Traffic Engineering
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Lecture 61
Blackspot Analysis

Welcome to module I lecture three. In this lecture, we shall discuss about Blackspot Analysis.

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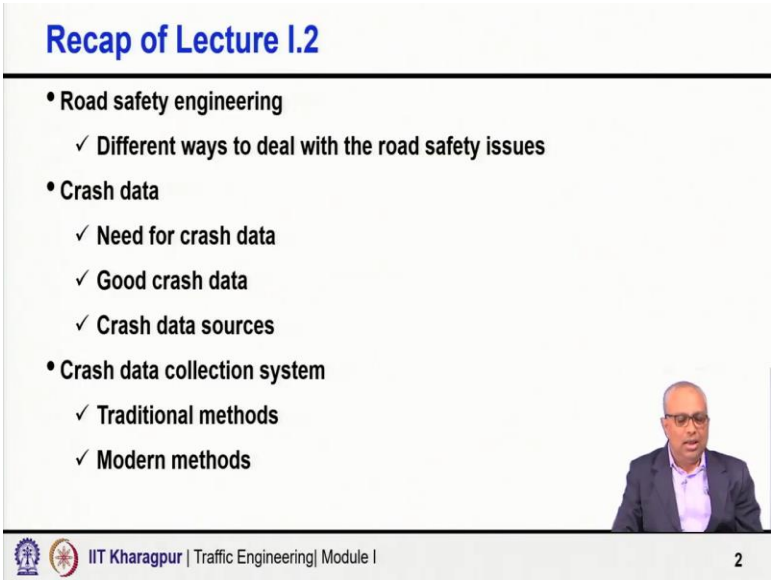

In lecture 2, I mentioned to you about what is road safety engineering and what are the different ways to deal with safety issues. Then, why do we need crash data, what we expect from good crash data, what all we can do if we have good crash data, then about the crash data collection system, what was the traditional approach and what are the modern trends for crash, the collection and database development. So, now you have the data. So, you have the good crashed data that is database is available with you.

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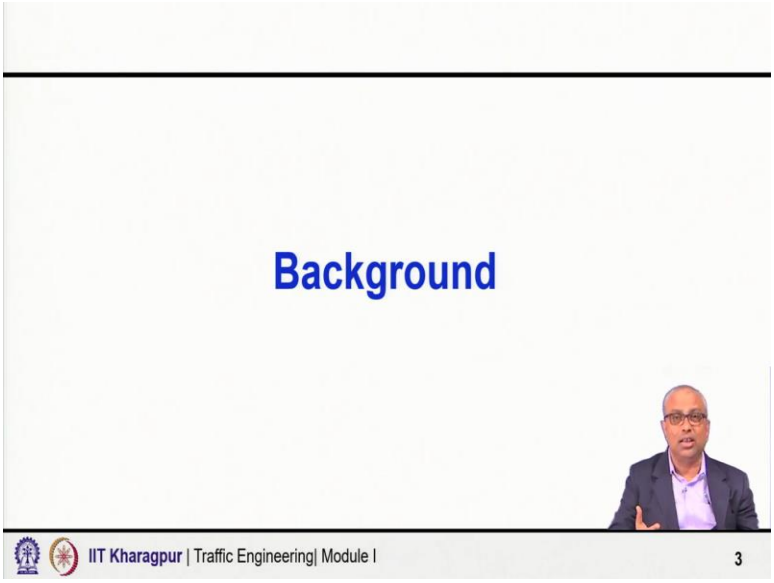

The next is blackspot analysis. So, first about the background, what is black spot, why we need to identify black spot and then what are the different methods or techniques that can be deployed to identify blackspots.

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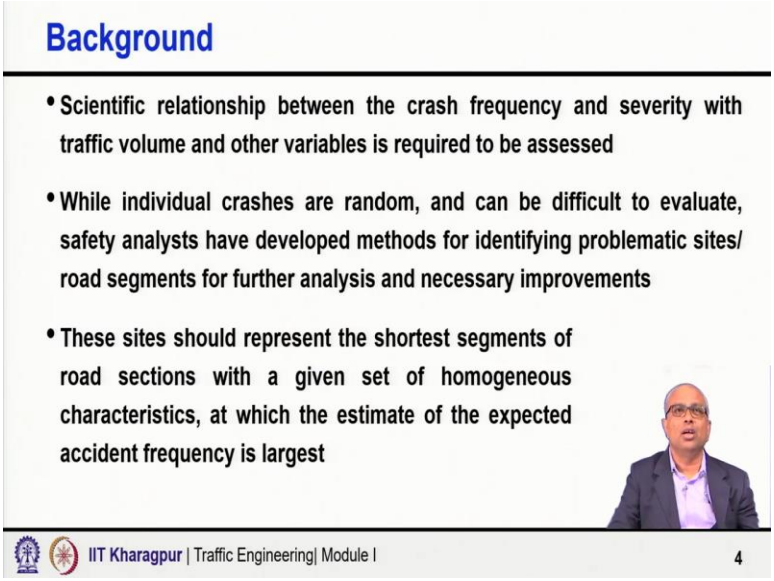

Scientific relationship between the crash frequency and severity, it might be frequency, the number of crashes or the severity, how many are fatal crashes, how many are major injury crashes and so on. That is on one side and the traffic volume and other variables on the other side. And there are

scientific relationships, relationships between what between crash frequency or crash severity and the traffic volume and other variables.

Now, individual crashes are random. It is always we can say the what type of crashes we that it will occur, it depends on so many things and obviously it is it can be described as a random variable and therefore can be expressed only in terms of with the help of probability. So, individual crashes are there and can be difficult to evaluate. But then safety analysts have developed a number of methods for identifying problematic sites or problematic, problematic road segments.

It could be problematic sites or problematic road segments for further analysis and necessary improvements. So, not all segments are same, not all sites are same some sites or some segments have got genuine road safety issues as reflected in their database. So, these metrics are to identify such problematic sites and route segments once through the identification is the fastest.

Once we can identify them for that analysis can be done, you know that these are problematic segments, so you can always go and try to understand more why it is so or why they are problematic and then accordingly suggest necessary improvements. Now, these sites should represent the shortest segments of road sections with the given set of homogeneous characteristics at with the estimate of the expected or actual accident frequency is the largest or generally higher than what is acceptable or higher than those in other segments.

