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CHAPTER FORTY-TWO

SIGHT DISTANCE

42-1.0 STOPPING SIGHT DISTANCE

42-1.01 Theoretical Discussion

Stopping sight distance (SSD) is the sum of the distance traveled during a driver's perception/reaction or brake reaction time and the distance traveled while braking to a stop. To calculate SSD, the following formula is used:

$$SSD = 1.47Vt + \frac{1.075V^2}{a} \qquad \text{(Equation 42-1.1)}$$

Where: *SSD* = stopping sight distance, ft
V = design speed, mph
t = brake reaction time, 2.5 s
a = deceleration rate, 11.2 ft/s^2

The following discusses the theoretical rationale for each assumption within the SSD model.

1. Brake Reaction Time. This is the time interval between when an obstacle in the road can first be physically seen and when the driver first applies the brakes. The assumed value is 2.5 s. This time is considered adequate for 90% of drivers in simple to moderately-complex highway environments.

2. Speed. The SSD tables provide a minimum value which is based on the design speed.

3. Grade Adjustment. AASHTO 's *A Policy on Geometric Design of Highways and Streets* provides values to adjust the SSD for each grade which, theoretically, affects braking distances. Due to the conservative SSD model and the nature of the State's terrain, the use of the grade adjustment is not required.

4. AASHTO. AASHTO's *A Policy on Geometric Design of Highways and Streets* provides additional information on the assumptions used to develop the SSD model.

42-1.02 Passenger-Car Stopping Sight Distance

See Figure 42-1A, Stopping Sight Distance for Passenger Car. Stopping sight distance exceeding that shown in Figure 42-1A should be used where practical. In applying the SSD value for a passenger car, the height of eye is assumed to be 3.5 ft and the height of object 2 ft. The height of object is equivalent to the height of a passenger car's taillights.

The minimum SSD value for a passenger car represents the Department's Level One criterion for determining the need for a design exception. See Section 40-8.02.

42-1.03 Truck Stopping Sight Distance

Recommended stopping sight distance is based on passenger-car operation and does not explicitly consider design for truck operation. A truck, as a whole, especially a larger or heavier unit, needs a longer stopping sight distance for a given speed than does a passenger vehicle. However, the truck driver is able to see substantially father beyond vertical sight obstructions because of the higher position of the seat in the vehicle. Separate stopping sight distance values for a truck and a passenger car are therefore not used in highway design.

Where horizontal sight restrictions occur on a downgrade, particularly at the end of a long downgrade where truck speed closely approaches or exceeds that of a passenger car, the greater height of a truck driver's eye is of little value, even where the horizontal sight obstruction is a cut slope. Although the average truck driver tends to be more experienced than the average passenger-car driver and is quicker to recognize potential risks, it is desirable under such conditions to provide a stopping sight distance that exceeds the value shown in Figure 42-1A, Stopping Sight Distances for Passenger Cars.

42-2.0 DECISION SIGHT DISTANCE

42-2.01 Theoretical Discussion

A driver may be required to make a decision where the highway environment is difficult to perceive or where unexpected maneuvers are required. This occurs in an area of concentrated demand where the roadway elements, traffic volume, and traffic-control devices may all compete for the driver's attention. This relatively complex environment may increase the required driver reaction time beyond that provided by the SSD value (2.5 s). At such a location, the designer should consider providing decision sight distance to provide an additional margin of safety. Decision sight distance reaction time ranges from 3 to 14.5 s depending on the location and expected maneuver. The avoidance maneuvers used to develop Figure 42-2A, Decision Sight Distance, Columns A through E, are as follows:

1. Column A, Avoidance Maneuver A: Stop on rural road.

2. Column B, Avoidance Maneuver B: Stop on urban road.

3. Column C, Avoidance Maneuver C: Speed/path/direction change on rural road.

4. Column D, Avoidance Maneuver D: Speed/path/direction change on suburban road.

5. Column E, Avoidance Maneuver E: Speed/path/direction change on urban road.

Columns A and B were developed using Section 42-1.0, Equation 42-1.1. Columns C, D, and E were developed using Equation 42-2.1, as follows:

$$DSD = 1.47\ Vt \qquad \text{(Equation 42-2.1)}$$

where: *DSD* = decision sight distance, ft
V = design speed, mph
t = total time for the maneuver (reaction time + maneuver time), s

