**sight distance**

It is essential that the driver of a vehicle be able to see far enough ahead to assess developing situations and take appropriate action. For purposes of design, sight distance is considered terms of passing sight distance, stopping sight distance, and decision sight distance.

**Decision Sight Distance**

Normally, the stopping sight distance is an adequate sight distance for roadway design. However, there are cases where it may not be appropriate. In areas where information about navigation or hazards must be observed by the driver, or where the driver’s visual field is cluttered, the stopping sight distance may not be adequate. In addition, there are avoidance maneuvers that are far safer than stopping, but require more planning by the driver. These may not be possible if the minimum stopping sight distance is used for design. In these instances, the proper sight distance to use is the decision sight distance.

The decision sight distance is the distance traversed while recognizing an object or hazard, plotting an avoidance course, and making the necessary maneuvers. Unlike the stopping sight distance, the decision sight distance is quite complex. Various design values for the decision sight distance have been developed from research. The table below gives a few values for the decision sight distance (AASHTO, 1994).

It is up to the engineer to decide when to use the decision sight distance. Providing the extra sight distance will probably increase the cost of a project, but it will also increase safety. The decision sight distance should be provided in those areas that need the extra margin of safety, but it isn’t needed continuously in those areas that don't contain potential hazards.

|  |  |
| --- | --- |
| Design Speed (km/h) | Decision Sight Distance (meters) |
| Stop Rural Road | Stop Urban Road | Adjustment RuralRoad | Adjustment Suburban Road | Adjustment Urban Road |
| 50 | 75 | 160 | 145 | 160 | 200 |
| 80 | 155 | 300 | 230 | 275 | 315 |
| 90 | 185 | 360 | 275 | 320 | 360 |
| 110 | 265 | 455 | 335 | 390 | 435 |

**Stopping Sight Distance**

The stopping sight distance is the sum of two distances; the distance traveled during perception - reaction time and the distance required to stop the vehicle. In other words, it is the length of roadway that should be visible ahead of you, in order to ensure that you will be able to stop if there is an object in your path.

For example, let us say that you are negotiating a horizontal curve in a highway when you notice an object 200m ahead of you. If the distance you travel during your perception reaction time is 100 m and your braking distance is 130 m, you will not be able to avoid the collision. If the horizontal curve were not as tight, you would be able to see the object at a distance of 250 m, which would allow you to stop 20 m short of the object. A properly designed roadway will provide the minimum stopping sight distance at every point along its length.

In order to calculate the actual sight distance based on the geometry of the roadway, some assumptions are necessary. The main assumptions are the height of the driver's eyes above the roadway surface and the height of the object or hazard. In geometric design, these values are 1.05m and 0.15m respectively. .

To include the stopping sight distance in your design, calculate the stopping sight distance for a vehicle traveling on your roadway at the design speed, and then make sure the actual sight distance that you provide is at least as great as the stopping sight distance.

**Trucks and Busses**

Trucks and busses require longer braking distances than passenger cars, but their stopping sight distances are not considered in most designs. This is because the driver's eyes are higher and their sight distance is consequently increased. The drivers of these vehicles also tend to be more experienced and more alert. The net effect is that large vehicles can avoid obstacles even though the road was not specifically designed with them in mind. The engineer must decide when large vehicles may need extra sight distances and provide these distances where necessary.

**Perception Reaction Time**

The perception reaction time is the amount of time that elapses between the recognition of an object or hazard in the roadway and the application of the brakes. The length of the perception reaction time varies widely between individual drivers. An alert driver may react in less than 1 second, while other drivers may require up to 3.5 seconds.

The perception reaction time depends on an extensive list of variables, including:

* Driver characteristics such as attitude, level of fatigue, and experience.
* Environmental conditions such as the clarity of the atmosphere and the time of day
* The properties of the hazard or object itself, such as size, color and movement.

