Chapter 16

RURAL AND URBAN ARTERIALS

SOUTH CAROLINA ROADWAY DESIGN MANUAL

February 2021

SPACER PAGE

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Chapter 16
RURAL AND URBAN ARTERIALS

This chapter discusses the minimum criteria used in the design of arterial roads and streets. Information that is also applicable to the design of rural and urban arterials is included in the following chapters:

- Chapter 3 “Basic Design Controls,” Chapter 4 “Sight Distance,” Chapter 5 “Horizontal Alignment,” Chapter 6 “Vertical Alignment” and Chapter 7 “Cross Section Elements” provide guidance on geometric design elements.
- Chapter 9 “Intersections” provides information on the design of intersections, including intersection alignment, left- and right-turn lanes and channelization.
- Chapter 10 “Interchanges” discusses the type, location and design of interchanges.

16.1 FUNCTIONAL CLASSIFICATION

Chapter 16 addresses arterial highways, see Section 3.4.1 for additional guidance on functional classifications.

Arterial highways are generally characterized by their ability to quickly move relatively large volumes of traffic, but is often impacted by access to abutting properties. The arterial system typically provides for high travel speeds and the longest trip movements. The rural and urban arterial systems are connected to provide continuous through movements at approximately the same level of service.

The freeway is the highest level of an arterial. These facilities are characterized by full control of access, high design speeds and a high level of driver comfort and safety. For these reasons, freeways are considered a special type of highway within the functional classification system, and separate design criteria have been developed for freeways in Chapter 17 “Freeways.”

Arterials have the following general characteristics:

- consist of a connected network of continuous routes;
- in rural areas, provide a mix of interstate and intercounty travel service;
- provide service to, through or around urban areas from rural arterial routes and may be connecting links;
- provide for significant urban and suburban travel demands (e.g., between central business districts (CBD) and outlying residential areas, between major inner city communities, between major suburban centers);
- serve long distance traffic within an urban area by connecting major regional activity centers not served by connecting links or may provide service for trips of moderate length;

- may be a multilane undivided facility, divided facility, two-lane rural highway, major two-way city street or a one-way pair system;
- typically warrant management of access to the highway;
- may be included in the National Highway System (NHS); and
- may carry local bus routes and provide intra-community continuity, but generally will not penetrate neighborhoods.

To determine the functional classification of a facility, the designer should contact Road Data Services.

16.2 DESIGN ELEMENTS

16.2.1 Traffic Volumes

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

For urban streets, traffic volumes and characteristics usually dominate vehicular traffic demands. In addition, the designer must also consider pedestrians, bicyclists and transit service. For urban streets, the designer should determine the Annual Average Daily Traffic (AADT), peak-hour traffic, peak-hour factor, directional distribution, traffic composition and projection of future traffic demands for all modes of travel. The designer should review the *Highway Capacity Manual* for guidance on making these determinations.

16.2.2 Level of Service

Design the highway mainline, intersection or interchange to accommodate the selected design hourly volume (DHV) at the selected level of service (LOS). This may involve adjusting the various highway factors that affect capacity until a design is determined that will accommodate the DHV. Further discussion on the LOS design concept is included in Section 3.6.4. Detailed calculations, factors and methodologies are presented in the *Highway Capacity Manual*.

16.2.3 Design Speed

Design speed is a selected speed used to determine the various design features of the roadway. Design speeds for rural arterials are based on terrain, driver expectancy and the alignment. See Section 3.5.2 and the FHWA publication *Mitigation Strategies for Design Exceptions* for additional guidance on the selection of design speeds.

Urban arterial design speeds can vary from 30 mph to 60 mph, depending on available right of way, terrain, adjacent development, likely pedestrian presence and other site controls. Lower speeds apply in CBD and in more developed areas, while higher speeds are more applicable to outlying suburban and developing areas.

The geometric design tables in Section 16.3 provide the applicable design speeds for rural and urban arterials.

16.2.4 Sight Distances

See Chapter 4 “Sight Distance” for guidance on stopping, decision, passing and intersection sight distances.

16.2.5 Alignment

Designed for high-volume and high-speed operations, arterials 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 arterials. When designing arterial alignments, the designer should consider the following:

1. Horizontal Alignment Note the following:

   a. Rural Arterials The following guidelines should be applied when laying out the horizontal alignment:

      - Avoid the use of minimum length of curve.
      - Only use minimum radii where it is necessary due to restricted conditions.
      - Avoid alignments that require superelevation transitions on bridges, bridge approach slabs or intersections.

   b. Low-Speed Urban Arterials Where superelevation is required on low-speed urban streets ($V_d \leq 45$ mph), use AASHTO Method 2 in determining the design superelevation. See Chapter 5 “Horizontal Alignment” for minimum radii and superelevation rates for low-speed urban streets.

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. Note that curves that are too flat may produce flat areas that may cause drainage problems. For further guidance, see Chapter 6 “Vertical Alignment.”

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 curbed facilities and bridges, it is necessary to provide a minimum longitudinal grade of 0.3 percent to facilitate drainage. For curbed sections, ensure curb profiles provide positive 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. Climbing Lanes Section 6.4 discusses the warrants and design criteria for climbing lanes. For most arterials, climbing lanes are generally only warranted on rural two-lane arterials.

16.2.6 Cross Section Elements

The following sections summarize cross section criteria for arterials. For additional information concerning cross sections, the designer should review Chapter 7 “Cross Section Elements.”

16.2.6.1 Typical Sections

The following figures present typical sections for rural and urban arterials:

- Figure 16.2-A – Typical Rural Two-Lane Arterial

- Figure 16.2-B – Typical Rural Four-Lane Divided Arterial
- Figure 16.2-C – Typical Urban Four-Lane Divided Arterial
- Figure 16.2-D – Typical Urban Five-Lane Arterial (TWLTL) with Shoulders
- Figure 16.2-E – Typical Urban Five-Lane Arterial (TWLTL) with Curb and Gutter

16.2.6.2 Travel Lane and Shoulder Widths

Travel lane widths should be 12 feet. Provide a 10-foot shoulder, which includes a minimum paved width of 2 feet. In constrained urban areas with curb and gutter, the shoulder width may be just the 2-foot curb and gutter width. Where bicycles are to be accommodated on the shoulder, the designer should provide a minimum paved shoulder width of 4 feet. Low speed facilities with curb and gutter sections do not require a shoulder. For high speed facilities with curb and gutter sections, place the curb and gutter on the outside of the shoulder.

