Intermediate pavements are designed to lesser criteria than the high-type pavement. Intermediate-type pavements are a variety of bituminous surface treatments on a prepared base. These are generally used on collectors and local roads and streets.

3. <u>Low-Type Pavements</u>. Low-type surfaces are generally prevalent on very low volume roads and normally consist of earth-type base (sand-clay) and earth base with macadam, stabilized aggregate or some other type of stone surface. The Department has a very limited number of roadways with this type of pavement.

7.2.3 <u>Traveled Way</u>

The traveled way is the area upon which vehicles travel. The traveled way has a great influence on the operations and safety of a highway facility.

7.2.3.1 Lane Widths

Lane widths range from 9 to 14 feet, with the 12-foot width being the most common practice for State highway facilities. Lesser widths may be considered on 3R projects, see Chapter 18 "3R Projects (Non-Freeways)," and local roads and streets, see Chapter 14 "Local Roads and Streets." Consider the following factors when selecting lane widths:

1. <u>Safety</u>. Lane widths are one of many factors that may affect the roadway safety. The lane width of a roadway influences the comfort of driving, operational characteristics and, in some instances, the likelihood of crashes.

2. <u>Highway Classification</u>. Highway classification and type are major determining factors in the selection of lane width. Generally, highway classification is a function of expected traffic usage. Arterials and freeways will have wider widths while collectors and local streets and roads may have narrower widths. Chapters 14 through 17 provide lane widths for the various functional classifications.

3. <u>Context</u>. In rural areas, there is typically sufficient right of way available to provide wider lane widths. In urban areas, restrictive right of way may limit the travel lane widths.

4. <u>Traffic Volume</u>. The volume of traffic is also a factor in determining lane width. For example, a wider lane provides desirable clearances between vehicles traveling in opposite directions on two-lane, two-way rural highways when high traffic volumes and high percentages of commercial vehicles are expected.

5. <u>Capacity</u>. In general, wider lanes have a greater capacity than narrower lanes because motorists are less inhibited by the close proximity of adjacent traffic. This results in a higher running speed and, in some instances, increases capacity. However, widths greater than 12 feet do not necessarily increase traffic capacity. Therefore, the *Highway Capacity Manual* uses the 12-foot travel lane as the base width for determining capacity and reduction factors are provided for narrower lanes.

6. <u>Lateral Obstructions</u>. Consider the location of lanes with respect to curbs and other lateral obstructions. Motorists tend to avoid close obstacles; therefore, wider lanes are desired. The absence of a usable shoulder and the close proximity of obstructions to the edge of the traveled way also influence driver behavior. For more information on lateral obstructions and the effects on driver behavior, see the AASHTO *Roadside Design Guide* and the *Highway Capacity Manual*.

7. Trucks. Significant volumes of trucks influence the lane width selection. The size and location of trucks, within their respective travel lane, have a similar effect as a lateral obstruction on both opposing and adjacent traffic. Trucks tend to cause other traffic to travel at reduced running speeds, which reduces overall capacity.

7.2.3.2 Provisions for Bicycles on Traveled Way

For guidance on provisions for bicyclists, see Section 13.2 of this *Manual*, Department policies, and the AASHTO *Guide for the Development of Bicycle Facilities.*

7.2.3.3 Traveled Way Cross Slopes

The purpose of the pavement cross slope is to promote rapid removal of drainage from the pavement surface while enabling the driver to maintain control of the vehicle. Because low-type pavements are loose and pervious, they require a greater cross slope than high-type surfaces in order to reduce saturation of the unpaved surface and base materials. Figure 7.2-A presents cross slopes for the various types of pavements used by the Department.

Surface Class	Surface Type	Cross Slope
High	Hot Mix Asphalt Concrete Surface Course or Portland Cement Concrete on a Prepared Base.	2.00% (50H:1V) for first 2 lanes
Intermediate	Bituminous Surface Treatment on a Prepared Subbase.	2.00% (50H:1V)
Low	Earth Base/Stabilized Aggregate or Macadam.	2.50% (40H:1V) or 4.00% (25H:1V)

NORMAL PAVEMENT CROSS SLOPES
Figure 7.2-A

Cross slopes of 2.00 percent are permitted for up to two lanes plus one half the width of a flush median. Pavement beyond the second lane should have a cross slope of 2.50 percent. This is for travel lanes as well as auxiliary lanes. If a roadway section has curb and gutters and the profile grade is less than 2.00 percent, the designer may consider using a cross slope of 2.50 percent for the outside lane to improve drainage.

The following further describes the cross slopes used by the Department:

1. Two-Lane Highways. Crown the traveled way pavement at the centerline and use a cross slope as shown in Figure 7.2-A away from the centerline.

2. Four-Lane Divided Highways (Narrow Median). Crown the traveled way pavement at the inside edge of the traveled way and use a cross slope of 2.00 percent away from the median for all lanes.

3. Four-Lane Divided Highways (Wide Median). Crown the traveled way pavement at the centerline of each roadway and use a cross slope of 2.00 percent away from the centerline for all lanes.

4. Three-, Five- or Seven-Lane Highways (with TWLTL). Crown the pavement at the center of the TWLTL and use a cross slope of 2.00 percent away from the centerline for all lanes on three- and five-lane highways. For a seven-lane section, use a cross slope of 2.5 percent for the outside lanes.

5. Six-Lane Highways with a Concrete Median Barrier (CMB). The following will apply:

    a. CMB Raised. Crown the median at the centerline of the CMB and use a slope of 2.00 percent away from the center for the inside shoulders and for the first two travel lanes adjacent to the inside shoulder. Use a slope of 2.50 percent for the third lane breaking away from the outside edge of the second travel lane.

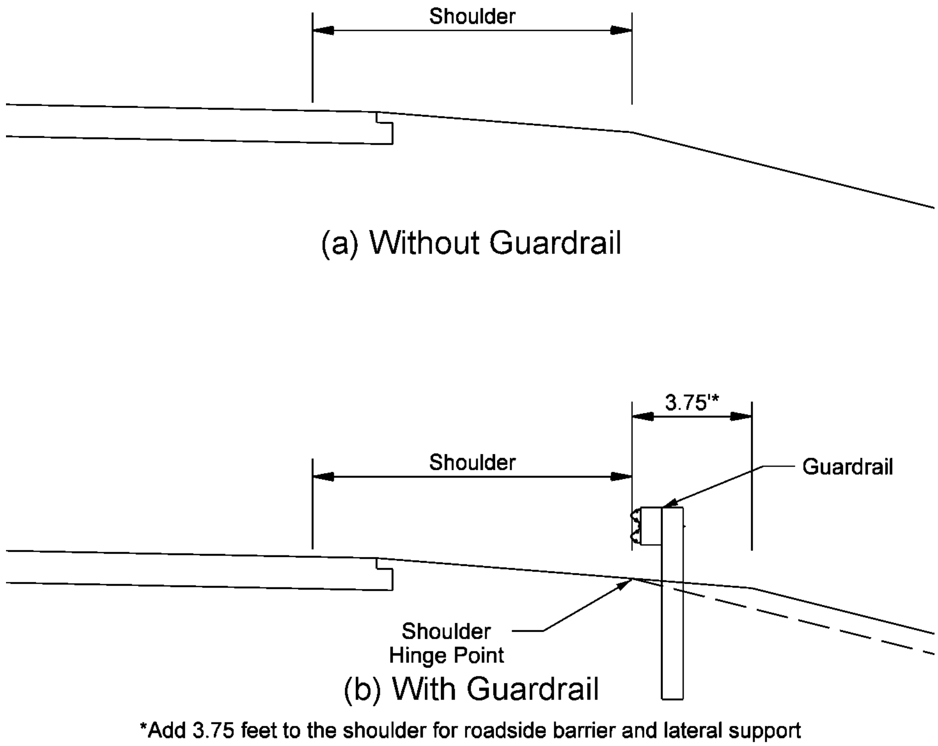
    b. CMB Depressed. When the median is lower than the adjacent traveled way, crown the traveled way between the first and second travel lanes (i.e., one lane sloping to the inside and two lanes sloping to the outside. The cross slope on all travel lanes will be 2.00 percent. The inside shoulder is sloped towards the CMB at a rate of 4.00 percent. When retrofitting existing facilities, do not break more than two lanes to the inside.

