



5C-2 Urban Geometric Design Criteria

The following considerations shall be used as a guide when designing arterial, collector and local streets (see Tables 1 to 5 for summary):

A. Adjacent land use and access control

1. Transitional Facilities are highways approaching or within urban areas that normally have design speeds between 45 and 55 mph.

Curbs are not desirable on transitional facilities since the design speeds are greater than 40 mph. However, when determining whether curbs should be used on transitional roadways the designer should also consider the best way to handle drainage, the need for access control, the degree of property development, and the presence of pedestrian traffic.

If curbs are being used on transitional roadways, the following guidelines apply:

- If the design speed is 40 mph or below, a 6-inch standard curb should be used. An option to a 6-inch curb would be an 8-inch curb when design speeds are 40 mph or below. The normal offset to the face of the curb is 2 feet. This offset should apply to both the median and outside curbs.
 - If the design speed is 45 mph or above, a 6-inch sloped curb should be used. The normal offset to the bottom edge of the sloped curb is 2 feet. This offset should apply to both the median and outside curbs.
 - Curbs for stop sign islands should match the design of the curb used on the mainline.
2. Reduced-Speed Urban Facilities are reduced-speed urban roadways (design speeds of 40 mph or less) with a 6-inch standard curb used for controlling surface drainage and access. The design provides at least a 2-foot offset to the face of the curb. This offset applies to the outside curb only. No offset is required to the median curb.
 3. Commercial and Industrial Areas are highly developed regions generally defined by commercial and industrial zoning districts where factories, office buildings, strip malls and shopping centers are or will be located.
 4. Fringe or Residential Areas are regions generally defined by residential or multi-family zoning districts where single-family houses, apartment buildings, condominium complexes and townhome developments are located. Fringe areas are regions located between rural areas and residential or commercial developments and are characterized by widely spaced and dispersed structures generally surrounding a municipality.
 5. Rural Areas generally are characterized by wide spaces and agriculturally oriented structures.

B. Design speed

A design speed will be used in establishing the geometric features for streets such as the critical length of grade, vertical and horizontal curves, intersections, curbs, etc.

Horizontal alignment design speed shall be consistent with the requirement for vertical alignment design speed. Design speed should be equal to or greater than posted speed. Generally, the design speed should be the posted speed plus 5 miles per hour.

C. Traffic capacity

1. **Design year traffic.** Defines the average daily traffic volumes (ADT) for roadway design that are expected to be generated during some future design year; minimum of 20 years from the date of construction completion. The range of volumes shown on 5C-1, Tables 4 and 5 (collectors and local streets) are guidelines only and may differ from projected or actual volumes. The design year traffic for arterial streets is based upon the Level of Service.
2. **Level of service (LOS).** Level of service (LOS) is a measure of the operating conditions of a roadway facility. LOS is based upon traffic performance related to speed, travel time, freedom to maneuver, traffic interruptions, and comfort and convenience. The LOS range from A (least congested) to F (most congested). Refer to the Highway Capacity Manual for a more thorough discussion of the LOS concept.

D. Desirable access spacing

The design and operation of urban streets includes the important considerations of access to abutting property and to intersecting streets. Along the margin of the street, driveways can be provided for commercial, industrial and residential property. At intersecting streets, access can be fully or partially restricted through use of traffic control devices and channelization. Major access points shall generally be located across from streets or other major accesses. The principal reason for placing controls on access along the edge of urban streets is to protect the functional integrity of the arterial or collector, and to a lesser extent the local street. Both safety and capacity of the urban street are affected by access points. Consideration by the Jurisdiction regarding access control should be made during the planning of the facilities in place of after the access becomes a problem.

See Section 5C-1, Tables 1 through 2 for recommended access spacing policy on major arterial roadways. For minor arterials, collectors and local street access, see Section 5H (Access Management).

E. Number of lanes

Defines the actual number of lanes for through traffic based on highway capacity. Additional lanes may be required for speed change, adding or dropping lanes.

1. **Capacity.** The 2000 Highway Capacity Manual and the 2001 AASHTO "Green Book" should be used in the design of the roadway to determine the number of lanes and intersection configuration at the desired LOS. As a broad evaluation and without the details of the roadway, the capacities of two lane highways, four-way stop conditions, and signalized intersections are provided from referenced documents. These values are provided as planning tools and should not be used in the detail design of the streets and highways. For example, the Des Moines Area Metropolitan Planning Organization has set some daily capacities for the LOS "D." (See Table 2)

Table 1: Planning capacity of two lane highways

a. Maximum ADT vs. LOS and type of terrain

Terrain	LOS		
	B	C	D
Level	3200 - 4800	5300 - 7900	9000 -13500
Rolling	1800 - 2800	3500 - 5200	5300 - 8000
Hilly	900 - 1300	1600 - 2400	2500 - 3700

b. Reduced capacity of narrow lanes with restricted lateral clearance

Usable shoulder width or clearance to obstruction (ft.)	Two Lane Roadway (Percent of Capacity of 12-ft. Lane)		
	12 ft. lanes	11 ft. lanes	10 ft. lanes
6	100	93	84
4	92	85	77
2	81	75	68
0	70	65	58

Table 2: Planning capacity at LOS "C" and "D"
Two way arterial streets (non-intersection)

Number of Lanes	Turn Lanes	Access Condition (side friction)			
		Minimal	Light (Residential)	Moderate (Mixed Zoning)	Heavy
		(VPD) C/D Capacity	(VPD) C/D Capacity	(VPD) C/D Capacity	(VPD) C/D Capacity
2 Lanes Undivided	Without turn lanes (2 lane div. w/o turn lanes)	10,700/ 12,900	10,000/ 12,000	9,100/ 10,900	7,500/ 9,000
	With left turn lanes (2 lane div. with turn lanes) (3 lane two-way unbalanced) (3 lane with center turn lane)	12,500/ 15,000	11,600/ 14,000	10,800/ 13,000	9,100/ 11,000
4 Lanes Undivided	Without turn lanes	20,700/ 24,900	19,800/ 23,900	19,100/ 23,000	15,800/ 19,000
	With left turn lanes (5 lane with center turn lane)	24,700/ 29,800	23,200/ 27,900	21,500/ 25,900	18,300/ 22,000
4 Lanes Divided	Without turn lanes	22,400/ 27,000	21,400/ 25,800	20,800/ 25,000	16,600/ 20,000
	With left turn lanes	25,700/ 31,000	24,100/ 29,000	23,200/ 28,000	19,900/ 24,000
	With left and right turn lanes (With left and right turn lanes and frontage roads)	27,400/ 33,000	25,700/ 31,000	24,900/ 30,000	21,600/ 26,000
LOS "C" equal to a V/C $\leq$.83					

