Section 1 – General Information

1.1 <u>Concept</u>

This chapter contains the basic roadway design criteria. The Project Engineer should develop the design consistent with this design criteria and the exercise of sound engineering judgement. Situations do arise that require special considerations and the Jurisdictional Engineer may allow exceptions to the design criteria with adequate justification by the Project Engineer.

1.2 <u>Conditions</u>

1. Roadway design shall conform to the latest versions of the following:

   A. The Design Standards Manual.

   B. Iowa Department of Transportation (IDOT) and the Federal Highway Administration (FHWA) for design of Federal Aid routes.

   C. The American Association of State Highway and Transportation Official (AASHTO)-"*A Policy on Geometric Design of Highways and Streets "* (Green Book.)

   D. The U.S. Department of Transportation - Federal Highway Administration - *"Manual on Uniform Traffic Control Devices"* (MUTCD)

   E. The Transportation Research Board - "Highway Capacity
      1) Manual - Special Report #209".

   F. The Institute of Transportation Engineers - *"Transportation and Traffic Engineering Handbook".*

   G. In case of a conflict between the above design standards, the Jurisdictional Engineer should be contacted for clarification.

2. Construction Standards

   A. Construction shall conform to the Cedar Rapids Metropolitan Area Standard Specifications and Details. For those projects involving State Highways and/or Federal Aid, the current "Standard Specifications for Highway and Bridge Construction - Iowa Department of Transportation" and supplemental specifications shall apply.

3. Project Submittals

   A. Projects are to be submitted to the Jurisdictional Engineer for review and acceptance. Projects involving IDOT must also be submitted to the

IDOT Office of Local Systems.

Section 2 – Street Classification

2.1 General

Streets and highways are functionally classified according to the character of service they are intended to provide. This classification recognizes that individual roads and streets do not function independently. Rather, most travel involves movements through networks of roads and can be categorized relative to their function. The three major functional classifications for urbanized areas are Arterials, Collectors and Local Streets.

The information contained in this section is based on AASHTO criteria. The Project Engineer should use the various AASHTO publications and particularly the AASHTO Green Book to verify the application of values provided herein when complex design conditions or unusual situations occur.

2.2 Arterial Streets

1. Major Arterial - Major arterials serve the major center of activities of urbanized areas, the highest traffic volume corridors, the longest trip desires and carry a high proportion of a total urban travel even though it constitutes a relatively small percentage of the total roadway network. The system should be integrated both internally and between major rural connectors. The major arterial system carries most of the trips entering and leaving the area as well as most of the through movements bypassing the central city. In addition, significant inter-area travel such as central business districts and outlying residential areas between major intercity communities and between major suburban centers are served by major arterials. Frequently, the major arterial carries important interurban as well as intercity bus routes. Finally, in urbanized areas, this system provides continuity for all rural arterials. Access to the major arterial is specifically limited in order to provide maximum capacity and through movement mobility. Although no firm spacing rule applies in all or even in most circumstances, the spacing between major arterials may vary from less than one mile in highly developed central areas to five miles or more in developed urban fringes.

2. Minor Arterial - Minor arterials inter-connect with and augment the major arterial system. It accumulates trips of moderate length at a somewhat lower level of travel mobility than major arterials. This system places more emphasis on land access but still has specific limits on access points. A minor arterial may carry local bus routes and provide inter-community continuity but ideally does not penetrate identifiable neighborhoods. This system includes urban connections to rural collector roads where connections have not been classified as urban principal arterials. The spacing of minor arterials may vary from 1/8 to 1/2 mile in highly developed areas to 2 miles in suburban fringes but is not normally more than 1 mile in fully developed areas.

2.3 Collector Streets

Collector streets collect traffic from local streets and residential and commercial areas at moderately low traffic speeds, and channel it into the arterial system. There is usually equal consideration of through movements and direct land access. Collector streets may also carry local bus routes.

2.4 Local Streets, Public and Private

Local streets provide for the movement of traffic between collectors, residential and commercial areas. Local streets provide the direct access to abutting residential and commercial property and carry low traffic volumes at low speeds on relatively short trips. Private streets are similar to the local streets but generally are located on dead-end roads less than 250 feet in length, short loop streets less than 600 feet in length or frontage roads parallel to public streets.

Section 3 – Design Criteria

3.1 General

Four design criteria (below) are used by Iowa DOT and local jurisdictions:

NO.	CONDITIONS		NORMAL DESIGN CRITERIA	RELATION TO METRO DESIGN STANDARDS
	ROUTE TYPE	FUNDING TYPE		
1.	Primary Highway	Federal Aid (NHS)	FHWA	N/A - Use IDOT Design Criteria
2.	Primary Highway	Non-Federal Aid & Federal Aid (STP)	IDOT Design Criteria	N/A - Use IDOT Design Criteria
3.	Non-Primary Roadway	Federal Aid (STP)	IDOT Urban Design Aids or Alternative Urban Design Guides	Table 5.1-Major Arterial
4.	Non-Primary Roadway	Non-Federal Aid	City & County Standards	Table 5.1-Major Arterial

Table 5.1 provides the basic roadway design criteria. Other design considerations should include but not be limited to the information in other chapters of the Design Standards Manual and the following:

- Adjacent land use and access control
- Topographic features

- Driver expectancy
- Composition of traffic
- Directional distribution
- Peak hour traffic
- Future traffic projections
- Lane and intersection capacity
- Intersection traffic controls
- Weaving sections
- Pedestrian and bike path traffic