6. Bike Lanes. Where there is an auxiliary lane adjacent to the bike lane, the bike lane cross slope is the same as the through lane.

7.2.4 Shoulders

7.2.4.1 Function

Shoulders are defined as that portion of the roadway contiguous to the traveled way. They extend from the edge of the travel lane to the intersection of the foreslope. Shoulders may either be earth type or paved or a combination of both. Useable shoulders constitute the actual width of shoulder available for emergency stopping. Figure 7.2-B provides examples of shoulders.



SHOULDERS
Figure 7.2-B

Shoulders serve many functions, some of which include:

- providing structural support for the traveled way,
- increasing highway capacity,
- encouraging uniform travel speeds,
- providing space for emergency and discretionary stops,
- improving roadside safety by providing more recovery area for run-off-the-road vehicles,
- providing a sense of openness,
- improving sight distance around horizontal curves,
- enhancing highway aesthetics,
- facilitating maintenance operations,
- providing additional lateral clearance to roadside appurtenances,
- facilitating pavement drainage,
- providing space for pedestrian and bicycle use, and
- providing space for bus stops.

7.2.4.2 Shoulder Width

Shoulder widths will vary according to functional classification, traffic volumes, and urban or rural location. Chapters 14 through 18 present the shoulder width criteria for the various conditions.

Wider paved shoulder widths should be provided to accommodate bicyclists on SC Touring Routes and routes designated by a bicycling plan adopted by an MPO or COG.

In addition, guardrail can influence the shoulder width. Where guardrail is provided, increase the width of the shoulder by 3.75 feet to maintain the desirable useable width and to provide support for the guardrail. See Figure 7.2-B.

7.2.4.3 Shoulder Cross Slopes

Greater cross slopes are provided on shoulders than on adjacent travel lanes for two reasons: 1) the runoff carried across the shoulder is a combined total of both the adjacent travel lane and the shoulder; and 2) in many cases, the shoulder surface material is rougher than the adjacent travel lane requiring a steeper slope to maintain a similar flow rate. Not all shoulders are paved, so it is necessary to remove the water as rapidly as possible before it penetrates the shoulder with the potential of reducing its structural support capabilities. Normal shoulder slopes are shown in Figure 7.2-C. See Section 5.3.5 for the treatment of shoulders through superelevated curves for new construction and reconstruction projects. On 3R projects, existing shoulder slopes may be retained; see Chapter 18 "3R Projects (Non-Freeways)."

All shoulders should be structurally adequate to support truck usage for emergency purposes. In addition, ensure shoulder materials are sufficiently stable to provide lateral support of the adjacent pavements.

For maintenance operations, it is advantageous for the shoulders to be delineated from the through traffic lanes. This generally can be accomplished by using a different surface treatment, a different surface gradation and finish, pavement markings if the same surface material is used for both the traveled way and shoulder, and rumble strips.

Surface Class	Surface Type	Cross Slope
Paved	Hot Mix Asphalt Concrete or Portland Cement Concrete	4.00%* (25H:1V)
Turf	Compacted Earth with Grass Surface	8.00% (12.5H:1V)

* *If the paved shoulder is 4 feet or less, use the adjacent travel lane cross slope.*

NORMAL SHOULDER CROSS SLOPES
Figure 7.2-C

7.2.5 <u>Rumble Strips</u>

Rumble strips are a proven, cost-effective way to reduce crashes. They alert drivers of lane departures by providing an audible and vibratory warning. Shoulder rumble strips help reduce roadway departures; whereas, centerline rumble strips reduce vehicular crossovers on undivided highways.

Engineering Directive 53 “Installation of Rumble Strips” provides the warrants for the placement of rumble strips on freeways and other highways. The *SCDOT Standard Drawings* provide the design details for milled rumble strips and stripes, and their application on freeways and other highways.

Place a note on the plan sheet showing “Begin Mill-in Rumble Strip” and “End Mill-in Rumble Strip” with an arrow to the appropriate location; see the *SCDOT Standard Drawings*.

7.2.6 Auxiliary Lanes

7.2.6.1 General Guidance

Auxiliary lanes are any lanes beyond the basic through travel lanes. They are intended for use by vehicular traffic for specific functions. The following will apply to the design of auxiliary lanes:

1. Width. The width of an auxiliary lane is typically the same as that of the adjacent through lane. Auxiliary lane widths for various classifications of highways are provided in the design tables in Chapters 14 through 17.

2. Types. Auxiliary lanes include:

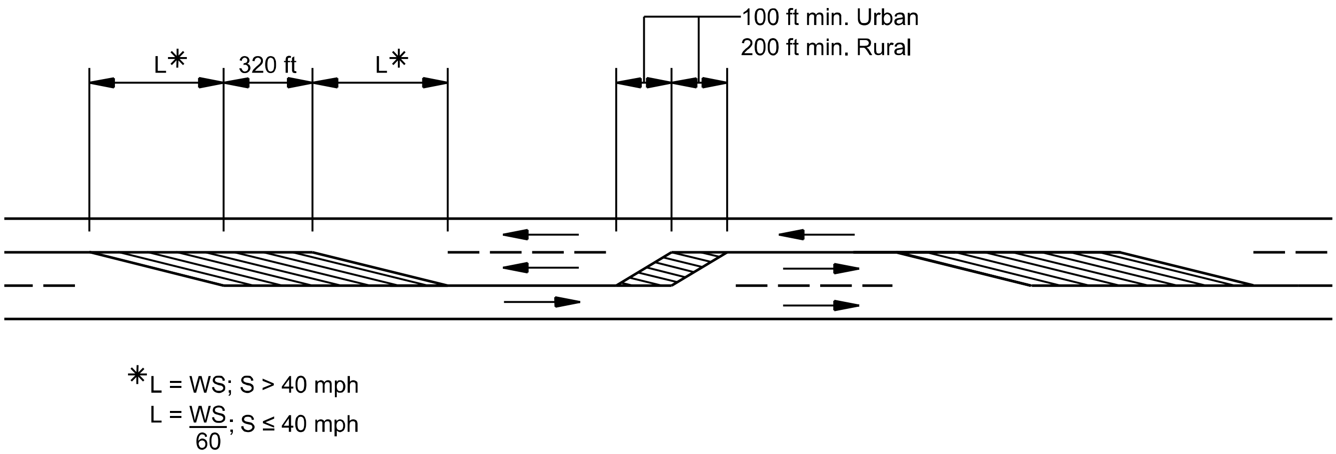
   - single left- and right-turn lanes at intersections,
   - double left- and right-turn lanes at intersections,
   - truck-climbing lanes,
   - acceleration/deceleration lanes at interchanges or intersections,
   - weaving lanes within an interchange,
   - continuous auxiliary lanes between two closely spaced interchanges,
   - parking lanes, and
   - passing lanes.

3. Shoulders. The shoulder width adjacent to the auxiliary lane should be the same as the normal shoulder width for the approaching roadway. At a minimum, the width should be 6 feet assuming the roadway has a shoulder width equal to or greater than 6 feet.