42-2.02 Applications

The designer should consider using decision sight distance at a relatively complex location where the driver reaction time may exceed 2.5 s. Example locations where decision sight distance may be appropriate include the following:

1. exit or entrance gore;
2. lane drop;
3. freeway left-side entrance or exit;
4. railroad/highway grade crossing;
5. approach to detour or lane closure;
6. toll plaza; or
7. intersection location where unusual or unexpected maneuvers are required.

As with SSD, the height of eye is 3.5 ft and the height of object is 2 ft.

42-3.0 PASSING SIGHT DISTANCE

42-3.01 Theoretical Discussion

Passing sight distance consideration is limited to a 2-lane, 2-way highway. On such a facility, a vehicle may overtake a slower-moving vehicle, and the passing maneuver must be accomplished on a lane used by opposing traffic.

The minimum passing sight distance is determined from the sum of four distances as illustrated in Figure 42-3A, Elements of Passing Sight Distance on a 2-Lane Highway. Figure 42-3B, Passing Sight Distance on a Two-Lane Highway, and the following provide the assumptions used to develop passing sight distance values.

1. Initial Maneuver Distance (d_1). This is the distance traversed during the perception and reaction time and during the initial acceleration to the point of encroachment on the left lane. For the initial maneuver, the overtaken vehicle is assumed to be traveling at a uniform speed, and the passing vehicle is accelerating at the rate shown in Figure 42-3B. The average speed of the passing vehicle is assumed to be 10 mph higher than that of the overtaken vehicle. Equation 42-3.1 is used to determine d_1 as follows:

$$d_1 = \frac{t_1}{0.68}\left(v - m + \frac{at_1}{2} \right) \qquad \text{(Equation 42-3.1)}$$

Where: t_1 = time of initial maneuver, s
a = average acceleration, mph/s
v = average speed of passing vehicle, mph
m = difference in speed of passed vehicle and passing vehicle, mph

2. Distance that Passing Vehicle is in Left Lane (d_2). This is the distance traveled by the passing vehicle while it occupies the left lane. The assumed time for while the passing vehicle occupies the left lane are shown in Figure 42-3B. Equation 42-3.2 is used to determine d_2 as follows:

$$d_2 = \frac{vt_2}{0.68} \qquad \text{(Equation 42-3.2)}$$

Where: t_2 = time during which the passing vehicle occupies the left lane, s
v = average speed of passing vehicle, mph

3. Clearance Distance (d_3). This is the distance between the passing vehicle at the end of its maneuver and the opposing vehicle. This distance at the end of the passing maneuver is assumed to be between 100 ft and 250 ft.

4. Opposing-Vehicle Distance (d_4). This is the distance traversed by an opposing vehicle during two thirds of the time that the passing vehicle occupies the left lane. As shown in Figure 42-3A, the opposing vehicle appears after approximately one third of the passing

maneuver (d_2) has been accomplished. The opposing vehicle is assumed to be traveling at the same speed as the passing vehicle. Therefore, $d_4 = 2/3\ d_2$.

42-3.02 Applications

Figure 42-3B provides the minimum passing sight distance for design on a 2-lane, 2-way highway. This distance allows the passing vehicle to safely complete the passing maneuver. The value should not be confused with the value shown in the MUTCD for the placement of no-passing-zone stripes, which are based on different operational assumptions (i.e., distance for the passing vehicle to abort the passing maneuver). The highway capacity adjustment in the *Highway Capacity Manual* for a 2-lane, 2-way highway is based on the MUTCD criteria for marking a no-passing zone. It is not based on the percent of passing sight distance from AASHTO's *A Policy on Geometric Design of Highways and Streets*.

