Introduction to Multimodal Urban Transportation Systems
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Lecture -30
Non-Motorized Transportation (NMT) Planning: Pedestrian Level of Service (PLOS) based on Flow Models

Welcome back friends. So in the last lecture we looked at all the different macroscopic pedestrian flow models and their applications for different type of pedestrian facilities. And in this lecture we will now look how the pedestrian level of service measures developed based on all those flow models.

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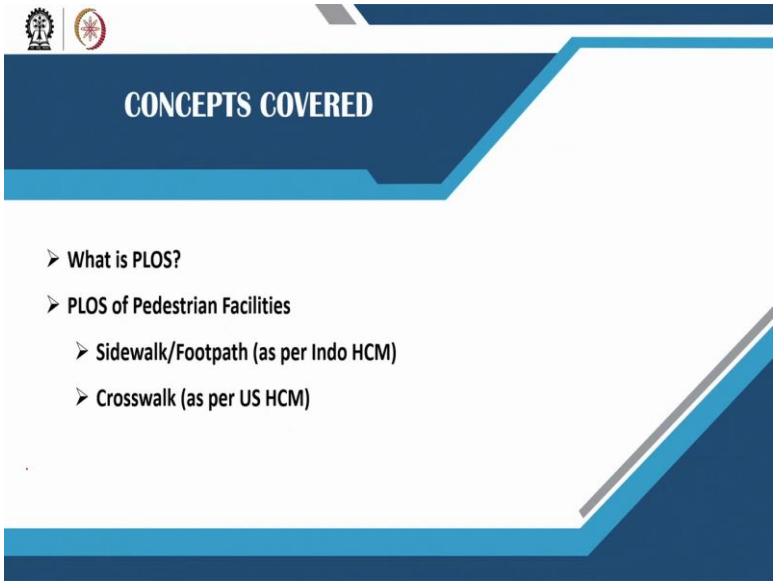

So in this lecture we will introduce you to the concept of pedestrian level of service or PLOS and we will show how PLOS is developed for two specific facilities, one is the sidewalk or the footpath, and the other is the crosswalk.

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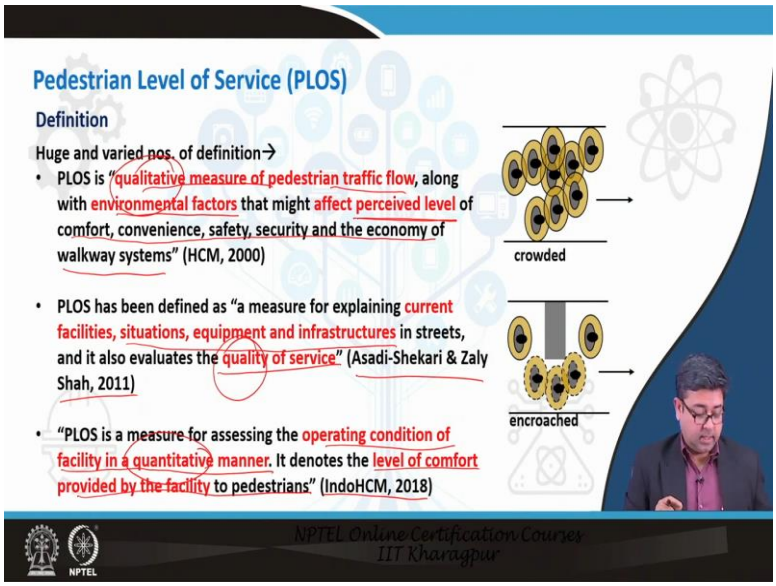

So when we say pedestrian level of service they have varied definitions, different researchers have given different definitions. However, if you look at the key words which are highlighted in red, you can see that it effectively is a qualitative measure of pedestrian traffic flow along with environmental factors that might affect the perceived level of comfort, convenience, safety, security and the economy of walkways. This is kind of the overarching theme in a pedestrian level of service. Qualitative measure of pedestrian traffic flow along with environmental factors that might affect the perceived level of comfort. So for many centuries we have just provided for sidewalks, or even for that matter the roads, and we have looked at it only from the point of view of engineering or design perspective. Only in the recent past decade or two decades or so in India we have started to think about what is the uses' perspective and how do we take into account the users' perspective while building these facilities because the public facilities that are being built are actually for the users. So how do we take them or their perception into account while we are building these facilities and PLOS is one such measure that takes their perception into account. Similarly, other researchers such as Zaly and Shah have also defined PLOS as a measure for explaining current facilities situations and equipment of infrastructure in streets also evaluates the quality of service, so you would see that everybody kind of has the word quality or qualitative in their level of service definition. Finally, the IndoHCM which was the most recent document that has come out in India. It defines PLOS as a measure for assessing the operating condition of a facility in a quantitative manner. It denotes the level of

comfort provided by the facility to pedestrians. So now the IndoHCM is saying that they have developed a quantitative mechanism for developing PLOS in India.

