Introduction to Multimodal Urban Transportation System
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Module No # 08
Lecture No # 38
Non-Motorized Transportation (NMT) Planning: Design of Pedestrian Infrastructure (contd.)

Now, that you have looked at designing pedestrian facilities, especially sidewalks or foot paths, and how to provide seamless access to pedestrian along those facilities, now let us look at in this lecture how to design cross-walks or midblock crosswalks along an urban street.

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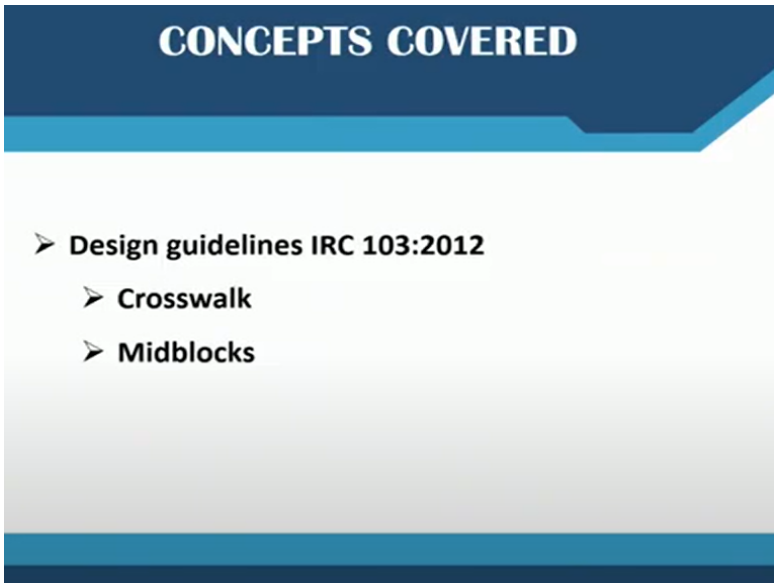

This is again as per IRC 103 published in 2012.

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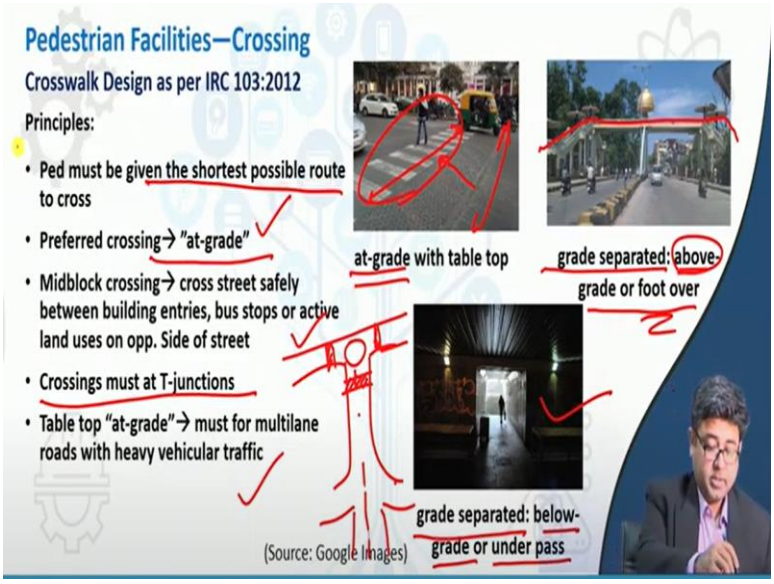

So what are cross-walks? Cross-walks are the zebra crossing marking or the pavement markings that are present either at signalized intersection or at other strategic locations, which may be present at midblocks as well. These are provided so that pedestrians crosses the shortest possible route. Otherwise if the pedestrian have to walk for long distance and then cross the road they may not be taking the pedestrian route and may instead be using a motorized mode of transport. In order to provide them the shortest crossing of an urban street, these cross walks are designed. Preferred cross walks are always at-grade. For example, this is an at-grade cross walk, it may be on a table-top. Table-top cross walk meaning there is a ramp that raises the crosswalk slightly above the right-of-way or the carriage-way and then the marking are provided here. But these are also considered at-grade. Whereas there are some crosswalks, also called foot-over bridges that are grade separated or above the grade. So such kinds of facilities are also crossing which are provided at certain location where it is necessitated. But they are not at-grade they are grade separated and are above the ground. In another case they may also be grade separated and below the ground; below the grade. They may be called under-passes. So there are three different types of pedestrian crossings that you have to consider on urban streets or along urban streets. You can either design them at-grade, above grade, or below grade depending upon the situation. Crossings are must at T junction, whenever you encounter road geometry forming a 'T'. Whenever you encounter something like a T junction, at such junction a cross walk is a must. You have to provide crosswalks otherwise pedestrians will not able to cross the road. So that is

the basic principle of designing of a crosswalk. It may be at-grade which is always preferred, they may be on a tabletop or they may not be at table top. In other situations there may be sometimes provided above grade or below grade.