To make highways reasonably safe, the engineer must provide a continuous sight distance equal to or greater than the stopping sight distance. As an integral part of the stopping sight distance, a value for the perception reaction time must be assumed. Extensive research has shown that 90% of the driving population can react in 2.5 seconds or less. The perception reaction time normally used in design, therefore, is 2.5 seconds. The distance traveled during the perception reaction time can be calculated by multiplying the vehicle's initial speed by the perception reaction time.

d1= 0.278Vt

where:

d1=  perception-reaction distance (m )

V=vehicle initial speed in (Km/hr)

t= perception-reaction time (sec)

Both the perception reaction time and the braking distance are used in the calculation of the stopping sight distance.

**Braking Distance**

The braking distance is the distance that a vehicle travels while slowing to a complete stop. The braking distance is a function of several variables. First, the slope (grade) of the roadway will affect the braking distance. If you are going uphill, gravity assists you in your attempts to stop and reduces the braking distance. Similarly, gravity works against you when you are descending and will increase your braking distance. Next, the frictional resistance between the roadway and your tires can influence your braking distance. If you have old tires on a wet road, chances are you'll require more distance to stop than if you have new tires on a dry road. The last parameter that we will consider is your initial velocity. Obviously, the higher your speed the longer it will take you to stop, given a constant deceleration.

The equation used to calculate the braking distance is a child of a more general equation from classical mechanics. The parent equation is given below.

Vf2=Vo2+2ad

Where:
Vf = Final velocity
Vo= Initial velocity
a = Acceleration rate
d = Distance traversed during acceleration

When calculating the braking distance, we assume the final velocity will be zero. Based on this, the equation can be manipulated to solve for the distance traversed during braking.

d = -Vo2/(2a)

Notice that the distance will be positive as long as a negative acceleration rate is used.

The acceleration of a braking vehicle depends on the frictional resistance and the grade of the road. From our knowledge of the frictional force, we know that the acceleration due to friction can be calculated by multiplying the coefficient of friction by the acceleration due to gravity.  Similarly, we know from inclined plane problems that a portion of the car's weight will act in a direction parallel to the surface of the road. The acceleration due to gravity multiplied by the grade of the road will give us an estimate of the acceleration caused by the slope of the road.

The final formula for the braking distance is given below.  Notice how the acceleration rate is calculated by multiplying the acceleration due to gravity by the sum of the coefficient of friction and grade of the road.

d2=

Where:
d2 = Braking Distance (m)
G = Roadway grade as a percentage; for 2% use 0.02
Vf = Final velocity (km/hr)
Vo= Initial velocity (km/hr)

f = Coefficient of friction between the tires and the roadway

The braking distance and the perception reaction time are both essential parts of the stopping sight distance calculations. In order to ensure that the stopping sight distance provided is adequate, we need a more in-depth understanding of the frictional force. The value of the coefficient of friction is a difficult thing to determine. The frictional force between your tires and the roadway is highly variable and depends on the tire pressure, tire composition, and tread type. The frictional force also depends on the condition of the pavement surface. The presence of moisture, mud, snow, or ice can greatly reduce the frictional force that is stopping you. In addition, the coefficient of friction is lower at higher speeds. Since the coefficient of friction for wet pavement is lower than the coefficient of friction for dry pavement, the wet pavement conditions are used in the stopping sight distance calculations. This provides a reasonable margin of safety, regardless of the roadway surface conditions. The table below gives a few values for the frictional coefficient under wet roadway surface conditions (AASHTO, 1984).

|  |  |
| --- | --- |
| Design Speed (mph) | Coefficient of Friction (f) |
| 20 | 0.40 |
| 30 | 0.35 |
| 40 | 0.32 |
| 60 | 0.29 |

 **Example**

While descending a -7% grade at a speed of 90 km/h, George notices a large object in the roadway ahead of him. Without thinking about any alternatives, George stabs his brakes and begins to slow down. Assuming that George is so paralyzed with fear that he won't engage in an avoidance maneuver, calculate the minimum distance at which George must have seen the object in order to avoid colliding with it. You can assume that the roadway surface is concrete and that the surface is wet.  You can also assume that George has apperception reaction time of 0.9 seconds because he is always alert on this stretch of the road.

