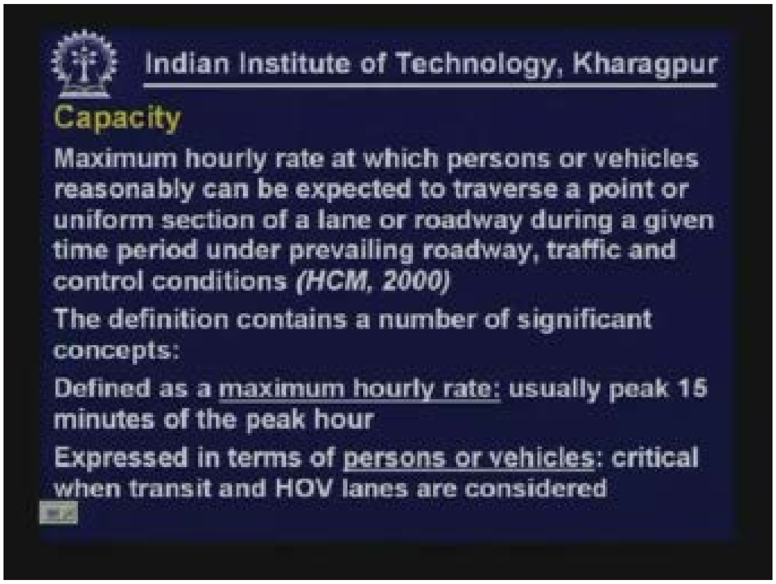
Introduction to Transportation Engineering
Dr. Bhargab Maitra
Department of Civil Engineering
Indian Institute of Technology, Kharagpur
Lecture - 6
Highway Capacity and Level of Service

After completing this lesson the student will be able to understand the concept of capacity and level of service for highway facilities, identify the factors affecting the capacity and level of service, the student will be able to estimate the capacity and surface volumes for different highway facilities. Let us try to understand the concept of capacity.

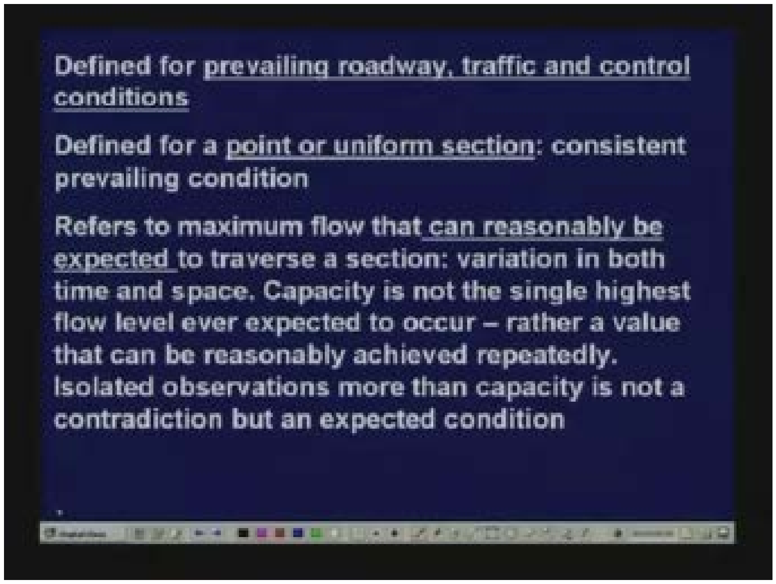
(Refer Slide Time: 1:38)



First a formal definition as given by Highway Capacity Manual 2000. Capacity is defined as maximum hourly rate at which persons or vehicles can be expected to traverse a point or uniform section of a lane or roadway during a given time period under prevailing roadway traffic and control conditions. There are several interesting and important aspects of this capacity concept as given in the definition so I would like to emphasize on those aspects. Carefully observe that capacity is defined as maximum hourly rate and not the volume. The difference in traffic volume and rate is already known to you. It is the maximum hourly rate. Usually peak 15 minutes is taken and expressed as equivalent maximum hourly rate so that rate capacity refers to maximum hourly rate. It is also defined or expressed in terms of persons or vehicles. So it may be in terms of vehicle capacity or it may be in terms of passenger capacity.

Passenger capacity concept is critical particularly when transit is considered or high occupancy vehicle lengths are considered. In that context person and capacity it is more meaningful and contextual.

(Refer Slide Time: 3:59)



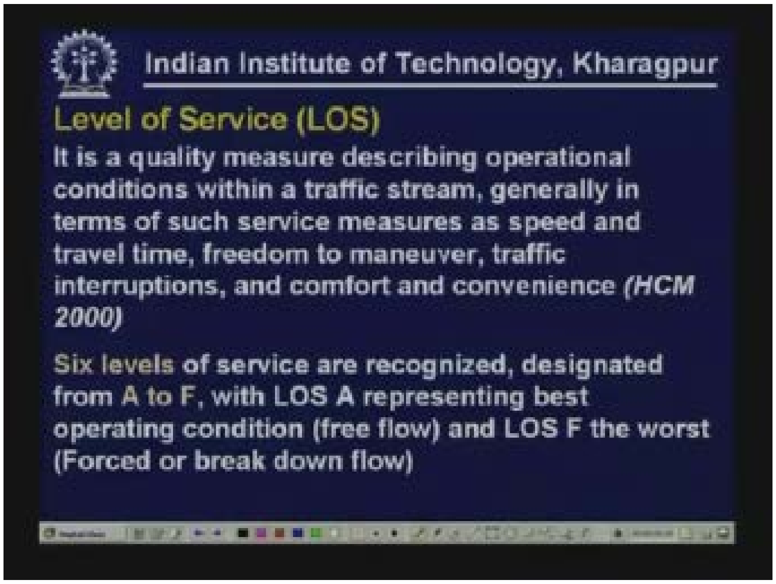
Observe that capacity is also defined for prevailing roadway traffic and control conditions. What is prevailing roadway traffic and control condition? If you pick up a roadway segment and try to understand the capacity it is under the given roadway, traffic and control conditions. That means capacity is linked or defined with respect to a given or prevailing roadway traffic and control conditions. You change the roadway condition you change the traffic condition you change the control condition then capacity is going to be in place, you will get different capacities.

Also, capacity is defined for a point or uniform section. This is again consistent with prevailing condition. Uniform section means uniform in terms of roadway traffic and control condition so along the length of a road at different segments or at different points the prevailing roadway traffic and control conditions vary so obviously the capacity also will change. So capacity is again referred to a point or uniform section. Also capacity refers to maximum flow that can reasonably be expected, this point is very very important. It can be reasonably expected to traverse a section. That means we are indicating that capacity varies both in time and space.

Remember that it is included in the definition that it can be reasonably expected. That means not the single highest flow level ever expected to occur for a facility rather we are referring to max flow rate a value that can be reasonably achieved repeatedly not once in a while once in a lifetime you achieve the highest flow and that you try to refer as capacity, no, that is not the capacity. Capacity is the max flow rate tat can reasonably be achieved again and again for a given facility. So capacity is not the single highest flow level. Therefore isolated observations more than capacity is nto a contradiction but an expected condition.

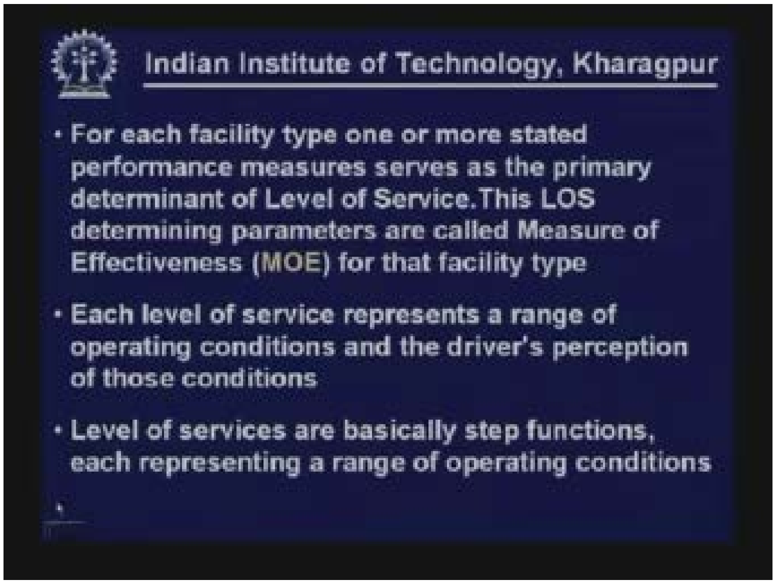
If you measure traffic flow and express it in terms of flow rate sometimes you may get even a value which is higher than the prescribed capacity of that facility under prevailing roadway traffic and control condition. It is not a contradiction to capacity definition. You should not think that since you have observed the flow more than the prescribed capacity there is something wrong. It is not a contradiction but an expected condition. With this concept of capacity let us now try to understand the concept of level of service. Again first a formal definition has been given by Highway Capacity Manual 2000. It is a quality measure describing operational conditions within a traffic stream generally in terms of such service measures as speed and travel time, freedom to maneuver and traffic interruptions, comfort and control.

