Introduction to Multimodal Urban Transportation System
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Module No # 08
Lecture No # 40
Non-Motorized Transportation (NMT) Planning: Design of Cycling Infrastructure (contd.)

Welcome back friends in the last lecture. We have looked at how to design bicycle facilities along your urban street we will now continue that lecture.

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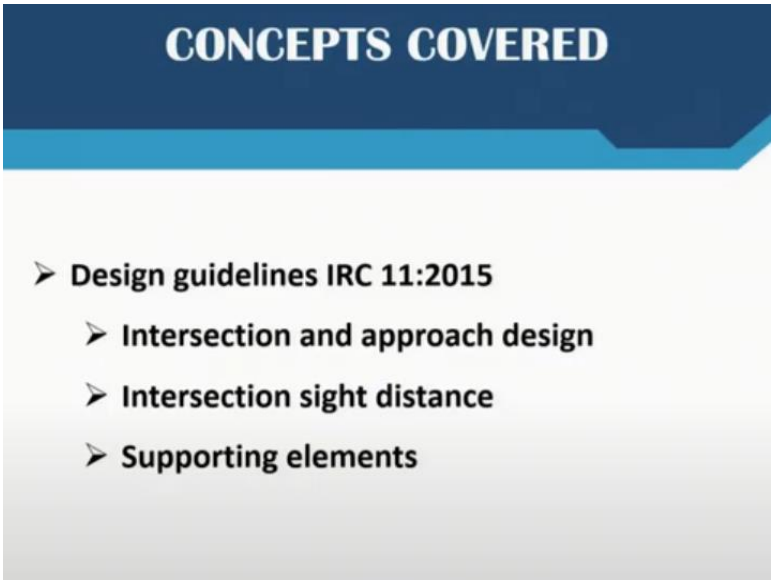

In this lecture part we will be looking at the design of cycling infrastructure and especially the intersection and approach design, intersection sight distance and other supporting elements that will help you design bicycle tracks or bicycle lanes in your urban area.

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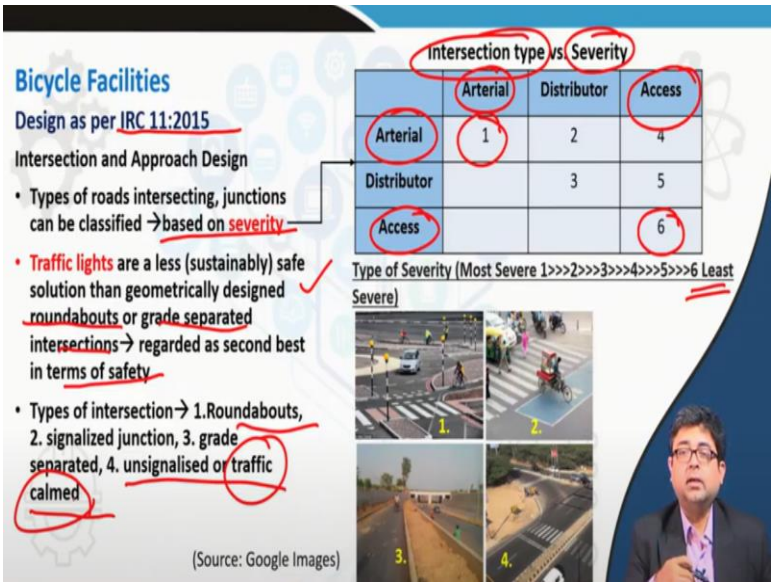

So, as far as IRC 11 is concerned, they have identified a methodology of determining severity based on different types of intersections for bicycle users. So, for example if an arterial road is intersecting with an arterial road, it has the highest possibility of severity if a bicycle is involved in an accident. So, when you are designing any lane which is at intersection of 2 arterials one has to be very careful and the design has to be very safe. However, the other extreme is an access road is intersecting with another access road, because these 2 types of roads have very low speed vehicular traffic, so even if a bicycle gets into an accident or a crash, the severity level is the least. So, there is this type of matrix that IRC recommends based on severity. IRC also recommends that traffic light or traffic signals are not the safest way of negotiating a bicyclist through an intersection. One should rather design for roundabouts or grade separated intersection in case of bicyclist. So, the best design would be roundabouts or traffic circles, if they are smaller roundabouts, it is sometimes called traffic circles. In case of bicyclists, at an intersection IRC recommends having a roundabout rather than a traffic signal. Traffic signal is maybe the second-best option when it comes to safety. Grade-separated options are always the last option because essentially, they are very expensive to build and maintain. However, they also provide the best form of safety, but that is always the last option for being constructed at an intersection. Again, there are different types of intersections, i.e., roundabouts, signalized junction, grade separated and un-signalized intersection which have traffic calming associated with it. This is the type of intersection which we often observe in our urban areas, where two

roads intersect, but there is neither a roundabout nor a traffic signal, it is an un-signalized intersection. When 2 lanes intersect and there is no signal or no roundabout at the junction, or in other words, it is an uncontrolled intersection, then it has to be traffic calmed. So, there has to be some traffic calming measure that has to be in place so that the bicyclist can safely negotiate the intersection.