**Solution**

First, we need to calculate the distance that George traveled during his perception reaction time. This is done using the equation d1= 0.278Vt from physics. Since George's perception reaction time was 0.9 seconds and his velocity was (90 km/h), the distance he traveled during his perception reaction time was 22.5 meters.  Second, we need to calculate the distance George will travel while braking. This is done using the equation shown below.

d2=

Where:
V = George's Velocity 90 km/h

f = Coefficient of friction, 0.29 ( we'll use the value for 96 km/h (60 mph) just to be conservative)
G = The grade of the road, -0.07 (-7%)

Solving the equation yields a distance of 145 meters. Summing the distance traveled while braking and the distance traveled during the perception reaction time yields a total stopping sight distance of 168 meters, which is about 15.2 meters short of two football fields. George needed to be about 168 meters away from the object at the instant he first saw it in order to avoid a collision

**Horizontal Curve Sight Distance**

Once you have a radius that seems to connect the two previously disjointed sections of roadway safely and comfortably, you need to make sure that you have provided an adequate stopping sight distance throughout your horizontal curve.

Sight distance can be the controlling aspect of horizontal curve design where obstructions are present near the inside of the curve. To determine the actual sight distance that you have provided, you need to consider that the driver can only see the portion of the roadway ahead that is not hidden by the obstruction. In addition, at the instant the driver is in a position to see a hazard in the roadway ahead, there should be a length of roadway between the vehicle and the hazard that is greater than or equal to the stopping sight distance. See figure 1.0



Figure 1:  Sight Distance

Because the sight obstructions for each curve will be different, no general method for calculating the sight distance has been developed. If you do have a specific obstruction in mind, however, there is an equation that might be helpful. This equation involves the stopping sight distance, the degree of the curve, and the location of the obstruction.

$$M=\frac{1746}{D}\left(1-\cos(\frac{S×D}{61})\right)$$

Where:
M = Distance from the center of the inside lane to the obstruction (m)
D = Degree of the curve. Where R = 1746/D
S = Stopping sight distance (m)
R = Radius of the curve (m)

**Example**

A large grain elevator is located 12m from the centerline of a two-lane highway, which has 3.6m wide lanes. The elevator is situated on the inside of a horizontal curve with a radius of 152 m. Assuming that the elevator is the only sight restriction on the curve, what is the minimum sight distance along the curve?

**Solution**

The first thing that we need to do is calculate the distance from the edge of the grain elevator to the center of the nearest lane. This turns out to be 12 m – 3.6/2m = 10.2 Next, we need to calculate the degree of the curve using the equation R = 1746/D. The degree of the curve turns out to be 11.49°. The last step involves solving for the sight distance using the equation below.

$M=\frac{1746}{D}\left(1-\cos(\frac{S×D}{61})\right)$=

Where:
M = Distance from the center of the inside lane to the obstruction, 10.2m
D = Degree of the curve, 11.49°.

Where R = 1746/D

S = Sight distance (m)
R = Radius of the curve, 152m

Substituting the values for the variables and solving for the sight distance yields a sight distance of112 m.

**Crest Vertical Curves**

Crest vertical curves are curves that connect inclined sections of roadway, forming a crest, and they are relatively easy to design. As you know from the module entitled ‘Vertical Curves,’ we only need to find an appropriate length for the curve that will accommodate the correct sight distance. The stopping sight distance is usually the controlling sight distance, but the decision sight distance or even the passing sight distance could be used if desired. The passing sight distance is rarely ever used as the design sight distance, because it demands long, gentle curvatures that are expensive and difficult to construct.

The sight distance and the length of the curve can be related to each other in one of two ways. The first possibility is that the sight distance is less than the length of the curve. Alternatively, the length of the curve could be less than the sight distance. See figure 2



Figure 2:  Sight Distance Possibilities for crest vertical curve

In any case, there are equations that relate these two parameters to the change in grade for both possible conditions. The designer must double-check that the equation that is used agrees with its own assumptions. For example, if the equation that is based on sight distances that are less than the curve length produces a curve length that is less than the sight distance, you know that the result is invalid. The equations that are normally used to calculate the lengths of crest vertical curves are given below.