(Refer Slide Time: 8:25)



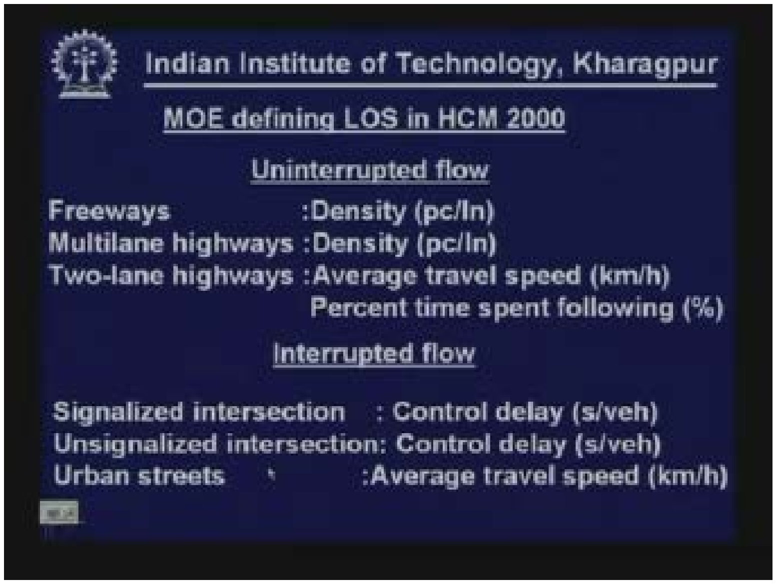
So, it is a quality measure which is describing operational conditions within a traffic stream in terms of service measures such as speed and travel time, freedom to maneuver and traffic interruptions, comfort and control. Now six levels of service are recognized, it is designated as from A to F so in short we say LOS A, LOS B and so on with LOS representing the best operating condition so now max freedom to maneuver is possible while it is a free flow condition so obviously Level of Service A is defined as free flow condition and LOS F is defined for worst possible operating condition that is the forced flow condition or breakdown flow condition.

(Refer Slide Time: 9:29)



For each facility type one or more stated performance measure serves as primary determinant of Level of Service. We have understood the concept of level of service but how to say that a given facility is operating under this particular level of service we need some quantity to basis for defining the level of service. The quantitative basis is called as measure of effectiveness, in short MoE for that facility. Now, each level of service represents a range of operating conditions and driver's perception for this condition. Whatever may be the measure of effectiveness it is within a prescribed range we call it a particular level of service. It is in another range we call it another level of service so each level of service represents a range of operating condition and the driver's perception of those conditions. So level of service essentially are stiff functions under certain it is A then B then C like that. So these are essentially stiff functions each representing a range of operating conditions.

(Refer Slide Time: 11:13)

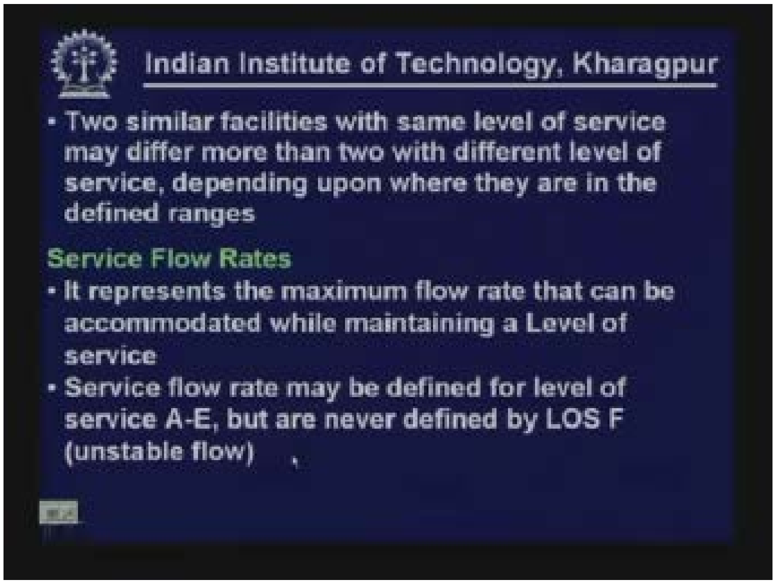


Let us have a look at some of the measure of effectiveness for different LoS for uninterrupted flow facilities and also for interrupted flow facilities. For uninterrupted flow facilities say freeways the measure of effectiveness is density. For different facilities different measure of effectiveness are defined. For freeways it is density which is normally expressed as passenger car per lane. How many passenger cars per lane, per kilometer?

For multilane vehicles again density is number of vehicles per lane per kilometer. For two-lane highways two measures of effectiveness are used. One is average travel speed and the other one is percentage time spent following because particularly for two-lane highways overtaking or passing opportunity is a crucial aspect. So often it may happen that when a heavy vehicle is going all the other vehicles are forced to follow that so what is the percentage of time spent for following is also a consideration. so it is based on average travel speed and percentage of time spent following.

For interrupted flow facilities signalized intersection and unsignalized intersection both is control delay, how many seconds delay per vehicle. We will discuss more about control delay, what is control delay. For urban streets it is average travel speed so it is may be kilometer per hour. These are general ideas about MoEs for different roadway facilities for both uninterrupted and interrupted. It is worthwhile to mention that two similar facilities with same level of service may differ more than two with different level of service depending upon where they are in the defined range.

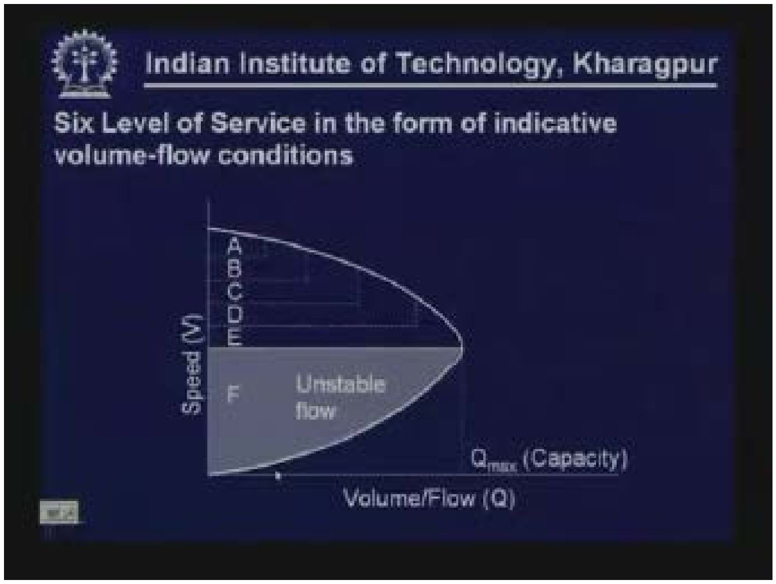
(Refer Slide Time: 13:30)



Let me try to explain this part. Suppose we are defining LoS in a range, supposing this is one range, let us call it LoS B and then this is the range for LoS C, so let us consider two operating conditions here both are defined by Level of Service C so in MoE values the difference may be much higher but both of them are under the level of service C whereas let us now consider another operating condition that is here, the difference between these two points are very less in terms of MoE values but one is the left side of the boundary and another is may be on the right side of the boundary so in one case it is the level of service B and another case it is the level of service C. So whatever measure of effectiveness we have considered you may follow that there are two operating conditions in the same level of service but MoE values are much different or as compared to another two operating conditions where you are actually telling them two levels of service but the difference in MoE is much lesser.

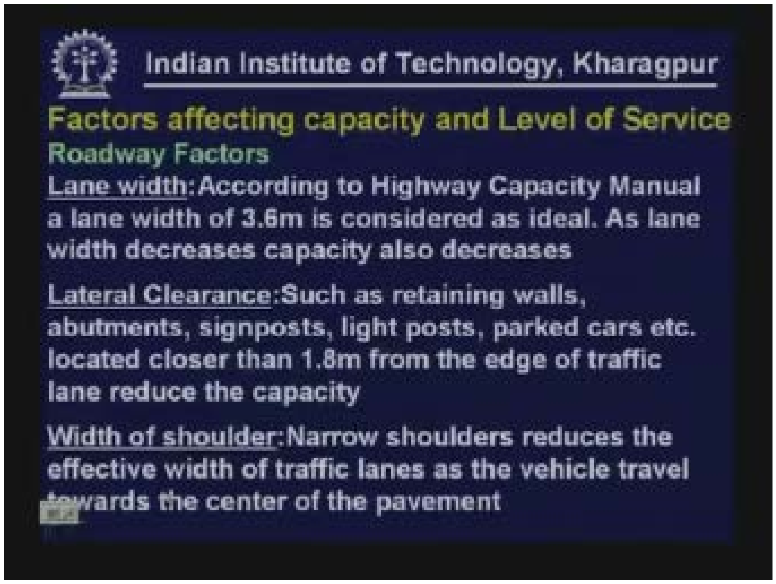
Coming to the concept of service flow rate this concept is again related to level of service. Service flow rates generally represent the max flow rate that can be accommodated while maintaining level of service. That means for a given level of service range what is the max flow that can be ……. That means max flow that can be accommodated within that level of service. Obviously it goes to the boundary condition. So service flow rates may be defined for levels of service A to E but service flow rates are not defined for LOS F. That is it is obvious because LOS F represents unstable flow operation or forced flow operation that you cannot really define the maximum service flow with respect to LOS F.

(Refer Slide Time: 16:45)



This is a representation of Level of service in the form of indicating volume condition. You are familiar with the shape of this curve it is speed volume car when the volume is practically significant in the lean hours in the morning or midnight you may find less number of vehicles which are traveling at a very high speed and then as vehicle volume or flow increases there is a drop in the speed so it may not be so steep but this is a conceptual depiction so you can define this whole operative range into different levels of service. This is level of service A, this is operating zone B, this is C, this is D, maximum service volume with respect to E, this is nothing but the capacity and then this whole shaded portion represents unstable flow. Therefore you can clearly understand why we don’t define service volumes with respect to Level of service F. this is a conceptual representation of level of service in speed volume flow.

