Introduction to Transportation Engineering
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Lecture - 12
Intersection Sight Distance - 1

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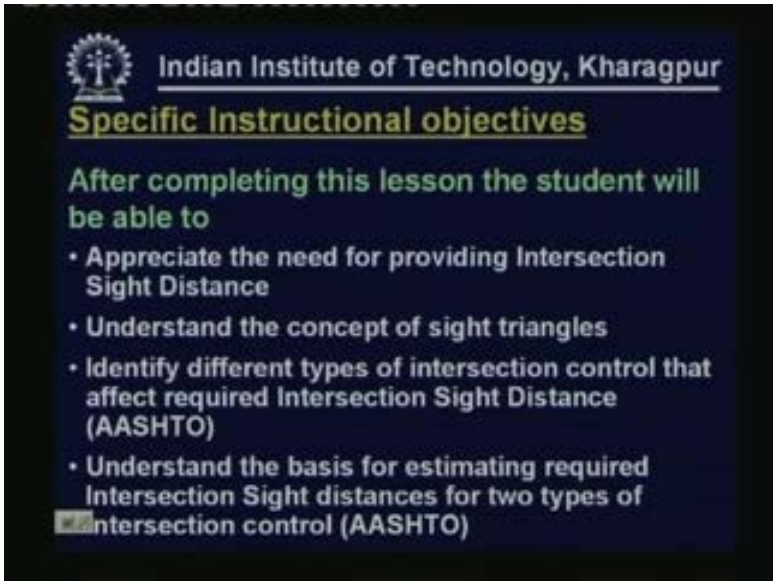

Intersection sight distance:
After completing this lesson the student will be able to appreciate the need for providing intersection sight distance, why it is required to provide intersection sight distance, understand the concept of sight triangle and important consideration for intersection sight distance. Also, the student will be able to identify different types of intersection control that affect required intersection sight distance. These are the considerations from AASHTO American Association of State Highways and Transport Officials and also understand the basis for estimating required intersection sight distance for two types of intersection control.

There are several types of intersection control as recommended by AASHTO. In today's lesson we shall cover two types of intersection control and accordingly try to understand the basis for obtaining intersection sight distance for those two types of intersection control.

First of all, intersection sight distance why it is important?
Basically inadequate sight distance is a major contributing factor to a large percentage of intersection crashes directly it affects the safety. Therefore adequate intersection sight distances should be provided for smooth efficient and safe operation of traffic at intersections

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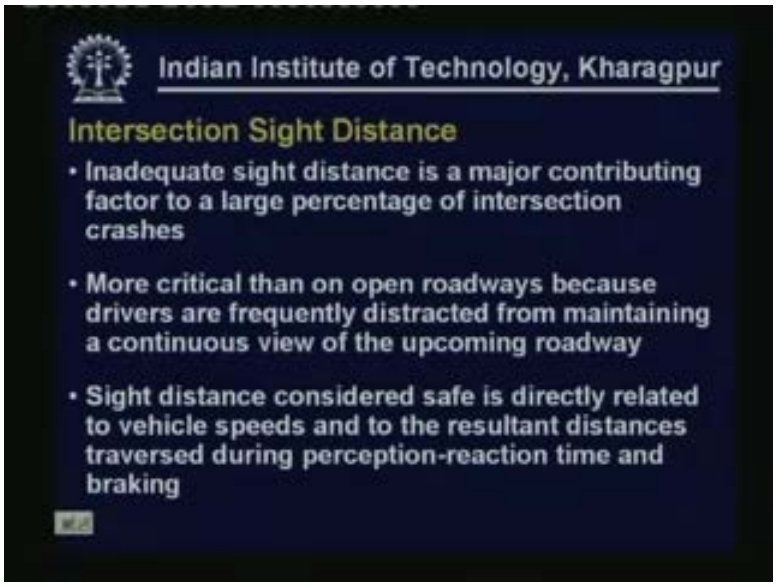

One should remember that intersection sight distance is more critical than open roadways because drivers are frequently distracted from maintaining a continuous view of the upcoming roadway therefore intersection sight distance becomes more crucial.

Sight distance which are considered safe directly depend on vehicle speed, always it depends on the vehicle speed and to the resultant distances traversed during perception reaction time and braking.

We have already discussed the sight distance consideration particularly say stopping sight distance. So you know there is a perception reaction component and then there is a braking component and obviously the required sight distance depends on the vehicle speed. So vehicle speed as well as the time for perception reaction as well as braking are other kinds of activities.

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Let us now try to understand the concept of sight triangle. Sight triangle is specified areas along intersection approach legs and across their included corners which should be clear of obstructions that might block a driver's view of potentially conflicting vehicles. That means when vehicle is approaching an intersection it is basically that triangular area near the corner which should be free from all kinds of obstructions that might block the view or the sight the line of sight.

Dimensions of sight triangles depends predominantly on two major considerations: one is the design speeds of intersecting roadways may be there is a major road and there is another minor road therefore the required sight distance will depend on the designs speeds of both roadways and it also depends on the type of control what is used in that intersection. It is very very important to understand this type of control because they actually mean different legal implications in terms of the behavior of drivers, what they are supposed to do as per the giving types of control in the intersection. So therefore their requirement in terms of sight distances depends predominantly on design speed of both roadways as well as the type of intersection control what is used at particular sight or intersections.

Then there are two types of sight triangle. We have understood the concept of sight triangle now but there are two types of sight triangle: one is approach sight triangle and the other one is called departure sight triangles. Now let us try to understand what is approach sight triangle and then what is departure sight triangle.

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Approach sight triangle as given here is the triangular area free of obstruction that might block an approaching driver's view of potentially conflicting vehicles. I would like to draw your attention on this particular aspect and approaching driver's view. That means when a vehicle is approaching the vehicle is in motion so at that time what is the triangular area that should be free from obstruction for the approaching vehicle.

Length of legs should be such that drivers can see any potentially conflicting vehicles in sufficient time to slow or stop before colliding with another vehicle within intersection area. That means when a vehicle is approaching it is not a stopped vehicle it is a vehicle in motion so at that time if it finds another conflicting vehicle then either it should be able to slow down the speed or it should be able to stop so the required sight distance or triangular area free from obstruction should be adequate enough either to change the speed or to stop before colliding with another vehicle within intersection area.

Another crucial point what we must understand in this context is the concept of decision point.
So decision point is the location at which the minor road driver should begin to brake to a stop if another vehicle is present on an intersecting approach. That means it is the point from which the vehicle if it finds another conflicting vehicle then the fast vehicle should be able to stop at a safe distance without colliding with another vehicle within the intersection area.

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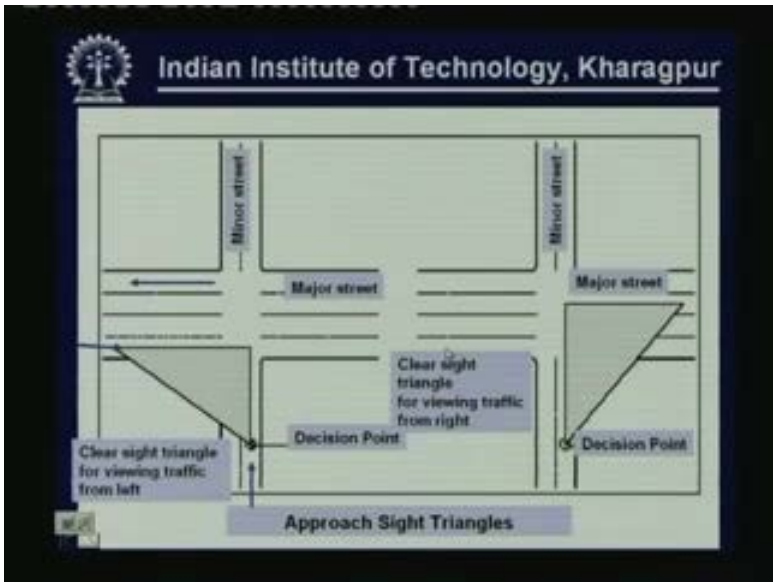

Look at this sketch now where the concept of approach sight triangles is explained. there it is a major road which is shown here, it is a major road this is the major road and this is another minor road, now a vehicle which is approaching from the minor road that means the vehicle coming from this direction has to take a left turn or may be right turn or maybe it is going straight so let us follow the AASHTO convention or US convention that means driving is like this as shown here (Refer Slide Time: 11:09). So when this vehicle is trying to enter into this area it is possible that a vehicle may come from the left side so there is a vehicle which may come from this end or from this side so this vehicle or the approaching vehicle should not collide with another vehicle so this is the shaded area what should be free from obstruction considering a vehicle from the left.