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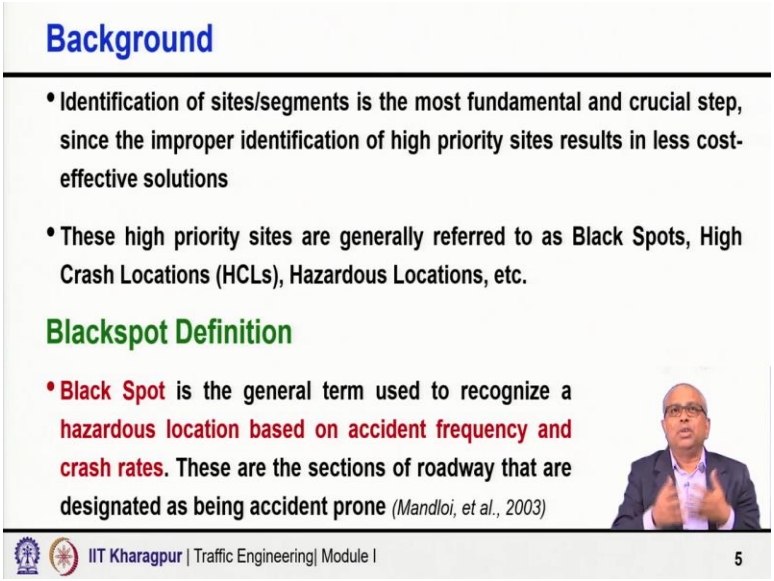

So, identification of sites or such segments, as I mentioned, is the most fundamental and crucial steps since improper identification of high priority sites results in less cost-effective solutions. That means, if we are able to correctly identify the most fundamental or most problematic sites and then treat them treat those sites so if we can identify the most problematic sites correctly, identify them and then treat those locations or segments, then maximum benefit will go to the community.

So, the in a way you know it becomes more efficient. So, identification of sites, segments identification of sites segments is the most fundamental and crucial step since improper identification of high priority sites results in less cost-effective solution. So, if I can really identify the most difficult and most problematic sites properly and treat them, I can say that I am able to give a written maximum benefit to the community.

Now, this high priority sites are generally referred to as sometimes blackspots, sometimes they are called high crash locations, sometimes they are called hazardous locations, hazardous locations, etc. Now, how we can then we understand why we need to identify blackspot and what is blackspot, but then how we can formally define blackspot.

So, blackspots is the general term used to recognize it hazardous location based on accident frequency and or crash rates and crash rates you can say. Now, these are the sections of roadway

that are designated as being accident prone. If we are driving, we often see that police board, this is accident prone, this location, how we identified?

If we can identify if we can inform users, then they become more careful. So, blackspots is a general term which is used to recognize that hazardous location based on accident frequency and crash rates. So, these are the sections of roadway of which are designated as being accident prone.

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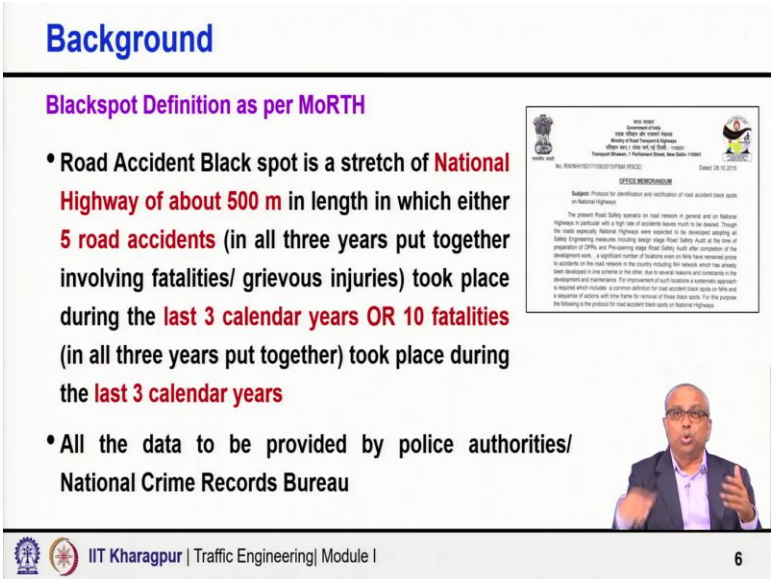

Ministry of Road Transport and Highways, Government of India they have said something how to identify blackspots in some way I will say you will see the other approaches we will discuss mostly relative and here this is more of in absolute terms. As per the blackspot definition, as given by Minister of Road Transport and Highways, road accident blackspot is a stretch of national highway of about 500 miter in which either 5 road accidents in all the 3 years under category fatalities or grievous injuries involving fatalities or grievous injuries took place during the last three years or 10 fatalities in all the 3 years put together, took place during the last 3 calendar years.

So, first of all, this definition is based on past 3 years data, that is number one. And divide the road into some homogeneous sections, approximately 500 meter length and in the last 3 years, either the site experienced 5 accidents involving fatalities or grievous injuries or the site experience 10 fatalities during the last 3 years. So, first one is, number of accidents, and the second is or that is the number of fatalities. 5 accidents involving fatalities or grievous injuries, or 10 fatalities in the

last three years. Now, all the data to be provided by the police authorities are national crime records on.