16.2.6.3 Cross Slopes

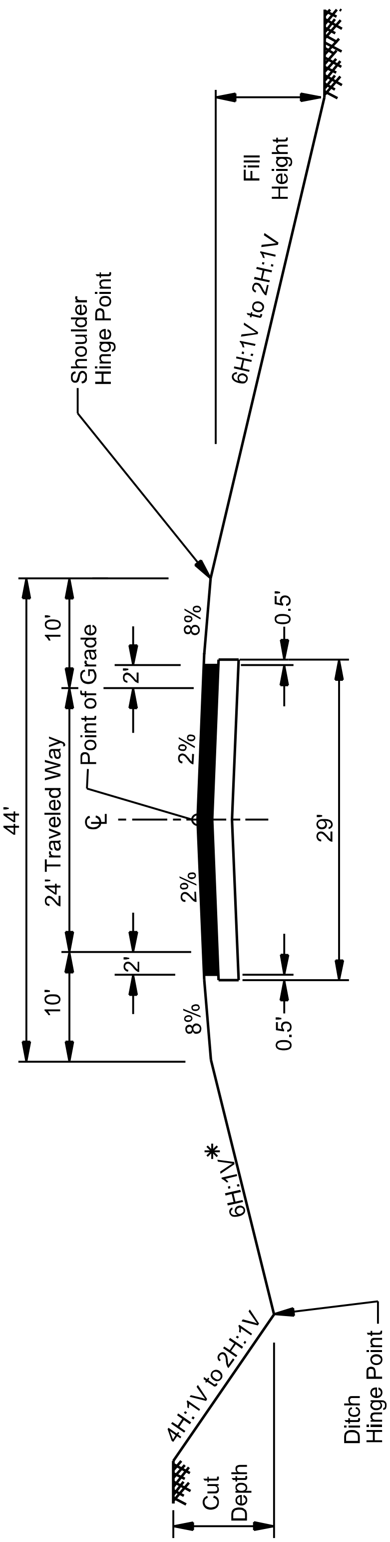
Use a cross slope of 2.00 percent for up to two lanes plus one half the width of the flush median or TWLTL. Travel lanes beyond the second lane on one side of the crown should have a cross slope of 2.50 percent. Crown the pavement at the center of the TWLTL and use a cross slope of 2.00 percent away from the centerline for all lanes on three- and five-lane highways. For a seven-lane section, use a cross slope of 2.50 percent for the outside lanes. 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.*

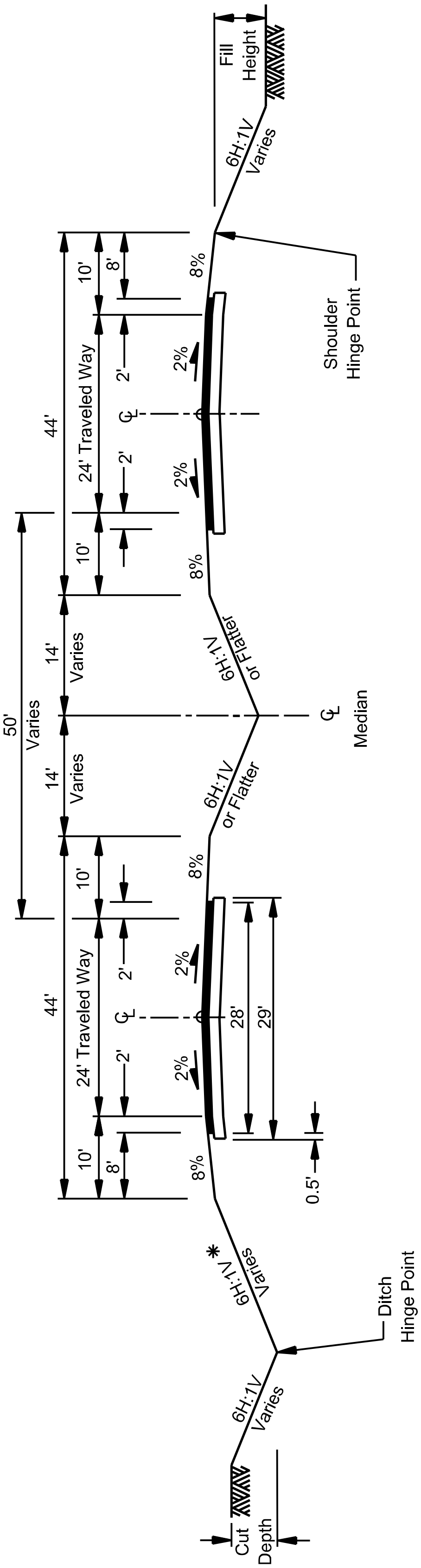
16.2.6.4 Auxiliary Lanes

Auxiliary lanes (e.g., passing lanes, parking lanes, turn lanes) are lanes beyond the through travel lanes intended for use by vehicular traffic for specific functions. Desirably, auxiliary lanes will have the same width and cross slope as the adjacent through lanes, although in many cases a lesser width may be appropriate. The geometric design tables in Section 16.3 present lane and shoulder widths for auxiliary lanes.



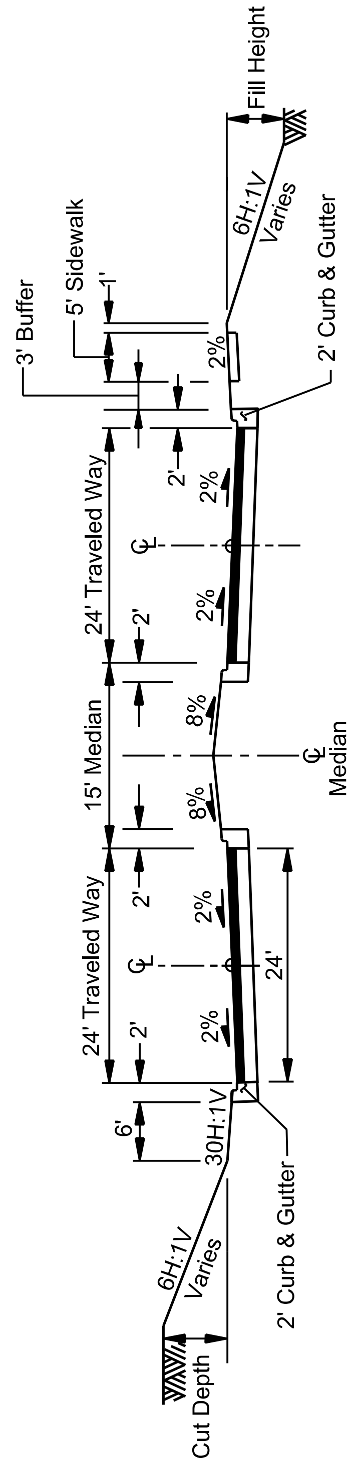
*This slope may vary between a minimum slope of 12.5H:1V to a maximum slope of 4H:1V. Where a deeper ditch than provided by a 4H:1V slope is necessary for drainage purposes, continue the 4H:1V slope until the necessary depth has been obtained. This will place the ditch further away from the roadway. Provide a separate profile for special ditch grades.