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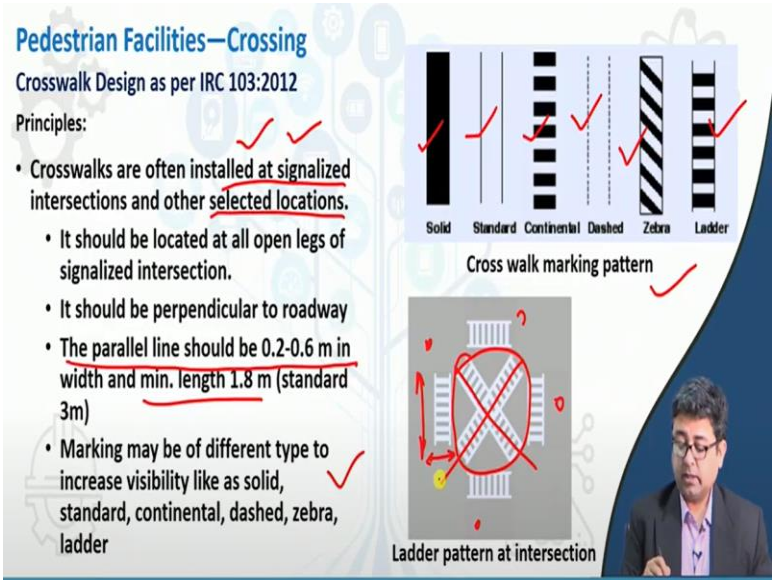

Now crosswalks are often installed at signalized intersections and select locations. These kinds of markings, be it zebra, ladder, dashed, continental, standard solid, any such kind of markings on the pavement denotes a cross-walk. There are some standard markings that denotes crosswalk. They are often provided at signalized location or at other select locations. So, select location meaning they may be midblock. But there is a reason for providing a crosswalk. Without any reason you should not provide cross walk at multiple locations. This will only obstruct the flow of vehicles on that street. So at either the junctions or at strategic location these cross walk should be provided. The parallel line should be 0.2 to 0.6 meter in width and the minimum length of 1.8 to 3 meter. The length of the cross walk is nothing but the width of the road that the pedestrian has to cross. Markings maybe different and we have already seen the different types of markings. So in the last lecture we were talking about this kind of crosswalks. These are provided at signalized intersection when there is an 'all-red' phase at all the 4 junctions. They allow people to crisscross at intersection which otherwise would have led pedestrians to cross in an L-shape pattern.

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Now the other thing to think about when you are designing cross walk is to look at the corner radius of the streets. Corner radius at the streets should be as small as possible, right. The smaller turning radii increase the pedestrian safety by reducing vehicular speed. But if this radius it is too high the vehicles will travel fast. If the vehicles turn fast then there will not be enough time for the pedestrian to cross. Hence one of the safest designs that is recommended, is to have very small turning radii at the intersection. So that is one thing you should always remember. The other thing to remember is the ramp slope. The slope of the ramp should be between 1:5 to 1:8 when, you are designing this cross walk on a table-top, right. So when you are designing the cross walk on a table-top ramp that you provide for the vehicles, this ramp allows the vehicles to slow down. Suddenly when they see a change in elevation they will slow down and that ramp should be anywhere between 1:5 to 1:8 to ensure the vehicles slow down at the crossing. Then the alignment with the desire-lines of pedestrian crossing at intersection should be located in such a way, that there is minimum deviation from the path of travel. Often you will see that the design is such, but user experience tells us that people will not take this path and will usually take this path. So you will often see a path that is developed by the user themselves, so we have to keep this in mind when we design the design the crossings at the intersections. Quickly summarizing what we learnt in this slide, you have a corner radius that is small. The curve radius should not exceed 6 meter in the residential areas. So that is a guideline provided by the IRC.

Ramps slopes should be such that they slow down the vehicles and have a value within 1:5 to 1:8. The desire lines should also be taken care of.

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The other thing to remember is at minor intersections, how to design for a cross walk. If the intersection is not signalized it is acceptable to raise the crossings that are perpendicular to the minor arms while the crossing at the major arms is provided at grade. So what happens is if it is an un-signalized intersection. There is an un-signalized intersection between a minor arm and the major arm. What is desirable here is to raise the crossing; that are perpendicular to the minor arm. So when you are trying to develop a pedestrian crossing, which are perpendicular to the minor arm you can raise this on a table top whereas perpendicular to the major arm you can provided at-grade. So that is one of the things to remember when you are designing between the major arm and the minor arm. For signalized intersection, if the crossing is at the level of the carriageway, each corner must be ramped. If this is the side walk and this is the cross walk then there should be a ramp and the width of the ramp should be at least 1.2 meters. The slope should be no steeper than 1 is to 10. These are some design guidelines that not only ensure that there is a safe crossing for the pedestrian, but also keeping in mind the vehicles. They will stop and reduce in speed while driving through at intersections which may or may not be signalized. You have to always remember the distinction between a signalized and unsignalized intersection and how to provide a crossing at each on them.