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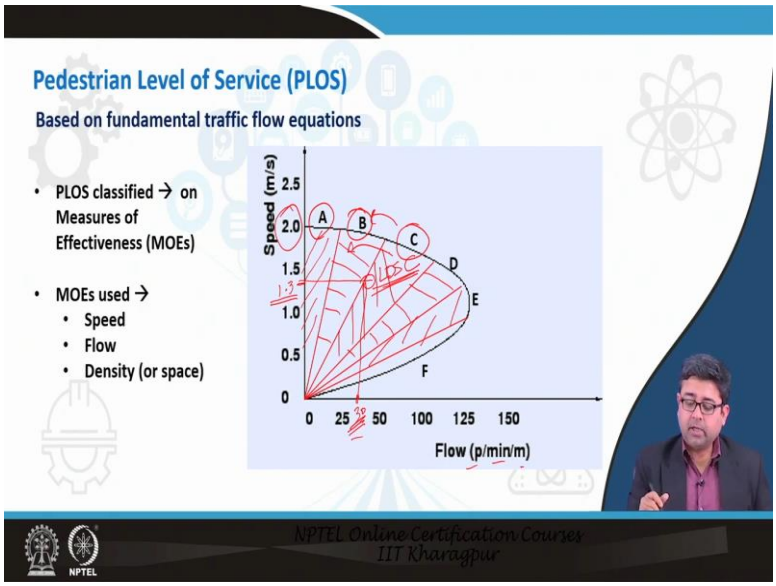

So if we look at a broader picture, the macro-level, since we have seen the macroscopic models, you may remember the speed and flow model and it is a parabolic model. So how these level of services are defined essentially is that this entire parabola is divided into different regimes. So if your value falls in any one of this accordingly they have been defined as A, B, C, D, E and F.

So for example if you have a flow on a facility of 30 people per minute per meter and you have the speed of around say 1.3. So you would see that this would fall in the regime of somewhere in level of service C. So what this tells you is that well the facility that you have currently is able to hold or accommodate 30 pedestrians per minute per meter and is able to give you a maximum speed of or is able to give you a speed of average speed of 1.3 meter per second.

So whereas opposed to that there is a maximum speed possible of 2 meter per second but because of this increased flow now the speed has reduced to 1.3 meter per second. So then you start thinking about should you improve the facility or should you make the facility wider, so how can you kind of go from a level of service C to a level of service B and maybe eventually to a level of service A. Whenever these tradeoffs are made there is always a money component involved because to move from a level of service C to B may require that you widen the facility, widen the sidewalk by a meter and the length of the sidewalk is maybe for a 5 kilometers. So you have to pour in that much of concrete or whatever material that you are

using. So there is money involved in it. And do you really want to put in that much money for improving from levels of service C to B that is a judgment call for the urban local bodies which they often make but here we will stick to our technical point of view and understand how these levels of services are defined.

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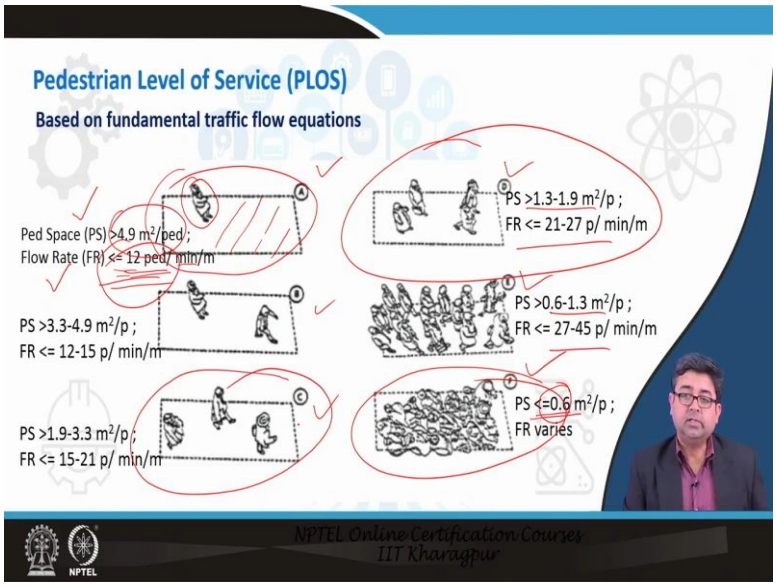

This is a very popular way of defining the level of service -- this is defined on the basis of two parameters pedestrian space and flow rate. So you would see that a pedestrian space of greater than 4.9 meter square per pedestrian and also at the same time has a flow rate which is less than or equal to 12 pedestrians per minute flow rate. So what it shows is that you have a very comfortable space for the pedestrian but your flow rate is very low. Remember in the last lecture we discussed that as the pedestrian space increases that means within that 4.9 meters there is not another person at all. So although this one person may be very comfortable walking but this entire space is not being utilized. So the flow rate is very low and hence such facilities are level of service A. So then it makes you think do you want all of your sidewalks to have a level of service A, we want such low flow rates and provide so much pedestrian space that is a judgment call that needs to be taken many countries that have lesser population density fewer people walking on the streets their sidewalks are most likely to have this kind of level of service. But again remember these thresholds should be set as per your local conditions.

So you can say that if your local conditions are such that there is a high pedestrian volume and the population density is very high then maybe these thresholds can be lowered or can be made

higher as per your local conditions. These but these are just guidelines these are showing you as to how levels of service can be delineated between A B C D E and F. So there are different threshold values that are given here. The level of service F is where it is a very congested situation and the space is less than 0.6 meter square per person. So that this kind of gives you guidelines saying that if your facility has become so congested that a person is having less than 0.6 square meter for himself or herself to walk on then possibly it is time that you think about a better facility. And so you can then but which is your best facility? Would you accept a level of service D versus level of service C, this is something which is a judgment call made by many urban local bodies. Because like I said this money involved, you always want your facilities to be the best but to achieve the best you have to put in money as you know in today's environment is very competitive. Should the agency put in money in improving sidewalks or should it put it in improving bicycle tracks or should it actually put in use for widening the road. So there are always tradeoffs that are made. And hence which level of service is agreeable is always a judgment call made by the authorities in the urban local bodies.