Table 3: Approximate LOS "C" service volumes (VPH) for four-way stop-controlled intersections (sum of all four legs)

Demand Split	Two Lanes on Each Street	Street 1: Two Lanes Street 2: Four Lanes	Four Lanes on Each Street
50/50	1200	1800	2200
55/45	1140	1720	2070
60/40	1080	1660	1970
65/35	1010	1630	1880
70/30	960	1610	1820

Table 4: Capacity criteria for planning analysis of signalized intersections

Critical Volume for Intersection, VPH*	Relationship to Probable Capacity
0 to 1,200	Under Capacity
1,201 to 1,400	Near Capacity
$\geq$ 1,401	Over Capacity
* (sum of all turning volumes & max. single lane volumes)	

As capacity cannot be precisely defined when signal design and the details of geometric and traffic conditions are not fully defined, the results of planning analysis are general determinations of the probable traffic conditions at the intersection.

The critical volume for the north-south street is the largest sum among:

NB left-turn volume plus the maximum single-lane volume for the SB through plus right-turn movement, or SB left-turn volume plus the maximum single-lane volume for the NB through plus right-turn movement.

Similarly, the critical volume for the east-west street is the greatest sum among:

EB left-turn volume plus the maximum single-lane volume for the WB through plus right-turn movement, or WB left-turn volume plus the maximum single-lane volume for the EB through plus right-turn movement.

The total critical volume for the intersection is the sum of the critical volumes for the north-south and east-west streets.

2. **Dropping, adding lanes, or redirecting through lanes.** An additional through lane shall be developed with a 15:1 taper ratio. When dropping a lane, the minimum taper ratio to be used shall be determined by the following formula:

$L = SW$ for velocities of 45 mph or more.

$L = \frac{WS^2}{60}$ for velocities of 40 mph or less.

L = Minimum length of taper.

S = Numerical value of posted speed limit or 85th percentile speed.

W = Width of pavement to be dropped or redirection offset.

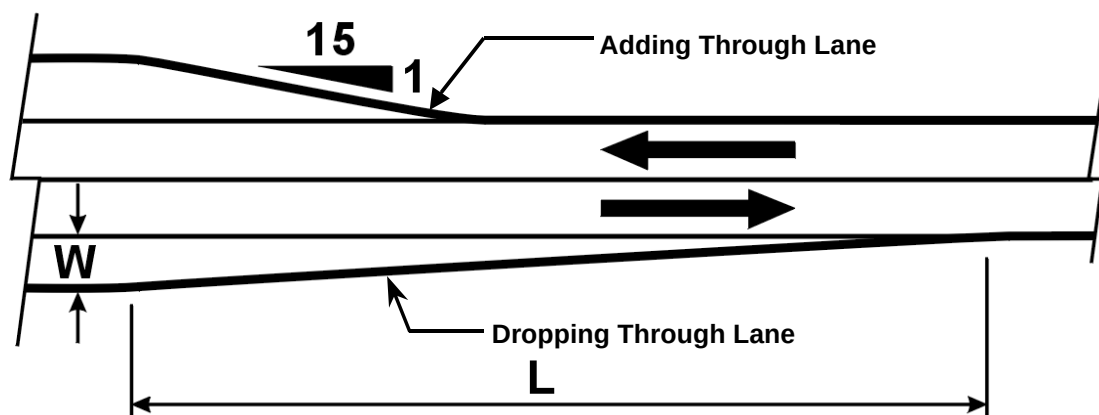
Preferably, taper ratios should be evenly divisible by 5. Calculations that result in odd ratios should be rounded up to the next increment of 5. The table below utilizes the formulas to determine the appropriate taper ratio for dropping a 12-foot wide lane. The ratio remains constant for a given design speed while the length varies with the pavement width.

The procedure for determining minimum taper ratios for redirecting through lanes is the same as for lane drops except for design speeds over 45 mph, the use of reverse curves rather than tapers is recommended.

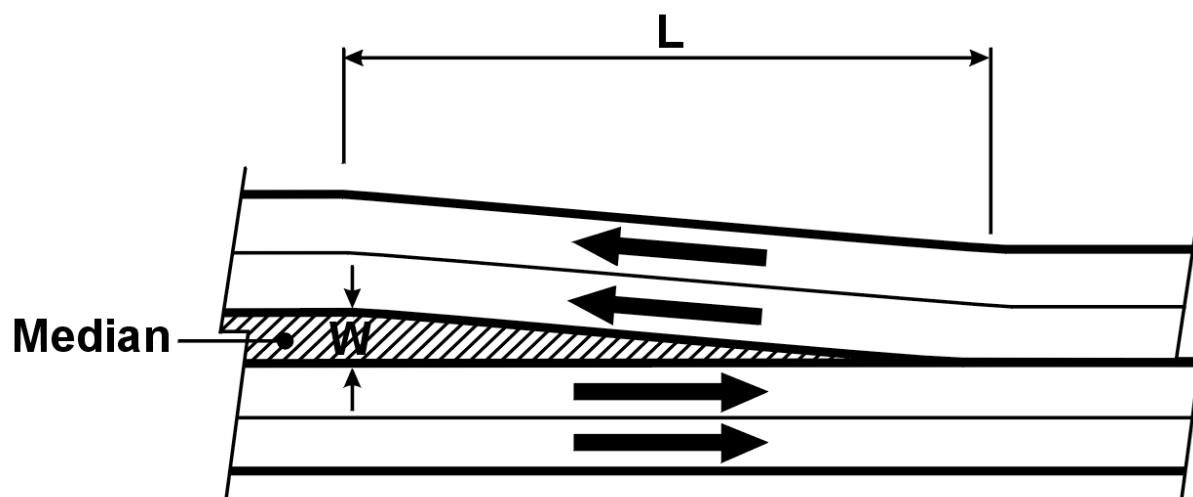
Table 5: Length and taper ratio for dropping 12-foot lane

Design Speed (MPH)	30	35	40	45	50	55	60	65	70
Taper Ratio	15:1	25:1	30:1	45:1	50:1	55:1	60:1	65:1	70:1
Length	180	300	360	540	600	660	720	780	840

Figure 1: Adding or dropping lanes or redirecting through lanes



Adding or Dropping Through Lanes



Redirecting Through Lanes

F. Travel lane width

The minimum traffic lane width shall be based on the type of roadway. Curb and gutter width will not be included as part of the travel lane width.