Similarly, if we consider the other condition, an approaching vehicle trying to enter or trying to cross or may be trying to take left turn or crossing the intersection a vehicle may come from the right side so again this vehicle approaching vehicle should not collide with the vehicle which is coming from the right side. That means this portion of the area should be free from obstructions so that the operation or the movement of vehicles in the intersection could be safe. This is the concept of departure sight triangles. So we have two triangles: one: considering the traffic coming from the left side and another considering the traffic from the right side.

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Departure sight triangles:
Departure sight triangles provide sight distances sufficient for a stopped driver on a minor road approach to depart from intersection and enter or cross the major road. the basic difference between approach sight triangle and departure sight triangle is in departure sight triangle we are considering a stopped vehicle that means a vehicle is stopped and then it wants to either take left turn or right turn or may be it wants to cross that major road. So under this condition for a stopped vehicle to accelerate, speed up and then cross the intersection what is the required intersection or the sight triangles so, that we are calling as departure sight triangles.

Understand this part clearly:
Provide sight distance sufficient for a stopped driver on a minor road approach to depart from intersection and enter or cross the major road. Now, departure sight triangles should be provided in each quadrant of each intersection approach controlled by generally a stop sign because wherever there is a stop sign the vehicle has to stop and then start the movement either to cross or to take left turn or to take right turn. For yield controlled intersections also vehicles may be required to stop before they cross the road or take left turn or right turns. Now it also should be provided that means the departure sight triangles should also be provided for some signalized approaches wherever it is necessary. We shall come back to this point later.

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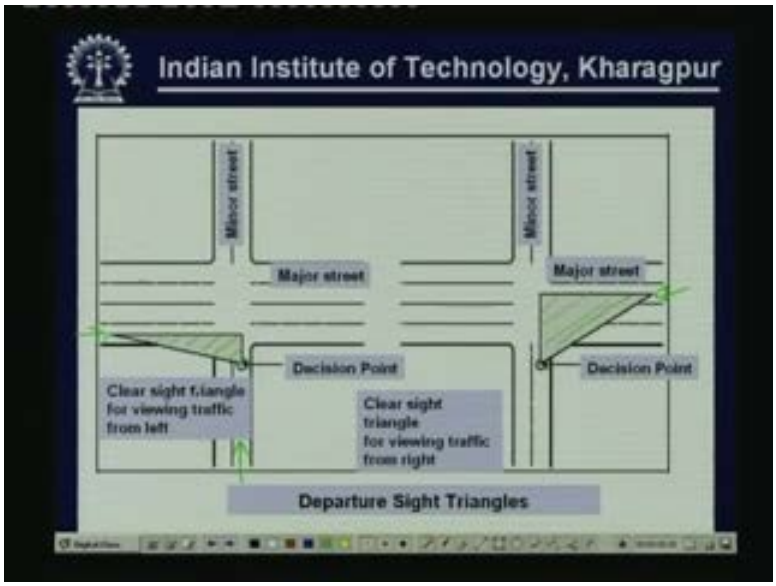

Now look at the sketch: the concept of departure sight triangles is explained here. It is similar to the concept of approach sight triangle except the vehicle is a stopped vehicle from the minor road. Therefore normally the required area, triangular area or the sight triangle dimension may be different. but in this case also say a driver or a vehicle is coming from the minor road, this is the minor road and this is the major road (Refer Slide Time: 15:58) so when a vehicle from the minor road is trying to enter into this major road from stopped position then a vehicle may come from the left side. It is also possible that a vehicle may come from the right side so required sight triangle is there or it is the required sight triangle considering the traffic from the left and this is the required sight triangle considering the traffic from the right side. Therefore we are showing here the clear sight triangle for viewing traffic from left and this one is the clear sight triangle for viewing traffic from the right hand side.

Remember that the movement we are considering like this and like this. This is different from whatever is followed normally in India. But predominantly this concept is used in AASHTO so we are using the same convention what is followed in AASHTO manual but the concept can be applied in the similar manner for Indian operating condition. The only difference will be whatever we are defining as left turning that would be actually right turning for Indian condition and whatever we are defining as right turn that will be actually left turn in Indian condition that is the small difference one should keep in mind.

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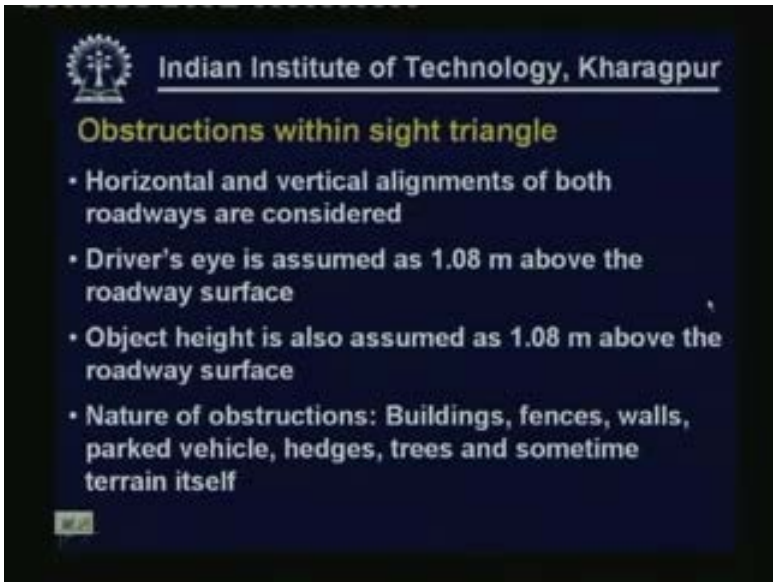

Obstructions within sight triangle: We know that sight triangles should be free from all types of obstruction for safe and efficient movement of traffic in intersection area. While looking at the obstructions within sight triangle one must consider both horizontal and vertical alignments of both roadways. That means we should consider the horizontal as well as vertical alignments because line of sight might be blocked due to all these factors. It is also necessary like for every other types of sight distance it is necessary to specify the height of driver's eye above road level and also the height of the object. In this case both are actually vehicles; one vehicle is approaching or trying to cross or trying to take left turn and that vehicle should not collide with another vehicle which is coming from other direction along the say major road so therefore height of driver's eye above road level and height of object above road level both are to be specified. In AASHTO both are taken as 1.08 m because both are actually vehicles. It was the same distance or it is the same distance which was used earlier when we discussed about passing sight distance and the design considerations and provisions in terms of AASHTO recommendations.

What could be the nature of obstructions?
It could be buildings, fences, walls, it could be parked vehicles, trees or sometimes even the terrain itself; the terrain profile could be such that it will cause obstruction to the line of sight.

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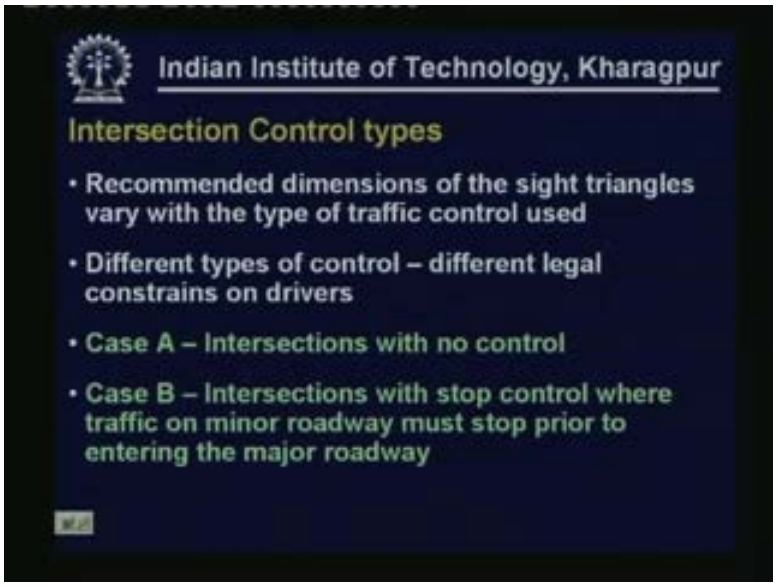

Intersection control types: Recommended dimensions of the sight triangles vary with the traffic control used. I have mentioned this point even earlier also. The required sight distance very much depends on the type of control used for the intersection. Why it is so because different types of control means different legal constraints on driver in terms of their behavior. So, different legal constraints on driver in terms of their behavior so obviously the requirement in terms of sight distance also will be different. AASHTO considers six different types of intersection control. Case A) intersection with no control; case B) intersections with stop control where traffic on minor roadway must stop prior to entering the major road.