TYPICAL RURAL TWO-LANE ARTERIAL
Figure 16.2-A

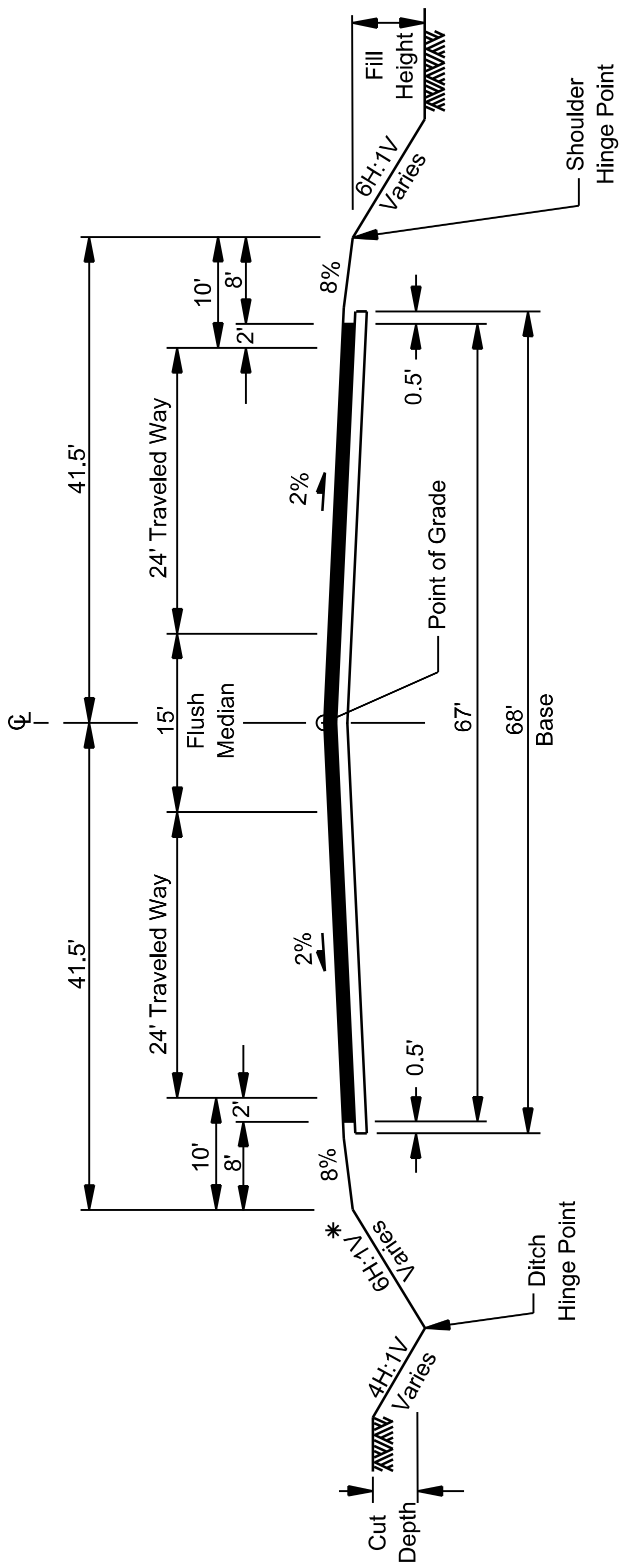


*This slope may vary between a minimum slope of 12.5H:1V to a maximum slope of 4H:1V. Where a deeper ditch than provided by a 4H:1V slope is necessary for drainage purposes, continue the 4H:1V slope until the necessary depth has been obtained. This will place the ditch further away from the roadway. Provide a separate profile for special ditch grades.

