Chapter 28

SIGHT DISTANCE

BUREAU OF LOCAL ROADS AND STREETS MANUAL

Chapter 28
SIGHT DISTANCE

Table of Contents

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28-1 STOPPING SIGHT DISTANCE (SSD)

SSD is the sum of the distance traveled during a driver's brake reaction time (i.e., perception / reaction time) and the braking distance (i.e., distance traveled while decelerating to a stop). To calculate SSD on level grade, use the following formulas:

$$SSD = 1.47\ Vt + 1.075\frac{V^2}{a} \qquad \text{(US Customary) Equation 28-1.1}$$

$$SSD = 0.278Vt + 0.039\ \frac{V^2}{a} \qquad \text{(Metric) Equation 28-1.1}$$

Where:

SSD	=	stopping sight distance, ft (m)
V	=	design speed, mph (km/h)
t	=	brake reaction time, 2.5 s
a	=	driver deceleration, ft/s^2 (m/s^2) – recommended at 11.2 ft/s^2 (3.4 m/s^2)

The following briefly discusses the basic assumptions within the SSD model:

1. Brake Reaction Time. This is the time interval between when the obstacle in the road can be physically seen and when the driver first applies the brakes. Based on several studies of observed driver reactions, the assumed value is 2.5 seconds.
2. Braking Action. The braking action is based on the driver's ability to decelerate the vehicle while staying within the travel lane and maintaining steering control during the braking maneuver. A deceleration rate of 11.2 ft/s^2 (3.4 m/s^2) is considered to be comfortable for 90% of the drivers.
3. Design Speed. The local facility's design speed is used to determine the initial driver speed.

Figure 28-1A provides SSD for vehicles on level grade (-3 to +3 percent). Figure 28-1B provides SSD for vehicles on downgrades or upgrades 3 percent or steeper. When applying the SSD values, the height of eye is assumed to be 3.5 ft (1.080 m) and the height of object 2 ft (600 mm).

US Customary				Metric			
Design Speed (mph)	Brake[1] Reaction Distance (ft)	Braking[2] Distance On Level (ft)	Design SSD (ft)	Design Speed (km/h)	Brake[1] Reaction Distance (m)	Braking[2] Distance On Level (m)	Design SSD (m)
20	73.5	38.4	115	30	20.9	10.3	35
25	91.9	60.0	155	40	27.8	18.4	50
30	110.3	86.4	200	50	34.8	28.7	65
35	128.6	117.6	250	60	41.7	41.3	85
40	147.0	153.6	305	70	48.7	56.2	105
45	165.4	194.4	360	80	55.6	73.4	130
50	183.8	240.0	425	90	62.6	92.9	160
55	202.1	290.3	495	100	69.5	114.7	185
60	220.5	345.5	570				

Notes:

1. *Brake reaction distance based on a time of 2.5 s.*
2. *Driver deceleration based on a rate of 11.2 ft/s^2 (3.4 m/s^2).*

STOPPING SIGHT DISTANCE ON LEVEL ROADWAYS

Figure 28-1A

US Customary							Metric						
Design Speed (mph)	Design SSD (ft)						Design Speed (km/h)	Design SSD (m)					
	Downgrades			Upgrades				Downgrades			Upgrades		
	3%	6%	9%	3%	6%	9%		3%	6%	9%	3%	6%	9%
20	116	120	126	109	107	104	30	32	35	35	31	30	29
25	158	165	173	147	143	140	40	50	50	53	45	44	43
30	205	215	227	200	184	179	50	66	70	74	61	59	58
35	257	271	287	237	229	222	60	87	92	97	80	77	75
40	315	333	354	289	278	269	70	110	116	124	100	97	93
45	378	400	427	344	331	320	80	136	144	154	123	118	114
50	446	474	507	405	388	375	90	164	174	187	148	141	136
55	520	553	593	469	450	433	100	194	207	223	174	167	160
60	598	638	686	538	515	495							

STOPPING SIGHT DISTANCE ON GRADES

Figure 28-1B

28-2 PASSING SIGHT DISTANCE (PSD)

PSD considerations are limited to two-lane, two-way highways. On these facilities, vehicles may overtake slower moving vehicles, and the passing maneuver must be accomplished on a lane used by opposing traffic.