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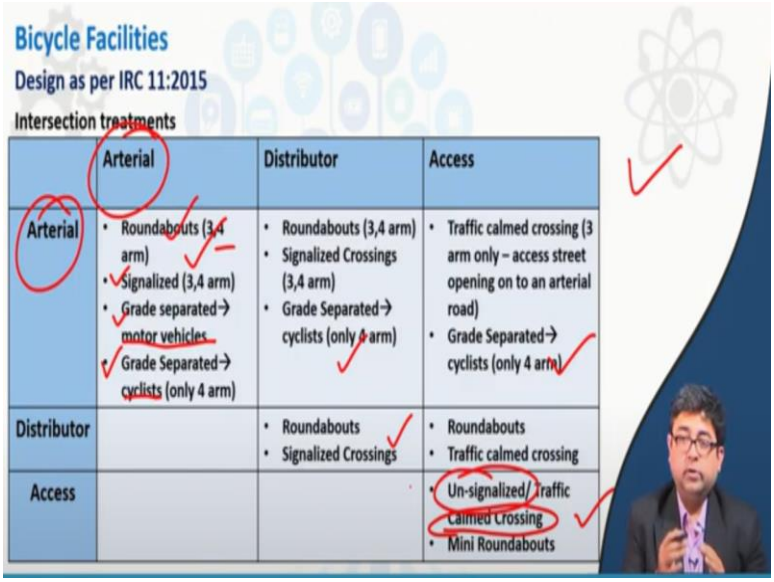

Similarly, this table shows you a comparison between different types of intersections and different types of road categories and the most likely form of traffic control that should be placed in order for the bicyclist to safely negotiate that intersection. So, if it is two arterials that are intersecting, roundabouts at all the 3 or 4 arms should be provided, right. Even if the junction has 3 arms, you can still design roundabout for that kind of a junction. And obviously, if it is a 4-arm junction you can have common roundabout designs. The next option should be signalized, and the next option after that should be grade-separated for motorcycles and then the final option is grade-separation for the cyclist. Now these grade separations for the cyclist are very recent phenomenon that is being adopted by some of the developed nations in Europe. In Europe especially in Netherlands you would see some major intersection that sees a lot of bicycle traffic they have grade separated arms at the intersection which are meant to be used by bicyclist. Now we do not see any such intersection in India yet. But if the case requires such an intersection or such a need for an intersection there is always an option that IRC has provided this. Similarly, you can read through the different types of option that are available to you especially when

different types of roads are intersecting with each other. But always remember give preference to roundabout as opposed to a signal. And if two low vehicular volume roads are intersecting then the there has to be traffic calming measures provided especially when it is un-signalized. If there are unsignalized there has to be calming, such as some rumble-strips or narrowing down of the road at intersection, etc.

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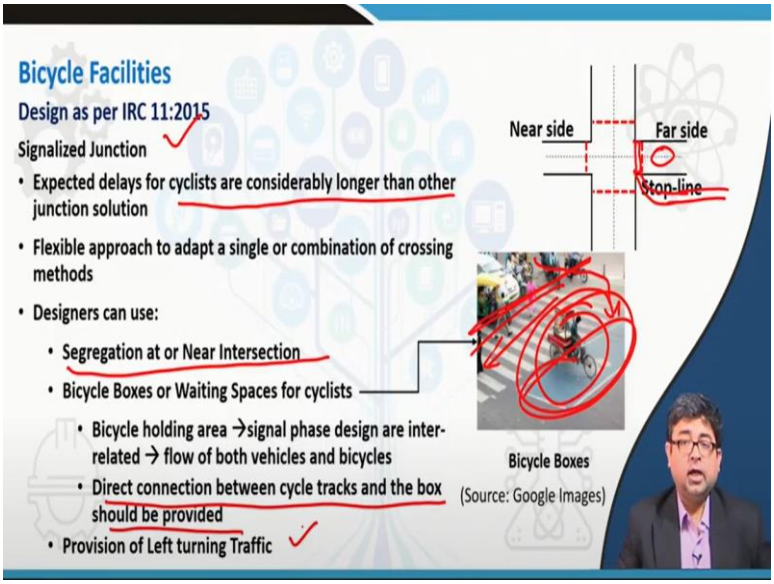

IRC now gets into the details of the different types of the junctions. So, at signalized junction the cyclist will incur significant delay. Just as the motor vehicles, there will be significant delay for bicyclists in case of a signalized intersection. So, in order to avoid that kind of a delay there are different types of techniques or designs that can be provided at the junction. For example, there can be segregation at or near the intersection. So once all the traffic approaches the intersection there could be a separate bicycle box which is ahead of the traffic and stops here behind the stop line. Then there is the pedestrian crossing, and ahead of that there could be a bicycle box, right. This kind of blue box which allows all the bicycles to come first to the traffic and stop at the signal ahead of all the traffic, so that when the signal turns green they are the first that can move ahead. So, in that manner the delay for the bicyclist can be reduced. Also, direct connections between the cycle tracks and the box should be provided. For example, if there is a cycle track here that is leading up to the box which is here, the cycle track should have a direct connection to the box, right. That will ensure that all the cyclist that are using this cycle track do not have to

mingle with the traffic in the motorized lanes and can directly go into the box and wait for the signal to turn green.

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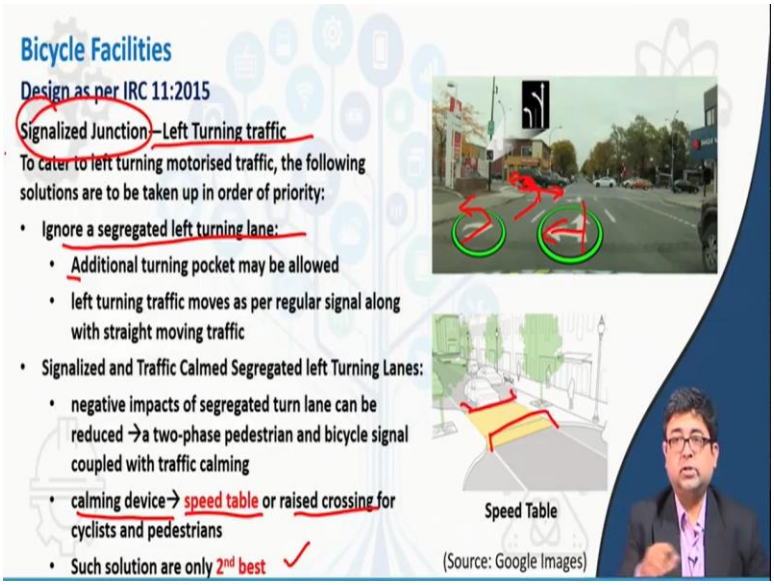