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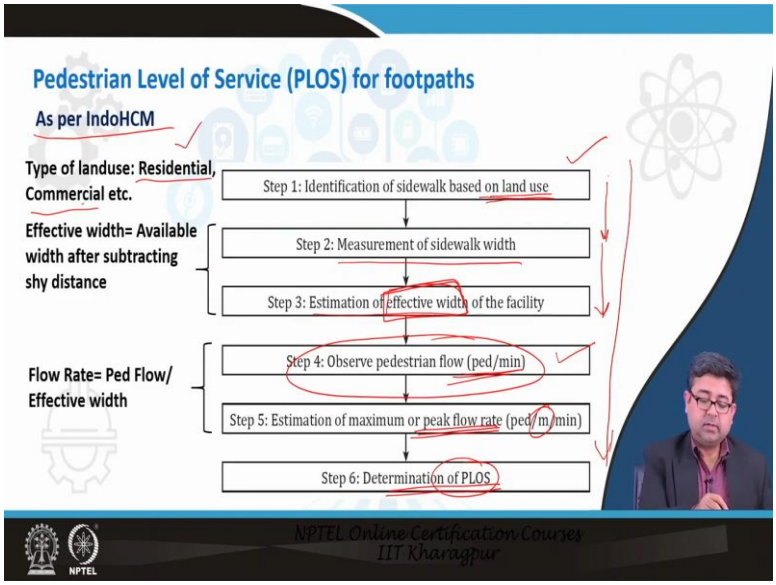

So as per the IndoHCM let us give you a quick run through of what are the different steps that needs to be taken in order to determine the level of service of the facility that you currently have. Maybe along residential streets or commercial streets. So on so forth. The first step of IndoHCM it to determine, in which area you are trying to find the pedestrian level of service. So determine or identify sidewalk based on land use. So whether are you trying to determine

the level of service in a residential area or a commercial area or terminal area so on and so forth. After you have determined that, you then come to measuring the width of the sidewalk which is a very straightforward thing to do. However, once you have measured the width of the sidewalk the next step is to estimate the effective width. How do you determine the effective width? Essentially what it says is that maybe the sidewalk is 4 meters wide but there are so many other things that are taking up the space in the sidewalk that effectively there is only 2 meters that the pedestrians can walk along. So that is essentially effective width and then you observe what the flow along that facility is. So how many people per minute are crossing a certain point along that facility, will give you the pedestrian flow and subsequently once you know the flow you can calculate the peak flow rate. Flow rate is nothing but pedestrian per minute per meter. So that is the flow rate and based on the flow rate you can then determine your pedestrian level of service. So these are a 6 step process in determining PLOS.

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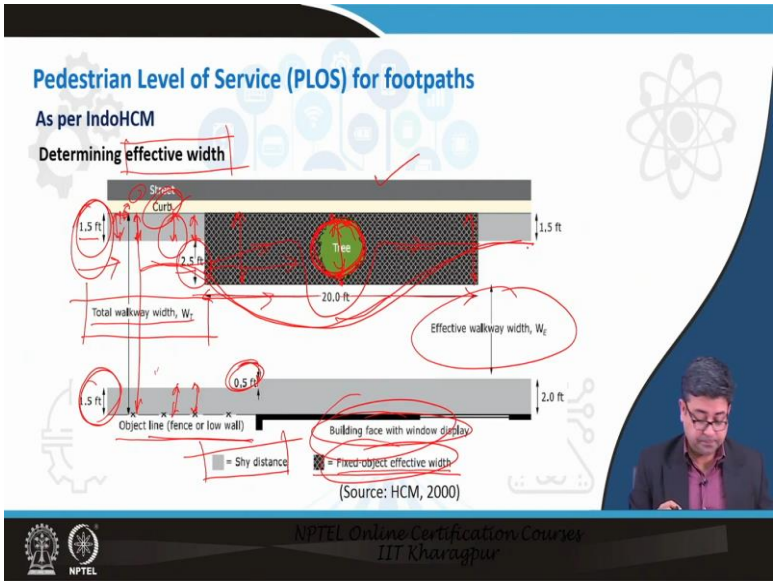

So in determining effective width like I said this is one of the basic steps in calculating the pedestrian level of service. So say this is a sidewalk, this is a street, then there is kerb and then you have the total width of the sidewalk. Here the total width of the sidewalk is given as let us see 1.5 + 2.5 + the effective width. So these are all different components of the total width of the sidewalk. Now there are two important things to be considered here in order to determine the effective width of the sidewalk, one is called the shy distance which is shown in this gray area here and one is the fixed object effective width, so fixed objects such as here is shown as a

tree. So what are these two things once you subtract the total width of the sidewalk or footpath. Once you subtract these two, the shy distance and the fixed object effective width from the total width you will get the effective width of the sidewalk. Okay, so now let us see what this shy distance is and what the fixed object effective width is.

