Traffic Engineering
Professor Bhargab Maitra
Department of Civil Engineering
Indian Institute of Technology, Kharagpur
Lecture 28
Intersection Control & Critical Aspects of Operation – II

Welcome to Module E, Lecture 2. In this lecture also, we shall continue our discussion on Intersection Control and Critical Aspects of Operation.

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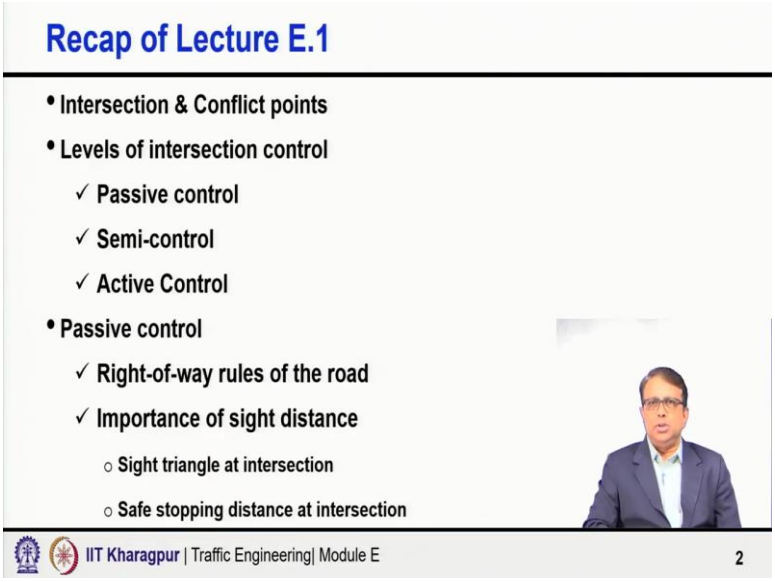

In lecture 1, we introduced you to the concept of intersection, the conflict points, major conflicts, minor conflicts, why the safety is so important at intersections. Then also discussed about various levels of intersection control: passive control, semi-control and active control. Then we started discussion about passive control. I mentioned that the right-of-way rules of the road govern for the operation of traffic at these kind of intersections.

And also highlighted why the concept of sight triangle is so important or the concept of sight distance is so important for this kind of operation. And then said that ideally from both approaches the sight distance, safe stopping sight distance should be available in order to ensure the safety of traffic operation at all the intersections with passive control.

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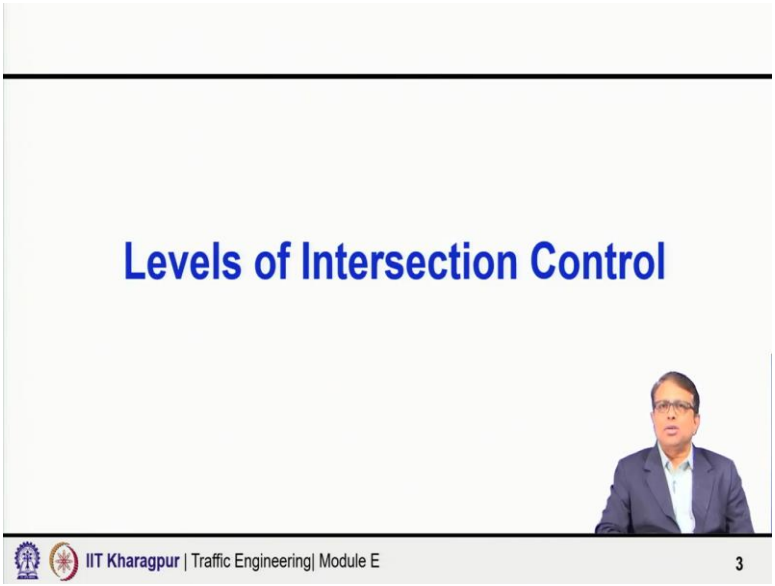