Sometimes provision of left turning traffic can also help the bicyclist but mostly such kind of segregated left turning lanes are usually avoided and we will see why. IRC also talks about these kinds of left turning traffic. They may be left only lanes or they may be through and left turn lanes as well. So, if there are no cycle tracks on this route and the bicyclists are sharing this kind of right of way with a motorized vehicle, in that case left turn lanes are sometimes allowed. But it is often recommended that segregated left turn lanes should be ignored because what happens is, if you happen to have segregated left turn lane and you have continuous free left going for vehicular traffic. Then the pedestrians or even the bicyclist that are trying to cross this road will always be at conflict with the left turning vehicle. So, usually segregated left turning lanes are not something that is recommended. But certain low volume cases you can allow segregated left turns because if the vehicular volume is less and cycle volume is high then in order to reduce the delay for the cyclist who are trying to turn left you can allow segregated left turn lanes. Also speed table can be used as a calming device. We have already talked about speed tables when we have looked at pedestrian crossings. They are nothing but a raised platform that allows cycles and pedestrian to cross the intersection. So that kind of raised crossing always helps in calming the motorized vehicle traffic. It reduces the speed but they are always definitely second best

because as we said the signalized junctions are second best. The best solutions are roundabouts, always.

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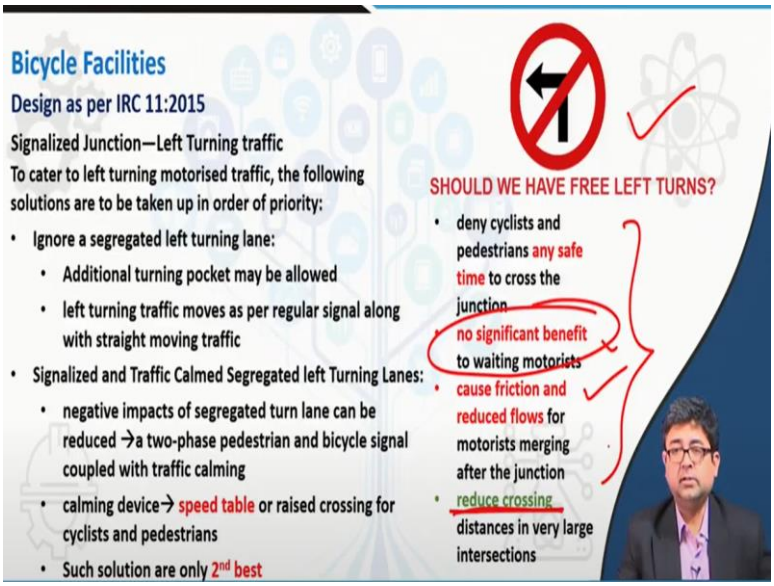

This is why usually we avoid free left turns because studies have shown that there are no significant benefit to the waiting motorist. And at the same time, it causes a lot of fiction between the merging motorist and the crossing of the pedestrian and the bicyclist. Though, it does reduce the crossing distances at very large intersection but there are more cons than pros and hence we usually try to avoid free left turn lanes even for bicyclist.

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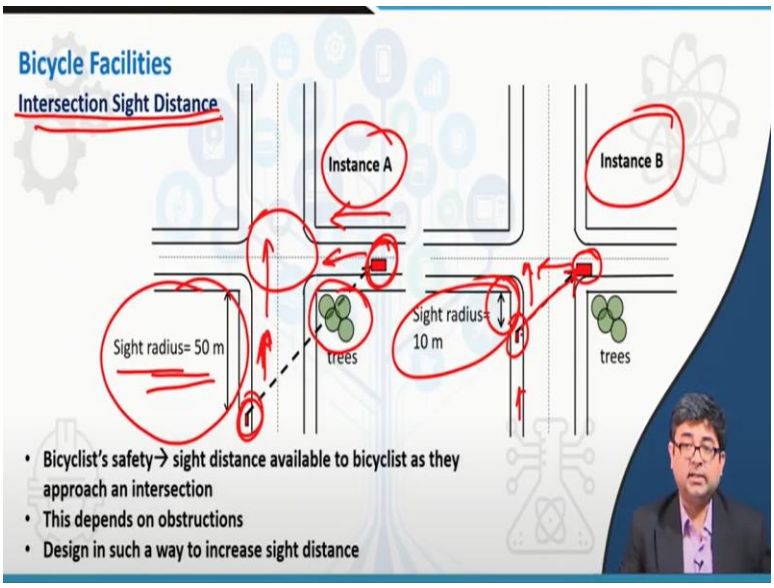

The next thing in design is to take into consideration what is called the intersection sight distance especially when the intersection is un-signalized. What usually happens is if a bicyclist for example is here and he or she is approaching an un-signalized instruction, and if the line of sight

is blocked by bunch of trees, for example, or it may be anything such as parked vehicles, buildings, etc., anything that obstruct his or her line of vision and he or she is unable to see the approaching vehicle, which is also moving towards the intersection. Then what might happen is this cyclist may or may not be able to safely negotiate through this intersection. Especially because this is un-signalized, he or she may not be able to apply break in time or maintain speeds so that they are safely able to negotiate their intersection. Usually there should be a sufficient sight distance that should be provided. Sight radius or sight distance that should be provided in order for this non-motorized form of transport to safely negotiate any traffic that is coming from the opposite direction or from the perpendicular direction. What usually happens is, say at an instance A, i.e., at certain time period, the cyclist is here and because of these trees he or she is not able to see this vehicle. But after say an instance, may be 5 seconds later, the bicyclist has now moved up to this position and the vehicle has also moved up to this position. And now this is the first time that he or she is able to see this vehicle but he or she only has about 10 meters left. Whereas here if there was no obstruction there the bicyclist would had almost 5 times the distance and that would have allowed him or her to safely negotiate the intersection. Whereas now he has only one-fifth distance and this may cause some kind of a crash situation between the motor vehicles and the bicyclist. Intersection sight distance is very important especially in case of un-signalized intersection for a bicyclist.