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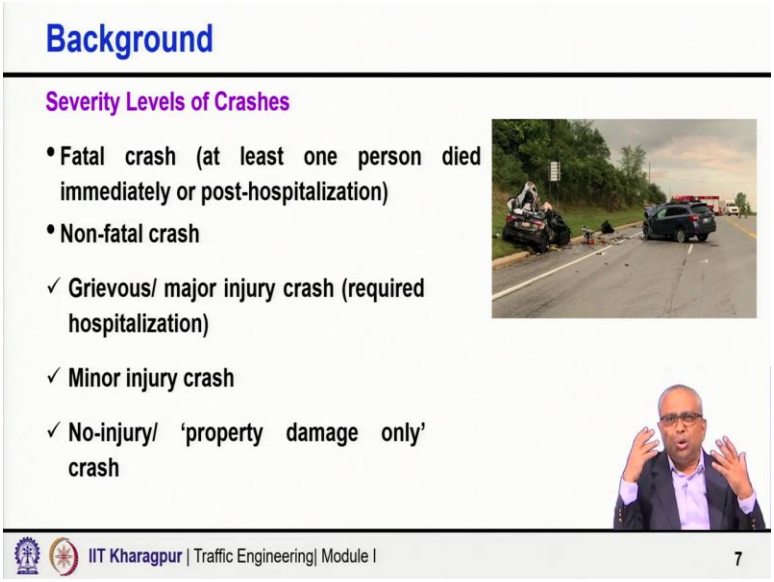

When we are talking about crashes, then the severe it is very important. Crash can broadly be classified as fatal crash, non-fatal crash. Fatal crash means at least one person died immediately or post hospital. It may be that the person died immediately or maybe after transfer to hospital so post hospitalization and at least one person. So, at least one death immediately or post hospitalization that we will call as fatal crash.

If there is no death, then we will call non-fatal crash. Non-Fatal crash can be again divided into 3 classes, grievous or major injury, so lot of you know (11:30) probably the highest where hospitalization is required, minor injury crash, where only minor injury happened no hospitalization is required, the third no injury or property damage only, that means okay, it goes and hit a small house or some shop or something which got damaged property got damaged, but no injury, no death happened. So, Non-Fatal crash could be major injury crash or grievous injury, minor injury or no injury or just property damage only. Now, let us look at the different techniques which are used for identification of accident blackspots.

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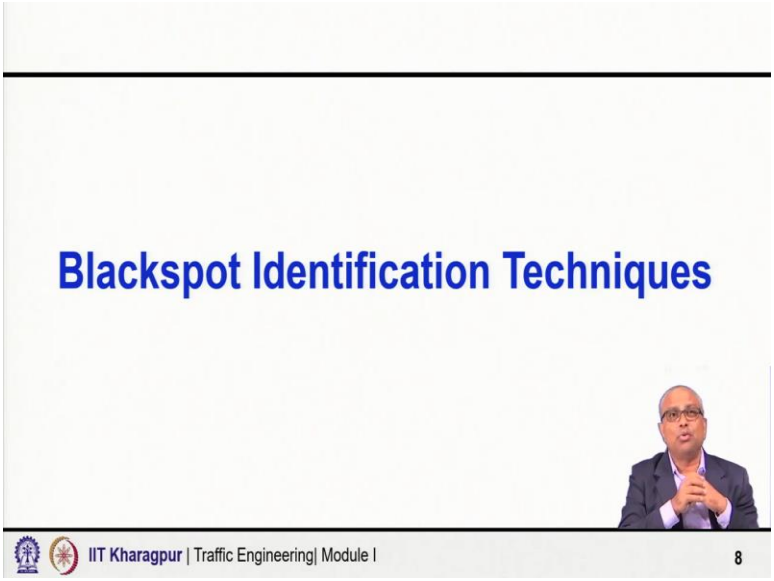

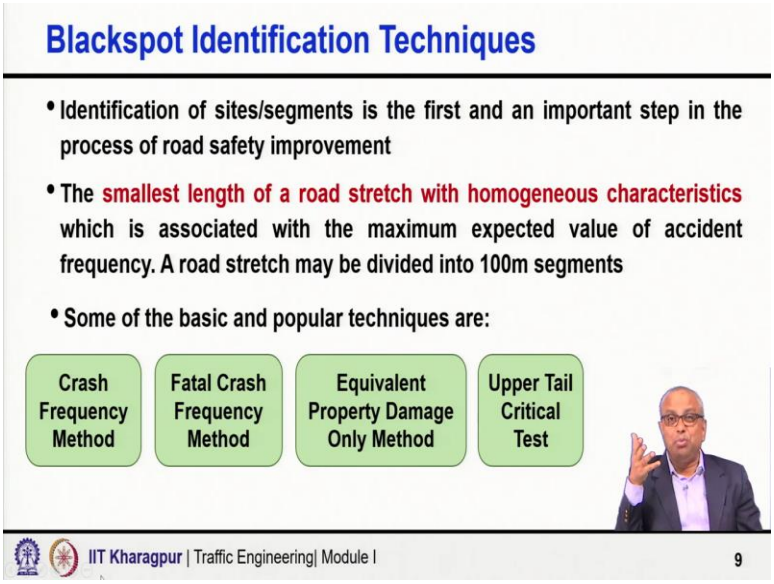

Identification of sites or segment is the first and an important step in the process of the road safety improvement. Based on the data, we want to know where the problem exists, location specific and as I said, that accidents can occur due to or crash can occur due to so many reasons. And these are naturally to be randomly distributed. But do we really find that at some location, distinctly high or higher number of crashes are happening at certain locations as compared to other locations.

That tells you probably there is something wrong with the location or there could be location specific problem which are contributing to so many accidents or so many fatal accidents or so far at certain geographic locations or certain short segments. So, we need to identify those segments

and unless we identify correctly, our treatment and the overall investment will not be able to bring or get maximum benefit out of that investment.

The smallest length of a road stretch with homogeneous characteristics, which is associated with the maximum expected value of accident frequency, and for doing that, we can divide the road stretch into small segments, if you have very good data and you can make it the segment, you can take it in half a kilometer or 500 meters segments or even 1 kilometer segment also.

Be careful and look at the thing at what accuracy the data is available or we put accuracy the database is developed, make things compatible. Now, some of the basic and popular techniques are for identification of black spot, obviously. And these techniques are crash frequency method, fatal crash frequency method, equivalent property damage only method and upper tail critical test method. So, I am going to discuss these 4 techniques very briefly.

