CHAPTER 6
COLLECTOR ROADS AND STREETS

INTRODUCTION

This chapter presents guidance on the application of geometric design criteria to facilities functionally classified as collector roads and streets. The chapter is subdivided into sections on rural and urban collectors.

The function of a collector may be understood by referring to those functional classes above and below it—the arterial and the local road or street. The collector has aspects of both arterials and local roads and often serves as a connection between them. Since the function of a collector combines aspects of both arterials and local streets, collectors serve a dual function: collecting traffic for movement between arterial streets and local roads and providing access to abutting properties.

Collector streets link neighborhoods or areas of homogeneous land use with the arterial street system. These streets not only serve traffic movements between arterials and local streets, but also serve through traffic within local areas. Collector streets should be planned so as not to disrupt the activities within the areas they serve.

The collector street is a public highway, usually serving moderate traffic volumes. There may be few discernible differences between collectors and local streets within a neighborhood, since collectors provide access function to adjacent residential development and to some neighborhood facilities. However, the design of a collector street should reflect its function as a collector and should not be conceived or developed simply as a continuous access street. The collector should allow access to abutting properties consistent with the level of service desired.

The use of design criteria exceeding those described in this chapter is encouraged, where practical. Every effort should be made to obtain the best possible alignment, grade, sight distance, and drainage that are consistent with terrain, present and anticipated development, safety, and available funds.

Drainage, both on the pavement itself and from the sides and subsurface, is an important design consideration. Inadequate drainage can lead to high maintenance costs and adverse operational conditions. In areas of significant snowfall, roadways should be designed so that there is sufficient storage space, outside the traveled way, for plowed snow and proper drainage for melting conditions.

Safety is an important factor in all roadway improvements. On low-volume roads or streets or in urban areas, it may not be practical to provide an obstacle-free roadside. However, every effort should be made to provide as much clear roadside as is practical. The judicious use of flatter slopes, roadside barriers, and warning signs helps to improve roadside safety. Proper placement of utility features also assists in achieving safer roadsides.

It may not be cost-effective to design collector roads and streets that carry less than 400 vehicles per day using the same criteria applicable to higher volume roads or to make extensive traffic operational or safety improvements to such very low-volume roads. AASHTO is currently evaluating alternative design criteria for collector roads that carry less than 400 vehicles per day based on a safety risk assessment.

Noise abatement may need to be considered on collector roads and streets; for further information, see the section on "Noise Control" in Chapter 4.

The *Highway Capacity Manual* (HCM) (**1**) provides the designer with a tool to evaluate level of service for the highway facility under consideration. Collector streets should generally be designed for level-of-service C to D. In rural areas, level-of-service C is desirable for collector roads. In heavily developed portions of metropolitan areas, conditions may necessitate the use of level-of-service D. Level-of-service D is also a practical choice where unusually high traffic volumes exist or where terrain is rolling or mountainous. For further information, see the section on "Levels of Service" in Chapter 2. Collector roads and streets cannot be designed entirely on the basis of functional classification. Many other facets of design must also be considered, as described below.

RURAL COLLECTORS

General Design Considerations

Two-lane collector highways constitute an important part of the rural highway system. Rural collectors should be designed with the most favorable alignment and cross section practical, consistent with traffic and topography. Basic information needed for design of rural collectors includes crash history, traffic volumes, terrain, and alignment.

Design Traffic Volumes

Rural collector highways should be designed for specific traffic volumes and specified acceptable levels of service. Usually, the design year is 20 years from the date of construction completion but may be any number of years within a range from the present (for restoration projects on existing roads) to 20 years in the future (for new construction projects).

The average daily traffic (ADT) volume for the design year should serve as the basis for the project design.

Design Speed

Geometric design features should be consistent with a design speed appropriate for the conditions. Low design speeds of 70 km/h [45 mph] and below are generally applicable to highways with curvilinear alignment in rolling or mountainous terrain, or where environmental conditions dictate. High design speeds of 80 km/h [50 mph] and above are generally applicable to highways in level terrain or where other environmental conditions are favorable. Exhibit 6-1 identifies minimum design speeds for rural collector roads as a function of the type of terrain and design traffic volumes. The designer should strive for higher values than those shown where specific safety concerns are present and costs are not prohibitive.

Sight Distance

Stopping sight distance and passing sight distance are a direct function of the design speed. An eye height of 1,080 mm [3.5 ft] and an object height of 600 mm [2.0 ft] are used to determine stopping sight distance. An eye height of 1,080 mm [3.5 ft] and an object height of 1,080 mm [3.5 ft] are used to determine passing sight distance. For further information on sight distance, see Exhibits 6-2 and 6-3 and the section on “Sight Distance” in Chapter 3.

Grades

Exhibit 6-4 identifies suggested maximum grades for rural collectors in specific terrain and design conditions.

Alignment

The designer should provide the most favorable alignment as practical for rural collectors. Horizontal and vertical alignment should complement each other and should be considered in combination to achieve appropriate safety, capacity, and appearance for the type of improvement proposed. Topography, traffic volume and composition, and right-of-way conditions are controlling features. Abrupt changes in horizontal alignment should be avoided. Vertical curves should meet the sight distance criteria for the design speed. In addition, frequent opportunities for passing should be provided, where practical. For further information, see the sections on “Horizontal Alignment” and “Vertical Alignment” in Chapter 3.

Cross Slope

Pavement cross slope should be adequate to provide proper drainage. Normally, cross slopes range from 1.5 to 2 percent for high-type pavements. High-type pavements are those that retain smooth riding qualities and good non-skid properties in all weather under heavy traffic volumes and loadings with little maintenance required.

Low-type pavements are those with treated earth surfaces and those with loose aggregate surfaces. A cross slope of 3 to 7 percent is desirable for low-type pavements. For further information, see the section on “Cross Slope” in Chapter 4.