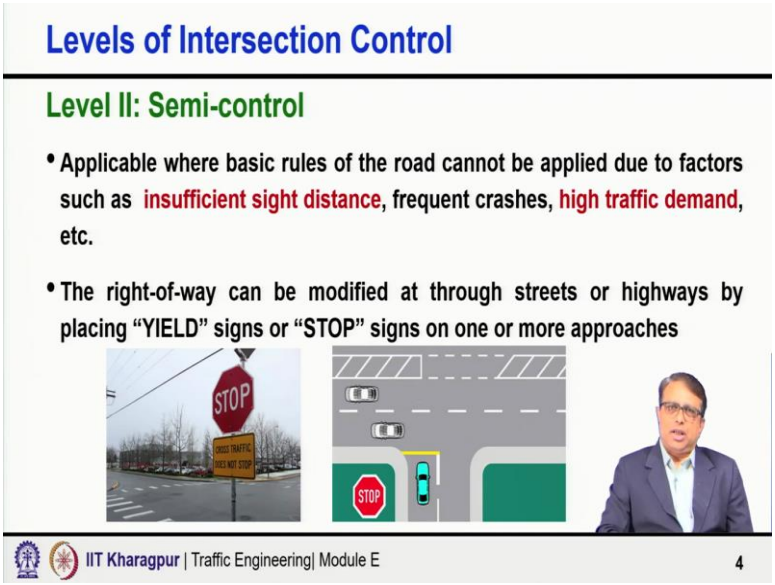

So, we shall today continue our discussion on levels of intersection control. The next level of control is called as level 2, semi-control. Now, these semi-controls are applicable where basic of the rules of the road; semi-controls are applicable where basic rules of the road cannot be applied due to various factors.

Say for example, we left operations of intersection with basic rules of road. But then we may find that maybe the required sight triangle is not available. So, the sight distance available is not adequate. Or maybe the lot of crashes are happening with level 1 control. Or maybe there is so much of high traffic demand that the overall it is not able to help us to operate it with required efficiency and safety level.

So, then the next level of improvement that can be attempted. So, the right-of-way in semi-control operation can be modified at through streets or highways by providing either YIELD sign or STOP sign on one or more of the approaches. So, I have shown here a STOP sign or you know placed on the minor road approach. That means, there is the priority of these two roads is not same. You have a major road maybe a national highway or a state highway and traffic from the minor road is coming and trying to do the maneuver at this intersection.

So, the priority here is clearly on the traffic on highways or the major roads. So, the traffic which is approaching from the minor road has to give priority to traffic movement on the major road. And the whole control is through YIELD sign or STOP sign. The YIELD sign and STOP signs both are under coming under semi-control. But the functions or the instructions are not same. I shall discuss it in the next slide.

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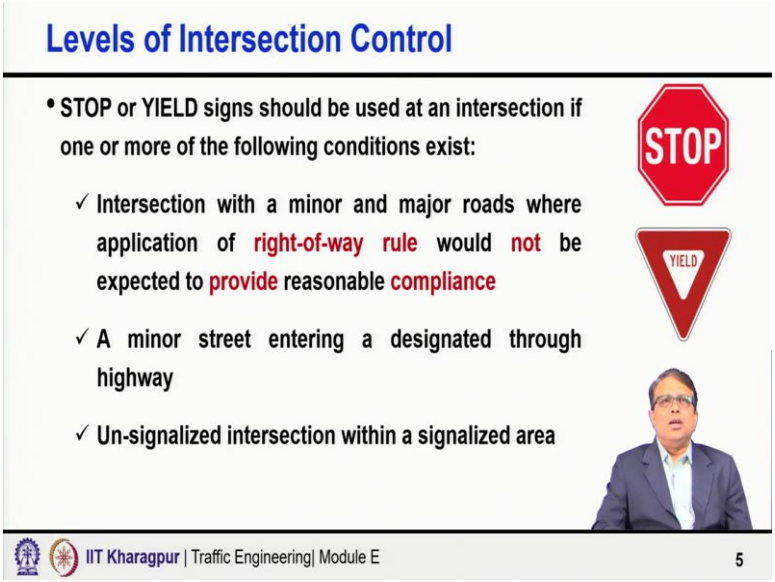

So, STOP or YIELD sign should be used at intersection if one or more of the following conditions exist. I already discussed some of those. First, intersections with minor and major roads. That means the priority is not same. Priority is higher for certain movement on certain roads or approaches as compared to other approaches or other movements.