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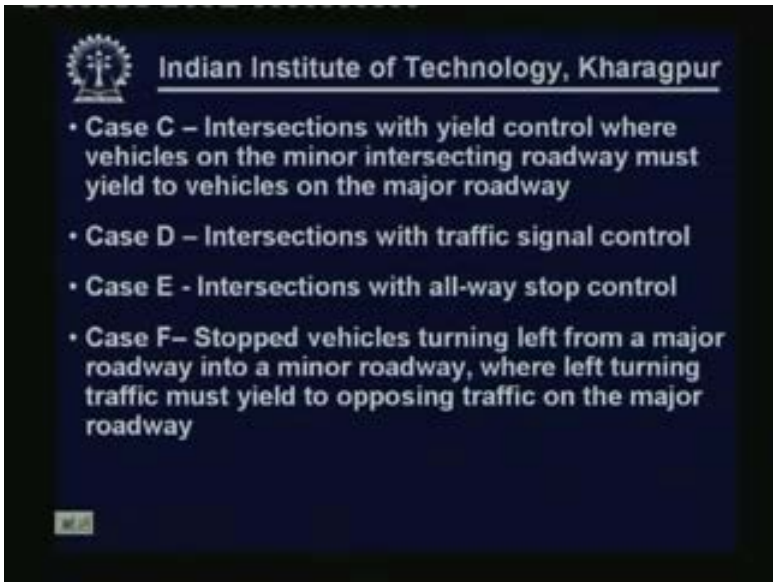

Now there are other four types: case C) intersections with yield control where vehicles on the minor intersecting roadway must yield to vehicles on the major roadway. It may not stop, the vehicle from the minor road may not stop but it must yield to vehicles on the major roadway; case D) intersections with traffic signal control; case E) intersections with all-way stop control and case F) stopped vehicle turning left from a major roadway. One must notice this part; from a major roadway that means a vehicle which is stopped and trying to take left turn following US convention of driving and trying to enter minor roadway where left turning must yield to opposing traffic again on the major roadway. That means it should be able to take right turn and it must yield to opposing traffic on the major roadway. So under these control conditions what should be the requirement for sight distance and what should be the dimensions of sight triangle that we shall discuss under case F. So these are the six major control types or the type of control which is considered in AASHTO manual.

In today's lesson we shall discuss about the first two types of intersection control and try to understand the basis for obtaining the sight triangle dimensions.

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Case A) no control or what we say uncontrolled intersection.
In this case intersections are not controlled by yield signs, stop signs or traffic signal. Therefore drivers of a vehicle approaching an intersection of this type must be able to see potentially conflicting vehicles in sufficient time to stop before reaching the intersection. So, in no control intersection vehicles are free to approach intersection area but when a vehicle is approaching an intersection area it must be able to see potentially conflicting vehicles on other roads with sufficient safety margin so that the vehicle if necessary should be able to stop before colliding with other vehicles within intersection area.

Now you can understand clearly; this is a case where approach sight triangles should be considered because vehicle is in motion, vehicle is not bound to stop under normal conditions,

it will stop only if it is necessary and if there is another potentially conflicting vehicle on the other road. Therefore in this case approach sight triangles should be considered.

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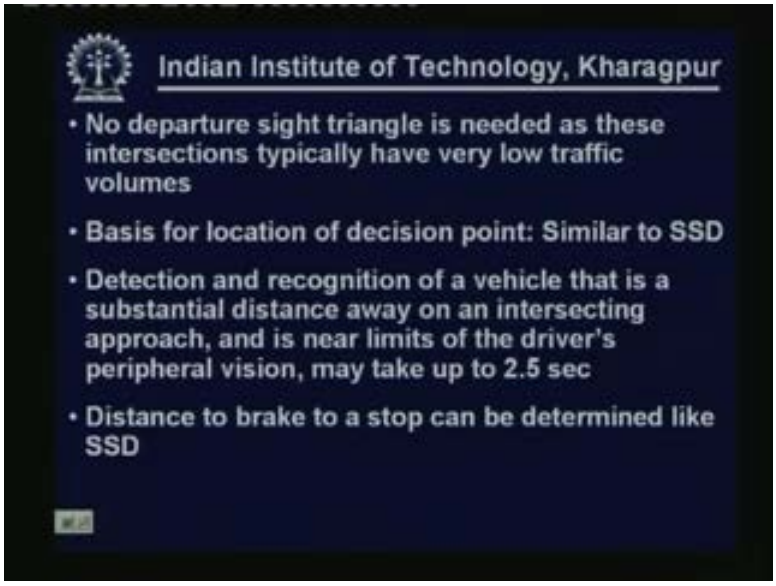

Normally no departure sight triangle is needed as these intersections typically have very low traffic volumes. Yes, a vehicle say from a minor road or even from the major road also; let us consider a vehicle from the minor road suppose it is stopped because there is a potentially conflicting vehicle coming along the other road but because such intersection has very low volume intersections it is unlikely that once the vehicle is stopped then before it crosses or before it takes turn it is unlikely that another vehicle or another potentially conflicting vehicle will reach there. It is quite unlikely particularly because these are very low traffic volume intersections. Therefore it is not necessary to consider the requirements in terms of departure sight triangle.

Now what should be the basis for location of decision points or trying to understand or trying to calculate the dimensions of approach sight triangles?
The basis is very similar to what we discussed for stopping sight distance again as per AASHTO approach. Why? Because the only thing is under emergency conditions vehicles should be able to stop before entering and colliding with another vehicle within that intersection area. Therefore the basic approach or basic consideration for calculation of distance is very similar to what was used earlier for stopping sight distance, I repeat; but with a slightly different assumptions, why, let us try to understand that point.

Now here also there are two components: one is the perception reaction time as it was there for stopping sight distance and then another component is the braking component that is when the brake is applied then it is the distance required by the vehicle before it stops.

Now the first part: Detection and recognition of a vehicle that is a substantial distance away on an intersecting approach, and is near limits of the driver's peripheral vision, may take up to 2.5 seconds. This is observed or this is found from field observations. In some cases it might be even

shorter time lesser that 2.5 seconds but it may take up to 2.5 seconds. So actual breaking if necessary it starts after 2.5 seconds and it may start up to after 2.5 seconds. Then how one can calculate the stopping distance? That means distance to brake to a stop that can be determined as it was determined for the case of stopping sight distance.

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Now here one must remember some very important considerations as to what makes it different from the calculation what was used in stopping sight distance. Now vehicles reduce speed to approximately 50 percent of their mid block running speed even when no potentially conflicting vehicles are present. That means whenever any vehicle is approaching an uncontrolled intersection or an intersection with no control it is observed from field that vehicles or drivers normally reduce their speed up to about 50 percent of the running speed or more specifically the mid block running speed. These they do even when there is no conflicting vehicle solely because of the nature of the control because drivers are aware that they are approaching an uncontrolled intersection.