Type of terrain	Metric: Design speed (km/h) for specified design volume (veh/day)			US Customary: Design speed (mph) for specified design volume (veh/day)		
	0 to 400	400 to 2000	over 2000	0 to 400	400 to 2000	over 2000
Level	60	80	100	40	50	60
Rolling	50	60	80	30	40	50
Mountainous	30	50	60	20	30	40

Note: Where practical, design speeds higher than those shown should be considered.

Exhibit 6-1. Minimum Design Speeds for Rural Collectors

Metric: Design speed	Design stopping sight distance	Rate of vertical curvature, K[a] (m/%)		US Customary: Design speed	Design stopping sight distance	Rate of vertical curvature, K[a] (ft/%)	
(km/h)	(m)	Crest	Sag	(mph)	(ft)	Crest	Sag
20	20	1	3	15	80	3	10
30	35	2	6	20	115	7	17
40	50	4	9	25	155	12	26
50	65	7	13	30	200	19	37
60	85	11	18	35	250	29	49
70	105	17	23	40	305	44	64
80	130	26	30	45	360	61	79
90	160	39	38	50	425	84	96
100	185	52	45	55	495	114	115
				60	570	151	136

[a] Rate of vertical curvature, K, is the length of curve per percent algebraic difference in the intersecting grades; i.e., K = L/A (see Chapter 3 for details).

Exhibit 6-2. Design Controls for Stopping Sight Distance and for Crest and Sag Vertical Curves

Metric			US Customary		
Design speed (km/h)	Design passing sight distance (m)	Rate of vertical curvature, K[a] (m/%)	Design speed (mph)	Design passing sight distance (ft)	Rate of vertical curvature, K[a] (ft/%)
30	200	46	20	710	180
40	270	84	25	900	289
50	345	138	30	1090	424
60	410	195	35	1280	585
70	485	272	40	1470	772
80	540	338	45	1625	943
90	615	438	50	1835	1203
100	670	520	55	1985	1407
			60	2135	1628

[a] Rate of vertical curvature, K, is the length of curve per percent algebraic difference in the intersecting grades; i.e., K = L/A (See Chapter 3 for details).

Exhibit 6-3. Design Controls for Crest Vertical Curves Based on Passing Sight Distance

	Metric								US Customary								
	Maximum grade (%) for specified design speed (km/h)								Maximum grade (%) for specified design speed (mph)								
Type of terrain	30	40	50	60	70	80	90	100	20	25	30	35	40	45	50	55	60
Level	7	7	7	7	7	6	6	5	7	7	7	7	7	7	6	6	5
Rolling	10	10	9	8	8	7	7	6	10	10	9	9	8	8	7	7	6
Mountainous	12	11	10	10	10	9	9	8	12	11	10	10	10	10	9	9	8

Note: Short lengths of grade in rural areas, such as grades less than 150 m [500 ft] in length, one-way downgrades, and grades on low-volume rural collectors may be up to 2 percent steeper than the grades shown above.

Exhibit 6-4. Maximum Grades for Rural Collectors

Superelevation

Many rural collector highways have curvilinear alignments. A superelevation rate compatible with the design speed should be used. For rural collectors, superelevation should not exceed 12 percent. Where snow and ice conditions may be a factor, the superelevation rate should not exceed 8 percent. Superelevation runoff denotes the length of highway needed to accomplish the change in cross slope from a section with the adverse crown removed to a fully superelevated section and vice versa. Adjustments in design runoff lengths may be needed to provide a smooth ride, surface drainage, and good appearance. The section on "Horizontal Alignment" in Chapter 3 provides a detailed discussion on superelevation for appropriate design speeds.

Number of Lanes

The number of lanes should be sufficient to accommodate the design volumes for the desired level of service. Normally, capacity conditions do not govern rural collector roads, and two lanes are appropriate. For further information, see the section on "Highway Capacity" in Chapter 2.

Width of Roadway

For high-type surfaces, the minimum roadway width is the sum of the traveled way and shoulder widths shown in Exhibit 6-5. Shoulder width is measured from the edge of the traveled way to the point of intersection of shoulder slope and foreslope. Where roadside barriers are included, a minimum offset of 1.2 m [4 ft] from the traveled way to the barrier should be provided, wherever practical. For further information, see the sections on "Shoulders" and "Longitudinal Barriers" in Chapter 4 and the section in Chapter 3 on "Traveled Way Widening on Horizontal Curves" for vehicle offtracking information.

Where bicycle facilities are included as part of the design, refer to the AASHTO *Guide for the Development of Bicycle Facilities* (**2**).

Foreslopes

The maximum rate of foreslope should depend on the stability of local soils as determined by soil investigation and local experience. Slopes should be as flat as practical, taking into consideration other design constraints. Flat foreslopes improve safety by providing a maneuvering area in emergencies, are more stable than steep slopes, aid in the establishment of plant growth, and simplify maintenance work. Roadside barriers may be used where topography and right-of-way are restrictive and a need is justified.

Metric					US Customary				
Design	Minimum width of traveled way (m) for specified design volume (veh/day)[a]				Design	Minimum width of traveled way (ft) for specified design volume (veh/day)[a]			
speed (km/h)	under 400	400 to 1500	1500 to 2000	over 2000	speed (mph)	under 400	400 to 1500	1500 to 2000	over 2000
30	6.0[b]	6.0	6.6	7.2	20	20[b]	20	22	24
40	6.0[b]	6.0	6.6	7.2	25	20[b]	20	22	24
50	6.0[b]	6.0	6.6	7.2	30	20[b]	20	22	24
60	6.0[b]	6.6	6.6	7.2	35	20[b]	22	22	24
70	6.0	6.6	6.6	7.2	40	20[b]	22	22	24
80	6.0	6.6	6.6	7.2	45	20	22	22	24
90	6.6	6.6	7.2	7.2	50	20	22	22	24
100	6.6	6.6	7.2	7.2	55	22	22	24	24
					60	22	22	24	24
	Width of shoulder on each side of road (m)					Width of shoulder on each side of road (ft)			
All speeds	0.6	1.5[c]	1.8	2.4	All speeds	2.0	5.0[c]	6.0	8.0

[a] On roadways to be reconstructed, a 6.6-m [22 ft] traveled way may be retained where the alignment and safety records are satisfactory.

