Introduction to Multimodal Urban Transportation System

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Lecture - 34
Non-Motorized Transportation (NMT) Planning- Bicycle Facilities and Level of Service (BLOS)

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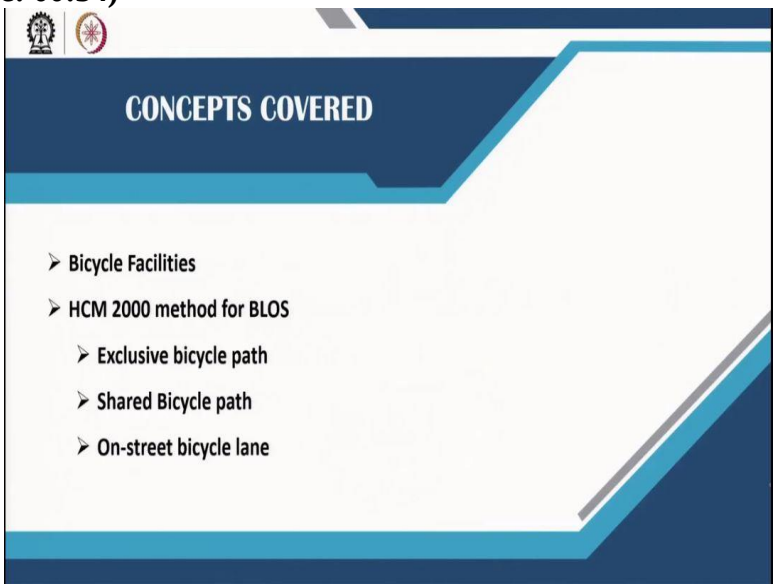

Welcome back friends! In this lecture we are going to now introduce you to the bicycle facilities and how to measure the level of service of bicycles. We have already looked at how to determine the level of service of pedestrian facilities and sidewalks in an urban area. Now, we are going to introduce you to the different bicycle facilities and how do you measure the level of service using the HCM 2000 method. This is a little bit older method but will expose you to this method, because of its ease of calculation so that you understand what the concepts are, and once you understand them, we might expose you to methods later that is in HCM 2010 as well. We are going to tell you how to develop level of service for exclusive bicycle paths, for shared bicycle paths and also for on street bicycle lanes. These are usually the three different categories of bicycle facilities for which the level of service will be shown.

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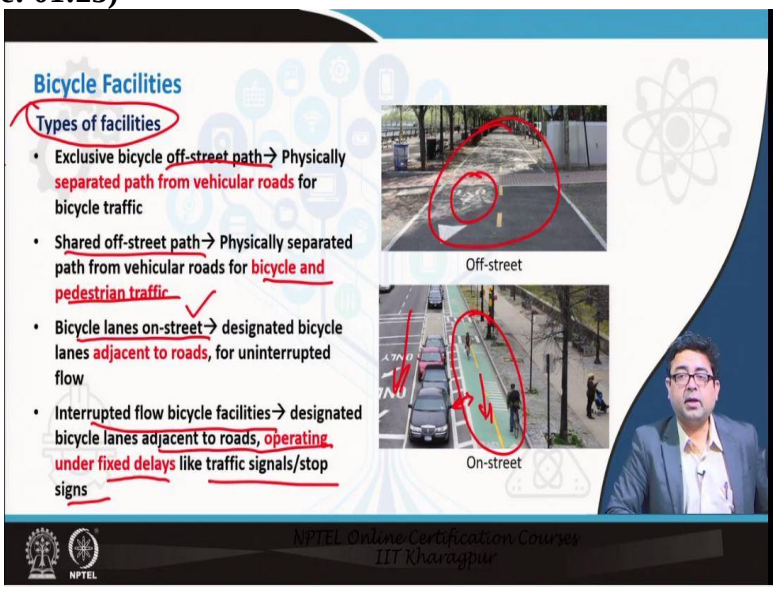

So when we talk about bicycle facilities these are usually modern facilities that we are talking about. We have been riding bicycles for many years now but we never had facilities that are dedicated to bicyclists. We always used to ride along with the traffic and so the quality of the pavement and the volume of the vehicles on the right of way, used to determine what level of service is provided to the bicyclist. But now whether there are dedicated bicycle paths that are dedicated bicycle lanes on the right of way, there are newer methods of determining how level of services are calculated when we talk about exclusive off street bicycle paths. What we usually mean is that they are physically separated paths from regular roads and they are only for bicycle traffic. You might have seen some such facilities where no other traffic that is allowed other than bicycles. So they are called exclusive bicycle off street paths. There could be shared off street paths where bicycle and pedestrian traffic can share the same route so if this is only bicycle by that symbol that is shown, that there could be shared paths as well, where bicyclists and pedestrians can share the same path. Then there are bicycle lanes on the street so these are examples of bicycle lanes on the street where you have these that are depicted by a different pavement colour. Here in this case it is green, it may be red or it may be some other colour but it is somehow demarcating the bicycle route from the regular traffic route. So there is some kind of a demarcation saying that bicycles can take that route so they are called bicycle lanes, on-street. Then there are interrupted bicycle flow facilities which are designated bicycle lanes adjacent to roads operating under fixed delays like traffic signals and stops so these are more regular facilities that are along with the bicycle tracks. There is no physical separation between

these two they may be along with the regular traffic, so they may be on the road along with the regular traffic and are interrupted just as other traffic is interrupting so essentially these are the different categories or types of bicycle facilities.