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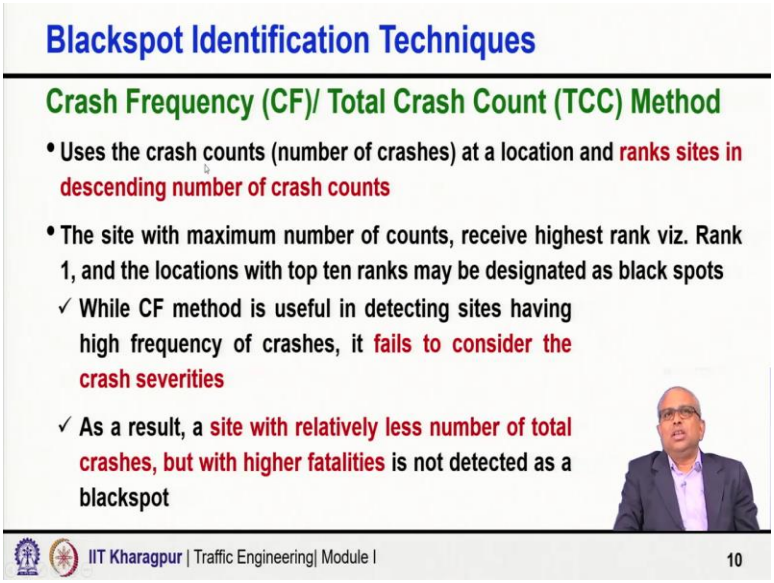

First, crash frequency or total crash count method, it is called safe or TCC method. What we are doing? We are using the crash counts or number of crashes you have divided the roads into a small, homogeneous multiple homogeneous section, for each section we want to see maybe last 3 years, how many total crashes occurred. Somewhere in 5, 0, somewhere 2, 5, 7, 3.

Just look at the total number of crashes that occurred over the last 3 years in each segment. Then, based on the number we simply rank the sites in descending number of crash count. Top Segment or location or segment with the maximum number of crashes in the last 3 years, followed by the next highest, next highest like that.

So, this site with maximum number of counts receives the highest strength that is, we can call it rank 1 and the locations with top 10 ranks when you were taking maybe hundreds of such segments, the top 10 segments you can easily consider as the blackspot or you can consider that the higher numbers are higher in those segments as compared to others.

So, you can maybe top 10 or top 20 such locations you can take. Now, same method or when you are using crash frequency it is useful in detecting sites having high frequency of crashes because total number of crashes you are considering nothing else but then it fails to consider the crash severity because you can always argue that maybe two locations, same number of cases that happening, but in one case, more fatal crashes are happening, so I should have a higher priority to that logically.

So, it fails to consider that aspect because you are using only crash frequency or total crash count, so you are not able to consider the crash severity. So, as a result, a site with relatively less number of total crashes but with higher fatalities may not be detected as the blackspot it will not come in the top five or top 10 or top 20, may come may not come also.

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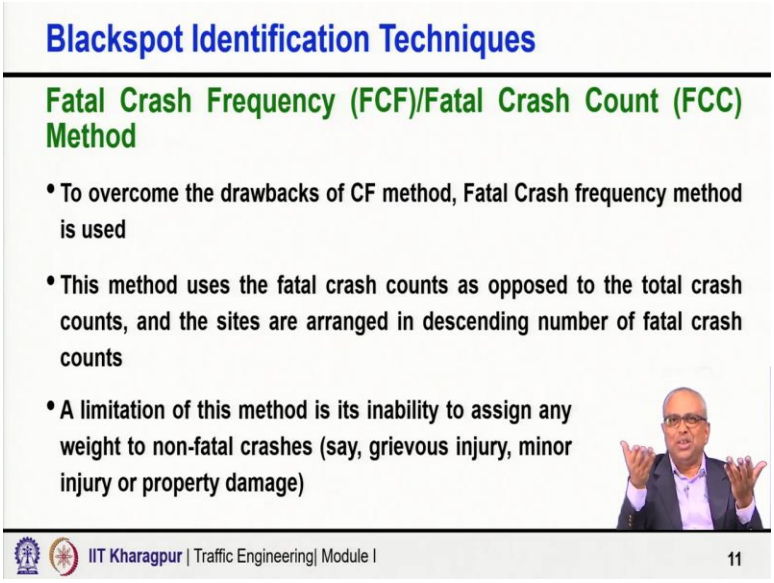

Now, to overcome this difficulty or the drawback, another method is suggested, where we are using fatal crash frequency or fatal crash count instead of total crash count, our crash frequency, we are using fatal crash frequency or fatal crash count. So, only fatal crashes are considered number of fatal crashes. So, this method uses fatal crash counts as opposed to total crash counts and the sites are arranged in descending number of fatal crash counts. Again, this has got a limitation the good thing is yes, fatal crashes are most important, so I am considering that, but I am only considering that nothing else.

So, that means the limitation of this method is its inability to assign any weight to non-fatal crashes I am not assigning any weight to non-fatal crashes I am considering only the fatal crashes, nothing else 0 weightage to non-fatal crashes, grievous injuries, minor injury, property damage I am not at all putting any weightage.

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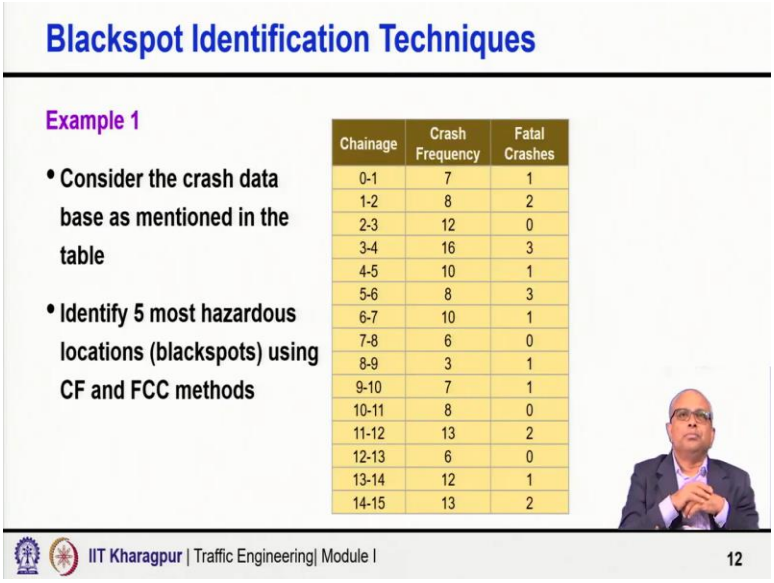

Let us take an example, consider the crash data as given in the table. And identify 5 most hazardous locations or blackspots using crash frequency and fatal crash count methods, safe and efficiency. So, I have both challenge wise here to have taken 1-kilometer segments. So, 0 to 1, 1 to 2, 2 to 3 like that here the data is given up to 15 km every kilometer. The crash frequency is known total number of crashes and the fatal crashes are also known.