So, here are typically applicable for intersections with a minor and major road where application of right-of-way rule would not be expected to provide reasonable compliance. People are not following it completely. Compliance is not that high. There are safety issues. There are operational issues. Also, maybe a minor street entering a designated through

highway, as also I mentioned earlier. Similar kind of operation that it is a minor street entering a designated through highway.

Or un-signalized intersection within a signalized area. That means, the generally the area in the whole area, the traffic is controlled by providing signalized intersection. But there may be an intersection in between which is un-signalized. And some of the movements are giving higher priority over others using either STOP sign or the YIELD sign.

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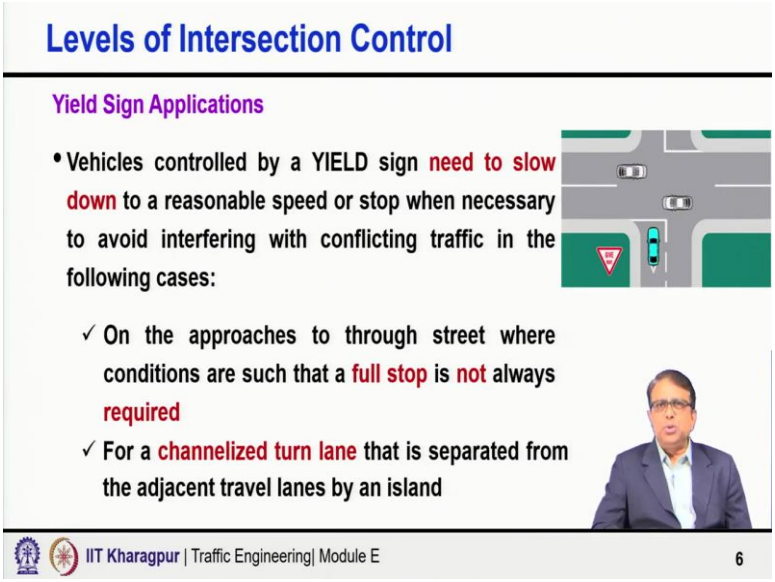

Now, where to put YIELD sign and where to put STOP sign? Or what is the fundamental difference between YIELD sign applications and STOP sign applications? Now, in YIELD sign, if we are approaching from a typically from a minor road and trying to do some maneuvers, required maneuver at the intersections with a major road, then if I find that a YIELD sign is present, as I have shown in this figure, then I have to understand that the priority of movement is for the main road traffic.

And I have to wait. I must slow down. And if required, suppose the gap is not available. Here in this case, you can see the blue vehicle approaching from the minor road which is actually controlled by YIELD sign. And the gap is not sufficient. So, the vehicle stopped. And now, when the vehicle found sufficient gap, then the maneuver is completed. So, that means, if there is sufficient gap then I can simply slow down, ensure that the gap is sufficient and then I can do the maneuver without stopping. But if the gap is not sufficient, then I have to stop and wait for the suitable gap and then do the maneuver.

So, what I have said? Here vehicles controlled by YIELD sign need to slow down to a reasonable speed or stop. Stopping is not mandatory. Not that you have to stop. So, that is very, very important. Need to slow down to a reasonable speed or stop when necessary to avoid interfering with conflicting traffic in the following cases.

One, on the approaches to through street where conditions are such that a full stop is not always required. A full stop means it is not YIELD sign but it is controlled by a STOP sign. And if it is a STOP sign, it indicates that the vehicle has to stop. There is nothing like slow down to a reasonable speed or stop. But in that case if it is a STOP sign, it is mandatory stopping. The vehicle has to stop. First stop. Then look for suitable gap. And then if the suitable gap is available, then only you do the maneuver.

So, it is on the approaches to through street where conditions are such that a full stop is not always required. That means it is possible to operate the intersections safely by providing only YIELD sign. No need to put very strict like no need to put a STOP sign to be even more strict in that sense. Second, for a channelized turn lane, this is separated from the adjacent travel lane by an island. So, a channelized, second for the channelized turn lane that is separated from the adjacent travel land by an island.

So, maybe there is a channelized turn lane and left turning is happening. But yes, it is a free left. But it is to tell that that you are allowed to merge but priority is for that through traffic. So, merge with a YIELD sign control. So, for a channelized turn lane that is separated from adjacent travel lane by an island.

