Chapter 17

FREEWAYS

SOUTH CAROLINA ROADWAY DESIGN MANUAL

February 2021

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Chapter 17
FREEWAYS

17.1 GENERAL

Freeways/Interstates are functionally classified as principal arterials constructed with full control of access. Freeways are intended to provide high levels of safety and efficiency in moving high volumes of traffic at high speeds. The operational efficiency, capacity, safety and cost of the highway facility are largely dependent upon its design. Rural freeways connect roadway links between major cities, towns and urban areas. Similarly, urban freeways provide service for large volumes of traffic within and through urban areas. This chapter provides guidance in the design of rural and urban freeways/Interstates including specific design criteria, frontage roads, lane drops, justification for grade separations, access control along the freeway and safety. Additional information that is applicable to freeways is also included in the following chapters:

- Chapter 3 “Basic Design Controls” provides guidelines for access control along interchange crossroads. It also discusses the procedures for depicting control of access in the plans.
- Chapters 3 “Basic Design Controls,” 4 “Sight Distance,” 5 “Horizontal Alignment,” 6 “Vertical Alignment” and 7 “Cross Section Elements” provide guidance on geometric design elements applicable to freeways.
- Chapter 10 “Interchanges” discusses type, location and design of interchanges and ramps.

17.1.1 Rural Versus Urban Freeways

Rural and urban freeways are similar in that they are intended to provide safe, rapid and high-quality transportation facilities for motorists. However, it is important to consider the differences between rural and urban freeways when applying freeway design criteria to a project. The primary difference between rural and urban freeways is in the concept of operational freedom. Motorists on rural freeways expect more operational freedom and higher travel speeds than urban motorists. Rural freeways are normally constructed at ground level and right of way is typically less constrained.

Urban freeways are designed to carry large traffic volumes and have multiple lanes in each direction. Typically, urban freeways have two lanes in each direction, and can be designed for three or more lanes in each direction. Urban freeways take many forms (e.g., depressed, ground level, elevated embankment, elevated viaduct or a combination of these forms). In most instances, right-of-way restrictions require designers to evaluate various proposed alternatives to balance socio-economic, right of way, environmental and construction factors.

17.1.2 Design Studies

Freeway design considerations evolve around design year traffic volumes, design speed and level of service. These are the primary factors that either individually or collectively are instrumental in governing the selection of appropriate roadway geometric criteria and/or cross section elements. When developing a freeway alignment, the designer should first determine the location and types of interchanges then develop the freeway alignment between the interchanges. Other factors that may influence the freeway alignment include:

- the location of grade separations, including major river crossings;
- access control along the freeway and along interchange crossroads;
- topography;
- environmental restrictions; and
- property lines and right-of-way restrictions.

17.1.3 Project Scope of Work

17.1.3.1 New Construction

A freeway is considered new construction when a freeway is on new location and has a new alignment. The designer is required to meet all the criteria presented in Chapter 17 and the applicable criteria provided elsewhere in this *Manual*.

17.1.3.2 Reconstruction

Reconstruction of an existing freeway will typically include the addition of travel lanes, reconstruction of existing horizontal and vertical alignment, widening the roadway and flattening side slopes, but the freeway will remain essentially within the existing highway corridor. Because of the significant level of work for reconstruction, the design of the project will meet the criteria for new construction presented in Chapter 17 and the applicable criteria provided elsewhere in this *Manual*.

17.2 DESIGN ELEMENTS

17.2.1 Traffic

17.2.1.1 Traffic Volume

Traffic volumes are a major consideration in justifying highway facilities and in the establishment of preliminary geometric and cross section design characteristics. The designer should use the design year traffic volumes to determine the design elements of urban and rural freeways.

The traffic volumes used for design of Interstates should be the 30th highest hourly volume of the design year. This is the total traffic in both directions of travel is referred to as the design hourly volume (DHV).

17.2.1.2 Level of Service

The level of service (LOS) consideration in the design of freeways is determined using the *Highway Capacity Manual* or traffic modeling software. Because LOS is a measure of the freedom of movement and operational delays for traffic, it is appropriate to design freeways to operate at a high LOS.

Rural freeways should be designed to operate at a LOS B. LOS B is in the stable traffic flow range in which the motorist's freedom to select the desired operating speed is relatively unaffected and motorist's freedom of maneuvering is only slightly restricted. In rural mountainous terrain, it may be necessary to reduce the design to LOS C in which the ability to maneuver within the traffic stream becomes increasingly affected by the presence of other vehicles. Further discussion on the LOS design concept is included in Section 3.6.4.

For urban freeways, a LOS C is desirable, but in some cases it may not be economically feasible.

17.2.2 Design Speed

Freeways are intended to accommodate high speed traffic. For rural freeways, the design speed should be 70 miles per hour or higher. In mountainous terrain, rural freeway design speeds may be reduced to 55 miles per hour. For urban freeways, limited right of way, high construction costs and social or environmental concerns may suggest a lower design speed. Urban freeway design speeds should be at least 60 miles per hour to maintain an overall high quality, smooth-flowing facility. Decisions to use design speeds less than 60 miles per hour may be justified and supported with appropriate documentation.

17.2.3 Alignment

Designed for high volume and high speed operations, freeways should have smooth horizontal and vertical alignments. Proper combinations of curvature, tangents, grades, variable median widths and separate roadway elevations all combine to enhance safety and aesthetics of freeways. When designing freeway alignments, the designer should consider the following guidelines:

1. Horizontal Alignment. The following guidelines should be applied when laying out the horizontal alignment:

   - Use large radius curves.
   - Only use minimum radii where it is necessary due to restricted conditions.
   - Avoid alignments that require superelevation transitions on bridges or bridge approach slabs.
   - Consider sight distance restrictions from longitudinal barriers on the roadside and in the median.

2. Vertical Alignment. Even though the profile may satisfy all design controls, the use of minimum criteria may appear forced and angular. Therefore, the designer should use higher values to produce a smoother, more aesthetically pleasing alignment keeping in mind curves that are too flat will produce flat areas that may cause drainage problems.

3. Horizontal and Vertical Combinations. Consider the relationship between horizontal and vertical alignments simultaneously to obtain a desirable condition. Section 6.2.2 discusses this relationship in detail and its effect on aesthetics and safety.

4. Minimum Grades. Desirably, the longitudinal grade should be 0.5 percent or greater. For bridges, it is necessary to provide a minimum longitudinal grade of 0.3 percent to facilitate drainage. For uncurbed facilities, a minimum longitudinal grade of 0.0 percent may be considered if adequate cross slopes are provided. Ensure superelevation transitions are not developed in areas with 0.0 percent grades. Special ditch grades may be necessary to ensure proper drainage.

5. Freeway River Crossings. During the development of freeways, the alignment may need to cross major rivers, streams or bays. In selecting the location for a bridge site, consider the following guidelines:

   a. Crossing Angle. Where practical, cross the river at a right angle to minimize the length of the bridge.

   b. Bluffs. If a bluff exists adjacent to the river, try to locate one of the abutments on a bluff closest to the river. This will minimize the overall length of the bridge and, therefore, reduce the cost of the structure.

   c. River Bends. Avoid locating the bridge on a bend in the river. Locating a bridge on a bend may result in unnecessarily long spans and may increase the chance of ships and boats colliding with the main bridge piers.

   d. Freeway Alignment. Examine how the freeway alignment will tie into the ends of the bridge. Approach horizontal and vertical alignments can significantly improve the aesthetics of the bridge location. Where practical, avoid placing horizontal curves and superelevation transitions on the bridge.

e. Foundation Conditions. Investigate the soil conditions at each bridge abutment and at each pier location. Poor foundation conditions may limit possible bridge sites.

f. Existing Structures. Existing structures may limit the location of a new bridge. Provide sufficient separation between structures.

g. Environmental Considerations. Avoid or minimize the impact on environmentally or historically sensitive areas, wherever practical, in conjunction with the above guidelines.

6. Interchanges. When developing the alignment and profile of freeways near proposed interchanges, see Chapter 10 "Interchanges" for detailed guidelines.