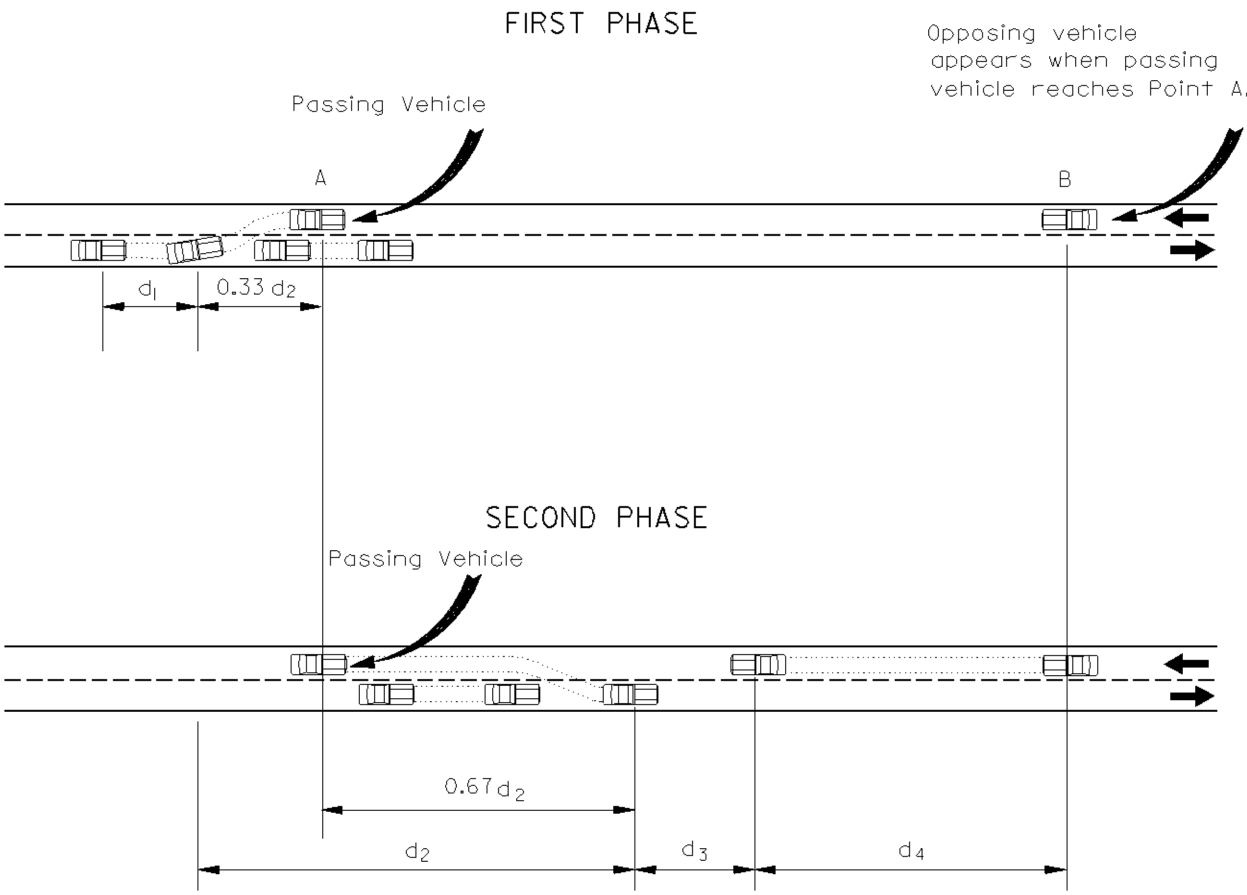
The minimum PSD for two-lane highways is determined from the sum of four distances as illustrated in Figure 28-2A. For a discussion on how to determine these four distances, review the American Association of State Highway and Transportation Officials (AASHTO) *A Policy on Geometric Design of Highways and Streets (The Green Book)* and/or Section 47-2 of the *Bureau of Design and Environment (BDE) Manual*.

Figure 28-2B provides the minimum PSD for design on two-lane, two-way highways. These distances allow the passing vehicle to safely complete the entire passing maneuver. These values should not be confused with the values presented in the *Illinois Supplement to the Manual of Uniform Traffic Control Devices (ILMUTCD)* for the placement of no-passing zone stripes. These values are based on different operational assumptions (i.e., distance for the passing vehicle to abort the passing maneuver). The designer should also realize that the highway capacity adjustment in the *Highway Capacity Manual (HCM)* for two-lane, two-way highways is based on the *ILMUTCD* criteria for marking no-passing zones. It is not based on the percent of PSD from *The Green Book* and shown in Figure 28-2C.