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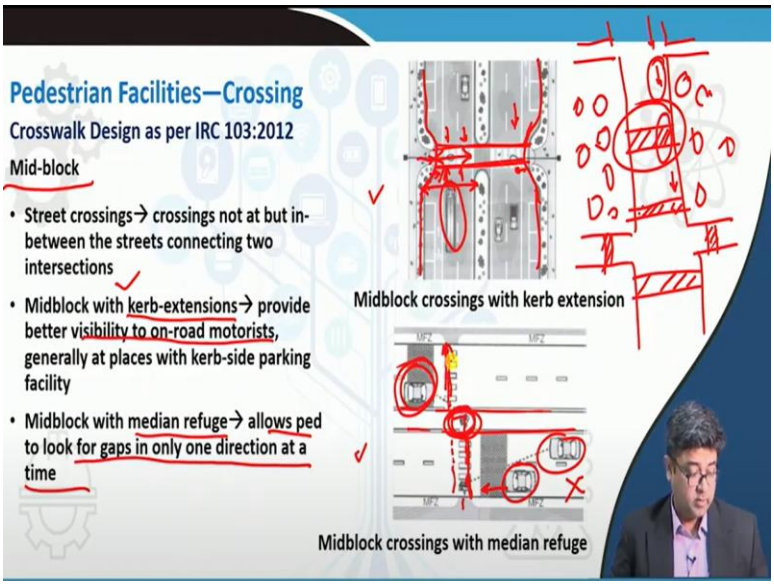

Now the next scenario could be that there are 2 intersection wide apart, and in a middle of the 2 intersections there are lot of pedestrian activities that happen due to the landuse along that street. Then you are bound to provide a midblock cross-walk. This similar situation is shown in both of these pictures. Extra care has to be taken while designing this midblock crosswalk because it is at mid-block when the vehicles are usually at top speed right. So when a vehicle has just crossed this signalized intersection and is now heading south, it has already picked up pace because it has crossed the intersection and only here will it eventually reduce space because it is then approaching another intersection. So in between where the cross walk is, it may be at a very high speed. When you are dealing with such a situation where there is high speeding vehicles and no signals available, at such a spot, when you design for a cross walk you have to be very careful and safety has to be paramount. What you usually do is you provide curb extensions for better visibility to on-road motorist. What is usually done is if the curb is like this on the both the sides and you want to provide a cross-walk right here, you usually extended the curb out a little bit. So these are called curb extension. What now happens is this vehicle that is coming here suddenly sees that curb line is moving towards the vehicles and the vehicle kind of stops. So somebody coming here they will see the curb line is moving towards this vehicle and they will stop. And on top of it you can have a ramp up and down on both sides for the crosswalk design. So not only does it enable vehicles to see better but also help the pedestrian to cross better as it shortens the distance that the pedestrian has to travel. Now he or she has to travel this shorter distance

whereas when there is no curb extension, they had to travel a little bit more distance. So what happens by curb extensions it allows (a) motorist to visualize or to see the pedestrian more clearly, those who are trying to cross and, (b) it also decreases the distance that the pedestrian now has to cross along the cross-walk. This is one way of providing midblock cross walks—to provide curb extensions. The other way is to provide a median refuge island. Allow pedestrian to look for gaps in only 1 direction at a time. So the other way to do this is you can have a refuge island in between and you can stagger the cross walks as well. The cross walk is now kind of staggered. When the cross walk is staggered you should also provide ramps. Since you have provided no curb extension, you have to provide ramps. And now because there is a refuge island here this is either a refuge island or median or whatever you may call it. So because there is space for the pedestrian to stand at that position now, he or she can only look at this traffic while crossing these lanes. Then they can stop at this refuge-island or median and has to only worry about this traffic and then crossover here. So these are two different design method by which you can design a midblock cross walk. Again you have to be very careful when you are designing midblock crosswalk because, (a) usually the speeds of the vehicles between the 2 intersection is highest at the middle of the 2 intersections and, (b) because there may or may not be too many people that are wanting to cross at the location, so the expectation of a motorist to encounter a pedestrian may not be very high. So because of these 2 reasons you will have to very carefully design for a midblock cross walk.