4. Cross Slope. The cross slope for an auxiliary lane will depend on the number of lanes and cross slope of the adjacent traveled way. If the auxiliary lane is the second lane from the crown, provide a cross slope of 2.00 percent. If the auxiliary lane is the third or fourth lane from the crown, use a cross slope of 2.50 percent. See Section 7.2.3.3 for additional information on cross slopes.

7.2.6.2 2+1 Roadways

The 2+1 roadway is a continuous three-lane cross section with striping to provide for passing in alternate directions; see Figure 7.2-D. A 2+1 roadway may be considered as an alternative to two-lane highways where passing lanes are necessary to obtain the desired level of service, but the traffic volumes are not high enough to justify a four-lane facility. The decision to use the 2+1 roadway will be determined on a case-by-case basis based on long-range planning objectives for the facility, available right of way, existing cross section, topography and the need to reduce platooning and passing problems.



2+1 ROADWAY
Figure 7.2-D

When designing 2+1 roadways, consider the following:

1. Sight Distance. Provide stopping sight distance throughout the 2+1 roadway. Desirably, provide decision sight distance to the lane drops and at intersections.

2. Level of Service. A 2+1 roadway will typically operate at least two levels of service higher than a conventional two-lane highway serving the same traffic volume.

3. Capacity. Do not consider a 2+1 roadway where current or projected traffic volumes exceed 1200 vehicles per hour in one direction of travel. A four-lane facility is generally more efficient at these traffic volumes.

4. Terrain. Only use 2+1 roadways in level or rolling terrain. In mountainous terrain or on isolated steep grades, a climbing lane is generally more appropriate.

5. Cross Sections. The lane and shoulder widths should match the adjacent section of the two-lane highway.

6. Major Intersections. Locate major intersections in the transition area between opposing passing lanes, and provide striping for left-turn lanes at the intersection, as applicable. Low-volume intersections and most driveways may be accommodated within the passing lane sections.

7. Signing and Pavement Markings. Signing and pavement markings for a passing lane should meet the criteria in the *MUTCD*.

7.2.7 Parking

7.2.7.1 Guidelines

Adjacent land use may create a demand for on-street parking along an urban street. Parking lanes provide convenient access for motorists to businesses and residences. However, on-street parking reduces capacity, impedes traffic flow and increases crash potential.

The decision to retain existing on-street parking or to introduce on-street parking will be based on a case-by-case assessment in cooperation with the local community. Evaluate the following factors:

- prior crash experience or potential safety concerns;
- impacts on the capacity of the facility;
- current or predicted demand for parking;
- actual needs versus existing number of spaces;
- alternative parking options (e.g., off-street parking);
- input from local businesses;
- impacts on right of way;
- impacts on bicyclists and pedestrians;
- pedestrian accessibility;
- construction costs; and
- projected traffic volumes.

7.2.7.2 Parking Types

The two basic types of on-street parking are parallel and angle parking. Parallel parking is the preferred arrangement where street space is limited and traffic capacity is a major factor. Angle parking provides more spaces per linear foot than parallel parking, but a greater cross street width is necessary for its design. The total entrance and exit time for parallel parking exceeds that required for angle parking. Parallel parking also requires a vehicle to stop in the travel lane and await an opportunity to back into the parking space. However, angle parking requires the vehicle to back into the lane of travel when adjacent parked vehicles may restrict sight distance and where this maneuver may surprise an approaching motorist.

7.2.7.3 Design

In many communities, local codes or regulations dictate the dimensions for parking layouts. For guidance on parking stall widths, stall layouts and other parking design criteria, the designer should review the Institute of Transportation Engineers' *Traffic Engineering Handbook*.

7.2.7.4 Location

For most sites, conduct a parking occupancy turnover study and a sight distance evaluation. In addition to State and local regulations when locating parking spaces, consider the following:

- Prohibit parking within 20 feet of any crosswalk.

- Prohibit parking at least 10 feet from the beginning of the curb radius at mid-block approaches (e.g., alleys, driveways).
- Prohibit parking within 50 feet of the nearest rail of a railroad/highway crossing.
- Prohibit parking from areas designated by local traffic and enforcement regulations (e.g., near school zones, fire hydrants). See local ordinances for additional information on parking restrictions.
- Prohibit parking near bus stops (see Section 11.8).
- Prohibit parking within 30 feet on the approach leg to any intersection with a flashing beacon, stop sign or traffic signal.
- Prohibit parking on bridges or within a highway tunnel.
- Eliminate parking across from a T- intersection.
- Prohibit parking in the intersection sight triangle.

7.2.8 <u>Curbs</u>

7.2.8.1 Usage

Curbs are often used on urban facilities to control drainage, delineate the pavement edge, channelize vehicular movements, control access, limit right of way needs, provide separation between vehicles and pedestrians and present an attractive appearance. Curbs are generally not used in rural areas. For urban and suburban areas, determining if curbs will be used depends upon many variables, and the decision will be made on a case-by-case basis. Evaluate the following factors to determine whether a curbed section is preferred:

- local preference,
- drainage impacts,
- construction costs,
- impacts on maintenance operations,
- roadside safety impacts,
- sidewalks (see Section 13.3),
- control of access to abutting properties,
- impacts on traffic operations,
- right-of-way restrictions,
- vehicular speeds, and
- potential for future widening.

Curbs used along the outside pavement edges serve a variety of functions (e.g., drainage control, delineating edges of pavement and pedestrian walkways, aesthetics, reduce right of way). Pedestrian accommodations are usually warranted where curb and gutter is present. Curbs are also used as aids in channelizing vehicle movement at intersections, controlling access points and providing lateral support of the roadway or shoulder pavement. The use of curbs predominates in urban areas as opposed to rural.

Curbs may be provided on urban ramps if they are located at outside edge of the paved shoulder. If curbing is provided on ramp, it should be within the gore area or along the ramp proper. Curbing should not be provided along the freeway mainline.

7.2.8.2 Types

There are two basic types of curbs, vertical curb and sloping curb. Either curb type may be constructed with an integral gutter to form a curb and gutter section. Curbs are constructed of concrete either cast-in-place or extruded. Where curb and gutter is used, whether vertical or sloping curb, the gutter portion is not considered a part of the traveled way.

The design details for the following curb types used by the Department are provided in the *SCDOT Standard Drawings*:

1. Vertical. Vertical curbs are normally 6 inches in height with steep vertical faces (1H:6V). They are intended to discourage vehicles from leaving the traveled way. Do not use vertical curbs adjacent to travel lanes where design speeds exceed 45 miles per hour. Instead, use a sloping curb placed at the outer edge of the shoulder.

2. Sloping. Sloping curbs are generally 6 inches in height with a sloped face (4H:5V). Sloping curbs will allow a vehicle to mount the curb and can be used with any design speed. If the design speed is greater than 45 miles per hour, place the curb on the outside edge of the shoulder. For freeways and ramps, only use sloping curbs at the outside edge of the shoulder, where necessary. With this curb type, the designer needs to select the appropriate drainage structure.

3. OGEE. The OGEE curb is a gently rounded curb approximately 4 inches high. Vehicles can easily transverse over the curb. It can be used for roadside access (e.g., driveways) where curb cuts are not desired. Where drainage structures are required, provide a special detail to transition the OGEE curb to the standard drainage inlet. Accessibility and on-street parking should be evaluated due to the ease of mounting OGEE curb.

4. 9 inch x 15 inch. The 9 inch x 15 inch curb can be used with raised medians where the adjacent pavement is sloped away from the median. It is a sloping curb that can be easily mounted.