PSD for passenger cars is measured from a 3.5 ft (1.080 m) height of eye to a 3.5 ft (1.080 m) height of object. The 3.5 ft (1.080 m) height of object allows the opposing driver to see the top of a typical passenger car. The recommended value of truck driver eye height for design is 7.6 ft (2.330 m) above the roadway surface.

On rural new construction / reconstruction projects, the designer should attempt to provide PSD over the length of the project consistent with the percentages shown in Figure 28-2C. In determining the percentages, each PSD segment should be greater than 1,500 ft (450 m). It is generally not cost effective to make significant improvements to the horizontal and vertical alignment solely to increase the available PSD.

Appreciable upgrades can increase the sight distances required for safe passing maneuvers. Where these upgrades are encountered in the design of the project, take this into account when selecting the appropriate PSD.



d_1 = Initial maneuver distance, ft (m)
d_2 = Distance while passing vehicle occupies left lane, ft (m)
d_3 = Clearance length, ft (m)
d_4 = Distance traversed by the opposing vehicle, ft (m)

Notes:

1. *To determine d_1, d_2, d_3, and d_4, see The Green Book and/or Section 47-2 of the BDE Manual.*
2. *The ILMUTCD definition for passing sight distance uses only the second phase of signing and pavement markings distances.*

ELEMENTS OF PASSING DISTANCE
(Two-Lane Highways)

Figure 28-2A

US Customary		Metric	
Design Speed (mph)	Design Passing Sight Distance (ft)	Design Speed (km/h)	Design Passing Sight Distance (m)
20	710	30	200
25	900	40	270
30	1090	50	345
35	1280	60	410
40	1470	70	485
45	1625	80	540
50	1835	90	615
55	1985	100	670
60	2135		

MINIMUM DESIGN PASSING SIGHT DISTANCE
(Assumes Entire Maneuver is Completed)

Figure 28-2B

Terrain	Minimum Percent Passing Sight Distance		
	Arterials	Collectors	Local
Level	60%	50%	40%
Rolling	40%	30%	20%

GUIDELINES FOR PERCENT PASSING DISTANCE
(Rural)

Figure 28-2C

28-3 INTERSECTION SIGHT DISTANCE (ISD)

28-3.01 General

In general, ISD refers to the corner sight distance available in intersection quadrants that allows a driver approaching an intersection to observe the actions of vehicles on the crossing leg(s). ISD evaluations involve establishing the needed sight triangle in each quadrant by determining the legs of the triangle on the two crossing roadways.

Within this clear sight triangle, the objective is to remove or lower any object that obstructs the driver's view, if practical. Sight obstruction may include:

- buildings,
- parked vehicles (see Section 31-1),
- vegetation (trees, hedges, bushes, un-mowed grass, tall crops)
- fences,
- roadside hardware,
- highway structures, railroad structures,
- retaining walls, and
- the actual ground line.

The additional costs and impacts of removing sight obstructions are often justified. If it is impractical to remove an obstruction blocking the sight distance; consider providing traffic control devices or design applications (e.g., warning signs, turn lanes) which may not otherwise be considered.

In general, point obstacles (e.g., traffic signs, utility poles) are not considered sight obstructions (i.e., the driver can move slightly to avoid these obstacles). Crops and un-mowed grasses are considered seasonal / non-permanent obstructions, give consideration to crops and un-mowed grasses within the corner sight distance triangle.

The height of eye for passenger cars is assumed to be 3.5 ft (1.080 m) above the surface of the minor road. The height of object (approaching vehicle on the major road) is also assumed to be 3.5 ft (1.080 m). An object height of 3.5 ft (1.080 m) assumes that a sufficient portion of the oncoming vehicle must be visible to identify it as an object of concern by the minor road driver. If there are a sufficient number of trucks to warrant their consideration, see Section 36-6 of the *BDE Manual*.