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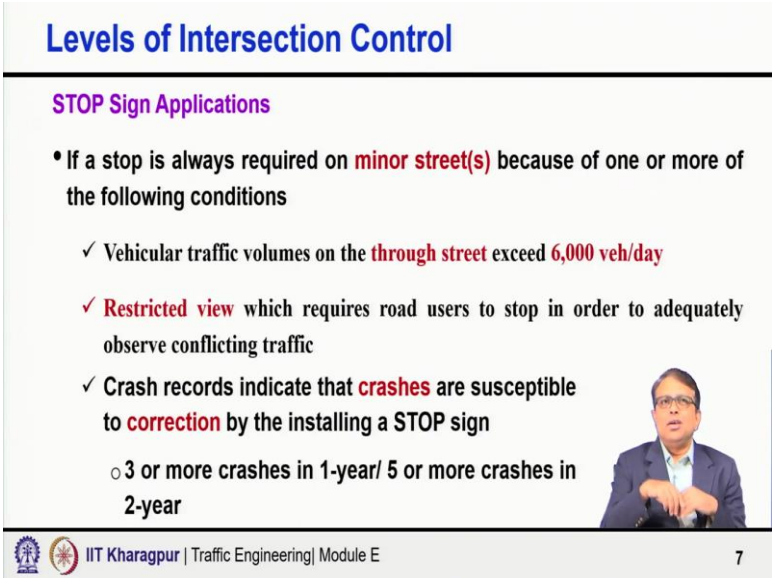

Now, next or suppose the YIELD sign applications also is not able to produce a very high level of safety. And often again, still there are reports of violation and also crashes are occurring. In that case, you go for the more stringent control like STOP sign. So, if a STOP sign is there, then it is always required on minor roads street vehicles to stop.

And where we require such kind of STOP sign applications? There are many possible situations. Maybe where the vehicle volume on through streets exceeds 6000 vehicles per day. That is one possible application of STOP signs. Then restricted view which requires road user to stop in order to adequately observe conflicting traffic.

Maybe you are approaching from a minor road and the sight distance is not available as per the requirement and you cannot probably see the road vehicles which are approaching from different approaches. You only need to stop. Then only you can look left, right and then see that how or whether there is adequate gap to do the maneuver safely. In such locations we will use.

Third, as I say that safety is a major consideration for installation of STOP sign. So, therefore, crash records, if the crash record indicates that crashes are susceptible to correction by installing a STOP sign, then you must prefer a STOP sign application. Say for example 3 or more crashes in one year or maybe 5 or more crashes in over the last two years. Such kind of situations typically may indicate that a STOP sign application is appropriate. If necessary, correction is expected by installing a STOP sign. So, you carefully understand the difference between the STOP sign and the YIELD sign.

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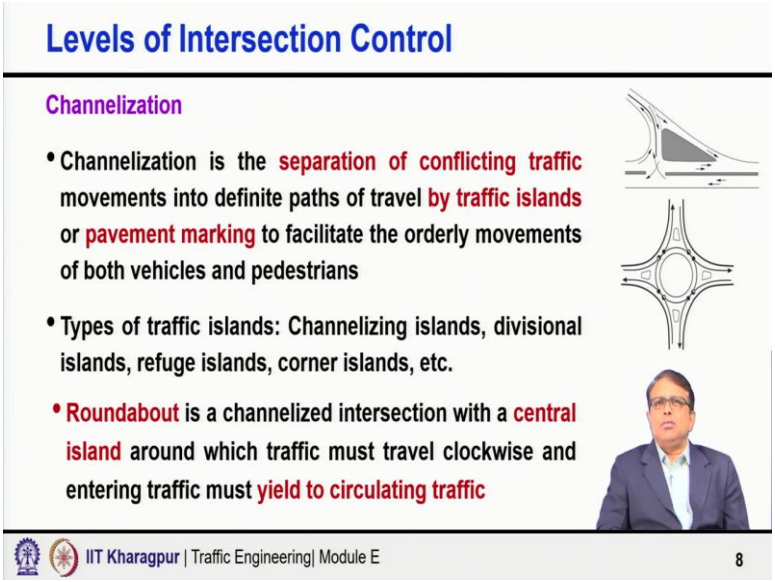

Next, often such intersections are also improved further particularly to improve the safety performance by providing channelization. Channelization of course, sometimes maybe done even for intersections which are controlled by level 1 control or passive control. There are also some times you can provide channelization.