For major arterial streets and industrial streets, the lane width should typically be 12 feet. This is due to the heavy volume of truck traffic expected on these streets.

Pavements on divided arterials should be designed with lanes 12 feet wide. On curved rural roadways, the lane widths may have to be increased in curved portions. See the latest AASHTO criteria.

G. Curb and gutter width

Curb and gutter width is measured from the back of curb to the edge of the travel lane. Gutter width may be included as part of the parking lane width.

A curb and gutter cross section shall consist of a 6-inch vertical curb with a concrete gutter which includes the curb. Eight inch high curbs may be required in certain high type arterial and major collector design. The use of sloping or rolled curbs (6 inches high with one foot slope face) requires special approval and is normally used when design speeds are greater than 45 mph.

Where the street paving is integral Portland cement concrete there shall be no separation between the curb and gutter section and the paving.

On cul-de-sacs and loop streets located in local residential areas, a 6-inch roll-type curb may be permitted, upon Jurisdictional approval.

H. Parking

Where curb and gutter sections are used, the gutter width may be included as part of the minimum width of parking lane. For no parking, the roadway width will include the lane width plus the gutter width.

1. As a rule, parking lanes will not be permitted on arterial streets.
2. Although on-street parking may impede traffic flow, parallel parking may be allowed by the Jurisdiction on urban collectors where sufficient street width is available to provide parking lanes.
3. Where parking is allowed, a parallel parking lane must be provided on one or both sides as the conditions of lot size and intensity of development may require. Parking is normally not allowed on both sides of the street and will require approval of the Jurisdictional Engineer.

Parking lane width determinations should include consideration for likely ultimate use as lane for moving traffic either during peak hours or continuously. If this is the case, this extra lane/parking width should be a minimum of 11 feet.

I. Median width

A median is a highly desirable element on all arterials carrying four or more lanes. A median is defined as the portion of a divided highway separating the traveled way for traffic in opposing directions. The median width is expressed as the curb-face-to-curb-face dimension. The principal functions of a median are to provide the desired freedom from the interference of opposing traffic, to provide for speed changes and storage of left-turning and U-turning vehicles, to minimize headlight glare, and to provide width for future lanes. Another benefit of a median in an urban area is that it may add an open green space. For maximum efficiency, a median should be highly visible both night and day and in definite contrast to the through-traffic lanes. Medians should be as wide as feasible but of a dimension in balance with other components of the cross section.

Medians and boulevards are not normally used on collector streets. However, when permitted, the median or boulevard should conform to the same design standards as set forth for arterial streets.

Cost of construction and maintenance increases generally with an increase in the width of roadbed. The additional cost may not be appreciable compared with the cost of the highway as a whole in the use of wider medians on roadways for adequate shelter for vehicles crossing at intersections with public roads and at crossovers serving commercial and private drivers. However, wide medians are a disadvantage when the intersection is signalized. The increased time for vehicles to cross the median may lead to inefficient signal operation.

J. Shoulder width

Where no curb and gutter is constructed there will be an earth, granular, or paved shoulder.

A vehicle stopped on the shoulder should clear the pavement edge by 2 feet. This preference has led to the adoption of 10 feet as the normal usable shoulder width that should be provided along high-type facilities. In difficult terrain and on low-volume highways, usable shoulders of this width may not be feasible. A minimum usable shoulder width will follow the Iowa Department of Transportation criteria. Heavily traveled and high-speed highways and those carrying large numbers of trucks should have usable shoulders at least 10 feet and preferably 12 feet wide.

Where roadside barriers, walls, or other vertical elements are used, the graded shoulder should be wide enough that these vertical elements can be offset a minimum of 2 feet from the outer edge of the usable shoulder. It may be necessary to provide a graded shoulder wider than used elsewhere on the curved section of a roadway or to provide lateral support for guardrail posts and/or clear space for lateral dynamic deflection required by the particular barrier in use. On low-volume roads, roadside barriers may be placed at the outer edge of the shoulder; however, a minimum of 4 feet should be provided from the traveled way to the barrier.

K. Roadway widths

The roadway width for arterials (Section 5C-1, Tables 1 through 3) is the sum of the travel lane width and curb and gutter width. The roadway width for collectors and local roads (Section 5C-1, Tables 4 and 5) is the sum of parking lanes (when allowed), travel lanes and curb and gutter widths.

L. Vertical alignment

1. **Minimum grades.** Flat and level grades on uncurbed pavements are virtually without objection when the pavement is adequately crowned to drain the surface laterally. With curbed pavements, longitudinal grades should be provided to facilitate surface drainage. A minimum grade for the usual case is 0.5%, but a grade of 0.4% may be used in isolated areas where the pavement is accurately crowned and supported on firm subgrade. The minimum allowance grade for bubbles and cul-de-sacs is 1%. Particular attention should be given to the design of storm water inlets and their spacing to keep the spread of water on the traveled way within tolerable limits. Roadside channels and median swales frequently require grades steeper than the roadway profile for adequate drainage.
2. **Maximum grade changes.** Except at intersections, the use of grade breaks, in lieu of vertical curves, is not encouraged. However, if a grade break is necessary and the algebraic difference in grade does not exceed 1%, the grade break will be considered by the Jurisdictional Engineer.
3. **Maximum grades.** The following maximum grades are based on design speed and the type of roadway. Steeper grades require approval of the Jurisdictional Engineer.

Design Speed	Maximum Grades, Percent by Roadway Classification				
	Transitional Facilities	Reduced Speed	Minor Arterials	Collectors	Local Streets
55	5	---	---	---	---
50	6	---	---	---	---
45	6	---	---	---	---
40	---	6	6	8	---
35	---	7	7	8	---
30	---	8	---	---	9

4. **Vertical curves.** Vertical curves to effect gradual change between tangent grades may be any one of the crest or sag types depicted in Figures 2 and 3. Vertical curves should be simple in application and should result in a design that is safe, comfortable in operation, pleasing in appearance, and adequate for drainage. To provide adequate drainage, the gutter line grade should be checked so that for every 25 feet there is 0.1 feet elevation difference. The major control for safe operation on crest vertical curves is the provision of ample sight distances for the design speed. Minimum stopping sight distance should be provided in all cases. Wherever economically and physically feasible, more liberal stopping sight distances should be used. Further additional sight distance should be provided at decision points.
 - a. **Crest vertical curves.** Minimum lengths of crest vertical curves as determined by sight distance requirements generally are satisfactory from the standpoint of safety, comfort, and appearance.

