Introduction to Transportation Engineering
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Lecture - 5
Traffic Stream Characteristics

Lesson 2.4, Traffic Studies Part-2

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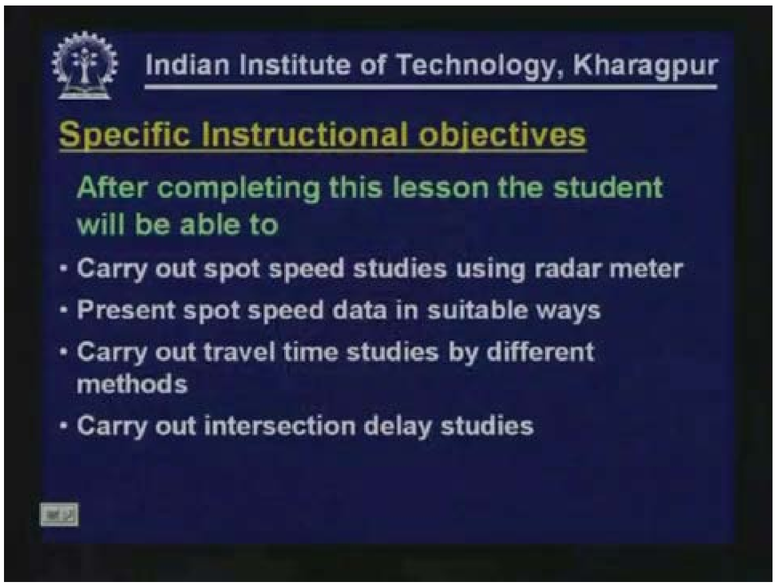

After completing this lesson the student will be able to carry out spot speed studies using radar meter, student will be able to present spot speed data in suitable formats, carryout travel time studies by different methods and also the student will be able to carry out intersection delay studies.

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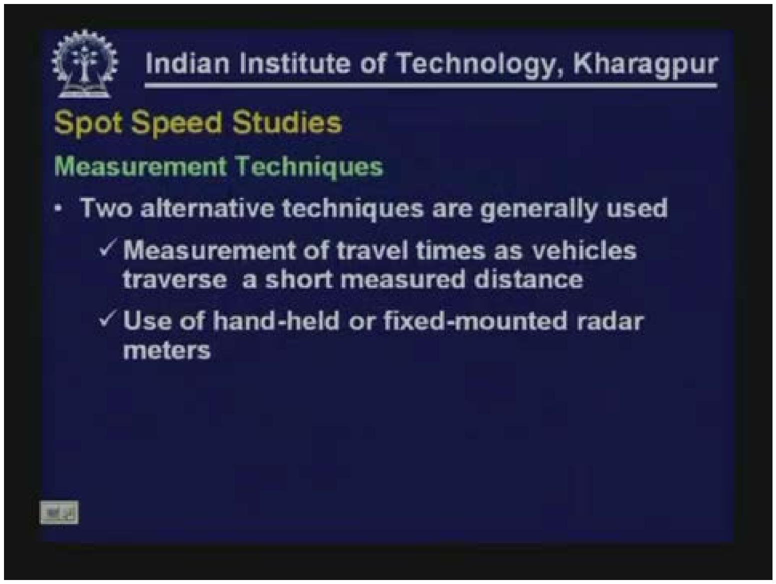

In the last lesson we discussed about traffic volumes studies and we also started talking about the spot speed studies, there are two alternative methods that we were discussing. One is measurement of travel times as vehicles traverse short measured distance. We talked about the possibility of error which is called as parallax, which is a systematic error and also, we mentioned about the procedure for elimination of the systematic error. We also talked about the other kind of error which occur due to the early or late pressing of the stop watch, so that error normally is randomly distributed and we discussed about that also. So in continuation to that approach, for spot speed studies based on measurement of travel time as vehicles traverse a short distance. Let us now understand about an equipment which is known as Enoscope.

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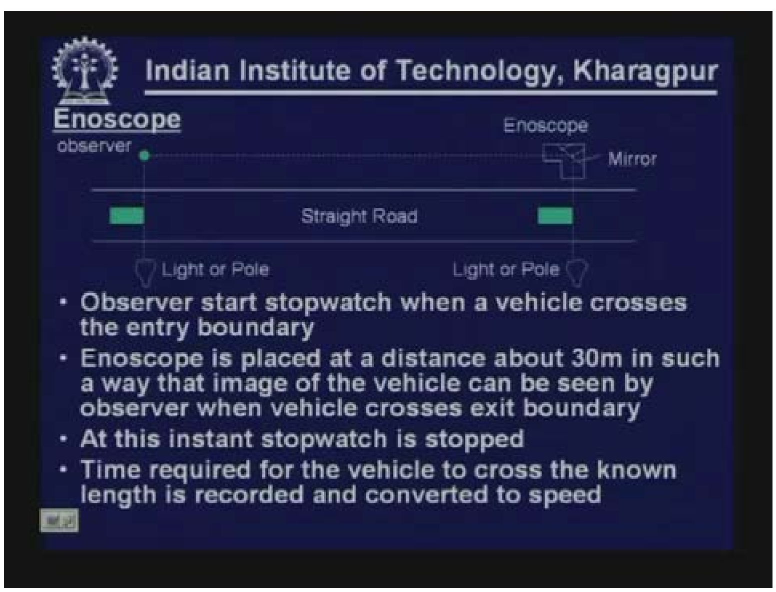

In many places endoscope is still used for measurement of spot speed, where observer start 'stop watch' when a vehicle crosses the entry boundary. Let us try to locate-this is one entry boundary and this is the exit boundary. So observer is located here and the equipment which is called enoscope is placed here. In enoscope the mirror is placed which is shown here, the observer is standing here by the side of the road, so as soon as the vehicle crosses this line the stopwatch is pressed, and the moment the vehicle crosses this exit line the image gets reflected in the mirror and from the enoscope the observer can see that the vehicle is crossing that line so immediately we press the 'stop watch' again. So the time interval is noted and that is the time of travelling this distance by the vehicle.

Now, once you know the travel time over this short stretch accordingly the speed may be calculated. So let us try to summarize these steps again. Observer start stopwatch when a vehicle crosses the entry boundary, Enoscope is placed at a distance about 30 m, so this distance is normally 30 m. In such a way that the image of the vehicles can be seen by observer when vehicle crosses exit boundary, the vehicle is crossing the exit boundary the image of the vehicle gets reflected here and observer can see that. When the observer finds the vehicle, locates the vehicle, at the exit boundary the stop watch is stopped so the time required for the vehicle to cross the known length which is about 30 meter is recorded and accordingly the speed may be calculated.

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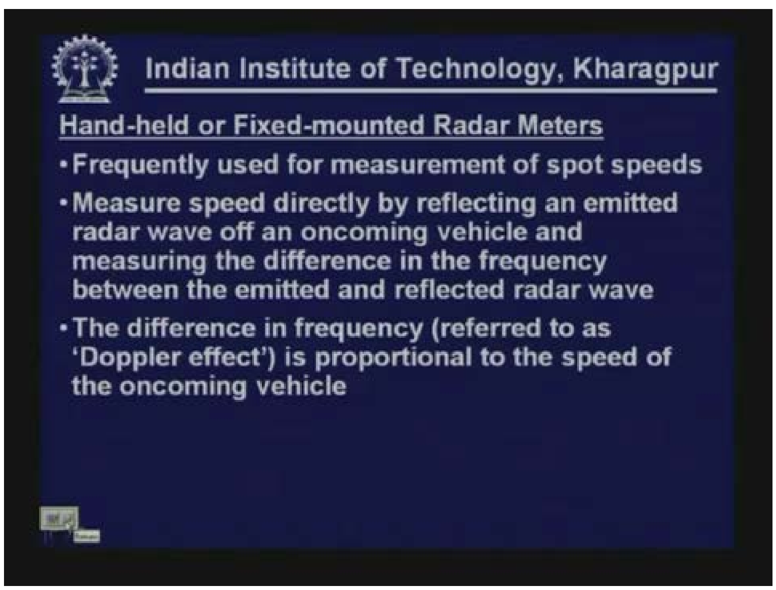

Now, coming to the other procedure for measurement of spot speed that is, by using radar meters. Let us have a look- This radar meters are frequently used for measurement of spot speed. It measures speed directly by reflecting an emitted radar wave of an oncoming vehicle and measuring the difference in the frequency between the emitted and reflected radar wave. It is radar meter which is targeted to a vehicle, so the wave, the frequency between the emitted and reflected wave that the difference is used to calculate the speed. Now the difference in frequency- This is normally referred to as Doppler effect. You might have studied in your school about this Doppler effect, so dynamometer actually works based on the principle that is Doppler effect, So the difference in frequency is proportional to the speed of oncoming vehicle. So that way the instrument calculates or estimates the speed.

So now, there are certain aspects which are also to be discussed, there are certain practical limitations of using radar meters. So it is an equipment which are used widely by, you know traffic engineers, even by traffic police, but you should know the limitations or the difficulties associated with using radar meter. Let us try to understand those points.