The necessary clear sight triangle is based on the type of traffic control at the intersection and on the design speeds of the two roadways. Some of the cases are further divided by the movement at the intersection, however; the values in the figures in Section 28-3 will cover all movements. The types of traffic control and maneuvers are as follows:

- Case A – Intersections with no control,
- Case B – Intersections with stop control on the minor road,
    - B-1 (Left turns) / B-2 (Right turns) / B-3 (Crossing)
- Case C – Intersections with yield control on the minor road;
    - C-1 (Crossing) / C-2 (Left or right turns)
- Case D – Intersections with traffic signal control,
- Case E – Intersections with all-way stop control, and
- Case F – Left turns from the major road.

Gap acceptance is used as the conceptual basis for ISD criteria. For additional guidance on the gap acceptance design, see *The Green Book*.

US Customary									
Approach Grade (%)	Design Speed (mph)								
	20	25	30	35	40	45	50	55	60
- 6	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2
- 5	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
- 4	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1
- 3 to + 3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
+ 4	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9
+ 5	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9
+ 6	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Metric								
Approach Grade (%)	Design Speed (km/h)							
	30	40	50	60	70	80	90	100
- 6	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2
- 5	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1
- 4	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1
- 3 to + 3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
+ 4	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9
+ 5	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9
+ 6	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9