- b. **Sag vertical curves.** At least four different criteria for establishing lengths of sag vertical curves are recognized to some extent. These are (1) headlight sight distance, (2) rider comfort, (3) drainage control, and (4) a rule-of-thumb for general appearance.

Headlight sight distance has been used directly by some Jurisdictions. When a vehicle traverses a sag vertical curve at night, the portion of highway lighted ahead is dependent on the position of the headlights and the direction of the light beam. General use is given to a headlight height of 2.0 feet and a 1° upward divergence of the light beam from the longitudinal axis of the vehicle. The upward spread of the light beam provides some additional visible length but this is generally ignored.

Vertical curve design data
(AASHTO - 2001)

DESIGN SPEED	K (MINIMUM FOR STOPPING SIGHT DISTANCE)	
	CREST	SAG
20	7	17
25	12	26
30	19	37
35	29	49
40	44	64
45	61	79
50	84	96
55	114	115
60	151	136
65	193	157
70	247	181

$$L(\text{ft}) = K(g_2 - g_1) \quad \text{where } g_1 \text{ and } g_2 \text{ are in percent}$$

$$K = \frac{L(\text{ft})}{(g_2 - g_1)}$$

Figure 2: Design controls for crest vertical curves, for stopping sight distance and open road conditions (from 2001 AASHTO "Green Book," Exhibit 3-75)

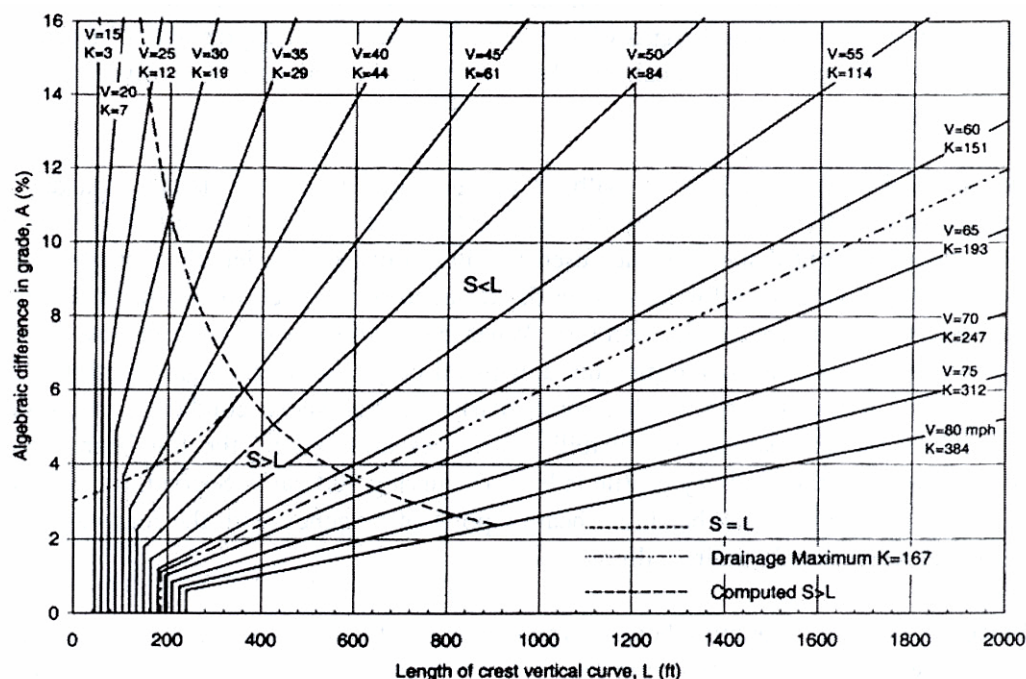
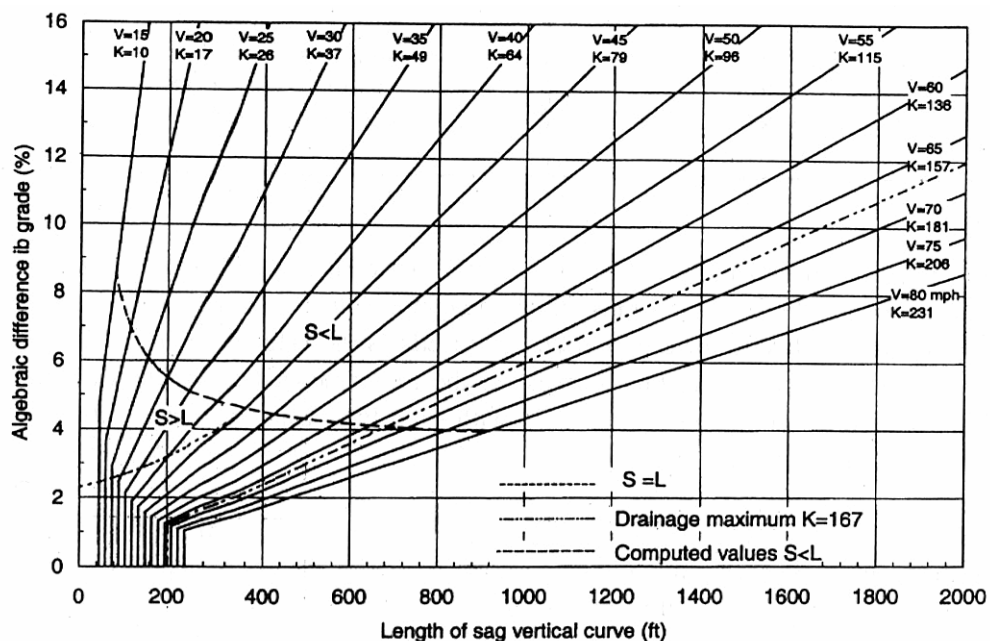


Figure 3: Design controls for sag vertical curves, open road conditions upper range (from 2001 AASHTO "Green Book," Exhibit 3-78)



5. **Pavement crowns.** The following pavement crowns are considered desirable sections. If the Project Engineer desires to use parabolic crowns for roadways at or greater than 31-foot B-B width, an approval is required from the Jurisdictional Engineer.