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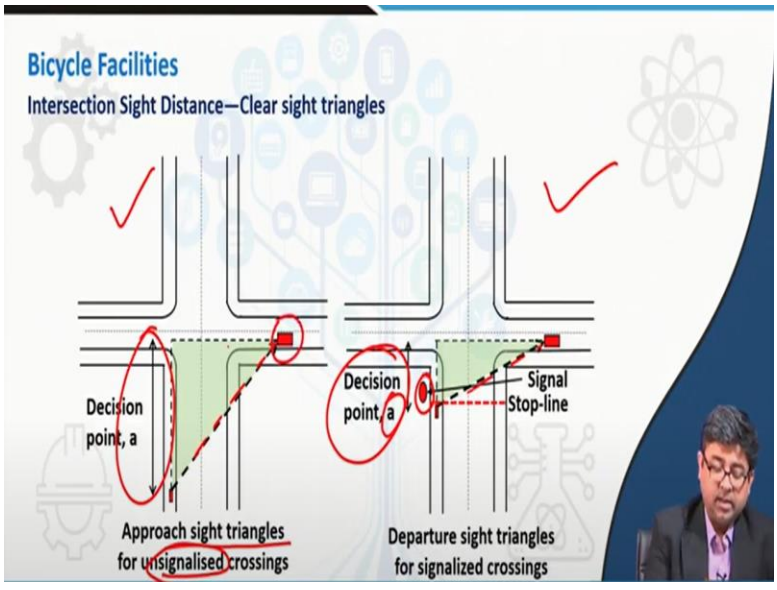

If you take another example of a signalized intersection, in case of signalized intersection since stop bar is very close to the intersection and that point in time the bicyclist would be a stationary, so at for a signalized intersection he or she would not require much of a stopping sight distance because he or she is already stopped at the stop bar which is very close to the intersection. Now his line of sight is pretty clear to all the vehicles. So, a shorter stopping signal distance 'a' is also permissible. Whereas when somebody is approaching unsignalized intersection it is always advisable to have a larger stopping sight distance so that he or she can see this motorized vehicle and take a decision whether to break or go through the intersection.

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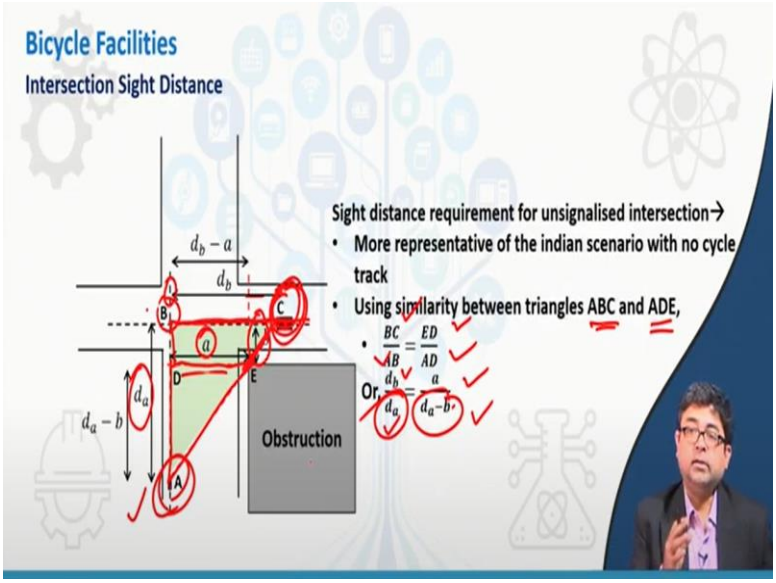

So, in order to calculate what that distance should be or what this distance 'da' should be we can simply use the principle of similar triangles. For example, consider the first larger triangle when the cyclist is at this position and the car is at this position. So, if, you consider the larger triangle of ABC and the smaller triangle of ADE right. If this is the obstruction and the time at which this bicyclist has first been able to locate this motor vehicles, because motor vehicle has just cross this obstruction edge E. So, if you consider the similar triangle principle then we can say that

$$\frac{BC}{AB} = \frac{ED}{AD}$$

Now BC is the distance that this vehicle would have to travel in order to meet the bicyclist at this point. 'db' and AB would be the distance that bicyclist would have to travel in order to meet the vehicle at this point that is 'da'. We already know that it is the distance between the corner point

of the obstruction. And the linear distance between the corner point and the straight line of sight of the bicyclist that is ‘a’. AD is nothing but the entire distance ‘da’ minus ‘b’, ‘b’ is the distance of the edge of the obstruction to the straight line of sight of the car right. So, if you know all these, each of these distances, you would be able to predict what ‘da’ should be.

$$\frac{d_b}{d_a} = \frac{a}{d_a - b}$$

This much of sight distance has to be provided on any obstruction, which is in between the line of sight, and thus should be removed.

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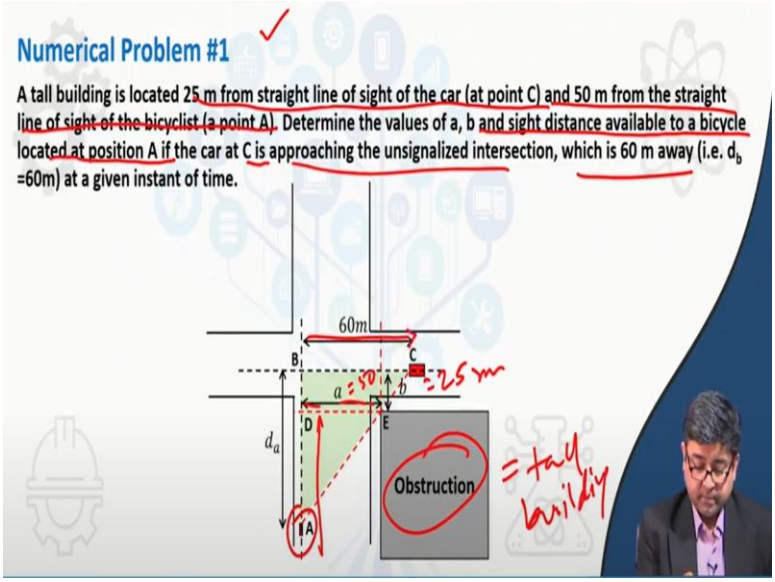