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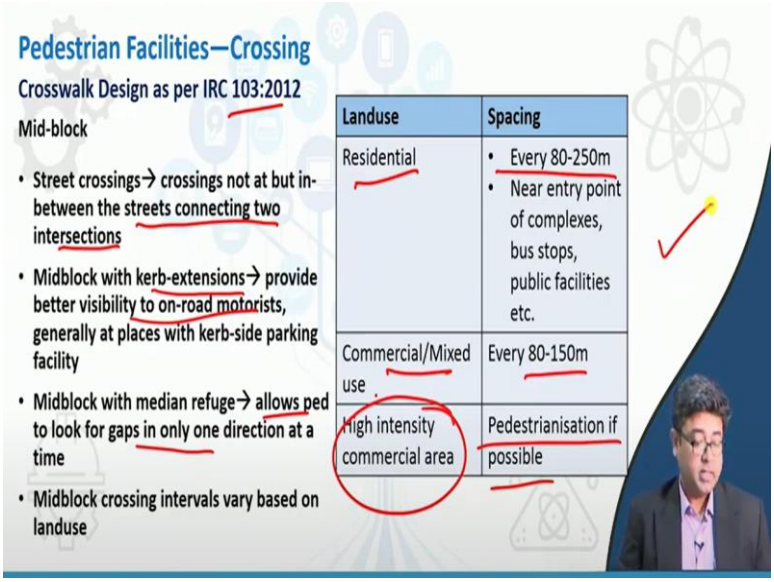

As per IRC, crossings should be spaced every 80 to 250 meter in residential land uses whereas in commercial and mix land uses, this value may be between 80 to 150 meter. And in high intensity commercial areas there should be pedestrianization as much as possible. When there is lot of pedestrian activity in highly commercialized zone you should provide crossing as per the need. Pedestrian crossings takes the priority and vehicular movement does not take priority in such a case. We have already talked about mid blocks with curb extensions which provides better visibility to on-road motorists and refuge islands which allows pedestrians to cross with ease. So we have already looked at each of these and some standard IRC recommendations are provided.

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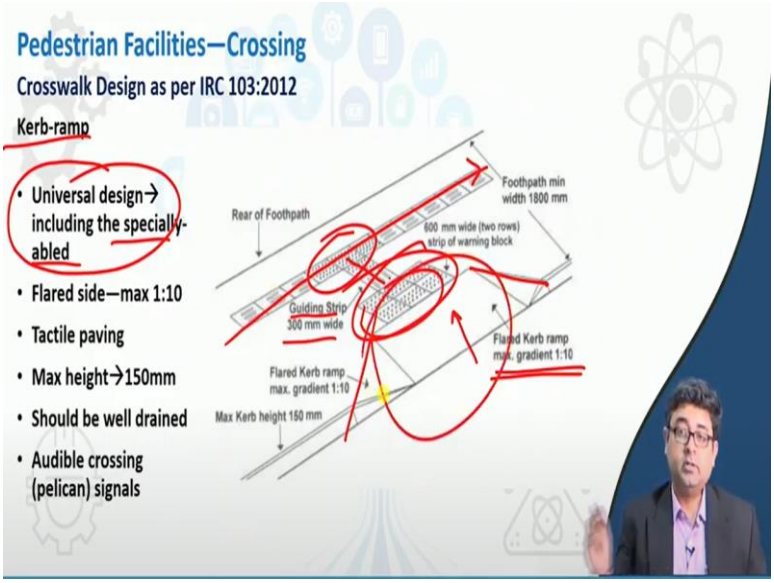

Now typical curb ramp design for a curb at a crossing has to be taken care of, as shown in IRC. Again, remember universal design has to be applied. It has to take care of pedestrians which who are specially-abled. Not only are we talking about small children and elderly people crossing and but also about especially abled people crossing by themselves. They may not be always accompanied by somebody else. So the design of your sidewalk or crosswalk should always include universal design principles. You have to have a flared ramp maximum of 1 is to 10 grade. A flared ramp means it has to have a flare like that. It has to have a maximum gradient of 1 is to 10. There has to be a tactile flooring or tactile paving that will allow the person who are visually impaired, to be guided properly during their walk. There has to be a guiding step which is 300 mm wide that has to be provided. And then there has to be a continuous longitudinal tactile paving and guiding blocks so that it enables the differently abled people to navigate

through the sidewalk as well. So these are some design principle to be kept in mind when you are looking at especially the crossing. These are where people will get on and off the sidewalk.

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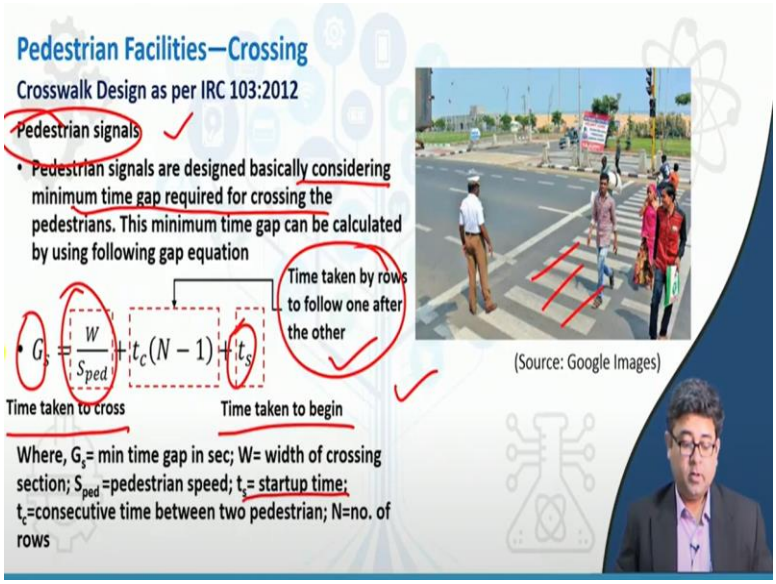