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In India also we have these facilities that are coming up; either they are coloured in red in Daman & Diu and sometimes in green. Ahmedabad has some dedicated bicycle lanes segregated from the main traffic and so has Pune. So these are some of the urban areas which are seeing dedicated bicycle facilities which are helping the safety and helping in the operations of the general traffic lanes as well. So now there are fewer slower moving vehicles on the regular traffic lanes, the congestion is reducing on those lanes and by providing such dedicated facilities for bicyclists they are improving their safety as well.

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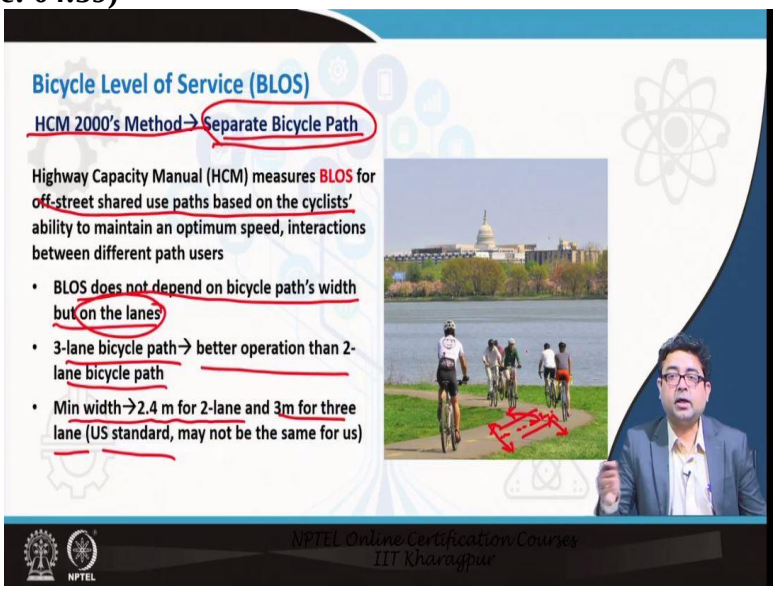

HCM, which is the highway capacity manual developed in the United States, develops a level of service method for separate bicycle paths, which are only for bicyclists. There cannot be any other types of users on that facility not even pedestrians so they are they are off street. They could be shared-use as well, they could be for pedestrians but they could be only for bicycles as well. So, BLOS does not depend on the path's width but on the lane. What the method says is that it does not depend on the width of this but it actually depends on whether it is demarcated into 2 lanes or not. So that is one of the important criteria in understanding or in developing the bicycle level of service for shared use paths or for dedicated bicycle lanes. Three lane bicycle paths has better operation than 2 lane bicycle paths because what the third lane or the centre lane does is it allows fast moving bicycles to overtake slow moving bicycles. Just like in the regular traffic lanes you have cars or vehicles that want to move faster versus cars and traffic that wants to move slower, so always the faster moving traffic wants to overtake. So in case you can provide a third bicycle lane in your dedicated facility that helps in the manoeuvring of the fast moving and slow moving vehicles and in turn provides better level of service. HCM 2000 says that a minimum of 2.4 meter for a 2 lanes and 3 meter for a 3 lane should be used. Again, these are USA standards so we can have our own standards in India as well based on our conditions, bicycling behaviour and available space in our urban areas. But the point to remember is you have to set a standard width. The width has to be there but within that width the more important thing is you have to have dedicated lanes or you have to have demarcated lanes. These lanes help in understanding or in dividing the bicycle traffic into upstream and

downstream or one way and the other way. So you can demarcate bicyclist going in the up direction, which can go in one lane, and in the down direction can go in other lane, and if you can provide a third lane which allows the overtaking, that is even better.

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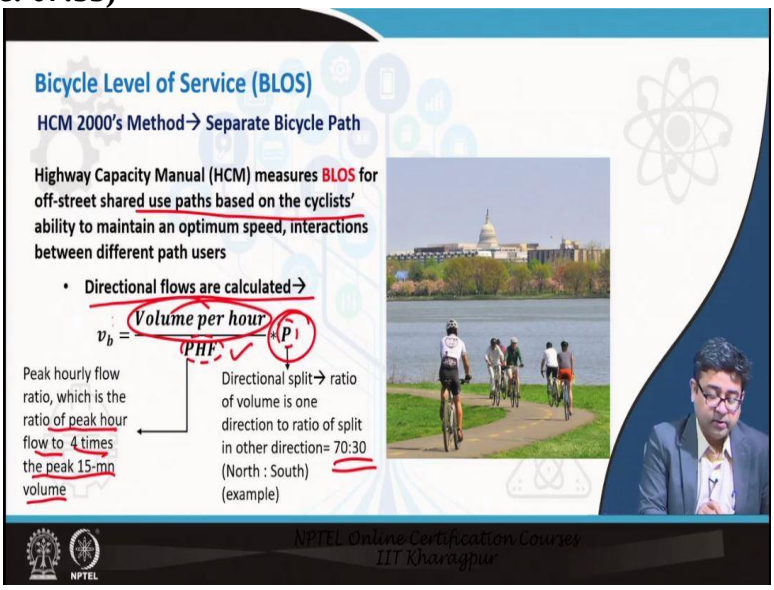