Let’s quickly look at a numerical. A tall building is located 25 meter from the straight line of the sight of the car at point C and 50 meter from the straight line of the bicyclist at point A. So the b = 25 meter. And 50 meter the straight line of sight of the bicyclist. This is the straight line of sight of bicyclist and it is located 50 meter so a = 50 meter. Determine the value of ‘a’, ‘b’ and the sight distance available to the bicyclist located at position A if the car is at C and is approaching the un-signalized intersection which is 60 meter away. So this is 60 meter way. So if you have to know what is a minimum ‘da’ , it should be provided.

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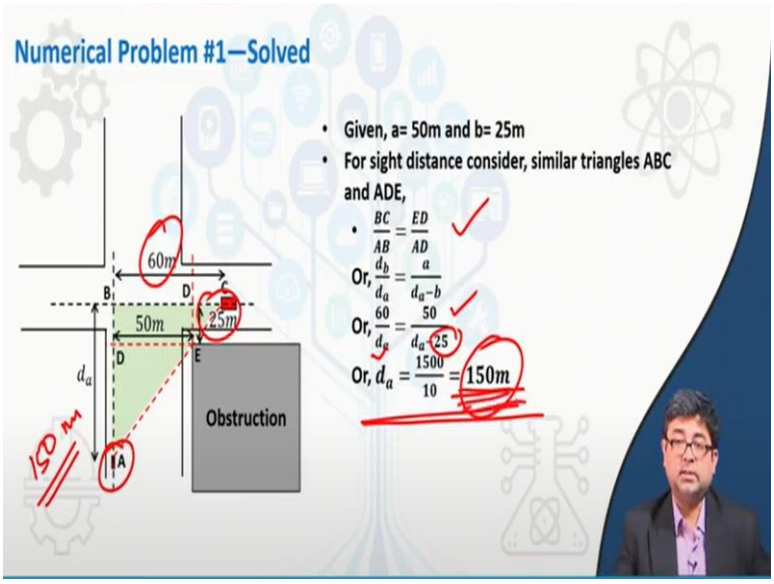

You can again simply use the similar triangles principle. You already know 'db' = 60 meters, 'da' you have to calculate, a=50 meters which is given and 'da' minus 'b, and 'b' is 25 meter, which is already given. So you can calculate that at least 150 meters before approaching the straight line of the sight of the vehicle, the cyclist has to be at least 150 meters away. So that he or she can see that vehicle that is moving at, whatever the safe speed is, at that intersection. So any obstruction that dis-allows this type of distance should be taken away. Should be cut or the intersection should be so designed at least 150 meters of sight distance is provided to the bicyclist.

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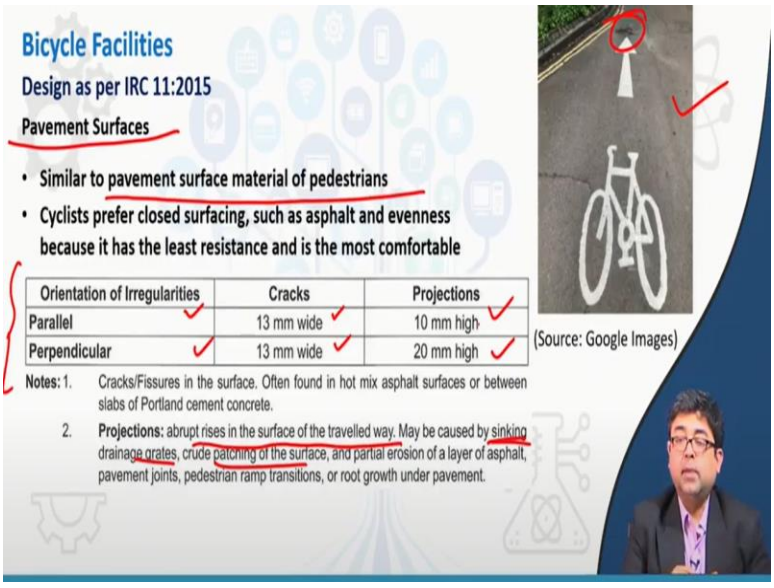

The next item that IRC looks at is the pavement surfaces on which such bicycle lanes or bicycle tracks are provided. They are similar to pavement surface materials for pedestrians as well. So, we have already looked at what type of materials should be provided for a pedestrian crossing. So, these types of surfaces are similar for bicyclists as well. What has been noticed is that if there are bicycle tracks that are provided, usually there are parallel and perpendicular cracks that are developed, and these cracks are very minor but they do develop. Cracks which are 13 mm wide and there are some projections and raises in the surface of the travel way, such as these. They appear due to maybe crude patching or drainage grates that are sunk. So, such kind of projection and cracks makes the surface uneven and does not provide a good comfort level to the bicyclist. So, such type of preventive maintenance has to be taken care of so that the surface is smooth.