Now, breaking at greater deceleration rate as assumed in stopping sight distance it was assumed as 3.4 m per second square that can begin up to 2.5 seconds after a vehicle on the intersection approach comes into view. That means even if there is no conflicting vehicle still the vehicle speed is reduced and drivers apply deceleration rate up to 1.5 m per second square which is lesser deceleration rate as compared to what was assumed for calculation of braking distance in stopping sight distance consideration. So altogether, what is happening when vehicles are approaching an intersection with no control? The vehicle speed is reduced substantially up to 50 percent and the perception reaction component and the braking component both are happening with a lesser speed than what was the average running speed in mid block condition. So altogether, the distance traveled by an approaching vehicle the distance traveled means during the perception-reaction as well as braking is lesser as compared to the distance traveled by vehicles when we consider stopping sight distance. Therefore these values are normally lesser than the values for stopping sight distance.

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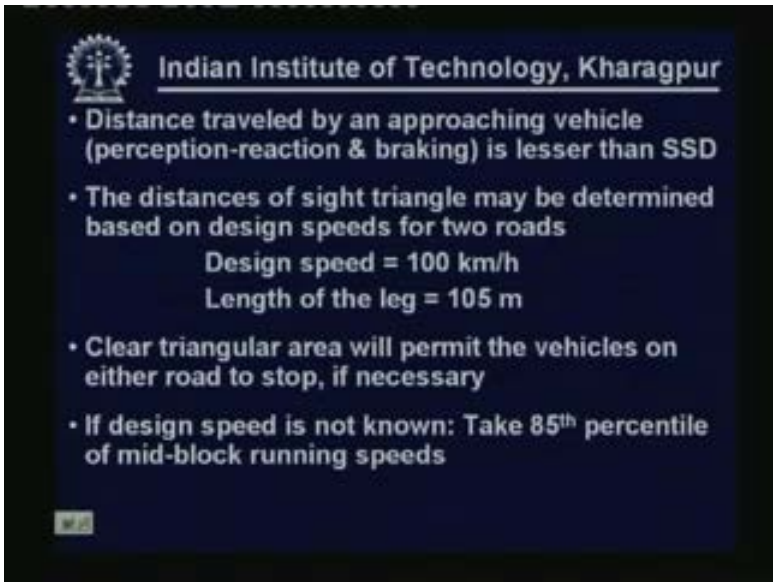

Now, based on field observations AASHTO has suggested different length of leg making it as a function of the design speed. All those considerations are there: vehicles decelerate up to 1.5 m per second square, drivers reduced speed approximately up to 50 percent of the mid block running speed, they may take up to 2.5 seconds in the perception reaction component and if necessary then they apply brakes. Considering all these things AASHTO has given designed values for the length of leg making it as a function of the design speed.

Say for example, the distance of sight triangle may be determined based on design speeds for the two roads. Say, if the design speed is 100 kilometer then AASHTO says the required length is 105 m. So accordingly for each approach if we know the design speed accordingly from the table we can get what is the required length. But to ask it is important to understand the basis for this design values which I have explained.

Now, clear triangular area will permit the vehicles on either road to stop if necessary so this should be provided on each approach when the intersection is uncontrolled or intersection is with no control.

If the design speed is known one can use the design speed and accordingly take the value. if the design speed is not known then 85th percentile of mid block running speeds can be taken as representative design speed and accordingly the length of the triangle or the dimensions of the triangle may be decided.

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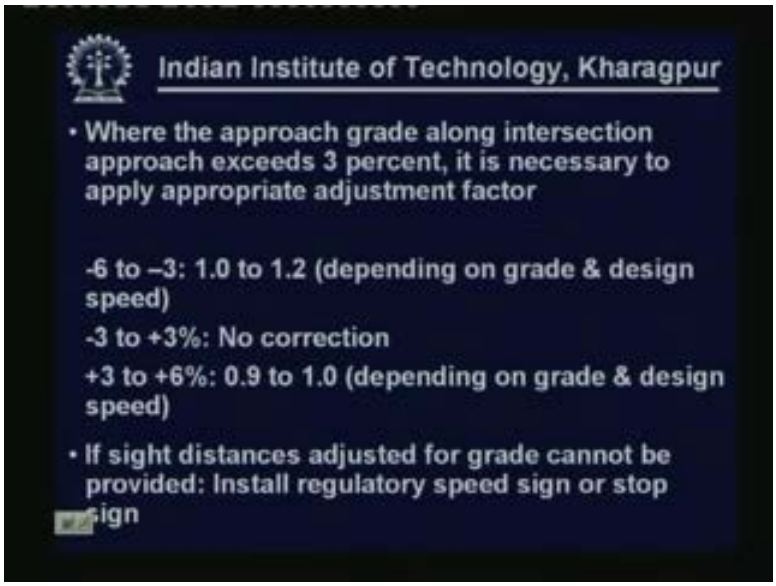

Some more considerations, some more points you must understand: When the approach grade along intersection approach exceeds 3 percent it is necessary to apply appropriate adjustment factor. That means whatever values are given in AASHTO table those values are essentially for approach grade plus minus 3 percent that means up grade or down grade but if the grade is different or outside this range then suitable correction factors are to be applied. Those factors are also given in AASHTO manual. Say, for minus 6 to minus 3 percent approach grade correction factors vary from 1 to 1.2 depending on actual grade and actual design speed. As I indicated from minus 3 to plus 3 no correction factors are required and from plus 3 to plus 6 percentage grade the correction factors are recommended at 0.9 to 1 but again the actual value will depend on grade and the design speed.

Finally if sight distances are adjusted for grade cannot be provided then one must explore the possibility of installing regulatory speed sign or even stop sign to make the operations of traffic in the intersection area safe.

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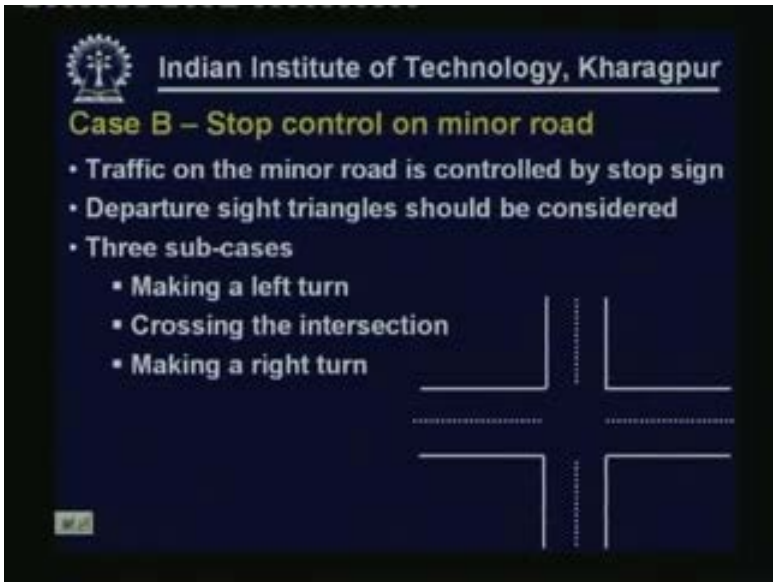

Now, Case B) stop control on minor road:
Here traffic on minor road is controlled by stop sign; traffic on minor road is controlled by stop sign and obviously because we are looking at the requirements of a stopped vehicle that means the stopped vehicle to accelerate and complete the time either take left turn, right turn or crossing so what is the requirement so it is the case for departure sight triangles and there are three sub-cases as shown here in this case so may be this is the minor road, a vehicle is coming from the minor road, it may take a left turn, it may take a right turn or it may even cross the major road.
So there are three types of movements so there are three different sub-cases making a left turn, making a right turn and crossing the road. Let us see the requirement in terms of sight distance for each possible condition.