- a. **Urban roadways (curb & gutter).** Width greater than 31-foot B-B - The first 12 feet of travel lane from the centerline should be 2%. The remaining travel lanes and outside gutter will be 3% to the back of curb form grade.

31-foot B-B Streets or below - For concrete and asphalt streets, the cross slope will be 2.5%.

- b. **Rural roadways.** For pavement crowns, a 2% cross slope is normal with 4% shoulder slope. Iowa DOT Standards should be checked for Federal Aid, Farm to Market and Secondary Roads.

6. **Intersection grades**

- a. The grade of the "through" street shall take precedence at intersections. At intersections of roadways with the same classifications, the more important roadway, shall have this precedence. Side streets are to be warped to match through streets with as short a transition as possible which provides a smooth ride. Consideration must be given to minimize sheet flow of storm water across the intersection due to loss of crown on the side street.

Carrying the crown of the side street into the through street is not permitted. In most cases the pavement cross slope at the warped intersection should not exceed the grade of the through street.

The maximum desirable grades of the through street at the intersection and the side street cross slope should be 2% and should not exceed 3%. The maximum desirable approach grade of the side street should not exceed 4% for a distance of 100 feet from the curb of the through street.

Establishing intersection spot grades by matching "curb corners" of intersecting streets is not recommended since it may result in an undesirable travel path from the through street to the side street because of the resulting bump on the side street centerline. A detail of the jointing layout with staking elevations shall be shown on the plans.

- b. The center line of a street approaching another street from the opposite side should not be offset. If the offset cannot be avoided, the offset should be 150 feet or greater for local streets. The center line of a local street approaching an arterial or collector street from opposite side shall not be offset unless such offset is 300 feet or greater.

M. Horizontal alignment (roadway curvature)

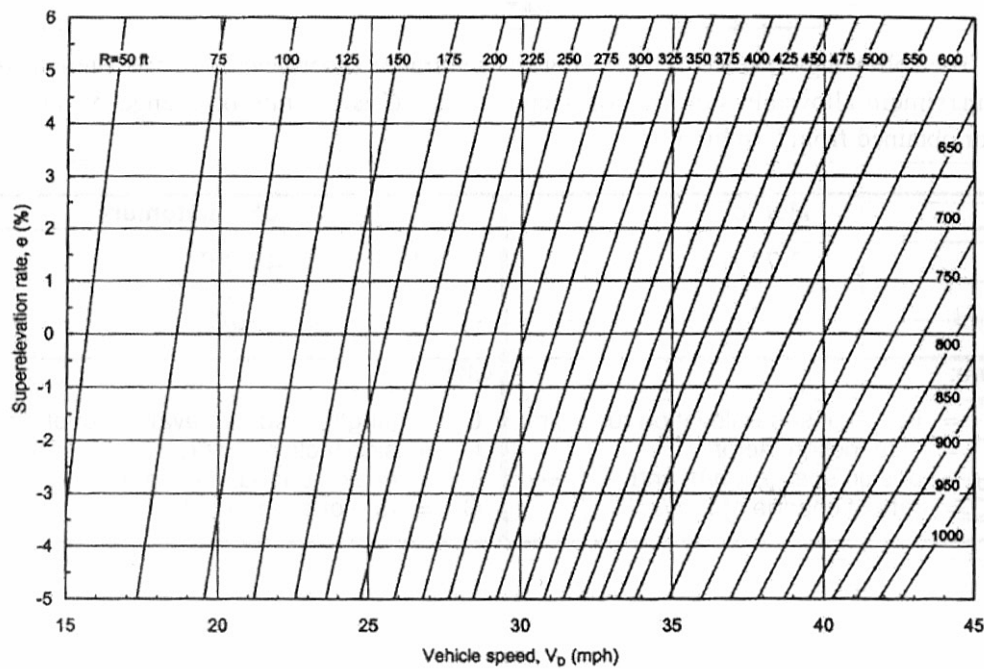
The following figure represents roadway radii for various speeds and super elevation for low-speed urban streets. They are derived from the simplified curve formula:

$$R = \frac{V^2}{15(e + f)}$$

where: R = Curve radius
 V = Speed (mph)
 e = Super elevation
 f = Side friction factor

On low speed curved roadways (at or below 40 mph) the use of normal crown is not detrimental to the user (See Figure 4 below). For roadways where super elevation is used particularly above 40 mph the Project Engineer should refer to Chapter 3 of 2001 AASHTO "Green Book".

Figure 4: Maximum safe and comfortable speed for horizontal curves on low-speed urban streets (from 2001 AASHTO "Green Book," Exhibit 3-40)



N. Sight distances

1. **General.** The information contained herein is taken from the 2001 AASHTO "Green Book". The Project Engineer should check AASHTO when specific information is needed to verify values provided.