TYPICAL RURAL FOUR-LANE DIVIDED ARTERIAL
Figure 16.2-B

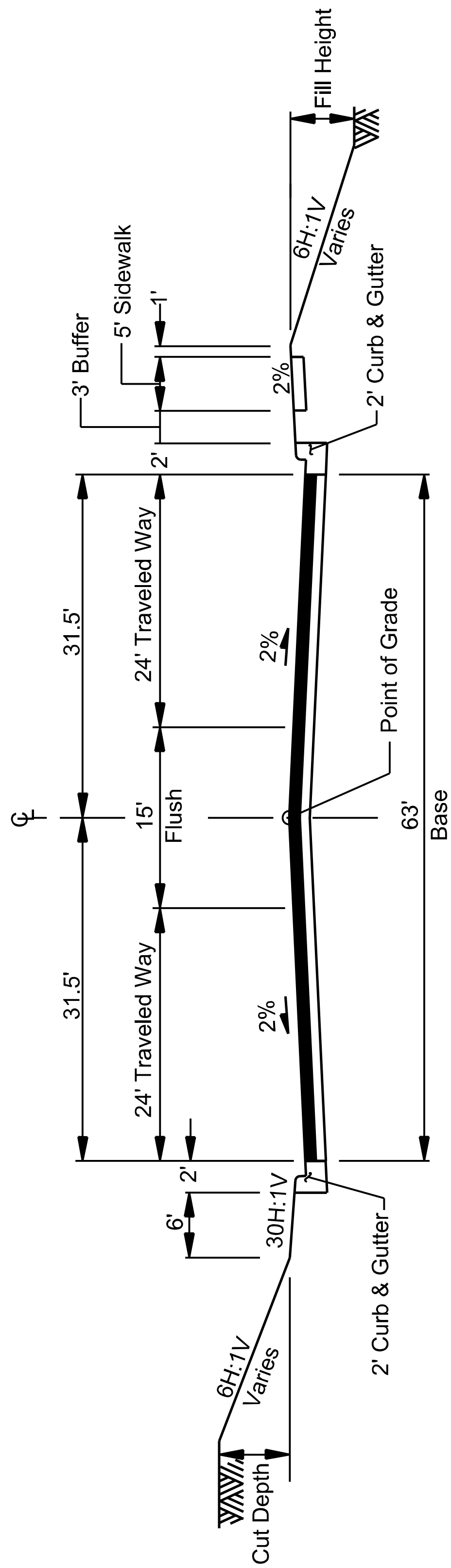


TYPICAL URBAN FOUR-LANE DIVIDED ARTERIAL
Figure 16.2-C



*This slope may vary between a minimum slope of 12.5H:1V to a maximum slope of 4H:1V. Where a deeper ditch than provided by a 4H:1V slope is necessary for drainage purposes, continue the 4H:1V slope until the necessary depth has been obtained. This will place the ditch further away from the roadway. Provide a separate profile for special ditch grades.

TYPICAL URBAN FIVE-LANE ARTERIAL (TWLTL) WITH SHOULDERS
Figure 16.2-D



TYPICAL URBAN FIVE-LANE ARTERIAL (TWLTL) WITH CURB AND GUTTER
Figure 16.2-E

16.2.6.5 Medians

A median should be considered on many multilane arterials. The principal functions of a median are to provide a separation from opposing traffic, to provide for turning movements, to manage access, to provide pedestrian refuge and to provide width for future lanes. Medians on arterials may be one of the following median types:

1. Flush Medians Flush medians provide an area for left-turn movements and permit direct access to adjoining properties. This allows for numerous unrestricted conflict points. The flush median may serve as refuge for disabled vehicles and serve as a temporary lane for emergency vehicles. The two-way, left-turn lane (TWLTL) is considered a flush median. Desirably, the roadway cross section with a flush median will allow development of a TWLTL, where appropriate.

2. Raised Medians Raised medians restrict left-turn movements to select locations, which allows for better access management. This median may provide a refuge area for pedestrians and an open space for aesthetic considerations.

3. Depressed Medians Although additional right of way is required, depressed medians provide wider separation between opposing flows and greater drainage capabilities. Wide depressed medians may provide for future widening.

For guidance on medians and TWLTL, see Chapter 7 “Cross Section Elements.”

16.2.6.6 Transitions

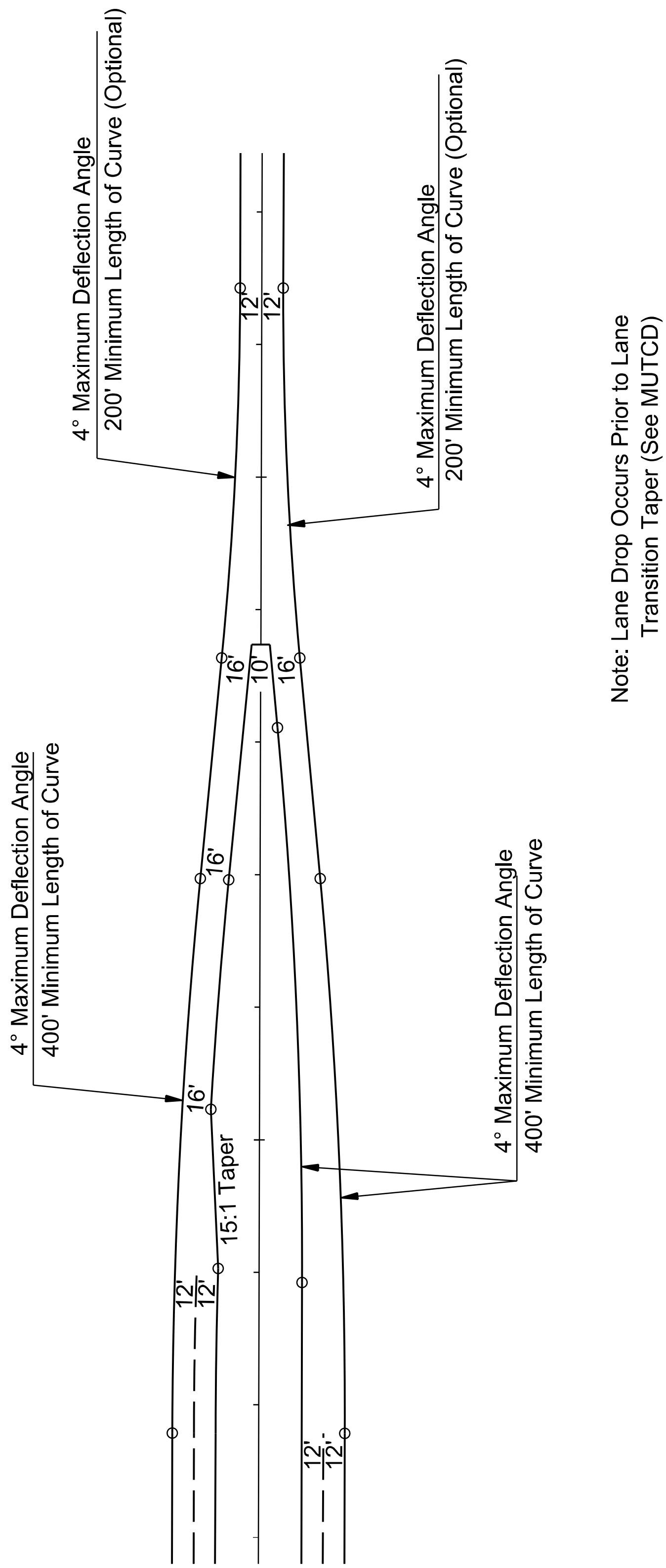
The designer needs to give careful consideration to the design of transitions from multilane facilities to two-lane facilities; see Figure 16.2-F. These are complex decision-making areas for a driver, who may not be expecting the lane reduction.

The horizontal alignment for permanent and temporary transitions should follow the criteria presented in Chapter 5 “Horizontal Alignment.” Desirably, design all temporary connections as new facilities. This includes, but is not limited to, superelevation, transition lengths, reverse curves and the tangent length between curves.

The designer should provide decision sight distance to and throughout the transition area. To achieve this objective, the project termini may need to be adjusted.