(Refer Slide Time: 18:12)



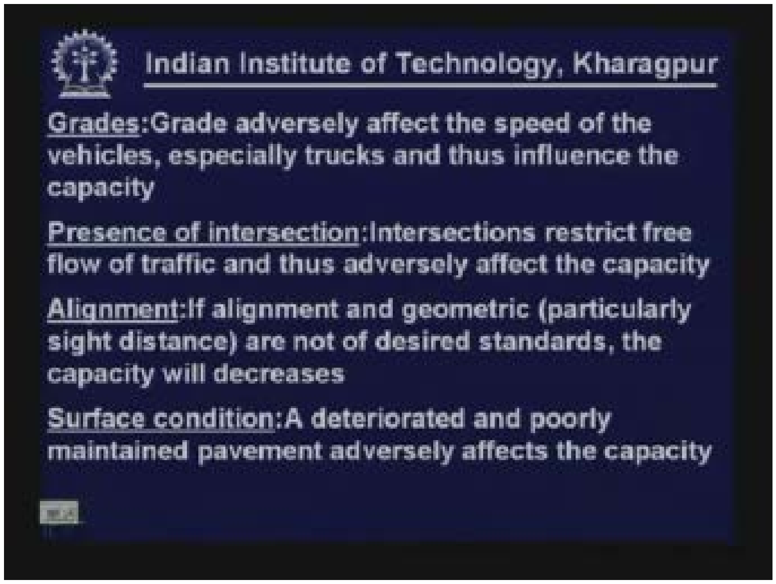
Now coming to the factors affecting capacity and level of service there are several factors under some broad categories. First we have the roadway factors.

We have the land width: according to the Highway Capacity Manual a lane width of 3.6m is considered ideal. So, if the lane width is varying or is lesser than 3.6m obviously the capacity will be lesser or the capacity will decrease.

Lateral clearance: constructions such as retaining walls, abutments, signposts, light posts, parked cars etc is located closer than 1.8m from the edge of traffic lane means that lateral clearance is less than 1.8m so this obstruction will show different capacities and therefore the capacity will reduce.

The next roadway factor is width of shoulder: the narrow shoulders reduce capacity, effective width of traffic length as the vehicle travels towards the pavement. Therefore the narrow shoulder also affects the capacity.

(Refer Slide Time: 20:00)



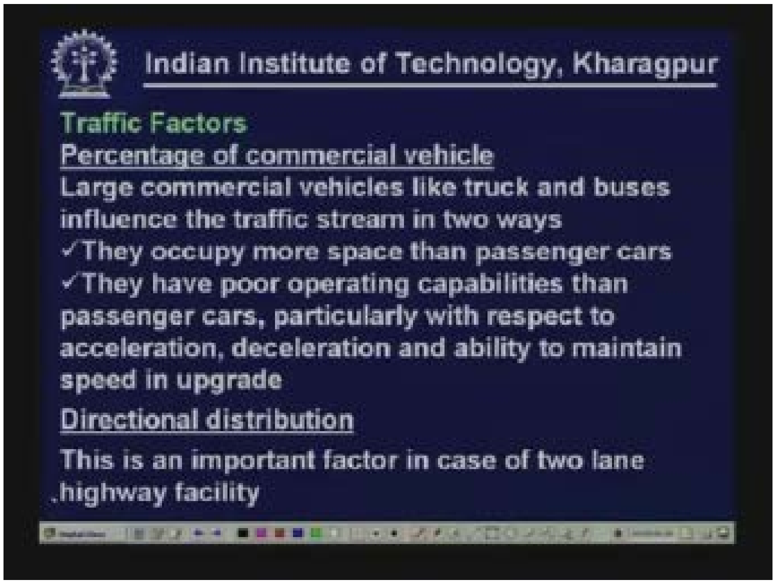
Grade: also affects the speed of vehicle particularly if you have substantial proportions of commercial vehicles or heavy vehicles. Therefore on grades the presence of heavy vehicles together may really influence the capacity to a large extent.

Presence of intersections also influences capacity because intersections restrict the free flow of traffic and thus adversely affect the capacity.

Alignment also influences the capacity particularly sight distance. If adequate sight distance is not available then that will affect the safety as well as the capacity on the road.

Surface condition also will affect capacity. If the road surface condition is very poor then obviously the speed will be reduced because the vehicles cannot travel at higher speeds and therefore the capacity will get lesser with roads with bad surface conditions. So these are all namely roadway factors which affect the capacity.

(Refer Slide Time: 21:20)



There are traffic factors, these are a set of factors which again affect the capacity. Particularly the percentage of commercial vehicles are very important. If there are more commercial vehicles in percentage then the capacity is going to be affected. Larger commercial vehicles like trucks and buses influence the traffic stream in two different ways. First they occupy more space than passenger cars because they are bigger vehicles but they are distinctly different in terms of acceleration and deceleration….. so that is another major aspect as to why the percentage of commercial vehicles affect capacity. They have more operating capabilities than passenger cars particularly with respect to acceleration and deceleration and the ability to maintain speed in upgrade conditions. That is why traffic factors are affected.

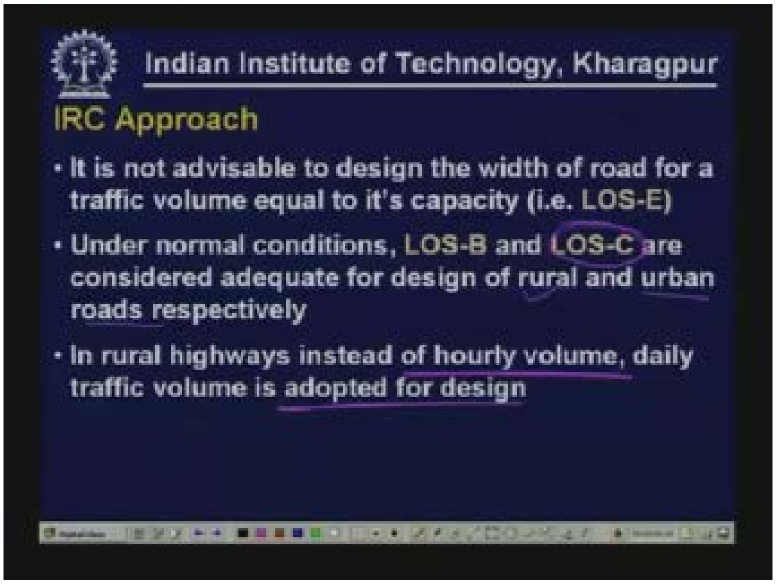
Directional distributions also play an important role particularly for two-lane highway facilities. Both for upstream and down stream traffic they use the same road. A two-lane road is not a divided road therefore the capacity is also influenced by the directional distribution of the ……….22:47

Let us look at some of the main points as mentioned in the Indian Roads Congress guidelines. As per IRC it is not advisable to design the width of a road for a traffic volume equal to its capacity. Obviously there is a reason for that because if the facility is designed for level of service E then there is no doubt that the traffic volume can be accommodated but with a poorer performance. The speed will reduce, the density will become very high, the freedom to maneuver will come down drastically. Therefore the quality of traffic operation will not be up to the desired level. Therefore the facility is not designed with respect to the service volume with respect to level of service E for capacity.

IRC recommends that under normal conditions level of service E may be adopted for rural roads and facility may be designed for level of service C for urban roads.

Accordingly instead of capacity we can take level of service B or level of service volumes while designing rural and urban roads. In rural highways instead of hourly volume daily traffic volume is adopted for design. So IRC manual guideline suggests that daily volume is adopted for design of roads.

(Refer Slide Time: 25:00)



Obviously the daily hourly volume is derived assuming 8 to 10% of the daily traffic has peak hour time. So there is relation and th……25:17 hourly volume is also considered but IRC quote says that capacity is in terms of daily volume but not in terms of hourly traffic.

Design service volume considered for design purpose is expected volume at the end of design life. That means when we are going for road infrastructure planning we plan the facility or we consider economic life period. Normally for a road project it is 20 years so the traffic volume what we are taking and comparing with maximum service volume with respect to level of service B for rural highways that traffic volume is not the present traffic volume but the projected traffic volume at the end of design life. Therefore at the end of design life what is going to be the traffic volume we take that and accordingly we decide what will be the lane requirement or capacity requirement.

Obviously this can be computed by projected or forecasted traffic by projecting the present volume at an appropriate traffic growth rate. so we take the present traffic volume and estimate the ADT Average Daily Traffic, we take into consideration the seasonal variation so we estimate AADT Annual Average Daily Traffic, use suitable growth factors to project this base year or the current year Annual Average Daily Traffic to forecast traffic at the end of design.

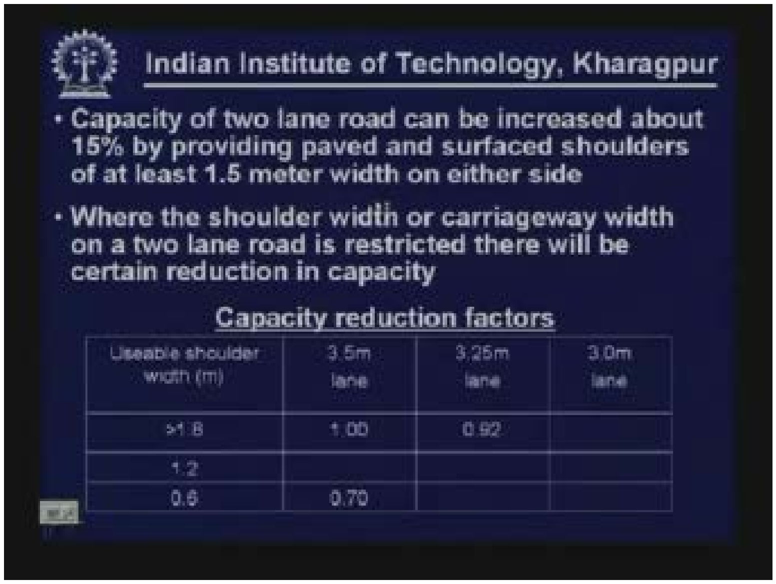
Hence the traffic growth rate should be established. It should be done after carefully studying the past trends and potential for future growth of traffic. So there are different methods of estimating traffic growth rate. We are not going into the details. But the basic steps are estimated by ….27:42 traffic use suitable growth factor, forecast base year traffic. The growth factors are estimated by looking at the past traffic trends and also by looking at the future strategy of development in the influence area of the project.

This is an example of the design service volumes as given in IRC manual.