So in measuring the bicycle level of service for off –street paths, the first step in this method is to determine the directional flows. The directional flows are nothing but volume per hour divided by the peak hour factor.

$$v_b = \frac{Volume\ per\ hour}{PHF} * P$$

We have already told you what the peak hour factor is, because the flow rate peak or flow ratio which is the ratio of the peak hour flow to 4 times the peak 15 minute volume. In 1 hour and within an hour there may be times when the bicycle flows in peaks and when there are times when there have, off-peak, lesser peaks. So peak hour flow is nothing but the ratio of the peak hour flow to 4 times the peak 15 minutes so if you know the peak 15 minutes and you will know we have multiplied by 4 times that will give you the entire hour. And then you divided by the peak hour flow so that gives you the peak hour factor. You multiply the volume by peak hour factor by the directional split, i.e., the ratio of the split in north-south direction. That is why 2 lanes are given so if you multiply it by the directional split for the 70-30 or 60-40 whatever it is 0.6 or 0.7 that will give you the directional flow.

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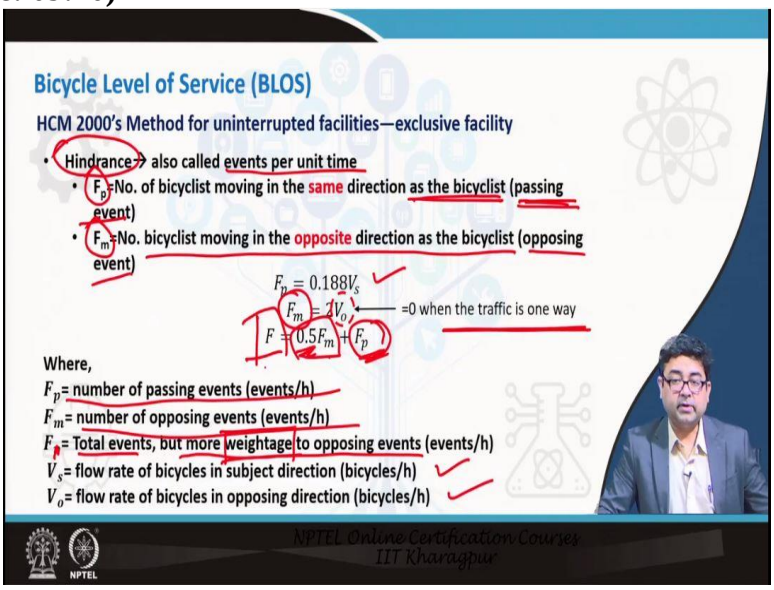

The first thing the highway capacity manual tells you to calculate, is what is the hindrance faced by these bicyclists? They have coined this term called hindrance, which are also called events per unit time. So what are these events, it is the number of bicyclists that are passing or the number of bicycles that are opposing you as a bicyclist.

$$F_p = 0.188V_s$$

$$F_m = 2V_o$$

$$F = 0.5F_m + F_p$$

So these two are given by F_p and F_m so, what F_p says is the number of bicycles moving in the same direction as the bicyclist. If you are riding your bicycle and the number of bicycles that are riding in the same direction, this is called a passing events. So you may have to either overtake or may have to pass them, so that is a type of an event. So you are confronted by another bicyclist whom you have to pass or overtake, that is an event. The other type of event is number of bicycles moving in the opposite direction as the bicyclist. Now suddenly if there is a bicycle coming in the opposite direction that is also an event. You have to be careful to manoeuvre safely away from the bicyclist that is coming in the opposite direction. So these are the 2 events on which the bicycle level of service depends upon. So it says that the first event is the passing event is given by 0.188 times V_s where V_s is volumes per hour and the second event is called the F_m, which is in the opposite direction and is 2 times V_o. But $V_o = 0$ when the traffic

is one way. So if both lanes are going in one direction, there is no point of calculating the opposing events because it has no bicycles, so V_o is the flow rate of bicycles in the opposing direction whereas V_s is the flow rate of bicycles in the subject direction, and you already know how to calculate flow rates. So if you know the number of passing events and the number of opposing events, then the total events F is given by 0.5 times $F_m + F_p$. If you know the total events, then weightage is given to opposing events because it has been noticed in the field that it is only when there are large number of opposing bicyclists that you encounter, that your level of service goes down. You will see how level of service is measured eventually. But it has been noticed that when there are lot of opposing traffic or opposing bicyclists in your direction of travel then you tend to be riding slower, you feel uncomfortable, you feel unsafe. So that is why the weightage to the opposing traffic is even higher, whereas F_p that is the number of passing events has a lower rate so it is 0.5 times $F_m + F_p$ will give you the total events.