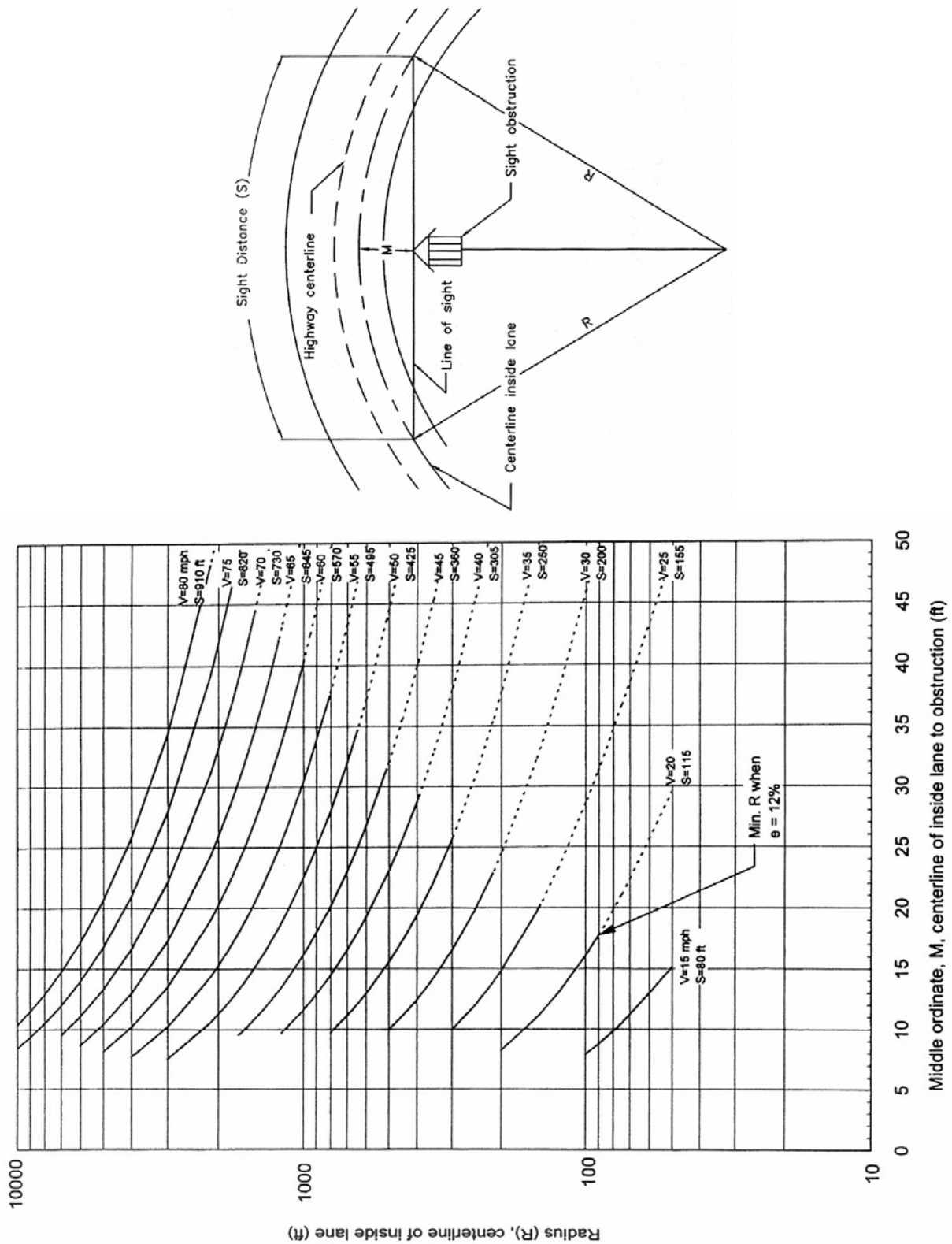
For all sight distance calculations, the height of the driver's eye is considered to be 3.50 feet above the roadway. For stopping sight distance calculations, the height of object is 2.0 feet above the road surface. The height of the object for passing sight distance is 3.5 feet above the road surface.

2. **Horizontal curves sight distances.** Horizontal alignment must provide at least the minimum stopping distance for the design speed at all points. This includes visibility at intersections as well as around curves and roadside encroachments.

Where an object off the pavement restricts sight distance, the minimum radius of curvature is determined by the stopping sight distance. (See Figures 5 and 6). In no case shall the stopping sight distance be less than as specified in Table 6. A likely obstruction may be a bridge abutment or line of columns, wall, cut side slope, or a side or corner of a building. The sight distance design procedure shall assume a 6-foot-0-inch fence (as measured from actual finished grade) exists at all property lines except in the sight-distance triangles required at all intersections.

The lateral clearance, inner edge of pavement to sight obstruction, for various radii of inner edge of pavement and design speeds, is shown graphically in Figures 5 and 6. The position of the driver's eye and the object sighted are assumed to be 6 feet from the inner edge of pavement, with the sight distance being measured along this arc.

Figure 5 and Figure 6: Sight distances for horizontal curves
(from 2001 AASHTO "Green Book," Exhibits 3-57 and 3-58)



3. **Stopping sight distance.** The minimum stopping sight distance is the distance required by the driver of a vehicle traveling at the design speed to bring the vehicle to a stop after an object on the road becomes visible (See Table 6). The Project Engineer should check the latest edition of the AASHTO "Green Book" for additional considerations particularly for complex conditions such as correction to values shown in Table 6 for grade adjustment, decision sight distances, etc.
4. **Passing sight distance.** Passing sight distance is the minimum sight distance that must be available to enable the driver of one vehicle to pass another safely and comfortably without interfering with oncoming traffic traveling at the design speed. Two-lane roads should provide adequate passing zones. Required passing sight distance for given design speeds is given in Table 6.

Table 6: Minimum stopping and passing sight distance
(from 2001 AASHTO "Green Book," Exhibits 3-1 and 3-7)

Design Speed (MPH)	Stopping Sight Distance	Passing Sight Distance
20	115	710
25	155	900
30	200	1090
35	250	1280
40	305	1470
45	360	1625
50	425	1835
55	495	1985

5. **Intersection sight distance.** There should be an unobstructed sight distance along both approaches of both sides at an intersection and across their included corners for distances to allow the operators of vehicles, approaching simultaneously, to see each other. Any object within the sight triangle more than 3.5 feet above the elevation of the adjacent roadway shall constitute a sight obstruction, and should be removed or lowered. Such objects include: buildings, cut slopes, hedges, trees, bushes, utility cabinets or tall crops. This criteria also requires the elimination of parking within the sight triangle and applies whether the intersecting roads are level or on grades.

The following cases are provided for determination of the sight triangle.

CASE I: Includes only local urban streets to local urban street crossings at which no traffic control or stop sign exist and the basic right-of-way rule controls. For example, assuming a 25 mph approach speed for each leg of the intersection which places each vehicle 115 feet from their intersecting point. This determination was based on Case A, intersections with no control, of the 2001 AASHTO "Green Book". This reference should be used to determine rural sight distance, where speeds greater than 25 mph apply.

CASE II: Includes intersections where the minor street is posted with yield signs as its legs intersect the major street. The sight distance for the vehicle operator on the minor street must be sufficient to allow the operator to observe a vehicle on the major street, approaching from either the left or the right, and then through perception, reaction and braking time, bring the vehicle to a stop prior to reaching the intersection. Where a property sight distance cannot be achieved for the vehicle on the minor street, it may be necessary to reduce the approach speed on the minor street.

In the event that the minor street must stop, sight distance must be able to include the stopped vehicles to cross or enter the major street as explained in Case III, below.

When an obstruction, which cannot be removed except at a prohibitive cost, sets the vertices of the sight triangle to points that are less than the design stopping sight distance, appropriate adjustments must be made for the design speed and for the safe stopping sight distance for at least one of the streets concerned. (See Case C, intersections with yield control on the minor road, of the 2001 AASHTO "Green Book").