Table 5.1 Design Criteria

Type of Facility[1]	Major Arterial					Minor Arterial (40 mph standard)				
TYPE AREA	Commercial or Industrial		Fringe or Residential		Rural	Commercial or Industrial		Fringe or Residential		Rural
Number Traffic Lanes[2]	**4**	**2**	**4**	**2**	**2**	**4**	**2**	**4**	**2**	**2**
Design Speed (mph)[3]	40	40	50	40	55	40	40	50	40	55
Stopping Sight Distance	305	305	425	425	495	305	305	425	305	495
Minimum CL Radius[4]	565	565	930	565	1190	565	565	930	565	1190
Max. Gradient (%)[5]	5	5	7	8	5	5	5	7	8	5
Travel Lane Width	12	12	12	12	12	12	12	12	12	12
Parking Lane Width[6]	--	6	--	6	--	--	6	--	6	--
Curb & Gutter Width[7]	2.5	3.5	2.5	3.5	--	2.5	3.5	2.5	3.5	--
Shoulder Width[15]	--	--	--	--	10	--	--	--	--	8
Median Widths										
Raised Curb	4	--	4	--	--	4	--	4	--	--
With Left Turn	16	--	16	--	--	16	--	16	--	--
Vertical Clearance	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
Horizontal Clearance[8]	10	10	10	10	RDG	10	10	10	10	RDG
Right-of-Way Width[9]	100	100	100	100	100	80	80	80	80	80
Desirable Access Spacing[10]	300 to 600 ft					300 ft				
Roadway Width[11]										
A. With Parking One Side	--	--	--	--	--	--	--	--	--	--
B. Without Parking	53	31	53	31	24	53	31	53	31	24
Cul-de-Sac										
A. Radius	--	--	--	--	--	--	--	--	--	--
B. Right-of-Way	--	--	--	--	--	--	--	--	--	--
Curb Radii										
A. Int. Local	35	35	35	35	35	30	30	30	30	--
B. Int. Collector	35	35	35	35	35	30	30	30	30	--
C. Int. Arterial	Use Turning Templates					35	35	35	35	
D. Cul-de-Sac										
PCC Min. Depth[12]										

Table 5.1 (Continued) Design Criteria

Type of Facility[1]	Minor Arterial (35 mph alternative with design exception justification)					Collector					Local				
TYPE AREA	Commercial or Industrial		Fringe or Residential		Rural	Commercial or Industrial		Fringe or Residential		Rural	Commercial or Industrial		Fringe or Residential		Rural
Number Traffic Lanes[2]	**4**	**2**	**4**	**2**	**2**		**2**	**4**	**2**	**2**		**2**		**2**	**2**
Design Speed (mph)[3]	35	35	40	35	50		35	35	30	45		30		30	45
Stopping Sight Distance	250	250	305	250	425		250	250	200	360		165		165	360
Minimum CL Radius[4]	300	300	565	420	930		420	420	300	730		300		150	730
Max. Gradient (%)[5]	6	6	8	9	6		6	9	10	8		6		12	10
Travel Lane Width	12	12	12	11.5	12		12	12	11	12		12		11	12
Parking Lane Width[6]	--	8	--	8	--		8	8	8	--		6-8		5	--
Curb & Gutter Width[7]	1.5	1.5	1.5	1.5	--		1.5	1.5	1.5	--		1.5		1.5	--
Shoulder Width[15]	--	--	--	--	8		--	--	--	8		--		--	8
Median Widths															
Raised Curb	--	--	--	--	--		--	--	--	--		--		--	--
With Left Turn	--	--	--	--	--		--	--	--	--		--		--	--
Vertical Clearance	14.5	14.5	14.5	14.5	14.5		14.5	14.5	14.5	14.5		14.5		14.5	14.5
Horizontal Clearance[8]	7	7	7	7	RDG		7	7	3	10		3		3	10
Right-of-Way Width[9]	80	80	80	80	80		60-80	60-80	60-80	60-80		60		60	60
Desirable Access Spacing[10]	300 ft					300 ft					300 ft				
Roadway Width[11, 15]															
A. With Parking One Side	--	33	--	33	--		33	--	33	--		33		28	--
B. Without Parking	51	--	51	--	--		33	51	--	24		31		28	24
Cul-de-Sac															
A. Radius	--	--	--	--	--		--	--	--	--		50		44	44
B. Right-of-Way	--	--	--	--	--		--	--	--	--		65		60	60
Curb Radii															
A. Int. Local	30	30	30	30	--		25	25	25	25		25		25	25
B. Int. Collector	30	30	30	30	--		30		30	25		25		25	25
C. Int. Arterial	35	35	35	35	--		35		35	35		35		35	35
D. Cul-de-Sac												25		25	25
PCC Min. Depth[12]							8	8	8	7		8		7	7

NOTES :

1. According to Metro Transportation Plan
2. Actual number of lanes based on highway capacity – more than four lanes refer to AASHTO Green Book
3. Design speed should be posted speed plus 5 mph, if practicable.
4. Urban areas based on e=-0.025 (design speed 40 or less), e =0.04 (design speed 45 or more)
   R=100' may be allowed for local streets for cul-de-sacs and loop streets less than 600 feet in length
   R=50' may be allowed for local streets for these conditions:
   a) Minimum 200 feet of sight distance to beginning of 50 foot radius.
   b) Number of units beyond 50 foot radius is 10 or less.
   c) Maximum traffic volume is 100 vehicles per day or less (ADT).
5. Maximum gradients noted above may be increased by up to an additional 1 percent for minor arterials and up to an additional 2 percent for collector and local streets under the following conditions:
   a) Increased gradient is on a horizontal alignment tangent for distances less than 500 feet with no intersecting streets.

b) Intersection grades shall not be increased.
c) Increased gradients are not allowed on dead-end streets or streets with a cul-de-sac.

6. Gutter width may be included as part of the parking lane width.
7. Curbs should be mountable when the posted speed limit is 45 mph or more.
8. RDG = AASHTO Roadside Design Guide. Horizontal clearance measured from the back of curb; from travel lane on rural section.
9. Right-of-way width per Jurisdiction. See details at end of this chapter for Cedar Rapids requirements.
10. Unsignalized access locations.
11. Roadway width does not include median.
12. AASHTO methods shall be used to compare equivalent PCC and HMA sections, based on equivalent ESALs.
13. For horizontal and vertical alignments and sight distance, see Section 3.2.
14. All dimensions in feet unless noted otherwise.
15. Minimum widths allow two lanes of traffic with provisions for passing stalled vehicle.
16. Pave 2 foot shoulder each side at same pavement thickness as travel lanes.

3.2 Reference Information for Table 5.1

The following considerations shall be used to design arterial, collector and local streets.