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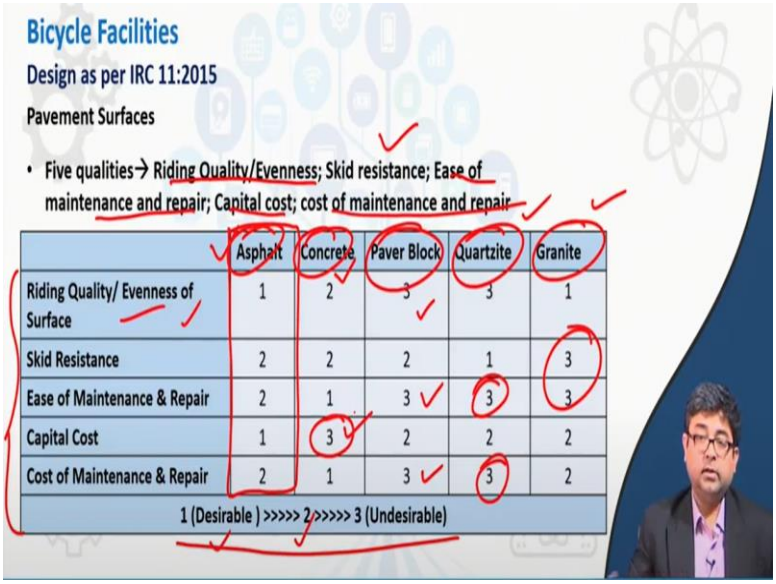

If you look at the different types of pavement surfaces that can be provided, 5 different qualities are usually compared for each of these different types of surfaces that can be provided for bicycle tracks. The 5 qualities include the riding quality and evenness, skid resistance, ease of maintenance and repair, the capital cost involved, as well as the cost of maintenance and repair. So, from the point of view of all of these 5, IRC has developed a methodology of rating on a 3 point scale. And you would see in case of asphalt surfaces most of the qualities are met or desirable. Asphalt seems to be the most preferred surface for bicyclist. Even for concrete just the "capital cost" involved is highly undesirable because you know concrete cost much more than flexible pavements. Paver blocks have some quality issues associated with it and ease of

maintenance is not very good. As well as repair and maintenance are not very easy with paver blocks. And similarly for a quartzite and granite there are other types of difficulties that makes them undesirable. And most likely you will encounter bicycle tracks that are asphalt and some of them could be concrete as well if you can take care of the capital cost.

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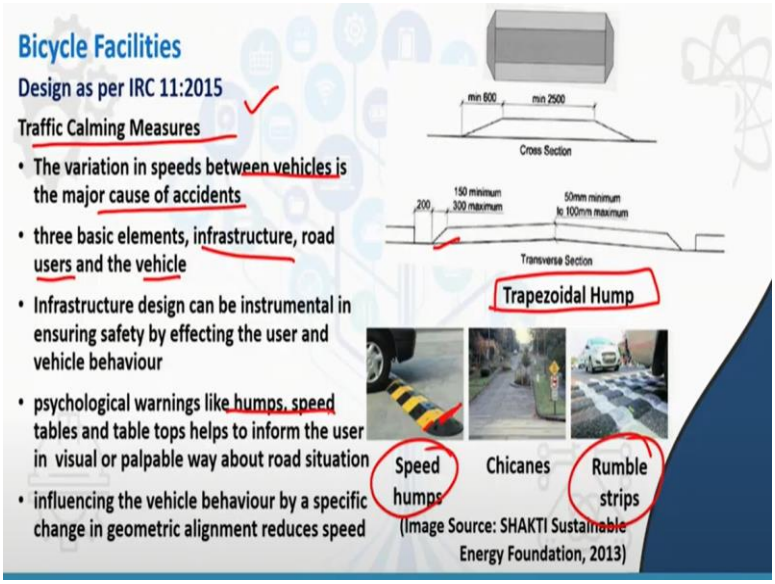

Next IRC recommends certain traffic calming measures in order for the cyclist to feel comfortable while they are riding either in their cycle tracks or along with motorized vehicles. If, for example, a cycle track is meeting a motorized carriage way at an intersection, such kind of traffic calming measure for the motorized vehicle is needed, so that the bicyclists feel very safe. You would see rumble strips are getting very popular nowadays. And speed humps that are designed mostly in the form of trapezoidal hump rather than good old speed humps with circular radius. Trapezoidal humps provide a platform on top. So, you have ramps from both side then the flat top which allows the bicyclist to safely negotiate these speed humps or rumble strips. Rather than the very steep speed humps that we usually see on the older roads or designs. Three basic elements—infrastructure, road user and vehicle have to be considered when you are looking at traffic calming measures. The variation in speed between vehicles is the major cause of the accidents because these motorized vehicles are going at a higher speed and the bicycle is at lower speed. This variation of two speeds causes a lot of crashes between bicyclist and motorized users. Such speed humps and rumble strips always improve the behavior of motorized vehicles as well. So, unless you put these measures in place, you know psychologically the

motorist always believes that the urban road or any street is for motorized vehicles only. So, unless and until you have such measure in place, such kind of behavior will not change.

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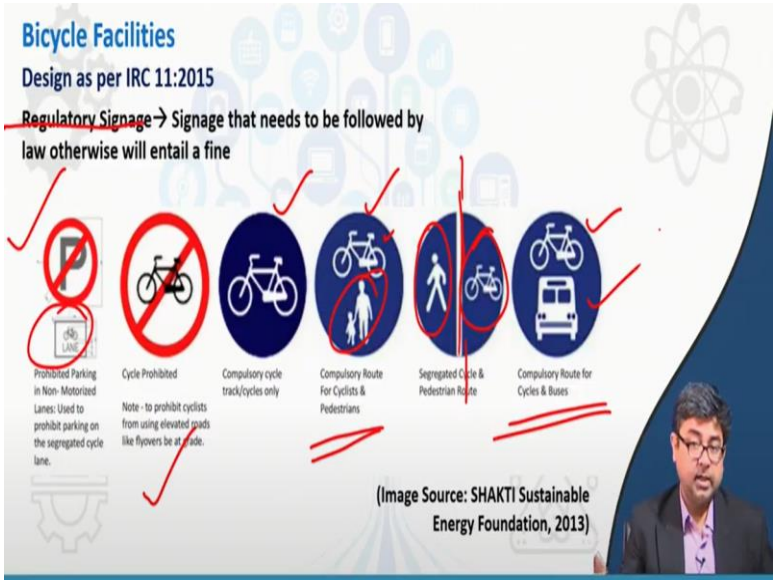