7. Climbing Lanes. Section 6.4 discusses the warrants and design criteria for climbing lanes. For most freeways, climbing lanes are not warranted unless a drop in the level of service is significant.

17.2.4 Sight Distance

Sight distances for freeways should desirably be provided based upon the decision sight distance in areas where driver confusion may occur (e.g., within interchanges, changes in cross sections, lane drops). See Chapter 4 "Sight Distance" for additional information on stopping and decision sight distances.

17.2.5 Cross Sections

17.2.5.1 Lane and Shoulder Widths

Lane and shoulder width criteria are provided in the geometric design tables in Section 17.3. The following mitigation strategies may be considered in addition to the design exception where reduced shoulder widths are provided:

- adding advisory and regulatory signing,
- providing additional raised pavement markings,
- constructing frequent emergency pull-outs,
- using changeable overhead message signs,
- providing continuous lighting,
- incorporating truck-lane restrictions, and/or
- setting up dedicated service patrols and other incident management measures.

For more information on cross section design elements, see Section 7.2.

17.2.5.2 Typical Sections

Figures 17.2-A through 17.2-C illustrate typical cross sections for various freeway designs. Figures 17.2-A and 17.2-B provide typical sections for a rural/urban divided freeway with a depressed median. Figure 17.2-C provides a typical section for a freeway with a concrete median barrier (CMB).

17.2.5.3 Cross Slopes

Use a cross slope of 2.00 percent for up to two lanes in the same direction. Lanes beyond the second lane on one side of the crown should have a cross slope of 2.50 percent. If a roadway 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. See Section 7.2.3.3.

For paved shoulders greater than 4 feet, provide a shoulder cross slope of 4.00 percent. For paved shoulders less than or equal to 4 feet, the cross slope should match the adjacent travel lane slope. For earth shoulders, provide a shoulder cross slope of 8.00 percent.

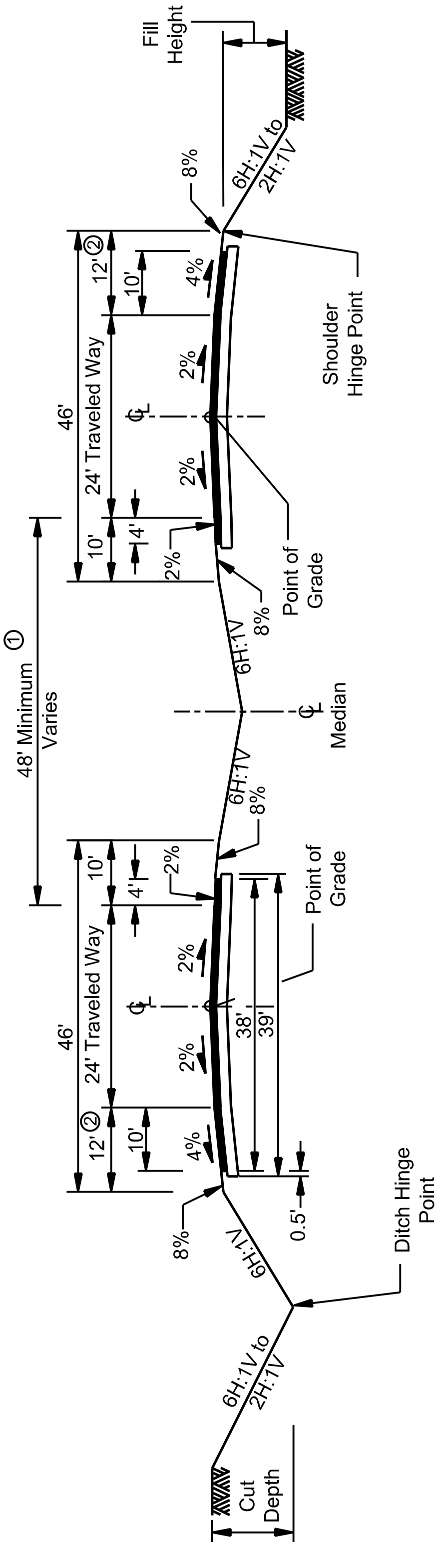
For cross slopes on bridges, see the *SCDOT Bridge Design Manual.*

17.2.5.4 Right of Way

Providing right-of-way widths that accommodate construction, drainage and proper maintenance of a collector is an important part of the overall design. Wider right of way allows for gentler side slopes, which results in reduced crash severity potential and easier maintenance operations. Right of way is typically configured to accommodate all proposed cross section elements throughout the project (e.g., travel lanes, shoulders, medians, ditches, outer slopes). If a long-range plan identifies a future widening, give consideration to accommodate a future proposed cross section. A uniform right-of-way width is preferred; however, do not base the width on the critical point of the project. A critical point may occur where the side slopes extend beyond the normal right of way, for clear areas at the bottom of traversable slopes, for wider clear areas on the outside of curves, where greater sight distance is desirable, for environmental considerations and for maintenance access.

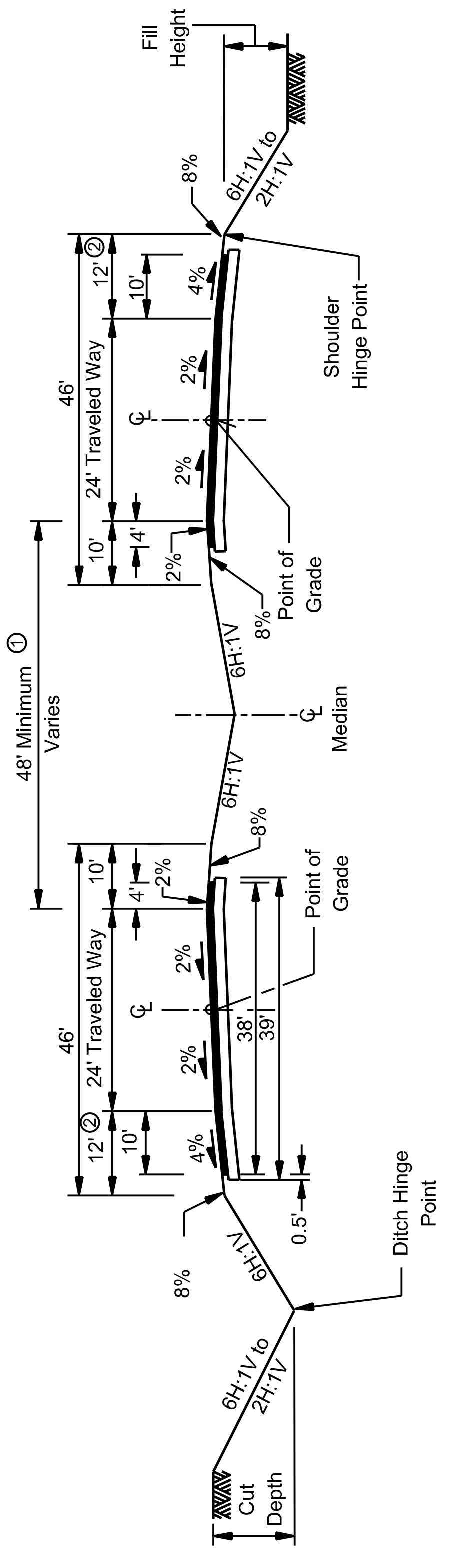
17.2.6 Roadside Safety

The designer should provide adequate horizontal clearance between the traveled way and roadside obstructions on freeways. The designer should provide roadside clear zones as discussed in the AASHTO *Roadside Design Guide*. Refer to Chapter 8 on Roadside Safety for information related to selection of median barrier.