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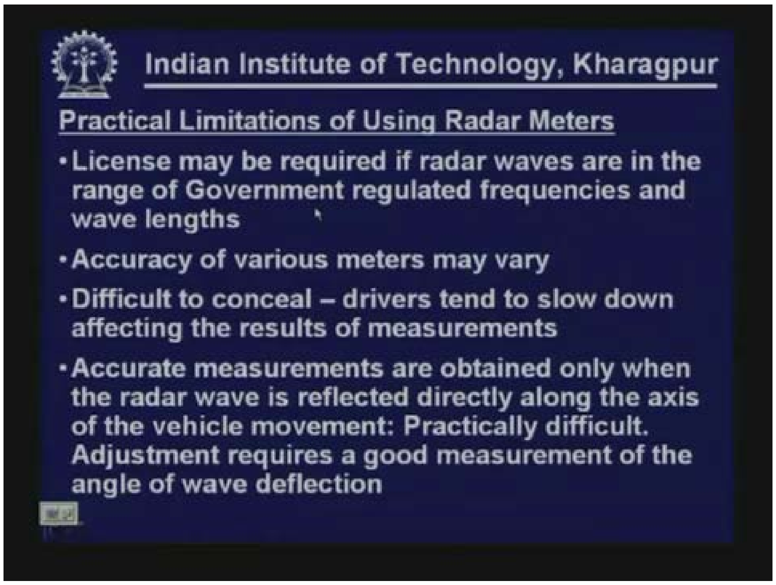

One is it may be required to have license from the government if the waves that are generated are within the regulated frequencies and wavelength. If it is so, then in some cases in some places it may be required to obtain license from the government. This is the procedural aspect what one may keep in mind.

Second is that the accuracy of various meters may vary, to what level of accuracy the speed measurement is made that depends on instrument to instrument so the accuracy may vary, so you must check the accuracy of the radar meter what you are using to what extent it can give correct reading.

Third is practically very difficulty. It is difficult to conceal the wave. Mostly radar guns are used. It looks like a gun, it is not a real gun but it looks like a gun, so you target it to the vehicle and take the reading. Now, drivers, the moment they find somebody is targeting the vehicle with an instrument like that, so, they may deviate from the normal behavior so they may either reduce the speed or maybe like to stop to see what is happening here. So it is necessary for all the surveys to conceal yourself and the survey team but in this case when you are using radar meter you cannot probably do that hundred percent. So it is very difficult to conceal and so drivers tend to slow down affecting the results of measurements.

The other difficulty is accurate measurements from radar meter are obtained only when the radar wave is reflected directly along the axis of the movement. That is where or when you can really get correct reading. But in some cases it is practically difficult. Supposing a vehicle is moving, you cannot really go ride in the middle of the road and then put the radar meter in the same line. So normally the measurements are taken from standing by the side of the road.

So if you were standing by the side of the road and then targeting or shooting the vehicle then the measurement is at an angle so it may be required to apply corrections. So it is practically difficult and adjustment requires a good measurement of the angle of wave deflection. So once you know this wave deflection may be some level of corrections one can apply. Those are the two different methods. One is you take the measurement or measure the travel time over a short stretch or use equipment like radar meters. We have understood the problems associated with both approaches, now, we want to discuss some practical issues related to spot speed measurements. General issues which are practical so we are calling them practical issues related to spot speed measurements. Let us have a look at those points.

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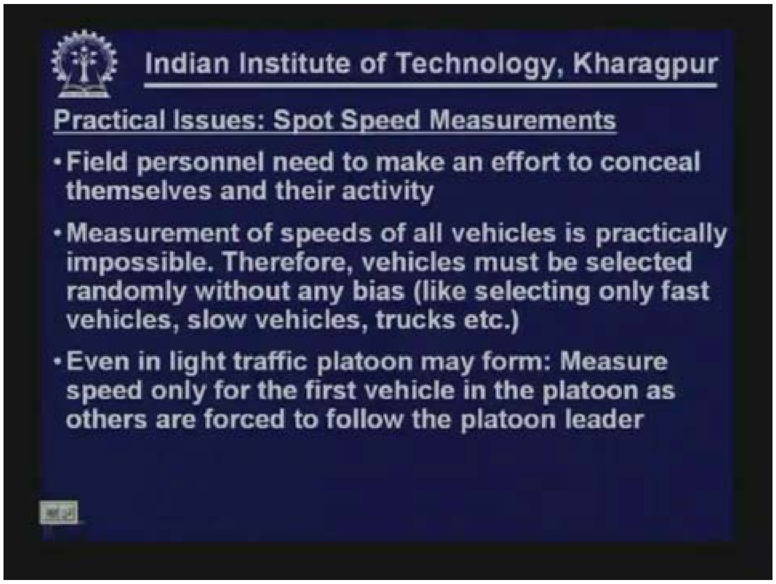

First is field personnel need to make an effort to conceal themselves and their activity. I am again and again highlighting these points. It is necessary because in volume count survey also the same thing is applicable but here it is more important to be away from the drivers. It's better if they cannot see you because the moment some activity is going on the road or some people are gathering together by the side of the road immediately that affects the driver's behavior and may be the driver will slow down or react to the situation when he looks at some people gathering by the side of the road. So it is necessary or at least we can say that field personnel need to make an effort to conceal themselves and their activity as far as possible.

Second is the measurement of speed of all vehicle is practically impossible. Whether you are actually measuring the travel time over a short distance or you were using equipment like radar meter it is practically impossible to measure speed of all the vehicles. Therefore what is essential is that vehicles must be selected randomly without any bias. What I mean by bias? Often enumerators or survey people tend to select some category of vehicle may be they target first vehicles or slow vehicles or they may target some particular vehicle type like trucks etc but that kind of biasness should not be there so it should be truly random selections of vehicles, don't get biased by selecting only the slow moving vehicle or only the fast moving vehicle or only the trucks or only the cars and so on because we want to get the feel of average speed of the vehicles at that location so it is essential to select vehicles randomly without any bias.

Third is difficulty is again a practical difficulty that even in light traffic platoon may form. Obviously if traffic is getting dislodged from an intersection you will expect that it will move in platoon but otherwise also in a light traffic a platoon may form. may be a truck is going or a commercial vehicle is going which is a slow moving vehicle so other vehicles are forced to follow that vehicle in front so essentially you may observe the traffic is generally light but still platoon formation is there. Now, once there is a queue the speed should be calculated only for the first vehicle or the queue leader. We should not take the speed of other vehicles in the platoon because that's not their normal or natural behavior. They are forced to travel at the speed of the platoon leader so that cautionary thing should be there and you must take into consideration when you are measuring spot speeds. So measurement of speed is only for the first vehicle in the platoon and others are forced to follow the platoon leader. So this point also should be kept in mind.

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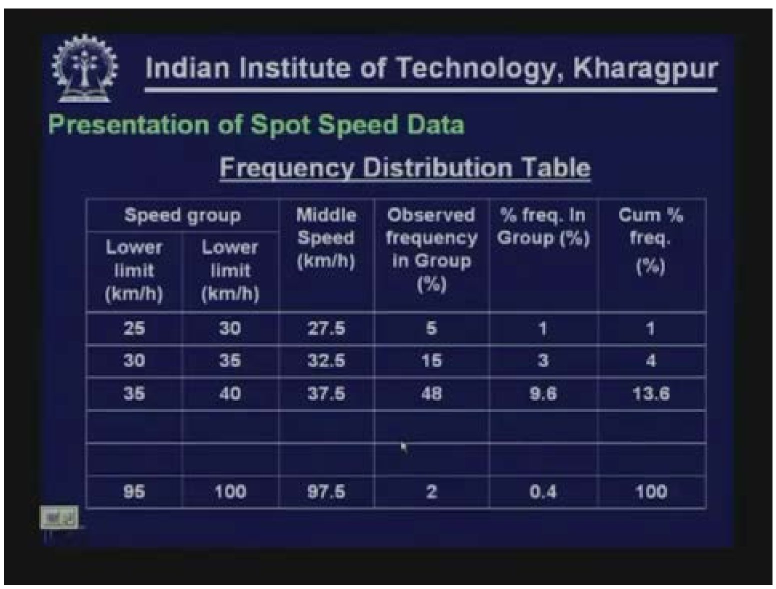

Speed group		Middle Speed (km/h)	Observed frequency in Group (%)	% freq. In Group (%)	Cum % freq. (%)
Lower limit (km/h)	Lower limit (km/h)				
25	30	27.5	5	1	1
30	35	32.5	15	3	4
35	40	37.5	48	9.6	13.6
95	100	97.5	2	0.4	100

Next comes how to present the spot speed data. You collect information so you have to present it in useful format. There are different ways spot speed data are presented and one of them is frequency table. What we do? Normally once you take the speed measurement may be let us consider you are taking spot speed measurements using radar meter so normally looking at the upper and the lower limit we decide the number of groups or classes. here this is just an hypothetical example to show you the procedure, suppose may be it is varying between 25 and 100 and suppose we decided to make group based on 5 Km interval and speed like 25 Km per hour is one group, then 30 to 35, 35 to 40 and the last may be 95 to 100 so we decide speed group based on certain lower limit and certain upper limit, this is the lower limit and this is actually the upper limit. So one lower limit is there and another upper limit is there. Then you decide the middle speed. Suppose in this hypothetical example if you decide for one group with 25 to 30 Km speed then the average speed may be 27.5. Then you note down the observed frequency in group. That means this is again not in percentage normally so you take the number of observation. That means may be we observe 5 vehicles traveling in the speed range between 25 and 30. Similarly, 15 vehicles we observe in the speed range between 30 and 35, 48 vehicles we observe in the speed range between 35 and 40 so once we fill up this column we know the total number of vehicles that are observed during this period.

Accordingly we can calculate percentage frequency in groups. That means 5 divided by this column total similarly, 15 divided by this column total, 48 divided by this column total so that gives us frequency for a particular group and then this gives the cumulative frequency. So here it is 1, here it is 4 because 1 + 3, then again 9.3 + 4 so cumulative frequency is 13.6 and so on obviously here you get hundred because that covers all the vehicles so the total obviously will be 100%.

Now this is one way of presenting the spot speed data. This same information we often present in terms of frequency distribution curve where in the x axis you plot the speed so it is the speed may be the middle value you can take or the range you can mention and in the y axis you mention percentage frequency. That means you take any speed group this bar is showing how much percentage of total vehicle are traveling with that speed range or within that group.