SCDOT also defines the curb based on the drainage direction. Catch curbs drain toward the curb and gutter. Spill curbs drain away from the curb and gutter. SCDOT curb types are typically catch curbs, but also can be a spill curb.

7.2.8.3 Accessibility

Provide curbs ramps at all pedestrian crossings to provide accessibility. See the *SCDOT ADA Transition Plan* and *SCDOT Standard Drawings* for details on the design and location of curb ramps.

7.2.9 Valley Gutter

Valley gutters are commonly used on local roads and streets. See Figure 7.1-D for a cross section with a valley gutter. On State routes, a valley gutter may be used to transition from a shoulder section to a curb and gutter section. The length of the transition from the shoulder section to the curb and gutter section should be based on the following:

- $L = WS$, where $S > 40$ miles per hour, feet; or
- $L = WS^2/60$, where $S \leq 40$ miles per hour, feet.

W is the difference in width between the shoulder width and the curb and gutter width.

7.3 ROADSIDE ELEMENTS

7.3.1 Roadside Safety

See the AASHTO *Roadside Design Guide* for specific criteria for clear zones based on the foreslope, ditch width and backslope combinations; barrier warrants; roadside and median barriers; barrier layouts; and impact attenuators.

7.3.2 Slopes and Ditches

7.3.2.1 Purpose

Earth slopes are required to provide safe roadside and median ditches adjacent to highway facilities and to provide a stable transition from the highway profile to adjacent terrain features. Flat slopes also facilitate turf establishment and are often required for soil stability. Flat and well-rounded side slopes, combined with proper roadway elevations above natural ground lines also enhance the roadway aesthetically as well as provide easy accessibility with regard to maintenance operations.

Using broad flat slopes on roadside ditches, which are visible to the driver, lessen the feeling of restriction and add considerably to a driver's willingness to use the shoulder and earth slope area in emergencies.

The designer should evaluate slopes in accordance with the *SCDOT Geotechnical Design Manual*. Coordinate slope modifications with the geotechnical designer.

7.3.2.2 Fill Slopes

Fill slopes are the foreslopes extending outward and downward from the shoulder hinge point to intersect the natural ground line. The slope criteria is dependent upon the functional classification, fill height, urban/rural location and the presence of curbs. Although Chapters 14 through 17 provide design guidance for fill sections for each of the classifications of roadways, the designer must also consider geotechnical design requirements, right-of-way restrictions, utility considerations, roadside safety and roadside development in determining the appropriate fill slope. Figure 7.3-A provides the fill slope ratios for typical conditions measured from the shoulder hinge point. The designer should evaluate each location to determine the appropriate fill slope ratios; however, 4:1 or flatter slopes are encouraged because they are easier to mow or otherwise maintain and safer to negotiate for errant vehicles.

Fill Height	*Foreslope Ratio
≤ 5 feet	6H:1V
5 < 10 feet	4H:1V
≥ 10 feet	2H:1V

***The designer should provide a transition between different foreslope ratios; see Section 7.3.2.4.*

TYPICAL FILL SLOPE RATIOS
Figure 7.3-A

7.3.2.3 Cut Slopes

The following applies to cut slopes:

1. Earth Cuts. In earth cuts on facilities without curbs, roadside ditches are provided to control drainage. The ditch section includes the foreslope, ditch width (typically a V ditch is used) and backslope as appropriate for the facility type. On facilities with curbs and no sidewalks, a shelf (typically 6 feet measured from the back of curb) is provided, and the backslope of 2H:1V is located beyond the shelf. See the typical cross sections in Chapters 14 through 17.

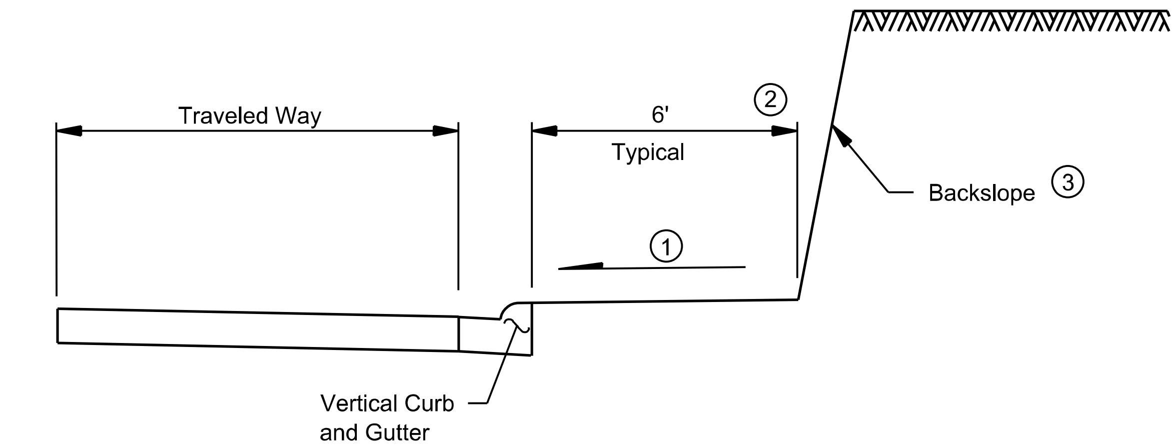
2. Rock Cuts. In rock cuts, the backslope generally is steeper than earth cuts; see Figure 7.3-B. For large cuts, benching of the backslope may be required. The geotechnical designer is responsible for determining the appropriate rock cut slopes.

   The designer should perform a hydraulic analysis to evaluate the need to control cascading water from the top of the cut and to determine the conveyance needs or roadside drainage at the toe of the cut.

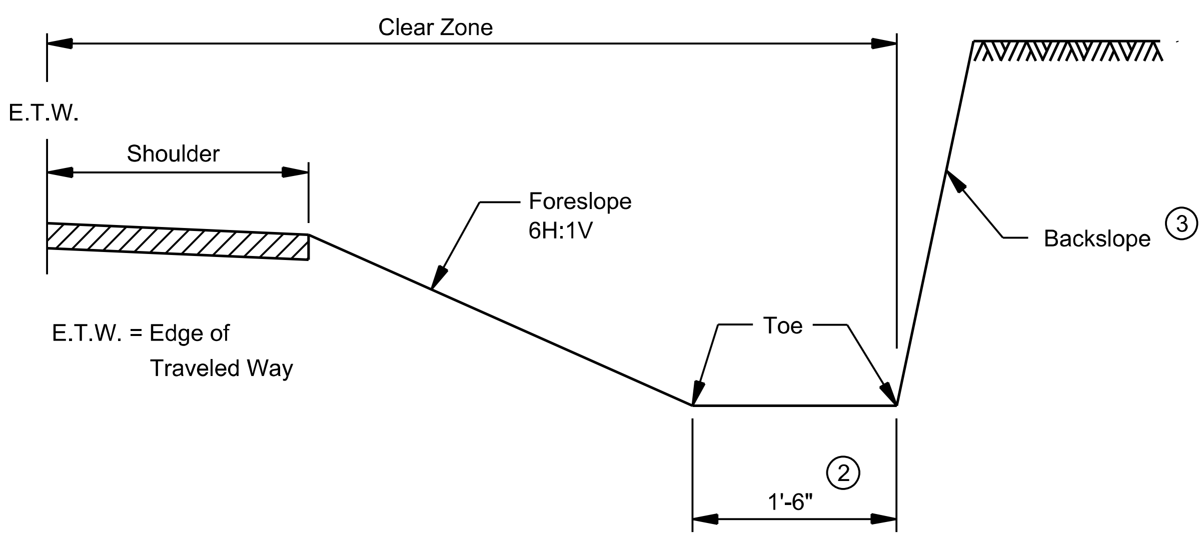
3. Daylighting. Daylighting extends or flattens backslopes and can provide several benefits, including:

   - enhancing aesthetics,
   - enhancing roadside safety,
   - providing needed fill material,
   - removing undesirable features,
   - obliterating existing roadbeds, and
   - providing convenient outfall points for roadside drainage.