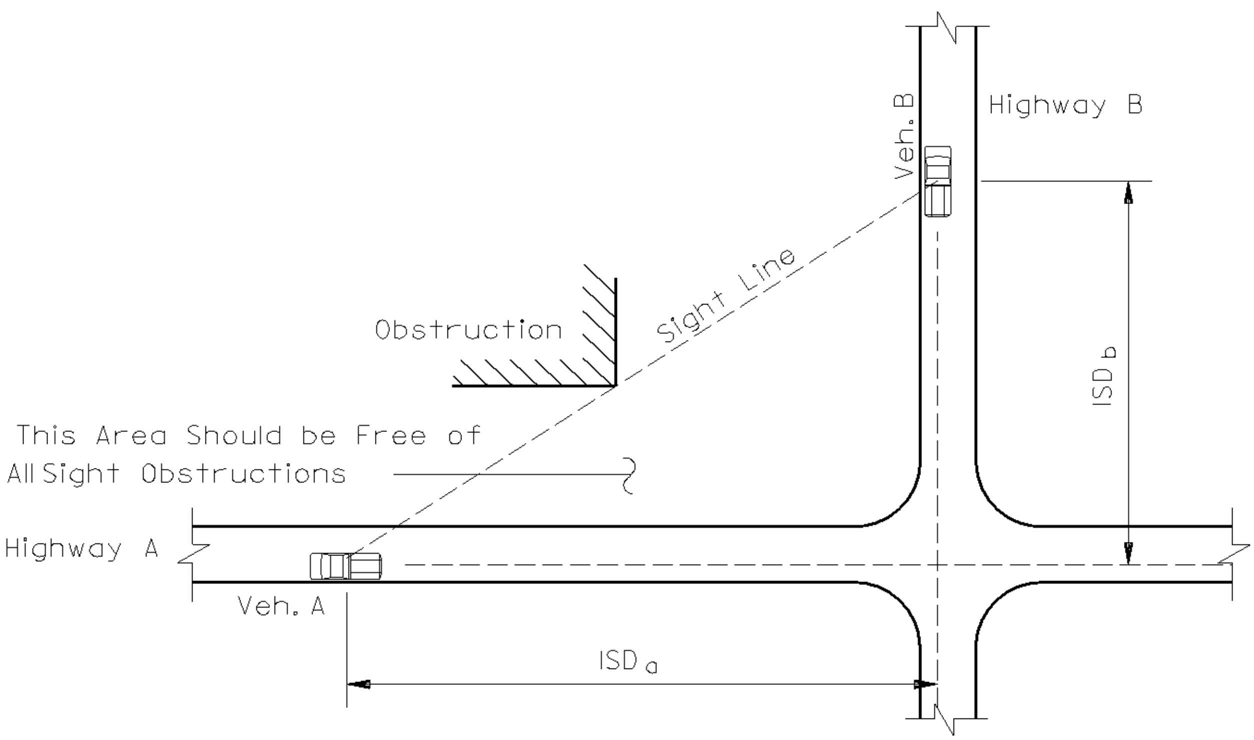
ADJUSTMENT FACTORS
FOR SIGHT DISTANCE BASED ON APPROACH GRADE

Figure 28-3A

28-3.02 Case A – Intersections With No Control

Intersections between low-volume and low-speed roads/streets may have no traffic control. At these intersections, sufficient corner sight distance should be available to allow approaching vehicles to adjust their speed to avoid a collision, typically a reduction to 50% of their mid-block running speed. Figure 28-3B illustrates the corner sight distance triangles for intersections with no traffic control. Figure 28-3C provides the ISD criteria for these intersections. Example 28-3(1) provides the steps in determining the length of each of the legs of an intersection's sight triangle. Consider providing the suggested sight distance, especially for new construction. If this sight distance cannot be provided, consider placing stop or yield signs on one of the roads, or installing intersection warning signs.

Where the grade along an intersection approach exceeds 3 percent, the leg of the clear sight triangle along that approach should be adjusted by multiplying the approach sight distance by the appropriate adjustment factor from Figure 28-3A.



MEASUREMENT OF INTERSECTION SIGHT DISTANCE
(Case A – No Traffic Control)

Figure 28-3B

US Customary		Metric	
Design Speed (mph)	Intersection Sight Distance (ft)	Design Speed (km/h)	Intersection Sight Distance (m)
20	90	30	25
25	115	40	35
30	140	50	45
35	165	60	55
40	195	70	65
45	220	80	75
50	245	90	90
55	285	100	105
60	325		

Note:

1. *For approach grades that exceed 3%, multiply by the value in Figure 28-3A.*

INTERSECTION SIGHT DISTANCE
(Case A – No Traffic Control)

Figure 28-3C

* *

Example 28-3(1)

Given: No traffic control at intersection
Approach grades are between -3% and +3%
Design speed – 40 mph (Highway A – see Figure 28-3B)
30 mph (Highway B – see Figure 28-3B)

Problem: Determine legs of sight triangle.

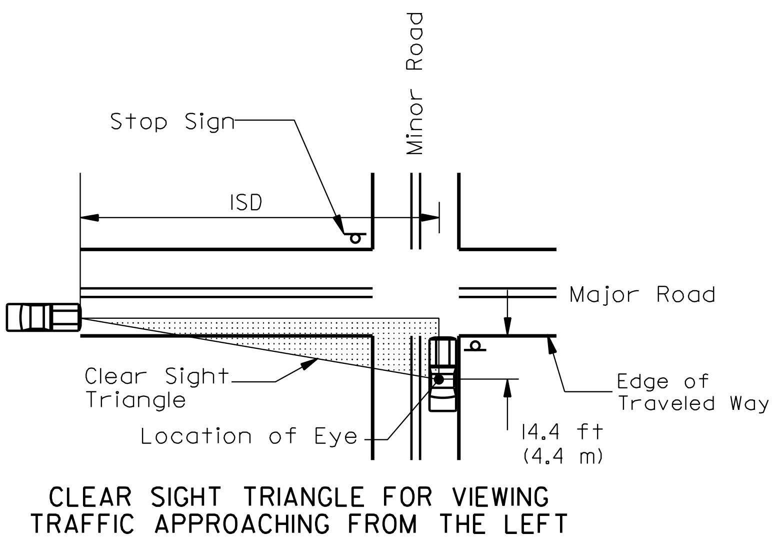
Solution: From Figure 28-3A – Adjustment Factor = 1.0
From Figure 28-3C – ISD_a = 195 ft
ISD_b = 140 ft