(Refer Slide Time: 28:05)

We consider three types of terrain: plain, rolling and hilly. Again we divide it based on the curvature low or high curvature and in which terrain condition. Curvature is defined based on degree per km, the horizontal deviation of the curvature in terms of degree per km so they define accordingly whether it is low or high and for each type of terrain with each type of curvature the designs are given in terms of passenger car unit per day. So it is so many cars per day. So it is daily volume that is considered.

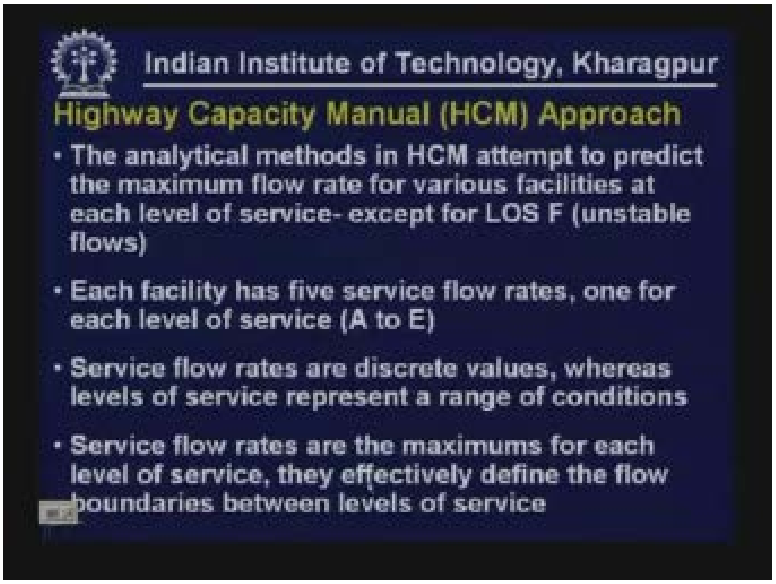
(Refer Slide Time: 29:05)



The capacity of two-lane road can be increased about 15% by providing paved and surface shoulder of at least 1.5m width on either side. This is again an IRC provision. So you provide paved and surface shoulders of at least 1.5m width on either side then the capacity of the service volume values may be increased by 15%.

Where the shoulder width or carriage width on a two-lane road is restricted there will be certain reduction in capacity so IRC guidelines also gives a table to calculate the factors like what is the usable shoulder and what is the lane width according to these factors that may be obtained or taken from the table given in IRC quote and accordingly this capacity reduction may be done.

(Refer Slide Time: 30:05)



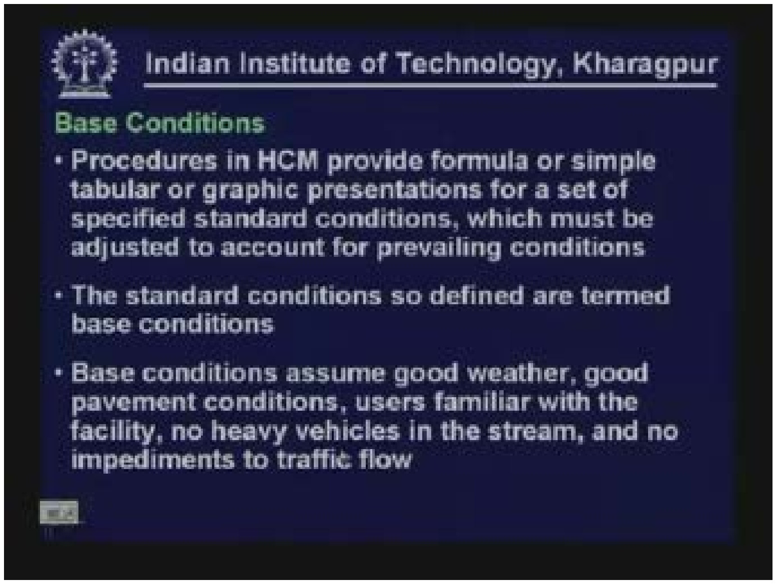
Highway Capacity Manual approach:

The analytical methods in HCM attempt to predict the maximum flow rate for various facilities at each level of service except LOS F as already stated because LOS F represents unstable flow.

Each facility has five service flow rates LOS A to LOS E representing one for each level of service that is A to E.

Service flow rates are discrete values whereas level of service represents a range of conditions. Level of service represents a range of condition but service flow rates are discrete values. To know the maximum traffic flow rate is only possible by maintaining given levels of service. Hence these are essentially boundary values. Therefore obviously service flow rates are discrete values and level of service represents a range of conditions. Service flow rates are at the maximum for each level of service and they effectively define the flow boundaries between levels of service. So obviously as I indicated these are the different levels of service. So the maximum level of service with respect to the flow rate is this one (Refer Slide Time: 31:38) and again here and again here. Hence essentially these are maximum flow rates for each level of service. They effectively define the flow boundaries between levels of service.

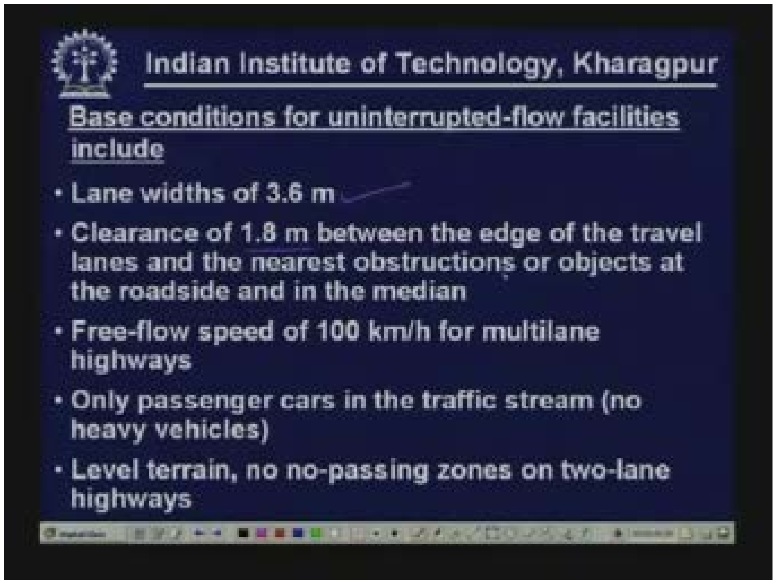
(Refer Slide Time: 32:05)



Now an understanding about the base condition is important. Procedures in HCM provide formula sometimes in a simple tabular form or a graphical representation for a set of specified standard conditions which must be adjusted to account for prevailing conditions. There are prevailing conditions which are not ideal or which are not the base conditions. HCM defines certain base conditions and then for a prevailing condition suitable correction factors may be applied to represent it or to estimate or assess the level of service for a given condition which is the prevailing roadway traffic and control conditions.

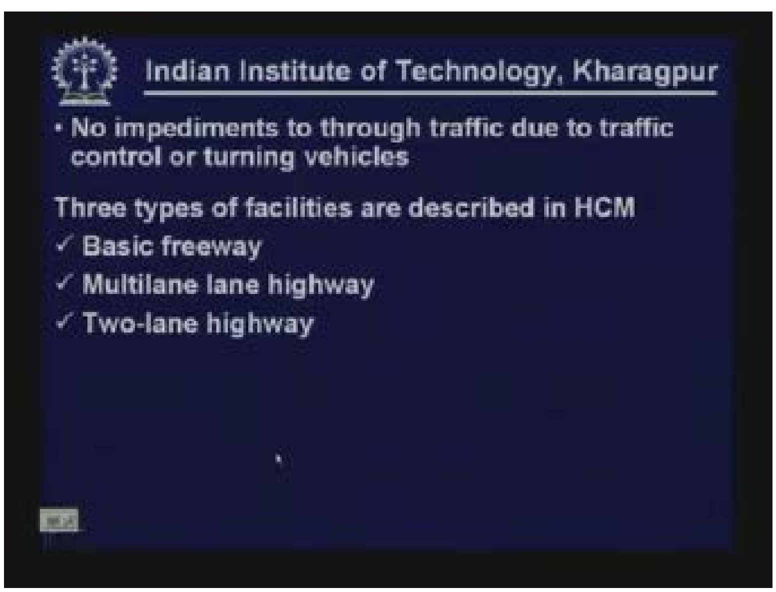
The standard conditions used in HCM so defined are termed as base conditions. Base conditions assume good weather, good pavement conditions. Assume that users are familiar with the facility that there are no heavy vehicles in the traffic stream and there is no impediment to traffic flow. Hence through all this the base condition or the ideal condition is defined. Let us have a re-look for the base conditions for uninterrupted flow facilities. Base is nearly an ideal condition.

(Refer Slide Time: 33:37)



- Lane width of 3.6m
- Clearance of 1.8m between the edge of the travel lane and the nearest obstruction or the object and the roadside or in the median
- Free-flow speed of 100 km/h for multilane highways
- Only passenger cars in the traffic stream that means no heavy vehicles are present in the traffic stream
- It is level terrain, there is no no-passing zones that means no restrictions for overtaking or passing on two-lane highways. These are the conditions which are considered for defining these things.