   The decision to use daylighting should be made on a case-by-case basis in coordination with the Project Development Team.



(a) Curb and Gutter Section



(b) Ditch Section

Notes:

① *Use 50H:1V if sidewalks are presented or anticipated. Use 30H:1V if sidewalks are not present or anticipated.*

② *Discuss with the geotechnical designer to determine extra width needed for falling rock.*

③ *Backslopes in rock may require benching. Contact the geotechnical designer for guidance.*

TYPICAL ROCK CUT SECTIONS
Figure 7.3-B

7.3.2.4 Slope Transitions

The designer should flatten and round side slopes to fit the topography consistent with the site conditions, roadside safety and cost effectiveness of the design. Gradual transitions from cut to fill slopes, or within a cut or fill slope, will avoid unattractive bulges and sharp depressions. Desirably, provide a 100-foot transition for every 1:1 slope difference (e.g., provide a 300-foot transition between a 6:1 slope and a 3:1 slope).

7.3.2.5 Ditch Section

A properly designed roadside ditch will ensure the proper drainage of the pavement subgrade and the adequate conveyance of surface flow without creating erosion. Roadside ditches are provided adjacent to embankment locations and in cut sections.

The Department typically uses a V-ditch section along facilities without curb and gutter. The ditch section includes the foreslope and backslope. If the longitudinal gradient is greater than 3 percent, the hydraulic designer will review the ditch design as well as include specially designed sediment control items and lining, as appropriate.

7.3.3 Sidewalks

The designer should evaluate the need for pedestrian accommodations on every project. See Section 13.3 for further guidance related to sidewalk design considerations.

7.3.4 Aesthetics

There are various methods in which to improve the visual impact of a roadway. Varying the cross section elements will typically improve the aesthetics of the roadway. This may include:

- increasing or decreasing the side slopes to reduce the magnitude of exposed cut and fill slopes;
- reducing ditch widths or depths to reduce the amount of cut, with the approval of the hydraulic designer;
- using slope rounding to blend cuts and fills into the natural ground;
- warping side slopes to match the natural landscape;
- retaining existing vegetation;
- using a raised or depressed median with plantings; and/or
- providing structures that match the natural landscape.

7.4 MEDIANS

7.4.1 Functions

A median is defined as the area of a divided highway separating the traffic into opposing directions. The principal functions of a median are to:

- provide separation from opposing traffic,
- prevent undesirable turning movements,
- provide an area for deceleration and storage of left-turning vehicles,
- provide an area for storage of vehicles for emergency stopping,
- facilitate drainage collection,
- provide a recovery area for run-off-the-road vehicles,
- provide an area for pedestrian refuge,
- provide width for future lanes, and
- minimize headlight glare.

7.4.2 Median Types

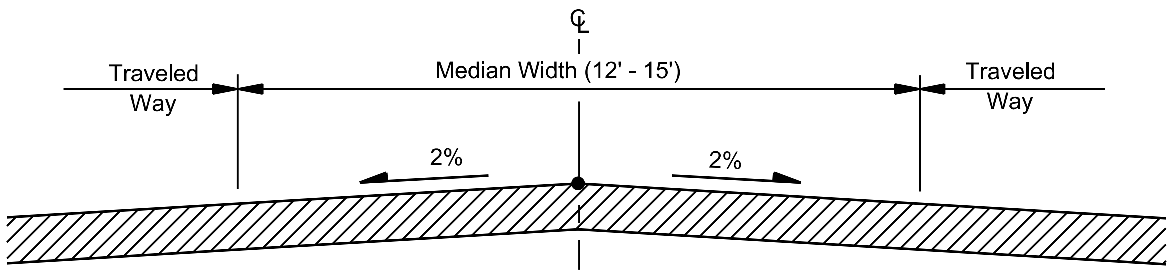
The decision on the median type to be used should be made as early as possible. Figure 7.4-A provides typical sections for the flush, flush with a concrete median barrier (CMB), raised and depressed medians.

7.4.2.1 Median Selection

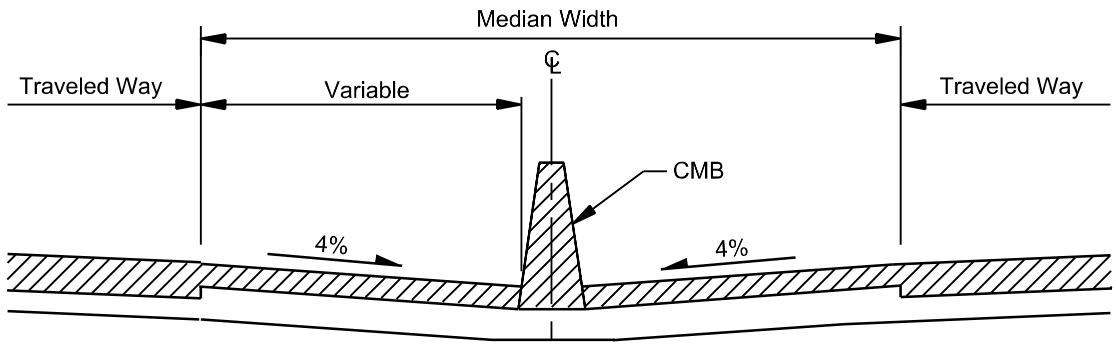
When selecting a median type, recognition must be given to urban/rural location, access needs, design speeds, availability of right of way, safety, crash history, capacity, intersection spacing, traffic signals, sight distance, turn-lane length, economics, environmental impacts, public appearance and functional classification. Higher functional classifications will warrant a greater effort in managing access to a street or highway and in retaining mobility. See Section 3.4.1 for a discussion on mobility.

On certain projects, more than one median type may be necessary and/or desirable. The length of a project will be a major influence in this determination. On relatively short highway sections, the number of different median types should be limited to a select few.

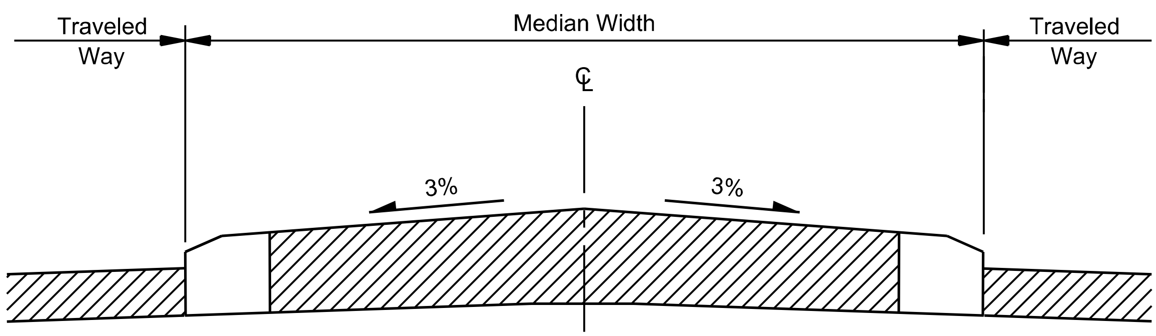
Non-traversable medians generally have a lower crash rate than flush medians. However, non-traversable medians will eliminate left-turn movements at some intersections and driveways, but may increase U-turn volumes at other locations on the same road or may divert some traffic to other roads.