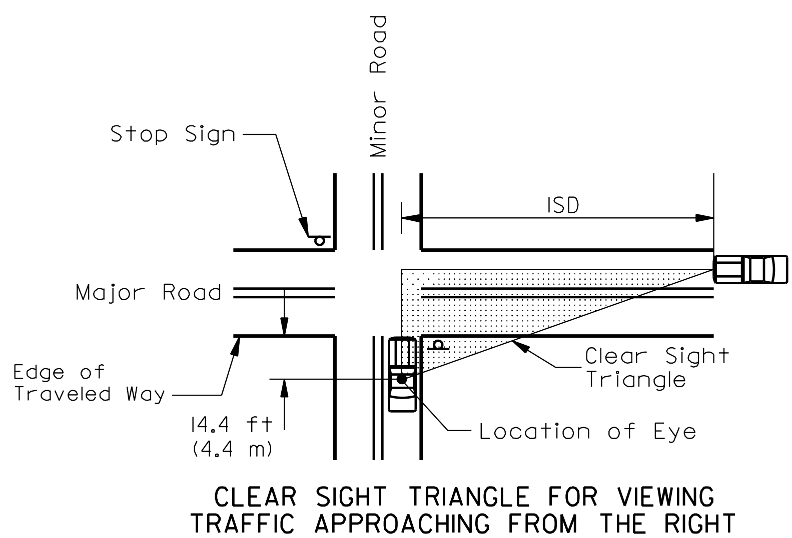
* *

28-3.03 Case B – Intersections with Stop Control on the Minor Road

Where traffic on the minor road of an intersection is controlled by stop signs, the driver of the vehicle on the minor road must have sufficient sight distance for a safe departure from the stopped position assuming that the approaching vehicle comes into view as the stopped vehicle begins its departure.

The ISD is obtained by providing clear sight triangles both to the right and left as shown in Figure 28-3D. The length of legs of these sight triangles is determined as follows:





CLEAR SIGHT TRIANGLES
(Case B – Stop-Controlled on the Minor Road)

Figure 28-3D

1. Minor Road. The length of leg along the minor road is based on two parts. The first is the location of the driver's eye on the minor road. This is typically assumed to be 15 ft (4.5 m) from the edge of traveled way for the major road and in the center of the lane on the minor road. The second part is based on the distance to the center of the vehicle on the major road. For right-turning vehicles, this is assumed to be the center of the closest travel lane from the left. For left-turning vehicles, this is assumed to be the center of the closest travel lane for vehicles approaching from the right. See Figure 28-3E.

2. Major Road. The length of the sight triangle leg or ISD along the major road is determined using the following equation:

   $$ISD = 1.47\ V_{major}\ t_g \qquad \text{(US Customary) Equation 28-3.1}$$

   $$ISD = 0.278\ V_{major}\ t_g \qquad \text{(Metric) Equation 28-3.1}$$

   Where:

   ISD = length of sight triangle leg along major road, ft (m)

   V_{major} = design speed of major road, mph (km/h)

   t_g = time gap for minor road to enter the major road, sec

   The critical time gap (t_g) varies according to the design vehicle, the maneuver type, the grade on the minor road approach, the number of lanes on the major roadway, the type of operation, and the intersection skew.

3. Design Vehicles. For local roads and streets, assume a passenger car as the design vehicle (i.e., t_g = 7.5 seconds).

4. Grades. If the approach grade on the minor road is on an upgrade that exceeds 3%, add 0.2 sec for each percent grade to t_g.

5. ISD Values. Figure 28-3E provides the ISD criteria for a passenger car turning left or right or crossing a two-lane major road. For other types of facilities (e.g., four-lanes, medians) or where trucks may control the design, see Section 36-6 of the *BDE Manual*.

At a minimum, provide Case B sight distance at all intersections for reconstruction and new construction projects. Also, provide Case B sight distance on projects where the vertical alignment is changed.

US Customary		Metric	
Design Speed (V_{major}) (mph)	ISD (ft) [(1)(2)]	Design Speed (V_{major}) (km/h)	ISD (m) [(1)(2)]
20	225	30	65
25	280	40	85
30	335	50	105
35	390	60	130
40	445	70	150
45	500	80	170
50	555	90	190
55	610	100	210
60	665		

Notes:

1. *These ISD values assume crossing or left or right turns onto a two-lane facility without a median for a passenger car. For other types of facilities (e.g., four-lanes, medians) or where trucks may control the design, see* [*Section 36-6*] *of the BDE Manual.*
2. *Where the approach grade on the minor road is on an upgrade that exceeds 3%, add 0.2 sec for each percent grade to t_g.*

INTERSECTION SIGHT DISTANCES
(Two-Lane Facilities)
(Case B – Stop Control on the Minor Road)