(Refer Slide Time: 34:27)



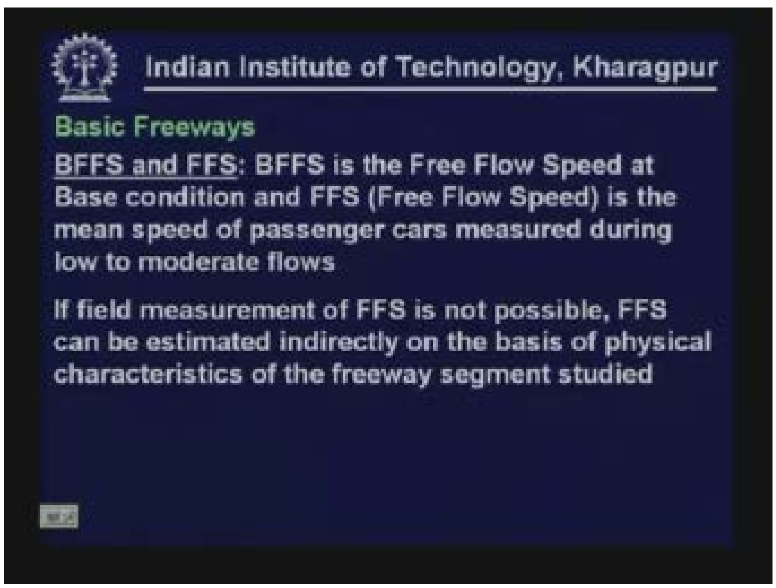
Also it is assumed that no impediments to through traffic due to traffic control or turning vehicles. So, if there are left turning or right turning of vehicles or other kinds of obstruction for movement of traffic that will again affect the capacity or division of the base condition. So in base condition assume that there is no impediment through traffic or traffic control or turning vehicles.

Three types of facilities are described in Highway Capacity Manual as follows:

- Basic freeway
- Multilane highway
- Two-lane highway

We will discuss about these three types of facilities and how the level of service can be calculated for prevailing roadway traffic and control conditions.

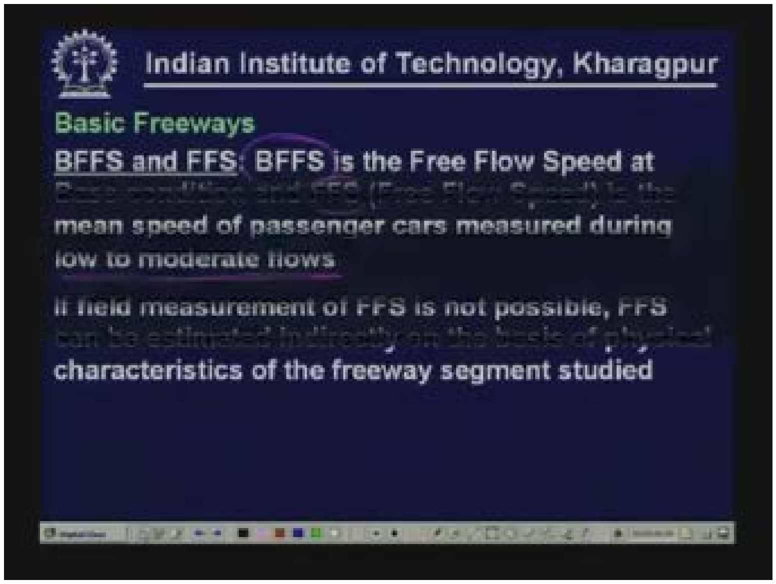
(Refer Slide Time: 35:25)



First is we have the Basic Freeways.

HCM defines free flow speed as base condition. This is denoted as BFFS Base Condition Free Flow Speed and also Free Flow Speed FFS under prevailing conditions. So FFS is the mean speed of passenger cars measured during low to moderate flows. So it is essentially free flow. Now, it is possible that FFS may be measured. If speed measurement of FFS Free Flow Speed is not possible then this can be estimated indirectly on the basis of the physical characteristics of the freeway segment that is studied. Let us look at this and find out how it is possible.

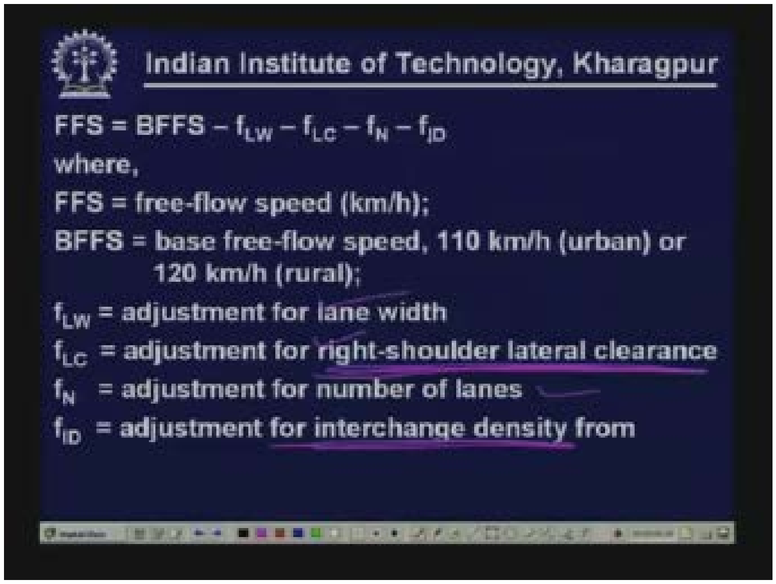
(Refer Slide Time: 36: 25)



Free flow speed equal to free flow speed under base conditions minus reductions due to a number of factors. For freeway segments the corrections are applied for adjustment of lane width, adjustment for right-shoulder lateral clearance following U.S. convention of driving, adjustment for number of traffic lengths, adjustments for interchange density. So these are the factors which may affect free flow speed and which may cause the FFS to be different from BFFS. Therefore appropriate corrections are ….37:20 for adjustments are lane width, adjustments for right-shoulder lateral clearance, adjustment for number of lanes and adjustment for interchange density.

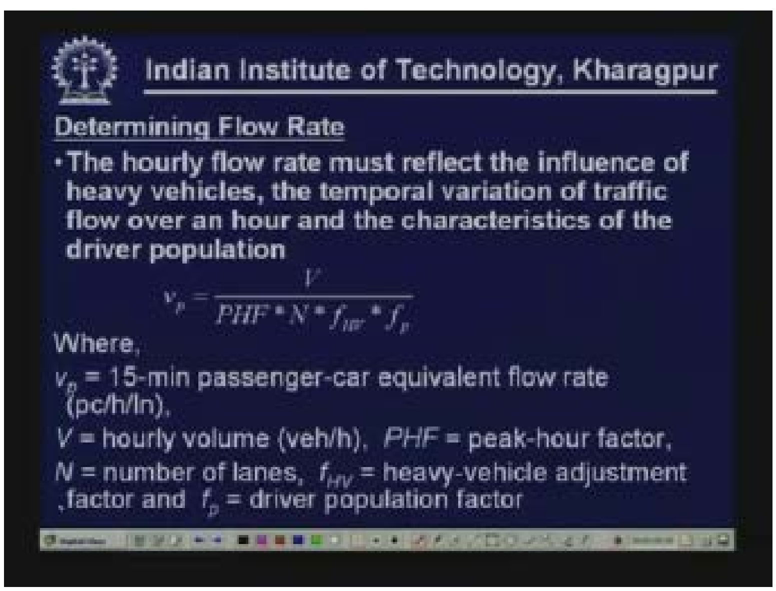
Now how to get these values. For further discussions the figures, charts and tables are given. So one can calculate these adjustment factors using those prescribed values and accordingly calculate FFS the Free Flow Speed for the prevailing condition.

(Refer Slide Time: 37:30)



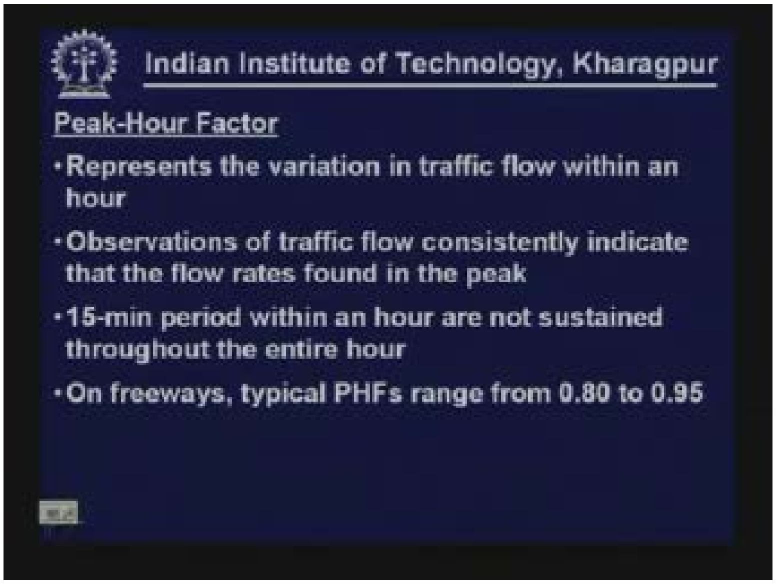
Next is determining flow rate. The hourly flow rate must reflect the influence of heavy vehicles. Because in the ideal condition or the base condition we assume that there is no commercial vehicles or heavy vehicles. So the hourly flow rate must reflect the influence of heavy vehicles, the temporal variation of traffic flow over an hour and also the characteristics of the driver population. These are the three factors we considered to estimate the determining flow rate.

(Refer Slide Time: 38:05)



Here Vp is the 15 minute passenger car equivalent flow rate, this we want to calculate. We know V which is the hourly volume, V by peak hour traffic so this is to account for temporal variation of traffic flow over an hour into n which is the number of traffic lanes, fHV to account for the influence of the heavy vehicles and fp to account for the characteristics of driver population. Again what should be the value of fHV, fP and peak hour factor then with the help of HCM we can get an idea about this flow.

