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TRANSPORTATION ENGINEERING – I

DEPARTMENT OF CIVIL ENGINEERING

FACULTY OF ENGINEERING & TECHNOLOGY

TRANSPORTATION ENGINEERING – I (Highway Engineering) UNIT-2 LECTURE -1

Topics to be covered:

- Sight Distance Overview
- Stopping Sight Distance
- PIEV Theory
- Intermediate Sight Distance
- Overtaking Sight Distance
- Headlight Sight Distance
- Problems on the Topics Discussed

PREPARED BY:

SHASHIKANT SRIVASTAVA

ASSISTANT PROFESSOR DEPARTMENT

OF CIVIL ENGINEERING

FACULTY OF ENGINEERING & TECHNOLOGY

RAMA UNIVERSITY UTTAR PRADESH, KANPUR (INDIA)

OVERVIEW OF SIGHT DISTANCE :

The safe and efficient operation of vehicles on the road depends very much on the visibility of the road ahead of the driver. Thus the geometric design of the road should be done such that any obstruction on the road length could be visible to the driver from some distance ahead. This distance is said to be the sight distance.

TYPES OF SIGHT DISTANCES : Sight distance available from a point is the actual distance along the road surface, over which a driver from a specified height above the carriage way has visibility of stationary or moving objects. Three sight distance situations are considered for design:

1) Stopping sight distance (SSD) or the absolute minimum sight distance.
2) Intermediate sight distance (ISD) is defined as twice SSD.
3) Overtaking sight distance (OSD) for safe overtaking operation.

Head light sight distance is the distance visible to a driver during night driving under the illumination of head lights. Safe sight distance to enter into an intersection.

The most important consideration in all these is that at all times the driver traveling at the design speed of the highway must have sufficient carriageway distance within his line of vision to allow him to stop his vehicle before colliding with a slowly moving or stationary object appearing suddenly in his own traffic lane. The computation of sight distance depends on:

(a) Reaction time of the driver
(b) Speed of the vehicle
(c) Efficiency of brakes
(d) Frictional resistance between the Tyre and The Road
(e) Gradient of the Road

STOPPING SIGHT DISTANCE (SSD):

➢Stopping sight distance (SSD) is the minimum sight distance available on a highway at any spot having sufficient length to enable the driver to stop a vehicle travelling at design speed, safely without collision with any other obstruction.

- There is a term called safe stopping distance and is one of the important measures in traffic engineering.
- It is the distance a vehicle travels from the point at which a situation is first perceived to the time the deceleration is complete.
- Drivers must have adequate time, if they are to suddenly respond to a situation.
- Thus in highway design, sight distance at least equal to the safe stopping distance should be provided.
- The stopping sight distance is the sum of lag distance and the braking distance.
- Lag distance is the distance the vehicle traveled during the reaction time t and is given by vt, where v is the velocity in m / sec.
- Braking distance is the distance traveled by the vehicle during braking operation.

If F is the maximum frictiona force developed and the brakin distance is l, then work done against friction in stoppin the vehicl is Fl = fWl where W is the total weight of the vehicle. The kinetic energy at the design speed is:

$$\frac{1}{2}mv^2 = \frac{1}{2}\frac{Wv^2}{g}$$

$$fWl = \frac{Wv^2}{2g}$$

$$l = \frac{v^2}{2gf}$$

Hence, **The Stopping Sight Distance (SSD) = Lag Distance + Braking Distance or**

SSD = v.t + v^2 / 2gf

Here, v is the speed in m/s^2, t is the reaction time taken, f is coefficient of friction, g is the acceleration due to gravity.

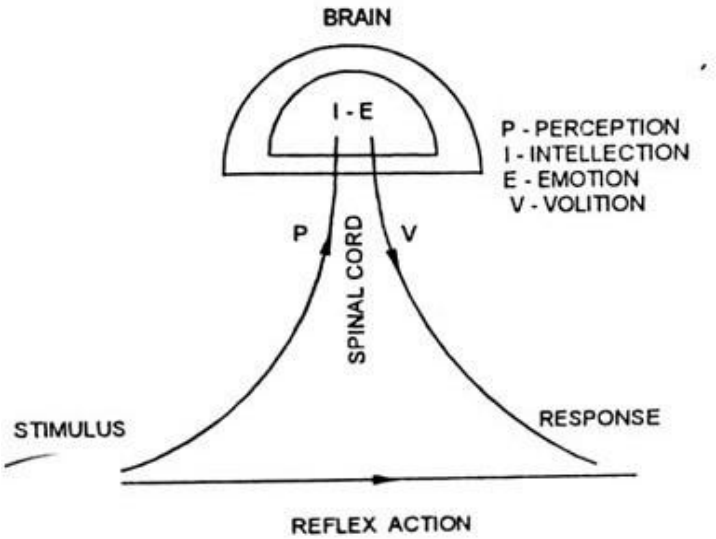
We can also derive the braking distance for a descending gradient which is performed similarly, and we get:

SSD = vt + (v^2/ (2g (f ±0.01n)))

PIEV THEORY :

PIEV stands for Perception-Intellection-Emotion-Volition. It states the overall process that happens in mind for taking any decision on road while moving onto it. The detailed information about every term is as follows:

1) Perception time: is time required for the sensations received by the eyes or ears of the driver to be transmitted to the brain through the nervous system & spinal cord or it is the time required to perceive an object or situation.
2) Intellection time : is the time require for the driver to understand the situation it is also the time required for comparing the different thoughts.
3) Emotion time: is the time elapsed during emotional sensational and other mental disturbance such as fear, anger or any other emotional feeling superstition etc.
4) Volition time: is the time taken by the driver for the final action such as brake application.



INTERMEDIATE SIGHT DISTANCE :

- Sight distance is one of the key areas in highway design. This is because the presence (or absence) of suitable sight distance has a large effect on road safety.
- It would be interesting to look up values for sight distance from different countries and see how they compare.
- A distance equivalent to twice the stopping sight distance, a distance where overtaking could be attempted with reasonable safety is termed as “intermediate sight distance” (ISD).
- ISD is usually twice the stopping sight distance.
- **Intermediate sight distance, Continuation sight distance, Meeting sight distance and Stopping sight distance for single lane roads, these all refer to ISD.**
- ISD has a limited application. ISD is only applicable to undivided 2-way road (single lane each way)” Other sources say that ISD is also used for rural single lane roads.
- The figures quoted for ISD are only suitable for cars travelling on surfaced roads in daylight.
- They do not apply to other vehicle types, other road surfaces, or cars travelling at night.
- Roads designed with these values for ISD may not be safe for these other circumstances.
- Mathematically, it can be stated that : **Intermediate sight distance (ISD) = 2 * SSD**

OVERTAKING SIGHT DISTANCE :

The overtaking sight distance is the minimum distance on a highway open to the vision of the driver of a vehicle to overtake slow moving vehicles ahead that are travelling in the same direction safely against opposing traffic in opposite direction.

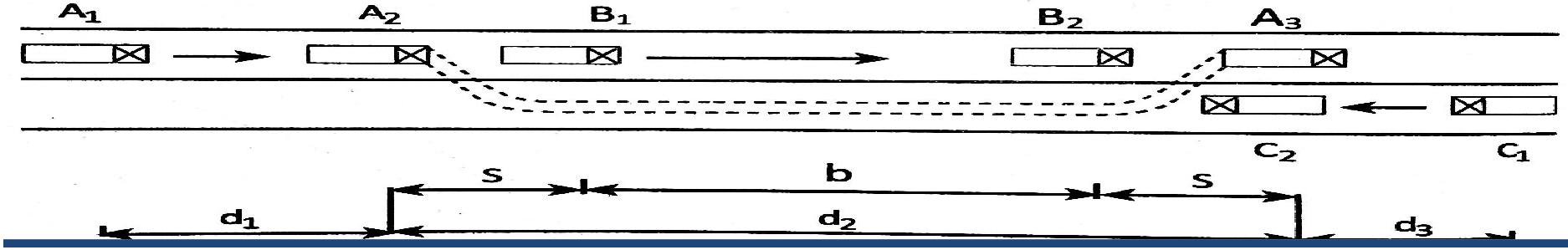
The factors that affect OSD are:

a) Speed of the overtaking vehicle, overtaken vehicle and the vehicle coming from the opposite direction
b) Spacing between the vehicles
c) Skill and reaction time of the driver
d) Rate of acceleration of the overtaking vehicle
e) Gradient of the road

Many overtaking models are made for the overtaking process but the data obtained from actual observations and from these models are not ver reliable. For the followin mode we have the followin assumptions:

a) The overtaken slow moving vehicle travels at uniform speed
b) The overtaking vehicle reduces its speed and follows the slow-moving vehicle as it prepares for overtaking
c) The overtaking vehicle requires the reaction time to perceive the situation, react and start acceleration
d) Overtaking is accomplished under a delayed start and early return and travel during actual overtaking operation are a uniformly accelerated travel.