Pedestrian signals are designed basically considering the minimum time gap required for the crossing and it is given by this formula.

$$G_s = \frac{W}{S_{ped}} + t_c(N-1) + t_s$$

Where, Gs= min time gap in sec; W= width of crossing section; Sped =pedestrian speed; ts= startup time; tc=consecutive time between two pedestrian; N=no. of rows

The first part of the formula takes care of the time to cross the carriage-way. The second part takes into account, time taken by a row to follow one after the other. Due to the width of the crosswalk there may be multiple people crossing in multiple rows and they may be queued up one behind the other. There is some time lost if there is queuing and also there is multiple rows in reflection there is additional time that takes to cross the carriage way. And the last part is the time taken to begin. You have to start from inertia, so the people who are closest to the pavement start first. There is also people queued behind who starts later. So there is some start-up time that is involved. So this will give you the minimum green time for the pedestrian crossings at the pedestrian signal. So if you have to design pedestrian signal you have to at least give that much

green time or which is called the minimum time gap in seconds in order to allow for the pedestrians to cross.

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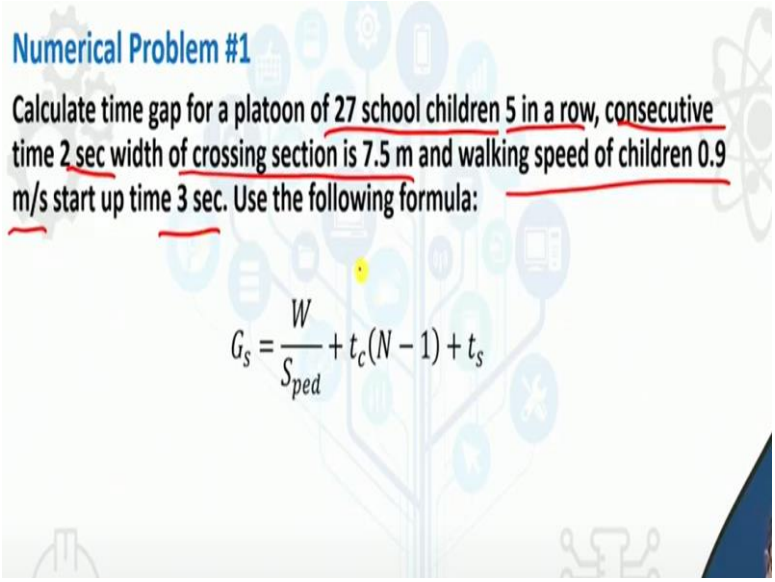
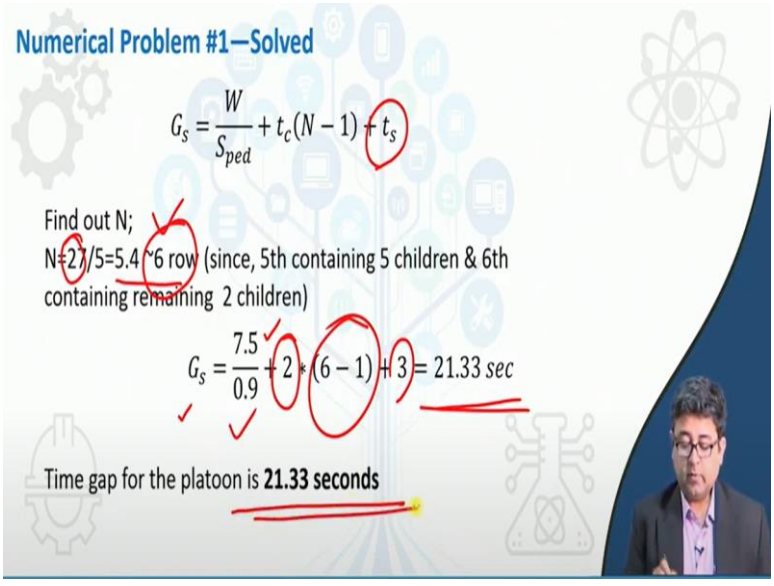


So if you just look at a simple exercise where you have been asked to calculate the time gap for a platoon of 27 school children, who are crossing 5 in a row. They have a consecutive time of 2 seconds between each other. Width of the crossing section is 7.5 meters. The walking speed of the children is 0.9 meter per second. A start-up time of 3 second. So how much minimum time gap should we give? We already know the formula for that. **(Refer Slide Time 22:17)**



Before you begin you just have to find out N. You have 27 children and 5 per row. So if you divide 27 by 5 you have approximately rows that are formed. You already know that the width of

the pavement, you already know the average speed at which the children are crossing. You already know that 2 seconds is the consecutive time. So time between 2 children walking is 2 seconds. You have calculated N as six. So, six minus one and the startup time is 3 seconds. So you are getting a time gap to the platoon as 21.33 seconds, which is needed for the entire platoon to cross that carriage way.