So, what I will do, I want to find out blackspot first 5 most hazardous locations using crash frequency. So, based on crash frequency only I will arrange the challenges and identify the top 5, when I want to use FCC method, then based on fatal crashes I will sort the challenges I will arrange the challenges as per the fatal crashes highest number on the top list, lowest number in the bottom and the top 5 challenges I will pick up.

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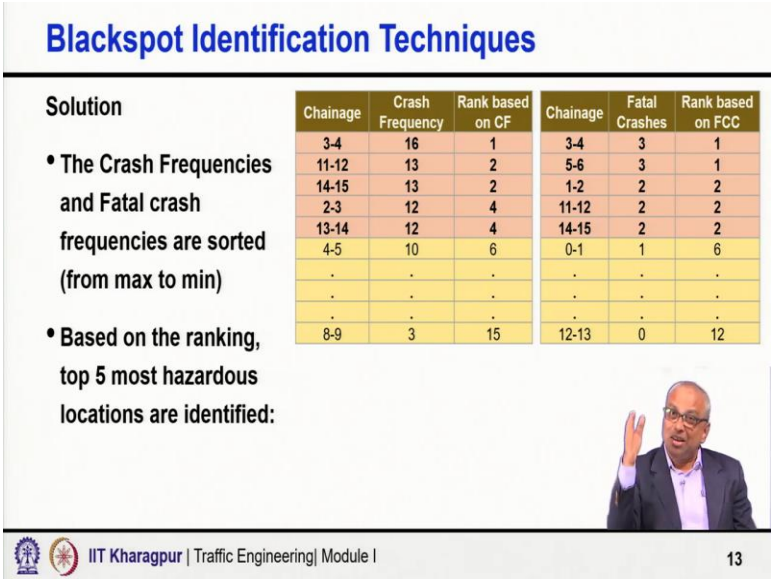

That is what I have done. So, here you can see using the crash frequency, I have sorted out the I have done the sorting. So, chainages 3 to 4, 16 crash frequency, 11 to 12, 13, 14 to 15, 13, 2 to 3, 12, 13 to 14, 12 and so on. So, the first 5 or 6, whatever you want you pick up. When I am using fatal crashes, FCC Fatal Crash Counts, then as per the Fatal Crash Count, we are arranging or we are sorting the challenges, sort the challenges based on this fatal crashes number of fatal crashes and highest on the top, lowest in the bottom.

And accordingly, again take the identified the top chainages 5 chainages or segments high segments. Incidentally, you can see here, maybe it is a coincident but 3 to 4, this challenge it is number one based on crash frequency also number one based on fatal crash count. So, sometimes we use different methods and check that whether the particular chainage is coming again and again, appearing within the first 5 or first 10 depending on how many segments you have.

Whether this some chainages are appearing everywhere that indicates that, no it is not once, but it is coming again and again. A chainage a particular segment got recorded the highest number of crashes also the highest number of fatal crashes. So, that tells you this you must look into it, you must consider this as a blackspot.

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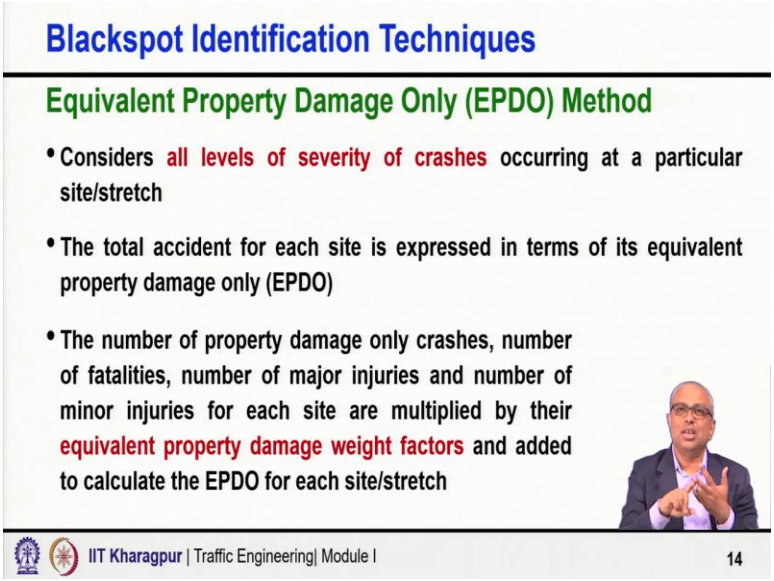

Third, we know the advantage and disadvantage with the first one when I used the total crash count or crash frequency and also, I know the second approach when they used the fatal crash frequency. Now, further improve, I want to consider all types of crashes but I want to give different weightages to fatal crashes, grievous or major injury, minor injury and property damage only, that is what is the method what we call as EPDO, Equivalent Property Damage Only method EPDO.

That means, all crashes we are considering and converting into equivalent number of property damage crashes, as we use the concept of passenger car equivalency or passenger car unit, a bus equal to 3 cars, a light commercial vehicle equal to 2 cars like that, similar kind, similar factors we want to use and convert all types of crashes to an equivalent number of property damage only.

So, consider all levels of severity of crashes occurring at a particular site or stretch the total accident for each site is expressed in terms of equivalent property damage only or EPDO the number of the property damage only crashes number of fatalities, number of major injuries and number of minor injuries for each site are multiplied by their equivalent property damage weight factor, this is something like passenger car equivalency. And then added together to calculate the EPDO for each site or stretch.