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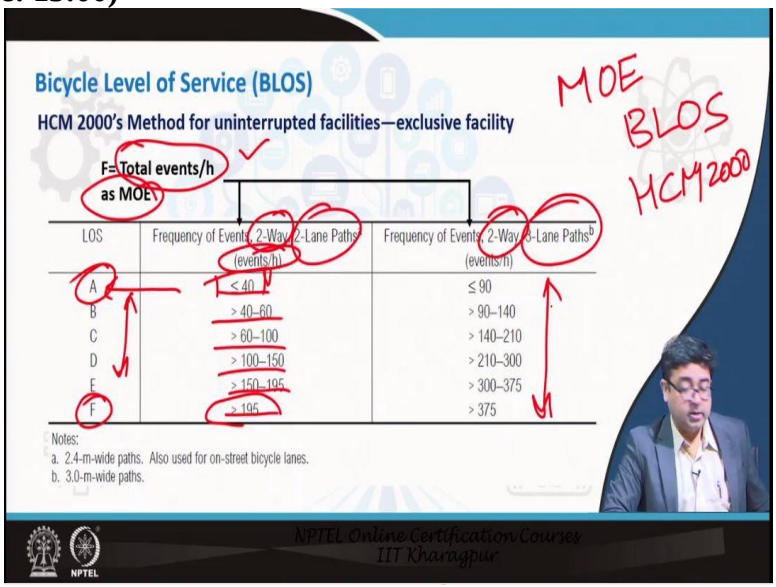

Now these total events per hour are then categorized into different levels and each of these levels are associated with a letter grade, which gives you eventually the bicycle level of service. So the measure of effectiveness or the MOE for the bicycle level of service is the total events per hour. So if anybody asks you what is the measure of effectiveness of bicycle level of service as per Highway Capacity Manual 2000? You have to remember that it is total events per hour so if it is a 2 way 2 lane path so 2 lanes and in both it is a 2 way path then if you have less than 40 such events per hour then you are at a level of service A, whereas if you have >195 we are at

a poor level of service and in between all of these are classified. Similarly, for a 2 way 3 lane path your values of total events per hour are given here.

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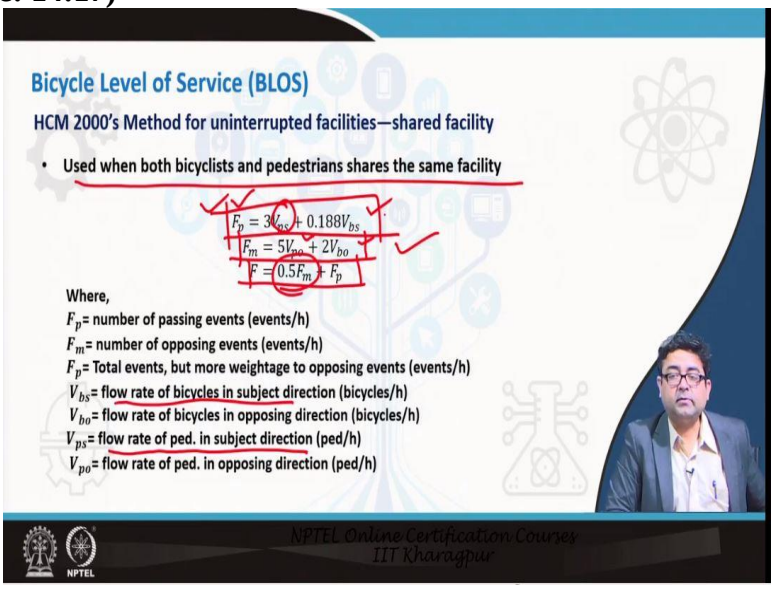

When both bicyclists and pedestrians share the path now, then in that case you are passing events are given by given by this formula, your opposing events are given by this formula, and again your total events, where your opposing events have a greater weightage, are given by this formula.

$$F_p = 3V_{ps} + 0.188V_{bs}$$

$$F_m = 5V_{po} + 2V_{bo}$$

$$F = 0.5F_m + F_p$$

So what this tells you is that for the passing events now you have something called V_{ps} as well. V_{ps} is nothing but the flow rate of pedestrians in the subject direction, we already have told you how to calculate flow rate of bicycles and you have to calculate the flow rate of pedestrians in a similar manner so the formula is 3 times the flow rate of pedestrians plus 0.18 times the flow rate of bicyclists which will give you the number of events in the passing direction. And similarly, number of events in the opposing direction will be given by 5 times the flow rate of the pedestrians plus 2 times the rate of the bicyclist. Simple enough, so the highway capacity manual 2000 was the first attempt at developing such levels of service for bicycles, so the calculations were very simple but this idea of incorporating the number of events which is passing events or opposing events was first introduced in the highway capacity manual the later

iterations of the highway capacity manual has further improved them. IndoHCM has still not incorporated the bicycle level of service but we hope to do in our next versions, as more and more such dedicated bicycle facilities are developed in our country we also hope to develop the bicycle levels of service.