16.2.6.7 Frontage Roads

Arterial highways are generally characterized by their ability to quickly move relatively large volumes of traffic, but often with restricted capacity to serve abutting properties. A frontage road may be proposed in conjunction with an arterial to provide access to abutting properties. Where frontage roads are proposed in conjunction with a multilane arterial, provide a contiguous, but independent right of way adjacent to the mainline right of way for the frontage road. In certain instances, it may be advantageous to provide frontage roads that run parallel to the arterial, but have a wider separation resulting in two independent rights of way.



LANE TRANSITION DESIGN ON TANGENT SECTION FROM FOUR TO TWO LANES
Figure 16.2-F

Where the profile grade of the arterial passes through major cuts and fills, the grade of the frontage road typically conforms to the existing ground line. The difference in elevation between the two adjacent facilities is provided for in the outer separations by earth slopes or possibly retaining walls. See Section 17.5.3 for additional information on frontage roads.

For rural multilane principal arterials, the frontage road should be designed using the rural two-lane arterial criteria, see Figure 16.3-A. For urban arterials, frontage roads may be designed as a two-lane urban arterial (Figure 16.3-C), collector (Chapter 15 “Collector Roads and Streets), or local street (Chapter 14 “Local Roads and Streets”).

16.2.6.8 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, parking lanes, bike lanes, sidewalks, ditches, outer slopes). If a long-range plan identifies a future widening, give consideration to accommodating 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, at intersections and junctions with other roads, at railroad-roadway grade crossings, for environmental considerations and for maintenance access.

16.2.7 Alternatives to Widening on Two-Lane Facilities

For rural two-lane arterials that are not candidates for widening to four-lane facilities, but are experiencing operational and safety problems or site-specific reductions in LOS, the designer should consider implementing one or more of the following improvements:

1. Realignment Passing sight distance for two-lane rural highways is critical to the safe operation and capacity of highways. The designer should consider realignment of the arterial to improve horizontal and/or vertical alignment. These improvements inherently increase the passing sight distance, thereby, increasing safety and capacity. Minimum passing sight distances for two-lane highways are discussed in Section 4.2.

2. Medians Medians can improve traffic flow and provide safety and operation benefits. Providing two-way, left-turn lanes (TWLTL) are viable alternatives where the number of left-turning vehicles is significant. Section 7.4 provides the guidelines and criteria for TWLTL. The use of the TWLTL for left-turning vehicles is typically not provided where design speed limits exceed 45 miles per hour. Therefore, their applicability to rural highways is usually near suburban areas or for roads passing through small towns. This alternative eliminates the possibility for the passing maneuver and does not increase through traffic capacity for the roadway segment.

3. Intersection Treatments Depending on the access demands for a particular two-lane facility, intersections can be a critical part of a facility’s design. The use of left-turn lanes

and bypass lanes to facilitate the movement and enhance the safety of through traffic at intersections is a cost-effective approach for upgrading two-lane highways. The designer should conduct detailed analyses of intersections in accordance with procedures in the *Highway Capacity Manual*. When modifying intersections, consider the following:

- design vehicle,
- signal warrants,
- sight distance,
- crash analyses,
- turning movements/lane warrants,
- intersection alignment,
- rights of way requirements,
- LOS analysis, and
- economic factors.

For additional guidance, see Chapter 9 “Intersections.”

4. Climbing Lanes In areas with steep grades, reduced truck speeds may significantly affect the facility’s capacity and safety. However, truck-climbing lanes can effectively increase capacity and safety. Warrants and design criteria for truck-climbing lanes are discussed in Section 6.4.

5. Passing Lanes Passing lanes, other than truck-climbing lanes, may be warranted on two-lane facilities where passing opportunities are not adequate or when an engineering study, operational experience and a capacity analysis concludes that there is a critical need. Section 7.2.6 discusses passing lane designs.

16.2.8 Roadside Safety

The designer should provide adequate horizontal clearance between the traveled way and roadside obstructions on arterials. The designer should provide roadside clear zones as discussed in the AASHTO *Roadside Design Guide*.

16.3 TABLES OF DESIGN CRITERIA

The geometric design tables in this section present the Department's design and alignment criteria for rural and urban arterial projects. The designer should consider the following when using these tables:

1. Applicability Note that some of the cross-section elements included in the tables (e.g., TWLTL) 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 tables are intended to provide a concise listing of design values for easy use. However, the designer should review the 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 arterials:

- Figure 16.3-A — "Geometric Design Criteria for Rural Two-Lane Arterials (New Construction/Reconstruction)"
- Figure 16.3-B — "Geometric Design Criteria for Rural Multilane Arterials (New Construction/Reconstruction)"
- Figure 16.3-C — "Alignment Criteria for Rural Arterials (New Construction/Reconstruction)"
- Figure 16.3-D — "Geometric Design Criteria for Urban Two-Lane Arterials (New Construction/Reconstruction)"
- Figure 16.3-E — "Geometric Design Criteria for Urban Multilane Arterials (New Construction/Reconstruction)"
- Figure 16.3-F — "Alignment Criteria for Urban Arterials (New Construction/Reconstruction)"

Design Element				Manual Section	Rural
Design Controls	Design Forecast Year			16.2.1	20 Years
	Design Speed	Level		16.2.3	Minimum: 60 mph
		Rolling			Minimum: 50 mph
		Mountainous			Minimum: 40 mph
	Access Control			3.8	Control by Regulation
	Level of Service			3.6.4	Level/Rolling: B Mountainous: C
Cross Section Elements	Travel Lane Width **(1)**			16.2.6	12 ft
	Shoulder	Total Width (**2)**		16.2.6	10 ft
		Paved Width			2 ft
	Auxiliary Lanes	Lane Width		16.2.6	12 ft
		Shoulder Width	Total		10 ft
			Paved		2 ft
	Bicycles	Bike Lane Width **(4)**		13.2	4 ft
		Shared Lane Width			14 ft
	Cross Slope	Travel Lane		16.2.6	2.00%
		Auxiliary Lane			2.00%
		Shoulder	Paved **(3)**		2.00%
			Unpaved		8.00%
	TWLTL			16.2.6	15 ft
	Right of Way Width			16.2.6	Project Specific
Roadway Slopes	Side Slopes	Cut Section	Foreslope	7.3.2	6H:1V to 4H:1V
			Ditch Type		V-Ditch
			Back Slope		4H:1V to 2H:1V
			Rock Cut		0.25H:1V
		Fill Section	0 ft – 5 ft	7.3.2	6H:1V
			5 ft – 10 ft		4H:1V
			> 10 ft		2H:1V
	Clear Zone				**(5)**