Lastly there are lot of signs that IRC has recommends. Firstly, different types of regulatory signs have to be in placed so that can be enforced. You might have seen no parking signs along the bicycle lanes. If there are dedicated bicycle lanes there may be no parking especially of motorized vehicles or any other bicyclist also parking on the bicycle lane sometime is also witnessed. Those kinds of signs have to be put in place and then of course they have to be enforced also. But the first step is to put this sign up and make people aware of these facilities. Some highways do not allow bicycles also. Bicyclists also need to be aware of which facilities are for them and which are not for them. And they should not for example bicycle on express ways or grade separated highway that is not for them. Then you have compulsory cycle tracks for cycles only or have shared use paths which are both for cyclist and pedestrians. They may be segregated, one side of the track maybe for bicycles and the other for pedestrians. Also there may be some certain lanes where bicycles share lane with buses. So there are different types of sign which are very essential for the users to understand and be aware of them so that enforcement becomes easy and transparent.

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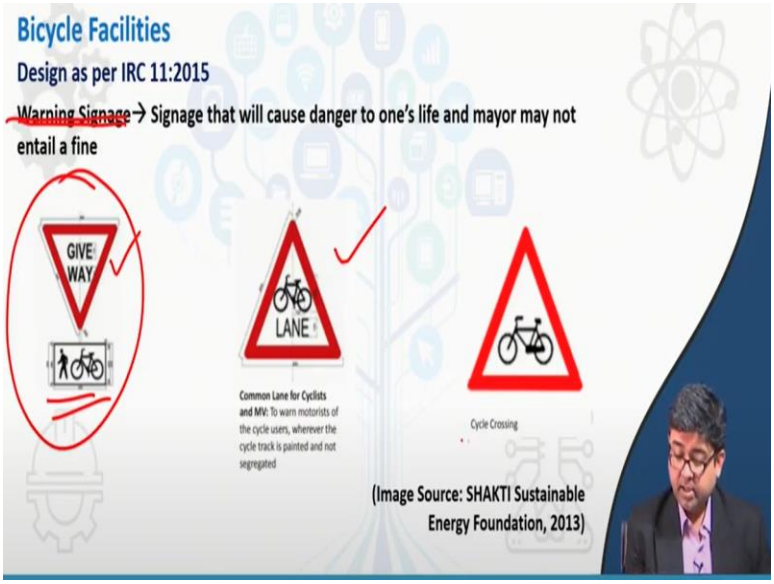

Next category of the signs is the warnings signs, right. You have to give way to bicyclist or pedestrian, especially when such kind of separated tracks or paths are crossing the motorized track. In that case the motor vehicle has to give way to them. In certain cases where the bicyclists ride along with the motorist on the same right-of-way. The motorist is made aware that this lane is being shared both by non-motorized bicyclist as well as motorized vehicle such that they behave in a proper manner. Maybe if there is an upcoming cycle crossing, warning signs has to be posted in place, prior to the crossing.

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The next set of signs are informatory signage that provides information to the bicyclist as well as the motorist about what are the upcoming facilities. Parking facilities for bicycles are for bicyclists' information and may be given about where they can park. Information about where the bicycle tracks begin can also be provided. If it common for both bicyclists and pedestrians. Such kind of signage is also very important, which provides information about tracks or ramps which are accessible to wheelchair users.

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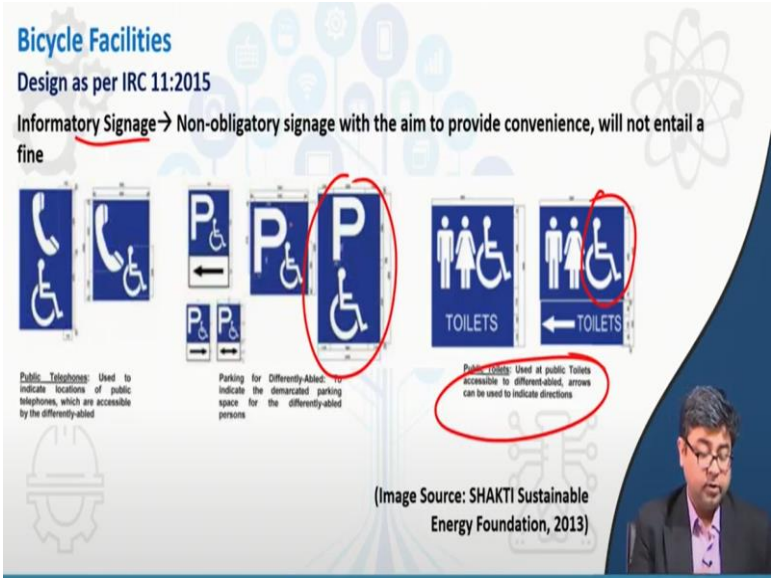

The last type of informatory sign includes information like where public toilets are located for specially-abled people, parking for specially-abled people, etc. Remember whenever we are designing for an NMT we have to take into consideration the universal design. So it is not only in the case of pedestrians but also in the case of bicyclist, we have to provide those signs. And there are public telephone signs as well.

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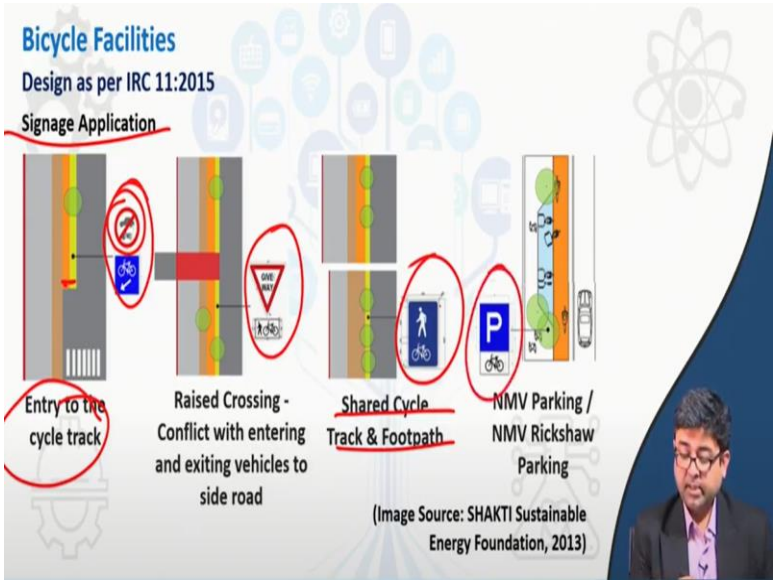