[b] A 5.4-m [18-ft] minimum width may be used for roadways with design volumes under 250 veh/day.

[c] Shoulder width may be reduced for design speeds greater than 50 km/h [30 mph] as long as a minimum roadway width of 9 m [30 ft] is maintained.

See text for roadside barrier and offtracking considerations.

Exhibit 6-5. Minimum Width of Traveled Way and Shoulders

Drivers who inadvertently leave the traveled way can often recover control of their vehicles if foreslopes are 1V:4H or flatter and shoulders and ditches are well rounded or otherwise made traversable. Such recoverable slopes should be provided where terrain and right-of-way conditions allow.

Where provision of recoverable slopes is not practical, the combinations of rate and height of slope provided should be such that occupants of an out-of-control vehicle have a good chance of survival. Where high fills, right-of-way restrictions, watercourses, or other problems render such designs impractical, roadside barriers should be considered, in which case the maximum rate of fill slope may be used. Reference should be made to the current edition of the AASHTO *Roadside Design Guide* (**3**). For further information, see the section on “Traffic Barriers” in Chapter 4.

Cut sections should be designed with adequate ditches. Preferably, the foreslope should not be steeper than 1V:3H and, where practical, should be 1V:4H or flatter. The ditch bottom and slopes should be well rounded, and the backslope should not exceed the maximum needed for stability.

Structures

The design of bridges, culverts, walls, tunnels, and other structures should be in accordance with the current AASHTO *Standard Specifications for Highway Bridges* (**4**), or with the AASHTO *LRFD Bridge Design Specification* (**5**). Except as otherwise indicated herein, the dimensional design of structures should also be in accordance with these standard specifications.

The minimum design loading for bridges on collector roads should be MS-18 [HS 20]. The minimum roadway widths for new and reconstructed bridges should be as shown in Exhibit 6-6.

Metric			US Customary		
Design volume (veh/day)	Minimum clear roadway width for bridges[a]	Design loading structural capacity	Design volume (veh/day)	Minimum clear roadway width for bridges[a]	Design loading structural capacity
400 and under	Traveled way + 0.6 m (each side)	MS-18	400 and under	Traveled way + 2 ft (each side)	HS-20
400 to 1500	Traveled way + 1 m (each side)	MS-18	400 to 1500	Traveled way + 3 ft (each side)	HS-20
1500 to 2000	Traveled way + 1.2 m (each side)[b]	MS-18	1500 to 2000	Traveled way + 4 ft (each side)[b]	HS-20
over 2000	Approach roadway (width)[b]	MS-18	over 2000	Approach roadway (width)[b]	HS-20

[a] Where the approach roadway width (traveled way plus shoulders) is surfaced, that surface width should be carried across the structures.

[b] For bridges in excess of 30 m [100 ft] in length, the minimum width of traveled way plus 1 m [3 ft] on each side is acceptable.

Exhibit 6-6. Minimum Roadway Widths and Design Loadings for New and Reconstructed Bridges

Bridges to Remain in Place

Because highway geometric and roadway improvements may encourage higher speeds and attract larger vehicles, existing structures also should be improved correspondingly. Because of their high cost, reasonably adequate bridges and culverts that meet tolerable criteria may be retained.

Where an existing highway is to be reconstructed, an existing bridge that fits the proposed alignment and profile may remain in place when its structural capacity in terms of design loading and roadway width are at least equal to the values shown for the applicable traffic volume in Exhibit 6-7.

The values in Exhibit 6-7 do not apply to structures with a total length greater than 30 m [100 ft]. Such structures should be analyzed individually by taking into consideration the clear width provided, crash history, traffic volumes, remaining life of the structure, design speed, and other pertinent factors.

Metric			US Customary		
Design volume (veh/day)	Design loading structural capacity	Minimum clear roadway width (m)[a]	Design volume (veh/day)	Design loading structural capacity	Minimum clear roadway width (ft)[a]
under 400	MS 13.5	6.6	under 400	H 15	22
400 to 1500	MS 13.5	6.6	400 to 1500	H 15	22
1500 to 2000	MS 13.5	7.2	1500 to 2000	H 15	24
over 2000	MS 13.5	8.4	over 2000	H 15	28

[a] Clear width between curbs or railings, whichever is less, should be equal to or greater than the approach traveled way width, wherever practical.

Exhibit 6-7. Structural Capacities and Minimum Roadway Widths for Bridges to Remain in Place

Vertical Clearance

Vertical clearance at underpasses should be at least 4.3 m [14 ft] over the entire roadway width, with an additional allowance for future resurfacing.

Horizontal Clearance to Obstructions

For rural collector roads with a design speed of 70 km/h [45 mph] or less, a minimum clear zone of 3 m [10 ft] measured from the edge of the traveled way should be provided. This recovery area should be clear of all unyielding objects such as trees, sign supports, utility poles, light poles, and other fixed objects. The benefits of removing these obstructions should be weighed against any environmental and aesthetic effects.

For rural collector roads with a design speed of 80 km/h [50 mph] or more, the AASHTO *Roadside Design Guide* (**3**) should be used for guidance in selecting an appropriate clear zone width.