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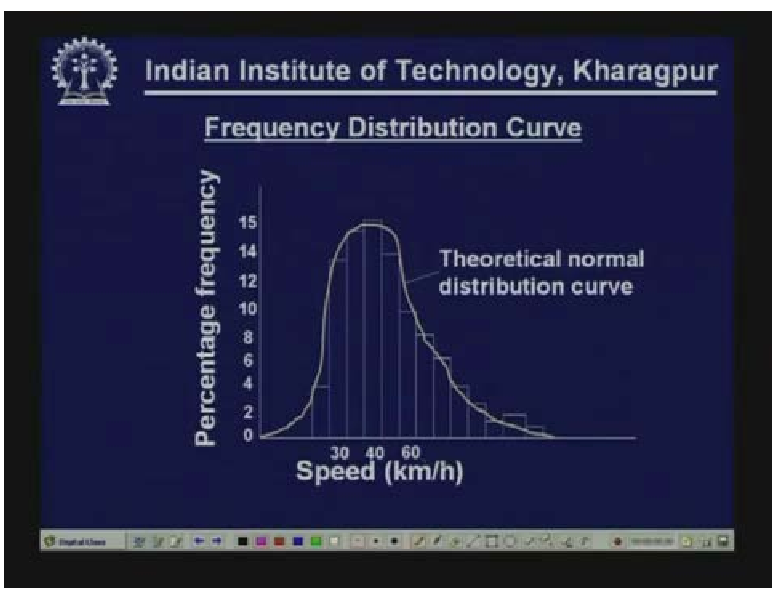

So you normally put it and generally if we try to see the theoretical curve it will look like a normal distribution curve. It may look generally but it may be other distribution also but this is normally the shape, I have just shown a typical shape but there could be different types of distribution of speed. So that way one can present this spot speed data which is known as frequency distribution curve. You can also present data it in terms of cumulative frequency distribution curve where again X is the speed and Y is percentage of vehicles at lower speed than X axis because it is cumulative frequency and a typical shape is shown here so you can see how it looks like. This is the typical shape that you get for the cumulative frequency distribution curve

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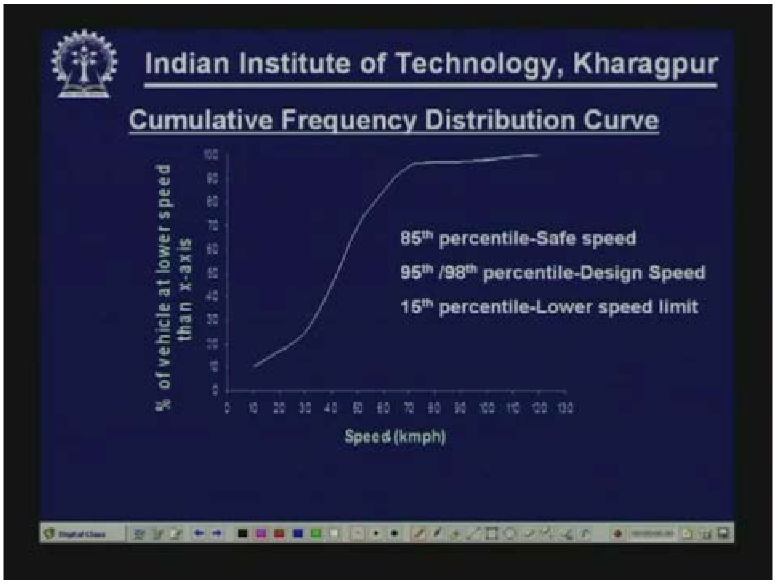

Now, this cumulative distribution frequency curve is very useful, you can calculate eighty fifth percentile speed what is normally taken as the same speed in many cases, you can calculate the ninety fifth or ninety eight percentile speed, you can also calculate the percentile speed which is normally used as the lower speed limit, there are many ways and varieties of information are extracted from this cumulative distribution curve and they are used in traffic engineering application. But this is one way of representing the spot speed data. That generally completes our discussion about spot speed measurement.

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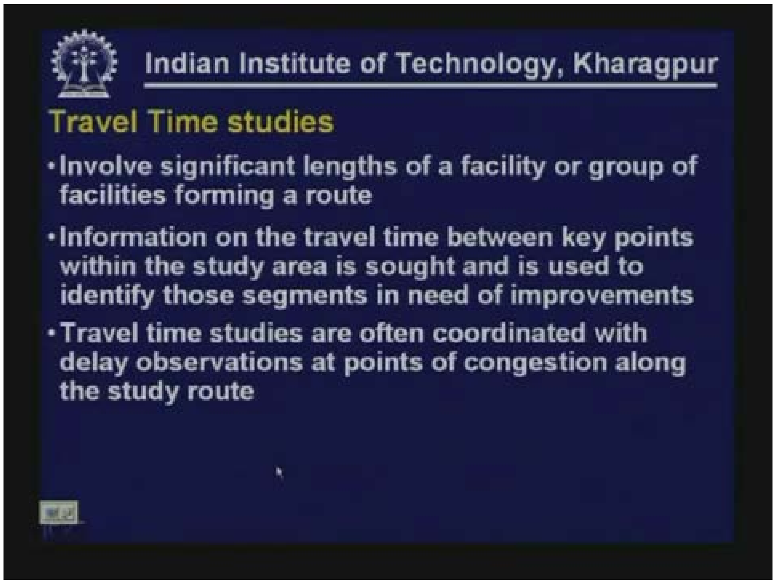

So we have discussed different approaches for spot speed measurement, their limitations, practical issues associated with measurements now we will switch over to travel time studies.

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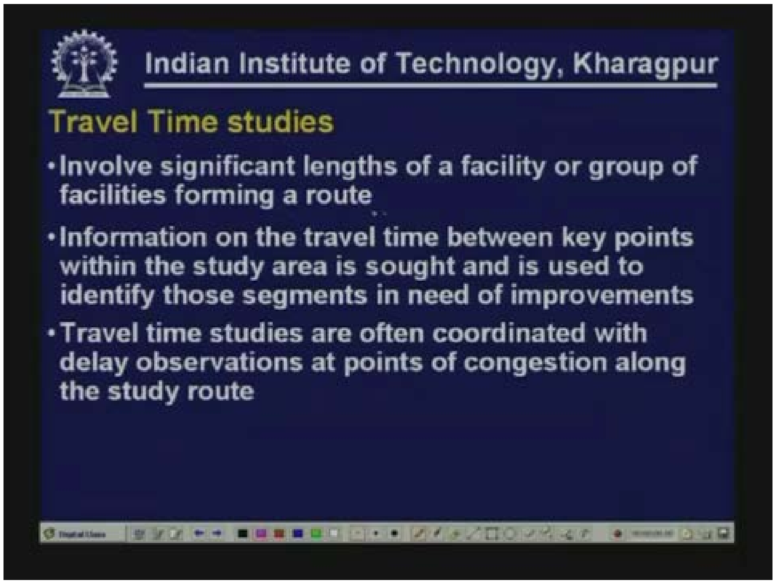

Travel time studies are normally carried out involving significant length of a facility or group of facilities forming a route may be you take a road there could be some intersections, the road geometry may vary, the width of the road also may vary, the road side activity may vary so often we need information on travel time between key points within the study area and we use such information to identify those segments in need of improvement. may be along the complete road not the complete road is having problems but may be certain segments certain stretches or small length or particular intersection that are problematic. So to identify those problematic locations we carry out travel time studies. Now travel time studies are often coordinated with delay observations also so we also calculate delays at points of congestion along the study road. May be there is an intersection here so we also calculate separately what kind of delay is experienced when we carry out travel time studies. So, often travel time studies are coordinated with delay observations.

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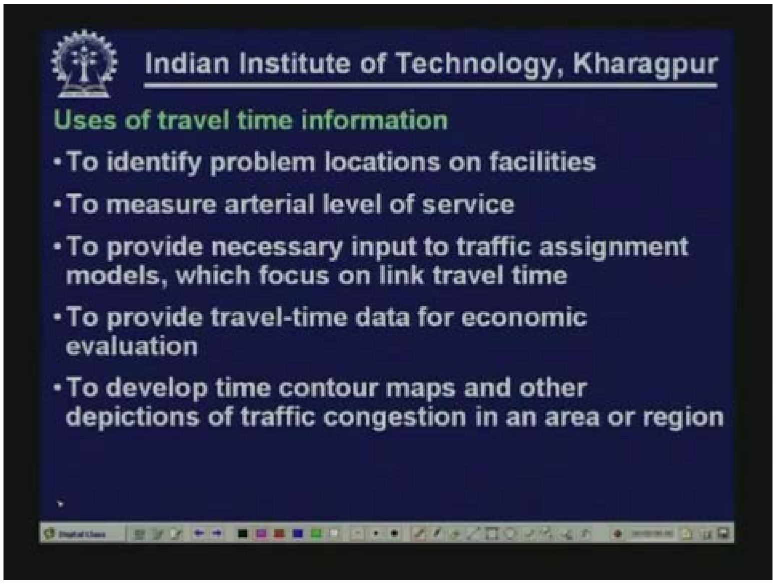

Why we carry out travel time information? I am just trying to summarize some of the uses or some of the reasons for carrying out travel time studies. Primarily it is to identify problem locations on facilities as I have indicated. along the route not that the complete route is problematic may be certain locations where there is bottleneck, where you have problems, where congestion is occurring or delay is occurring so we want to identify problematic locations on facilities. So, if we carry out travel time and delay studies we can identify those problematic locations.

To measure arterial level of service, we measure the average travel time over the segment so we measure the average speed that is operating. So accordingly we use that information to calculate or to see what is the present operating level of service. Then to provide inputs to traffic assignment models which focus on link travel time. Actually we have not discussed about this traffic assignment part but route selection is a key issue in urban transportation where you have alternative roots. May be you are traveling from point 'I' to point 'J' and there alternative roots are available. Not that everybody in an urban context use a single road. Normally people get disturbed. In a non-congested situation may be everybody can take a shorter route. So travel time is the key issue in doing this traffic assignment. That means assigning the complete demand to different alternative routes and this assignment is done normally based on the travel time on alternative roads. What are the travel times in route one route two and route three and so on. So accordingly there are several assignment techniques ranging from the simplest to very complicated and sophisticated assignment techniques through which we distribute the traffic to different routes. So we need the travel time information and link travel time information and that data can also be gathered through these studies.