GEOMETRIC DESIGN CRITERIA FOR RURAL TWO-LANE ARTERIALS
(New Construction/Reconstruction)
Figure 16.3-A
(Continued on next page)

Design Element			Manual Section	Rural
Structures	New Bridges	Structural Capacity	7.5.1	HL-93
		Clear Roadway Width **(6)**		44 ft
	Existing Bridges to Remain in Place	Structural Capacity	7.5.1	**(6)**
		Clear Roadway Width **(6)**		44 ft
	Vertical Clearance (Arterial Under) **(8a)**	New and Replaced Overpassing Bridges **(8b)**	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		Coordinate with Utility Office
	Clearance (Arterial 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	See Environmental Services Office
		Major Lakes & Reservoirs (with boat traffic)		8 ft – 0 in above the high water mark
		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.

Footnotes

(1) Travel Lane Width. An existing 22-foot traveled way may be retained where the alignment is satisfactory and there is no crash pattern suggesting the need for widening.

(2) Shoulder (Total Width). Where guardrail is required, increase the shoulder width an additional 3.75 feet.

(3) Shoulder Cross Slope. For paved shoulders wider than 4 feet, provide a 4.00 percent shoulder cross slope.

(4) Bicycle Facilities Lane Width. 4-foot bicycle lane width is measured exclusive of curb & gutter or rumble strips/stripes. For design speeds greater than 45 miles per hour, increase the bike lane width in accordance with AASHTO *Guide for the Development of Bicycle Facilities*.

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

(6) 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.

(7) 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.

(8) Vertical Clearance (Arterial 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 TWO-LANE ARTERIALS
(New Construction/Reconstruction)
Figure 16.3-A
(Continued)

Design Element				Manual Section	Rural
Design Controls	Design Forecast Year			16.2.1	20 Years
	Design Speed	Level		16.2.3	Minimum: 60 mph
		Rolling			Minimum: 50 mph
		Mountainous			Minimum: 40 mph
	Access Control			3.8	Control by Regulation
	Level of Service			3.6.4	Level/Rolling: B Mountainous: C
Cross Section Elements	Travel Lane Width **(1)**			16.2.6	12 ft
	Shoulder Width	Right	Total **(2)**	16.2.6	10 ft
			Paved		2 ft
		Left	Total **(2)**		10 ft
			Paved		2 ft
	Auxiliary Lanes	Lane Width		16.2.6	12 ft
		Shoulder Width	Total		10 ft
			Paved		2 ft
	Bicycles	Bike Lane Width **(4)**		13.2	4 ft
		Shared Lane Width			14 ft Outside Travel Lane
	Cross Slope	Travel Lane		16.2.6	2.00%
		Auxiliary Lane			2.00%
		Shoulder	Paved **(3)**		2.00%
			Unpaved		8.00%
	Median Width	Depressed		16.2.6	48 ft
	Right of Way Width			16.2.6	Project Specific
Roadway Slopes	Side Slopes	Cut Section	Foreslope	7.3.2	6H:1V to 4H:1V
			Ditch Type		V-Ditch
			Back Slope		6H:1V to 2H:1V
			Rock Cut		0.25H:1V
		Fill Section	0 ft – 5 ft	7.3.2	6H:1V
			5 ft – 10 ft		4H:1V
			> 10 ft		2H:1V
	Clear Zone				**(5)**

GEOMETRIC DESIGN CRITERIA FOR RURAL MULTILANE ARTERIALS
(New Construction/Reconstruction)
Figure 16.3-B
(Continued on next page)

Design Element			Manual Section	Rural
Structures	New Bridges	Structural Capacity	7.5.1	HL-93
		Clear Roadway Width **(6**)		44 ft
	Existing Bridges to Remain in Place	Structural Capacity	7.5.1	**(7)**
		Clear Roadway Width **(6)**		44 ft
	Vertical Clearance (Arterial Under) **(8a)**	New and Replaced Overpassing Bridges **(8b)**	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		Coordinate with Utility Office
	Vertical Clearance (Arterial 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	See Environmental Services Office
		Major Lakes & Reservoirs (with boat traffic)		8 ft – 0 in above the high water mark
		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.

Footnotes

(1) Travel Lane Width On reconstructed arterials, an existing 22-foot traveled way may be retained where the alignment is satisfactory and there is no crash pattern suggesting the need for widening.

(2) Shoulder (Total Width) Where guardrail is required, increase the shoulder width an additional 3.75 feet.

(3) Shoulder Cross Slope For paved shoulders wider than 4 feet, provide a 4.00 percent shoulder cross slope.

(4) Bicycle Facilities Lane Width 4-foot bicycle lane width is measured exclusive of curb & gutter or rumble strips/stripes. For design speeds greater than 45 miles per hour, increase the bike lane width in accordance with AASHTO *Guide for the Development of Bicycle Facilities*.

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

(6) 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 the widths for the left and right shoulders. See Section 7.5.1.1 for further guidance.

(7) 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.

(8) Vertical Clearance (Arterial 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 MULTILANE ARTERIALS
(New Construction/Reconstruction)
Figure 16.3-B
(Continued)

Design Element		Manual Section	Design Speed						
			45 mph	50 mph	55 mph	60 mph	65 mph	70 mph	75 mph
Stopping Sight Distance **(1)**		4.1	360 ft	425 ft	495 ft	570 ft	645 ft	730 ft	820 ft
Passing Sight Distance		4.2	700 ft	800 ft	900 ft	1000 ft	1100 ft	1200 ft	1300 ft
Decision Sight Distance **(2)**		4.3	675 ft	750 ft	865 ft	990 ft	1050 ft	1105 ft	1180 ft
Intersection Sight Distance **(3)**		4.4	500 ft	555 ft	610 ft	665 ft	720 ft	775 ft	830 ft
Minimum Radii	e_{max} = 8%	5.2		758 ft	960 ft	1200 ft	1480 ft	1810 ft	2210 ft
	e_{max} = 6%		643 ft	833 ft					
Superelevation Rate **(4)**		5.3	6%	6% or 8%	8%	8%	8%	8%	8%
Horizontal Sight Line Offset **(5)**		5.4	25 ft	30 ft	32 ft	34 ft	35 ft	37 ft	38 ft
Vertical Curvature (K-Values) **(6)**	Crest	6.5	61	84	114	151	193	247	312
	Sag		79	96	115	136	157	181	206
Maximum Grade	Level	6.3.1	5%	4%	4%	3%	3%	3%	3%
	Rolling		6%	5%	5%	4%	4%	4%	4%
	Mountainous		7%	7%	6%	6%	5%	5%	5%
Minimum Grade **(7)**		6.3.2	0.5%						

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) Intersection Sight Distance. Table values are for passenger cars for assumed conditions described in Figure 4.4-C. See Section 4.4 for truck values.