The approach roadway (traveled way plus shoulders) should be carried across an overpass or bridge, where practical. Approach roadside barriers, anchored to the bridge rails or parapets, should be provided. Sidewalks should extend across a bridge if the approach roadway has sidewalks or sidewalk areas. To the extent practical, where another highway or railroad passes over the roadway, the overpass structure should be designed so that the pier or abutment supports have lateral clearance as great as the clear zone on the approach roadway. Where a setback beyond the clear zone is not practical, roadside barrier protection should be provided at the piers.

Right-of-Way Width

The provision of right-of-way widths that accommodate construction, adequate drainage, and proper maintenance of a highway is an important part of the overall design. Wide rights-of-way permit the construction of gentle slopes, resulting in greater safety for the motorist and provide for easier and more economical maintenance. The acquisition of sufficient right-of-way, at the time of initial construction, permits subsequent widening of the roadway and the widening and strengthening of the pavement at a reasonable cost as traffic volumes increase.

In developed areas it may be desirable to limit the right-of-way width. However, the right-of-way width should not be less than that needed for all elements of the design cross section, utility accommodation, and appropriate border areas.

Intersection Design

Intersections should be carefully located to avoid steep profile grades and to ensure adequate approach sight distance. An intersection should not be situated just beyond a sharp crest vertical curve or on a sharp horizontal curve. Where there is no practical alternative to such a location, the approach sight distance on each leg should be checked and, where practical, backslopes should be flattened and horizontal or vertical curves lengthened, to provide additional sight distance. The driver of a vehicle approaching an intersection should have an unobstructed view of the entire intersection and sufficient lengths of the intersecting roadway to permit the driver to anticipate and avoid potential collisions. Sight distances at intersections with six different types of traffic control cases are presented in Chapter 9.

Intersections should be designed with a corner radius for pavement or surfacing adequate for the larger vehicles anticipated; for information on minimum edge radius, see Chapter 9. Where turning volumes are substantial speed-change lanes and channelization should be considered.

Intersection legs that operate under stop sign control should intersect at right angles, wherever practical, and should not intersect at an angle less than 60 degrees. For more information on intersection angle, see Chapter 9.

A stopping area that is as level as practical should be provided for approaches on which vehicles may be required to stop.

Railroad-Highway Grade Crossings

Appropriate grade crossing warning devices should be installed at all railroad-highway grade crossings on collector roads and streets. Details of the devices to be used are given in the *Manual on Uniform Traffic Control Devices* (MUTCD) (**6**). In some states, the final approval of these devices may be vested in an agency having oversight over railroads.

Sight distance is an important consideration at railroad-highway grade crossings. There should be sufficient sight distance along the road for an approaching driver to recognize the railroad crossing, perceive the warning device, determine whether a train is approaching, and stop if necessary. Adequate sight distance along the track is needed for drivers of stopped vehicles to decide when it is safe to proceed across the tracks. For further information on railroad-highway grade crossings, see Chapter 9.

The roadway width at railroad crossings should be the same as the width of the approach roadway. Crossings that are located on bicycle routes that are not perpendicular to the railroad may need additional paved shoulder width for bicycles to maneuver over the crossing. For further information, see the AASHTO *Guide for the Development of Bicycle Facilities* (**2**).

Traffic Control Devices

Traffic control devices should be applied consistently and uniformly. Details of the standard traffic control devices and warrants for various conditions are found in the MUTCD (**6**). Geometric design of rural collectors should include full consideration of the types of traffic control to be used, especially at intersections where multi-phase or actuated traffic signals are likely to be needed. For further information, see the section on "Traffic Control Devices" in Chapter 3.

Erosion Control

Design of rural collectors should consider preservation of the natural ground cover and desirable growth of shrubs and trees within the right-of-way. Shrubs, trees, and other vegetation should be considered in assessing the driver's sight line and the clear recovery distance. Seeding, mulching, sodding, or other acceptable measures for covering slopes, swales, and other erodible areas should also be considered in the rural collector design. For further information, see the section on "Erosion Control and Landscape Development" in Chapter 3.

URBAN COLLECTORS

General Design Considerations

A collector street is a public facility for vehicular travel and includes the entire area within the right-of-way. The urban collector street also serves bicycle and pedestrian traffic and often accommodates public utility facilities within the right-of-way. The development or improvement of streets should be based on a functional street classification established as part of a comprehensive community development plan. The design criteria should be those for the ultimate planned development. Design criteria for collector streets should exceed those shown below, where practical.

The function of urban collectors is equally divided between mobility and access. Few cities have effective access control restrictions along collector streets; almost all such streets permit access to abutting properties, except where access rights have been acquired. Many new collectors are planned and constructed with little or no access restriction. However, uncontrolled access may eventually result in the obsolescence of a collector facility. Therefore, management of driveway access to urban collectors is desirable.

When a major objective of the design is to expedite traffic mobility, there are many additional criteria for which guidelines are appropriate. Such criteria include minimizing conflict points, providing adequate storage length for all turning movements, minimizing conflicts with pedestrians and bicyclists, coordinating driveway locations on opposite sides of the roadway, locating signals to meet progression needs, and maintaining efficient circulation while providing adequate ingress and egress capacity. By using these design criteria, an optimum system of access can be developed.

Access control on urban collector streets should be used primarily to ensure that access points conform to the adopted criteria for safety, location, design, construction, and maintenance.

Design Traffic Volumes

Traffic volumes are a major factor in determining the geometric criteria to be used in designing urban collector streets. Specifically, the design traffic volumes projected to some future design year should be the basis of design. It usually is difficult and costly to modify the geometric design of an existing collector street unless provisions are made at the time of initial construction. The design traffic should be estimated for at least 10 and preferably 20 years from the anticipated completion of construction.