1. Area

   A. Commercial and industrial areas are generally defined by commercial and industrial zoning districts where factories, office buildings, strip malls and shopping centers are or will be located.

   B. Residential areas are generally defined by residential or multi-family zoning districts where single-family houses, apartment buildings, condominium complexes and townhouse 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 surrounding a municipality.

   C. Rural areas generally are characterized by wide spaces and agricultural use.

2. 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.

   A. Capacity

      The Highway Capacity Manual, Special Report 209 and the AASHTO Green Book should be used to determine the number of lanes and intersection configuration at the desired Level of Service (LOS).

   B. Dropping, Adding Lanes, or Redirecting Through Lanes

      An additional lane should 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 speeds of 45 mph or more
L = $WS^2/60$ for speeds 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.

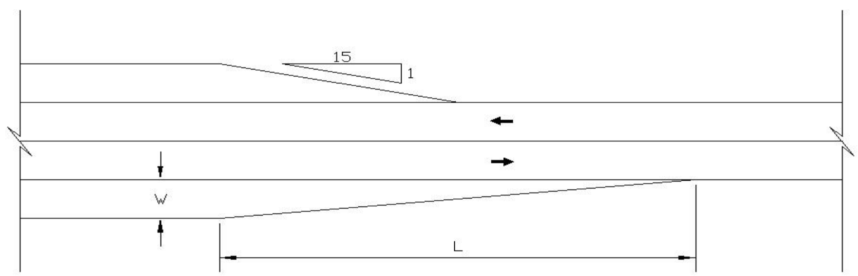
Preferably, taper ratios should be evenly divisible by 5. Calculations that result in odd ratios should be rounded up to the next increment of 5. The following table utilizes the formulas to determine the appropriate taper ratio for dropping a 12' wide lane. The ratio remains constant for the design 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.

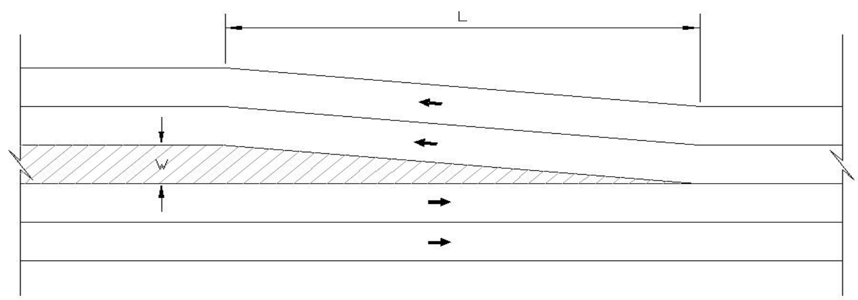
Table 5.2 Length and Taper Ratio for Dropping 12' Lane

Posted 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 5.1 Adding or Dropping Lanes or Redirecting Through Lanes



ADDING OR DROPPING LANES



REDIRECTING THROUGH LANES

3. Design Year Traffic:

Defines the average daily traffic volumes (ADT) that are expected during a future design year; at least 20 years from the date of construction.

4. Design Speed:

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 and vertical alignment design speed shall be consistent with each other. The design speed shall be the posted speed plus 5 miles per hour unless approved by the Jurisdictional Engineer.

5. Desirable Access Spacing:

The design and operation of urban streets includes access to abutting property and to intersecting streets. At intersecting streets, access can be fully or partially restricted through use of traffic control devices and channelization. Access controls are placed along urban streets to protect the functional integrity of the arterial or collector and to a lesser extent, the local street. Both safety and capacity of urban streets are affected by access points.

See Table 5.1 for recommended access spacing on arterial roadways. For collector and local street access, see Section 5, Access Criteria.

6. Parking:

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

A. Generally parking lanes are not permitted on arterial streets. There may be exceptions, such as in central business districts.

B. 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.

C. Where parking is allowed a parallel parking lane must be provided on one or both sides as lot size and intensity of development may require. Except for local residential streets, parking is normally not allowed on both sides of the street and will require approval of the Jurisdictional Engineer.

7. Travel Lane Width:

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

8. Curb and Gutter:

Curb and gutter width may be included as part of the parking lane width. The width of curb and gutter is specified in Table 5.1. The 6" integral curb is required on all but local streets. The 3 ¼" rolled curb may be used on local streets except at intersections with pedestrian ramps, where the 6" curb is used along and extended beyond the intersection radii. Refer to the pedestrian ramp design aids in Chapter 8 for more information.

9. Roadway Widths:

See Table 5.1 based on functional classification.

10. Median Width:

The median width is the spacing between the through-lane edges. The median provides freedom from the interference of opposing traffic, allows for speed changes and storage of left-turning and U-turning vehicles, minimizes headlight glare and provides width for future lanes. Other benefits of a median in an urban area include open green space and/or refuge area for pedestrians. 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. 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.

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 for arterial streets.

11. Shoulder Width:

When no curb and gutter is constructed there will be a granular or paved shoulder.

A vehicle stopped on the shoulder should clear the edge of traveled way by at least two feet. It is preferable that this clearance area be paved. A preferable usable shoulder width of ten feet should be provided along high-volume facilities. In difficult terrain and on low-volume highways, ten feet wide shoulders may not be feasible. 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.

It may be necessary to provide a graded shoulder wider than used elsewhere on the curbed 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.

12. Minimum Horizontal Clearance (Clear Zone)

Horizontal clearance is measured from the back of curb in urban sections and from the edge of travel lane in rural sections.

The desired width is dependent upon the traffic volumes and speeds, and on the roadside geometry. The recovery area should be clear of all non-breakaway objects such as trees, sign supports, poles, hydrants and any other fixed objects that might severely damage an out-of-control vehicle. At selected locations, such as the outside of a sharp curve for rural roads, a broader recovery area with greater horizontal clearances should be provided to any roadside obstruction.

The latest AASHTO Roadside Design Guide shall be used to verify the horizontal clearance dimensions.

13. Cul-de-sacs:

A local street open at one end only should have a cul-de-sac constructed at the closed-end for turn-around. The maximum length of street leading to a cul-de-sac should be 300 feet. The turning area shall be circular (not hammerhead) and have a radius appropriate to the type of vehicles expected. Table 5.1 provides the minimum radius for cul-de-sacs. Temporary rock turnarounds shall have the same radii as permanent cul-de-sacs. The maximum desirable center line grade in a cul-de-sac is 4%. The absolute maximum grade shall be 6%.