If S > L then

$$L=2S-\frac{200\left(\sqrt{h\_{1}}+\sqrt{h\_{2}}\right)^{2}}{A}$$

If S < L then

$$L=\frac{AS^{2}}{100\left(\sqrt{2h\_{1}}+\sqrt{2h\_{2}}\right)^{2}}$$

Where:
L = Length of the crest vertical curve (m)
S = Sight distance (m)
A = The change in grades ( |G2-G1| as a percent)
h1 = Height of the driver's eyes above the ground (m)
h2 = Height of the object above the roadway (m)

The heights in the calculations above should be those that correspond to the sight distance of interest. For the stopping sight distance, h1 = 1.05 m and h2 = 0.15 m   For the passing sight distance, h1 = 1.05 and h2 = 1.3m .

While the sight distance has been portrayed as the only parameter that affects the design of vertical curves, this isn't entirely true. Vertical curves should also be comfortable for the driver, aesthetically pleasing, safe, and capable of facilitating proper drainage. In the special case of crest vertical curves, it just so happens that a curve designed with adequate sight distances in mind is usually aesthetically pleasing and comfortable for the driver. In addition, drainage is rarely a special concern for crest vertical curves.

Example

 You have been instructed to design a crest vertical curve that will connect a highway segment with a 3% grade to an adjoining segment with a -1% grade. Assume that the minimum stopping sight distance for the highway is 162 m. If the elevation of the VPC is 450m, what will the elevation of the curve be at L/2?

**Solution**

The first step in the analysis is to find the length of the crest vertical curve. The grade changes from 3% to -1%, which is a change of -4% or A = |-4%|.  In addition, for the stopping sight distance h1 = 1.05 m and h2 = 0.15 m. Since we know S = 162m, we can go ahead and solve for the length of the crest vertical curve.

If S > L then

$L=2S-\frac{200\left(\sqrt{h\_{1}}+\sqrt{h\_{2}}\right)2}{A}=2×162-\frac{200\left(\sqrt{1.05}+\sqrt{0.15}\right)2}{4}=224.3$(Invalid because L > S)

If S < L then

$$L=\frac{AS^{2}}{100\left(\sqrt{2h\_{1}}+\sqrt{2h\_{2}}\right)2}=\frac{4×162^{2}}{100\left(\sqrt{2×1.05}+\sqrt{2×0.15}\right)2}=263.2m$$

The curve length calculated from the 'S < L' equation was 263.3, which is greater than the sight distance of 162m. To find the elevation of the curve at a horizontal distance of L/2 from the VPC, we need to use the equation below.

$$Y=VPCy+BX+\frac{AX^{2}}{200L}=$$

Where:
Y = Elevation of the curve at a distance x from the VPC (m)
VPCy = Elevation of the VPC, 450,B = Slope of the approaching roadway, or the roadway that intersects the VPC, 0.03
A = The change in grade between the disjointed segments, -4 (From 3% to -1% would be a change of -4%)
x = L/2 = 263.3 /2 = 131.65m

The equation above yields a curve elevation of 452.6 33at a distance L/2 from the VPC.

**Sag Vertical Curves**

Sag vertical curves are curves that connect descending grades, forming a bowl or sag. Designing them is very similar to the design of crest vertical curves. Once again, the sight distance is the parameter that is normally employed to find the length of the curve. When designing a sag vertical curve, however, the engineer must pay special attention to the comfort of the drivers. Sag vertical curves are characterized by a positive change in grade, which means that vehicles traveling over sag vertical curves are accelerated upward. Because of the inertia of the driver's body, this upward acceleration feels like a downward thrust. When this perceived thrust and gravity combine, drivers can experience discomfort.