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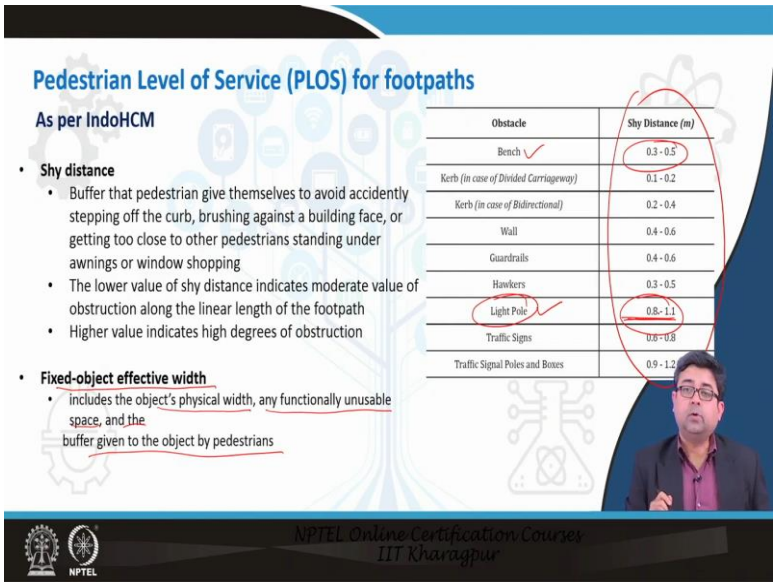

So the shy distance is nothing but the buffer that the pedestrians give to themselves to avoid accidentally stepping off the curb, brushing against a building face or getting too close to other pedestrians standing under an awning or window shopping or something. So what it is telling you is that if we go back to the slide, people who are walking on this sidewalk will never walk too close to the curb. Because they always fear that they may fall over or trip over and actually walk along the street and then there is interaction of the vehicles and there is a probability of a crash or an accident happening so they always give themselves some distance away from the curb to walk. So in essence what they are doing is they are not utilizing that space although the space is empty but they are not utilizing that space because that is a behavior in which we usually walk. So this 1.5 feet is what they have people have measured on an average people leave from the curb and they do so also from the fence line or low wall or the object line. So if you have a building face on this side they will leave an additional 0.5 feet, so not only do they leave the 1.5 feet from this side but when once a building face comes then they will leave another 0.5 feet and walk effectively only in this whitespace. We have not yet gotten to that tree but first understand what the shy distance is. So the shy distance is a width or space that is left

by the pedestrians it is a buffer that the pedestrians give to themselves not only from the curb but also from the building face that is under. You do not want to walk to close to a wall of the building, right, you give some space yourself so that is essentially what this shy distances.

Now secondly what are what is the fixed object effective width it includes the objects physical width any functionally unusable space and the buffer given to the object by the pedestrians. These are three different things put together okay. So the objects physical with any functionally unusable space as well as the buffer given to the object by the pedestrians. So for example in this case notice that there is a tree here. What pedestrians would usually do is they would in addition here they were only taking a shy distance of 1.5 feet. So they were only walking 1.5 feet away from the kerb but now here because of this tree or this width of this tree or the diameter of this tree now they are giving an additional 2.5 feet distance before this from the curb. So now it is 1.5 + 2.5 around 4 feet of distance leaving from the curb and walking here. So that essentially is what is called a fixed object effective width. So not only is the width the tree effecting the movement of the people but also the buffer from the tree, so they are also leaving an additional buffer here on the tree. Okay so that is also affecting and in turn, what it is also seen is that this affects for a very long distance along the sidewalk. So the tree may be right here but essentially people do not do this kind of a movement. People usually do these kind of a movement. Okay so people do not come too close to the tree and then go past it, they start giving themselves a lot of buffer from way before the tree actually comes in their path and then go back to their original path way after the tree has passed them. So in essence and obstruction takes up a lot of space which would otherwise have been used by the pedestrians for walking. So these are some standard shy distances that are given in the IndoHCM for example if there is a bench so the shy distance is anywhere between 0.3 to 0.5 meters. Whereas if it is a light pole the shy distances anywhere closer to up to 1 meter. So that is why many times care is taken that the location of the light pole along the sidewalk is always a matter of concern right? When you design a sidewalk along with the light pole are usually not put right in the middle of the footpath. It is put at least on one side of the footpath not obviously on the curb side but on the other side of the building face side. So that is why it has to be taken care of. Light poles are very necessary but the way it is designed because if you put it right in the center it is effectively going to reduce the width of the sidewalk by almost as much as 1.1 meter. Okay so that has to be taken into account.

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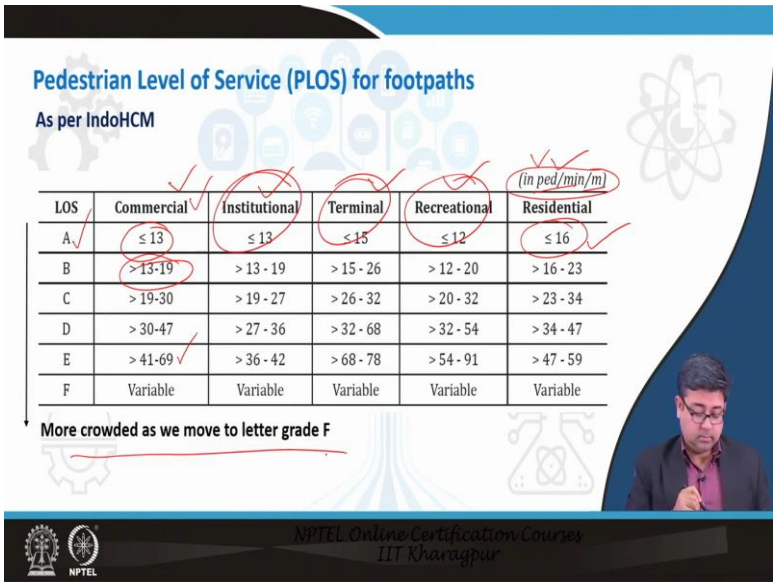