14. Vertical Alignment:

A. Minimum Grades:

A minimum longitudinal grade for curbed and uncurbed streets is 0.5 percent. The desirable minimum grade is 0.6% to account for construction tolerances. The desirable grade should be used when possible to avoid ponding of storm water runoff. 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 the design limits. Roadside channels and median swales frequently require grades steeper than the roadway profile for adequate drainage.

B. Minimum Grade Changes:

1) Except at intersections, the use of grade breaks, in lieu of vertical

curves is allowed only when a design exception is granted. If a grade break is justified for extenuating circumstances and the algebraic difference in grade does not exceed one percent, the grade break may be considered by the Jurisdictional Engineer. A minimum of 0.5 percent grade shall be maintained in gutter lines in crest and sag curves.

C. Maximum grades:

See Table 5.1 Steeper grades require approval of the Jurisdictional Engineer.

D. Vertical Curves:

Vertical curves should be simple in application and result in a design that allows safe and comfortable travel, pleasing appearance and adequate drainage. To provide adequate drainage, the gutter line grade should be at least 0.5%. 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 possible, stopping sight distances greater than minimum should be used. Additional sight distance should be provided at decision points.

The K value is a measure of vertical curvature and is defined as the horizontal distance in feet required to effect a one percent change in gradient. The K value is useful in determining minimum lengths of vertical curves for various design speeds. The minimum and desirable K values are shown in Table 5.3.

Desirable K values are based on sight distance to a 6-inch high object. These should be used whenever possible. Minimum K values are based on a 2-foot object height. These may be used when a design exception is granted under extenuating circumstances. Examples are connecting to an existing street, and where subsurface rock precludes more desirable vertical curves. Also use care when selecting K values that exceed the desirable limit. This could result in a flat roadway grade with potential to pond storm runoff.

1) Crest Vertical Curves:

Desirable lengths of crest vertical curves as determined by sight distance requirements generally are satisfactory from the standpoint of safety, comfort and appearance.

2) Sag Vertical Curves:

At least four criteria for establishing lengths of sag vertical curves are considered. These are (1) sight distance, (2) rider comfort (3) drainage control, (4) overall appearance.

Table 5.3 Vertical Curve Design Data

DESIGN SPEED	CREST K_{MIN}	$K_{DESIRABLE}$	SAG K_{MIN}	$K_{DESIRABLE}$
20	7	10	17	20
25	12	20	26	30
30	19	30	37	40
35	29	50	49	50
40	44	80	64	70
45	61	120	79	90
50	84	160	96	110
55	114	220	115	130
60	151	310	136	160
65	193	400	157	180
70	247	540	181	220

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

or

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

E. Cross Slope:

For urban (curb and gutter) sections, the cross slope will be 2.5%. For rural sections, a 2 percent cross slope is typical with 4 percent shoulder slope.

F. Intersection Grades:

1) The grade of the "through" street shall take precedence at intersections. At intersections of roadways with the same functional classification, the more important roadway shall take precedence. Side streets are to be warped to match through streets with as short a transition as possible and still provide a smooth ride. Consideration must be given to avoid drainage conflicts with pedestrian ramps.

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 grades of the through street at the intersection and the side street cross slope should be 2%. The maximum approach grade of the side street should not exceed 4% for a distance of 75 feet from the curb of the through street. Begin vertical curves on side streets beyond the cross walk locations. At signalized intersections, the crowns of both the through street and the side street should be removed to maintain design profiles through the intersection from any direction.

2) 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.

15. Roadway horizontal curvature:

A. On low speed curved roadways (at or below 40 mph) the use of normal crown is not detrimental to the user. For roadways where superelevation is used and design speed exceeds 40 mph, the Project Engineer should refer to the AASHTO Green Book.

B. Reverse horizontal curves on low speed streets shall include a minimum 50-foot tangent between the curves. An abrupt reversal in alignment makes it difficult for drivers to stay in their own lanes.

16. Sight distance:

A. The Project Engineer should check the AASHTO Green Book when specific information is needed.

B. Horizontal curve sight distance: 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. In no case shall the stopping sight distance be less than as specified in Table 5.4. A possible obstruction may be bridge abutment or line of columns, wall, cut side slope or a side or corner of a building. The sight distance design shall assume a 6' -0" fence (as measured from actual finished grade) exists at all property lines except in the sight-distance triangles required at all intersections.

C. 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. The Project Engineer should check the latest edition of the AASHTO Green Book for additional considerations such as adjustment of values shown in Table 5.4 for steep grades, decision sight distance, etc.

D. 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 minimum passing sight distance for given design speeds is given in Table 5.4.

Table 5.4 Minimum Stopping and Passing Sight Distance

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

E. Intersection sight distance - provide unobstructed sight distance along approaches of an intersection and their corners to allow drivers approaching simultaneously to see each other. Any object within the sight triangle causing a sight obstruction should be removed or lowered. Such objects include buildings, cut slopes, vegetation, and utility cabinets. When an obstruction 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. Avoid skewed intersections if possible. Refer to the AASHTO Green Book for the appropriate intersection sight distance design parameters.

17. Curb Radii

A. Minimum curb return radii are shown in Table 5.1. Where truck traffic is significant, curb return radii shall be provided according to the AASHTO Green Book. Turning templates are used in this design.

18. Pavement Thickness

    A. Minimum pavement thickness – Arterial streets must be individually designed for pavement thickness. In no case shall arterial pavement thickness be less than 9 inches. Collector and local streets must meet the minimum pavement thickness according to Table 5.1 unless known soil and subgrade conditions require additional design and pavement thickness.

    B. 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, develop appropriate design assumptions based on land use, number of lots, trips generated, etc.

Section 4 – Pavement Design

4.1 General

Rigid and flexible pavement thickness design should be based on the latest addition and supplements of the AASHTO Guide for Design of Pavement Structures.