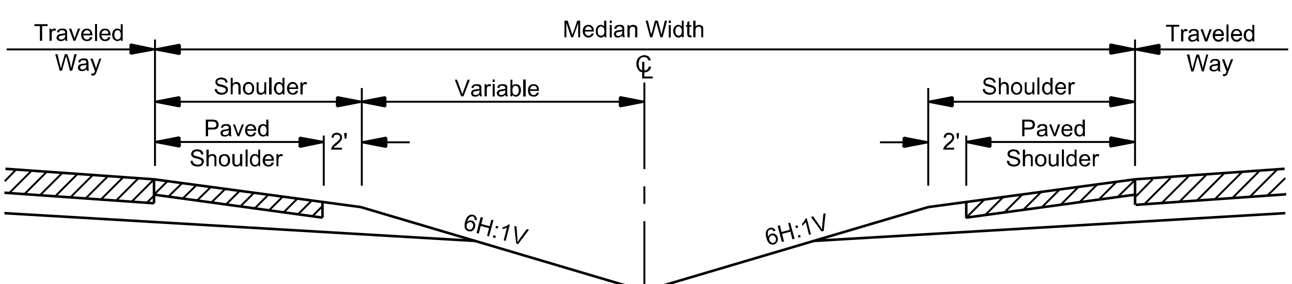
(a) Flush Median
Painted Left-Turn Lanes Or TWLTL



(b) Flush Median
With Concrete Median Barrier (CMB)



(c) Raised Median



(d) Depressed Median

MEDIAN TYPES
Figure 7.4-A

7.4.2.2 Flush Medians

A flush median is defined as the paved median surface at essentially the same plane as the adjoining traveled way. Flush medians are used most often on urban highways and streets where design speeds are 45 miles per hour or less. The following will apply:

1. Flush. Typical widths for a flush median can range from 4 to 30 feet. While medians 4 to 6 feet may be provided under restrained conditions, medians 12 to 30 feet wide provide a protected storage area for left-turning vehicles at intersections. To provide proper drainage, flush medians are typically crowned in the center with a cross slope of 2 percent in each direction.

2. Flush Median with TWLTL. Two-way, left-turn lanes (TWLTL) are considered flush medians. See Section 7.4.3 for guidance on TWLTL.

3. Flush with CMB. A flush median with a CMB may be used on urban freeways where the right of way may prohibit widening to the outside. Desirably, the medians should be sufficiently wide to allow for the addition of 12-foot wide travel lanes and 10-foot shoulders adjoining the CMB where there are three or more travel lanes in each direction. However, the predominant median width for most urban freeways in South Carolina is 36 feet. This allows for the use of two 12-foot travel lanes, a 2.5-foot wide CMB and two 4.75-foot wide shoulders.

7.4.2.3 Raised Medians

A raised median may be proposed for managing access, improving operations and improving safety. When used, the designer should consider the following:

1. Design Speed. Due to the curb associated with raised medians, they are generally only used where the design speed is 45 miles per hour or less. Higher design speeds may be considered, but normal shoulder widths will apply.

2. Width. Enough right of way should be available for widths that will provide space for the initial and future installation of left-turn lanes at public street intersections and high-traffic generator locations. At intersections, the raised portion is typically 4 feet wide. The length may be determined by need for control of turning maneuvers near the intersection.

3. Access Control. Raised medians restrict access to driveways and other private developments unless a median opening is provided.

4. Planted Medians. A raised median with plantings in the center may be proposed for aesthetic purposes. Use curbing to delineate green areas in the center of roadways. Ensure adequate drainage is provided. Give special attention to eliminate areas that trap water in transition from normal to superelevated sections. Cross slopes in the median are typically 30H:1V. Consider roadside safety concerns and sight distances when determining plantings in the raised median.

7.4.2.4 Depressed Medians

A depressed median is typically used on freeways and other divided rural arterials. For non-freeways, a depressed median is usually considered where managed access to the street and control of left-turn movements are desired. Depressed medians typically have good drainage characteristics and, therefore, are preferred on major highways.

Depressed medians should be as wide as practical to allow for the addition of future travel lanes on the inside while maintaining a sufficient future median width. The minimum width is 48 feet. This allows for the initial development of a depressed median with 6H:1V side slopes and a ditch with sufficient depth to accommodate the runoff. Avoid slopes steeper than 6H:1V. The 48-foot width allows for two future travel lanes with two 10-foot shoulders and a 4-foot CMB section. The maximum width for a depressed median is approximately 84 feet with 8H:1V side slopes. Beyond this, the two roadways of the divided facility are typically placed on independent alignments.

7.4.3 Two-Way Left Turn Lanes (TWLTL)

The applicability of a TWLTL is a function of the traffic conditions that result from the adjacent land use. Selection of a TWLTL should be coordinated with the local land use plan.

The designer should consider the following guidance:

1. Advantages. TWLTL offer several advantages when compared to no median; for example, TWLTL:
   - reduce travel time;
   - improve capacity;
   - reduce crash frequency, particularly of the rear-end type;
   - increase flexibility (e.g., the lane can be used as a travel lane during closure of a through lane); and
   - are generally preferred by drivers and owners of abutting properties.
2. Access Control. TWLTL may be inappropriate at some locations. TWLTL tend to increase rather than control access opportunities. Where better access control is desired (e.g., along arterials), the Project Development Team may need to consider replacing an existing TWLTL with a non-traversable median.
3. Locations. Consider providing a TWLTL:
   - in areas with a high number of existing driveways per mile (e.g., 10 to 35 driveways per mile on both sides of the street);
   - in areas of existing high-density commercial development;
   - in areas with substantial mid-block left turns; and/or

- on facilities with four travel lanes or less.

Do not provide a TWLTL if there is less than 200 feet of space available.

4. Speed. The use of TWLTL is not normally provided where the design speed exceeds 45 miles per hour. Their applicability to rural highways is typically near suburban areas or for roads passing through small towns.

5. Median Width. SCDOT generally requires a 15-foot TWLTL. Minimum TWLTL widths are provided in Chapters 14 through 18. To obtain the TWLTL width, the designer may consider the following:

   - reducing the width of existing through lanes and analyzing side road radius returns,
   - eliminating existing parking lanes and reconstructing curb and gutter and sidewalks,
   - reconstructing existing shoulders and ditches,
   - replacing existing shoulders and ditches with curb and gutter,
   - eliminating existing buffer areas behind curbs and reconstructing curb and gutter and sidewalks, and/or
   - acquiring additional right of way to expand the pavement width by the amount needed for the TWLTL.