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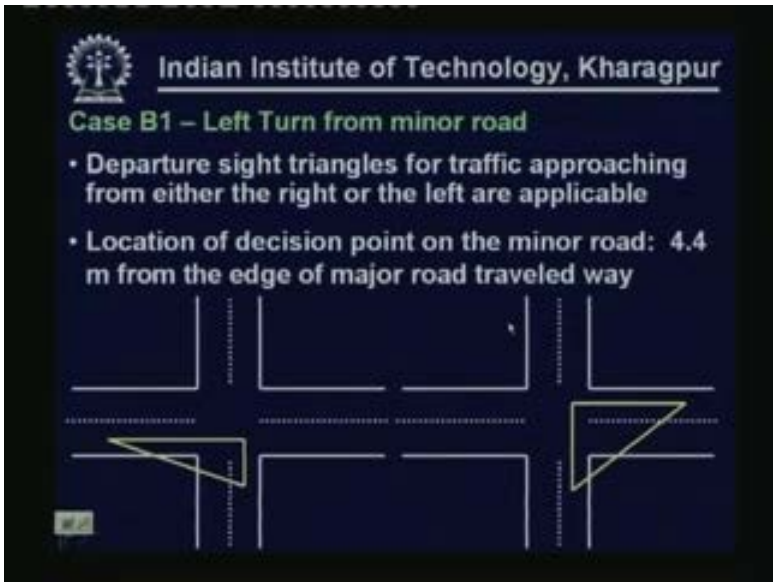

Case B1) Left turn from minor road:
Here departure sight triangles for traffic approaching from either the right or the left are applicable. So here again let us see the sketch here. This is the vehicle, so when this stopped vehicle is trying to do maneuver it is possible that a vehicle may approach from the left side so this is the triangular area which should be free from obstruction, it is also possible that the when the vehicle is trying to move a vehicle may come from the right side so again this area should be free from obstructions and location of the decision point on the minor road should be decided.

Therefore, there are two cases: considering a vehicle from the left side as discussed and the other case is a vehicle from the right side so this is the case.

Now, location of decision point on the minor road: As per AASHTO it is 4.4 m from the edge of major road traveled way. That means essentially this is the distance what we are calling as 4.4 m from the edge of the traveled way. Now how this 4.4 m is taken, let us again try to understand the basis.

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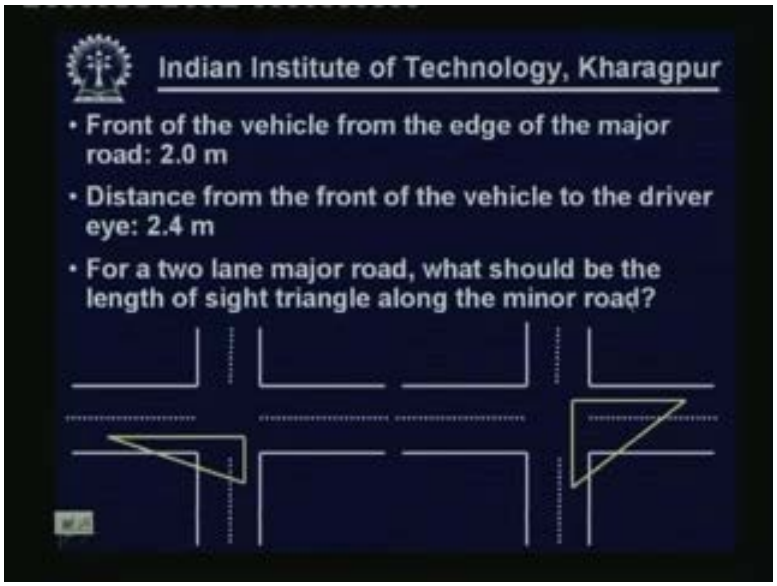

Front of the vehicle from the edge of the major road it is found say 2 m so we have taken this complete thing as 4 m. Now this complete thing is 4.4 m which includes front of vehicle from the edge of the major road as say 2 m and distance from the front of vehicle to driver's eye because driver's eye, the driver is sitting at a distance from the front of the vehicle so that normally in American condition it is 2.4 m so altogether this distance becomes 4.4 m. So what should be the length of sight triangle along the minor road if we consider a two lane major road? Now in this case it is 4.4 m plus half of the lane width because if it is a two lane major road if we consider then it is one lane for each direction so it is half lane half of the lane width which should be added to this distance 4.4; in this case it is 4.4 plus one and a half lane one and a half lane so that way we can calculate the dimension of this sight triangle.

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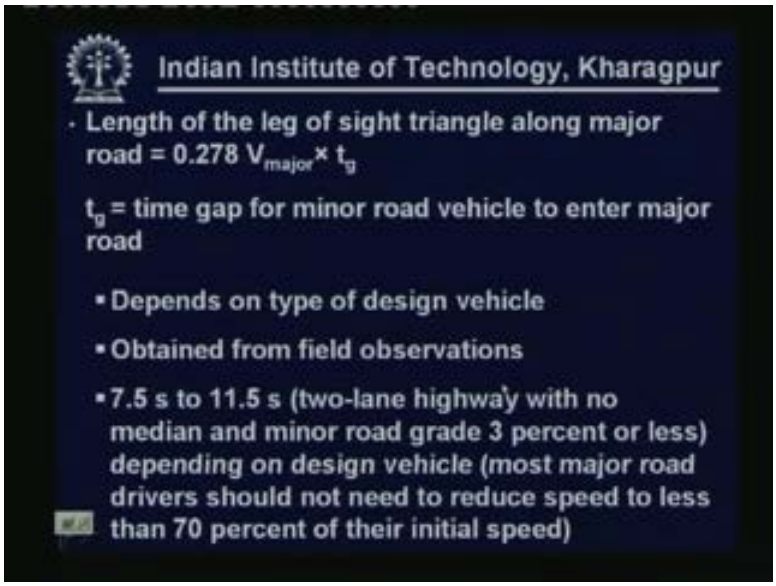

Now let us see how we calculate this length this dimension along the major road. The distance is calculated in this fashion 0.278 V major into t g. now V major is the design speed for the major road and t g is the time gap for minor road vehicle to enter major road. That means a vehicle is stopped so how much time it will take for the vehicle to accelerate from stopped position and complete the turn either complete the turn. Now this time 0.27 is the multiplying factor because we are considering or taking the design speed in kilometer per hour so this is the convection factor.

Now this t g what should be the value?
This t g value depends on type of design vehicle. That means if the stopped vehicle is actually a car the time requirement will be different as compared to the condition where the design vehicle is a commercial vehicle. So it depends on the design vehicle or the type of vehicle and the values what are recommended in AASHTO they are actually obtained from field observations and it is found that this time gap varies from 7.5 seconds to 11.5 seconds depending on design vehicle say for car it is 7.5 for other commercial and heavier vehicles it has been more and this value 7.5 seconds to 11.5 seconds as recommended in AASHTO is based on two lane highway with no median and minor road grade 3 percent or less. That means this time gap is for two lane highway with no median and minor road grade 3 percent or less.

Now if this value is used; say for car if we use 7.5 seconds then AASHTO recommends that under this condition most major road drivers should need not reduce speed to less than 70 percent of their initial speed because it is found from field observations that vehicles which are traveling along major road also normally reduce their speed as compared to the speed in the mid block condition. But if we use this time gap as 7.5 seconds to 11.5 seconds depending on the vehicle type and other thing then vehicles on major road they will normally not required reducing speed to less than 70 percent of their initial speed.

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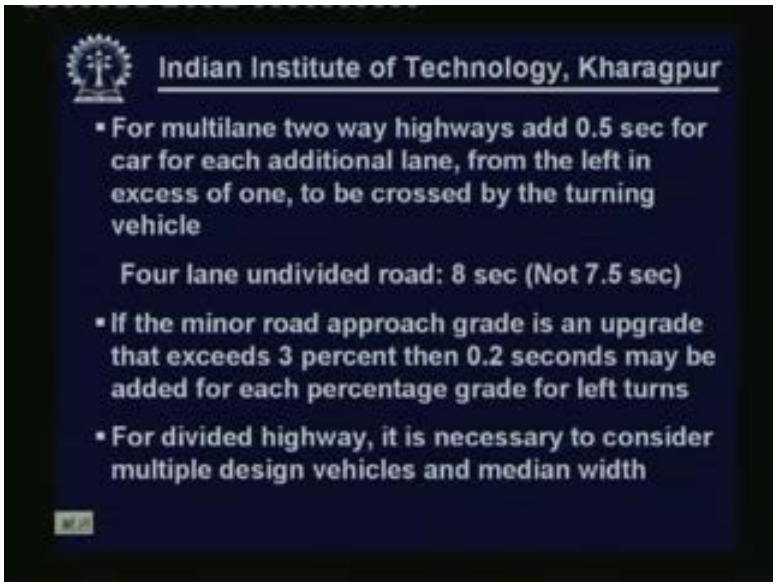

For multilane highways 0.5 seconds is to be added for car for each additional lane from the left in excess of 1 from the left in excess of 1 that should be noted carefully to be crossed by the turning vehicle. That means what we told 7.5 to 11.5 these are for two lane roads so for multilane highways some corrections are to be applied. How much additional time to be added that will depend on the vehicle type. Say for car here it is 0.5 seconds but for commercial vehicle the value is different. Now this should be added, 0.57 should be added for each additional lane from the left in excess of one to be crossed by the turning vehicle. So for four lane undivided road vehicle has to cross two lanes from the left instead of one so it is not 7.5 rather 0.5 into 2 so one more second to be added.