(Refer Slide Time: 40:00)

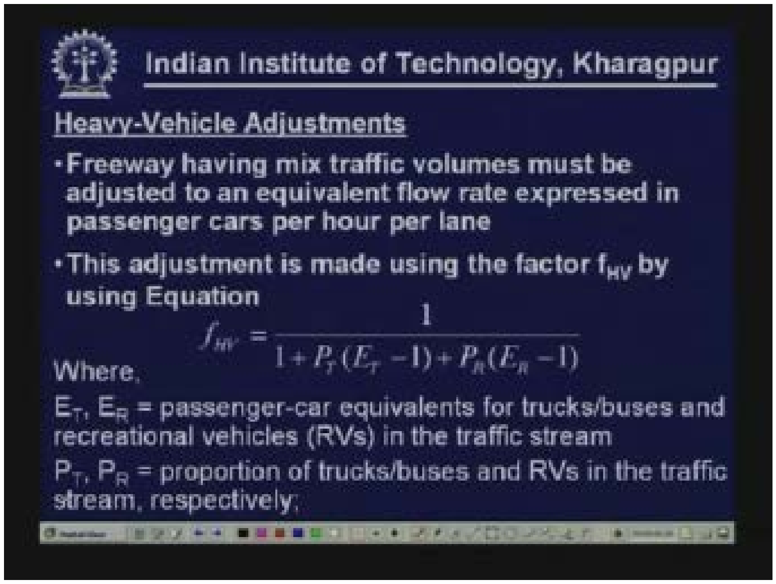


Peak-hour factor is basically to represent the variation of traffic flow within an hour.

Observations of traffic flow consistently indicate that the flow rates are found in the peak.

A 15 minute period within an hour is not sustained throughout the entire period and that is why we need to use the peak-hour factor. Normally on freeways the peak-hour factor values range from 0.80 to 0.95. So if the peak hour factor is known then the same value may be used or suitable values may be adopted at a range of 0.80 or 0.95 matching the conditions.

(Refer Slide Time: 40:53)



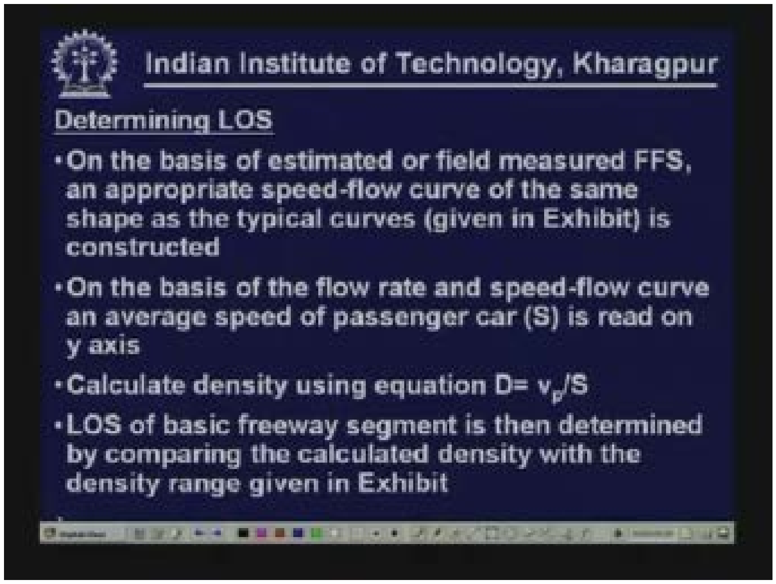
Heavy vehicle adjustment factor what I have indicated here this fHP component we are now going to discuss a little bit more about this fHP or the heavy vehicle adjustment factor.

Freeway having mixed traffic volumes must be adjusted to an equivalent flow rate expressed in passenger car per hour per lane. This adjustment is made using the factor fHV for heavy vehicle and how we calculate fHV is by using this equation (Refer Slide Time: 41:35).

Now here in ET and ER two different types of heavy vehicles are normally considered in highway capacity manual. It is the passenger car equivalent for trucks and buses, ER is passenger car equivalent for recreational vehicles. Recreational vehicles are also heavy vehicles and on certain routes the recreational vehicles do operate so if there are recreational vehicles accordingly then its ER value is to be taken. Again to find out what should be the value of ER and ET so further discussions are made in Highway Capacity Manual and one can pick up some of these values.

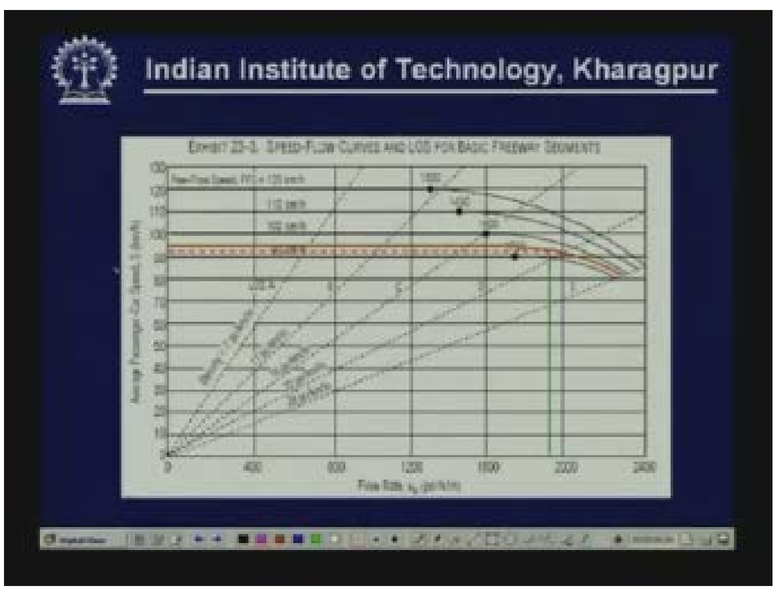
Now PT and PR are proportion of trucks and buses, and PR is the proportion of recreational vehicles in the total traffic stream. Therefore once we know all these PT and PR the ET and ER values may be obtained from HCM manual, we can calculate the fHV the factor which is to be used for heavy vehicle adjustment.

(Refer Slide Time: 43:00)



Now determining LOS we estimated field measured free flow speed so we have mentioned how we can calculate FFS and the appropriate free flow curve of the same shape of the typical curves is constructed then on the basis of the flow rate and the speed of curve and the average speed of the passenger car is read on the y axis.

(Refer Slide Time: 43:40)



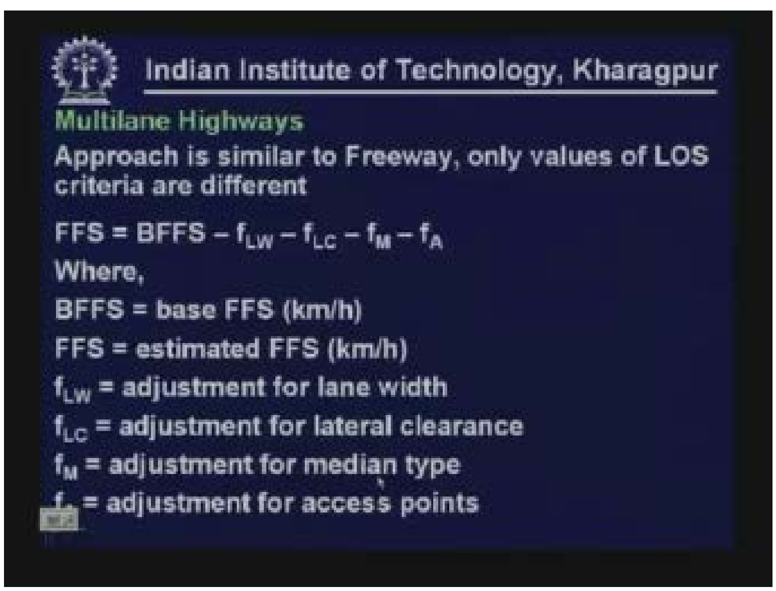
Let us take this one as an example. So these are different speed flow curves which are given. This is (Refer Slide Time: 43:52) a line which is representing a free flow speed of 120 km and this is another line which is representing a free flow speed of 110 km, this is another operation which is representing a free flow speed of 100 km and this is another which is representing 90 km.

Suppose once we calculate our free flow speed for the prevailing condition say 95 km so what we are trying to indicate is you have this line for 100 km (Refer Slide Time: 44:20), you have this line for 100 km so in between the red line indicated may be considered for representing a free flow rate of 95. Therefore we know that we can construct this line or the speed volume relationship. Then if we know the speed say it is 1700 or 1800 then accordingly we can understand the speed that can be read.

So first we construct this curve and then for a given volume we calculate the speed. Now the speed is known and the volume is known. So once the speed is known and the volume is known we can calculate the density and volume by speed, so the speed we have taken on y axis, VP is also known, so now we know VP and S where S is the density. Now remember that for freeway segment measure of effectiveness is density. So that is why we are calculating density. Now once the density is known then for a given condition we can refer the appropriate table and estimate the ………46:10 and what will be the service volume corresponding to that length.

Now further discussions are available and the actual tables are given in terms of exhibit….. and those are available in highway capacity manual. So LOS of basic freeway segment is determined by comparing the calculated density with the density range given in exhibit and the service volumes also can be estimated. These are some of the details about freeways.

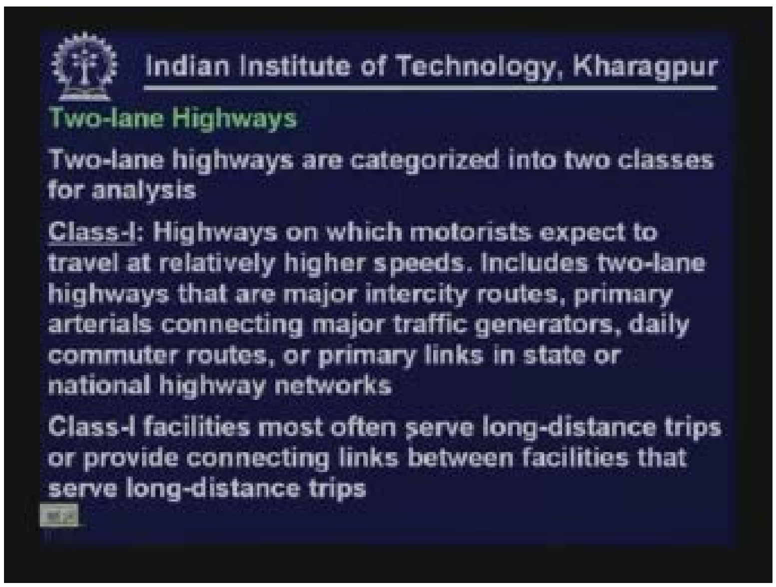
(Refer Slide Time: 46:45)



Now coming to multilane highways the approach is similar whatever we have discussed for freeways but the only thing is the values and corrections and the factors are different for multilane highways. For example, here also appropriate corrections are necessary to obtain free flow speed under prevailing conditions either from the base conditions or ideal conditions. But here also we have applied similar corrections but look at the corrections they are different from what we applied for freeways.