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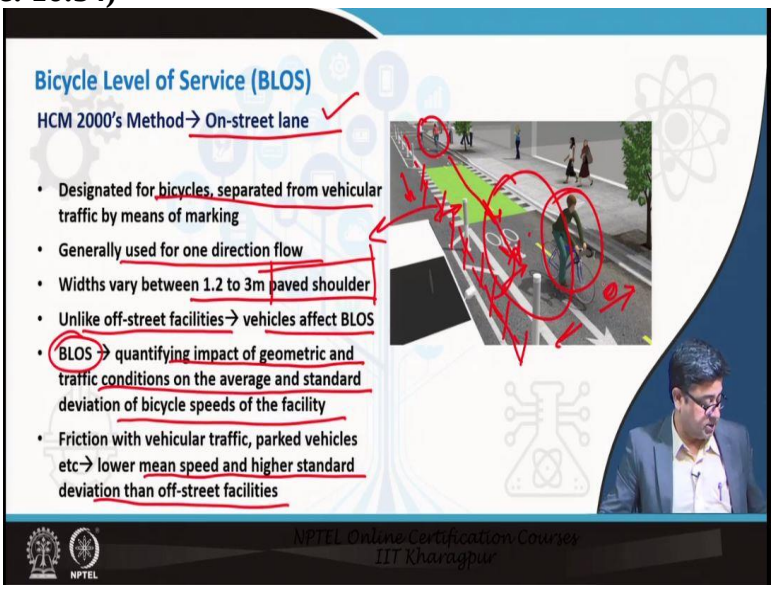

Similarly the table is given here for shared facilities. The third type of facility is the on street lane. So you can have bicycle lanes on-street, but somehow demarcated from the traffic lanes, and designated for bicycles, are generally used for one directional flow. So since they are on the street as well so you may have one direction here and you may have another direction on the other side of the street, where the regular traffic is also flowing. The picture here shows bi-directional on street bicycle traffic lane, but you may have one direction on one side and the other direction in a completely different side, which may vary from 1.2 to 3 meters but the important thing to remember is if you have a paved shoulder, and that paved shoulder can be easily demarcated as a bicycle lane. Unlike off street facilities, vehicles do affect the bicycle level of service in this case of facilities. So, there is an impact, although it is segregated from the vehicular traffic, but since they are at the same grade, there is some impact of these moving vehicles on the level of service of bicycles. Quantifying impact of geometric and traffic conditions on the average and standard deviation of bicycle speeds of the facility. So when you are developing the BLOS for on-street lanes you have to look at the impact the geometry and the traffic conditions have on the average and standard deviation of the bicycle speeds. Friction with vehicular traffic and parked vehicles. So if there is a regular parking lane here, so it causes

some friction with the bicyclists. Maybe this car has parked and now they open the door to get inside, so opening this door always makes the life of a bicyclist very difficult because he or she may get hit by that open door. That causes a lot of friction and that friction also lowers the mean speed and higher standard deviation is seen in the speeds of on-street bicycle lanes.

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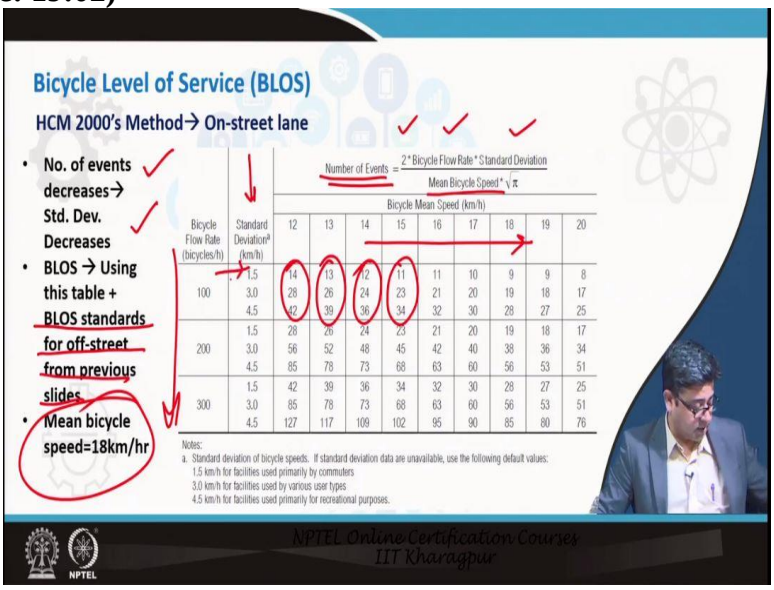

So here you can see again the number of events is the measures of effectiveness, bicycle flow rate given here, the standard deviations are given here, and the mean speeds are given here.

$$\text{Number of Events} = \frac{2 * \text{Bicycle Flow Rate} * \text{Standard Deviation}}{\text{Mean Bicycle Speed} * \sqrt{\pi}}$$

Number of events in this case is given by 2 times the bicycle flow rate times the standard deviation divided by the mean bicycle speed times the square root of Π. That is a formula to determine the number of events. So as the number of events decreases the standard deviation also decreases and the bicycle level of service uses this table plus the BLOS standards for the off street from the previous slides, and the mean bicycle speed of 18 kilometres per hour is considered. So these are all values of number of events that take place for such kind of flow rate and that standard deviation.