The length of sag vertical curves, which is the only parameter that we need for design, is determined by considering drainage, driver comfort, aesthetics, and sight distance. Once again, the aesthetics and driver comfort concerns are normally automatically resolved when the curve is designed with adequate sight distance in mind. Driver comfort, for example, requires a curve length that is approximately 50% of the curve length required for the sight distance. Drainage may be a problem if the curve is quite long and flat, or if the sag is within a cut. For more information on these secondary concerns, see your local design manuals.

The theory behind the sight distance calculations for sag vertical curves is only slightly different from that for crest vertical curves. Sag vertical curves normally present drivers with a commanding view of the roadway during the daylight hours, but unfortunately, they truncate the forward spread of the driver's headlights at night. Because the sight distance is restricted after dark, the headlight beams are the focus of the sight distance calculations. For sight distance calculations, a 1° upward divergence of the beam is normally assumed.

In addition, the headlights of the vehicle are assumed to reside 0.6m above the roadway surface. As with crest vertical curves, these assumptions lead to two possible configurations, one in which the sight distance is greater than the curve length, and one in which the opposite is true. The figure 3 illustrates these possibilities.

Figure 3:  Sight Distance Possibilities for sag vertical curve

As with crest vertical curves, each possibility has a different design equation. All that you need to do, therefore, is make sure that the results from the equation that you use are consistent with that equation's assumptions. For example, if you employ the equation that assumes the sight distance is greater than the curve length, you should make sure that the resulting curve length is less than the sight distance. The equations for each possibility are given below.

If S > L then

$$L=2S-\frac{200\left(H+S\tan(B)\right)}{A}$$

If S < L then

$$L=\frac{AS^{2}}{200\left(H+S\tan(B)\right)}$$

Where:
L = Curve length (m)
S = Sight distance (m) (normally the stopping sight distance)
B = Beam upward divergence (°) (normally assumed as 1°)
H = Height of the headlights (m) (normally assumed as 0.6 m)
A = Change in grade (|G2-G1|) as a percent

The stopping sight distance is normally the controlling sight distance for sag vertical curves. At decision points, the roadway should be illuminated by other means so that the sight distance of the driver is extended. Where possible, increased curve length may also be provided.

Highway overpasses or other obstacles can occasionally reduce the sight distance on sag vertical curves. In these instances, separate equations should be used to determine the correct curve length. These equations are:

S>L



H1

H2

C



E

L/2

L/2

G1

G2

S/2

S/2

Critical edge of structure

 Figure 4:  Sight Distance( underpasses), S>L

S<L

L=

H1

H2

C



E

L/2

L/2

G1

G2

S/2

S/2

Critical edge of structure

 Figure 5:  Sight Distance( underpasses), S<L

Where:

H1= vertical height of driver's eye above roadway surface, meter

H2 vertical height of object above roadway surface, meter

S= sight distance, meter

L= length of vertical curve, meter

A= Algebraic difference in grades, percent

C=vertical clearance of underpass, meter

**Example**

 If a stopping sight distance of 120m is to be maintained on a sag vertical curve with tangent grades of -3% and 0%, what should the length of the curve be? Assume a headlight beam upward divergence angle of 1°.

**Solution**

Since we know everything that we need to know to solve this problem, we'll jump straight into the equations.

If S > L then

$$L=2S-\frac{200\left(H+S\tan(B)\right)}{A}=2×120-\frac{200\left(0.6+120×\tan(1^{°})\right)}{3}=60.4m$$

If S < L

$L=\frac{AS^{2}}{200\left(H+S\tan(B)\right)}=\frac{3×120^{2}}{200\left(0.6+120×\tan(1)\right)}=80.2$ then (invalid because L < S)

Solving the equations above results in a curve length of 60.4m. You can find the elevation of any point along the curve once you have the curve length.

 **Passing Sight Distance**

While passing is not an event that is a major factor in the design of four-lane highways, it is a critical component of two-lane highway design. The capacity of a two-lane roadway is greatly increased if a large percentage of the roadway's length can be used for passing. On the other hand, providing a sufficient passing sight distance over large portions of the roadway can be very expensive.