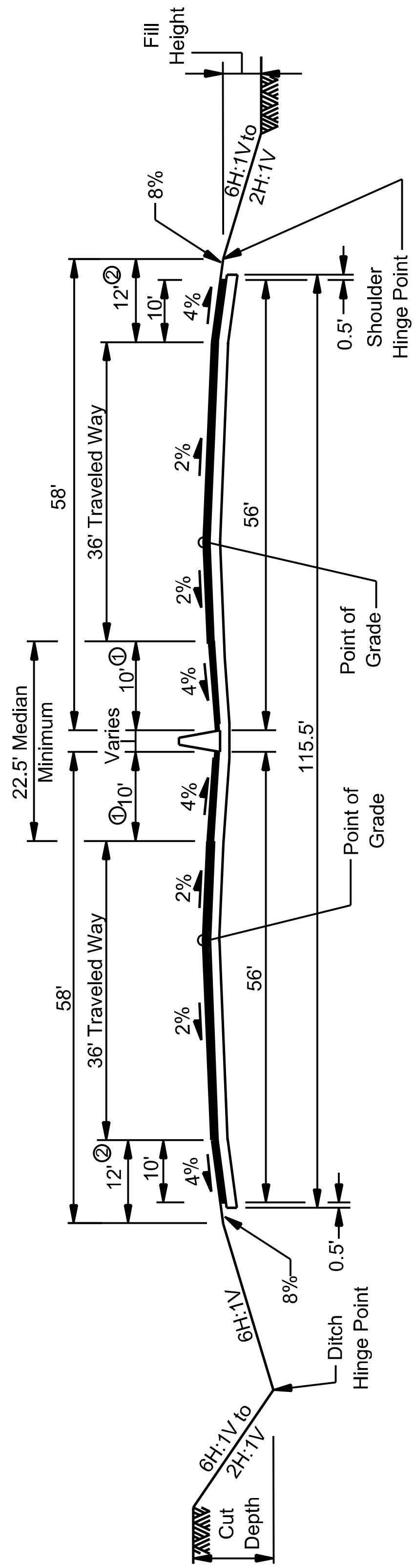
① In rural areas, a wider median may be desirable to accommodate future widening.
② Add 3.75 feet where guardrail is used.

TYPICAL RURAL/URBAN FOUR-LANE DIVIDED FREEWAY
(Crowned Roadways)
Figure 17.2-A



① Add 3.75 feet where guardrail is used.

TYPICAL RURAL/URBAN FOUR-LANE DIVIDED FREEWAY
(Uniform Cross Slope Traveled Way)
Figure 17.2-B



① When adding travel lanes to an existing median less than 48 feet, a design exception will be required to reduce the left-shoulder width to less than 10 feet.

② Add 3.75 feet where guardrail is used.

TYPICAL RURAL/URBAN SIX-LANE DIVIDED FREEWAY
Figure 17.2-C

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17.3 TABLES OF DESIGN CRITERIA

Figures 17.3-A and 17.3-B present the Department's design criteria for rural and urban freeway projects, respectively. Figure 17.3-C presents the alignment criteria for freeway projects. The designer should consider the following when using these figures:

1. Applicability. Note that some of the cross-section elements included in the figures (e.g., flush CMB) are not automatically warranted in the project design. The values in the figures only apply after the decision has been made to include the design element in the highway cross section.

2. Manual Section References. These figures are intended to provide a concise listing of design values for easy use. However, the designer should review the *Manual* section references for more information on the design elements.

3. Footnotes. The figures include many footnotes, which are identified by a number in parentheses (e.g., **(3)**). The information in the footnotes is critical to the proper use of the design tables.

The following design tables are provided for freeways:

- Figure 17.3-A — "Geometric Design Criteria for Rural Freeways (New Construction/Reconstruction)"
- Figure 17.3-B — "Geometric Design Criteria for Urban Freeways (New Construction/Reconstruction)"
- Figure 17.3-C — "Alignment Criteria for Freeways (New Construction/Reconstruction)"

Design Element				Manual Section	Rural
Design Controls	Design Forecast Year			17.2.1	20 Years
	Minimum Design Speed **(1)**			17.2.2	70 mph
	Access Control			3.8	Full Control
	Level of Service	Desirable		3.6.4	B
		Minimum			C
Cross Section Elements	Travel Lane Width			7.2.3	12 ft
	Shoulder Width	Right	Total Width	7.2.4	12 ft
			Paved **(2)**		10 ft
		Left	Total Width		10 ft
			Paved **(3)**		4 ft
	Auxiliary Lanes	Lane Width		7.2.6	12 ft
		Shoulder Width	Total Width		12 ft
			Paved		10 ft
	Cross Slope	Travel Lane **(4)**		7.2.3	2.00%
		Auxiliary Lane **(5)**		7.2.6	2.00%
		Shoulder	Paved	7.2.4	4.00%
			Unpaved		8.00%
	Median Width	Depressed		7.4.2	Minimum: 48 ft
		Flush (CMB)			Minimum: 22.5 ft
Roadway Slopes	Side Slopes	Cut Section	Foreslope	7.3.2	6H:1V
			Ditch Type		V-Ditch
			Back Slope		6H:1V to 2H:1V
			Rock Cut **(6)**		0.25H:1V
		Fill Section	0 ft – 5 ft	7.3.2	6H:1V
			5 ft – 10 ft		4H:1V
			> 10 ft		2H:1V
	Median Slopes			7.4.2	6H:1V
	Clear Zone			-	**(7)**

GEOMETRIC DESIGN CRITERIA FOR RURAL FREEWAYS
(New Construction/Reconstruction)
Figure 17.3-A
(Continued on next page)

Design Element			Manual Section	Rural
Structures	New Bridges	Structural Capacity	7.5.1	HL-93
		Clear Roadway Width		**(8)**
	Existing Bridges to Remain in Place	Structural Capacity	7.5.1	**(9)**
		Clear Roadway Width		**(8)**
	Vertical Clearance (Freeway Under) **(10a)**	New/Replaced Overpassing Bridges **(10b)**	6.6	17 ft – 0 in
		Existing Overpassing Bridges		16 ft - 0 in
		Pedestrian Bridges		18 ft – 0 in
		Overhead Signs		17 ft – 6 in
		Overhead Utilities		Contact Utility Office
	Clearance (Freeway Over)	Railroads	6.6	23 ft – 0 in
		Underpass Width	7.5.2	Traveled Way plus Clear Zone
	Vertical Clearance (Over Water)	Navigable Water	6.6	Contact Environmental Services Office
		Major Lakes & Reservoirs (with boat traffic)		8 ft – 0 in above the high water elevation
		Rivers		2 ft – 0 in above the design high water. Freeboard may be increased to a maximum of 7 ft – 0 in for large rivers.
		Tidal Waters		2 ft above the 10-year high water elevation including wave height.

GEOMETRIC DESIGN CRITERIA FOR RURAL FREEWAYS
(New Construction/Reconstruction)
Figure 17.3-A
(Continued on next page)

Footnotes for Figure 17.3-A

(1) Minimum Design Speed. In mountainous terrain, a minimum design speed of 55 miles per hour may be considered.

(2) Shoulder Width (Right). Where the directional distribution of trucks exceeds 250 DDHV, consider providing a 12-foot paved shoulder.

(3) Shoulder Width (Left). Where there are three or more lanes in one direction, provide a 10-foot left paved shoulder. If the directional distribution of trucks exceeds 250 DDHV, consider providing a 12-foot paved left shoulder.

(4) Travel Lane Cross Slope. On a six-lane highway crowned at the center line with CMB, use 2.00 percent for first two travel lanes adjacent to inside shoulder and 2.50 percent for third lane breaking away from outside edge of second travel lane.

(5) Auxiliary Lane Cross Slope. For auxiliary lanes adjacent to two travel lanes sloped in the same direction, use a cross slope of 2.50 percent.

(6) Side Slopes (Cut Section). Cut rock slope may vary based on a detailed geotechnical investigation.

(7) Clear Zone. See the AASHTO *Roadside Design Guide* for the applicable clear zones.

(8) Bridge Widths. Clear roadway bridge widths are measured from face to face of parapets or rails. Bridge widths are normally defined as the sum of the approach traveled way width plus total width for both shoulders. See Section 7.5.1.1 for further guidance.

(9) Existing Bridges to Remain in Place. Consult with the State Bridge Maintenance Engineer to determine the allowable structural capacity of bridges to remain in place.

(10) Vertical Clearance (Freeway Under).

- (a) The clearance must be available over the traveled way, shoulders and any future widening identified in a long-range plan.
- (b) Table value includes allowance for future overlays.