Again IndoHCM then gives different level of service values for different types of land uses. So they have 5 different types of land uses and all the level of service values are given for different flow rates. So if you have a flow rate in a commercial area less than 13 pedestrians per minute per meter then your level of service A whereas if it goes anywhere close to up to 70 pedestrians per minute per meter your facility or your sidewalk is completely jam packed. So the level of service then is not good. You would see how it varies from commercial to a residential area. So in a residential area you would give at least less than 16 pedestrians per minute would still be a level of service A whereas 16 for a commercial would fall in a level of service B category. So this can vary from different types of land uses.

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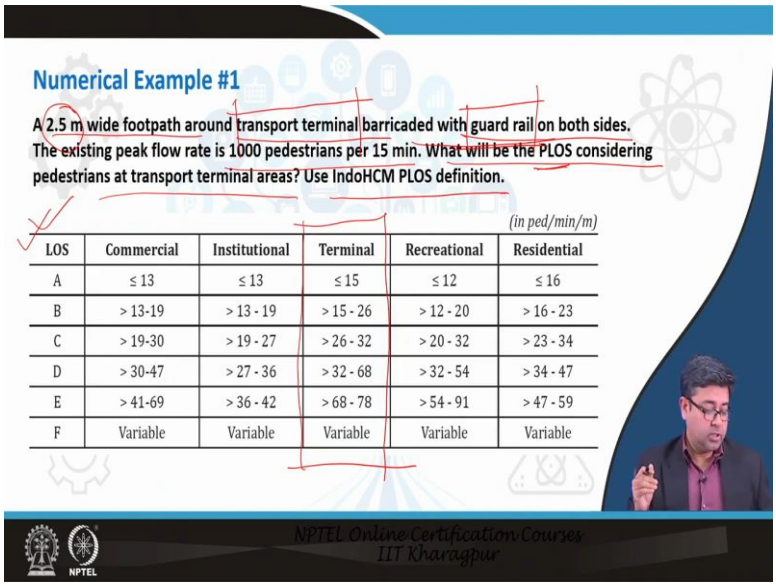

Now if for example if you are given a situation where you have a 2.5 meter wide footpath around a transport terminal barricaded with guardrail on both sides right. So you have to read the problem carefully. The existing peak flow rate is 100 pedestrians per minute peak flow rate okay 100 pedestrians per minute what will be the pedestrian level of service considering pedestrians at the transport terminal areas use the IndoHCM PLOS definition. So when we say the IndoHCM PLOS definition we mean that use this chart. So based on this chart, because this chart is developed already, and based on your situation calculate what is the pedestrian level of service. So let us follow the 6 steps that we have shown you in order to determine what the pedestrian level of service is.

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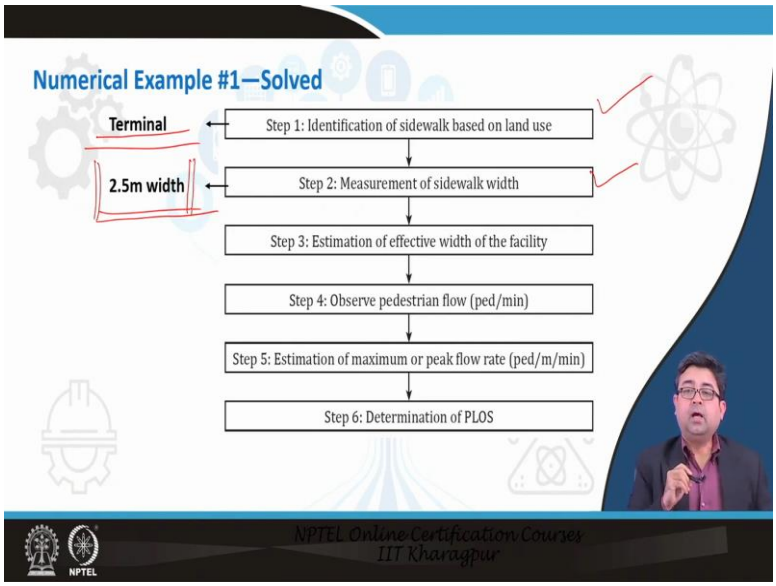

So remember in the first step what you have is the identification of sidewalks based on land use. So in this case we go back what is the land use? The land use is a terminal land use, it is a transport terminal. So you are looking only at now this column right we are only looking at this column. Second is measurement of sidewalk width. So you are already given that the sidewalk with this 2.5 meter. So 2.5 meters sidewalk within the terminal area. Next is the estimation of the effective width of the facility now how do you determine the effective width of a facility? Remember, from the total width you have to subtract all the shy distance as well as the fixed object width.