To provide travel time data for economic evaluation: For most of the road projects or road development projects we need to carry out economic evaluation and normally that's the termination point actually. We carry out all sorts of thing. We explore different alternatives but decision making point is economic evaluation what is finally coming out after economic evaluation. So there majority of the transportation projects offer some benefits in terms of travel time savings. So we need to calculate and need to understand travel time data for economic evaluation. It is also necessary for developing time contour maps and other depictions of traffic congestion in the study area. Hence traffic congestion may be represented in many ways so to develop this time contour maps and other depictions of traffic condition we still use these kinds of things.

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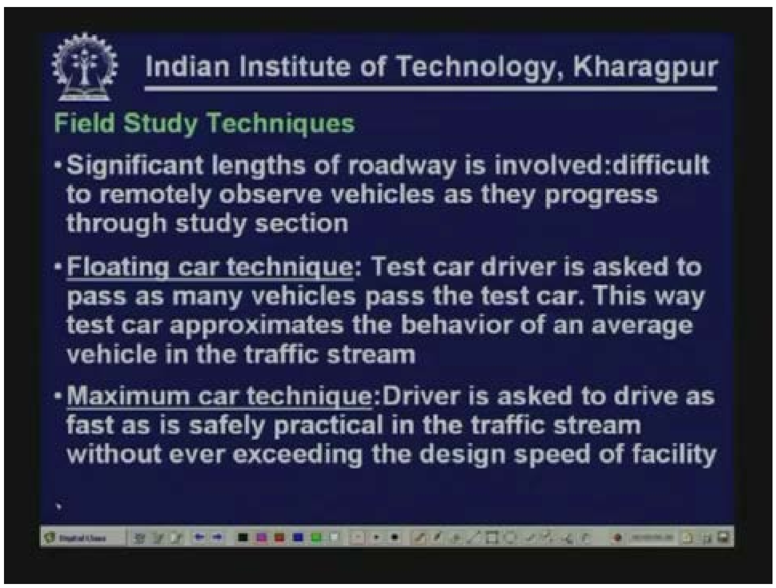

Now let us come to Field Study Techniques. Significant length of the roadway is involved. Remember that we are carrying out a travel time delay study over a reasonable length of the road. It is not some 20 m or 50 m or 70 m or 100 m road, it is longer than that. Therefore it is very difficult to remotely observe the traffic movement on this complete steady state because on the longer routes there are road side establishments so you may not get a suitable location where from you can record or you can observe the complete traffic movement over the stretch. So it is difficult to remotely observe vehicle as they progress through the study section and that's why we go for different techniques. There are three techniques which are normally used; one is floating car technique. Another is maximum car technique and another is average car technique.

Now what is floating car technique? Here we drive a test car and the test car driver is asked to pass as many vehicles past the test car, this way the test car approximates the behavior of an average vehicle in the traffic stream. Let us try to understand this part again. Through this we are trying to find out the average travel speed representative of the traffic stream. So what we do is, when the test car is moving may be some vehicle is trying to overtake that then we normally try to balance between this overtaking and the overtaken vehicle. Suppose three vehicles have overtaken the test car and if the test car has also overtaken three vehicles then both are equal, overtaking and overtaken vehicles are equal so we can generally assume that whatever travel time we are getting in the test car and whatever speed we are calculating based on that it is representative of the average strip area. Hence that may be representing the average travel time or speed of the traffic.

In Maximum Car Technique the driver is asked to drive as fast as is safely practical in the traffic stream without ever exceeding the design speed of the facility. That means in this case the driver is asked to drive the vehicle as fast as possible keeping the safety consideration in mind and without violating the speed limit. So he should not violate the speed limit and driving fast as far as possible safely within the given condition. So there whatever travel time you get that travel time will give a lower range of travel time or higher range of speed that is normally expected within the given condition. But this is not the average behavior that is representing the lower range of travel time or upper range of speed which is possible within the given situation.

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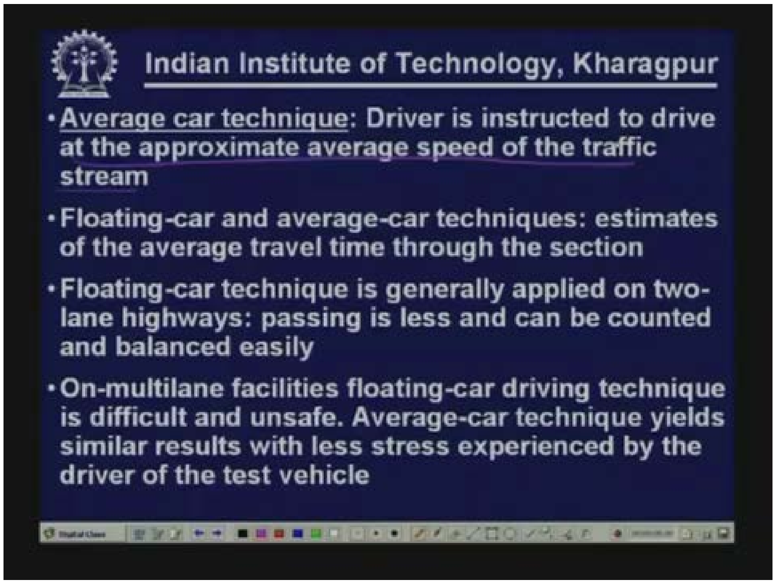

In average car technique the driver is instructed to drive at the approximate average speed of traffic stream. We don’t put any condition here like overtaking and overtaken vehicles, and number of overtaking and overtaken vehicles are to be equal, it is nothing of that sort but the driver is instructed to drive generally following an average speed of the vehicle. In that process you may overtake some vehicles, or some vehicles may overtake the test car so you record the speed, record those numbers but we ask the driver to generally drive following an average speed. Remember that in floating car and average car techniques we get estimates of average travel time through the section, this gives the average stream behavior. So it is the average travel time through the section.

Now, floating car where overtaking and overtaken vehicles are equal that is generally applicable and suitable on two lane highways where passing is less and can be counted and balanced easily because it is typically for two lane roads this floating car technique is suitable because the passing is less and can be counted and balanced easily.

On multilane highway if the test vehicle is driven using floating car technique then it may be difficult and it may be unsafe also because of so many vehicles and so many overtaking opposing vehicles all those things are there so the operation is much more complicated. So here it may not be same to ask the driver to overtake that many number of vehicles which has overtaken him. So here if we try to balance the overtaking an overtaken vehicle there may be problem and we may face unsafe conditions. So here the average car technique yields similar results with less stress experienced by the driver of the test vehicle so in such cases we use average car technique instead of using floating car technique.

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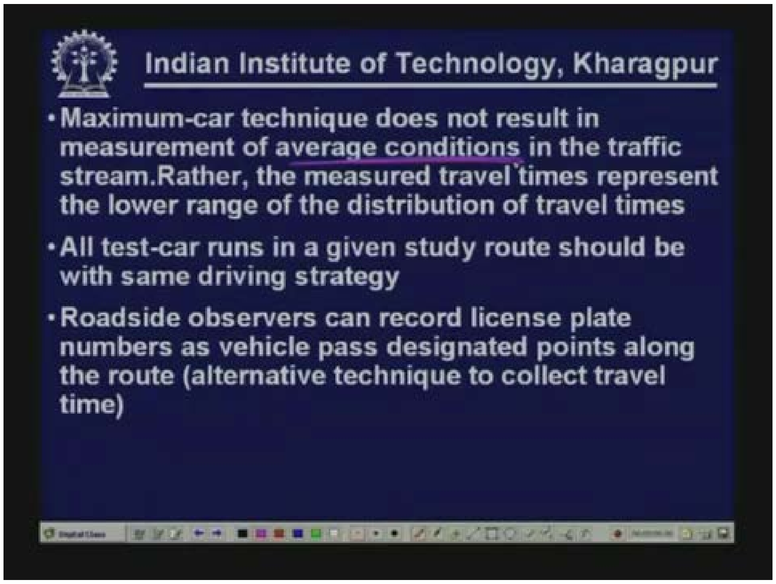

Maximum-car technique as I have mentioned already does not result in measurement of average condition because maximum car technique we are asking the vehicle or the test driver to drive as fast as possible keeping the safety condition in mind and keeping the speed limit in mind. Therefore it does not give average condition in the traffic stream rather the major travel times represent the lower range of distribution of travel types. You can get the indication of the lower range of distribution of travel time by following maximum travel technique.

Remember that all test runs in a given study road should be with the same driving strategy because we normally take multiple run to get a represented data, represented condition so all test runs should be with the same driving strategy we should not mix up with it. One is if we are following maximum car technique let us follow maximum car technique and if we are following average car technique let us follow the same average car technique for all the test runs. So all test runs in a given study road should be with same driving strategy.

And alternative to this approach is where road side observers can record license plate numbers as vehicle pass designated points along the road. This is essentially an alternative technique to collect travel time. What we are doing is instead of using test car and suppose if these are the different control points we note down the registration plate number here somebody helps noting down the registration plate number here, somebody helps noting down the registration number plate here and the time also is recorded so afterwards by matching the registration number we can find how much time that vehicle has taken to travel this distance, how much time it has taken to travel this small stretch and so on so that way also we can get the travel times between the control points or designated points and accordingly we can also calculate what is the average travel time or what is the average travel speed. This is an alternative to moving vehicle method.