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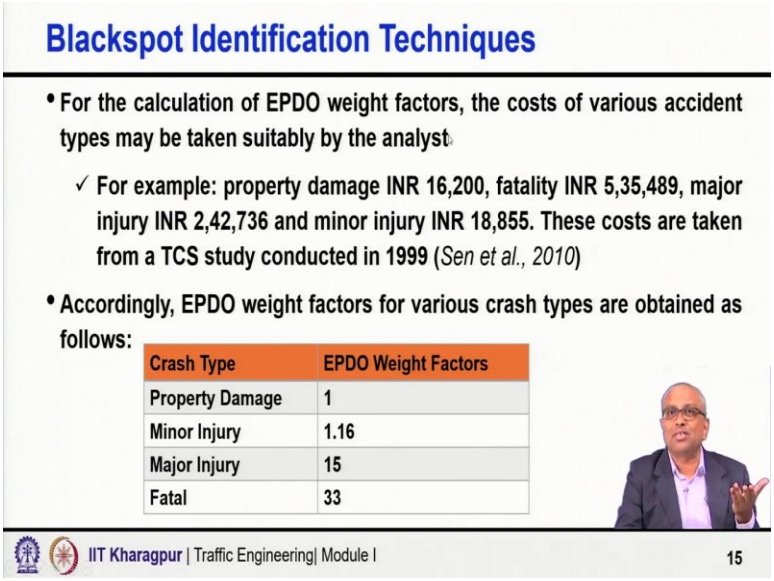

For the calculation of EPDO weight factors, the cost of various accident times may be taken suitably by the analyst on an average, what is the cost? what is the loss due to a property damage crash only. What is the average in economic sense, you can, you know, separate studies required to calculate all this based on the past cases, evidences, interviewing, surveying the people, what is the real economic loss to the family and various factors to consider. It is not like that that we are trying to value the life in terms of money, you cannot value that.

If a fatal crash occurs, it is enormous loss you cannot quantify with equivalent, but it is for the scientific analysis purposes we want to give a lot of weightage to that, so as compared to property damage, we need to understand the, assign a value to that. For example, a study which was carried out by TCS way back in 99, they worked out the cost what is the average cost, property damage, 16,200 Indian rupees.

Compared to that, the fatality is 5 lakh, or 5,35,489. So, 33 times it was taken. So, it was for this purpose that when we are doing the analysis, we want to assign more weightage to fatal, then major, then minor injury and property damage is 1. Convert everything into equivalent property damage only. So, based on this cost estimate it was carried out using a separate dedicated studies, such kind of studies can be done, and based on that, as in the Indian scenario this are the EPDO weight factors which were developed based on this TCS study.

So, property damage 1, minor injury 1.16 major 15, fatal 33. So, every time I am taking a fatal injury is happening, a fatal accident is happening, one person is dying I am putting 33 times higher weightage then an accident or crash where only property damage is happening, that way giving higher weights, obviously highest fatal, then major injury, then minor, then property damage, property damage is taken as the basic unit, or is considered as 1.

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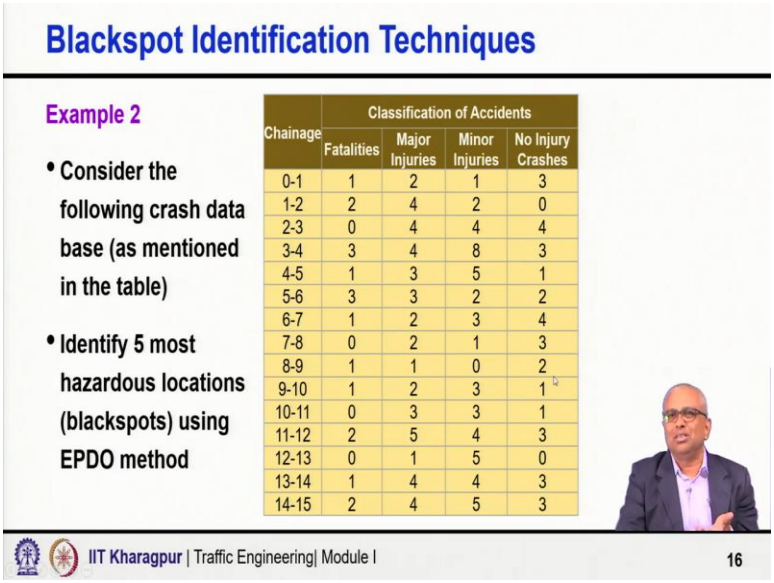

Now, consider the following crash database as given, challenge wise again the fatalities and major injuries, minor injuries, no injury, all are given. So, now if I want to use EPDO method, what I will do?

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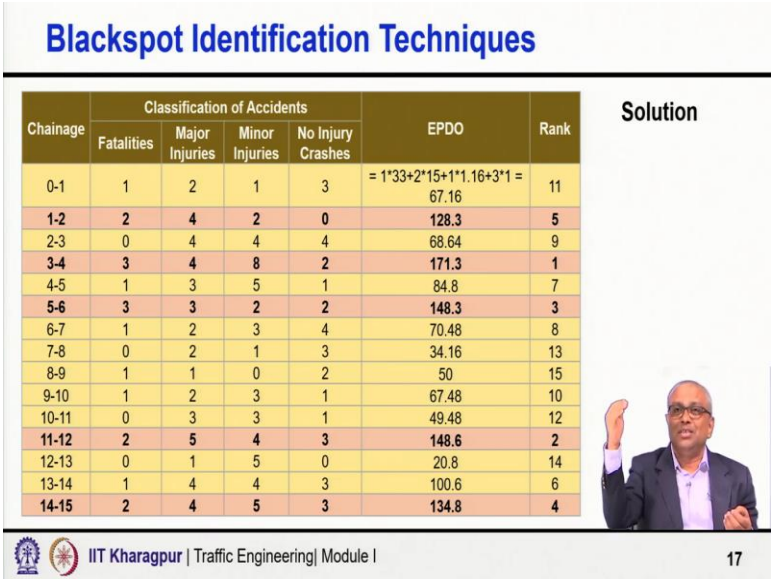

Chainage	Classification of Accidents				EPDO	Rank
	Fatalities	Major Injuries	Minor Injuries	No Injury Crashes		
0-1	1	2	1	3	= 1*33+2*15+1*1.16+3*1 = 67.16	11
1-2	**2**	**4**	**2**	**0**	**128.3**	**5**
2-3	0	4	4	4	68.64	9
3-4	**3**	**4**	**8**	**2**	**171.3**	**1**
4-5	1	3	5	1	84.8	7
5-6	**3**	**3**	**2**	**2**	**148.3**	**3**
6-7	1	2	3	4	70.48	8
7-8	0	2	1	3	34.16	13
8-9	1	1	0	2	50	15
9-10	1	2	3	1	67.48	10
10-11	0	3	3	1	49.48	12
11-12	**2**	**5**	**4**	**3**	**148.6**	**2**
12-13	0	1	5	0	20.8	14
13-14	1	4	4	3	100.6	6
14-15	**2**	**4**	**5**	**3**	**134.8**	**4**

I will do it fatal, let us see that, what I will do? I will take the fatal 1 multiplied by 33 plus 2 major injury multiplied by 15 plus minor injury 1 multiplied by 1.16 plus 3 no injury, that means only property damage, so 3 into 1. So, 67.16. Like that, for every segment, I can calculate the EPDO value and then I will rank the site as per EPDO, the highest will be tough ranked 1, followed by next maximum value and like that I will get the sites number 1, number 2, number 3, number 4, number 5, like that that is what I have done.