What is channelization? It is the separation of conflicting traffic movements into definitive path of travel by traffic islands. You may provide it with physical island, typically with curve and the raised island or that island could be only by created by pavement marking. Both serves the purpose. And of course, there are merits and demerits.

If you are providing really with raised curve sometimes that itself may be a safety hazard. If you are doing pavement marking that is better. But then the compliance has also to be done. If the compliance level is very low, drivers know in some cases or in certain areas where the drivers really do not respect that. So, enforcement cannot be done adequately or is not done adequately. There may be the physical traffic island may be more useful.

A variety of things are possible in terms of channelization. For example, it could be channelizing island, it could be divisional island or a refuge and or a corner island. Many possibilities. I will show you some of the photographs to explain that how different kinds of channelization are done. Here also you can see one sketch in the top where an island has been provided. So, traffic approaching from this side can go straight and merge to the traffic. And the traffic which is taking right turn are channelized in specific path.

So, what we are doing? One thing is very important for you to understand. If the intersection area is open, large one, many possible paths for movement then naturally the safety level might be low. So, the more you channelize vehicle in a definite path, that if you are taking you know merging, taking a left turn, then all the vehicles are actually traveling along this path. And exactly at certain angle, the merging is happening. That kind of thing we can control and we can design it so that the overall safety is enhanced.

And without say even for this intersection, you can see in case of in case this island is not provided, then the right turning movement, left turning movement, multiple possibilities will be there. Some vehicle taking right turn may take one path. Some other vehicle may follow another path. Left turn also one vehicle may follow some path. Next vehicle may follow a different path. At different angles things are going to happen.

But here at the moment to provide channelization you are actually making definite path. That vehicle all vehicles will follow this path. So, you have more control. You are actually controlling even the angle, the exact path they should take. So, less confusion, more uniformity in that sense. So, overall safety is improved.

Also, you know roundabout is very popular in many places especially in rural areas. I have shown here in this figure a roundabout. All of you are familiar. You must have seen several such roundabouts in different areas. It is also channelized intersection with the central island around which traffic must travel clockwise. So, whenever we are approaching, we should travel clockwise and then whatever is the appropriate exit we can exit.

Second, also this is very important. Entering traffic must yield to circulating traffic. That means if I am entering into this roundabout, I must keep in mind the priority is always high for the traffic which is already there inside that rotary intersection. So, the entering traffic must yield to circulating traffic. So, 2 major criteria here is: traffic must, all the traffic must travel clockwise and second entering traffic must yield to circulating traffic. Both these conditions have to be satisfied.

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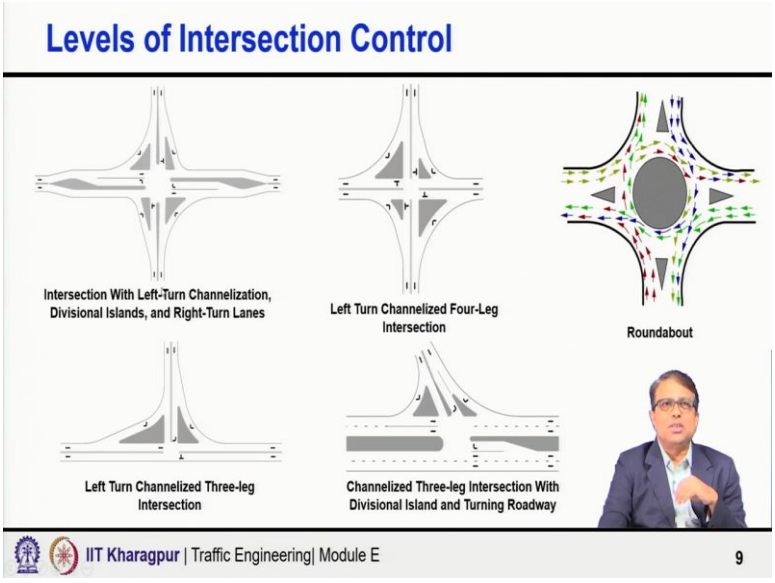

Now, here I have shown you several sketches showing that how the channelization can help in you know regulating the traffic movement as per requirement in a safer manner. So, you can see the first case in this case, it is intersection with left turn channelization. You can see from all approaches the left turn is actually made using some kind of channelization. So, merging is controlled. At which angle and how you want the traffic to merge you are controlling the movement by providing channelization.