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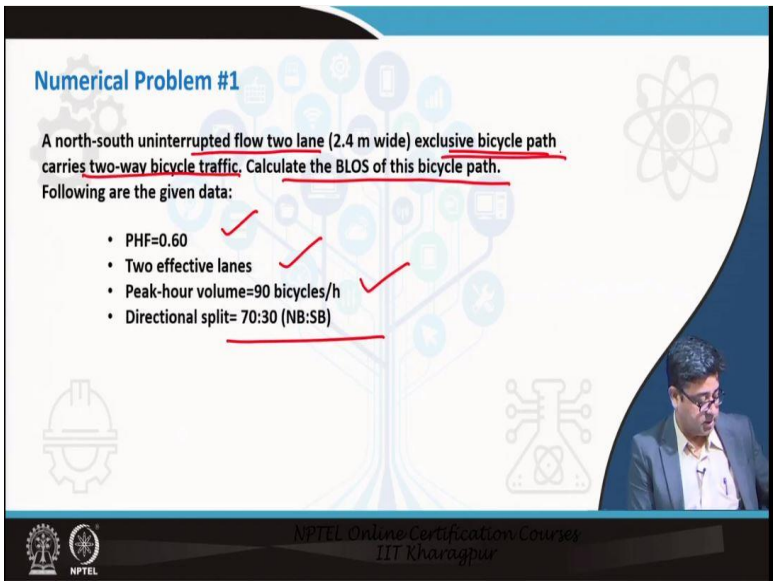

We will give you an example and it will be easier for you to follow. The first example says in a north-south uninterrupted flow, 2 lane exclusive bicycle path carries 2 way bicycle traffic. Calculate the BLOS for this bicycle path given the following data, the peak hour factor is 0.6, 2 lanes, peak hour flow is 90 bicycles per hour, the directional split is 70-30. So what do you know about it is it is an uninterrupted flow of 2 lanes exclusive bicycle path.

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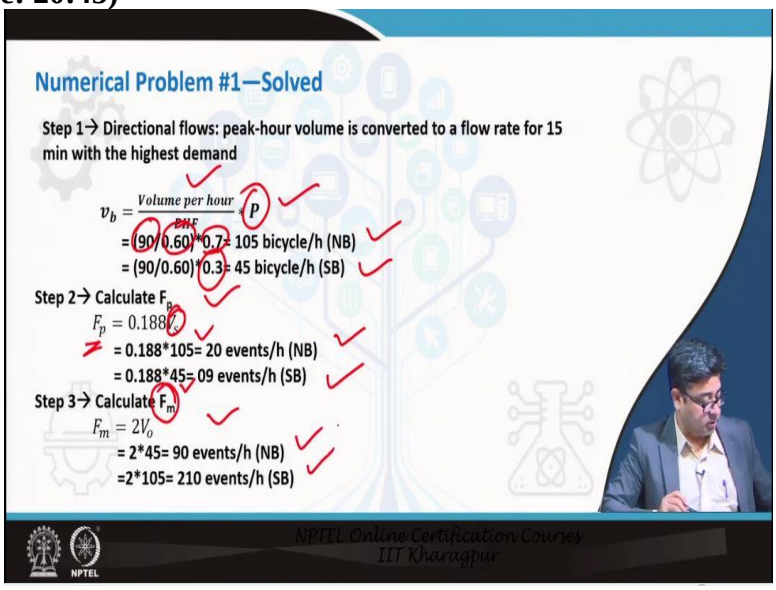

So for the exclusive bicycle paths you know that to calculate F_p and F_m however first you need to know the directional flows. In order to know the directional flows you know the peak hour which is 90, you already know the peak hour factor and you know the directional split so

northbound is 70. Then southbound is 30. So you can calculate flow rates which are northbound and southbound and using those flow rates you can calculate the F_p for northbound and F_p for southbound. So when you are using the V_s you are using the 105 for northbound and 45 for southbound. Similarly for F_m you can calculate for northbound and southbound and then.

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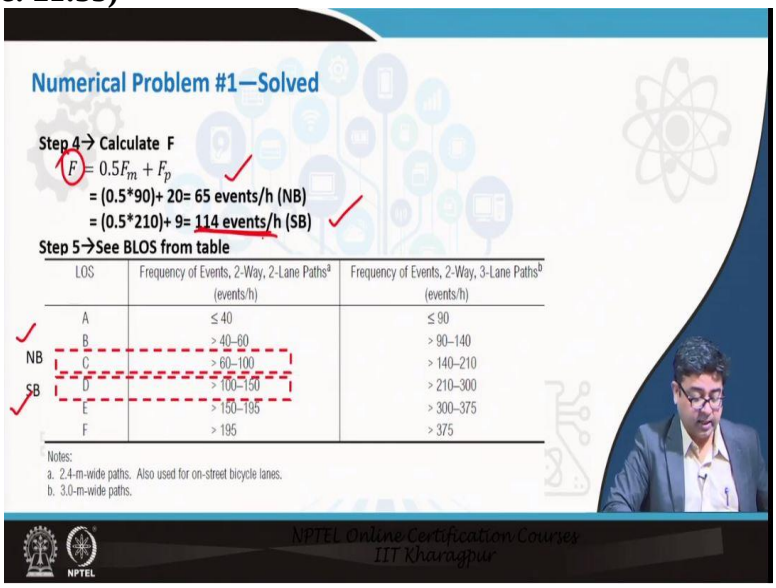