GEOMETRIC DESIGN CRITERIA FOR RURAL FREEWAYS
(New Construction/Reconstruction)
Figure 17.3-A
(Continued)

<table>
<tr><th colspan="4">Design Element</th><th>Manual Section</th><th>Urban</th></tr>
<tr><td rowspan="5">Design Controls</td><td colspan="3">Design Forecast Year</td><td>17.2.1</td><td>20 Years</td></tr>
<tr><td colspan="3">Minimum Design Speed (1)</td><td>17.2.2</td><td>Minimum: 50 mph</td></tr>
<tr><td colspan="3">Access Control</td><td>3.8</td><td>Full Control</td></tr>
<tr><td rowspan="2">Level of Service</td><td colspan="2">Desirable</td><td rowspan="2">3.6.5</td><td>C</td></tr>
<tr><td colspan="2">Minimum</td><td>D</td></tr>
<tr><td rowspan="14">Cross Section Elements</td><td colspan="3">Travel Lane Width</td><td>7.2.3</td><td>12 ft</td></tr>
<tr><td rowspan="4">Shoulder Width</td><td rowspan="2">Right</td><td>Total Width</td><td rowspan="4">7.2.4</td><td>12 ft</td></tr>
<tr><td>Paved (2)</td><td>10 ft</td></tr>
<tr><td rowspan="2">Left</td><td>Total Width</td><td>10 ft</td></tr>
<tr><td>Paved (3)</td><td>4 ft</td></tr>
<tr><td rowspan="3">Auxiliary Lanes</td><td colspan="2">Lane Width</td><td rowspan="3">7.2.6</td><td>12 ft</td></tr>
<tr><td rowspan="2">Shoulder Width</td><td>Total Width</td><td>12 ft</td></tr>
<tr><td>Paved</td><td>10 ft</td></tr>
<tr><td rowspan="4">Cross Slope</td><td colspan="2">Travel Lane (4)</td><td>7.2.3</td><td>2.00%</td></tr>
<tr><td colspan="2">Auxiliary Lane (5)</td><td>7.2.6</td><td>2.00%</td></tr>
<tr><td rowspan="2">Shoulder</td><td>Paved</td><td rowspan="2">7.2.4</td><td>4.00%</td></tr>
<tr><td>Unpaved</td><td>8.00%</td></tr>
<tr><td rowspan="2">Median Width</td><td colspan="2">Depressed (6)</td><td rowspan="2">7.4.2</td><td>48 ft</td></tr>
<tr><td colspan="2">Flush (CMB) (7)</td><td>Minimum: 22.5 ft</td></tr>
<tr><td rowspan="9">Roadway Slopes</td><td rowspan="7">Side Slopes</td><td rowspan="4">Cut Section</td><td>Foreslope</td><td rowspan="4">7.3.2</td><td>6H:1V</td></tr>
<tr><td>Ditch Type</td><td>V-Ditch</td></tr>
<tr><td>Back Slope</td><td>6H:1V to 2H:1V</td></tr>
<tr><td>Rock Cut (8)</td><td>0.25H:1V</td></tr>
<tr><td rowspan="3">Fill Section</td><td>0 ft – 5 ft</td><td rowspan="3">7.3.2</td><td>6H:1V</td></tr>
<tr><td>5 ft – 10 ft</td><td>4H:1V</td></tr>
<tr><td>> 10 ft</td><td>2H:1V</td></tr>
<tr><td colspan="3">Median Slopes</td><td>7.4.2</td><td>6H:1V</td></tr>
<tr><td colspan="3">Clear Zone</td><td>-</td><td>(9)</td></tr>
</table>

GEOMETRIC DESIGN CRITERIA FOR URBAN FREEWAYS
(New Construction/Reconstruction)
Figure 17.3-B
(Continued on next page)

Design Element			Manual Section	Rural
Structures	New Bridges	Structural Capacity	7.5.1	HL-93
		Clear Roadway Width		**(10)**
	Existing Bridges to Remain in Place	Structural Capacity	7.5.1	**(11)**
		Clear Roadway Width		**(10)**
	Vertical Clearance (Freeway Under) **(12a)**	New/Replaced Overpassing Bridges **(12b)**	6.6	17 ft – 0 in
		Existing Overpassing Bridges		16 ft - 0 in
		Pedestrian Bridges		18 ft – 0 in
		Overhead Signs		17 ft – 6 in
		Overhead Utilities		Contact Utility Office
	Clearance (Freeway Over)	Railroads	6.6	23 ft – 0 in
		Underpass Width	7.5.2	Traveled Way plus Clear Zone
	Vertical Clearance (Over Water)	Navigable Water	6.6	Contact Environmental Services Office
		Major Lakes & Reservoirs (with boat traffic)		8 ft – 0 in above the high water elevation
		Rivers		2 ft – 0 in above the design high water. Freeboard may be increased to a maximum of 7 ft – 0 in for large rivers.
		Tidal Waters		2 ft above the 10-year high water elevation including wave height.

GEOMETRIC DESIGN CRITERIA FOR URBAN FREEWAYS
(New Construction/Reconstruction)
Figure 17.3-B

(Continued on next page)

Footnotes for Figure 17.3-B

(1) Design Speed. The design speed selected should be consistent with the anticipated operating speed of the freeway during both peak and non-peak hours.

(2) Shoulder Width (Right). Where the directional distribution of trucks exceeds 250 DDHV, consider providing a 12-foot paved shoulder.

(3) Shoulder Width (Left). Where there are three or more lanes in one direction, provide a 10-foot left paved shoulder. If the directional distribution of trucks exceeds 250 DDHV, consider providing a 12-foot paved left shoulder.

(4) Travel Lane Cross Slope. On a six-lane highway crowned at the center line with CMB, use 2.00 percent for first two travel lanes adjacent to inside shoulder and 2.50 percent for third lane breaking away from outside edge of second travel lane.

(5) Auxiliary Lane Cross Slope. For auxiliary lanes adjacent to two travel lanes sloped in the same direction, use a cross slope of 2.50 percent.

(6) Depressed Median Widths. In urban areas, existing 36-foot medians may be allowed to remain in place.

(7) Flush Median Widths (CMB). In urban areas, existing 12-foot to 14-foot medians may be allowed to remain-in-place. Where travel lanes are added to an existing median less than 48 feet, a design exception will be required to reduce the left-shoulder width to less than 10 feet.

(8) Side Slopes (Cut Section). Cut rock slope may vary based on a detailed geotechnical investigation.

(9) Clear Zone. See the AASHTO *Roadside Design Guide* for the applicable clear zones.

(10) Bridge Widths. Clear roadway bridge widths are measured from face to face of parapets or rails. Bridge widths are normally defined as the sum of the approach traveled way width plus total width for both shoulders. See Section 7.5.1.1 for further guidance.

(11) Existing Bridges to Remain in Place. Consult with the State Bridge Maintenance Engineer to determine the allowable structural capacity of bridges to remain in place.

(12) Vertical Clearance (Freeway Under).

(a) The clearance must be available over the traveled way, shoulders and any future widening identified in a long-range plan.

(b) Table value includes allowance for future overlays.

GEOMETRIC DESIGN CRITERIA FOR URBAN FREEWAYS
(New Construction/Reconstruction)
Figure 17.3-B
(Continued)

Design Element		Manual Section	Design Speed					
			50 mph	**55 mph**	**60 mph**	**65 mph**	**70 mph**	**75 mph**
Stopping Sight Distance **(1)**		4.1	425 ft	495 ft	570 ft	645 ft	730 ft	820 ft
Decision Sight Distance **(2)**		4.3	750 ft	865 ft	990 ft	1050 ft	1105 ft	1180 ft
Minimum Radii (e_{max} = 8%)		5.2	758 ft	960 ft	1200 ft	1480 ft	1810 ft	2210 ft
Superelevation Table		5.3	8%	8%	8%	8%	8%	8%
Horizontal Sight Line Offset **(3)**		5.4	30 ft	32 ft	34 ft	35 ft	37 ft	38 ft
Vertical Curvature (K-Values) **(4)**	Crest	6.5	84	114	151	193	247	312
	Sag		96	115	136	157	181	206
Maximum Grade **(5)**	Level	6.3.1	4%	4%	3%	3%	3%	3%
	Rolling		5%	5%	4%	4%	4%	4%
	Mountainous		6%	6%	6%	5%	5%	N/A
Minimum Grade **(6)**		6.3.2	Desirable: 0.5% Minimum: 0.0%					

Footnotes

(1) Stopping Sight Distance. Table values are for passenger cars on level grade.