Simply put, the passing sight distance is the length of roadway that the driver of the passing vehicle must be able to see initially, in order to make a passing maneuver safely.

Our real goal is to provide most drivers with a sight distance that gives them a feeling of safety and that encourages them to pass slower vehicles.

Calculating the passing sight distance required for a given roadway is best accomplished using a simple model. The model that is normally used incorporates three vehicles, and is based on six assumptions:

1.)  The vehicle being passed travels at a constant speed throughout the passing maneuver.
2.)  The passing vehicle follows the slow vehicle into the passing section.
3.)  Upon entering the passing section, the passing vehicle requires some time to perceive that the opposing lane is clear and to begin accelerating.
4.)  While in the left lane, the passing vehicle travels at an average speed that is 16 km/hr faster than the vehicle being passed.
5.)  An opposing vehicle is coming toward the passing vehicle.
6.)  There is an adequate clearance distance between the passing vehicle and the opposing vehicle when the passing vehicle returns to the right lane.

Under these assumptions, the passing sight distance can be divided into four quantifiable portions:

**d1**: The distance the passing vehicle travels while contemplating the passing maneuver, and while accelerating to the point of encroachment on the left lane.
**d2**: The length of roadway that is traversed by the passing vehicle while it occupies the left lane.
**d3**: The clearance distance between the passing vehicle and the opposing vehicle when the passing vehicle returns to the right lane.

**d4**: The distance that the opposing vehicle travels during the final 2/3 of the period when the passing vehicle is in the left lane.

Figure 6Diagram of Passing Sight Distance Components

**d1**
The perception-reaction-acceleration distance isn't hard to understand or to justify. The only aspect of this distance that might be confusing is the simultaneous nature of the perception and acceleration. Some drivers will begin accelerating before they enter the passing section and will continue to accelerate while they scan the opposing lane for traffic. These drivers tend to accelerate at a reduced rate. Other drivers will avoid accelerating until they have determined that the opposing lane is clear, but they will accelerate at a higher rate once they have decided to pass. The net effect is that the perception-reaction-acceleration distance is identical for both types of drivers. The distance d1 and the corresponding time t1 were measured for several different passing vehicle speeds. More recent research has confirmed that the accepted values are conservative. See table 1.

Let’s say that we make the passing section length equal to the passing sight distance as defined in reality (d = d1 + d2 + d3 + d4). If an opposing vehicle appears just after the first third of the interval t2 is over, the passing car can still safely pass the slower car and return to the right lane before the opposing car becomes a threat. This is because the opposing vehicle is a distance 2/3\*d2 +d3 + d4 away from the passing vehicle. By the time that the passing vehicle has traveled the remaining 2/3\*d2 and returned to the right lane, the opposing car will have traveled d4, and the clearance distance d3 will separate them. This is why we add the distances d3 and d4 to the passing sight distance. The distance d4 is calculated by multiplying the speed of the opposing vehicle (normally assumed to be the speed of the passing vehicle) by 2/3\*t2.

The table below summarizes the results of field observations directed toward quantifying the various aspects of the passing sight distance (AASHTO, 1994).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Speed Group (km/h)** | **50-65** | **66-80** | **81-95** | **96-110** |
| **Average Passing Speed (km/h)** | **56.2** | **70.0** | **84.5** | **99.8** |
| ***Initial Maneuver:*** |
| Average acceleration (km/h/s) | 2.25 | 2.30 | 2.37 | 2.41 |
| Time (s) | 3.6 | 4.0 | 4.3 | 4.5 |
| Distance Traveled (m) | 45 | 65 | 90 | 110 |
| ***Occupation of the Left Lane:*** |
| Time (s) | 9.3 | 10.0 | 10.7 | 11.3 |
| Distance Traveled (m) | 145 | 195 | 250 | 315 |
| ***Clearance Length:*** |
| Distance Traveled (m) | 30 | 55 | 75 | 90 |
| ***Opposing Vehicle:*** |
| Distance Traveled (m) | 95 | 130 | 165 | 210 |
|  |
| **Total Distance (m)** | **315** | **445** | **580** | **725** |