You can sum it up, measure the total events which are 65 events per hour in the northbound and 114 events per hour in the southbound so the northbound and southbound have 2 different levels of service where you see that the southbound is has a poor level of service because it has higher events per hour than it is facing so you can even know it per direction. So if you have bi directional flows you can even know the level of service in 2 different directions.

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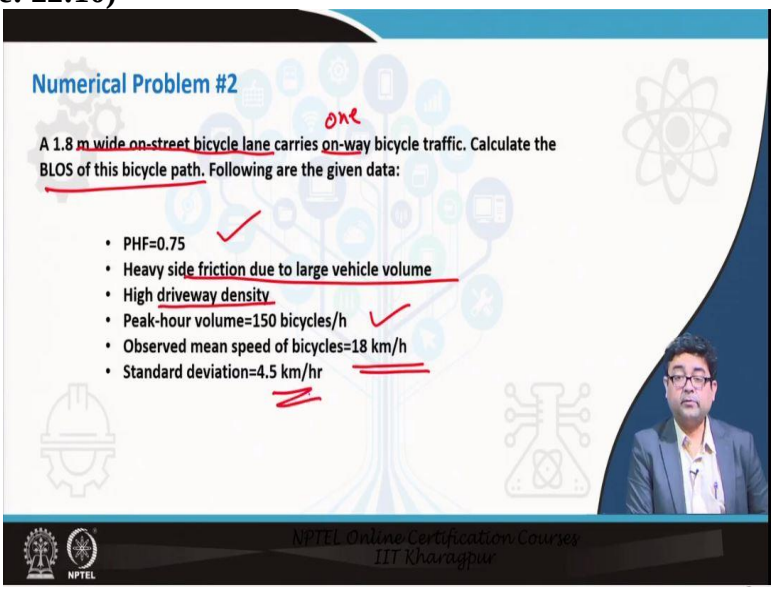

The second example is a 1.8 meter wide onstreet bicycle lane which carries 1-way bicycle traffic. Now if you have to calculate the bicycle BLOS given the following factors, let us see how we can do it. You know the peak hour factor given is 0.75 that is heavy side friction due to large vehicular volume. There is high driveway density, means a lot of land uses that have access points to the main road which will interrupt the bicycle flow as well. Peak hour volume is 150 bicycles per hour, mean speed of bicycle is 18 kilometres per hour and the standard deviation is 4.5 kilometres per hour.

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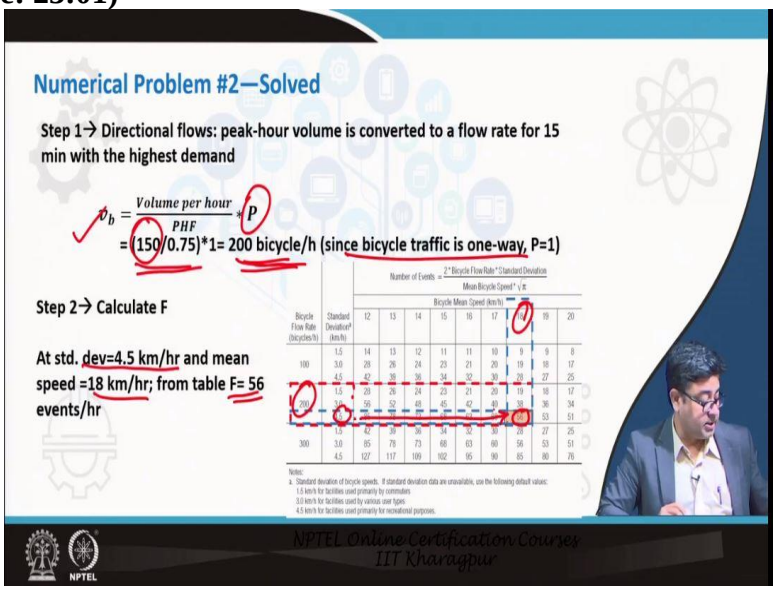

So since it is a one-way bicycle lane, P will be equal to 1, so when you calculate the peak hour volume, it is converted in directional flows by just dividing this by the peak hour factor. You know that it is 200 bicycles per hour and given the standard deviation of 4.5 kilometres per hour and speed of 18 kilometres per hour from the table you know that is 200 here and the standard deviation is 4.5 so within 200 you can have different standard deviations you pick the 4.5 and go here. So this will be the total number of events which is 56.