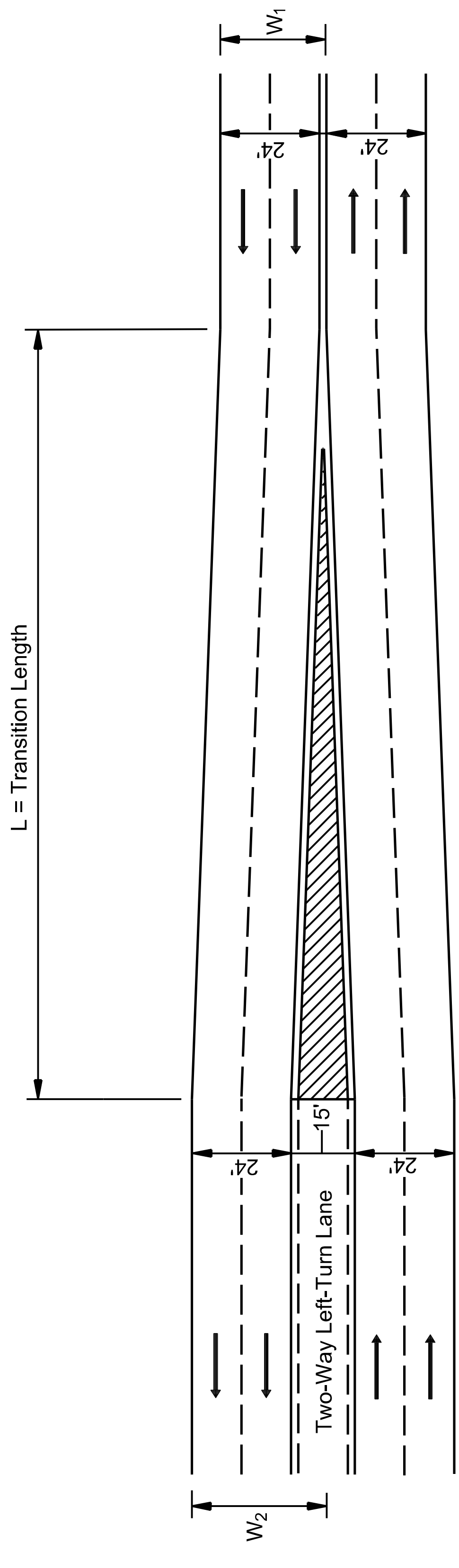
   The TWLTL width may be reduced to 12 feet to accommodate bicycle facilities on an existing roadway or 10 feet on a 3R project. Median widths less than 12 feet are not recommended where posted speeds are greater than 35 mph and the percentage of trucks, buses and recreational vehicles is greater than 5 percent of the AADT.

6. Intersection Treatment. At intersections with public roads, the designer should coordinate with Traffic Engineering to determine the appropriate design treatment of the TWLTL (i.e., end the TWLTL prior to the intersection or to continue the TWLTL through the intersection).

7. Operational/Safety Factors. Provide proper signing and stopping sight distance at the beginning and end of each TWLTL. Where a number of turning movements are expected into and out of entrances located close to a major intersection, it is desirable to provide a channelized design for the exclusive left-turn lane; see Section 9.5.

8. Transitions. Figure 7.4-B provides an example lane transition design for a four-lane roadway to a five-lane TWLTL facility. Figure 7.4-C provides an example lane transition design from a two-lane roadway to a five-lane TWLTL.

For additional information on the use and design of a TWLTL, see the AASHTO *A Policy on Geometric Design of Highways and Streets*.

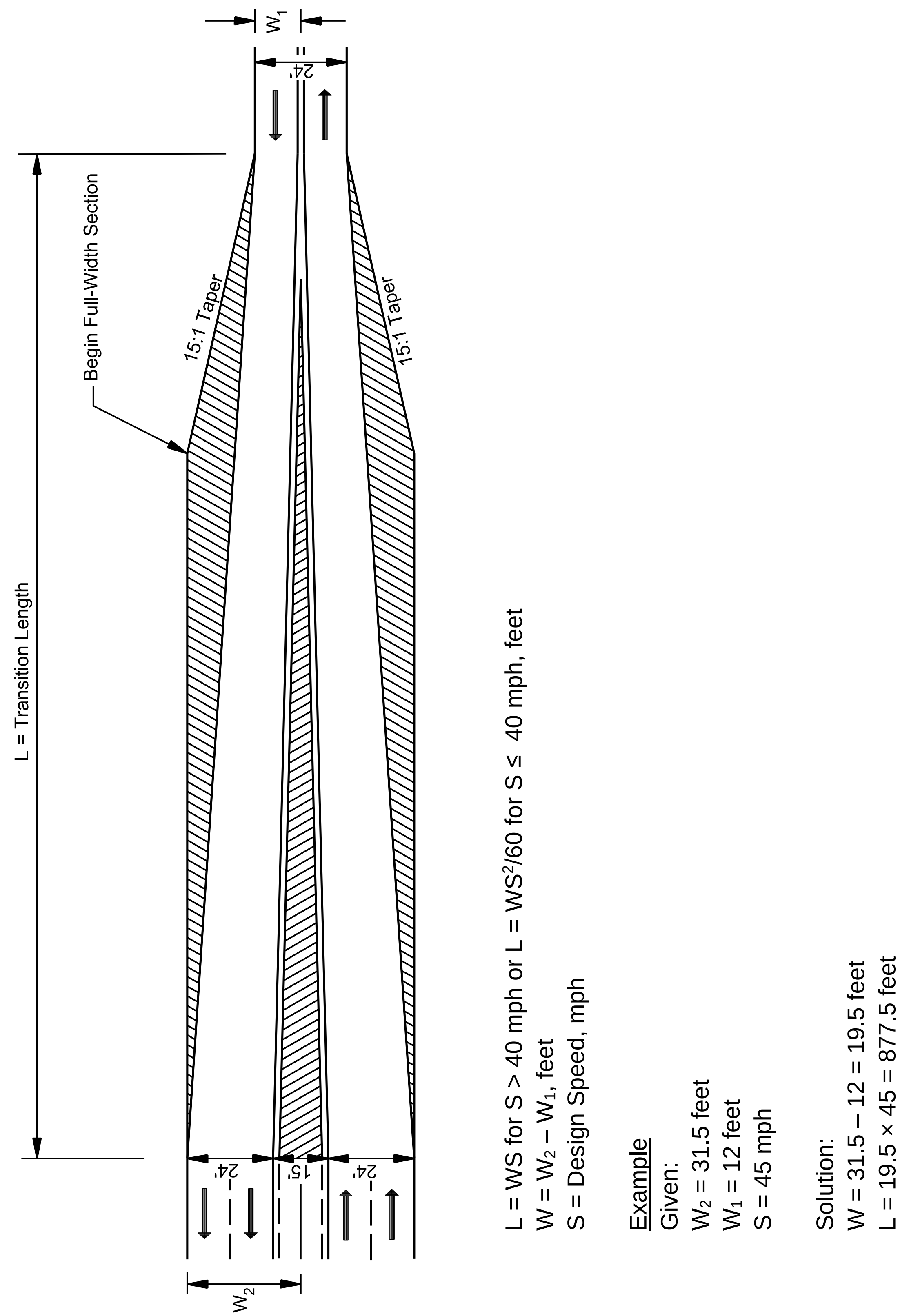


$L = WS$ for $S > 40$ mph or $L = WS^2/60$ for $S \leq 40$ mph, feet
$W = W_2 - W_1$, feet
S = Design Speed, mph