ANALYSIS OF OVERTAKING SIGHT DISTANCE



ANALYSIS OF OVERTAKING SIGHT DISTANCE :

The process of overtaking is shown in the figure which consists of three parts:

1. The distance travelled by overtaking vehicle A during reaction time (t) i.e. (d1)
2. The distance travelled by the overtaking vehicle during the actual overtaking operation in time (T) i.e. (d2)

3.The distance travelled by on-coming opposing vehicle C during the overtaking operation in time (T) i.e. (d3)

Therefore,

$OSD = d1 + d2 + d3$

The assumption is that the overtaking vehicle reduces its speed with respect to the overtaken vehicle and travels behind it during the reaction time (t) of the driver.

Then, $d_1 = v_b * t$

During the overtaking operation the distance travelled in time (T) is,

Or, $d_2 = 2*s + v_b * T$

During this time the vehicle is accelerated from initial velocity (vb) and overtaking is done to reach the final velocity (v). Then the distance travelled is,

Or, $d_2 = v_b * T + 0.5 * a * T^2$

Or, $2*s + v_b * T = v_b * T + 0.5 * a * T^2$

Or, $2 *s = 0.5 * a * T^2$

Therefore,

$T = \sqrt{(4*s) / a}$

When acceleration is given in kmph,

$T = \sqrt{(14.4*s) / a}$

Then the distance is given by, $d_2 = 2*s + v_b * \sqrt{(4*s) / a}$

ANALYSIS OF OVERTAKING SIGHT DISTANCE :

The distance travelled by the vehicle C moving at design speed (v) during overtaking operation is given by:

Or, $d_3 = v*T$

Therefore the total overtaking sight distance is given by:

$OSD = v_b*t + 2*s + v_b * \sqrt{(4*s)/a} + v*T$

Where, v_b is the velocity of the slow moving vehicle in m/s, t is the reaction time in seconds, s is the spacing between the two vehicles in meter and a represents the acceleration of the overtaking vehicle in m/s^2. The value of s can be found from the following formula: $s = 0.69v_b + 6.1$, Where, v_b is in m/s

Or, $s = 0.19v_b + 6.1$, Where, v_b is in km

In case the speed of the overtaken vehicle is not given it can be assumed that it moves 16kmph slower than the design speed i.e.

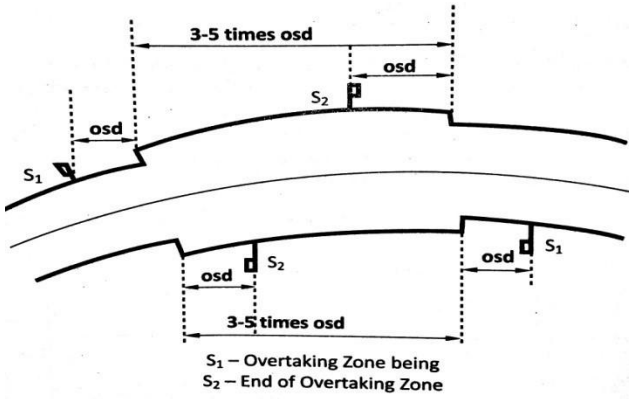
$_b = v - 16$

It should be kept in mind that on divided highways d_3 need not be considered. On divided highways with four or more lanes, it is not necessary to provide OSD but only SSD is sufficient.

OVERTAKING ZONES : Overtaking zones are those areas provided when OSD cannot be provided throughout the highway length. These zones include traffic signs which inform the driver about the start or the end of the overtaking zone kept at the distance of OSD. These zones are used for overtaking operations and are marked with wide roads.