Design Speed

Design speed is a factor in the design of collector streets. For consistency in design, a design speed of 50 km/h [30 mph] or higher should be used for urban collector streets, depending on available right-of-way, terrain, adjacent development, likely pedestrian presence, and other site controls. See Exhibit 6-1 and the section on "Design Speed" in Chapter 2 for additional information.

In the typical urban street grid, closely spaced intersections often limit vehicular speeds and thus make the consideration of design speed of lesser significance. Nevertheless, the longer sight distances and curve radii commensurate with higher design speeds result in safer highways and should be used to the extent practical.

Sight Distance

Stopping sight distance for urban collector streets varies with design speed. Design for passing sight distance seldom is applicable on urban collector streets. For further information, see Exhibits 6-2 and 6-3 and the section on "Sight Distance" in Chapter 3.

Grades

Grades for urban collector streets should be as level as practical, consistent with the surrounding terrain. A minimum grade of 0.30 percent is acceptable to facilitate drainage. However, it is recommended that a grade of 0.50 percent grade or more be used, where practical, for drainage purposes. Where adjacent sidewalks are present, a maximum grade of 5 percent is recommended to meet the *Americans with Disabilities Act Accessibility Guidelines* (ADAAG) and other applicable criteria, where terrain conditions permit (**7**, **8**). The grade of an urban street is generally depressed below the surrounding terrain to direct drainage from adjacent property to the curb area so that it can reach the storm drain system. Applicable gradients, vertical curve lengths, and other pertinent features are discussed in the section on "Vertical Alignment" in Chapter 3. Maximum grades for urban collector streets should be as presented in Exhibit 6-8.

Alignment

Alignment in residential areas should fit closely the existing topography to minimize the need for cuts or fills without sacrificing safety.

Cross Slope

Pavement cross slope should be adequate to provide proper drainage. Cross slope should normally be from 1.5 to 3 percent where there are flush shoulders adjacent to the traveled way or where there are outer curbs.

Superelevation

Superelevation, in specific locations, may be advantageous for urban collector street traffic operation. However, in built-up areas, the combination of wide pavement areas, proximity of adjacent development, control of cross slope, profile for drainage, frequency of cross streets, and other urban features often combine to make its use impractical or undesirable. Where used, superelevation on urban collector streets should be 6 percent or less. The absence of superelevation on urban collectors for low speeds of 70 km/h [45 mph] and below generally is not detrimental to the motorist. Often, some warping or partial removal or reversal of the tangent pavement crown may facilitate operations. When warping or removing the pavement crown, drainage should be considered. For further information, see the sections on "Horizontal Alignment" and "Design for Low-Speed Urban Streets" in Chapter 3.

	Metric								US Customary								
	Maximum grade (%) for specified design speed (km/h)								Maximum grade (%) for specified design speed (mph)								
Type of terrain	30	40	50	60	70	80	90	100	20	25	30	35	40	45	50	55	60
Level	9	9	9	9	8	7	7	6	9	9	9	9	9	8	7	7	6
Rolling	12	12	11	10	9	8	8	7	12	12	11	10	10	9	8	8	7
Mountainous	14	13	12	12	11	10	10	9	14	13	12	12	12	11	10	10	9

Note: Short lengths of grade in urban areas, such as grades less than 150 m [500 ft] in length, one-way downgrades, and grades on low-volume urban collectors may be up to 2 percent steeper than the grades shown above.

Exhibit 6-8. Maximum Grades for Urban Collectors

Number of Lanes

Two moving traffic lanes plus additional width for shoulders and parking are sufficient for most urban collector streets. Where the street is developed in stages, initially a rural cross section with shoulders may be used. The street should be planned for later conversion of the shoulder width to a parking lane or a through lane, usually with outer curbs. Where the initial development utilizes a rural cross section, a clear zone consistent with rural conditions and commensurate with the design speed should be provided. When the conversion of the shoulder occurs, the clear zone can be modified to that appropriate for urban conditions. If practical and economically feasible, the initial construction should be four lanes with curbs, allowing parking on the two outer lanes until later development necessitates the use of all four lanes for traffic movement.

In some cases, in commercial areas where there are mid-block left turns, it may be advantageous to provide an additional continuous two-way left-turn lane in the center of the roadway.

The number of lanes to be provided on urban collector streets with high traffic volumes should be determined from a capacity analysis. This analysis should consider both intersections and mid-block locations, when appropriate, in assessing the ability of a proposed design to provide the desired level of service. Such analyses should be made for the future design year traffic volume utilizing the procedures in the most recent edition of the *Highway Capacity Manual* (**1**). For further information, see the section on “Highway Capacity” in Chapter 2.

Width of Roadway

The width of an urban collector street should be planned as the sum of the widths of the ultimate lanes for moving traffic, parking, and bicycles, including median width where appropriate.

Lanes within the traveled way should range in width from 3.0 to 3.6 m [10 to 12 ft]. In industrial areas, lanes should be 3.6 m [12 ft] wide except where lack of space for right-of-way imposes severe limitations; in such cases, lane widths of 3.3 m [11 ft] may be used. Added turning lanes at intersections, where used, should range in width from 3.0 to 3.6 m [10 to 12 ft], depending on the percentage of trucks. Where shoulders are used, roadway widths should be determined by referring to Exhibit 6-5.

Where bicycle facilities are included as part of the design, refer to the AASHTO *Guide for the Development of Bicycle Facilities* (**2**).

Parking Lanes

Although on-street parking may constitute a safety problem and may impede traffic flow, provision of parking lanes parallel to the curb is conventional on many collector streets. Parallel parking is normally acceptable on urban collectors where sufficient street width is available to provide a parking lane. In residential areas, a parallel parking lane from 2.1 to 2.4 m [7 to 8 ft] in width should be provided on one or both sides of the street, as appropriate for the lot size and density of development. In commercial and industrial areas, parking lane widths should range from 2.4 to 3.3 m [8 to 11 ft] and are usually provided on both sides of the street.