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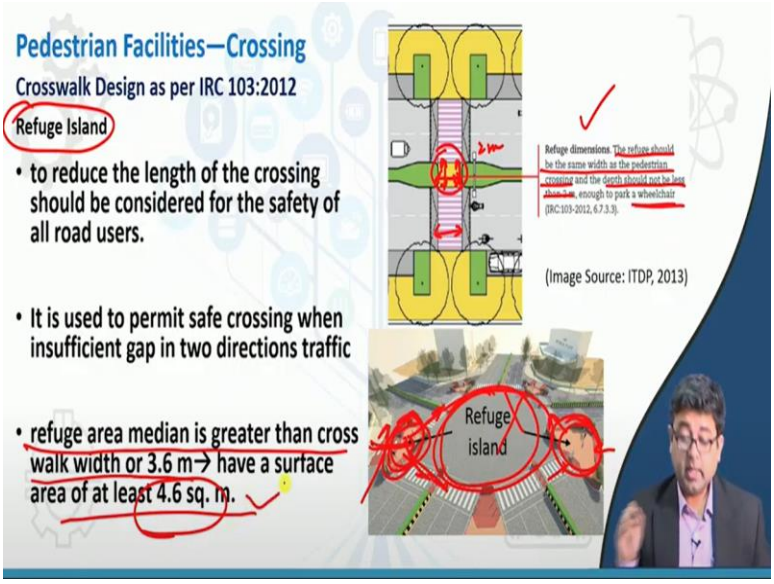

Now when you have to design a refuge island. We have already discussed about what a refuge island does. It allows for other pedestrian to cross two different streams of traffic by only looking at one stream at a time. If there are more than 2 lanes per direction, a refuge island is usually recommended. And if there are 2 lanes in one direction and another 2 lanes in the other direction it is not advisable to provide one long cross walk especially when the lanes are wide enough. So you have to provide a midblock refuge island. Then the pedestrian crosses one traffic stream, and waits in the refuge island for a gap to cross the next traffic stream. The refuge island dimensions should be the same width as the pedestrian crossing and the depth should be no less than 2 meters which is enough to park a wheel chair. So that is kind of a design criteria that has been given here. The refuge area median should have surface area of at least 4.6 square meter. At very big intersections, there may be multiple refuge islands. So it allows multidirectional crossings. You can have a refuge island of sort, that is usually provided when there is left channelization available for vehicles to turn left. Then there is a refuge island that is provided here where you

can cross either this way or that way and such a refuge island should at least have an area of 4.6 square meters.

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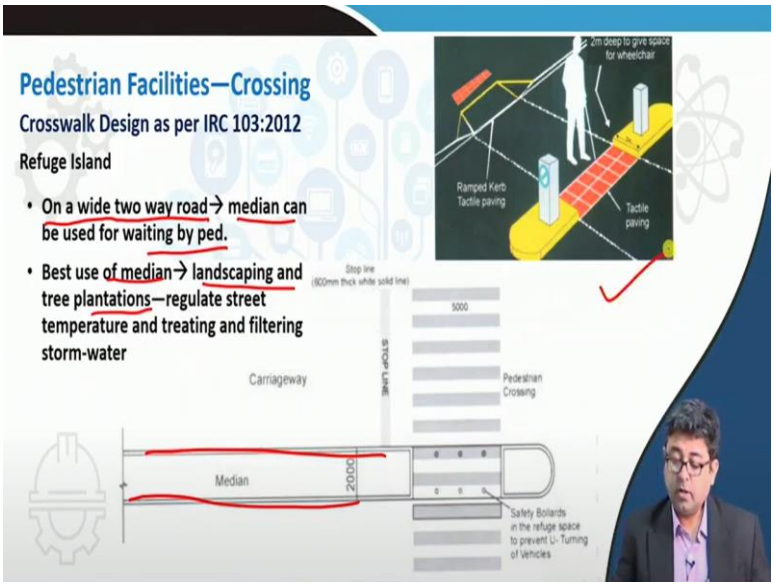

This again is design of a refuge island on a wide two-way road, the median can be used by the pedestrians for waiting. As we had already discussed, refuge islands can also be on a median. It can also be a median between 2 directions of the traffic where people can stop. The best use of median can be landscaping with tree plantations, which can regulate street temperature and treatments with filtering and collecting storm water. So that is how you can treat a median, it is often we think that the median does not need to be taken care of. Usually that is not true because medians are for not only for beautification and landscaping, they have other functions as well. So the medians have to be properly taken care of one of the function is that it may act as a refuge island for pedestrians. This is another example of a crossing design for specially-abled pedestrian.