Here we are applying corrections or adjustments for lane width, we are applying adjustment for lateral clearance, we are applying adjustment for median time and also we are applying adjustment for excess points. Earlier the access point adjustment was not there. So the approach is similar but actual adjustments which are applied are different. So again suitable values may be given and further discussion are given in highway capacity manual and you can get the values for fLW, fLC, fM and fA and accordingly you can calculate FFS for multilane ………

(Refer Slide Time: 48:15)

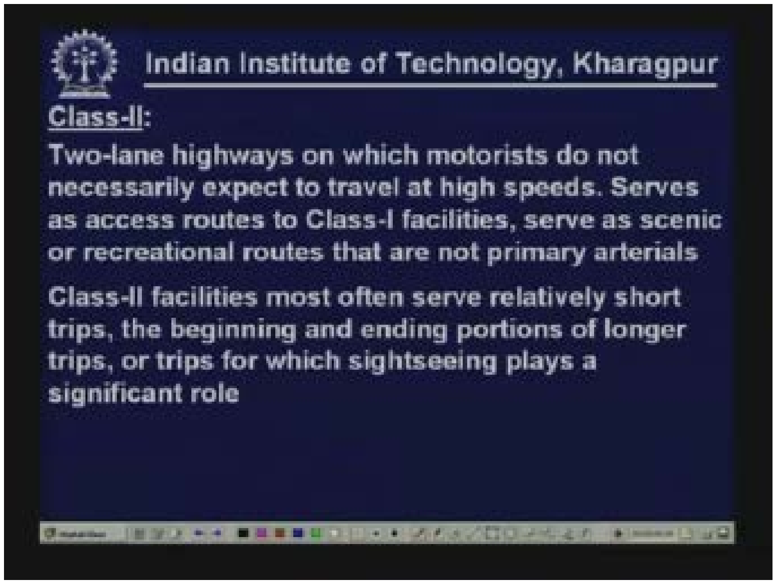


Basically two-lane highways are classified in two classes for analysis purpose such as class I and class II because two-lane highways are different from multilane highways and freeways. Class I is highways on which motorists are expected to travel at relatively high speeds. So here speed is a major consideration because motorists are expected to travel at relatively higher speeds so that is one classification.

Class I includes two-lane highways that are major inter-city roads where the speed will be higher. Primary arterials connecting major traffic generators differ, the speed is a major concern for the daily commuter routes which are normally used for commuting purposes or primarily links in state or national highway networks. These are the roads which are normally included under classification.

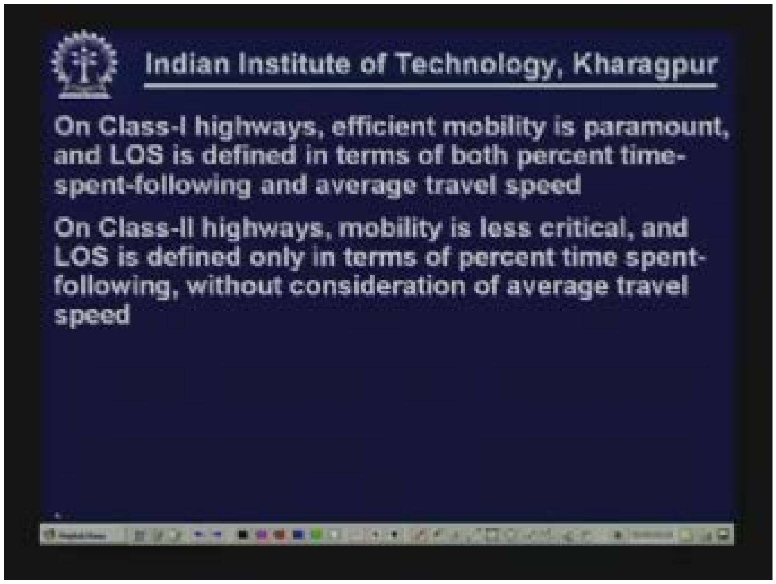
Class I facilities most often serve long-distance trips, they are important and that is why speed is important or provide connecting links between facilities that serve long-distance trips.

(Refer Slide Time: 49:55)



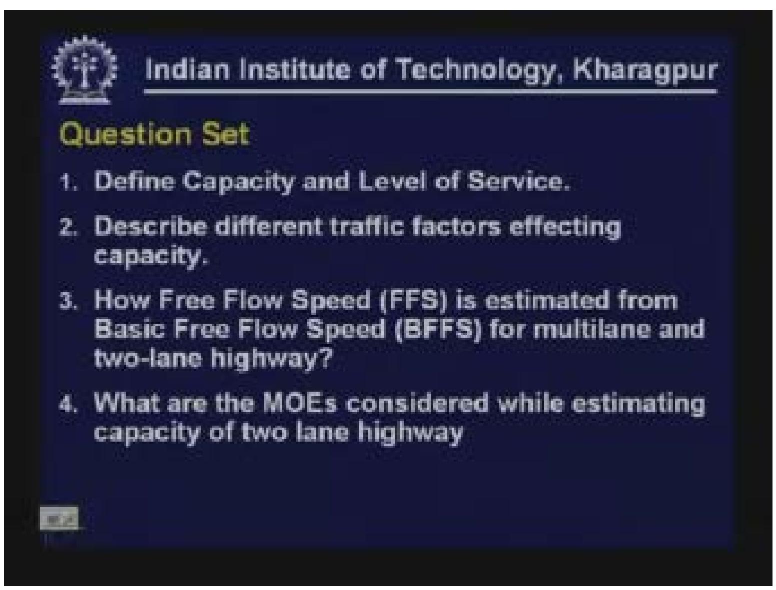
Now coming to class II these are two-lane highways on which motorists do not necessarily expect to travel at high speeds. Generally this type of road serves as access route to class I facilities and motorists necessarily do not travel at high speeds. They normally serve as scenic or recreational routes that are not primary arterials. Therefore very high speeds are not expected. Hence speed is not the major consideration. Therefore in class II facility most of them relatively short trips, the beginning and end portion of longer trips and trips for which sightseeing plays a significant role. So that way class I and class II routes are different. Now the remaining task is easy. It is now easily understood or we can get convinced that in class I highways efficient mobility is paramount, and LOS is therefore defined in terms of both percent time spent following and average travel speed.

(Refer Slide Time: 51:05)



On class II highways the mobility is less critical and therefore LOS is defined only in terms of percent time spent following without consideration of average travel speed. So that is why LOS is different, the measure of effectiveness is different on the class I and class II type two-lane highways.

(Refer Slide Time: 52:12)

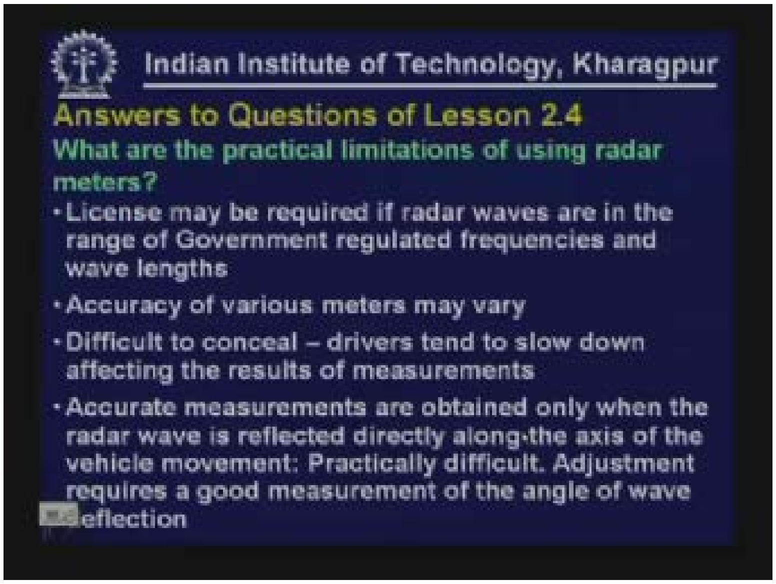


Question Set:
Some of the questions for you to answer:

Define capacity and level of service:
Describe different traffic factors affecting capacity:
How Free flow Speed (FFS) is estimated from Basic Free Flow Speed from multilane and two-lane highways, what are the corrections required?
What are the MOEs considered while estimating the capacity of two lane highways?

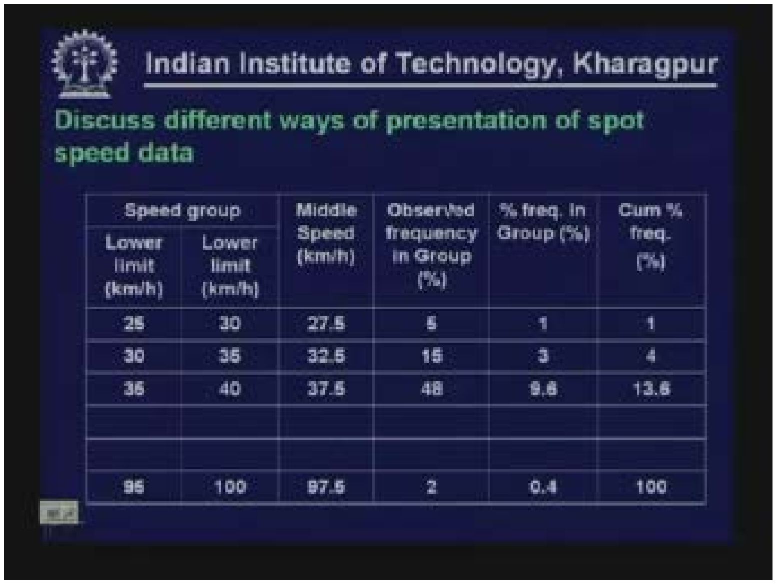
Try to answer these questions. Now I will try to answer the questions of lesson 2.4.