(4) Superelevation Rate. See Section 5.3 for superelevation rates based on e_{max}, design speed and radii of horizontal curves. For horizontal curves to remain in place, an e_{max} of 8 percent may be considered to remain in place. Where a crossroad intersection lies within the limits of a mainline horizontal curve, see Figure 5.3-A for the maximum superelevation rates allowed on the mainline curve.

(5) Horizontal Sight Line Offset. Table values provide the necessary middle ordinate assuming the design speed, stopping sight distance and minimum radii based on an e_{max} = 6 percent for the 40 miles per hour design speed or e_{max} = 8 percent for design speeds of 50 to 75 miles per hour.

(6) Vertical Curvature (K-Value). K-values are based on the level stopping sight distances.

(7) 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 RURAL ARTERIALS
(New Construction/Reconstruction)
Figure 16.3-C

Design Element				Manual Section	Urban
Design Controls	Design Forecast Year			16.2.1	20 Years
	Design Speed			16.2.3	Minimum: 30 mph
	Access Control			3.8	Limited/Control by Regulation
	Level of Service			3.6.4	Desirable: C
Cross Section Elements	Travel Lane Width **(1)**			16.2.6	12 ft
	Shoulder Width	Total		16.2.6	10 ft or Curb and Gutter
		Paved			2 ft or Curb and Gutter
	Auxiliary Lanes	Lane Width		16.2.6	12 ft
		Shoulder Width	Total		10 ft or Curb and Gutter
			Paved		2 ft or Curb and Gutter
	Parking Lane Width **(2)**			7.2.7	12 ft
	Bicycle	Lane Width **(4)**		13.2	4 ft
		Shared Lane Width			14 ft
	Cross Slope	Travel Lane		16.2.6	2.00%
		Auxiliary Lane			2.00%
		Shoulder	Paved **(3)**		2.00%
			Unpaved		8.00%
	Curb and Gutter	Type **(5)**		7.2.8	Vertical or Sloping
		Width			2 ft
	Sidewalk Width			13.3	5 ft
	Median Width	TWLTL		16.2.6	15 ft
		Raised			Desirable: 12 ft Minimum: 4 ft
	Right of Way Width			16.2.6	Project Specific
Roadway Slopes	Side Slopes	Cut Section	Foreslope	7.3.2	6H:1V to 4H:1V
			Ditch Type		V-Ditch
			Back Slope **(6)**		4H:1V to 2H:1V
		Fill Section	0 ft – 5 ft	7.3.2	6H:1V
			5 ft – 10 ft		4H:1V
			> 10 ft		2H:1V
	Flush/TWLTL Slopes			7.3.2	2.00%
	Clear Zone				**(7)**

GEOMETRIC DESIGN CRITERIA FOR URBAN TWO-LANE ARTERIALS
(New Construction/Reconstruction)
Figure 16.3-D
(Continued on next page)

Design Element			Manual Section	Urban
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 (Arterial Under) **(10a)**	New and Replaced Overpassing Bridges **(10b)**	6.6	17 ft – 0 in
		Existing Overpassing Bridges	6.6	16 ft – 0 in
		Pedestrian Bridges	6.6	18 ft – 0 in
		Overhead Signs	6.6	17 ft – 6 in
		Overhead Utilities	6.6	Coordinate with Utility Office
	Vertical Clearance (Arterial 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	See Environmental Services Office
		Major Lakes & Reservoirs (with boat traffic)		8 ft – 0 in above the high water mark
		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 TWO-LANE ARTERIALS
(New Construction/Reconstruction)
Figure 16.3-D
(Continued on next page)

Footnotes for Figure 16.3-D

(1) Travel Lane Width. In CBDs, an 11-foot traveling lane may be used if the truck volumes are less than or equal to 5 percent.

(2) Parking Lane Width. A parking lane width as narrow as 10 feet may be acceptable.

(3) Shoulder Cross Slope. For paved shoulders wider than 4 feet, provide a 4.00 percent shoulder cross slope.

(4) Bicycle Lane Width. 4-foot bicycle lane width is measured exclusive of curb & gutter or rumble strips/stripes. For design speeds greater than 45 miles per hour, increase the bike lane width in accordance with the AASHTO *Guide for the Development of Bicycle Facilities*.

(5) Curb and Gutter (Type). If curb and gutter is used on streets with design speeds greater than 45 miles per hour, place the curb and gutter outside of the shoulder and use a sloping curb.

(6) Side Slopes. Generally on curb and gutter sections, provide a maximum slope of 2H:1V.

(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, both shoulders and median width, where applicable. For curbed sections, the clear roadway width will be the curb-to-curb width plus the sidewalk width on one or both sides. 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 (Arterial 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 TWO-LANE ARTERIALS
(New Construction/Reconstruction)
Figure 16.3-D
(Continued)