(2) Decision Sight Distance. Table values are for speed/path/direction change on rural road, Avoidance Maneuver C. See Section 4.3 for other maneuvers.

(3) Horizontal Sight Line Offset. Table values provide the necessary middle ordinate assuming the minimum radii and stopping sight distance.

(4) Vertical Curvature. The K-values are based on stopping sight distances.

(5) Maximum Grade. Grades 1 percent steeper may be provided in constrained urban areas or where necessary in mountainous terrain.

(6) Minimum Grade. Longitudinal gradients of 0.0 percent may be acceptable on some pavements that have cross slopes that have adequate drainage. Ensure superelevation transitions are not developed in areas with 0.0 percent grade. Special ditch grades may be necessary to ensure proper project runoff management.

ALIGNMENT CRITERIA FOR FREEWAYS
(New Construction/Reconstruction)
Figure 17.3-C

17.4 INTERCHANGES/GRADE SEPARATIONS

Where there is a need to provide for the safe and efficient movement of traffic through a series of intersecting roads, it can most effectively be accomplished by providing grade separations and/or interchanges. This allows for the greatest capacity and level of service that can be achieved by providing continuous uninterrupted travel for highway users. On fully access-controlled facilities, each intersecting highway must be terminated, rerouted or provided with a grade separation or interchange. The designer must evaluate the importance of the continuity of the crossing road, feasibility of alternative routes, traffic volumes, construction costs, maintenance costs, environmental impacts, etc., to determine the most appropriate option.

17.4.1 Interchanges

Section 10.1.1 discusses several guidelines that must be considered in determining whether an interchange should be provided. In general, interchanges are provided at all freeway-to-freeway crossings and other major highways based on the anticipated demand for regional access.

Section 10.1.2 discusses the procedures for adding or revising an interchange access point to the freeway system.

17.4.2 Grade Separations

Grade separations are provided to allow two transportation facilities to cross at different elevations (e.g., highways, railroads, pedestrian crossings, bicycle paths). Separations are defined in terms of the major highway crossing over (overpass) or under (underpass) the less major facility.

The type of bridge structure provided at overpasses and underpasses is based upon site conditions and span lengths required to obtain the necessary horizontal and vertical clearances.

17.4.2.1 Justification

For each crossroad along the freeway, which is not an interchange, the designer must make a determination whether the crossroad should be closed, rerouted or provided with a grade separation; primarily comparing the respective cost and social factors for each alternative. Although cost is a major factor, the designer should review the following additional considerations:

1. Operations. Grade separations should be of sufficient number and adequate capacity to accommodate the crossroad traffic, traffic diverted to crossroads from other roads and streets terminated by the freeway, and the traffic generated by access connections to and from the mainline.

2. Locations. The location of grade separation structures is determined by assessing the need to provide for community and commercial continuity and traffic demand.

3. Site Topography. There are some sites where existing topography creates a condition in which the only rational design approach is to provide for grade separations.

4. Local Considerations. Closing the crossroad can have a significant impact on local users and the overall local road system integrity due, primarily, to changes in travel patterns. These may include:

   a. School Bus Routes. The effect of a road closure on the bus route system can be two fold. There may be an increase in the operating cost due to longer bus routes and an increase in the travel time for school children.

   b. Emergency Personnel. The financial effect of the longer detour route on emergency vehicles is generally not a concern. However, the extra response time could adversely affect the health and safety of local citizens.

   c. Businesses/Farms. Access to businesses and farms must be evaluated to ensure that these operations can continue without severe economic hardship. For businesses, the road closure can significantly affect their deliveries and the number of customers they receive (e.g., customers may be unwilling to travel the extra distance). For farmers, the road closure may require the transportation of large, slow-moving farm equipment along busy alternative facilities.

   d. Social Factors. Parks, churches, cemeteries, public facilities, and other areas or buildings of social concern generally cannot be relocated. Limited access to these facilities may create undue hardship.

   e. Land Use Planning. Consider future land use within a suburban environment to ensure adequate access and reciprocation factors are available.

When interchanges cannot be justified by traffic demands and economics, grade separations along freeways may be provided when the following conditions are met:

- there will be a decrease in traffic and/or road-user costs,
- there is a need for route continuity,
- where the intersecting road cannot be cost effectively re-routed through the use of frontage or other local roads,
- a critical need exists to maintain local access, and
- a critical need exists at railroad crossings for safety or special crossings for pedestrians or bicycle users.

17.4.2.2 General Design Considerations

Often the proposed highway grade separation (i.e., carrying the mainline over or under the crossroad) is based on topographical features or highway classification. When designing grade separations, the designer should consider the following guidelines:

1. Over versus Under. The decision on whether the freeway should be over or under the crossroad is normally dictated by topography and cost. If the topography does not favor one profile over the other, use the following guidelines to decide which highway should cross over the other:

a. Cost Effectiveness. The designer should consider the alternative that will be more cost effective to construct. Some elements to consider are the amount of embankment and excavation, span lengths, angle of skew, gradients, sight distances, alignment, vertical clearances, constructability, traffic control, right of way, access, drainage, soil conditions and construction costs.

b. Classification. Select the alternative that provides the highest design for the mainline road. Typically, the crossroad has a lower design speed and, therefore, the minor road can be designed with steeper gradients, lesser roadway widths, steeper side slopes, etc.

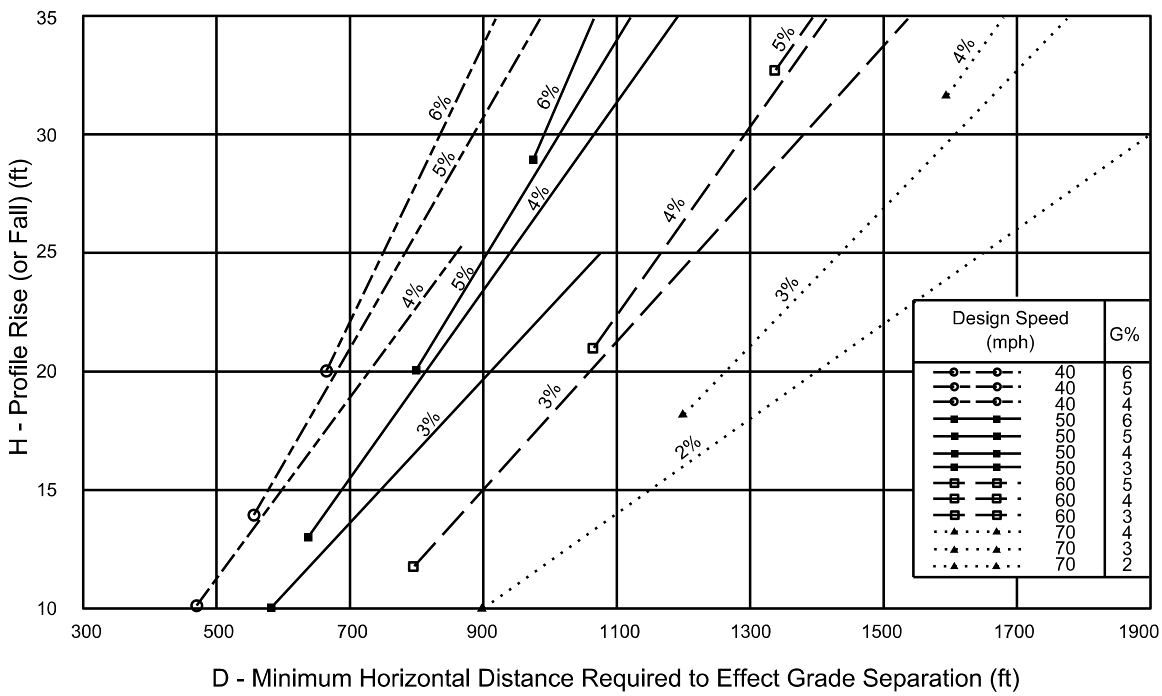
c. Future Crossings. If any crossings and/or structures are planned for a future date, the mainline should be under these future crossings. Overpasses are easier to install and will be less disruptive to the freeway when they are constructed in the future.

d. Aesthetics. Through traffic is given aesthetic preference by a layout in which the more important road is the overpass. A wide overlook can be provided from the structure and its approaches, giving drivers a minimum feeling of restriction.