Also, there are divisional islands. The major road is a divided road. There all approaches in fact are divided. And also there are right turn lanes. So, the traffic which is approaching and wants to take right turn, you can see there is a storage lane here, right turning storage lane which is again you know the channelization helps us to provide that kind of facility and then safe right turn can happen.

And the traffic will, right turning traffic will stop safely without disturbing the movement of the through moving vehicles. Similarly, there is also a left turn channelized four-leg intersection. In the remaining two are three-arm intersection and different kinds of channelization are done to regulate the movement as per the requirement.

So, channelization can really help you to improve the safety performance because as I said that as when there will be multiple possibilities for doing the same maneuver using multiple path, always it will be more confusing and the safety level will be low. Because different vehicles, their trajectories will be different.

For the same maneuver, the trajectories will be different. The paths will be different. But if I know that particular kind of merging or diverging or whatever you kinds of movement you say is safer than the other possibility, then provide the channelization. Guide the traffic. Ensure that that is the path they have to take without any alternative. So, overall the safety will be improved.

And here I have also shown a roundabout and I have shown the movement. You can say always you have to enter and move clockwise. And then whatever exit, if you want to exit one, exit two or exit three, you can choose an appropriate exit. And remember that whenever a vehicle is trying to enter into this intersection, the priority has to be high for the or higher for the vehicles which are already inside. So, channelization helps us a lot.

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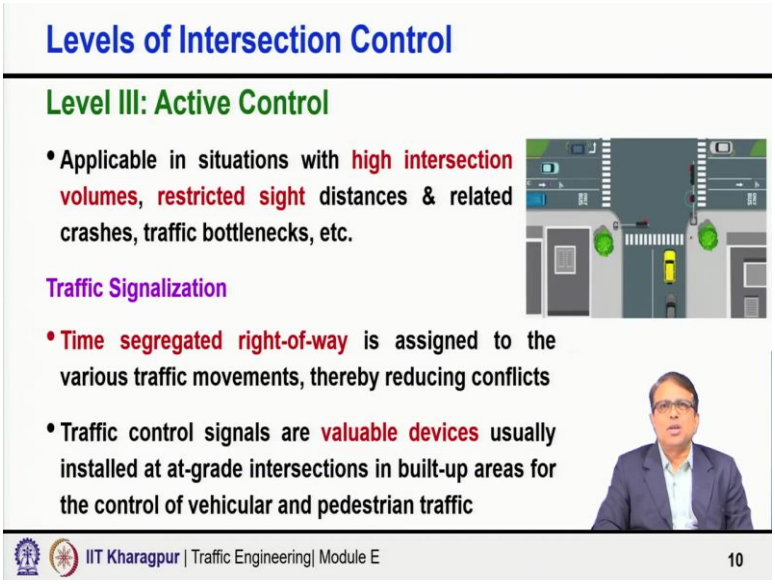

Now, even with this level of control, sometimes still the operation may not be acceptable in terms of safety, in terms of overall efficiency. And you may still find that the volume is such that it does not give really good opportunities. You have used a STOP sign. Maybe initially YIELD sign, then even more stringent or strict control by providing a STOP sign but still you may find that the overall geometry, overall configuration of the intersection, traffic volume altogether, still the end of the day the operation is not safe.

Or sometimes even the minor road traffic is not at all getting an opportunity to do the maneuver safely. Maybe they have to wait for a long time which itself is also not very desirable in overall sense. Yes, the priority is more for the mainstream traffic but the minor traffic approaching from the minor road should also get an opportunity, reasonable opportunity to do the maneuver. That is not coming.