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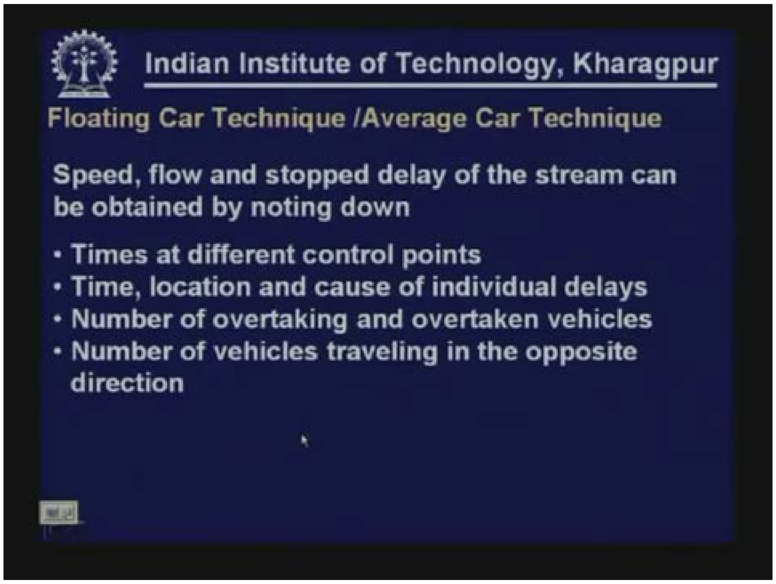

A little bit further discussion on floating curve technique or average car technique these two are almost equal. Only in one case the overtaking and overtaken vehicle are made equal but in the other case they may vary. In floating car technique or average car technique speed, flow and stop delay of the stream can be obtained by noting down the following;

Times at different control points: Along the route you have different control points so at different control points we can note down the time

Time, location and cause of individual delay, maybe there is an intersection here so in this intersection how much delay is occurring, the location, the time and the cause all these things can be known and can be recorded.

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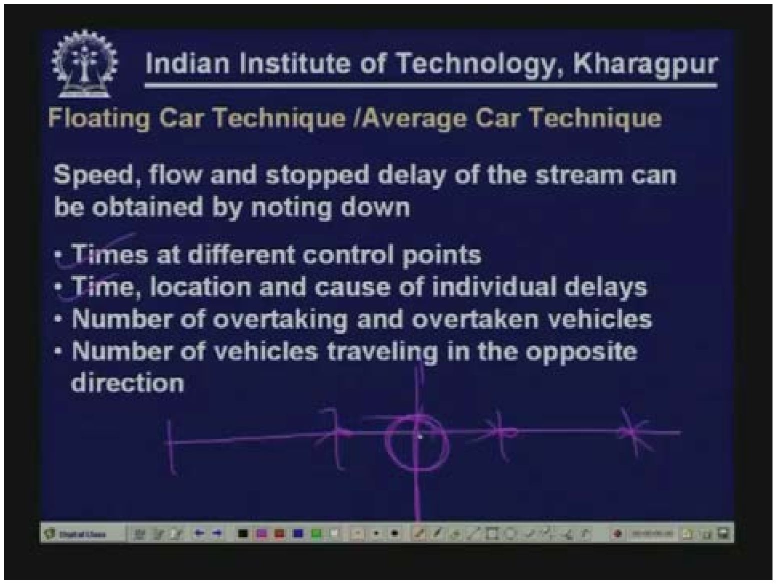

Number of overtaking and overtaken vehicles is recorded. So what are overtaken vehicles? When the test drive vehicle is moving in this direction how many vehicles are really overtaking the stopped vehicle in the same direction is the number of overtaking vehicle and the test car may also overtake some of the slow moving vehicles so basically we take count of those overtaken vehicles also. So number of vehicles traveling in the opposite direction is also noted. Suppose we are going in this direction some vehicles are traveling in the opposite direction we take a count of those opposing traffic also as how many vehicles are coming in the opposite direction. So we count number of vehicles which are overtaking, which are overtaken and also number of vehicles which are coming from the opposite direction.

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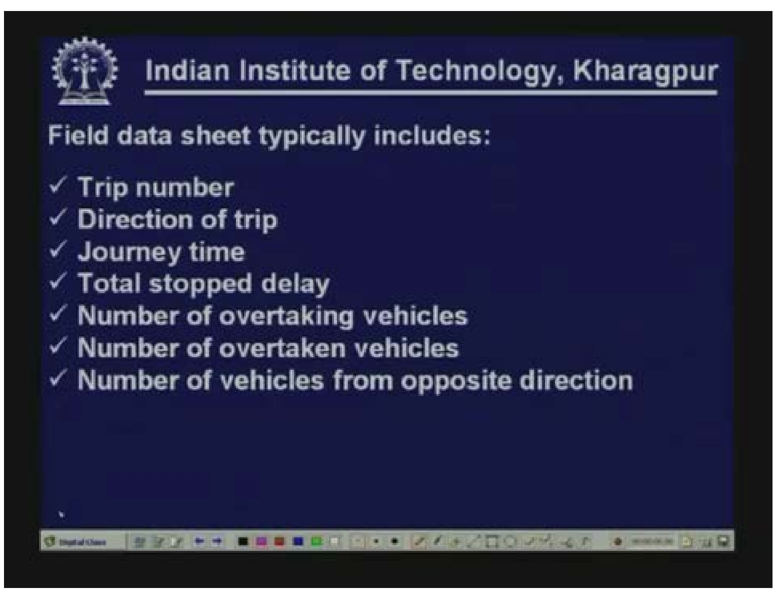

For this survey or field studies field data sheets are used which typically include the following information. I am not showing the full format but I am trying to indicate the items that are normally included in the format. Trip number, direction of trip because you are going and then again coming back so both directions and then again going and then again coming back so we don't want to note down the trip number, we want to know the direction of travel whether it is this way or that way, what is the journey time, what is the total stop delay, what is the number of overtaking vehicle that is when the vehicle is traveling, when it is not so when it is traveling towards the north what are the number of overtaking vehicles, overtaken vehicle and vehicle coming from opposite direction.

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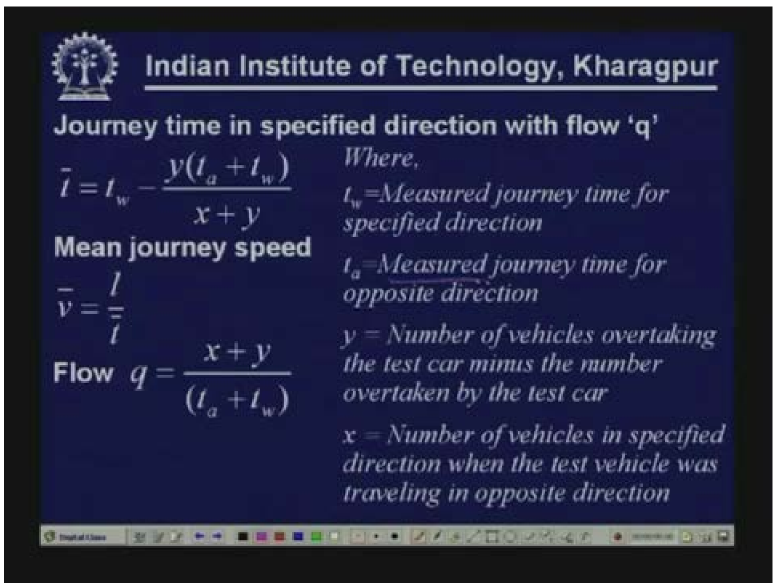

Similarly when the test car is traveling towards south again we note down the overtaking vehicle, overtaken vehicle which is coming from the opposite directions so all this data are required. From the recorded data from multiple runs we calculate the journey time and specified average journey time in a specified direction with the flow queue, how the flow is calculated? Flow is X + Y by Ta + Tw. What is Ta? Ta is measured journey time for opposite direction.

Suppose we are trying to make count flow in this direction so measured journey time in opposite direction means when the vehicle is traveling in this direction that is Ta, Tw is measured journey time for specified direction in this direction and we have x and y where x is number of vehicles in specified direction with the test vehicle when the test vehicle was traveling in opposite direction. So when the test vehicle was traveling in opposite direction how many vehicles moved in the specified direction, so we are trying to find out the flow in this direction so when the test vehicle was moving in the opposite direction how many vehicles were going in this direction plus Y. Y is number of vehicles overtaking the test car minus the number of overtaken vehicles by the test car so that they also reach to this place within this Ta + Tw time so we add that component. Y may be positive Y may be negative depending on the number of overtaking and the overtaken vehicles. So you calculate the flow.

Now consider any direction of travel. Let us consider the travel time for specified direction. Now if this is Tw we are not very sure in average car technique whether this Tw really represents the average travel time. So when we can assume that it is really representing the average travel time is when the overtaking and overtaken vehicle numbers are equal. If they are equal then this Ta + Tw what is Ta? Ta plus Tw by X + Y into Y, what is Y? Y is number of vehicles overtaking the test car minus the number of overtaken vehicles by the test car. so if overtaking and overtaken vehicle in this specified direction are same then this Y value becomes 0 so then average journey time T bar = Tw if not then we are applying some correction.

Suppose the number of overtaking vehicles are more or overtaken vehicles are more than accordingly you can understand whether the test car was really traveling at a slightly slower speed or at a slightly lesser speed than the average traffic stream or at a slightly higher speed than the average traffic stream so accordingly this correction is applied to get average journey time representative of the traffic stream from the measured journey time. And as I mentioned if the number of overtaking and overtaken vehicles are generally equal then this correction factor this whole component becomes 0 then the measured journey time for specified direction will be equal to the representative average journey time in the specified direction. Now, once you know this T value the travel time the length is known so the mean journey speed can be calculated by this thing.

Next is, intersection delay studies. Normally this travel time and delay studies as I indicate of course we called it travel time study but we also measure delay but delay is end route delay at certain critical points and when the study covers a reasonable length of the road including the mid block locations and intersection locations. But in some cases especially for signalized intersections it is necessary for various traffic engineering application and work to measure the delay at intersection. So we shall also discuss this part the field measurement of delay at intersections particularly signalized intersection. This comes under intersection delay studies.