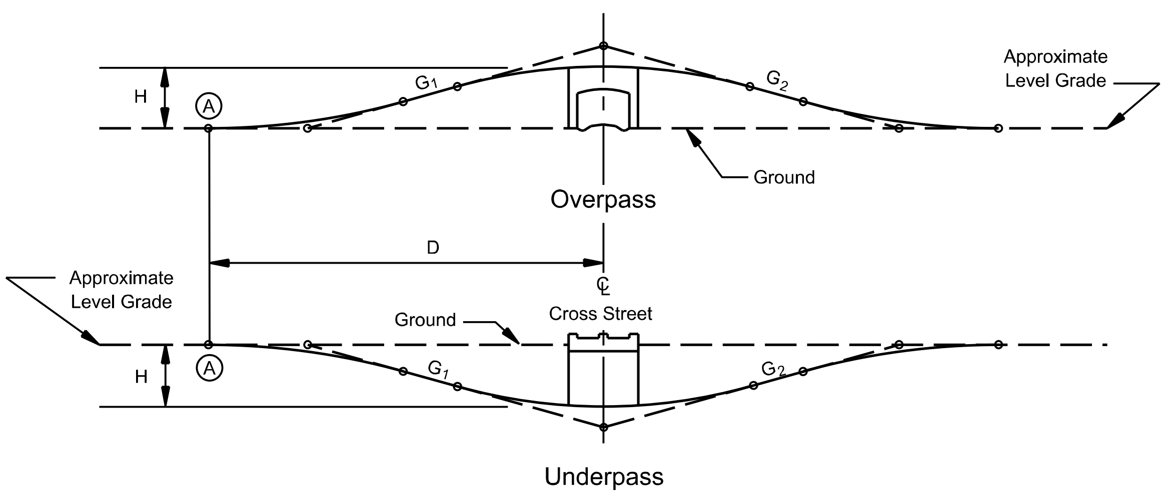
e. Turning Traffic. Where turning traffic is significant, the ramp profiles are best fitted when the major road is at the lower level. The ramp grades then assist turning vehicles to decelerate as they leave the major highway and to accelerate as they approach it. In addition, for diamond interchanges, the ramp terminal is visible to drivers as they leave the major highway.

2. Horizontal Distance. The distance required for adequate design of a grade separation depends on the design speed, the roadway gradient and the amount of rise or fall necessary to affect the separation. Figure 17.4-A can be used during preliminary design to quickly determine whether a grade separation is feasible for a given set of conditions, what gradients may be involved, and what profile adjustments may be necessary on the crossroad. Also, carefully study the sight distance requirements, because these will often dictate the required horizontal distance along the crossroad. When using Figure 17.4-A, consider the following:

a. Minimum Horizontal Distances. The plotted lines on Figure 17.4-A are derived assuming the same approach gradient on each side of the structure. However, values of D (D = minimum horizontal distance from center of structure required to effect grade separation) from Figure 17.4-A also are applicable to combinations of unequal gradients. Distance D is equal to the length of the initial vertical curve, plus one-half the central vertical curve, plus the length of tangent between the curves. Lengths of vertical curves are based on stopping sight distances. However, longer vertical curves are desirable from an aesthetic and safety standpoint. Conversely, longer curve lengths may be costlier due to increased earthwork quantities. However, these additional costs may be a less important consideration if crossroads or access points exist near the grade separation structure.



Note: Symbols on ends of lines indicate the point below which the grade is not feasible, necessitating the use of next flatter curve.



GRADE SEPARATION DETERMINATION
Figure 17.4-A

b. Maximum Gradient. The lower terminal point of each gradient line (G) on Figure 17.4-A, marked by a small symbol, indicates the distance where the tangent between the curves is zero and below which a design for the given grade is not feasible (i.e., a profile condition where the minimum central and end curves for the gradient would overlap).

c. Restricted Gradients. For the usual profile rise or fall required for a grade separation (H of 25 feet or less) (H = required profile rise or fall), do not use gradients greater than 3 percent for a design speed of 70 miles per hour, 4 percent for 60 miles per hour, 5 percent for 50 miles per hour and 6 percent for 40 miles per hour. For values of H less than 25 feet, use flatter gradients.

d. Relationship. For a given H and design speed, distance D is only shortened a negligible amount by increasing the gradient. However, the distance D varies to a greater extent for a given H and G with respect to the design speed.

e. Elevation. Considering the vertical clearance and structural depth, an elevation distance of H is typically between 23 and 25 feet for the grade separation of two highways. H is typically the same for a freeway under a railroad. For a railroad facility under a freeway, H is typically 30 to 31 feet.

f. Design Speed. To provide additional safety at rural grade separations where the crossroad passes over the freeway, consider designing the crest vertical curve with a design speed of 55 miles per hour or greater.

3. Sight Distance. In rolling topography or in rugged terrain, major-road overcrossings may be attainable only by a forced alignment and rolling gradeline. Where there is no pronounced advantage to the selection of either an underpass or an overpass, the design that provides the better sight distance (desirably passing distance if the crossroad is two lanes) on the major road should be preferred.

4. Hydrology Considerations. Carrying the major highway over without altering the crossroad grade may reduce drainage problems. In some cases, drainage issues alone may be sufficient reason for choosing to carry the major highway over rather than under the crossroad.

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Example 17.4-1

It is proposed that an existing crossroad be provided with an overpass over a new freeway.

Given: Crossroad Design Speed – 50 miles per hour
Difference between the proposed crossroad profile grade line and the proposed freeway profile grade line is 25.0 feet.

Problem: Determine where along the crossroad the profile grade line will need to be adjusted to provide a 25-foot profile rise.

Solution: Assume a longitudinal gradient of 4 percent. Reading into Figure 17.4-A, the minimum distance required to provide the 25-foot height distance is approximately

940 feet. Note that when using a 5 percent longitudinal gradient the distance will be approximately 900 feet.

* * * * * * * * * *

17.4.2.3 Underpass Roadway

For each underpass, the dimension, load, foundation and general site needs should determine the type of structure used for that particular location. Only the dimensional details are reviewed in this section. For guidance on the bridge design, see the *SCDOT Bridge Design Manual.*

An underpass is only one component of the total facility and should be consistent with the design criteria of the rest of the facility to the extent practical. It is desirable that the entire roadway cross section, including the median, traveled way, shoulders and roadside clear zone areas, be maintained through the structure. Possible limitations may require some reduction in the basic roadway cross section (e.g., structural design limitations, lateral clearance limitations, controls on grades and vertical clearance, limitations due to skewed crossings, appearance or aesthetic dimension relations, cost factors). However, where conditions permit a substantial length of freeway to be developed with desirable lateral dimensions, an isolated overpass along the section should not be designed as a restrictive element. In these cases, the additional structural costs are strongly encouraged to ensure consistency throughout the facility.

For a two-lane roadway or an undivided multilane roadway, the cross section width at underpasses will vary, depending on the design criteria appropriate for the particular functional classification and traffic volume. The minimum lateral clearance from the edge of the traveled way to the face of the protective barrier should be the normal shoulder width. On divided highways, the clearances on the left side of each roadway are usually governed by the median width and clear zone.

17.5 MISCELLANEOUS ELEMENTS

17.5.1 Freeway Lane Drops

Lane reductions occur when there is a sufficient change in traffic volume in which the basic number of lanes can no longer be justified. Lane drops may occur as the result of:

- the introduction of auxiliary lanes at interchanges,
- in areas where there are multiple interchanges, and/or
- collector-distributor roads necessitating multiple lanes that no longer are required to handle existing or projected traffic volumes.