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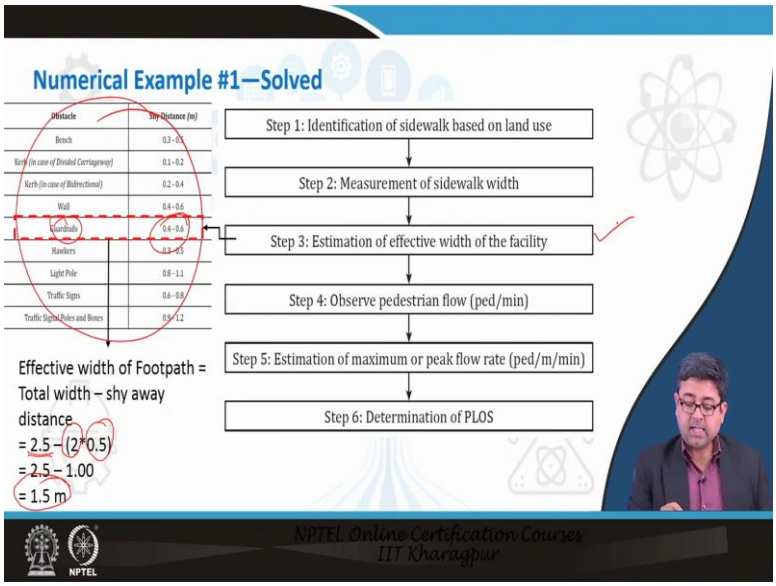

Now in order to help us, this table has also been developed. So it is not necessary for you to go on the field and measure every object that is there and measure what is the distance that it is taking up or what is the area is taking up. It has been given here that in case of guard rails now because we said that this area is guarded by guard rails on both sides. So we are to assume that there is nothing else but guard rails there are no trees there are no light poles nothing else. It is only guarded by guard rails. So in order to find out what is the shy distance to be used for guard rails indication is given that it is anywhere between 0.4 to 0.6. So let us pick a value of 0.5 and since in the guard rails are along both sides of the facility we multiplied by 2. So if you subtracted from the total width of the sidewalk now you have the effective width of the sidewalk that you are dealing with is only 1.5 meters. Okay. So now you have already completed this step. The next step is to observe the pedestrian flow.

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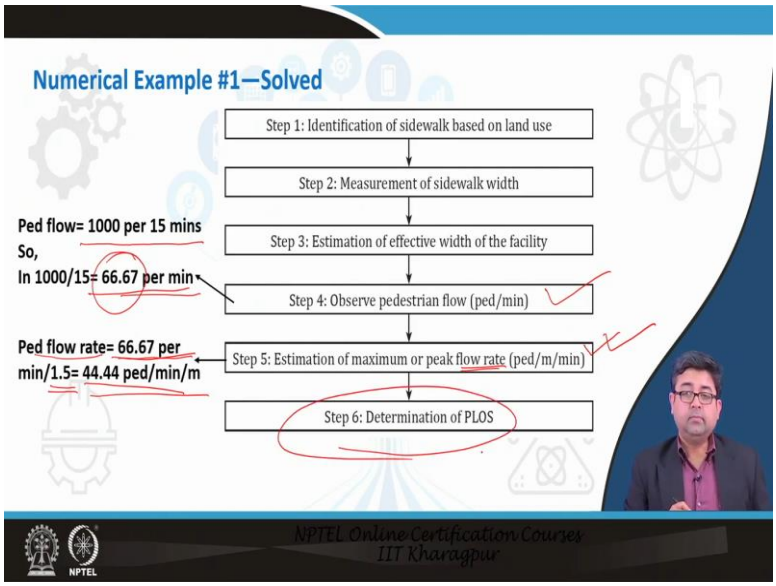

Now the pedestrian flow gives us 1000 pedestrians per 15 minutes. So how much would it be per minute? This divided by 15, so it is approximately 67 pedestrians per minute. Now you know the pedestrian flow, the next step would be to estimate the maximum or the peak flow rate. So the flow rate because this is the just the flow the 66 approximate 67 persons per minute in order to get the flow rate you have to divide it by the width of the sidewalk right. So you can use 1.5 meter of width in the 1.5 meter of the effective width 66.67 persons per minute are able to walk. So per meter how much you are able to walk. So if it is 1.5 meters the flow is 66.67 per meter it would be 44.44 pedestrians per minute per meter. Now that you know the flow rate you can use your table that has already been developed to determine the pedestrian level of service.

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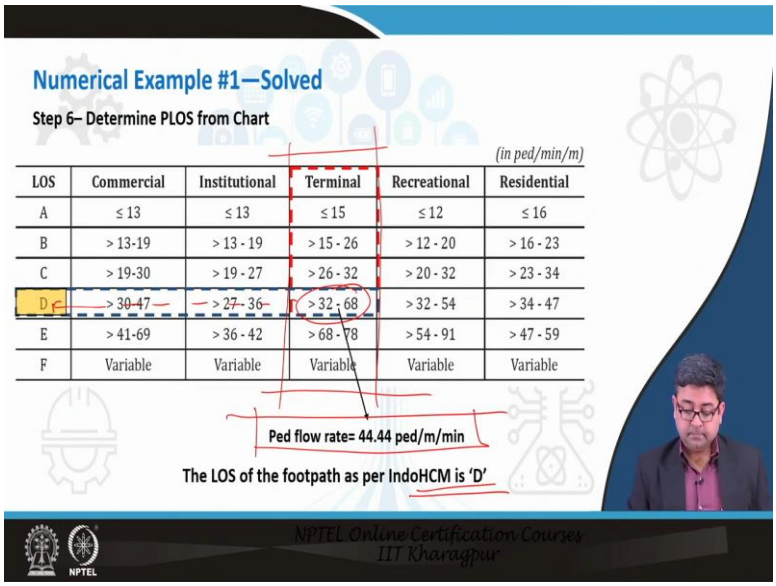