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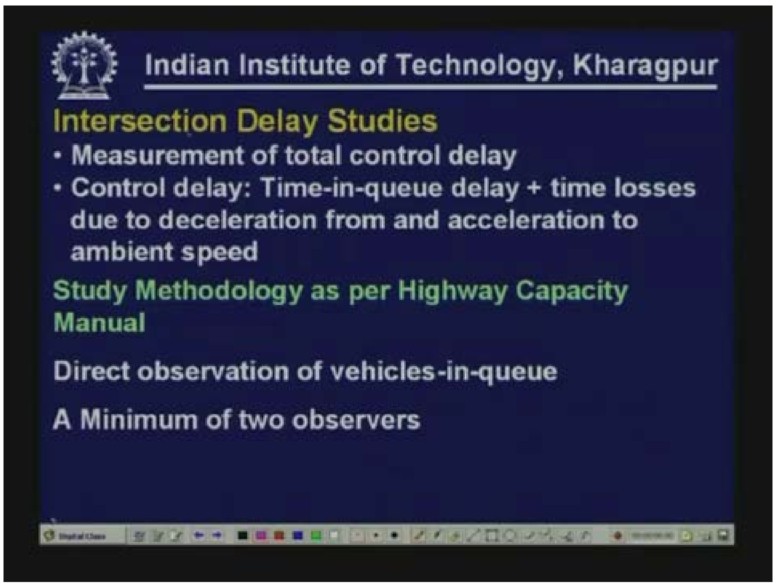

What we try to do here is essentially we try to measure the total control delay. So what we normally measure is total control delay. Of course in many traffic engineering studies it may be required to measure only the stop delay not really the control delay. But the recent development or whatever is prescribed in highway capacity manual we normally measure the total control delay. So let us try to understand what control delay is.

Control delay is basically time in queue delay plus time losses due to acceleration from and acceleration to ambient speed. So a vehicle which is traveling at a normal speed if there is no intersection and there is no other obstruction then it will travel in its own speed. So from that the travel time may be more or the delay may occur due to two reasons, one is the time in queue delay when the vehicle is in the queue, at that time because the vehicle is in the queue what is the delay that is taking place, and the second is there is also delay due to acceleration and deceleration of vehicle.

Vehicle decelerates from the ambient speed and also once it is cleared it will accelerate to ambient speed so there are essentially two parts both are considered in the control delay. So control delay is defined as the time in queue delay plus time losses due to acceleration from and acceleration to ambience speed. With this background now let us try to understand the study methodology as per highway capacity manual. We are only discussing the methodology that has been prescribed or that has been suggested by the highway capacity method. Here there are two salient features; one is direct observation of vehicle in queue. We directly observe in the field the vehicle in queue. Of course we measure so many other quantities also which we will discuss in details. And to carry out this intersection delay studies as per highway capacity manual we require a minimum of two observers. So we shall now elaborate what these observers are expected to do, what observer I will do and what observer II will do to get a more detailed understanding about the data requirement and the process.

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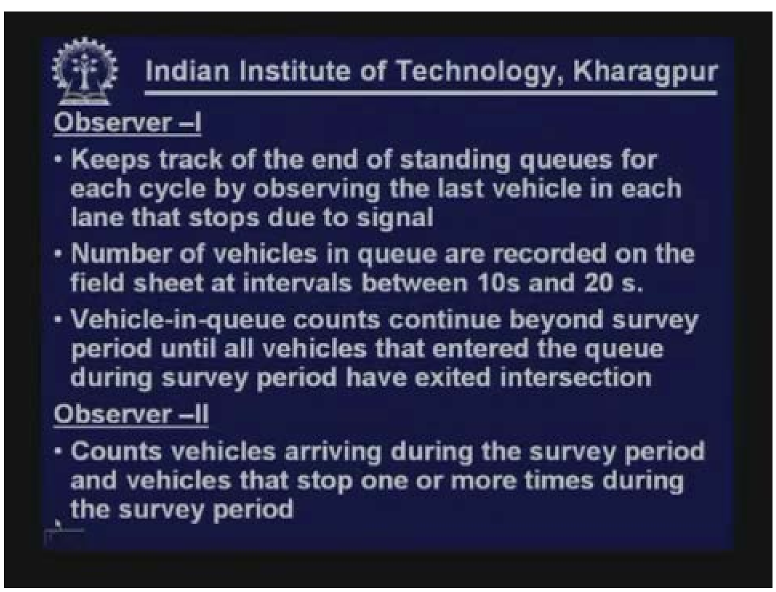

Observer I: Observer I keeps track of the end of standing queue for each cycle by observing the last vehicle in each lane that stops due to signal. Now because of the signal the vehicle will stop. So observer I will keep track of the end outstanding queue for each cycle by observing the last vehicle in each lane that stops due to signal. here number of vehicles in queue are recorded in the field sheet at intervals of may be ten seconds or twenty seconds depending on what is the signal cycle time.

Vehicle in queue counts continue beyond survey period, this is very important. You should understand this part clearly and remember it. So vehicle in queue count continues beyond survey period until all vehicles that entered the queue during the survey period have exited the intersection. So during the survey period whatever number of vehicles has entered and till all of them cross the intersection or exit the intersection this vehicle in queue count will continue because the other is we will miss those vehicles.

Now let us see what observer II is expected to do. Observer II actually counts primarily two things. One is vehicle arriving during the survey period, the total number of vehicles, how many vehicles are really arriving during the survey period; this vehicle arrival is different from vehicles which are getting discharged from an intersection. So this fellow will count vehicles which are arriving during the survey period and also a separate count from vehicles that stop one or more times during the cycle period. So one is the total as how many vehicles are entering, that is how many vehicles are arriving that's one count and the second count is how many vehicles are stopped.

Not that all vehicles which are entering will stop all of the vehicles may not stop so a separate count is made for the vehicles which do stop one or more times. Now here it is worthwhile to mention that even if a vehicle stop more than once that vehicle will be counted only once. I repeat it, if a vehicle stops more than once the vehicle will be counted only once and it is not that how many times the vehicle is stopping. What we are trying to count is how many vehicles are stopping not how many times. So whether it is stopping one time, whether vehicle is stopping three times it is a single vehicle which is stopping that much is necessary.

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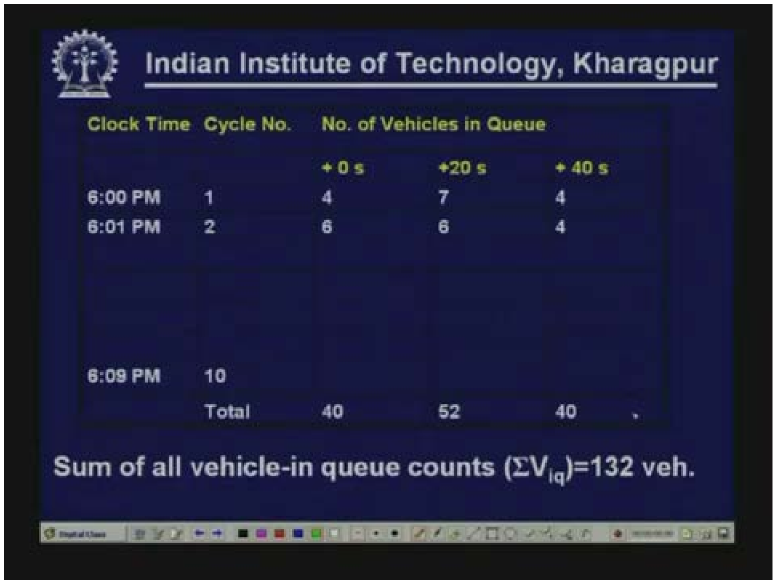

Clock Time	Cycle No.	No. of Vehicles in Queue		
		+ 0 s	+20 s	+ 40 s
6:00 PM	1	4	7	4
6:01 PM	2	6	6	4
6:09 PM	10			
	Total	40	52	40

Sum of all vehicle-in queue counts (ΣV_{iq})=132 veh.

Now let us take a small example to show you farther calculations. Instead of directly giving you the formulation it will be easy to understand if I explain with an example. So observer I will typically record data like this. Of course there will be so many other things which are being included in the field data sheets, I am not showing the detailed one but I am only showing an example of that. This is the clock time, suppose we consider it from 6 pm to 6. 09 that means it is for a ten minute duration. Cycle numbers are 1, 2, 3, 4 like that up to 10 so for ten cycles we have observed the number of vehicles in queue and we have taken measurements at every twenty seconds interval. So + 0 second + 20 second + 40 seconds so you can see here the number of vehicles in queue have been recorded at 0 seconds + 20 seconds + 40 seconds for all these ten cycles. So here sum of all vehicles in queue count is nothing but sum of all vehicles which are observed. Let us assume that this + 0 second total is 40 + 20 second total is 52 + 40, second total is 40. So what is the sum of all vehicles in queue counts? It is 40 + 52 + 40 = 132 vehicles and that is denoted as sum over Viq.