4.2 Pavement Joints

Joints shall conform to the Cedar Rapids Metropolitan Area Standard Specifications and Details. Design considerations include the following: type of subbase, proper joint spacing to keep movement to a minimum, adequate load transfer units, and the selection and application of the sealant material. Effective sealing is an important requirement to assure the continuing function of concrete pavement joints. Water percolation and infiltration can prevent the best joint design from functioning properly.

1. Transverse Contraction Joints:

   Transverse joints across pavement lanes are spaced to control cracking of the concrete pavement as a result of stress due to moisture loss and thermal changes during the curing process. Transverse joints generally are perpendicular to the pavement centerline.

   A. Plain Contraction Joints: Commonly referred to as "C" joints are normally used in local and collector streets where load transfer is not a major factor. Any load transfer for "C" joints occurs through the adjacent irregular fractured surfaces. Typical joint spacing is 15 feet.

   B. Doweled Contraction Joints: Commonly referred to as "CD" joints or baskets. They are used to supplement the load transfer produced by aggregate interlock and stabilized subbase. They are spaced to resist shear as dynamic loads cross the joint; thus helping reduce deflection and stress of the joint. The need for CD joints depends on subgrade conditions and the service the roadway is to provide. They are normally used on arterial streets or collectors where the pavement thickness is 8" or greater and where the pavement is subject to heavier truck traffic.

2. Transverse Expansion Joints:

When transverse contraction joints are spaced as previously outlined, expansion joints are not normally required except under special conditions. Expansion joints are required only at fixed objects provided that:

A. Pavement is divided into relatively short panels by contraction joints spaced to control transverse cracking.

B. Contraction joints are properly maintained to prevent infiltration.

C. Pavement is constructed during periods when the ambient temperatures are well above freezing.

3. Transverse and Longitudinal Construction Joints:

Construction joints are necessary for planned interruptions such as at the end of each day's run, at box-outs for bridges and intersections and where emergency interruptions suspend operations for 30 minutes or more.

Planned transverse construction joints such as used at the end of a day's run, are installed at normal joint locations. They are butt-type joints with dowels since there is no aggregate interlock to provide load transfer. Planned longitudinal construction joints at intersections are Keyway joints that provide load transfer to the adjacent slab. The tie bar in these joints keeps the joint from opening to ensure joint effectiveness.

4. Longitudinal Contraction Joints

Longitudinal contraction joints generally divide the lanes of traffic to accommodate dynamic loading forces applied on one lane at a time causing the slab to hinge. Longitudinal contraction joints release stresses built up by restrained warping and dynamic loading. Under certain conditions such as rapidly dropping air temperature during the night, longitudinal cracks may occur early. In such cases, early formation of the joint is required.

In most cases, the longitudinal joint should be placed at the center of the pavement not only to help delineate separation of opposing traffic but to allow the pavement to hinge due to lane loading.

4.3 Railroad Crossings

Railroad crossings can be treated in various ways including adequate signing, signals, gates, and grade separation. The design will involve the volume and speed of traffic on the roadway and railroad, available sight distance, and safety benefits. Traffic control systems for railroad-highway grade crossings shall conform to the MUTCD. The Jurisdiction should contact the railroad company for specific requirements.

Precast concrete crossing panels are preferred. The designer or railroad company should also determine if a subdrain or track rehabilitation under the crossing panels is necessary.

4.4 Pavement Smoothness

When preparing specifications for a pavement with design speed greater than 35 mph, provide pavement smoothness requirements according to the Metro Standard Specifications, or as otherwise directed by the Jurisdiction.

Section 5 – Access Criteria

5.1 General

The efficiency and safety of a street or highway depends to a large extent upon the amount and character of interruptions to the movement of traffic. The primary cause of these interruptions is vehicular movements to and from businesses, residences and other developments along the street or highway. Regulation and overall control of access is necessary to provide efficient and safe highway operation and to utilize the full potential of the highway investment.

5.2 Access Permit Procedure

An Access Permit may be required from the Jurisdictional Engineer for a public or private access constructed to a public street. The Jurisdictional Engineer will determine if a permit is required. Access to streets or highways under the jurisdiction of the Iowa Department of Transportation (IDOT) will be governed by requirements of the IDOT with Jurisdictional review.

The following general criteria will be used by the Jurisdiction when reviewing an access request:

1. Safety to the traveling public.

2. Perpetuation of the traffic-carrying capacity of the highway.

3. Protection of the rights of the traveling public and of property owners including the rights of abutting property owners.

5.3 Definitions

The following terms are defined:

1. Access: A means of ingress or egress between public right-of-way and abutting properties.

2. Built-Up Area: An area adjacent to a roadway that meets the follow general

criteria -

A. The lots or areas abutting the roadway do not have sufficient setback for the construction of a frontage road, and the development in depth precludes the establishment of a frontage-type road to the rear of the lots or area.

B. When a "built-up area" exists on one side of roadway, the other side of the road is also considered to be "built-up" to determine access requirements.

3. Entrance: A physical connection between a highway or street and abutting property for the purpose of access.

4. Fringe Area: A suburban-type area adjacent to a roadway that meets the following general criteria: The layout of the lots or area abutting the roadway including intermittent or unrelated development, permits construction of a frontage road in front of, or a frontage-type road to the rear of, the development.

5. Frontage: The length along public right-of-way of an individual lot. Corner property at an intersection of two public roads has separate frontage along each roadway.

6. Frontage Road: A public or private road or street auxiliary to and usually located alongside and parallel to a roadway for maintaining local road continuity and for control of access.

7. Median: The portion of a divided highway or divided entrance separating the traveled ways from opposing traffic. Medians may be depressed, raised or painted. Openings in the roadway median to accommodate entrances are governed by the following:

A. New median openings should not be permitted except to accommodate intersecting local public roads or streets or large traffic generating facilities such as large shopping centers or industrial plants. Median openings may be permitted in these instances if satisfactorily justified and in the public interest.

B. If a median opening exists prior to the construction of a driveway of local public road or street, the opening may be modified to accommodate the turning movements of the traffic expected.

8. Predetermined Access Location: A location of access reserved for the adjacent property at the time access rights are acquired.