If the minor road approach grade is an upgrade that exceeds 3 percent and up to 3 percent there is no correction. It is still 7.5 to 11.5 but if it exceeds 3 percent then 0.2 seconds may be added for each percentage grade for left turn. And for divided highway it is necessary to consider multiple design vehicles and median width because it will vary substantially depending on what is the exact median width; whether it can store a vehicle that means it will also depend indirectly on the type of designed vehicle. So there are appropriate considerations for all these conditions considering the effect of median width and different designed vehicles.

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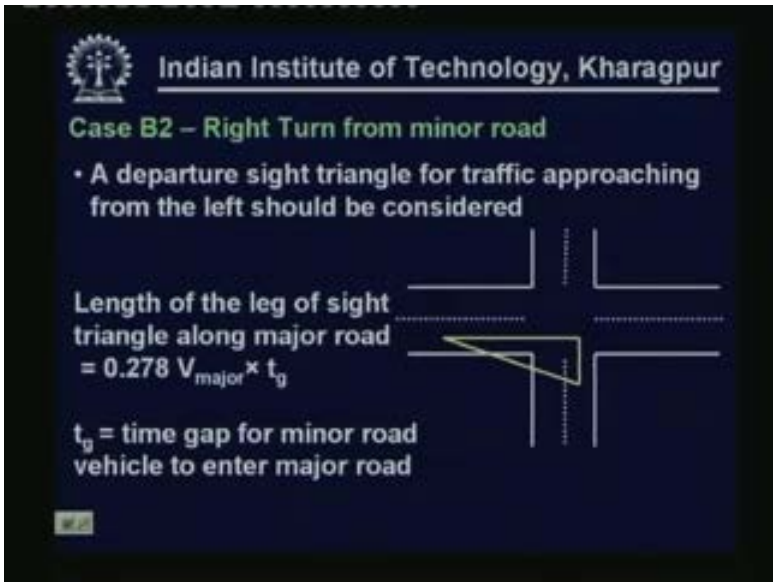

Now case B2) right turn from minor road:
Here also the departure sight triangle for traffic approaching from the left should be considered because the traffic is taking right turn. Here also the length of leg of sight triangle along the major road is calculated using a similar formula as what was used for left turn. But in this case the time gap t g for minor road vehicle to enter major road is slightly different.

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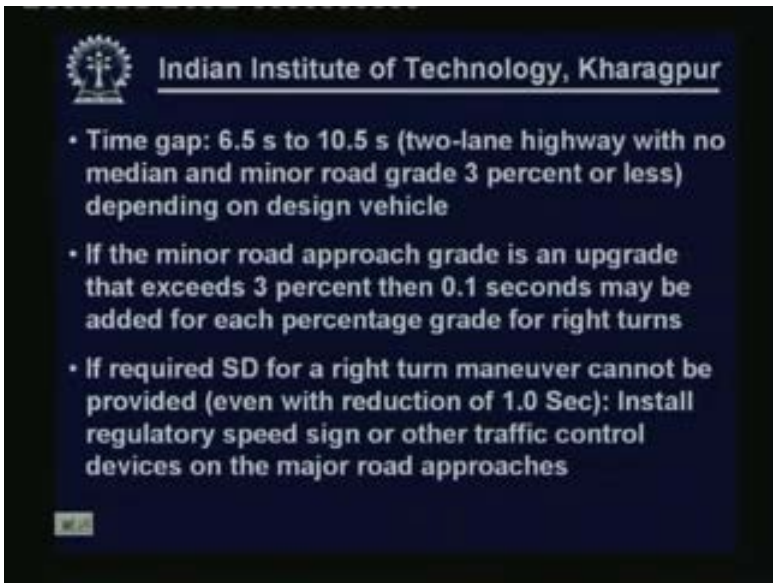

It is observed that vehicles normally accept for right turn, vehicle accepts a slightly lesser time gap; AASHTO says that one can consider one second lesser time as compared to what is recommended for left turn. So for left turn it was 7.5 to 11.5 here it is 6.5 seconds to 10.5

seconds but these value again depend on the type of vehicle, whether it is a car. For a car it should be 6.5 and commercial vehicles, heavy vehicles it should be more and this is the value which is applicable for two lane highway with no median and minor road grade 3 percent or lesser. So in this case also if the minor road approach grade exceeds 3 percent then AASHTO recommends 0.1 seconds may be added for each percentage grade for right turns.

Now, if required sight distance for a right turn maneuver cannot be provided even considering this reduction in time by one second then in that case one should explore the possibility of installing regulatory speed sign or other types of traffic control devices on the major road approach on the major road approach so that the speed can be regulated on the major road.

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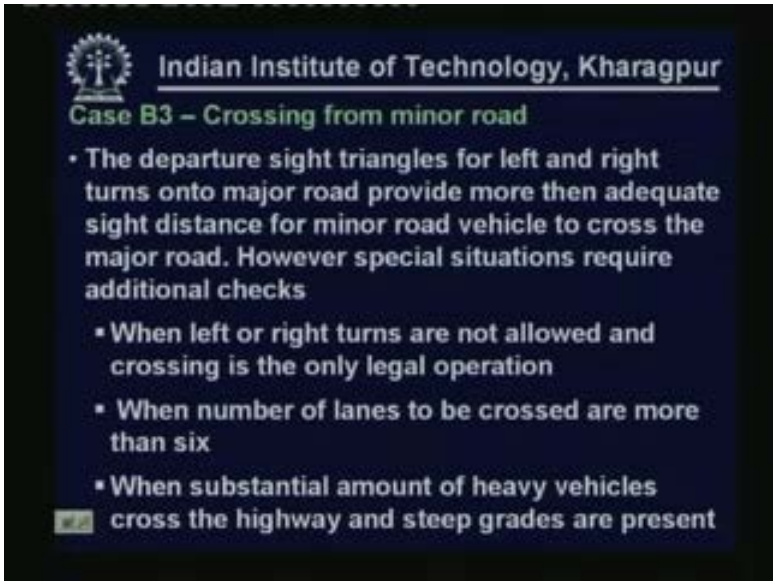

Now Case B3) crossing the minor road:
Normally the departure sight triangles for left and right turns onto major road provide more than adequate sight distance for minor road vehicle to cross the major road. Therefore normally no separate consideration is required but there are certain special situations like when left or right turns are not allowed and crossing is the only legal operation or when number of lanes to be crossed are more than 6 or when substantial amount of heavy vehicles crossed the highway and steep grades are present. Those are the special cases where one has to look for the required sight distance for crossing the minor road.

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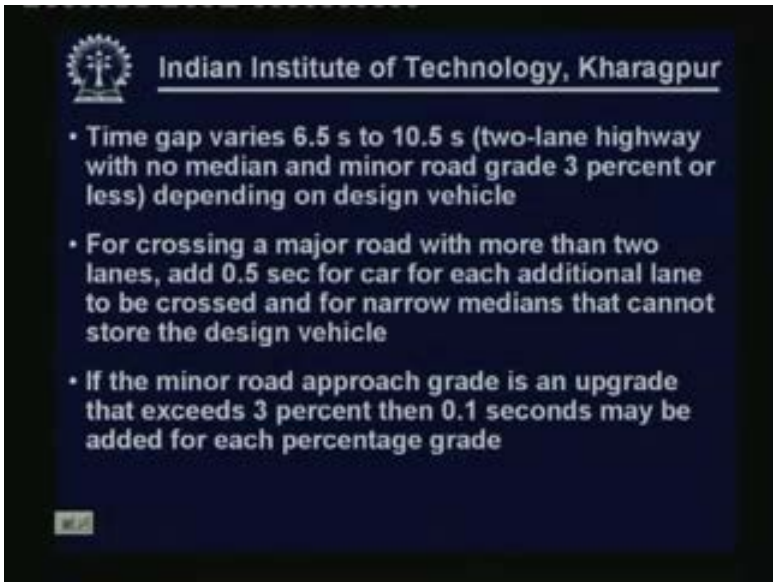

In normal condition the time gap varies from 6.5 seconds to 10.5 seconds as it was used for case B2 that means for right turn. It is the same consideration here but for crossing a major road with more than two lanes, add 0.5 seconds per car, the value is different for commercial vehicles for each additional lanes to be crossed and for narrow medians that cannot store the design vehicles. Similarly, a similar correction is applied for the grade if the grade is more than 3 percent.