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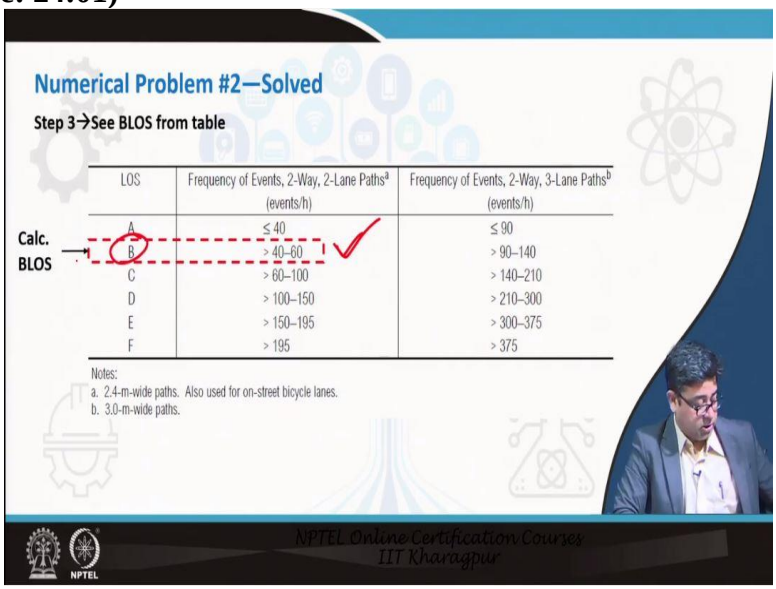

So if you have the total number of events as 56 and you can go back to your standard table and you can know that the level of service of that on street facility is B.

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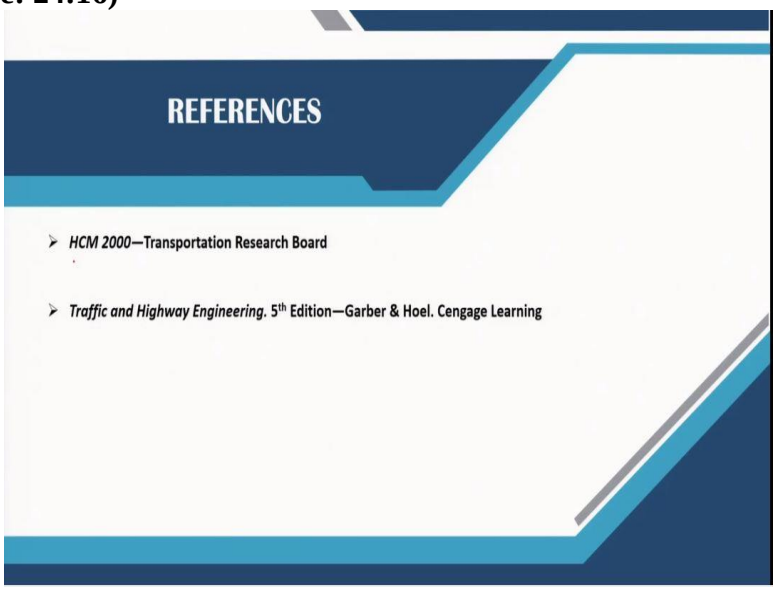

So that is how you measure the level of service of on-street facilities as well as have protected bicycle lanes that can be either exclusive to bicycles or can be shared with pedestrians as well. So we have shown you 3 different types of facilities and how do you calculate the bicycle level of service for these 3 different facilities using the highway capacity manual 2000 methodology. Here are some references for it.

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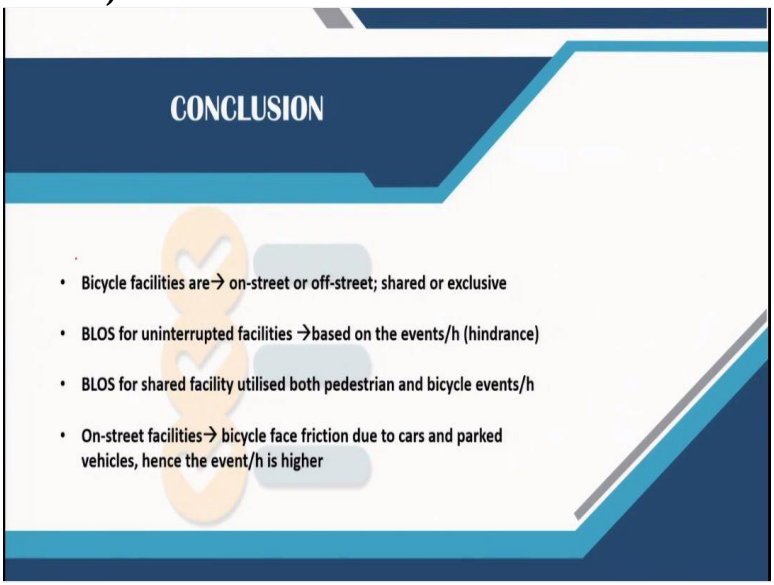

In conclusion, what we have looked at is bicycle level of service depends upon the hindrance faced by the bicyclist, so that is the terminology you have to remember. The measure of effectiveness of bicycle level of service as per highway capacity manual 2000 is given by the number of events per hour. They could be passing events or they could be opposing events, which is the basic thing you have to keep in mind. Thank you.