The principal problem of diagonal or angle parking, in comparison to parallel parking, is the lack of adequate visibility for the driver during the back-out maneuver. Collector street designs with diagonal or angle parking should only be considered in special cases. ADA guidelines concerning parking should be taken into consideration (**7, 8**). For further information, see the section concerning “On-Street Parking” in Chapter 4.

The determination of parking lane width should consider the appropriate width for any likely future use as a lane for moving traffic either continuously or during peak hours. Where curb-and-gutter sections are used, the gutter pan width may be considered as part of the parking lane width, but, where practical, the parking lane widths discussed above should be in addition to the gutter pan width.

Medians

Urban collector streets designed for four or more lanes should include width for an appropriate median treatment, where practical. For general types of median treatments for collector streets, the following widths may be considered: (1) paint-striped separation, 0.6 to 1.2 m [2 to 4 ft] wide; (2) narrow raised-curbed sections, 0.6 to 1.8 m [2 to 6 ft] wide; (3) raised curbed sections, 3.0 to 4.8 m [10 to 16 ft] wide, providing space for left-turn lanes; (4) paint-striped sections, 3.0 to 4.8 m [10 to 16 ft] wide, providing space for two-way left-turn lanes; and (5) raised-curb sections, 5.4 to 7.6 m [18 to 25 ft] wide to provide more space for left-turn lanes and for passenger cars to stop in median crossovers. Wider medians from 8 to 12 m [27 to 40 ft] may be used for a parkway design where space is available for landscaping. Thus, each increment in additional median width provides specific operational advantages. Median should be as wide as practical within the constraints of each particular site.

On urban collector streets with raised-curb medians, openings should be provided only at intersections with other streets and at reasonably spaced driveways serving major traffic generators such as industrial plants and shopping centers. Where practical, median openings should be designed to include left-turn lanes.

Median openings should be situated only where there is adequate sight distance. The shape and length of the median openings depend on the width of the median and the vehicle types that are to be accommodated. The minimum length of median openings should be that of the projected roadway width of the intersecting cross street or driveway. Desirably, the length of median openings should be great enough to provide a 15-m [50-ft] turning radius or the turning radius for the design vehicle for left-turning vehicles between the inner edge of the lane adjacent to the median and the centerline of the intersection roadway.

On many urban collectors it may be impractical to use a raised-curb median. A continuous center two-way left-turn lane, flush with the adjacent traveled way, is an alternative design that may also be considered. A further discussion on medians is found in the section on "Medians" in Chapter 4 and the section on "Median Openings" in Chapter 9.

Curbs

Collector streets normally are designed with curbs to allow greater use of available width and for control of drainage, protection of pedestrians, and delineation. The curb on the right side of the traveled way should be a vertical curb, 150 mm [6 in] high, usually with an appropriate batter. On lightly traveled residential streets with grades less than 2 percent, a sloping curb that is lower and does not require modification at driveway entrances may be used. The curb slope should be 1V:6H or flatter.

On divided streets, the type of median curbs should be determined in conjunction with the median width and the type of turning movement control to be provided. Where mid-block left-turn movements are permitted and the median width is less than 3 m [10 ft], a well-delineated flush or rounded raised median separator 50 to 100 mm [2 to 4 in] high is effective in channelizing traffic and in avoiding excessive travel distances and concentrations of turns at intersections. Where wider traversable medians are appropriate, they may be either flush or bordered with low curbs 25 to 50 mm [1 to 2 in] high. On narrow and intermediate-width medians, and on some wide medians, where cross-median movements are undesirable or create problems, a vertical curb should be used on the median side of the traveled way, usually 150 mm [6 in] high and with an appropriate batter. A median barrier should be used where positive separation of opposing traffic is essential, where there is no need for pedestrian crossings, and where local regulations permit. For further information, see the section on "Curbs" in Chapter 4.

Vertical curbs with heights of 150 mm [6 in] or more, adjacent to the traveled way, should be offset by 0.3 to 0.6 m [1 to 2 ft] from the edge of the traveled way. Where there is combination curb-and-gutter construction, the gutter pan width, which is normally 0.3 to 0.6 m [1 to 2 ft], may provide the offset distance.

Drainage

Surface runoff is gathered by a system of gutters, inlets, catch basins, and storm sewers. The gutter grade should be 0.3 percent or more. However, a gutter grade of 0.5 percent or more should be used, where practical, for better drainage. Inlets or catch basins with an open grate should be located in the gutter line and should be so spaced that ponding of water on the pavement does not exceed tolerable limits. In addition, grates should be designed to accommodate bicycle and pedestrian traffic. For additional details, see the drainage portions of Chapters 3 and 4.

Sidewalks

Sidewalks should be provided along both sides of urban collector streets that are used for pedestrian access to schools, parks, shopping areas, and transit stops and along all collectors in commercial areas. In residential areas, sidewalks are desirable on both sides of collector streets, but should be provided on at least one side. The sidewalk should be situated as far as practical from the traveled way, usually close to the right-of-way line. For further information, see the section on "Sidewalks" in Chapter 4. Additional design guidance on sidewalks can also be found in the AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities* (**9**).

The minimum sidewalk width should be at least 1.2 m [4 ft] in residential areas and should range from 1.2 to 2.4 m [4 to 8 ft] in commercial areas. Sidewalk widths of at least 1.5 m [5 ft] are recommended by the ADAAG (**7, 8**).

Sidewalk curb ramps should be provided at crosswalks to accommodate persons with disabilities. The section on "Pedestrian Facilities" in Chapter 4 discusses various design applications at such ramps.