(Refer Slide Time: 53:20)



What are the practical limitations of using the radar meters?
You know that in some cases you may have to obtain license if the frequencies are within the government regulated frequencies and wave lengths.
Accuracy may vary.
It is difficult to conceal the radar meter so the drivers tend to slow down.
Accurate measurements are obtained only when the radar wave is reflected directly along the axis of the vehicle movement which is practically difficult. Therefore adjustment requires a good measurement of the angle of wave deflection.

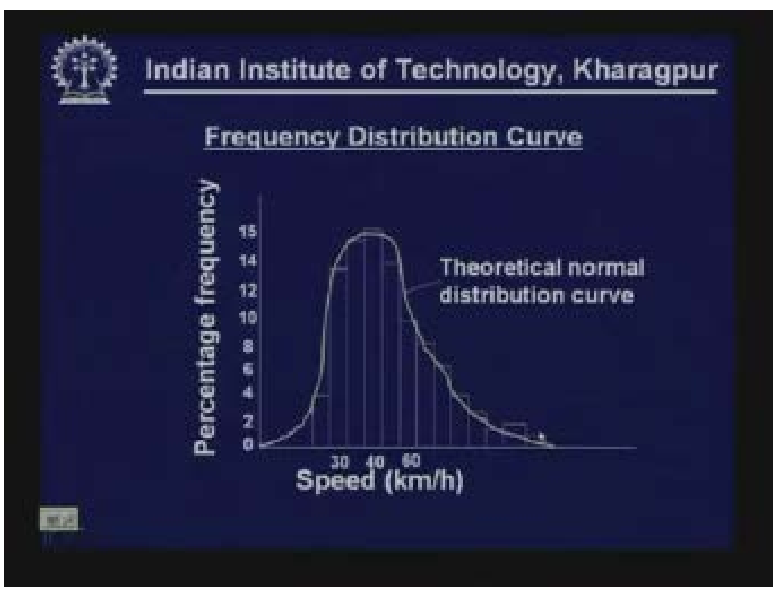
(Refer Slide Time: 53:50)



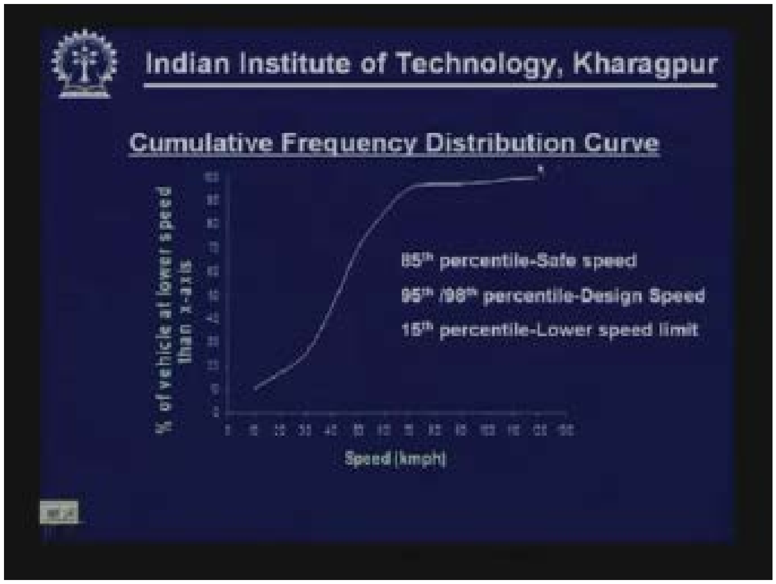
Different ways of presentation of spot speed data:

One is in the tabular form where you decide the upper limit and the lower limit and the middle value, observed frequency and the percentage frequency and the cumulative frequency and the frequency distribution table. You represent it using the Frequency Distribution Curves, you also represent it using the Cumulative Frequency Distribution Curve.

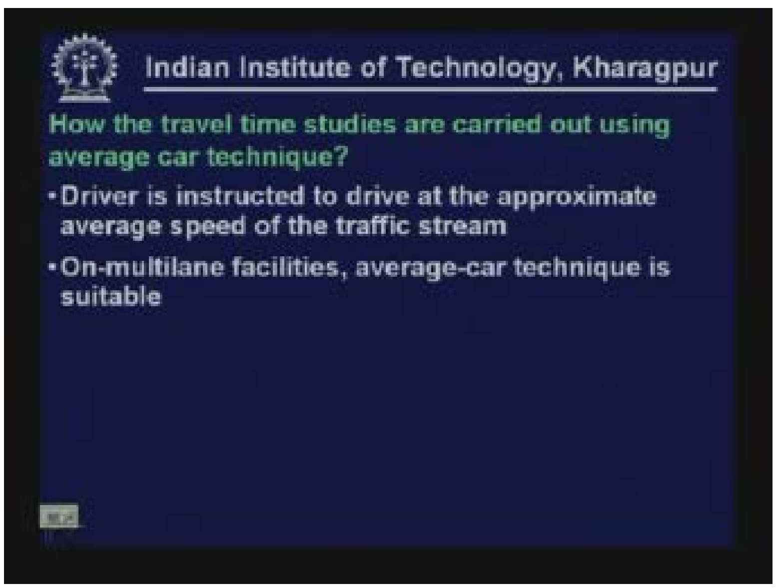
(Refer Slide Time: 54:09)



(Refer Slide Time: 54:15)

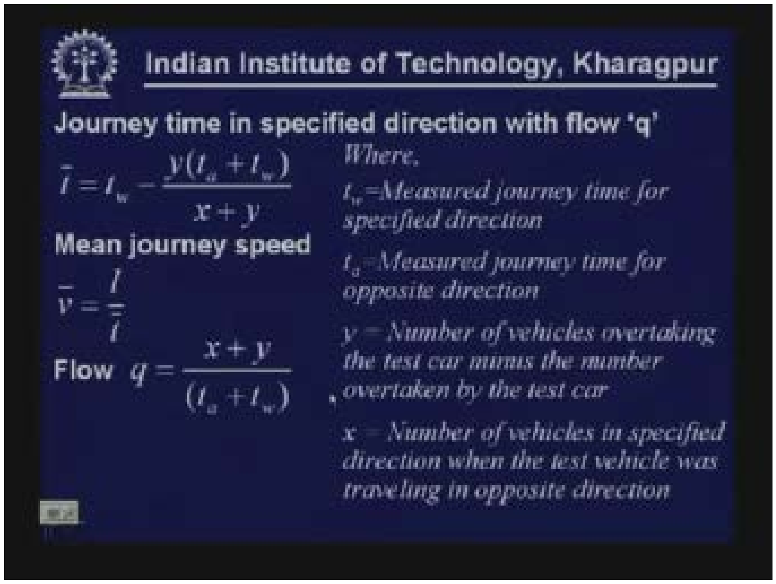


(Refer Slide Time: 54:44)



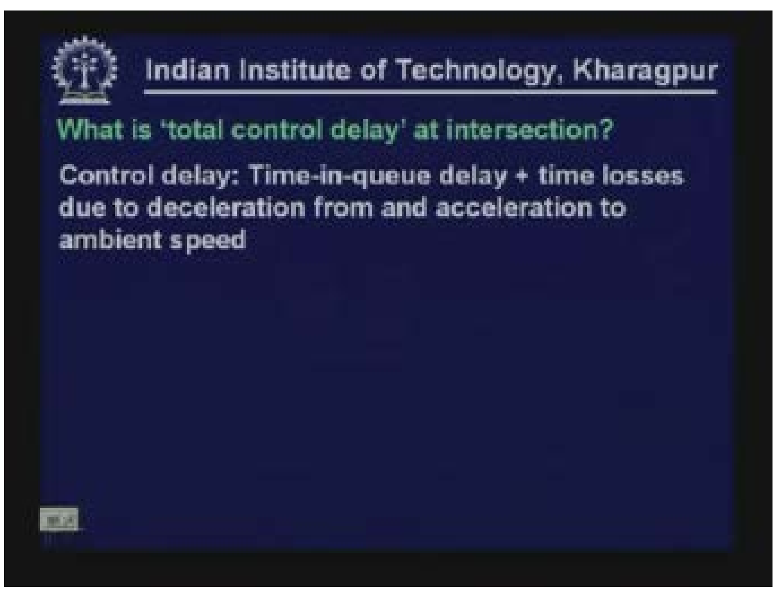
How is the travel time studies carried out using the average car technique?
Remember that in the average car the driver is instructed to drive at an approximate average speed of the traffic stream and this is particularly suitable for multilane facilities where it is difficult to follow the floating curve method. So there the average car technique is more appropriate considering safety and conveyance.

(Refer Slide Time: 54:55)



Now we record a number of data here and the travel time in each direction separately and for each direction of travel the number of overtaking vehicle, the number of overtaken vehicle and number of vehicles from opposite directions etc are recorded and then appropriately they are adjusted to calculate the average speed or the representative stream speed time and once we calculate the …… 55:23 using the appropriate calculations then you can calculate V and Q.

(Refer Slide Time: 55:30)



Finally let us look at what is the total control delay at intersection.

Total control delay generally includes time-in-queue delay and time losses due to acceleration from and deceleration to ambient speed. Suppose there is no intersection that the vehicle will go so the delay is due to the time-in-queue, the amount of time the vehicle is in queue so that is the delay which is one component and another component is from the normal speed once the speed is reduced because of this intersection there is deceleration so it is from ambient speed to lower speed following deceleration and again from stop condition to ambient speed using acceleration. So it is control delay the time-in-queue delay plus time losses due to deceleration from acceleration to ambient speed.