These are just some applications of this kind of signage. So when a cycle track begins at this point you have to have sign which says cycle track from here and have a prohibitory sign saying no motor vehicles in those tracks. When the cycle track is crossing a motor vehicle lane you have to give this kind of sign saying that motor vehicles have to give way to the pedestrians and bicyclist. If there is a shared cycle track you have to have this kind of sign. Also, parking for bicyclist has to be noted and proper signs have to be provided.

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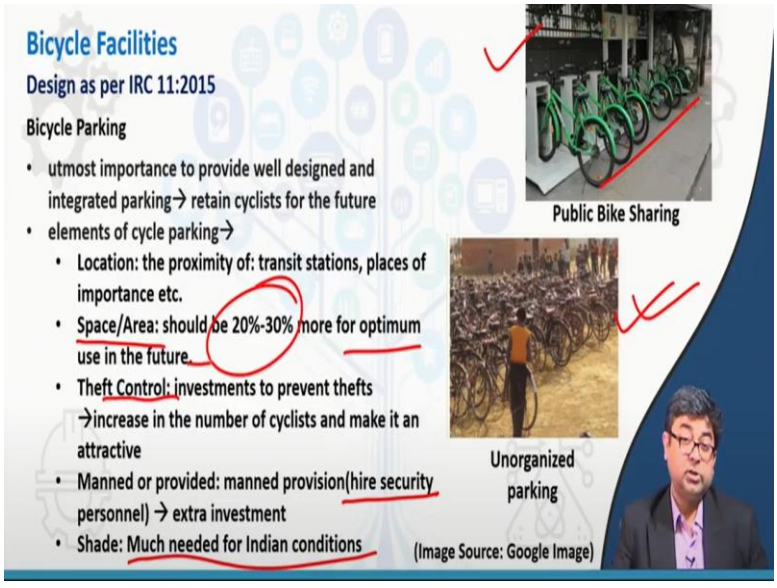

Just last slide on some information about bicycle parking in general. As we know, parking of vehicles is an issue in many of our Indian cities. Parking of 2 wheelers is an issue and so is a

parking of bicycle. We have hardly paid any attention to proper planned bicycle parking in any of the areas. Mostly it is un-organized parking, like this, but thanks to some of the newer technologies that have come up in the recent past such as public bicycle sharing system. These have dedicated parking facilities for the bicyclist that you can rent. Such systems have proper bicycle parking facilities always help bicyclist to take up bicycling and provides for the last mile connectivity. It encourages people to use NMT modes and discourage them from using motorized modes of transport. However, several designed elements have to be taken in to consideration while you are providing bicycle parking, such as shade may be needed especially for Indian conditions. There should be some form of security that should be provided so that the bicycle is not stolen or damaged, theft control should be enforced properly. And at least the area that is provided should be 20% or 30% more for optimum use in the future as well. So, thinking about the future on attracting more bicyclists to your transit or to your hotel or restaurant, you should always provide for bicycling parking. The next time you go to mall on bicycle, please make sure to see where the bicycle parking is. And if there is no bicycle parking, please make sure to make a note of it and pass it on to the authority saying that such large public places should have a proper bicycle parking. Transit stations, places of importance should have proper bicycle parking.

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So that brings us to the end of this entire module on non-motorized transportation. I hope that you have gained basic understanding of how non-motorized transportation should be planned

designed and operated. These are the references for this set of lectures. By now you must have had all the reference that was given to you over the last 4 weeks.

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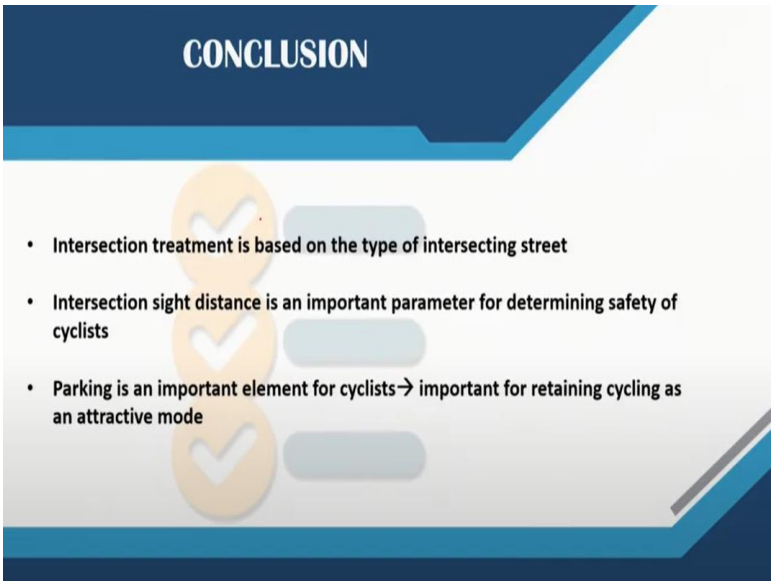

In conclusion for this lecture, we looked at different intersection treatments that is based on different types of intersecting streets. If an arterial is intersecting an arterial, you should have a different type of a design. Whereas if a local street is intersecting with the local streets, you design elements should be different. Other design elements that we looked at was intersecting sight distance which is a very important parameter to determine the safety of bicyclist especially at an un-signalized intersection, And lastly, we gave a brief overview of how and what parking elements should be taken into an account when you are looking at designing parking facilities for bicyclists. Thank you very much!