Freeway lane drops should normally occur on the freeway mainline away from any other turbulence (e.g., interchange exits and entrances). Figures 17.5-A and 17.5-B illustrate right side lane drops on a freeway. In addition, consider the following criteria when designing a freeway lane drop:

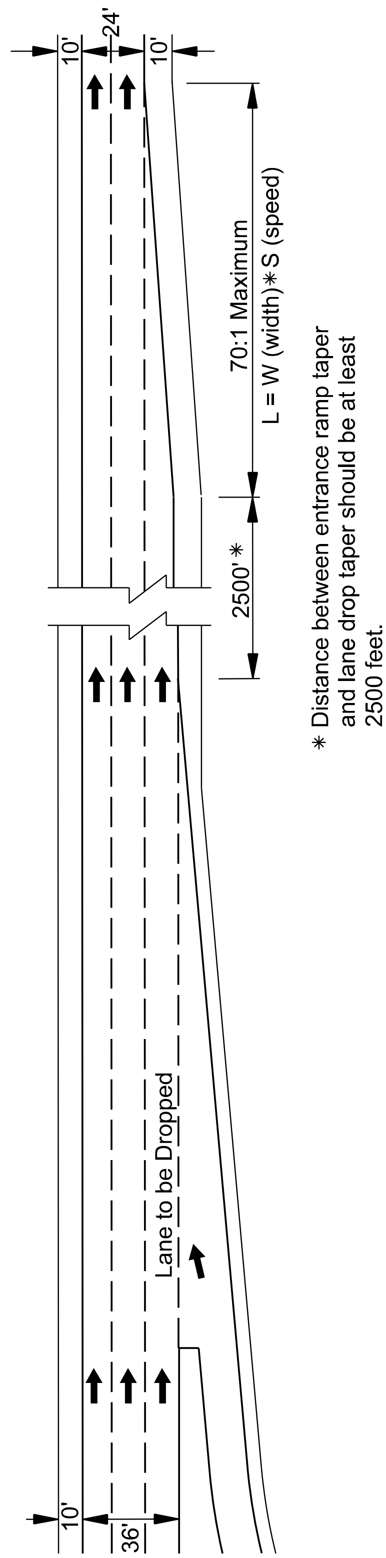
1. Location. The lane drop should occur approximately 2,500 feet beyond the previous interchange ramp; see Figure 17.5-A. The 2,500 feet allows for adequate signing and driver adjustments from the interchange, but is not so far downstream that drivers become accustomed to the number of lanes and are surprised by the lane drop. In addition, do not drop a lane on a horizontal curve or where other signing is required (e.g., an upcoming exit).

2. Transition. Transition the lane drop that involves pavement width changes over a length equal to the product of the change in lane width (W) times the design speed (S). Figure 17.5-C provides lane drop transition lengths for 12-foot lanes. The maximum transition taper rate is 70:1.

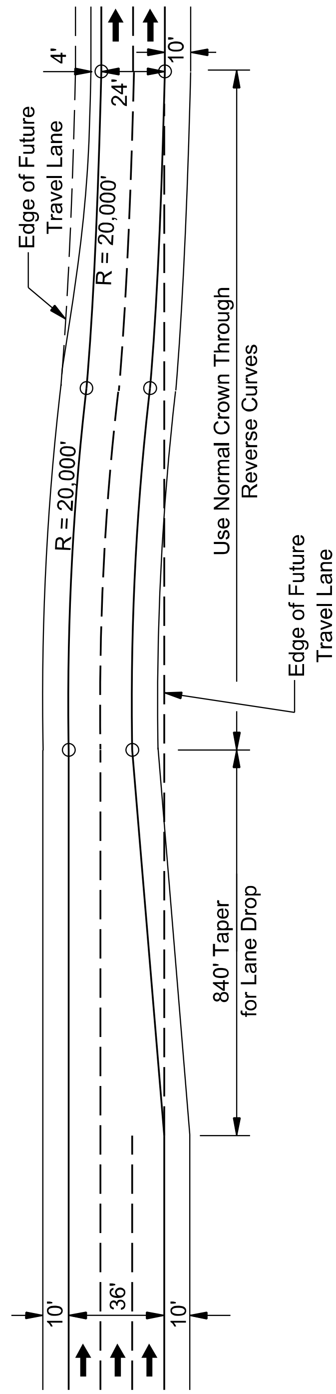
3. Sight Distance. Decision sight distance should be available to any point within the entire lane transition. See Section 4.3 for applicable decision sight distance values. This would favor, for example, placing a freeway lane drop within a sag vertical curve or at a location where the freeway lies on an upgrade, but not just beyond a crest.

4. Right-side Versus Left-side Drop. Right-side freeway lane drops are preferred due to the merging of slower vehicles and normal driver expectations. For the situation where the left lane is to be continued in the median in the future, the right-side lane drop is still preferred; see Figure 17.5-B. If a left-side lane drop is used, provide advance supplemental signing, longer taper lengths and 12-foot wide paved left shoulders beyond the area of the proposed lane drop.

5. Shoulders. Maintain the full-width right shoulder through a right-side lane drop.



TYPICAL FREEWAY LANE DROP (RIGHT SIDE)
Figure 17.5-A



TYPICAL FREEWAY LANE DROP (RIGHT SIDE)
Figure 17.5-B

Design Speed (mph)	Transition Length (feet)
55	660
60	720
65	780
70	840
75	840

TRANSITION LENGTH FOR 12-FOOT FREEWAY LANE DROP
Figure 17.5-C

17.5.2 Weaving

Design weaving segments of freeways so that the LOS within the area of weaving is consistent with the remainder of the highway. The design LOS of weaving sections depends upon their length, number of lanes, acceptable degree of congestion and relative volumes of individual traffic movements. Weaving sections may be considered as single or multiple. Detailed discussions of freeway weaving sections, relating to the operation and analysis, are contained in the *Highway Capacity Manual*.

17.5.3 Frontage Roads

17.5.3.1 General

Frontage roads are roadways adjacent to freeways and arterials that can serve many functions including providing access, maintaining traffic circulation or collecting local traffic between interchanges. The type and function of the frontage road provided is highly dependent on the function of the adjacent freeway and the area where it is located. The need for local service across and along rural freeway corridors is usually considerably less than the need along highly developed urban freeways. Frontage roads can be used on all types of freeways. Therefore, along rural freeways, frontage roads are usually intermittent and relatively short. Along urban freeways, frontage roads may extend throughout the freeway corridor to provide continuous and adjacent access to preserve the highway from subsequent development of the roadsides.

Frontage roads are outside the controlled access lines of freeways and other controlled access highways. It is preferable that frontage roads be located generally parallel to freeways on an independent right of way. For example, if the typical freeway right of way is 150 feet from the centerline of the median, then an additional 66 to 90 feet of right of way should be provided for the adjacent frontage road.

Providing adequate distance between ramp/crossroad and frontage road/crossroad intersections avoids operational and safety problems. The *SCDOT Access and Roadside Management Standards* provides the recommended distances along the crossroad between frontage roads and ramp terminals. Where right-of-way restrictions are not a consideration, the distance between the ramp terminal and frontage road should be as liberal as practical.

Where frontage roads are used on arterials without grade-separated cross roads, see Chapter 9 “Intersections” of the AASHTO *A Policy on Geometric Design of Highways and Streets* for more information.

17.5.3.2 Urban Frontage Roads

Connections between the main highway and the frontage road are an important design element in constrained urban conditions. In general, continuous frontage roads should be one way in the same direction as the adjacent freeway lanes. From an operational and safety perspective, one-way urban frontage roads are preferred to two way. Two-way frontage roads at high-volume, urban intersections may complicate crossing and turning movements. One-way operations may inconvenience local traffic to some extent, but the advantages in reducing vehicular and pedestrian conflicts at intersecting streets often fully compensates for this inconvenience. Continuous frontage roads that are parallel to the freeway permit the use of frontage roads as a backup system in case of freeway disruptions.