Minimum length of overtaking zone = 3 * OSD

Desirable length of overtaking zone = 5 * OSD

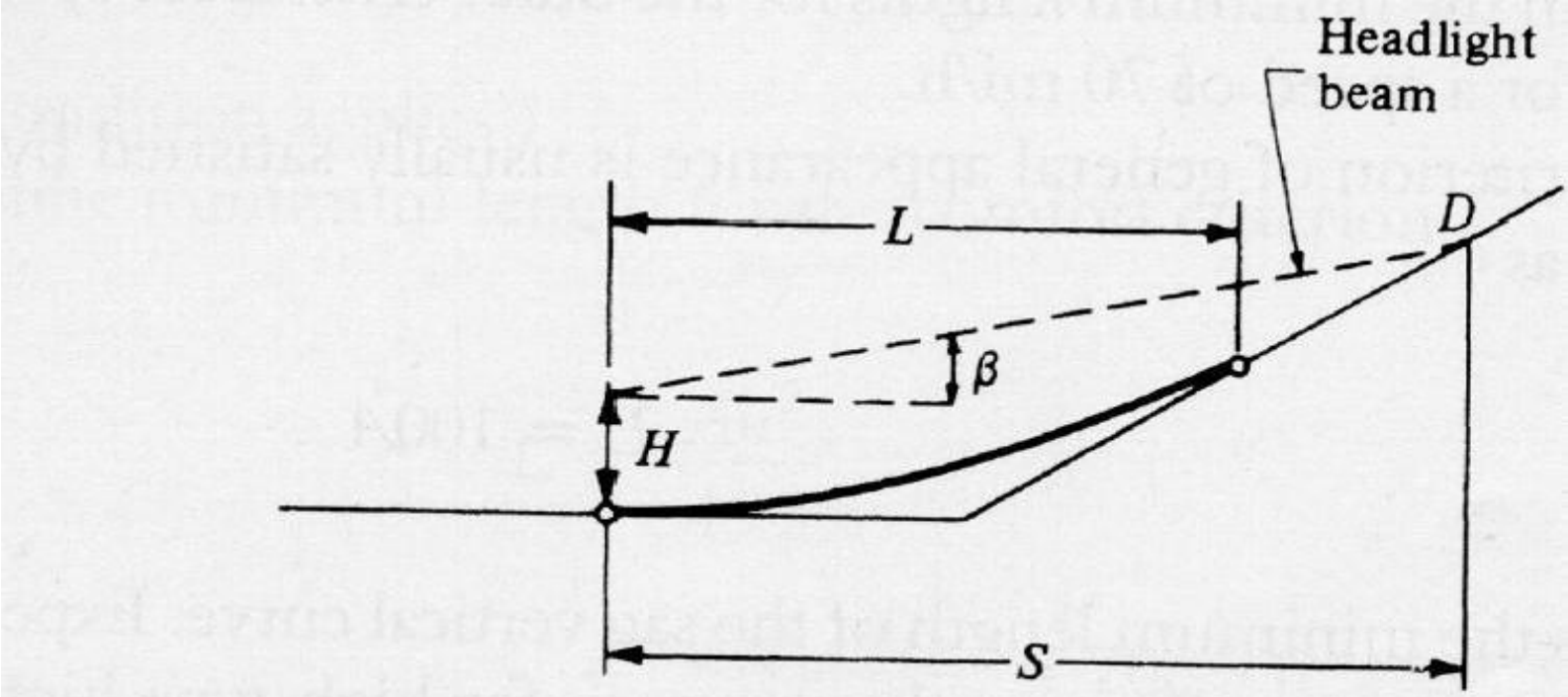


HEADLIGHT SIGHT DISTANCE :

Head light sight distance is the distance visible to a driver during night driving under the illumination of headlights.

The headlight sight distance is considered same as stopping sight distance in day time. It is the maximum distance visible ahead of a driver moving on vehicle during night time. The formula for Headlight Sight Distance stands same as in case of Stopping Sight Distance.

Headlight Sight Distance, **HSD = v.t + v^2 / 2gf**



Headlight Sight Distance on Sag Vertical Curves (S>L)

Problems on the Topics Discussed :

1. Calculate SSD for V =50kmph for (a) two-way traffic in a two lane road (b) two-way traffic in single lane road. (Hint: f=0.37, t=2.5) [Ans: (a)61.4 m (b) 122.8 m. Given: V =50km/hr = 13.9m/s f=0.37 t= 2.5 sec stopping distance=lag distance + braking distance SD = $vt + v^2/2gf$
2. Find minimum sight distance to avoid head-on collision of two cars approaching at 90 kmph and 60 kmph. Given t=2.5sec, f=0.7 and brake efficiency of 50 percent in either case. (Hint: brake efficiency reduces the coefficient of friction by 50 percent). [Ans: SD=153.6+82.2=235.8m] Given: V1 =90 Km/hr. V2 = 60 Km/hr. t = 2.5sec. Braking efficiency=50%. f=.7. Stopping distance for one of the cars.
3. Find SSD for a descending gradient of 2% for V=80kmph. [Ans: 132m]. Given: Gradient(n) = -2V = 80 Km/hr. SD = $vt + v\ 2/2g(f - n\%)$
4. Find head light sight distance and intermediate sight distance for V=65 kmph. (Hint: f=0.36, t=2.5 s, HSD=SSD, ISD=2*SSD) [Ans: 91.4 and 182.8 m]
5. Overtaking and overtaken vehicles are at 70 and 40 kmph respectively. find (i) OSD (ii) min. and desirable length of overtaking zone (iii) show the sketch of overtaking zone with location of sign post (hint: a=0.99 m/sec2) [Ans: (i) 278 m (ii) 834 m/1390]
6. Calculate OSD for V=96 kmph. Assume all other data. (Hint: Vb=96-16kmph. a=0.72, t=2.5s) [Ans: OSD one way 342m, OSD two way 646m]

"Thank you"

Have Any Query ?

Ask us @ shashikant.fet@ramauniversity.ac.in or shashikantchitransh3@gmail.com