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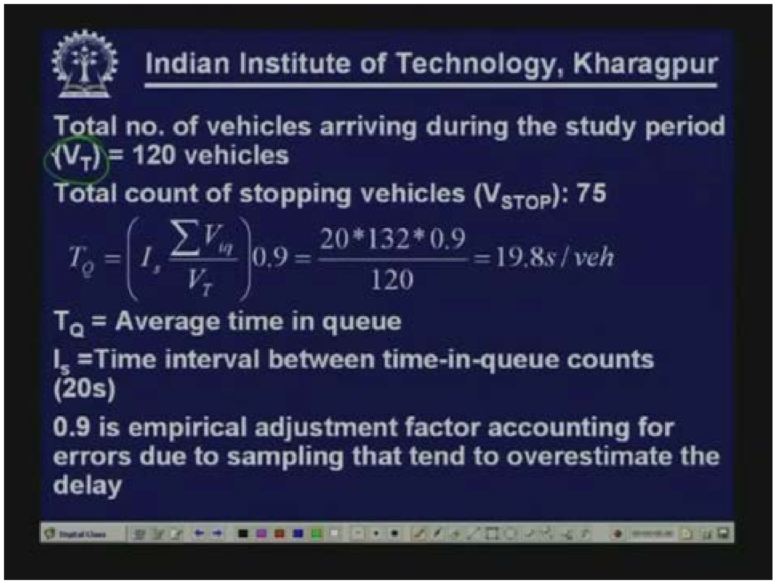

Total number of vehicles during the study period is normally denoted as Vt, this the second observer has noted it is 120 vehicle, total count of stopping vehicle is 75 and this again has been observed by second observer. So we are calculating average time in queue using this formulation where 'i' is the time interval between time in queue counts which is 20 seconds, you have seen that 0, 20 and 40 seconds, and 20 seconds you have taken so this is 20, Viq is 132, Vt is 120 and this .09 is an empirical adjustment factor which it suggests to account for errors due to sampling which tend to overestimate the delay so with that you calculate Tq as 19.8 seconds.

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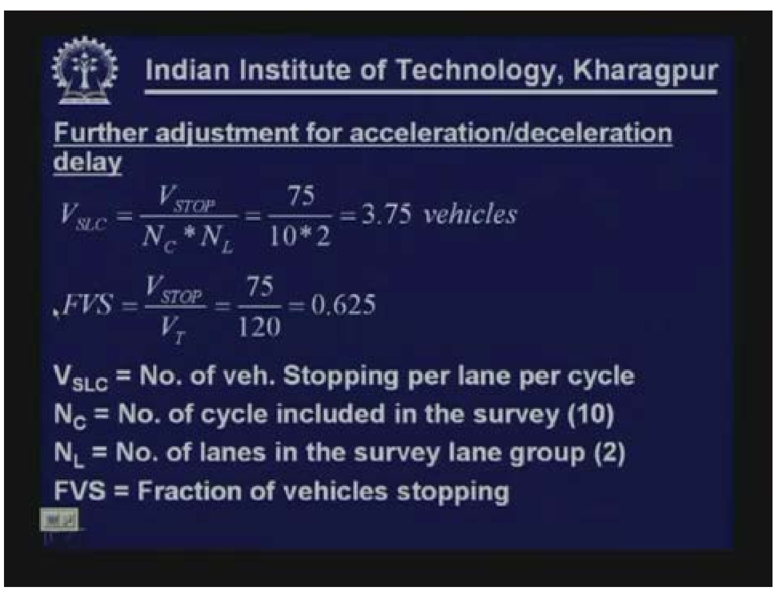

There are two further adjustments done to account for acceleration and deceleration delay. We calculate Vslc which is number of vehicles stopped per lane per cycle. The number of vehicles stopped per lane per cycle is total number of vehicles stopped divided by number of cycles and number of lanes. We have assumed that it is a two lane so this Vlc is 3.75 vehicles. Now FVS is Fraction of Vehicles Stopping: this is Vstop by Vt that shows the total of how many vehicles stopped out of the total vehicles which are active during that time. So this 0.625 is calculates in this example.

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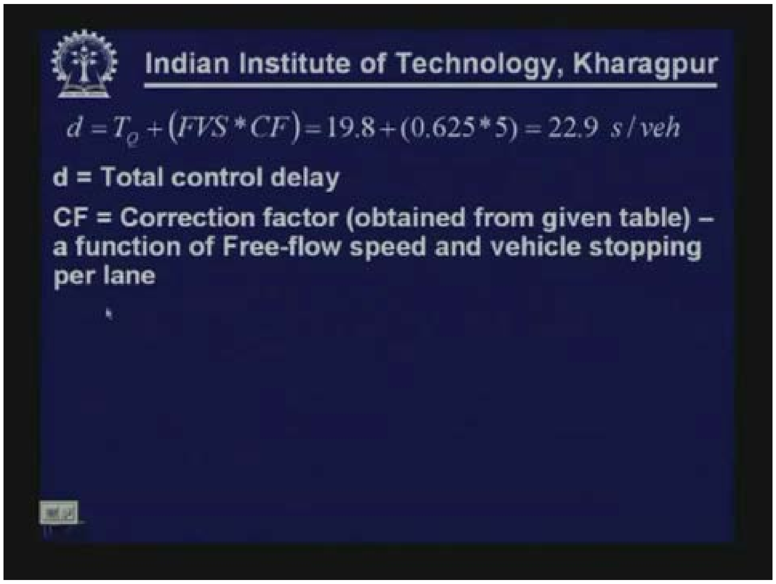

Now with this we calculate the total control delay which is Tq the earlier delay plus a correction factor. This component we account for acceleration deceleration part indirectly. Here FVS of vehicles is multiplied by CF and CF is the correction factor that may be obtained from the given table which is a function of free flow speed and vehicle stopping per lane as we calculated earlier. So with that you can take the value of CF multiplied by FVS and get this total control unit and by that way the total control can be calculated.

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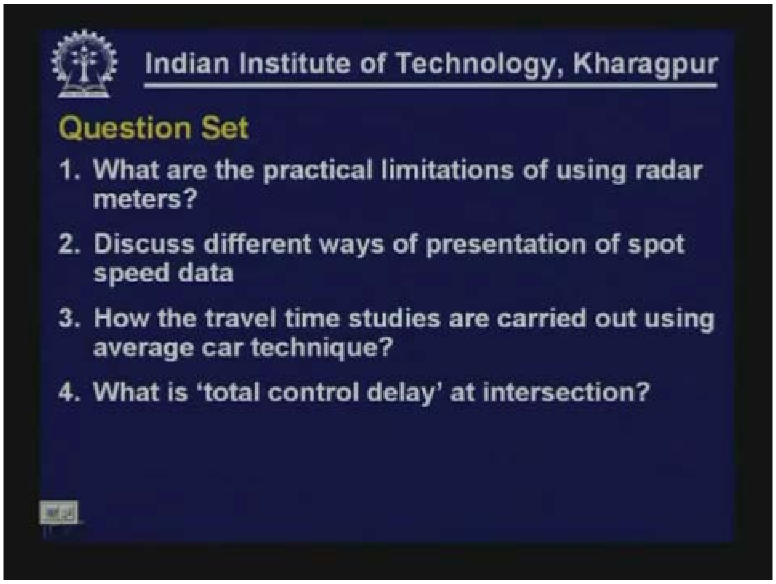

Few questions:

1) What are the practical limitations of using radar meters?
2) Discuss different ways of presentation of spot speed data:
3) How the travel time studies are carried out using average curve technique?
4) What is control delay and intersection? Explain your understanding about total control delay.

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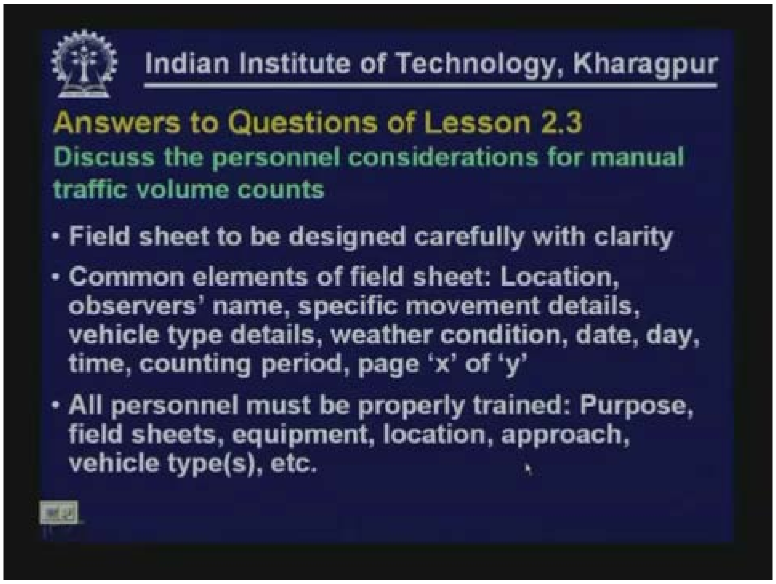

Now let me try to answer the questions of lesson 2.3.

Discuss the personnel considerations for manual traffic volume counts, design of field sheets, all personnel must be trained, training of personnel is another point, too many observers should not clutter at one location as they may obstruct driver and cause traffic interruptions, time must be carefully coordinated at all locations and among all counting personnel, number of counting personnel to be decided judiciously so that they can carry out the work comfortably, you must provide some relief personnel to make sure that the work goes smoothly and work carried out by counting personnel must be supervised, these are the salient considerations.

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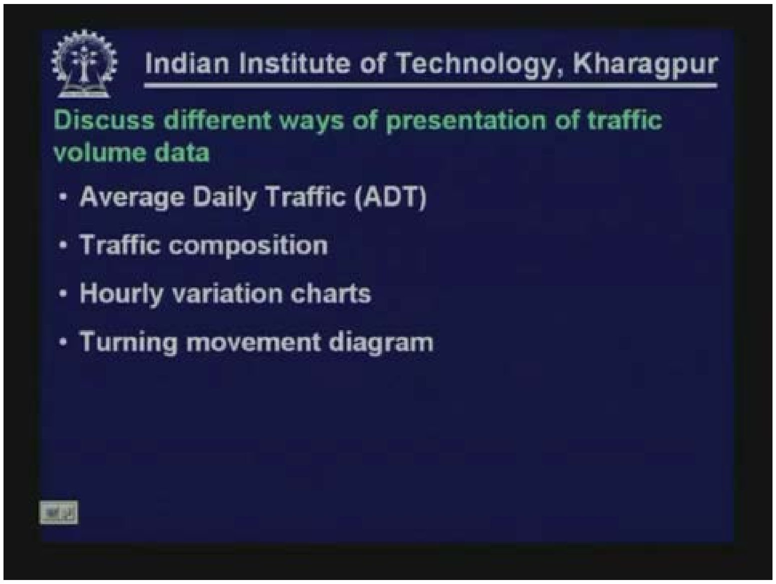

Discuss different ways of presentation of traffic data: we present traffic data in different ways;

- Average Daily Traffic (ADT)
- Traffic composition
- Hourly variation charts
- Turning moment diagram

This is the representation of average daily traffic.