5.4 Entrance Type

1. Type "A" Entrance. An entrance developed to carry sporadic or continuous heavy concentrations of traffic. An entrance of this type would normally consist of multiple approach lanes and may incorporate a median. Examples: racetracks, large industrial plants, shopping centers, subdivisions or amusement parks.

2. Type "B" Entrance. An entrance developed to serve moderate traffic volumes. An entrance of this type would normally consist of one inbound and one outbound traffic lane. Examples: Service stations, small businesses, drive-in banks or light industrial plants.

3. Type "C" Entrance. An entrance developed to serve light traffic volumes. The entrance would not normally accommodate simultaneous inbound and outbound vehicles. Examples: residential, farm or field entrances.

5.5 Entrance Design Criteria

1. Width Measurement

   The width of an entrance shall be measured at the property end of the radius return or flared taper. The curb opening may exceed the maximum allowable width of the entrance to accommodate the allowable radius or taper.

2. Dimensions and Spacings

Figure 5.2 Entrance Dimensions and Spacing

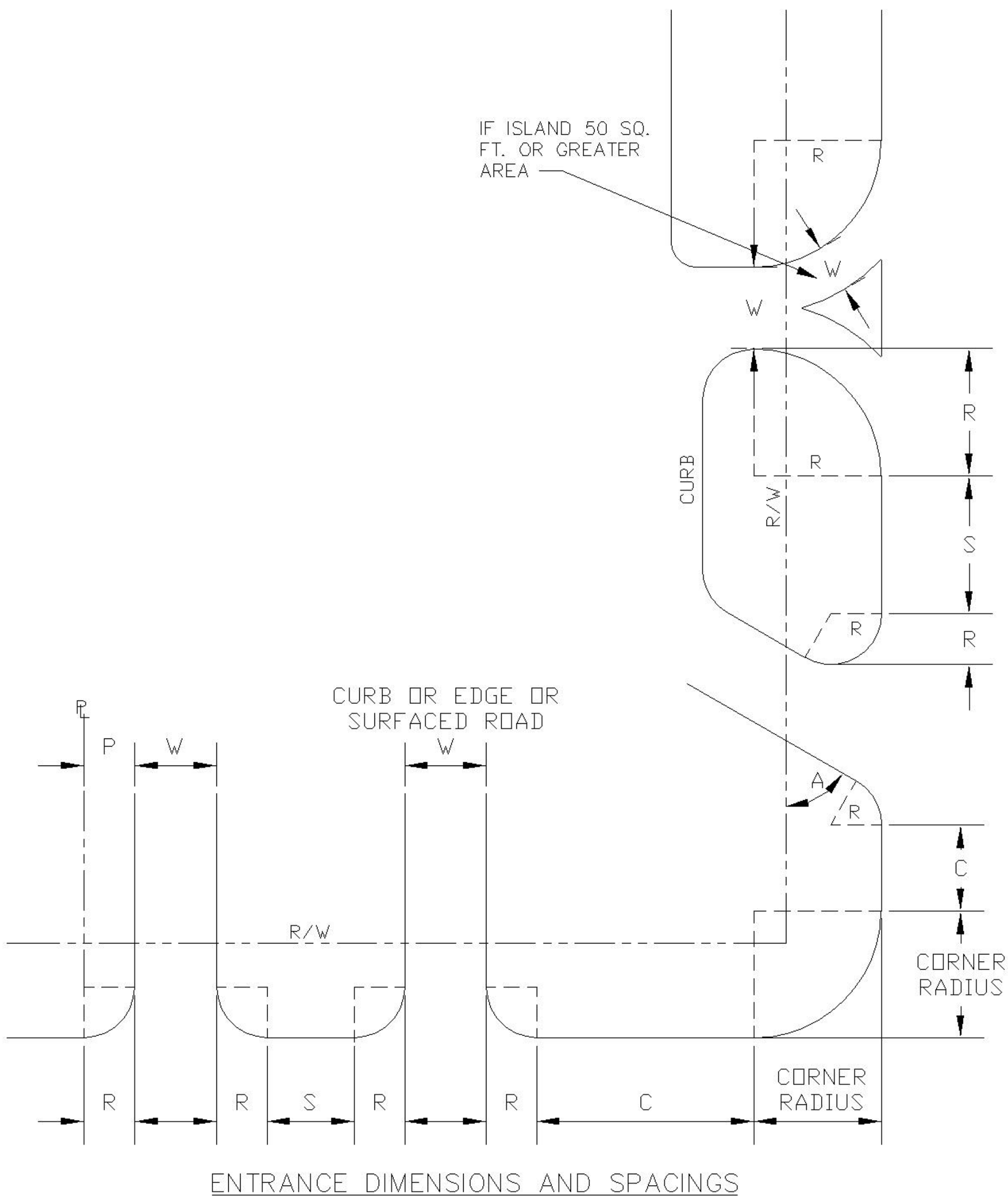


Table 5.5 Entrance Dimensions (ft)

		Local and Collector Streets				Major and Minor Arterials			
	Dimension Reference (See Fig. 5.2)	Residential	Commercial	Industrial	Agricultural	Residential	Commercial	Industrial	Agricultural
Entrance Type		C	B	B	C	C	A or B	A or B	C
Width[1]	W								
Minimum		10	24	24	15	10	24	24	15
Maximum[7]		24	30	40	30	24	40	50	30
Right Turn Radius[2]	R								
Minimum		5	15	20	10	5	15	20	15
Maximum		10	20	30	20	15	35	50	25
Minimum Spacing[3]									
From property line	P	R/F	R+10	R+10	R	R/F	R+10	R+10	R
From street corner	C	10	10	10	50	300	300-600	300-600	300
Between Driveways on same lot	S	30	60	60	300	30	60	60	300
Angle[4]	A	90°	90°	90°	90°	90°	90°	90°	90°
Pavement thickness in ROW		5”	6”	8”	N/A	5”	6”	8”	N/A

Notes:

1. The minimum width of commercial or industrial driveways is 15 ft. for one-way operation. The width is intended to be measured along the right-of-way line, in most instances at the Inner limit of a curbed radius or between the line of the radius and the near edge of a curbed island of at least 50 square feet in area.
2. Flares (F) may be used for residential entrances in lieu of radii, with a minimum 2:1 ratio (the 2 dimension being at a right angle to the street).
3. Measured along the curb or edge of pavement from the roadway end of the curb radius.
4. Any variation from 90° will be evaluated on a case basis. The minimum acute angle (measured from the edge of the pavement) for any one-way commercial or industrial driveway is 70°. The minimum acute angle for any residential driveway is 60°.
5. Shared driveways shall be approved by the Jurisdiction.
6. The spacing from an entrance to arterial street corner may be less than 300 feet if justified by a traffic study, entrance is right-in/right-out, or other site-specifics have been evaluated by the Jurisdiction.
7. Driveway on local residential street may have a maximum width of 36 feet for a garage with three or more stalls except where located within a cul-de-sac bulb, where maximum width shall be 24 feet regardless of number of stalls.