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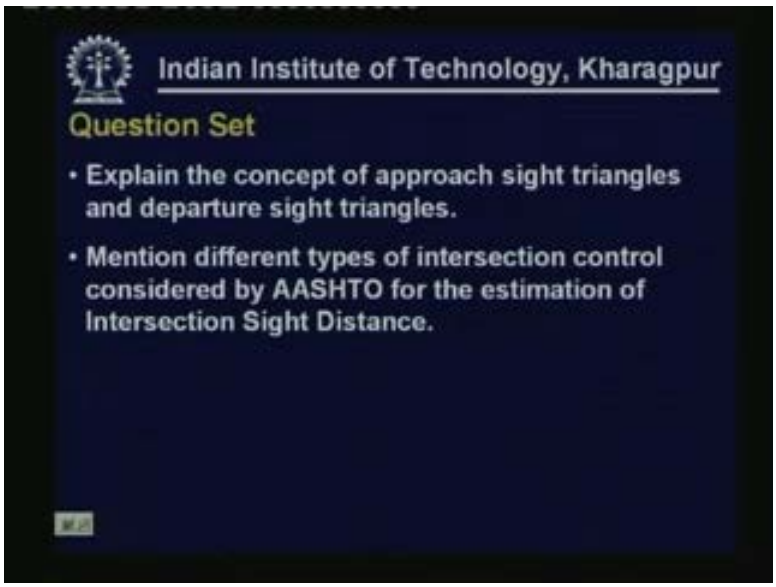

Now we have discussed two types of intersection control and tried to understand the basis. A few questions from the discussion.
Explain the concept of approach sight triangles and departure sight triangles:

Number 2: Mention different types of intersection control considered by AASHTO for the estimation of intersection sight distance.

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Third question: For an intersection with stop control you can consider it is a four lane intersection on minor roads, stop control on minor road, what should be the dimensions of sight triangle considering left turn from the minor roads under the following condition where the design vehicle is a car, design speed of the major road is 100 kilometer per hour, major road is a four lane undivided roadway and minor road approach is located on a 4 percent of grade. So under these conditions what should be the dimension of sight triangle?

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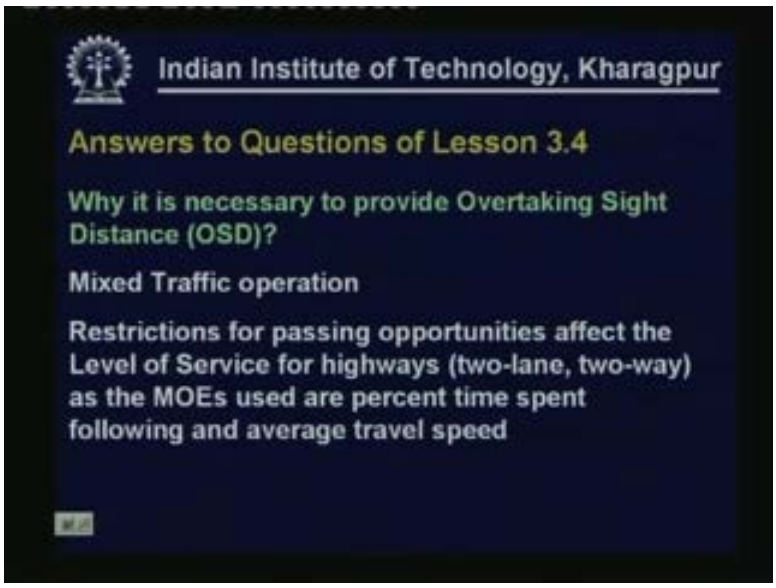

Now I shall try to answer the questions of lesson 3.4.

Why it is necessary to provide overtaking sight distance?
You know that every vehicle do not travel in the same speed particularly in mixed traffic operation. Therefore wherever there are traffic operations on highways and other types of roads particularly for mixed traffic operation in other cases also it is required but it is more required for mixed traffic operations due to the differential speed criteria so opportunity for overtaking should be given.

Also, restriction for passing opportunities affect the level of service for highway particularly two lane two way roads as the measure of effectiveness used are percentage time spent following and average travel speed. So, if adequate overtaking sight distance or overtaking sight opportunities are not provided then both these MOEs should be affected and level of service will be degraded.

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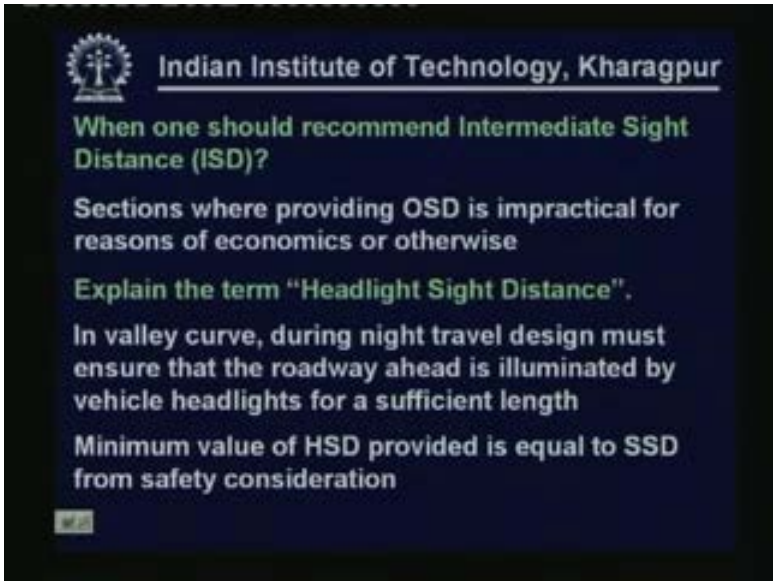

When one should recommend intermediate sight distance?
That means sections where providing overtaking or passing sight distance is impractical for reasons of economic and otherwise then it is a consideration by Indian Roads Congress. IRC says that provide double of stopping sight distance which is nothing but the intersection sight distance because it will give limited opportunity for overtaking.

Explain the term headlight sight distance:
Particularly in valley curve during night travel it is only the length of the road which is visible by the illumination of headlight that that portion is visible to driver. So particularly for valley curve it is crucial and therefore that distance should be adequate for emergency stopping of vehicle and we consider the distance as headlight sight distance. That means the distance which is visible by the illumination of headlight.