Back to the table, and we are looking at the terminal land use and we have determined that the flow rate is 44.4 pedestrians per minute per meter. So if you just go in this and find out where 44 lies. It lies right here. So the level of service of your pedestrian facility this level of service D. So that is how you estimate what is the level of service of your pedestrian facility using the IndoHCM method. Okay

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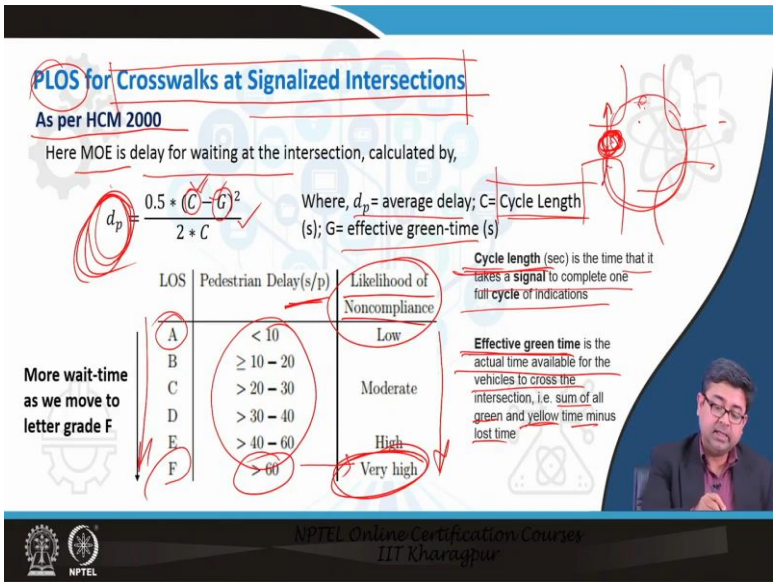

Now the second facility that we are going to tell you about when it comes to calculation of a pedestrian level of service is the crosswalks at the signalized intersections. So you also want to measure how good the crosswalks are doing, whether the crosswalk is allowing all the people to

cross in a given width, in a given time, or with minimal delay and so on and so forth. This is defined by the highway capacity manual developed in the US in the year 2000. And it says that the measure of effectiveness of how well a crosswalk is doing at a signalized intersection depends upon the delay at the intersection. How long is a person delayed while he or she is waiting at the intersection is the measure that helps you calculate the PLOS at a signalized intersection's crosswalk. So the delay or the average delay is given by this simple equation where C is the cycle length and G is the effective green time of that signal.

$$d_p = \frac{0.5 * (C - G)^2}{2 * C}$$

So you may recall the cycle length of a signal is nothing but the time that it takes a signal to complete one full turn of indications. So the second that it turns green you start your stopwatch and the entire four legs. So if it was a four legged intersection, and the signal here turned green. All of these signals will have to turn, this has to turn red then this has to turn green and this has to turn red. So all of this together when it again this same signal turns green that entire cycle is called a cycle length right. So from the time elapsed between the green indication in this leg to the next green indication in the same leg is called as the cycle length. And the effective green time is nothing but the actual time available for vehicles to cross the intersection for the vehicles to cross the intersection. Remember these are all cycle length is for green time for all the vehicles and effective green time is the actual time available for the vehicles to cross the intersection. So what is the actual time is the sum of all the green times and yellow time minus the lost time, so sometimes the vehicles are the turn off. There is some time lost in starting up the vehicle and some time is lost while slowing down and stopping. So all of those types minus it from the total green and yellow time that gives you the effective green time. And then once you have those two numbers you plug it in and you get a value for delay. So this person who is waiting at the intersection to cross is delayed by some seconds per person because of the cycle length and the effective green time at that signal. So if the delay is less than 10 seconds per person then you would say that it is pretty good level of service. Whereas if the delay is greater than one minute per person, so every time a person comes he or she has to wait for more than a minute at that intersection to cross or at that leg of the intersection. To cross then you would say that the level of service is very poor or F. And it also is an indication of people who also seen

that when the level of service is F there is a likelihood of non-compliance is very high meaning the person actually will not wait for the signal to turn red before it crosses signal meaning the signal for the vehicles. They will jaywalk and cross before the signal turns red. So the compliance or the likelihood of non-compliance also increases as the level of service varies. So that is why we said that when you are designing a signalized intersection please also keep in mind the pedestrian volume at that intersection. Do not give only the green time for the vehicles to cross the intersection but also reduce the delay or minimize the delay for all the people that are trying to cross that intersection.