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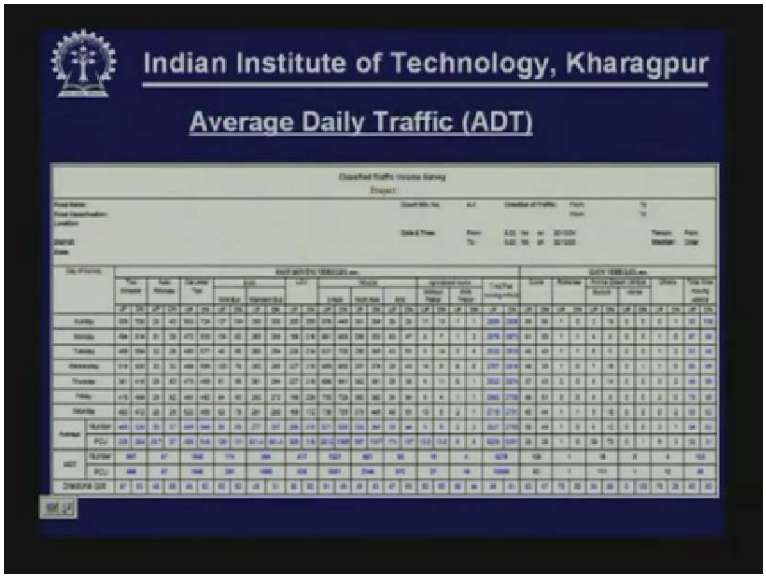

This is the representation of traffic composition.

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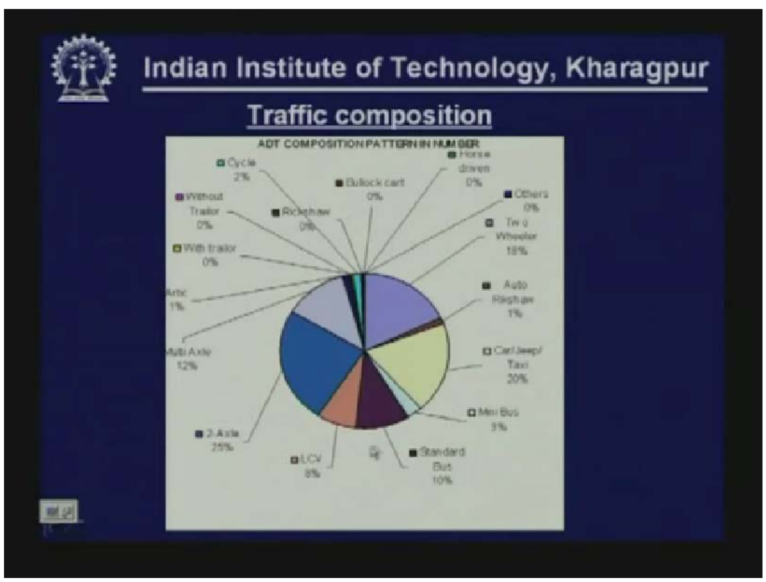

This is the representation of hourly variation chart.

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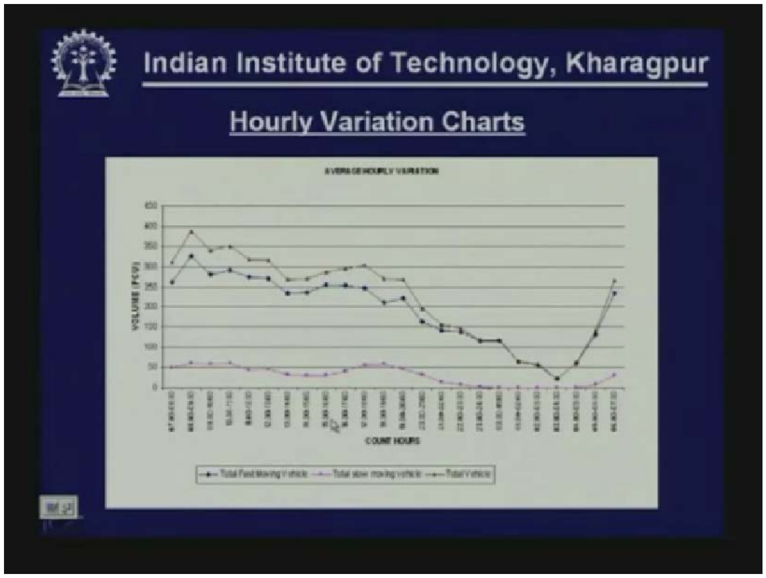

And here this is the representation of turning moment diagram.

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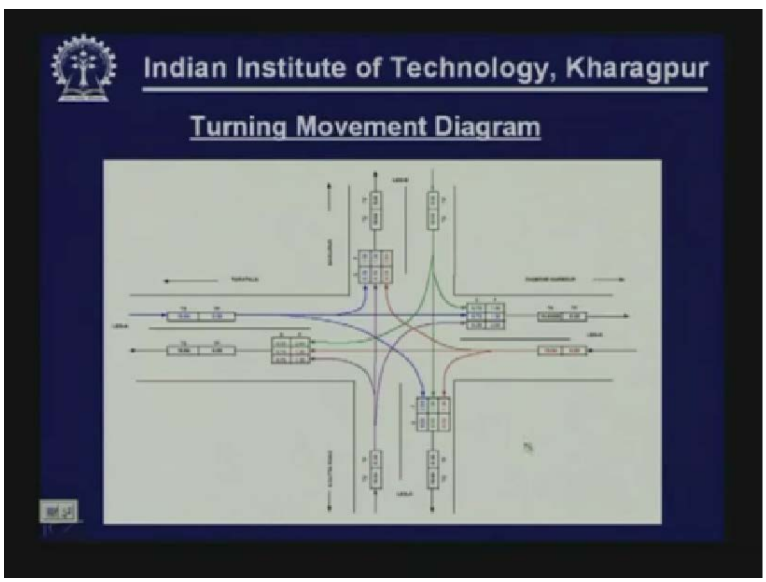

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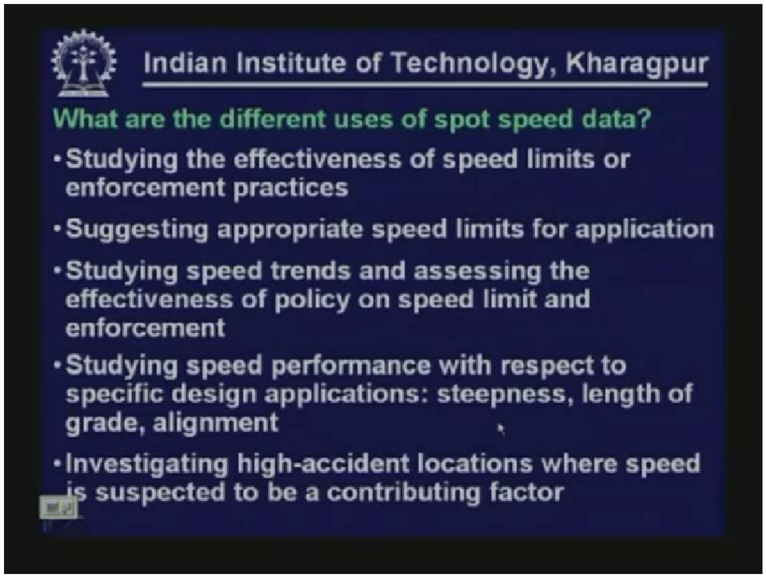

What are the different uses of spot speed data?
It helps us in studying the effectiveness of speed limits, enforcement studying speed trend, studying the performance with respect to design application, investigating high accident location, etc.

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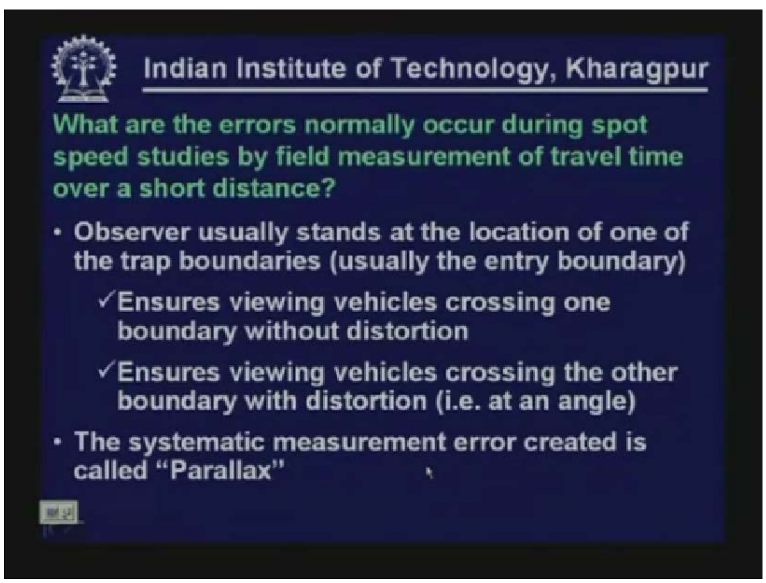

What are the errors normally we encounter during spot speed studies?
One is this parallax which is a systematic error and which may be removed easily. The other is basically due to early or late depressing of stopwatch of course this tends to be random and is expected to average out with a number of observations. And also this percentage error may be

minimized by using longer track length but you are carrying out spot speed study so obviously there is a limitation to what extent you can use the track line, thank you.

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