Driveways

Driveways should be regulated as to width of entrance, placement with respect to property lines and intersecting streets, angle of entrance, vertical alignment, and number of entrances to a single property. ADA guidelines should be considered in the design of driveways (**6, 7**). Further guidance on the design of sidewalk-driveway interfaces can be found in the AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities* (**9**).

Roadway Widths for Bridges

The clear width for all new bridges on urban collector streets with curbed approaches should be the same as the curb-to-curb width of the approaches. The bridge rail should be placed flush with the front face of the curb if no sidewalk is present to minimize the likelihood that vehicles will vault the rail. For urban collector streets with shoulders and no curbs, the full width of approach roadways should preferably be extended across bridges. Sidewalks on the approaches should be extended across all new structures. In addition, a sidewalk should be included on at least one side on all bridges on collector streets. Further discussion of roadway widths for bridges is presented in the section on "Traffic Barriers" in Chapter 4. Exhibits 6-6 and 6-7 apply to bridge widths on urban collector streets.

Vertical Clearance

Vertical clearance at underpasses should be at least 4.3 m [14 ft] over the entire roadway width, with an additional allowance for future resurfacing.

Horizontal Clearance to Obstructions

Roadside obstructions on urban collector streets should preferably be located at or near the right-of-way line and outside of the sidewalks. On urban collector streets that have curbs but no shoulders, a clearance of 0.5 m [1.5 ft] or more beyond the face of the curb should be provided to roadside obstructions, where practical. Where a continuous parking lane is provided, no clearance is needed, but a setback of 0.5 m [1.5 ft] to obstructions is desirable to avoid interference with opening car doors. In areas of dense pedestrian traffic, the provision of vertical curbing between the traveled way and adjacent street fixtures will discourage drivers from encroaching on the sidewalk. Urban collector streets with shoulders and without curbs should have clear zones, as described previously for rural collectors.

Roadside obstacles, such as trees, that might seriously damage out-of-control vehicles should be removed wherever practical. However, the potential benefits of removing such obstacles should be weighed against the adverse environmental and aesthetic effects of their removal. Therefore, trees should be removed only when considered essential for safety. However, it may only be practical to remove those fixed objects in very vulnerable locations. For further information, see the section on "Horizontal Clearance to Obstructions" in Chapter 4.

A wide and level border area should be provided along collector streets for the safety of the motorist and pedestrian, as well as for aesthetic reasons. However, the preservation and enhancement of the environment are of major importance in the design and construction of collector streets and may preclude provision of a border area. The street alignment should be selected to minimize cut and fill slopes.

Roadside barriers are not used extensively on urban collector streets except where there are safety concerns or environmental considerations such as along sections with steep foreslopes and at approaches to structures. Roadside barriers may also be needed to shield vehicles from over-crossing structures.

Right-of-Way Width

The right-of-way width should be sufficient to accommodate the ultimate planned roadway, including median, shoulder, grass border, sidewalks, bicycle facilities, public utilities, and outer slopes. The width of right-of-way for a two-lane urban collector street should generally range from 12 to 18 m [40 to 60 ft], depending on the conditions listed above.

Provision for Utilities

In addition to the primary purpose of serving vehicular traffic, urban collector streets may accommodate public utility facilities within the street right-of-way in accordance with state law or municipal ordinance. Use of the right-of-way by utilities should be planned to minimize interference with traffic using the street. The AASHTO *Guide for Accommodating Utilities Within Highway Right-of-Way* (**10**) presents general principles for utility location and construction to minimize conflicts between the use of the street right-of-way for vehicular movements and the secondary objective of providing space for locating utilities.

Border Area

The border area between the roadway and the right-of-way line should be wide enough to serve several purposes, including the provision of a buffer space between pedestrians, bicyclists, and vehicular traffic; a sidewalk; and an area for underground and above-ground utilities such as traffic signals, parking meters, and fire hydrants. A portion of the border area should accommodate snow storage and may include aesthetic features such as grass or landscaping. The border width should range from 2.4 to 3.3 m [8 to 11 ft], including the sidewalk width. For safety reasons, traffic signals, utility poles, fire hydrants, and other utilities should be placed as far back from the curb as practical. Breakaway features may be built into such obstacles, where practical, as an aid to safety.

Intersection Design

The pattern of traffic movements at intersections and the volume of traffic on each approach during one or more peak periods of the day, including pedestrian and bicycle traffic, are indicative of the appropriate type of traffic control devices, the widths of lanes (including auxiliary lanes), and where applicable, the type and extent of channelization needed to expedite the movement of traffic. The arrangement of islands and the shape and length of auxiliary lanes may differ depending on whether or not signal control is used. The composition and character of traffic is a design control; movements involving large trucks need larger intersection areas and flatter approach grades than those used at intersections where traffic consists predominantly of passenger cars. Bus stops located near an intersection may create a need for additional modification to the intersection design. Approach speeds of traffic also have a bearing on the geometric design as well as on the appropriate traffic control devices and pavement markings. For further information, see the section on "Traffic Control Devices" in Chapter 3.

The number and location of approach roadways and their angles of intersection are major controls for the intersection geometric design, the location of islands, and the types of control devices. Intersections at grade preferably should be limited to no more than four approach legs. When two crossroads intersect the collector highway in close proximity, they should be combined into a single intersection.

Important design considerations for at-grade intersections fall into two major categories: the geometric design of the intersection (including a capacity analysis) and the location and type of traffic control devices. For the most part, these considerations are applicable to both new and existing intersections although, for existing intersections in built-up areas, heavy development may make extensive design changes impractical.

Chapter 9 presents a discussion of all major aspects of intersection design.

Railroad-Highway Grade Crossings

Appropriate grade crossing warning devices should be installed at all railroad-highway grade crossings on collector streets. Details of these devices are given in the MUTCD (**6**). In some states, the final approval of these devices may be vested in an agency having oversight over railroads.