Figure 28-3E

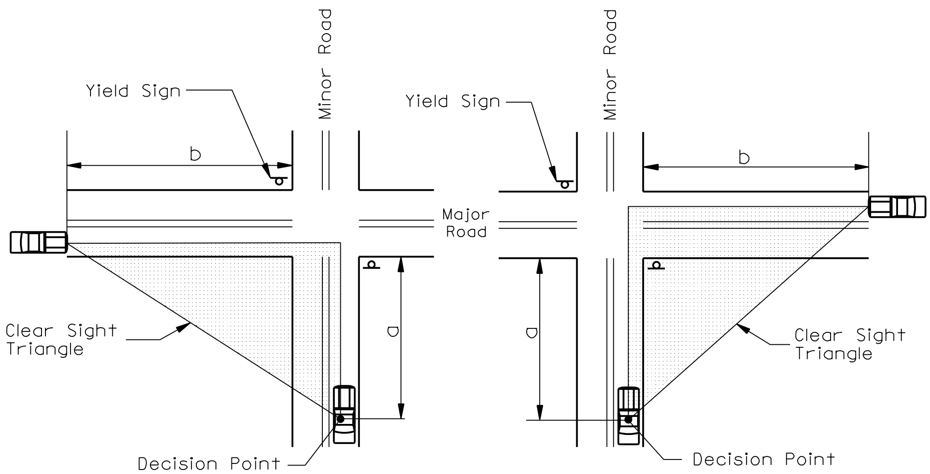
28-3.04 Case C – Intersections With Yield Control On the Minor Road

At intersections controlled by a yield sign, drivers on the minor road will typically:

- slow down as they approach the major road to approximately 60% of the approach speed;
- based on their view of the major road, make a stop/continue decision; and
- either brake to a stop or continue their crossing or turning maneuver onto the major road.

Yield control criteria is based on a combination of the no control ISD discussed in Section 28-3.02 and the stop-controlled ISD as discussed in Section 28-3.03. Where yield control is proposed, consider the Case C sight distance on new construction and reconstruction projects.

If adequate sight distance cannot be provided, consider replacing the yield sign with a stop sign. To determine the applicable clear sight triangles for a yield-controlled intersection, see Figure 28-3E.



US Customary			Metric		
Design Speed (mph)	Minor Road Approach (a) (ft)[1,2]	Major Road Approach (b) (ft)	Design Speed (km/h)	Minor Road Approach (a) (m)[1,2]	Major Road Approach (b) (m)
20	100	195	30	30	55
25	130	240	40	40	75
30	160	290	50	55	95
35	195	335	60	65	110
40	235	385	70	80	130
45	275	430	80	100	145
50	320	480	90	115	165
55	370	530	100	135	185
60	420	575			

Notes:

1. *For "T" intersections, use 85 ft (25 m).*
2. *Values shown are for passenger cars crossing a two-lane facility with no median and grades 3% or less. For approach grades that exceed 3%, multiply by the value in Figure 28-3A.*

INTERSECTION SIGHT DISTANCE GUIDELINES
(Case C – Yield Control)

Figure 28-3F

28-3.05 Case D – Intersections with Traffic Signal Control

At signalized intersections, provide sufficient sight distance from the stop bar so that the first vehicle on each approach is visible to all other approaches. Traffic signals are often used at high-volume intersections to address crashes related to restricted sight distances. Therefore, the ISD criteria for left- or right-turning vehicles as discussed in Section 28-3.03 are typically not applicable at signalized intersections. However, where right-turn-on-red is allowed, check to ensure that the ISD for a stop-controlled right-turning vehicle is available to the left. If it is not, consider restricting the right-turn-on-red movement. In addition, if the traffic signal is placed on two-way flash operation (i.e., flashing amber on the major-road approaches and flashing red on the minor-road approaches) under off-peak or nighttime conditions, consider providing the ISD criteria as discussed in Section 28-3.03 for a stop-controlled intersection.

28-3.06 Case E – Intersections With All-Way Stop Control

At intersections with all-way stop control, provide sufficient sight distance from the stop bar so that the first stopped vehicle on each approach is visible to all other approaches. Often, intersections are converted to all-way stop control to address limited sight distance at the intersection. Therefore, providing additional sight distance at the intersection is unnecessary.