CASE III and IV: Includes intersections where traffic controls, including stop signs have been placed on the minor street approaches and the major street is assigned the right-of-way. The leg of the stop-controlled road or street should be determined by the assumed location of the driver's eye. This is established as 20 feet behind the edge of pavement or curb line. There are three basic maneuvers that occur at the average intersection. These maneuvers are:

- a. To travel across the intersecting roadway by clearing traffic on both the left and the right of the crossing vehicle (See Case B3, crossing maneuver from minor road, of the 2001 AASHTO "Green Book");
- b. To turn left into the crossing roadway by first clearing traffic on the left and then to enter the traffic stream with vehicles from the right (See Case B, left turn from minor road, of the 2001 AASHTO "Green Book"); and,
- c. To turn right into the intersecting roadway by entering the traffic stream with vehicles from the left (See Case B.2, right turn from the minor road, of the 2001 AASHTO "Green Book").

The Project Engineer should determine the required sight distance along the major street in order for the vehicle on the minor street to make a decision on accomplishing the above maneuvers.

Intersections controlled by traffic signals are considered by many not to require a sight triangle. However, due to a variety of operational characteristics associated with intersections, sight distance based on Case III procedures should be available to the driver.

O. Clear zone

The AASHTO Roadside Design Guide (RDG), defines the clear zone as: "the total roadside border area, starting at the edge of the traveled way, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. The desired width is dependent upon the traffic volumes and speeds and on the roadside geometry."

The intent of the clear zone is to provide an errant vehicle that leaves the roadway with an unobstructed recovery area. This area should be kept free of all obstructions including utility and light poles, culverts, bridge piers, sign supports, etc. Any obstruction which cannot be placed outside of the clear zone should be shielded by traffic barriers or guardrail.

According to the AASHTO RDG, the width of this area varies based upon traffic volumes, design speed, and grade of the foreslope. The values shown in Table 7 give a range of allowable clear zone widths. The lower value should be considered the minimum clear zone with while the upper should be considered the desirable clear zone width.

For horizontal curves, an adjustment factor (Table 8) may be applied to the clear zone width taken from Table 7. This adjustment is only required at selected locations. Widening the clear zone should be considered at curves when a crash history suggests the need for additional clear zone width, or whenever the radius of the curve is less than 2860 feet, the design speed is 55 mph or greater, and the

curve occurs on a normally tangent alignment (one where the curve is preceded by a tangent more than a mile in length).

The clear zone values presented in Table 7 are applicable to rural roadways without curb.

For urban roadways with curb, the required clear zone, as measured from the back of curb, is given in Section 5C-1, Tables 1 through 5. The clear zone along an urban section may contain minor obstructions (traffic signs, mailboxes, etc.). In addition, along lower speed (<40 mph design speed) urban roadways, larger objects which are designed to "break-away" when struck by a vehicle may also be located within the clear zone (light poles, cast-iron fire hydrants, etc.)

All objects however, should be kept free from the object setback zone as described in the next section.

Table 7: Clear zone distances (in feet from edge of traveled way)

design speed (mph)	design ADT	fill slope (fs)			cut slope (cs)		
		fs ≥ 6:1	4:1 ≤ fs < 6:1	fs < 4:1	cs < 4:1	4:1 ≤ cs < 6:1	cs ≥ 6:1
speed < 40	ADT < 750	7–10	7–10	—**	7–10	7–10	7–10
	750 ≤ ADT < 1500	10–12	12–14	—**	10–12	10–12	10–12
	1500 ≤ ADT < 6000	12–14	14–16	—**	12–14	12–14	12–14
	ADT ≥ 6000	14–16	16–18	—**	14–16	14–16	14–16
40 ≤ speed < 50	ADT < 750	10–12	12–14	—**	8–10	8–10	10–12
	750 ≤ ADT < 1500	12–14	16–20	—**	10–12	12–14	14–16
	1500 ≤ ADT < 6000	16–18	20–26	—**	12–14	14–16	16–18
	ADT ≥ 6000	18–20	24–28	—**	14–16	18–20	20–22
50 ≤ speed < 60	ADT < 750	12–14	14–18	—**	8–10	10–12	10–12
	750 ≤ ADT < 1500	16–18	20–24	—**	10–12	14–16	16–18
	1500 ≤ ADT < 6000	20–22	24–30	—**	14–16	16–18	20–22
	ADT ≥ 6000	22–24	26–32*	—**	16–18	20–22	22–24
60 ≤ speed < 65	ADT < 750	16–18	20–24	—**	10–12	12–14	14–16
	750 ≤ ADT < 1500	20–24	26–32*	—**	12–14	16–18	20–22
	1500 ≤ ADT < 6000	26–30	32–40*	—**	14–18	18–22	24–26
	ADT ≥ 6000	30–32*	36–44*	—**	20–22	24–26	26–28
speed ≥ 65	ADT < 750	18–20	20–26	—**	10–12	14–16	14–16
	750 ≤ ADT < 1500	24–26	28–36*	—**	12–16	18–20	20–22
	1500 ≤ ADT < 6000	28–32*	34–42*	—**	16–20	22–24	26–28
	ADT ≥ 6000	30–34*	38–46*	—**	22–24	26–30	28–30

Table 8: Horizontal curve adjustments

radius (ft.)	design speed (mph)						
	40	45	50	55	60	65	70
2860	1.08	1.10	1.12	1.15	1.19	1.22	1.27
2290	1.10	1.12	1.15	1.19	1.23	1.28	1.33
1910	1.11	1.15	1.18	1.23	1.28	1.33	1.40
1640	1.13	1.17	1.22	1.26	1.32	1.39	1.46
1430	1.15	1.19	1.25	1.30	1.37	1.44	
1270	1.17	1.22	1.28	1.34	1.41	1.49	
1150	1.19	1.24	1.31	1.37	1.46		
950	1.23	1.29	1.36	1.45	1.54		
820	1.26	1.34	1.42	1.52			
720	1.30	1.38	1.48				
640	1.34	1.43	1.53				
570	1.37	1.47					
380	1.54						

$$CZ_C = (L_C)(K_{CZ})$$

Where:

CZ_C = clear zone on outside of curvature, feet

L_C = clear zone distance, feet (Table 3.12)

K_{CZ} = curve correction factor

P. Object setback

Like clear zone, object setback is intended to provide an area adjacent to the roadway that is clear of obstructions. However, the purpose of the object setback is to provide an operational clearance to increase driver comfort and avoid a negative impact on traffic flow. It also improves aesthetics, provides an area for snow storage and, in areas with curbside parking, provides a clear area to open car doors.