Now that we know how to calculate the required passing sight distance, how do we calculate the actual passing sight distance that we have provided in our geometric design? To do this, we simply assume that the driver's eyes are at a height of 1.05m from the road surface and the opposing vehicle is 1.3m tall. The actual passing sight distance is the length of roadway ahead over which an object 1.3m tall would be visible, if your eyes were at an elevation of 1.05m

**Example**

A vehicle moving at a speed of 80 Km/h is slowing traffic on a two-lane highway. What passing sight distance is necessary, in order for a passing maneuver to be carried out safely?

Calculate the passing sight distance by hand, and then compare it to the values recommended by AASHTO. In your calculations, assume that the following variables have the values given:

* Passing vehicle driver's perception/reaction time = 2.5 sec
* Passing vehicle's acceleration rate = 2.37 Km/h/sec
* Initial speed of passing vehicle = 80 Km/h
* Passing speed of passing vehicle = 96 Km/h
* Speed of slow vehicle = 80 Km/h
* Speed of opposing vehicle = 96 Km/h
* Length of passing vehicle = 6.6m
* Length of slow vehicle = 6.6m
* Clearance distance between passing and slow vehicles at lane change = 6m
* Clearance distance between passing and slow vehicles at lane re-entry = 6m
* Clearance distance between passing and opposing vehicles at lane re-entry = 75m

You should also assume that the passing vehicle accelerates to passing speed before moving into the left lane.

**Solution**

* The first step in calculating the passing sight distance is the calculation of the distance **d1**. This distance includes the distance traveled during the perception/reaction time and the distance traveled while accelerating to the passing speed. The distance traveled during the perception reaction time is computed using **da**=0.278VT from physics, where V = 80 Km/h and T = 2.5 seconds. Solving for **da** yields a value of 55.6m. The distance traveled during the acceleration portion of **d1** is computed using the equation:
* $d\_{b}=0.278\frac{V\_{f}^{2}-V\_{i}^{2}}{2A}$
* where Vf = 96 Km/h (60 mph), Vi = 80 Km/h (50 mph),

and A = 2.37 Km/h/sec Solving for $d\_{b}$ yields a value of m.  The total distance d1 is 55.6+ 165.1 = 220.7m.

The second portion of the passing sight distance is the distance d2, which is defined as the distance that the passing vehicle travels while in the left lane. This distance can be calculated in the following way.

While in the left lane, the passing vehicle must traverse the clearance distance between itself and the slow vehicle, the length of the slow vehicle, the length of itself, and the length of the clearance distance between itself and the slow vehicle at lane re-entry. The time it takes the passing vehicle to traverse these distances relative to the slow vehicle can be computed from the equation d=0.278VT, where d = 25.2m (6m + 6.6m + 6.6m + 6m) and V = 16 Km/h relative speed of passing vehicle with reference point on the slow vehicle).

Solving for the time T2 yields a value of 5.7 seconds. The real distance traveled by the passing vehicle during the time T2 is calculated using D=0.278VT, where V = 96 Km/hr and T = 5.7 seconds. Solving for d yields the distance d2 or 152.1m

The distance d3 is the clearance distance between the passing vehicle and the opposing vehicle at the moment the passing vehicle returns to the right lane. This distance was given as 75 m. The distance d4 is the final component of the passing sight distance and is defined as the distance the opposing vehicle travels during 66% of the time that the passing vehicle is in the left lane. This distance is computed using D=0.278VT, where V = 96 Km/hr and T = 3.7 seconds (5.7\*66%). Solving for d yields a value of 98.74 for d4.

The total passing sight distance is, therefore, d1 + d2 + d3 + d4 or 547m. The passing sight distance recommended by AASHTO for speeds within the 50 mph - 60 mph range is 315 m.