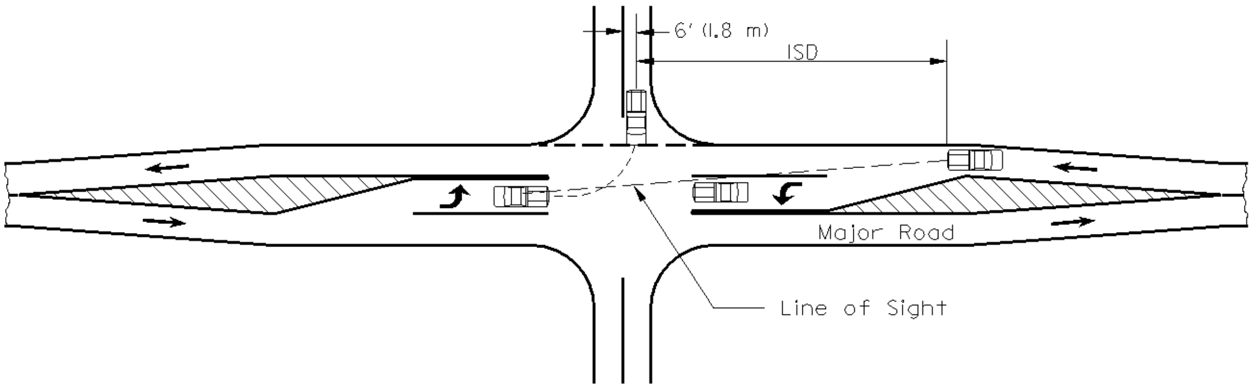
28-3.07 Case F – Left Turns from the Major Road

At all intersections, regardless of the type of traffic control, consider the sight distance needs for a stopped vehicle turning left from the major road. This situation is illustrated in Figure 28-3G. The driver will need to see straight ahead for a sufficient distance to turn left and clear the opposing travel lanes before an approaching vehicle reaches the intersection. Sight distance for opposing left turns may be increased by offsetting the left-turn lanes.

Figure 28-3G provides ISD values for passenger cars turning left from the major road.

28-3.08 Effect of Skew

Where it is impractical to realign an intersection that is greater than 30° from the perpendicular, the designer may need to adjust the gap acceptance times to account for the additional travel time required for a vehicle to make a turn or cross a facility. At oblique-angled intersections, determine the actual path length for a turning or crossing vehicle by dividing the total distance of the lanes and/or median to be crossed by the sine of the intersection angle. If the actual path length exceeds the total width of the lanes to be crossed by 12 ft (3.6 m) or more, see Section 36-6 of the *BDE Manual* for additional guidance.



US Customary			Metric		
Design Speed (mph)	ISD Crossing One-Lane[1] (ft)	ISD Crossing Two-Lanes[1,2] (ft)	Design Speed (km/h)	ISD Crossing One-Lane[1] (m)	ISD Crossing Two-Lanes[1,2] (m)
20	165	180	30	50	55
25	205	225	40	62	69
30	245	265	50	75	81
35	285	310	60	87	94
40	325	355	70	99	108
45	365	400	80	111	122
50	405	445	90	123	136
55	445	490	100	136	149
60	485	530			

Notes:

1. *Assumes no median on major road.*
2. *For crossing two-lanes an additional 0.5 seconds is added to the time gap of one-lane.*

INTERSECTION SIGHT DISTANCE FOR A STOPPED VEHICLE TURNING LEFT
(Case F – Left Turn from the Major Road)
Figure 28-3G

28-4 ACRONYMS

This is a summary of the acronyms used within this chapter.

AASHTO	American Association of State Highway and Transportation Officials
BDE	Bureau of Design and Environment
HCM	*Highway Capacity Manual*
ILMUTCD	*Illinois Supplement to the Manual of Uniform Traffic Control Devices*
ISD	Intersection Sight Distance
NCHRP	National Cooperative Highway Research Program
PSD	Passing Sight Distance
SSD	Stopping Sight Distance
The Green Book	AASHTO *A Policy on Geometric Design of Highways and Streets*

28-5 REFERENCES

1. *A Policy on Geometric Design of Highways and Streets (The Green Book)*, AASHTO, 6th Edition 2011.

2. NCHRP Report 400, *Determination of Stopping Sight Distances*, Transportation Research Board, 1997.

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

4. *Illinois Supplement to the Manual of Uniform Traffic Control Devices (ILMUTCD)*, IDOT.

5. NCHRP Report 383, *Intersection Sight Distance*, Transportation Research Board, 1996.

6. Chapter 36 "Intersections" and Chapter 47 "Rural Two-Lane/Multi-lane State Highways (New Construction/Reconstruction)," *BDE Manual*, IDOT.