For an existing highway, it will not be cost effective to improve the existing passing sight distance. On a rural new-construction or reconstruction project, the designer should attempt to provide passing sight distance over the project of the project consistent with the percentages shown in Figure 42-3C, Recommended Guideline For Percent Passing on Rural Facility. It will not be cost effective, however, to make significant improvements to the horizontal or vertical alignment solely to increase the available passing sight distance.

An appreciable grade can increase the sight distance required for safe passing. Passing tends to be easier for a vehicle traveling downgrade because the overtaking vehicle can accelerate more rapidly. However, so can the overtaken vehicle. For an upgrade, the passing sight distance should be greater than the derived minimum. Specific adjustments for use are unavailable. Consequently, the designer should use engineering judgment to make practical adjustments to the passing sight distance for an upgrade.

Passing sight distance is measured from a 3.5-ft height of eye to a 3.5-ft height of object. It is impractical to design a crest vertical curve to provide for passing sight distance because of high cost where a cut are involved.

42-4.0 INTERSECTION SIGHT DISTANCE

Section 46-10.0 discusses the design requirements for intersection sight distance.

Design Speed (mph)	Brake Reaction Time (s)	Brake Reaction Dist. (ft)	Braking Distance (ft)	Minimum Calculated SSD (ft)	Rounded SSD for Design (ft)
15	2.5	55.1	21.6	76.7	80
20	2.5	73.5	38.4	111.9	115
25	2.5	91.9	60.0	151.9	155
30	2.5	110.3	86.4	196.7	200
35	2.5	128.6	117.6	246.2	250
40	2.5	147.0	153.6	300.6	305
45	2.5	165.4	194.4	359.8	360
50	2.5	183.8	240.0	423.8	425
55	2.5	202.1	290.3	492.4	495
60	2.5	220.5	345.5	566.0	570
65	2.5	238.9	405.5	644.4	645
70	2.5	257.3	470.3	727.6	730