On facilities with lower operational speeds and one-way frontage roads, slip ramps or simple openings in a narrow outer separation may work reasonably well. Slip ramps from one-way frontage roads and freeways can be a necessary and appropriate feature in an urban corridor. Because slip ramps from a freeway to two-way frontage roads tend to induce wrong-way entry onto the freeway and may cause crashes at the intersection of the ramp and frontage road, access to the freeway must be provided only at an interchange. Do not use off or slip ramps joining two-way frontage roads because of the potential for wrong-way entry onto the freeway.

17.5.3.3 Rural Frontage Roads

Because of the lack of continuity and the type of service being provided, newly constructed frontage roads are normally two-way facilities in rural areas. Two-way frontage roads are best used where the adjoining street system is so irregular or so disconnected that one-way operation would introduce considerable added travel distance and cause undue inconvenience. Traffic operations are more complex at two-way frontage road intersections with grade separated crossroads; therefore, such intersections are generally located as far as practical from grade-separated structures and interchange ramp terminals.

Where rural freeways sever existing low-volume roads, the designer must determine if the road is to be closed, provided with a cul-de-sac, rerouted, provided with a grade separation or provided with a frontage road. This decision should be based on economics and, if necessary, through a benefit/cost study. Desirably, a freeway should be located so that a minimum number of properties are severed by its location. Realizing that this is not always practical or feasible, frontage roads are provided for access to severed properties. The designer, with the assistance of the Rights of Way Office, should conduct an economic justification study to determine if it is more economical to construct the frontage road or pay severance damages for loss of access.

17.5.3.4 Functional Classification and Design Criteria

The designer should provide the normal design elements of pavement width, cross slope, horizontal and vertical alignment, etc., consistent with the functional operation of the frontage road. That is, the same considerations relative to functional classification, design speed, traffic volumes, etc., apply to frontage roads as they apply to any other highway. The functional classification of the frontage road will be determined on a case-by-case basis.

The selection of the appropriate design criteria is based on the functional classification of the frontage road. Once the frontage road classification has been determined, the appropriate design elements (e.g., design speed, lane and shoulder widths) can be selected. For freeways, the frontage road design criteria can be found in Chapters 14 “Local Roads and Streets,” 15 “Collector Roads and Streets” and 16 “Rural and Urban Arterials.”

17.5.3.5 Outer Separations

The area between the traveled way and a frontage road or street is referred to as the outer separation. If there are no adjoining frontage roads or local streets, then these areas are referred to as borders. Basically, outer separations or borders provide areas for shoulders, slopes, drainage facilities, controlled access fencing, walls, ramps and noise abatement barriers. Outer separations may also serve as recovery areas for errant vehicles. In urban areas, the outer separation may require a reduced width due to certain restrictions (e.g., retaining walls, right-of-way restrictions). Some typical outer separations between freeways and frontage roads are shown in Figure 17.5-D.

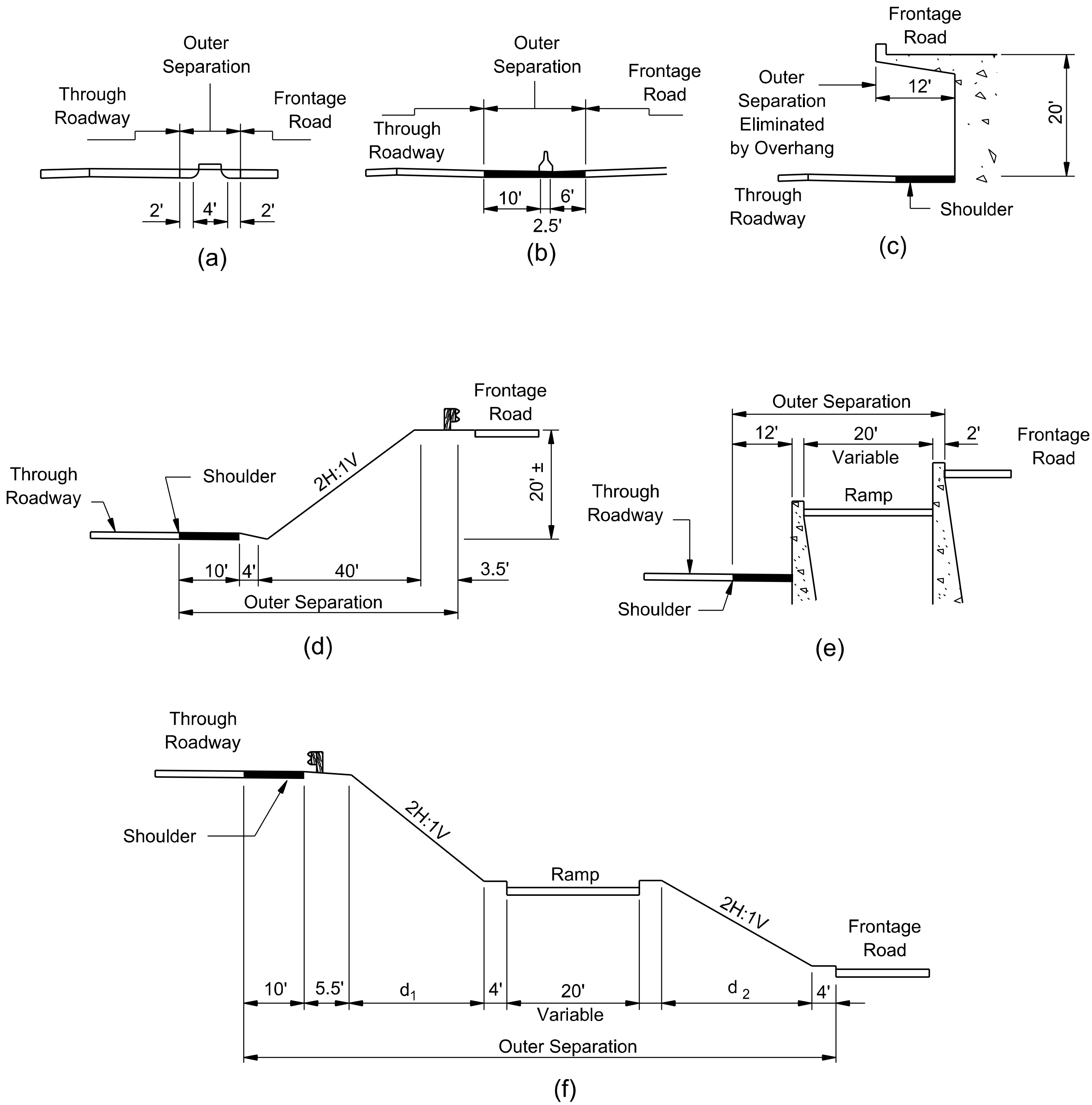
17.5.4 <u>Pedestrians</u>

Where planned freeway construction will divide established communities, resulting in the termination of streets and pedestrian accommodations, the designer should investigate the spacing of the remaining crossing streets and sidewalks. This should be done in conjunction with the volume of diverted pedestrian traffic and associated distances that pedestrian traffic is required to travel to determine the need for intermediate pedestrian grade separation crossings. The designer should review the AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities* for additional guidance.

17.5.5 <u>Noise Barriers</u>

The SCDOT *Traffic Noise Abatement Policy* provides SCDOT noise abatement requirements with respect to 23 CFR 772, “Procedures for Abatement of Highway Traffic Noise and Construction Noise.” SCDOT recognizes the adverse effects that highway traffic noise may have on the citizens of South Carolina and does what is practical to lessen these effects. During the project development process various noise abatement options are considered to abate noise impacts including alternative alignments or noise structures. The SCDOT Environmental Services Office is responsible for determining if noise abatement measures are required.

If a decision is made that noise barriers are required, the designer should ensure their construction will not compromise the highway safety. See Section 11.4 for guidance.



TYPICAL OUTER SEPARATIONS
Figure 17.5-D

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17.6 REFERENCES

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

2. *A Policy on Design Standards — Interstate System*, AASHTO, 2016.

3. *Freeway and Interchange: Geometric Design Handbook*, ITE, 2005.

4. *Highway Safety Design and Operations Guide*, AASHTO, 1997.

5. *Access and Roadside Management Standards*, SCDOT, 2008.

6. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, AASHTO, 2004.

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