Sight distance is an important consideration at railroad-highway grade crossings on collector streets. There should be sufficient sight distance along the street for the approaching driver to recognize the railroad crossing, perceive the warning device, determine whether a train is approaching, and stop if necessary. Adequate sight distance along the tracks is also needed for drivers of stopped vehicles to decide when it is safe to proceed across the tracks.

The roadway width at all crossings should be the same as the curb-to-curb width of the approaches. Where street sections are not curbed, the crossing width should be consistent with the approach street and shoulder widths. Sidewalks should be provided at railroad crossings where approach sidewalks exist or are planned within the near future. Provisions for future sidewalks should be incorporated into design, if they can be anticipated, to avoid future crossing work on the railroad facility.

Crossings that are located on bicycle routes that are not perpendicular to the railroad may need additional paved shoulder width for bicycles to maneuver over the crossing. For further information, see the AASHTO *Guide for the Development of Bicycle Facilities* (**2**).

The design of railroad-highway grade crossings is discussed more fully in Chapter 9.

Street and Roadway Lighting

Good visibility under both day and night conditions is fundamental to enabling motorists, pedestrians, and bicyclists to travel on roadways in a safe and coordinated manner. Properly designed and maintained street lighting should provide comfortable and accurate night visibility, which should facilitate vehicular, bicycle, and pedestrian traffic.

Decisions concerning appropriate street lighting should be coordinated with safety management, crime prevention, and other community concerns. The AASHTO publication *An Informational Guide for Roadway Lighting* (**11**) provides discussion on street and roadway lighting. Further information is also provided in the section on "Lighting" in Chapter 3.

Traffic Control Devices

Traffic control devices should be applied consistently and uniformly. Details of the standard devices and warrants for many conditions are found in the MUTCD (**6**).

Geometric design of streets should include full consideration of the types of traffic control to be used, especially at intersections where multi-phase or actuated traffic signals are likely to be needed. Signal progression, signal phasing (including pedestrian and bicycle phases), and traffic flow rates are important considerations in major signalized intersection design. For further information, see the section on "Traffic Control Devices" in Chapter 3.

Erosion Control

Design of streets should consider preservation of natural ground cover and desirable growth of shrubs and trees within the right-of-way. Seeding, mulching, sodding, or other acceptable measures for covering slopes, swales, and other erodible areas should also be considered in urban collector street design. For further information, see the section on "Erosion Control and Landscape Development" in Chapter 3.

Landscaping

Landscaping should be provided in keeping with the character of the street and its environment for both aesthetic and erosion control purposes. Landscape designs should be arranged to permit a sufficiently wide, clear, and safe pedestrian walkway. The needs of individuals with disabilities, bicyclists, and pedestrians should be considered. Combinations of turf, shrubs, and trees should be considered in continuous border areas along the roadway. However, care should be exercised to ensure that sight distances and guidelines on clearance to obstructions are observed, especially at intersections. The roadside should be developed to serve both the community and the traveling motorist. Landscaping should also consider maintenance problems and costs, future sidewalks, utilities, additional lanes, and possible bicycle facilities. For further information on landscaping, see the AASHTO *Guide for Transportation Landscape and Environmental Design* (**12**).

REFERENCES

1. Transportation Research Board. *Highway Capacity Manual*, Fourth Edition, Washington, D.C.: Transportation Research Board, 2000 or most current edition.
2. AASHTO. *Guide for the Development of Bicycle Facilities*, Washington, D.C.: AASHTO, 1999.
3. AASHTO. *Roadside Design Guide*, Washington, D.C.: AASHTO, 1996.
4. AASHTO. *Standard Specifications for Highway Bridges*, Washington, D.C.: AASHTO, 1996.
5. AASHTO. *LRFD Bridge Design Specification,* second edition, Washington, D.C.: AASHTO, 1998.
6. U.S. Department of Transportation, Federal Highway Administration. *Manual on Uniform Traffic Control Devices for Streets and Highways*, Washington, D.C.: 1988 or most current edition.

7. Architectural and Transportation Barriers Compliance Board (Access Board). *Americans with Disabilities Act Accessibility Guidelines* (ADAAG), Washington, D.C.: July 1994 or most current edition.
8. UFAS. Uniform Federal Accessibility Standards, most current edition.
9. AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, Washington, D.C.: AASHTO, forthcoming.
10. AASHTO. *Guide for Accommodating Utilities Within Highway Right-of-Way*, Washington, D.C.: AASHTO, 1994.
11. AASHTO. *An Informational Guide for Roadway Lighting*, Washington, D.C.: AASHTO, 1985.
12. AASHTO. *A Guide for Transportation Landscape and Environmental Design,* Washington, D.C.: AASHTO, 1991.
13. U.S. Department of Transportation, Federal Highway Administration. HEC 12. *Drainage of Highway Pavements*, FHWA-15-84-202. Washington, D.C.: Office of Engineering, Bridge Division, 1984.
14. Schoppert, D. W., and D. W. Hoyt. *Factors Influencing Safety at Highway-Rail Grade Crossings*, NCHRP Report 50, Washington, D.C.: Highway Research Board, 1968.
15. American Society of Civil Engineers, National Association of Home Builders, and the Urban Land Institute. *Residential Streets*, Washington, D.C.: American Society of Civil Engineers, 1974.
16. JHK and Associates. *Design of Urban Streets*, prepared for the U.S. Department of Transportation, Federal Highway Administration, Washington, D.C.: 1980.
17. Zegeer, C. V., R. Stewart, F. M. Council, and T. R. Neuman. *Roadway Widths for Low-Traffic Volume Roads*, NCHRP Report 362, Transportation Research Board, 1994.