STOPPING SIGHT DISTANCE
FOR PASSENGER CAR

Figure 42-1A

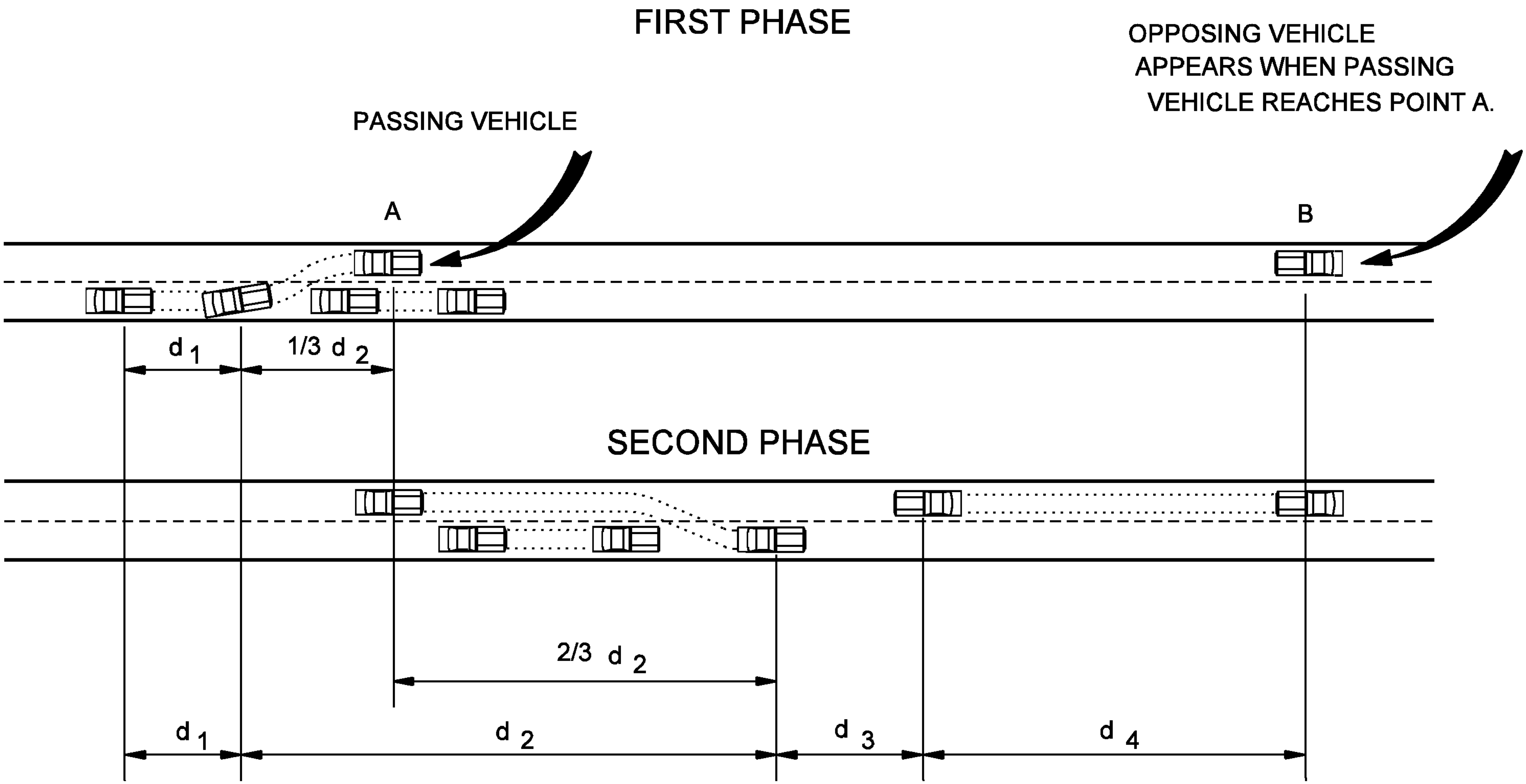
Design Speed (mph)	Decision Sight Distance, ft				
	Avoidance Maneuver A	Avoidance Maneuver B	Avoidance Maneuver C	Avoidance Maneuver D	Avoidance Maneuver E
30	220	490	450	535	620
35	275	590	525	625	720
40	330	690	600	715	825
45	395	800	675	800	930
50	465	910	750	890	1030
55	535	1030	865	980	1135
60	610	1150	990	1125	1280
65	695	1275	1050	1220	1365
70	780	1410	1105	1275	1445

Avoidance Maneuver A: Stop on rural road – t = 3.0 s
Avoidance Maneuver B: Stop on urban road – t = 9.1 s
Avoidance Maneuver C: Speed/path/direction change on rural road – t varies between 10.2 and 11.2 s
Avoidance Maneuver D: Speed/path/direction change on suburban road – t varies between 12.1 and 12.9 s
Avoidance Maneuver E: Speed/path/direction change on urban road – t varies between 14.0 and 14.5 s

DECISION SIGHT DISTANCE

Figure 42-2A

Note: Figures 42-2B, 42-2C, 42-2D, and 42-2E have been deleted.



ELEMENTS OF PASSING DISTANCE
(2-Lane Highways)

Figure 42-3A

Design Speed (mph)	Assumed Speeds		Passing Sight Distance	
	Passed Vehicle (mph)	Passing Vehicle (mph)	Calculated Value (ft)	Rounded for Design (ft)
20	18	28	706	710
25	22	32	897	900
30	26	36	1088	1090
35	30	40	1279	1280
40	34	44	1470	1470
45	37	47	1625	1625
50	41	51	1832	1835
55	44	54	1984	1985
60	47	57	2133	2135
65	50	60	2281	2285
70	54	64	2479	2480

PASSING SIGHT DISTANCE
ON TWO-LANE HIGHWAY

Figure 42-3B

Terrain	Functional Classification		
	Arterial	Collector	Local Road
Level	60%	50%	40%
Rolling	40%	30%	20%

RECOMMENDED GUIDELINE FOR PERCENT PASSING
(Rural)

Figure 42-3C