As discussed in the previous section on clear zone, minor obstructions and larger "breakaway" objects may be located in the clear zone on lower speed roadways (<40 mph design speed), but must be kept free from the object setback.

The maximum object setback possible should be provided. The minimum object setback allowed, as measured from the back of curb, is listed in Section 5C-1, Tables 1 through 5. Additional object setback beyond the minimum stated may be required near turning radii at intersections and driveways in order to provide sufficient clearance to keep the overhang of a truck from striking an object.

Q. Border area

Border area is the area between the roadway and the right of way line and sometimes referred to as the "parking" in urban areas. The vertical cross section grade for the border area is normally 1/2 inch/foot. See Chapter 8 for additional details. The border area between the roadway and the right of way line should be wide enough to serve several purposes including provision of a buffer space between pedestrians and vehicular traffic, sidewalk space, and an area for both underground and above ground utilities such as traffic signals, parking meters, and fire hydrants. A portion of the border area would serve snow storage and aesthetic features such as grass or other landscaping features. The border width will range from 8 to 15 feet, including the sidewalk width. Traffic signals, utility poles, fire hydrants, and other utilities should be placed as far back of the curb as practical for safety reasons. Breakaway features should be built when feasible and as an aid to safety considerations.

R. Cul-de-sacs

A local street open at one end only should have a cul-de-sac constructed at the closed-end or as a minimum of public turn-around. This turning area should be circular and have a radius appropriate to the type of vehicles expected. Section 5C-1, Table 5 provides the minimum radius for cul-de-sacs and may need to be increased if circumstances warrant such increases. The area between the back of curb and right of way line should be the same as the approach street. The transition radius with the approach street will be 50 feet for residential streets and 75 feet for commercial and industrial streets.

S. Bridge widths

The bridge widths listed in Section 5C-1, Tables 1 through 5 represent the clear roadway width (width between barrier rail faces). The widths shown do not account for barrier rail widths, sidewalk, recreational trails, etc.

For existing bridges, a structural analysis should be conducted. The existing bridge should be able to accommodate legal loads. Bridge guardrail should be upgraded if necessary.

T. Curb radii

Minimum curb return radii are shown in Table 9 below. Where truck traffic is significant, curb return radii shall be provided in accordance with the 2001 AASHTO "Green Book" Turning templates are used in this design. The Iowa Department of Transportation has an Iowa truck vehicle that can be used to check the proposed radii for truck routes.

Table 9: Curb return radii based upon roadway classification

Roadway Classification	Arterial	Collector	Local - Commercial or Industrial	Local - Fringe or Residential
Arterial	Special*	Special*	30'	30'
Collector	Special*	30'	30'	25'
Local – Commercial or Industrial	30'	30'	25'	25'
Local – Fringe/Residential	30'	30'	25'	25'

*Special design required. Use turning templates.

U. Pavement thickness

1. **Minimum pavement thickness.** All arterials and major collectors must be designed for pavement thickness on an individual street-by-street basis. If uniform and suitable soil exists or is planned for the subgrade for local residential street or minor collectors then the minimum pavement thickness as set forth in this section may be utilized without pavement thickness design.

The minimum thickness for concrete pavements shown in Table 10A is based on Class "C" concrete, 4,000 psi concrete (minimum).

There are many variables associated with determining hot mix asphalt pavement thickness such as percent asphalt binder, type of aggregate used, the different mix designs for base courses and surface courses, etc. Therefore, the minimum thickness for hot mix asphalt pavements are based on using Type "B" aggregate for the base course and Type "A" aggregate for the intermediate and surface courses. In addition, the minimum crushed stone content is 60% for local streets and collectors and 75% for arterials. If the actual HMA mix is different from this, the pavement thickness needs to be verified by a pavement determination

2. **Traffic data.** Where traffic data is available, actual counts shall be used along with projections of traffic growth in determining the pavement design. If traffic data is not available, Section 5C-1, Tables 4 and 5 may be used to determine data used in the pavement design. Arterials and major collectors will require special traffic data.
3. **Rigid and flexible pavement design parameters.** Design of pavement thickness should be based on the latest edition of AASHTO Guide for Design of Pavement Structures, American Concrete Pavement Associations Design of Concrete Pavements and the Asphalt's Institute's Thickness Design for Highways and Streets, MS-1. These documents are based on the AASHTO Guide. See Section 5F for a detailed explanation of parameters required to enter the AASHTO pavement equations and nomographs. These nomographs will determine the thickness (concrete) or structural number (asphalt).

4. Utilize methods outlined in Section 5F to determine plain jointed Portland Cement Concrete pavement thickness. It is assumed that the pavement is placed on natural and uniform subgrade. Minimum pavement thickness for each street classification is listed below.

Table 10A: Minimum PCC pavement thickness

Street Classification	Pavement Thickness		
	Commercial/ Industrial	Residential or Fringe	Rural
Local	7" (6" reinforced)	7" (6" reinforced)	7" (6 in reinforced)
Minor Collector (1)	8" (6" reinforced)	7" (6" reinforced)	7" (6" reinforced)
Major Collector	Special Design (See Section 5F)		
Minor/Major Arterial	Special Design (See Section 5F)		

(1) Load Transfer Devices Required.

5. Utilize methods outlined in Section 5F to determine the Hot Mix Asphalt pavement thickness and composition. It is assumed that the pavement is placed on natural uniform subgrade. Minimum pavement thicknesses are listed below.

Table 10B: Minimum HMA pavement thickness

Street Classification	Surface Course Thickness			Intermediate / Base Course Thickness			Total Pavement Thickness including Surface Course		
	C/I	Res	Rural	C/I	Res	Rural	C/I	Res	Rural
Local	2"	2"	2"	7"	6"	7"	9"	8"	9"
Minor Collector	2"	2"	2"	8"	7"	7"	10"	9"	9"
Major Collector	Special Design (See Section 5F)								
M/M Arterial	Special Design (See Section 5F)								

C/I = Commercial/Industrial at 5% trucks

6. Nothing in these standards shall prohibit the Jurisdiction from specifying the type of material to be used in any given section of pavement. The intent is to prohibit short sections of pavement where the pavement type will vary from one type to another.