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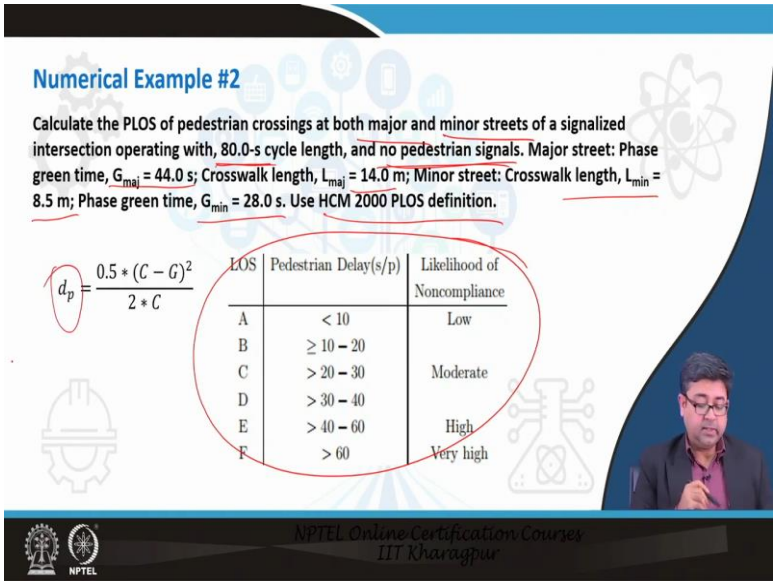

Similarly, if we look at another problem here it says calculate the PLOS of pedestrian crossings at both major and minor streets of a signalized intersection which has a cycle length of 80 seconds and no pedestrian signals. So there are no pedestrian signals. The major street has a green time of 44 seconds and the crosswalk length is 14 meters. Whereas the minor street the crosswalk length this 8.5 meters and has a green time of 28 seconds. It says to use the HCM 2000 PLOS definition. So you have to use this table, in order to calculate this delay.

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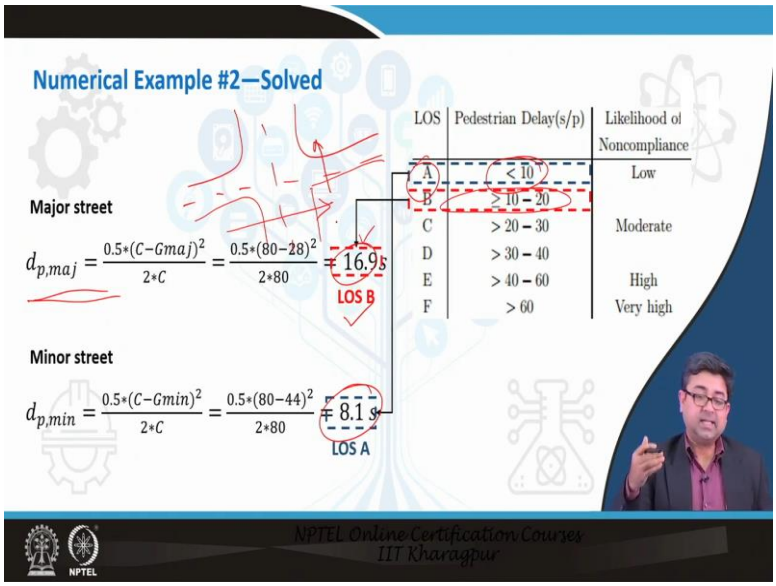

We know the formula if you just plug it in. So for the major street you see that the delay per person is 16.9 seconds. So which falls in the category of B. So for only the major street so anybody trying to cross the major street of the four legged intersection, so if you have a four legged intersection maybe this is the major street and this is the minor street right. So anybody trying to cross this major street he or she has to wait for an average of 16.9 seconds which is categorized as a level of service B. Whereas if anybody wants to cross the minor street he or she only has to wait about 8.1 seconds and that is a level of service A. So this is how you can calculate the level of service of people trying to cross at a signalized intersection.

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That ends this lecture session. Again the references are given for your further reading.

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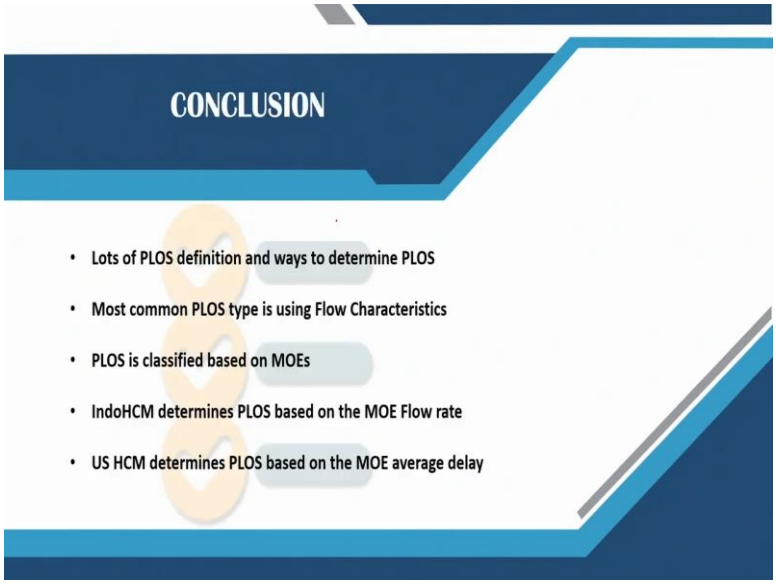

So in conclusion in this session we looked at the PLOS definition. Meaning what are the pedestrian level of service? How do you determine them? What are the different facility for which you can determine them? And also looked at couple of examples where you could calculate the pedestrian level of service for sidewalks as well as for crosswalks at a signalized intersection. Thank you.