And you can see here, 171.3 is the highest value among this this is example problem only 15 challenges 15 segments only we have taken, so out of this 15 maximum value you got 171.3, so that is ranked as 1, followed by next highest is 148.6 to rank as 2, third highest is 148.3 very close, but slightly lesser so ranked as 3, like that the sites are ranked.

So, all types of crashes we are considering, but we are also not giving the same weightage to all crashes, fatal giving higher, then major injury, then minor injury and then, you know one value is assigned to property damage only and everything we are converting to property damage only using factors which are very similar to PCU we have to convert heterogeneous traffic to a stream of equivalent stream of homogeneous traffic similar kind of thing we are doing.

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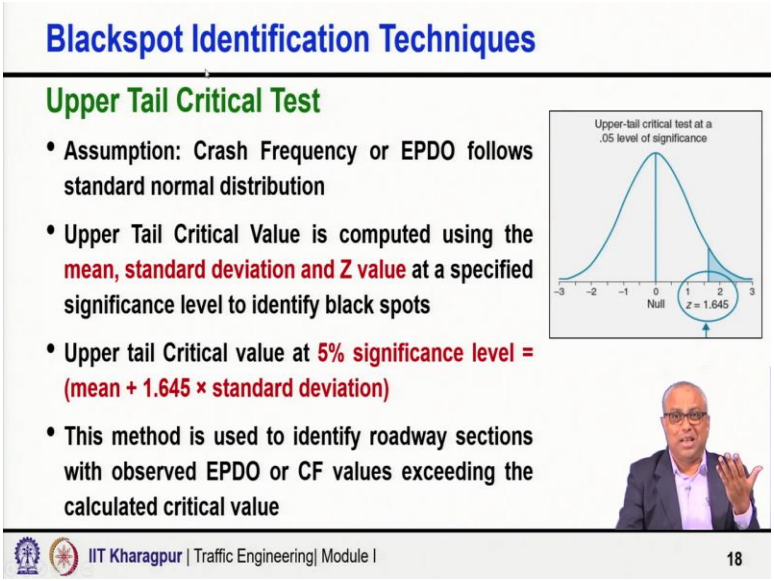

One more method that is also used quite acceptable, even I will say more scientific is the upper tail critical test, what is the assumption here? The crash frequency or EPDO values follows standard normal distribution, every segment you take, the number of crashes or even the EPDO values it is assumed that obviously the it is expressed as random variable.

So, it will follow the crash frequency or EPDO follows standard normal distribution, the normal distribution which is always random and described by a distribution suitable distribution but what is assumed that it is following normal distribution? And then up upper tail critical value is computed using the mean standard deviation and the Z value at a specified significance level for identifying the blackspot.

So, what is the upper tail critical value? Upper tail critical value is mean plus 1.645 into standard deviation. Now, it is 1.64 is the value of Z at 5 percent significance level. So, if you consider the different significance level, you may get a different value here. So, what it so this is the critical value, that means any challenge if having a crash frequency or EPDO value more than the critical value upper tail critical value, then we shall consider that particular segment or location as blackspot. So, that what it is, so this method is used to identify roadway sections with the observed EPDO or CF values exceeding the calculated critical value, and this critical value is upper tail critical value. So, that is what it is.

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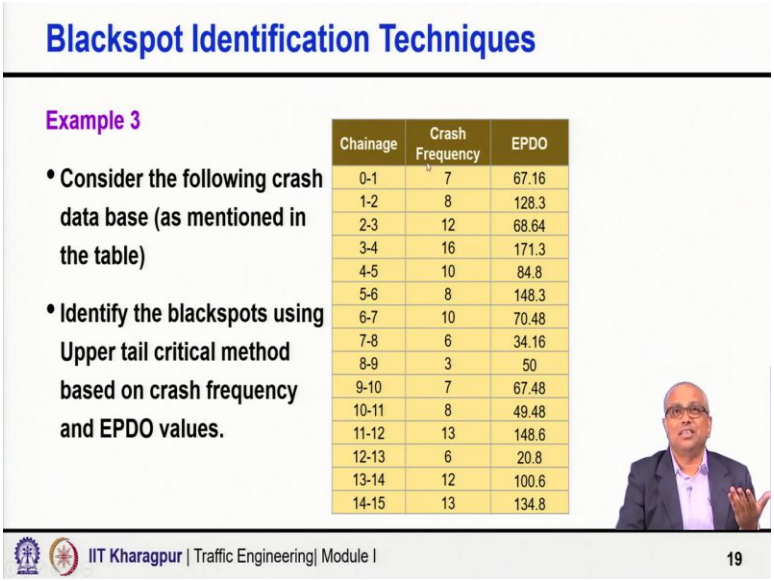