Design Element				Manual Section	Urban
Design Controls	Design Forecast Year			16.2.1	20 Years
	Design Speed			16.2.3	Minimum: 30 mph
	Access Control			3.8	Limited/Control by Regulation
	Level of Service			3.6.4	Desirable: C
Cross Section Elements	Travel Lane Width **(1)**			16.2.6	12 ft
	Shoulder Width	Right	Total	16.2.6	10 ft or Curb and Gutter
			Paved		2 ft or Curb and Gutter
		Left	Total		10 ft or Curb and Gutter
			Paved		2 ft or Curb and Gutter
	Auxiliary Lanes	Lane Width		16.2.6	12 ft
		Shoulder Width	Total		10 ft or Curb and Gutter
			Paved		2 ft or Curb and Gutter
	Parking Lane Width **(2)**			7.2.7	12 ft
	Bicycle	Lane Width **(4)**		13.2	4 ft
		Shared Lane Width			14 ft Outside Travel Lane
	Cross Slope	Travel Lane		16.2.6	2.00%
		Auxiliary Lane			2.00%
		Shoulder	Paved **(3)**		2.00%
			Unpaved		8.00%
	Curb and Gutter	Type **(5)**		7.2.8	Vertical or Sloping
		Width			2 ft
	Sidewalk Width			13.3	5 ft
	Median Width	TWLTL		16.2.6	15 ft
		Raised			Desirable: 12 ft Minimum: 4 ft
	Right of Way Width			16.2.6	Project Specific
Roadway Slopes	Side Slopes	Cut Section	Foreslope	7.3.2	6H:1V to 4H:1V
			Ditch Type		V-Ditch
			Back Slope **(6)**		4H:1V to 2H:1V
		Fill Section	0 ft – 5 ft	7.3.2	6H:1V
			5 ft – 10 ft		4H:1V
			> 10 ft		2H:1V
	Median Slopes	Depressed		7.3.2	6H:1V
		Flush/TWLTL			2.00%
	Clear Zone				**(7)**

GEOMETRIC DESIGN CRITERIA FOR URBAN MULTILANE ARTERIALS
(New Construction/Reconstruction)
Figure 16.3-E

(Continued on next page)

Design Element			**Manual Section**	**Urban**
Structures	New Bridges	Structural Capacity	7.6.1	HL-93
		Clear Roadway Width		**(8)**
	Existing Bridges Remain in Place	Structural Capacity	7.6.1	**(9)**
		Clear Roadway Width		**(8)**
	Vertical Clearance (Arterial Under) **(**10**a)**	New and Replaced Overpassing Bridges **(10b)**	6.6	17 ft – 0 in
		Existing Bridges	6.6	16 ft – 0 in
		Pedestrian Bridges	6.6	18 ft – 0 in
		Overhead Signs	6.6	17 ft – 6 in
		Overhead Utilities	6.6	Coordinate with Utility Office
	Vertical Clearance (Arterial Over)	Railroads	6.6	23 ft – 0 in
		Underpass Width	7.6.2	Traveled Way plus Clear Zone
	Vertical Clearance (Over Water)	Navigable Water	6.6	See Environmental Services Office
		Major Lakes & Reservoirs (with boat traffic)		8 ft – 0 in above the high water mark
		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 MULTILANE ARTERIALS
(New Construction/Reconstruction)
Figure 16.3-E
(Continued on next page)

Footnotes for Figure 16.3-E

(1) Travel Lane Width. In CBDs, an 11-foot traveling lane may be used if the truck volumes are less than or equal to 5 percent.

(2) Parking Lane Width. A parking lane width as narrow as 10 feet may be acceptable.

(3) Shoulder Cross Slope. For paved shoulders wider than 4 feet, provide a 4.00 percent shoulder cross slope.

(4) Bicycle Facilities Lane Width. 4-foot bicycle lane width is measured exclusive of curb & gutter or rumble strips/stripes. For design speeds greater than 45 miles per hour, increase the bike lane width in accordance with AASHTO *Guide for the Development of Bicycle Facilities*.

(5) Curb and Gutter (Type). If curb and gutter is used on streets with design speeds greater than 45 miles per hour, place the curb and gutter outside of the shoulder and use a sloping curb.

(6) Side Slopes. Generally on curb and gutter sections, provide a maximum slope of 2H:1V.

(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, right and left shoulders and median width, where applicable. For curbed sections, the clear roadway width will be the curb-to-curb width plus the sidewalk width on one or both sides. 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 (Arterial 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 MULTILANE ARTERIALS
(New Construction/Reconstruction)
Figure 16.3-E
(Continued)

Design Element		Manual Section	Design Speed						
			30 mph	35 mph	40 mph	45 mph	50 mph	55 mph	60 mph
Stopping Sight Distance **(1)**		4.1	200 ft	250 ft	305 ft	360 ft	425 ft	495 ft	570 ft
Decision Sight Distance **(2)**		4.3	490 ft	590 ft	690 ft	800 ft	910 ft	1030 ft	1150 ft
Intersection Sight Distance **(3)**		4.4	335 ft	390 ft	445 ft	500 ft	555 ft	610 ft	665 ft
Minimum Radii	e_{max} = 8%	5.2					758 ft	960 ft	1200 ft
	e_{max} = 6%		231 ft	340 ft	485 ft	643 ft	833 ft		
	e_{max} = 4%		250 ft	371 ft	533 ft	711 ft			
Superelevation Table **(4a)**		5.3	4% or 6% **(4b)**	4% or 6% **(4b)**	4% or 6% **(4b)**	4% or 6% **(4b)**	6% or 8%	8%	8%
Horizontal Sight Line Offset **(5)**		5.4	21 ft	23 ft	24 ft	25 ft	27 ft	32 ft	34 ft
Vertical Curvature (K-Values) **(6)**	Crest	6.5	19	29	44	61	84	114	151
	Sag		37	49	64	79	96	115	136
Maximum Grade	Level	6.3.1	8%	7%	7%	6%	6%	5%	5%
	Rolling		9%	8%	8%	7%	7%	6%	6%
	Mountainous		11%	10%	10%	9%	9%	8%	8%
Minimum Grade		6.3.2	Desirable: 0.5% Minimum: 0.3% (Curb and Gutter)						

Footnotes

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

(2) Decision Sight Distance. Table values are for stop on an urban road, Avoidance Maneuver B, as described in Figure 4.3-A.

(3) Intersection Sight Distance. Table values are for passenger cars for assumed conditions described in Figure 4.4-C. See Section 4.4 for truck values.

(4) Superelevation Rate.

(a) See Section 5.3 for superelevation rates based on e_{max}, design speed and radii of horizontal curves.
(b) The 6 percent superelevation rate should only be used on suburban arterials.

(5) Horizontal Sight Line Offset. Table values provide the necessary middle ordinate assuming the design speed, stopping sight distance and minimum radii based on an e_{max} = 6 percent for design speeds 30 to 50 miles per hour or e_{max} = 8 percent for design speeds of 55 and 60 miles per hour.

(6) Vertical Curvature (K-Value). K-values are based on the level stopping sight distances.

ALIGNMENT CRITERIA FOR URBAN ARTERIALS
(New Construction/Reconstruction)
Figure 16.3-F

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16.4 REFERENCES

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

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

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

4. *Highway Capacity Manual*, Transportation Research Board, 2010.

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