A. For individual properties, the number of entrances will be as follows:

(1) Single Family (SF) Residential - In general, each SF residential property shall have one access point. However where houses are located on corner lots, where frontage length is at least twice the width of the structure, or access is from heavy traveled roadway, more than one access point may be permitted.

(2) Multi-Family (MF) Residential - In general, access shall be determined a traffic study as required and Jurisdiction's concerns.

(3) Commercial - Commercial property with less than 200 feet of frontage and located mid-block shall be limited to one access point. A second access point may be allowed for commercial property having more than 200 feet of frontage. For commercial property located on a corner, one access to each street may be permitted provided there is adequate spacing between the intersecting street and the proposed entrance.

(4) Industrial - Access shall be determined on a case-by-case basis. The Jurisdiction may require submittal of a traffic study.

(5) Agricultural - Two accesses at minimum 300 foot intervals may be permitted provided there is a minimum spacing of 30 feet between two adjacent culverts.

3. Sight Distance

A. An access location should be established with adequate intersection sight distance according to the AASHTO Green Book. Increased sight distance may be required when grades are significant and/or when a significant number of trucks will be using the entrance.

B. On a four-lane divided primary highway where access is proposed at a location not to be served by a median crossover, sight distance is required only in the direction of the flow of traffic.

C. An access location should be established where desirable sight distance is available and shall not be authorized in a location providing less than minimum sight distance, as shown on the following table:

Table 5.6 Access Sight Distance

Posted Speed Limit (mph)	Desirable Sight Distance (ft)* Entrance Type A,B,C Arterial Street	Minimum Sight Distance (ft)* Entrance Type A,B,C Arterial Street	Minimum Sight Distance (ft)* Entrance Type C Collector/Local Street
25	300	250	150
30	375	325	200
35	475	400	225-250
40	575	475	275-325
45	700	550	325-400
50	850	650	400-475
55	1000	725	450-550

*Distances based on acceleration rates for passenger vehicles at nearly level conditions. Adjustments to these distances required when grades are significant and/or when a significant number of trucks will be using the entrance.

4. Grades and Dimensions

A. Curb and Gutter Streets - Table 5.5 and Figures 5.3 and 5.4 show the required grades and dimensions for an entrance connecting to a curb and gutter street.

B. Non-Curb and Gutter Roadways

1) Access to non curb and gutter streets should be located per Table 5.5. A culvert sized for the ditch flow should be installed at the established roadside ditch flowline beneath the private drive access.

5. Other Criteria

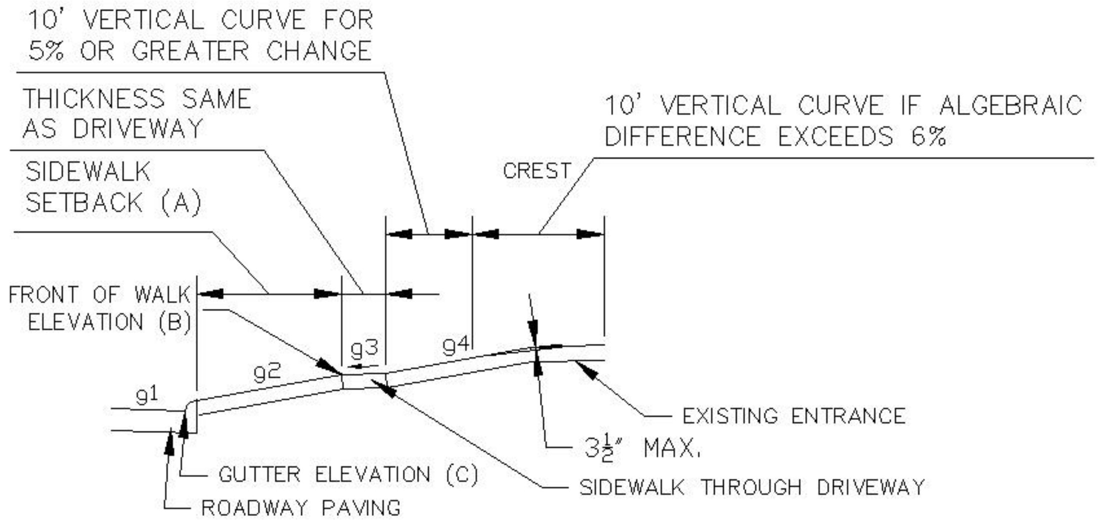
A. Adjustments to utility poles, street lights, fire hydrants, sewer structures, traffic signs and signals or other improvements as a result of curb openings or driveways shall be accomplished without cost to the Jurisdiction.

B. Driveways functioning as an entrance only or an exit only shall be signed by and at the expense of the property owner subject to approval of the Jurisdictional Engineer.

C. Abandoned curb openings or driveways shall be removed and the parking area and full-height curb restored by the property owner.

D. No depressed sidewalk through the entrance. Sidewalk must be at a higher elevation than the back of curb. Driveways shall rise from the gutter line to the sidewalk to keep major storm runoff in the right-of-way.