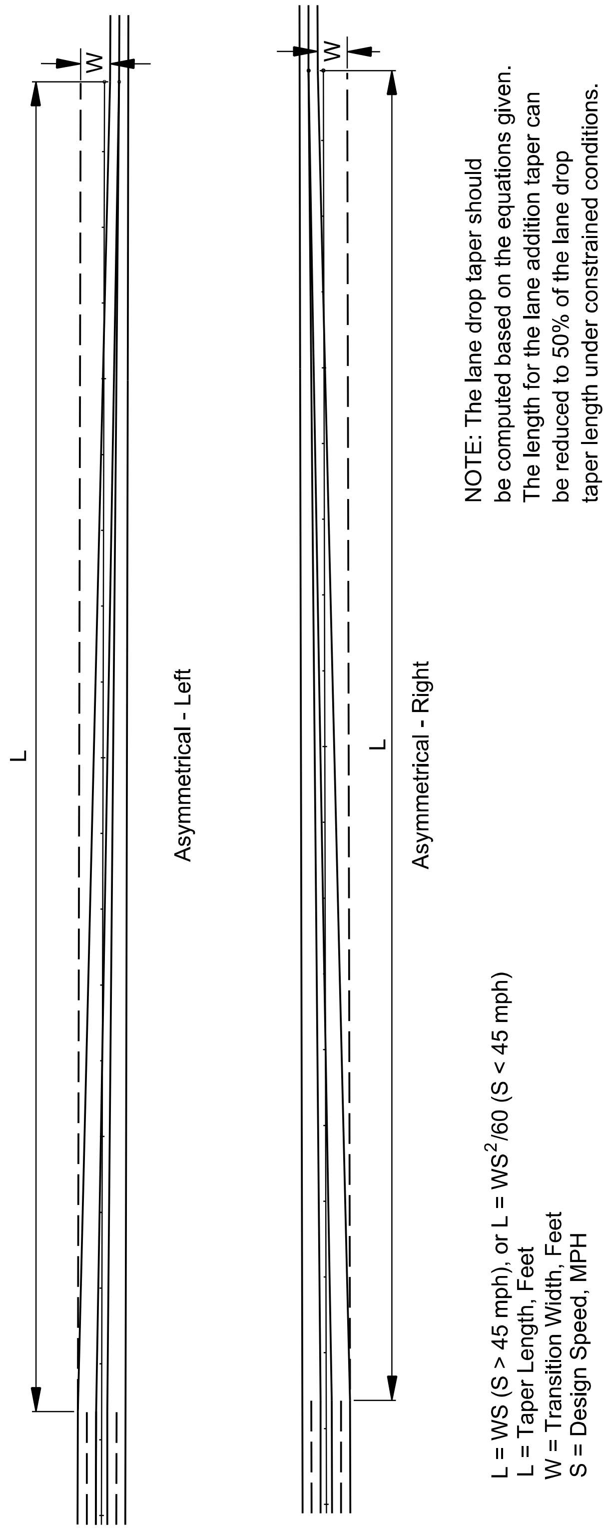
Example
Given:
$W_2 = 31.5$ feet
$W_1 = 24$ feet
$S = 40$ mph

Solution:
$W = 31.5 - 24 = 7.5$ feet
$L = 7.5 \times 40^2/60 = 200$ feet

TWLTL LANE TRANSITION
(Five-Lane TWLT to Four-Lane Section)
Figure 7.4-B



TWLTL LANE TRANSITION
(Five-Lane TWLT to Two-Lane Section)
Figure 7.4-C



TWLTL LANE TRANSITION
(Asymmetrical)
Figure 7.4-D

7.5 BRIDGE AND UNDERPASS CROSS SECTIONS

The roadway cross section should be carried over and under bridges, which often requires special considerations because of the confining nature of bridges and their high unit costs.

7.5.1 Bridges

7.5.1.1 Bridge Roadway Widths

In general, bridge widths should match the approach roadway widths (traveled way plus shoulders). Figure 7.5-A provides guidelines for bridge widths. However, in determining the width for major water crossings, the designer needs to consider the cost of the structure, traffic volumes and potential for future width requirements.

Approach Roadway	Conditions	Bridge Width (Gutter to Gutter)
Urban Streets (Curb and Gutter)	With or without concrete sidewalk	Provide a sidewalk on bridge matching roadway gutter hinge points with bridge gutter hinge points.
Freeways and Arterials	12-foot shoulder (10-foot paved + 2-foot unpaved)	Use 12-foot shoulder hinge point for bridge gutter line.
	10-foot shoulder (paved and unpaved)	Use 10-foot shoulder hinge point for bridge gutter line.
	10-foot shoulder (6-foot paved + 4-foot unpaved)	Use 10-foot shoulder hinge point for bridge gutter line on inside of divided highways.
	10-foot shoulder (4-foot paved + 6-foot unpaved)	
Rural Collectors and Local Roads	6- to 8-foot shoulders (2-foot paved + 4- to 6-foot unpaved) with paved roadway	Use shoulder hinge point for bridge gutter line. Bridge width is equal to width of roadway section (outside shoulder to outside shoulder).
Ramps	In direction of traffic (left) 10-foot shoulder (4-foot paved + 6-foot unpaved)	Use 10-foot shoulder line for bridge gutter line.
	In direction of traffic (right) 10-foot shoulder (6-foot paved + 4-foot unpaved)	
	With curb and gutter	Use the roadway gutter hinge point for bridge gutter line.

GUIDELINES FOR BRIDGE ROADWAY WIDTHS
Figure 7.5-A

7.5.1.2 Vertical Clearance

Establish vertical clearances above all sections of pavement including the shoulder. Section 6.6 and the design tables in Chapters 14 through 17 provide the minimum vertical clearances for new construction and reconstruction projects. For 3R projects, existing vertical clearances may be retained if the structure is not being reconstructed.

7.5.1.3 Highway Grade Separations

Horizontal clearances for highway grade separated structures, where guardrail or barrier protection is not provided, should conform to the clear zone requirements in the AASHTO *Roadside Design Guide*. Clearances may be reduced where protection is provided. These are minimum requirements; the designer should coordinate with the structural designer prior to finalizing the length of the bridge and the horizontal clearances.

7.5.1.4 Highway Overpassing Railroad

The horizontal clearance, measured from the centerline of the track to the face of the adjacent bridge substructure, should be a minimum of 25 feet. The horizontal clearance from the centerline of track to the face of the embankment fill slope, measured to the elevation to the highest rail, should be 20 feet. This 20-foot clearance may be increased at individual structure locations, as required, to provide adequate drainage or to allow adequate room to accommodate other special situations (e.g., future tracks).

When an existing overpass over a railroad is to be widened or rehabilitated, the existing horizontal clearances should be maintained, if less than 25 feet.

7.5.2 <u>Underpasses</u>

The approaching roadway cross section, including any auxiliary lanes, should be carried through the underpass. Desirably, include the clear zone width for each side through the underpass. It is important to consider the potential for further development or traffic increases in the vicinity of the underpass that may significantly increase traffic or pedestrian volumes. Provide sufficient lateral clearance for one additional lane in each direction, if warranted, for future widening.

7.5.3 <u>Traveled Way Width Reductions</u>

When approaching a narrow bridge or underpass, the traveled way width may need to be reduced to allow the roadway to pass over or under a bridge. The Department determines the need for traveled way reductions on a case-by-case basis. Where it is deemed necessary, design the traveled way reduction transitions using the taper rates in Figure 7.5-B.

Design Speed (mph)	**Taper Rate**
30	15:1
35	20:1
40	27:1
45	45:1
50	50:1
55	55:1
60	60:1
65	65:1
70	70:1

Note: Taper Length (L) = Taper Rate x Offset Distance

TAPER RATES FOR LANE REDUCTIONS
Figure 7.5-B

SPACER PAGE

7.6 REFERENCES

1. *A Policy on Geometric Design of Highways and Streets*, AASHTO, 2011.

2. *Guide for the Development of Bicycle Facilities*, AASHTO, 2012.

3. *SCDOT ADA Transition Plan*, SCDOT.

4. *Highway Capacity Manual* 2010, TRB, 2010.

5. *Roadside Design Guide*, AASHTO, 2011.

6. *Low Cost Methods for Improving Traffic Operations on Two-Lane Roads*, Report No. FHWA-IP-87-2.

7. NCHRP Report 375, *Median Intersection Design*, TRB, 1995.

8. NCHRP Report 395, *Capacity and Operational Effects of Midblock Left-Turn Lanes*, TRB, 1997.

9. *Manual on Uniform Traffic Control Devices,* FHWA, ATSSA, AASHTO and ITE, 2009.

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