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Now, here are multiple refuge islands. So this is the refuge island to cross a service lane and then the main right of way. So the refuge area width should be at least 1.2 meter wide and depends on the traffic speed. Width varies with speed of vehicles on road. 1.5 meter width for speeds up to 40 to 48 kilometer per hour and 2.4 meters for speeds within 56 to 72 kilometer per hour. What in turn, this is telling to you is that you have to design these refuge islands based on the speed of the vehicles that are in the traffic stream. If the speed is too high then the number of people that have accumulated in the refuge island will not be able to cross the road very quickly. So there will be more and more people that keeps on accumulating here and then it becomes very crowded. So based on the speed of the vehicles on the road the area of this refuge island has to be decided upon. Lower the speed the lower can be the area of the refuge island.

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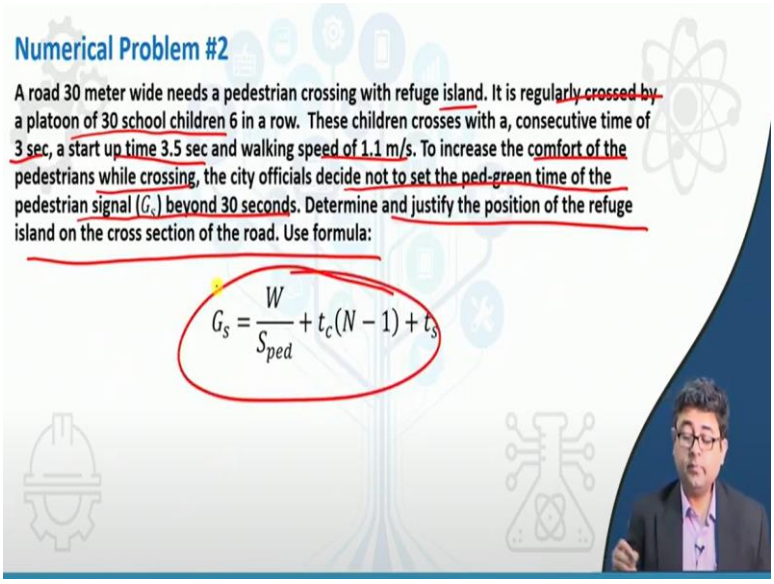

Again, if you take a look at another problem, a road that is 30 meter wide needs a pedestrian crossing with a refuge island. It is regularly crossed by a platoon of 30 school children, 6 in a row. These children will cross with a consecutive time of 3 seconds a startup time of 3.5 seconds the walking speed of 1.1 meter per second. To increase the comfort of pedestrian while crossing the city officials will decide not to set up pedestrian green time of the pedestrian signal beyond 30 second. Determine and justify the position of the refuge island on the cross section of the road. So if you were told to do such a design what should you do? You should first calculate the green time or the minimum time gap that should be provided for this kind of a situation.

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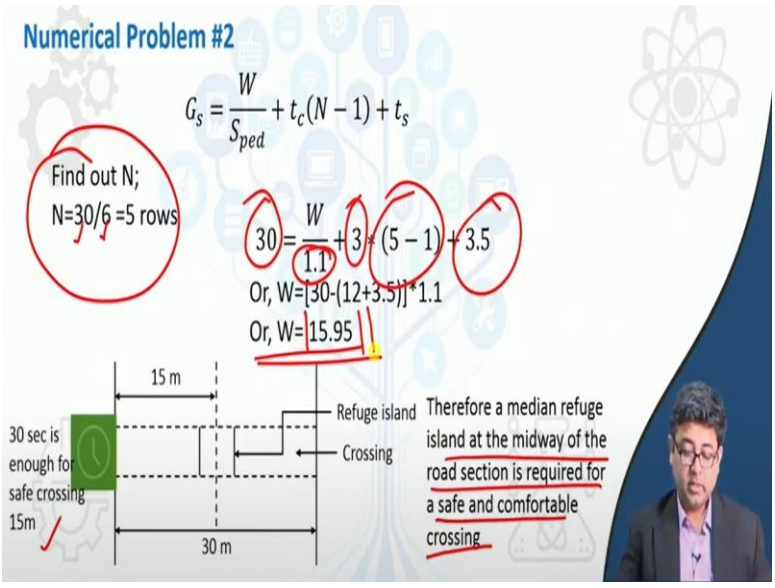

Firstly, calculate N. You already know there are 30 students that cross 6 in a row, and you have been told that a maximum of 30 seconds of green time is given. So if a maximum of 30 seconds is given and you know the average speed, the consecutive time, you know N=5, and start up time. So therefore a median refuge island at the midway of the road section is required for a safe and comfortable crossing. 30 seconds is enough for safe crossing of 15 meter. So if the road is 30 meter wide and the green time that you have provided is only 30 seconds. So in that, 30 seconds what you are seeing is that people can only cross 15.95 meters. So the rest 14 odd meters they still have to cross. So that tells you that there is a requirement for a refuge island somewhere in the middle of the road right. So that is what justifies that there must be a median refuge island somewhere the midway of the road section.