Figure 5.3 Typical Section – Commercial/Industrial Entrance



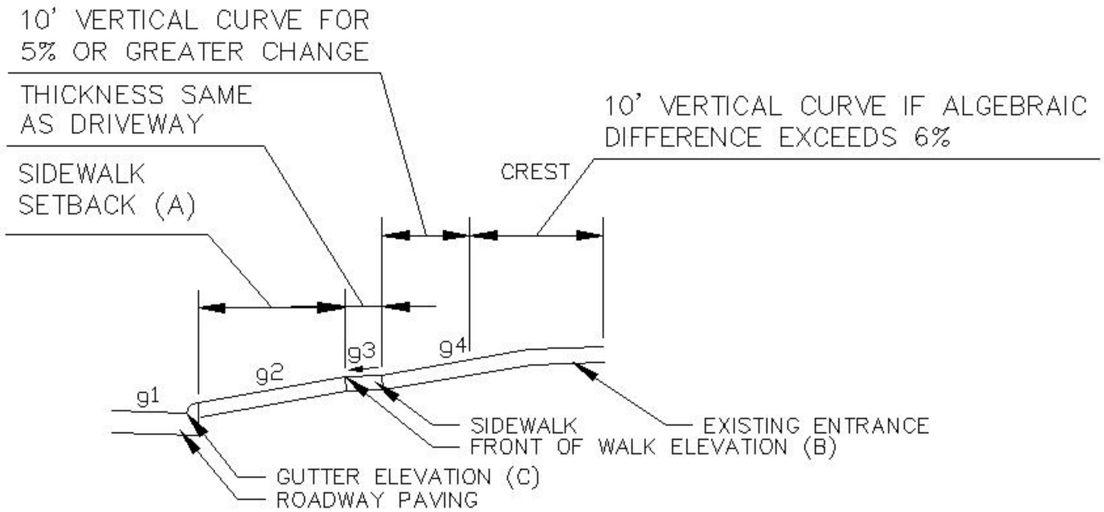
Notes:

1. g1 and g2 - Algebraic difference between g1 and g2 shall not exceed 9%.
2. g3 - Maximum slope 2%. Minimum slope 1.5%.
3. g4 - Maximum slope 9% Inclusive of tolerance; Use vertical curve between g3 and g4 if grade change is 5% or greater.
4. Surface drainage onto public right-of-way must be approved by jurisdictional engineer.

Table 5.7 Standard Sidewalk Elevations At Commercial/Industrial Driveway Entrance

SETBACK FROM BACK OF CURB TO FRONT OF WALK IN FEET (A)	FRONT OF WALK ELEVATON ABOVE GUTTER ELEVATION IN FEET (B-C)	FRONT OF WALK ELEVATION ABOVE GUTTER ELEVATION IN INCHES (B-C)
6	0.46'	5.50"
7	0.50'	6.50"
8	0.56'	6.75"
9	0.62'	7.50"
10	0.69'	8.25"
11	0.75'	9.00"
12	0.81'	9.75"
13	0.87'	10.50"
14	0.94'	11.25"
15	1.00'	12.00"
16	1.04'	12.50"
(B-C) VERTICAL TOLERANCE = ±0.04 FT OR ±1/2"		
(A) HORIZONTAL TOLERANCE = ±0.16 FT OR ±2"		

Figure 5.4 Typical Section – Residential Entrance



Notes:

1. g1 and g2 - Algebraic differences between g1 and g2 shall not exceed 12%.
2. g2 and g3 and/or g3 and g4 - Algebraic difference not to exceed 8%.
3. g3 -Maximum slope 2%. Minimum Slope 1.5%.
4. g4 - Slope (Max. 10% Inclusive of tolerance) - Use vertical curve between g3 and g4 if grade change is 5% or greater.

Table 5.8 Standard Sidewalk Elevations At Residential Driveway Entrance

SETBACK FROM BACK OF CURB TO FRONT OF WALK IN FEET (A)	FRONT OF WALK ELEVATON ABOVE GUTTER ELEVATION IN FEET (B-C)	FRONT OF WALK ELEVATION ABOVE GUTTER ELEVATION IN INCHES (B-C)
5	0.54'	6.50"
6	0.62'	7.50"
7	0.71'	8.50"
8	0.81'	9.75"
9	0.86'	10.25"
10	0.90'	10.75"
11	0.94	11.25"
12	0.98'	11.75"
13	1.02'	12.25"
14	1.06'	12.75"
15	1.10'	13.25"
16	1.14'	13.75"
(B-C) VERTICAL TOLERANCE = ±0.04 FT OR ±1/2"		
(A) HORIZONTAL TOLERANCE = ±0.16 FT OR ±2"		

Section 6 – Traffic Impact Studies

6.1 General

A traffic impact study may be required for commercial, industrial or residential developments in obtaining access. The Jurisdictional Engineer must be contacted to determine if additional requirements or guidelines will be required.

1. Factors in developing an access plan for a commercial site include determination of the potential traffic generated by the site and the directional distribution of site-generated traffic on the major approach routes and proposed driveways serving the site. Entrances serving commercial, industrial or high density residential developments represent an important element in the efficiency and safety of the roadway onto which their traffic enters and exits. To properly handle traffic from such entrances, the anticipated traffic volumes must be determined.

2. The location of entrances, particularly commercial ones, is a critical factor in minimizing the hazard and disruption to traffic and pedestrians. Sites must be designed to allow proper entrance location.

3. Adequate storage must be provided on commercial sites so vehicles do not impede roadway capacity. Adequate storage space is a function of the demand volume, service time per facility, and the number of service facilities available. The geometrics of the internal circulation control a portion of the service time. The service time is dependent upon the time required to maneuver into position and the time necessary to obtain the service. The radii of internal curves should be as large as possible. Buildings should be arranged on the site to allow for the maximum storage available on the site for exiting traffic, and situated so they will not disrupt the free flow of entering traffic.

4. Submit a site plan to the Jurisdiction for review showing the proposed access. Locations of adjacent and opposing entrances and location relative to nearest street connections should be included.

Section 7- Public Right-of-Way

7.1 Right-of-Way Requirements:

1. See Table 5.1 and the following details for minimum right-of-way requirements. The details only apply to projects in the City of Cedar Rapids.

2. Right of way at skewed intersections shall include adequate area to construct pedestrian ramps with ADA-compliant grades, utilities, and traffic signals as necessary.