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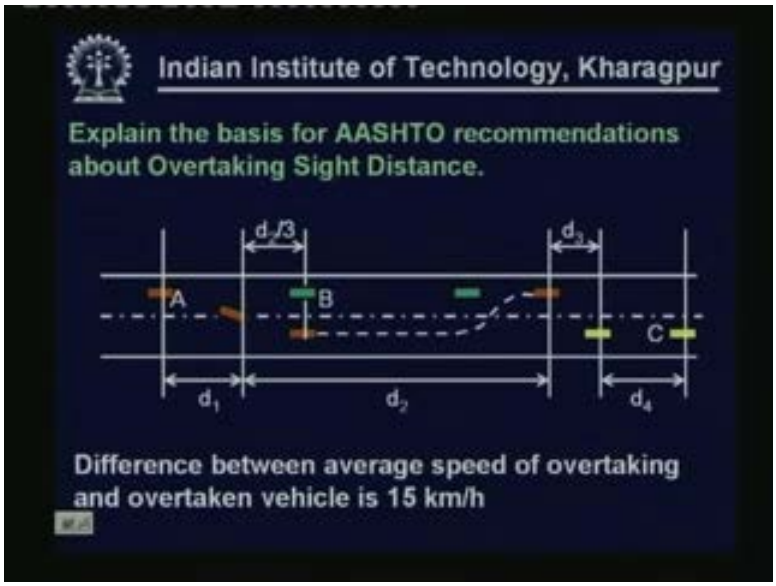

Last question was: Explain the basis for AASHTO recommendations about overtaking sight distance:
Now look at this sketch, AASHTO considers three vehicles: vehicle A which is trying to overtake (Refer Slide Time: 54:57) vehicle B which is the overtaken vehicle, different positions of the overtaken vehicle and vehicle C which is the vehicle coming from the opposite direction. Now there are four components which are considered: d 1 is the distance traveled by overtaking vehicle during the initial perception-reaction and acceleration up to the encroachment of opposing lane. So you can see the vehicle position here it is just trying to encroach the opposing lane so this distance is d 1; d 2 this is this component that the distance traveled during the actual overtaking.

So vehicle A from this position it goes to the opposing lane, completes the overtaking operation and then comes back to its original lane earlier lane. So this distance traveled is normally taken as d 2. d 3 is the safety margin; the clearance between the overtaking vehicle and the vehicle from the opposite direction after the overtaking vehicle has completed the overtaking maneuver. This is the overtaking vehicle (Refer Slide Time: 56:21) which has just completed the overtaking operation and then at the same time the opposing vehicle is in this position. So this time gap is taken as d 3 and d 4 is the distance traveled by the opposing vehicle during this overtaking maneuver.

How to calculate these distances?
There are provisions in AASHTO.

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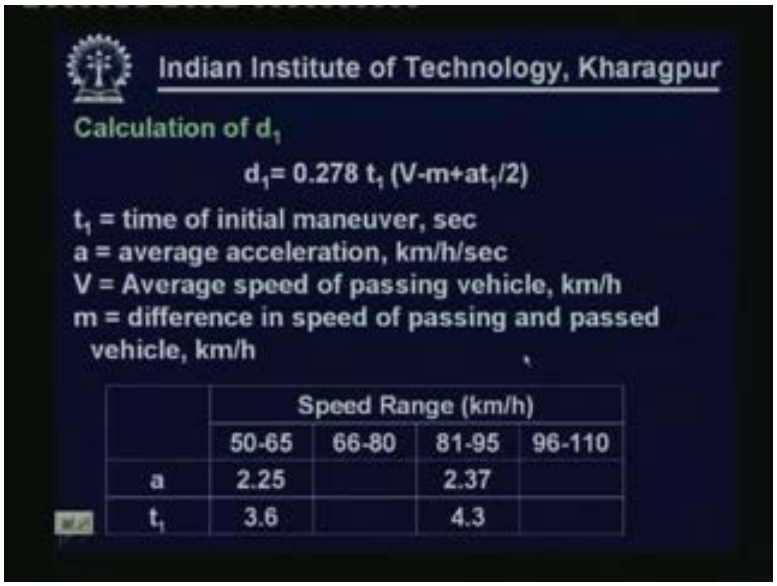

Now d 1 can be calculated with the help of this formulation 0.278 t 1 into V minus m plus a t 1 by 2. We have discussed the basis for this equation. Now, for different speed ranges the values of a that is the average acceleration and the value of t that is the time for initial maneuver they are decided so depending on the speed range the values can be selected from manual.

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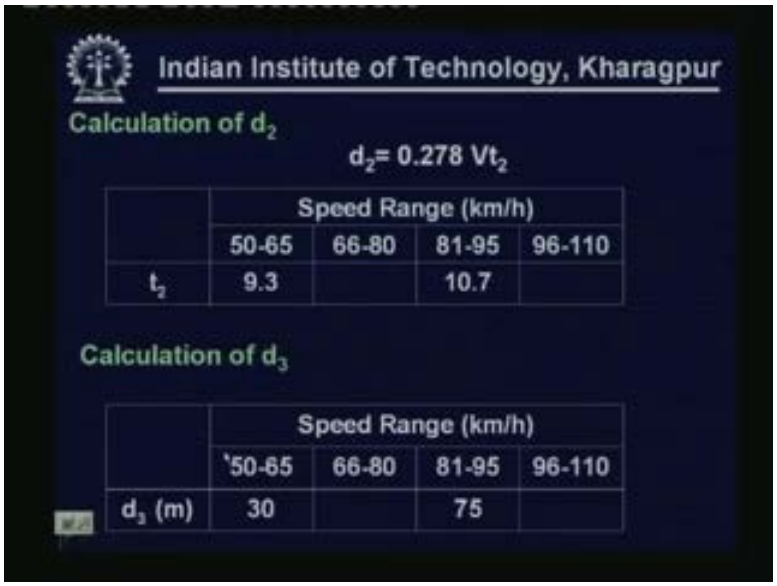

Similarly d 2 the basis we have discussed. There are different speed ranges so one can decide the value of d 2. Discuss this value of d 2.

Now equation is same but d 2 value is obtained experimentally and reported in manual. Then calculation of d three which is the clearance again depends on the speed range. For different speed range this d t values are given so suitable values can be taken.

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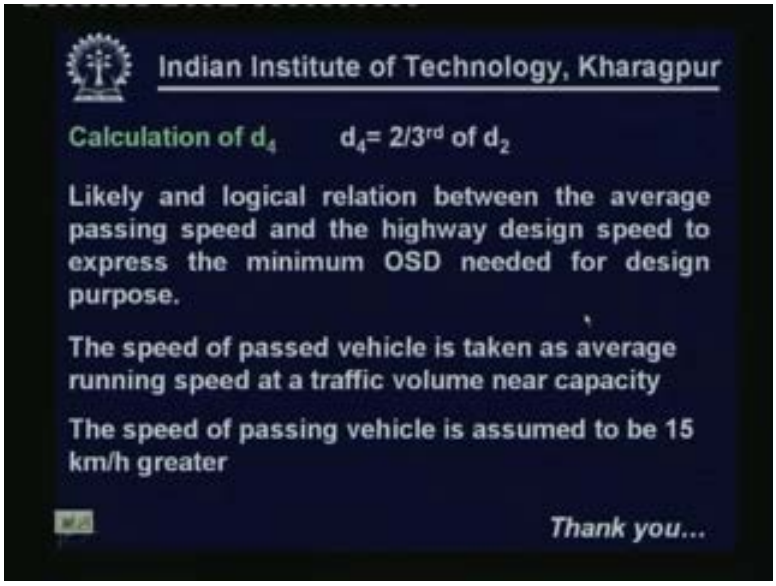

For d 4 it is taken as two third of d 2. Why two third is because after certain position the overtaking vehicle can really cancel the overtaking operation and it can go back to its original lane. So while calculating the distance covered by opposing vehicle it is not necessary to take complete d 2 length but it can be taken as two third of d 2. now all these d 1, d 2, d 3 and d 4 they are based on the average passing speed of vehicles. Therefore it is necessary to calculate or to establish a likely and logical relation between average passing speed and highway design speed. The highway design speed is known so therefore a logical relationship is to be established. If this is the design speed then what should be the average passing speed so then only d 1, d 2, d 3 and d 4 components can be calculated and they can be added together.

Now, the speed of passed vehicle or overtaken vehicle is taken as average running speed at a traffic volume near capacity. The traffic stream speed will be reduced once the volume is more. Now, when the road is operating at its capacity level that means when volume is near capacity then what should be the stream speed? The actual passed vehicle speed is assumed, it is the same as traffic stream speed when the volume is at or near capacity. So, that gives the basis for obtaining the speed of overtaken or passed vehicle.

Then the speed of passing vehicle is assumed as 15 kilometer per hour greater. So whatever be the speed of passed vehicle the passing vehicle speed is assumed as 15 kilometer per hour greater. So this speed is known now. Once this speed is known the passing vehicle average speed is known then d 1, d 2, d 3 and d 4 can be calculated and they may be added together to get the required overtaking sight distance, thank you.