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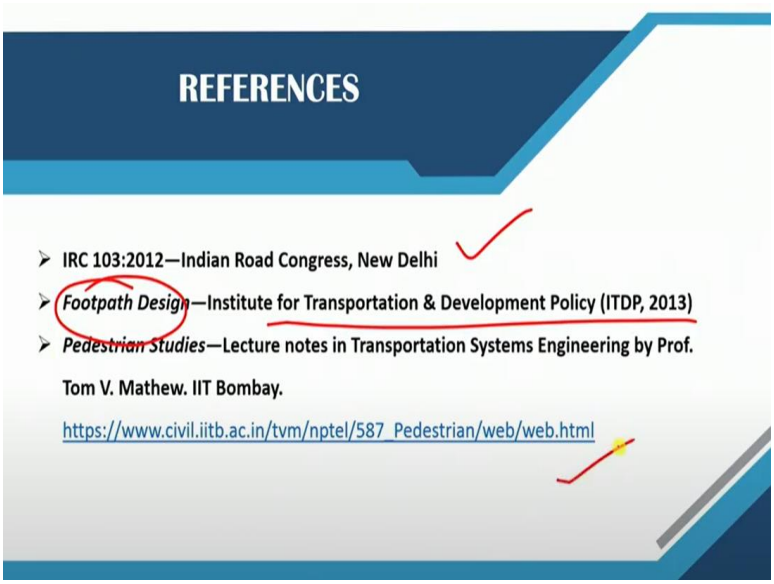
IRC 103 also provides some guidelines for a midblock-crossings as to what are different types of signage, which can be used. It also recommends that in-pavement raised markers could be used along the cross walk that will reflect light onto the motorist. And motorist will able to see the overhead pedestrian sign that may alert the motorist that there is somebody who is crossing on the cross walk. You can always have a pedestrian signal that have some animation in them about pedestrian crossing. At school zone typically you should provide sign with a simple school zone symbol. So many of these signs have been recommended in the IRC 35 and has been taken from the IRC 35 as well. This is a very typical road crossing “at-yield” signs, where there is no signal available, you have to yield for pedestrian. So my recommendation would be to go through this

IRC very carefully before you start designing for any kind of pedestrian crossings at your urban street. **(Refer Slide Time 33:02)**



So hopefully this lecture has given you some idea about how to design for cross walks on any of your city roads. IRC 103 is the main document. Also go through some of the ITDP policies that deal with footpath design which also includes cross walks. And of course like the previous lecture we have taken some picture from a previous NPTEL course developed by IIT Bombay which look at more traffic engineering related issues and also includes pedestrians.

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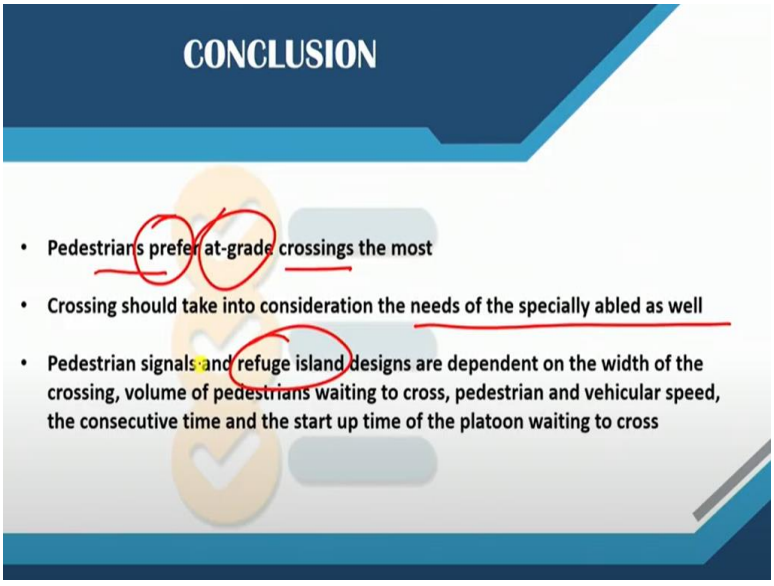

So, in conclusion we have looked at how to design for pedestrian crossings. They are preferred to be at-grade but at certain cases you may have to provide above or below grade facilities as well.

But in this lecture, we have looked how to design for at grade facilities; they should take into consideration the needs of the especially-abled people and how to design for refuge islands. Thank you very much for your attention!