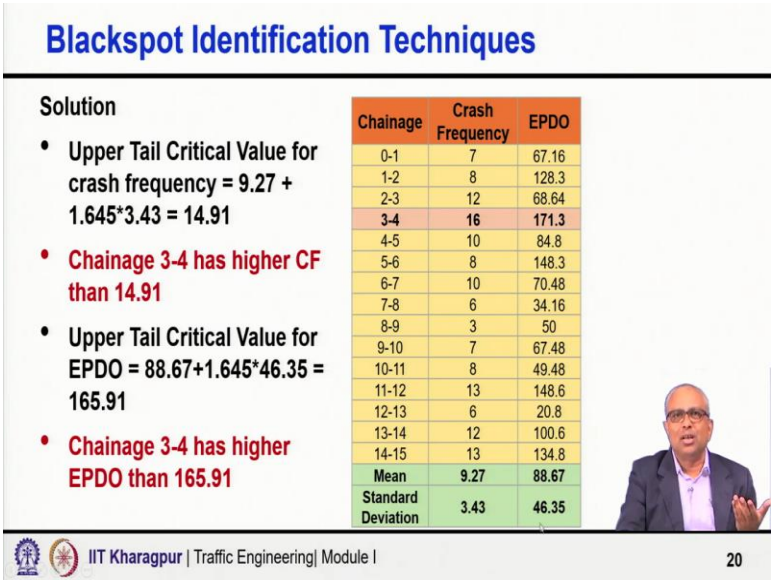

So, if I take an example, suppose the challenges and the crash frequency and EPDO values are known, then I want to use upper tail critical test method. So, simply I am calculating the mean and standard deviation in the case of crash frequency and also with the EPDO column and then I am calculating the upper tail critical value for crash frequency, which is what average is mean 9.27 standard deviation is 3.43, so 1.645, into 3.40 that is 14.91, and upper tail critical value for the considering the EPDO values mean is 88.67 plus standard deviation is 46.35 so 1.645 into 46.345.

So, you are getting actually 165.91. So, now I will search, let us say, crash frequency whether I have got any value, which is more than 14.91. And you can find we have got only one location where the crash frequency is higher than the upper tail critical value. So, only that will be recognized as the blackspot, no other location.

Similarly, if I look at the upper tail critical value for EPDO, it is 165.91, so I have to look at this column and see whether I have got any segment where this EPDO value is more than 165.91. And I find again 3 to 4, that is the only blackspot and incidentally this case probably is the same date, I do not remember.

So, this challenge 3 to 4 or this segment is the identified as the blackspot based on the crash frequency and also EPDO when we are using the upper tail critical test. So, there must be something wrong here, we should then in the next stage of work when we say that what we do and how we do, we should investigate further that location we have identified now and then try to get the of the counter measured.

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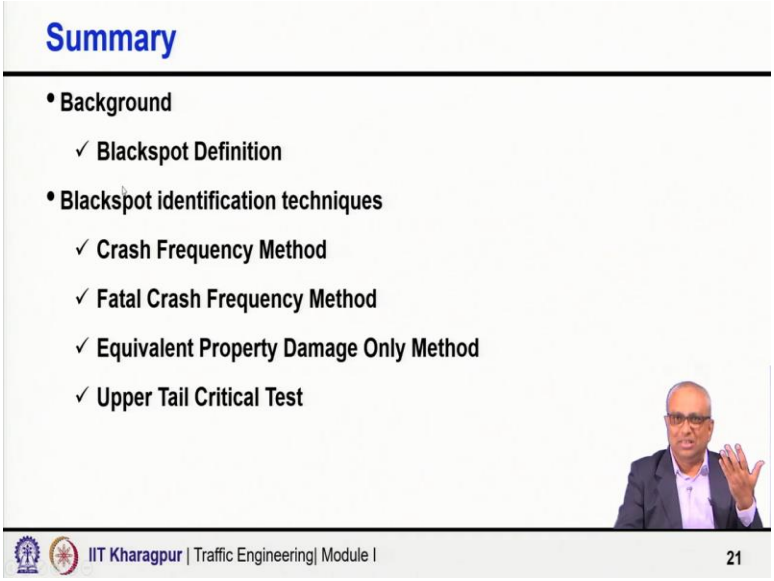

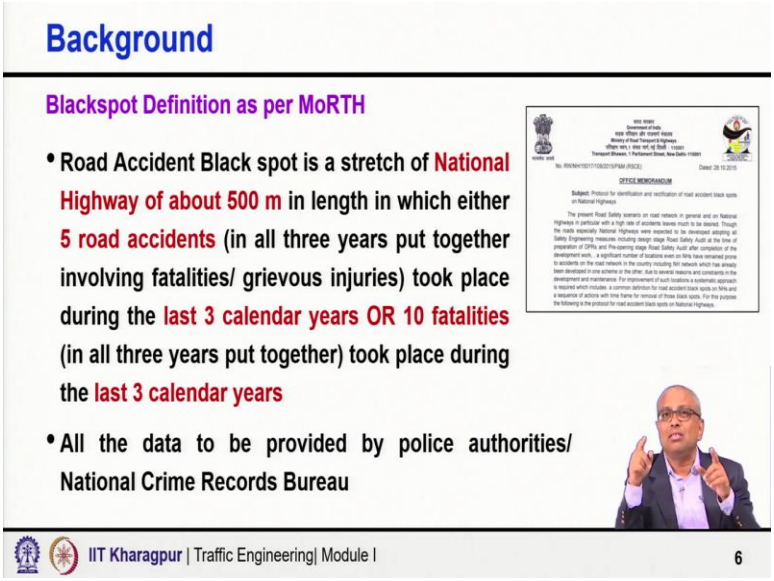

So, what I discussed in this lecture, I told you what, why we need to identify blackspot, how the blackspot is generally defined I will say again the proper definition is where statistically more number of crashes are fatal, total, EPDO whatever, we say more number of statistically higher number of crashes are happening as compared to other locations.

But then there are, you know, other definitions as well people use crash frequency method, people use fatal crash frequency method, people use equivalent property damage only method and simply rank the side and take depending on how many sites segments you have 100, 200, 50 and then accordingly they decide first top 5, top 40, top 20 locations that also people do upper tail critical test is more statistically we are trying to see that 5 percent significance level what is the with five percent significance level, what is the value of critical value, upper tail critical value considering the mean and standard deviation.

So, that way also we do very scientific and also there could be absolute thing, like the MORTH Ministry of Road Transport and Highways and as it says, let us go back to that slide once again before I close that five road accidents in the last three years and these are accidents of what type involving either fatal or grievous injury, either fatality or grievous injury or altogether 10 fatalities occur based on the last 3 years data.

But there are always alternative things, as you know, then you can say all road types are same? No, different traffic road will have different volume, different tenants, divided road, undivided

road, depending on volume, depending on type of vehicle so many variations are possible. So, I am sure you know, further and further works will happen and we will come out with maybe even more rational way of quantifying the blackspots. With this, I close this lecture, so thank you so much.