So, in such case you further improve it. So, applicable in situations with high intersection volumes, restricted sight distance, related crash and traffic bottlenecks. So, all these will actually tell you that you need to improve the intersection control. Further go to the next level. Now, when we go to the next level, first it is traffic signalization and then the grade-separation. So, if the traffic signalization provides satisfactory performance, fine. Even traffic signalization is not able to produce required capacity to maintain certain desired level of service, then you want to improve the operation further. Then go for grade-separation. First traffic signalization.

Time segregated right-of-way is assigned to the various movements thereby reducing conflict. So, you are not allowing the conflicting movement to occur at the same time. So, the same road space, it is at the, all are at grade intersection. But there are two movements which are

conflicting and not allowed to occur simultaneously. They are segregated by time. That means, if at a given time if I am allowing this movement, I am not then allowing the other movement. Where I am allowing this movement, I am not, you know, allowing the other movement to occur.

So, traffic control signals are valuable devices usually installed at at-grade intersections, typically in built up areas for the control of vehicular as well as pedestrian traffic. Because I mentioned it in my first lecture on this module that conflicts may be due to vehicle-to-vehicle movements or for movements or due to the movement of vehicle and pedestrians.

So, the conflict could be vehicle-to-vehicle movement conflict or vehicle-to-pedestrian movement conflict. Vehicle-to-bicycle movement conflicts. So, variety of conflicts may be there. So, it is vehicular movement as well as pedestrian traffic. So overall, we want to enhance the safety by providing time segregation or traffic signal control.

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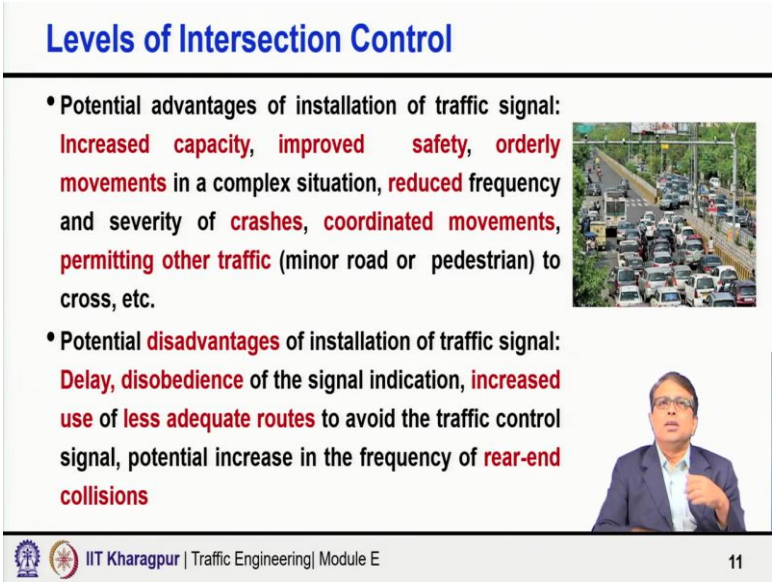

Traffic signal control has several potential advantages of traffic signals. For example, the it may help you to increase the safety. It may help you to improve the overall capacity of the intersection. Helps you to make orderly movements in a complex situation. Different, so many complex movements are happening. And similarly, it helps you to make the movements more orderly. Reduce frequency and severity of crash. Also helps you to do coordinated movement of vehicles along the corridor. Even helps you to permit other traffics to move safely.

That means minor road traffic or even the pedestrians to cross the road safely or in case of minor road traffic to do the maneuver safely. So, basic thing is the generally increased

efficiency, increase safety, orderly movement, etcetera. But also, there could be potential disadvantages to traffic signals depending on the context and in some cases the experience may not be good always. So, do not think that always putting a signal is a solution. Sometimes it may not work also.

For example, the moment you are installing signal, you are actually doing time segregation. That means there will be delay. You are not allowing all the movements to occur simultaneously. So, there will be delay. And sometimes that delay may be really significant because of the signal. You are improving safety but you are compromising in terms of delay.

Many cases it may be disobedience of signal indication. Violation may be an issue. Of course, it can be corrected as well, through proper enforcement. But it could be an issue. Sometimes increased use of less adequate routes to avoid the traffic control signal. People may simply try to avoid certain routes and use alternative route just because they have to stop too many times at the signals.

One more important thing that we want to enhance safety. That is our very primary objective. But some cases due to installation of signals, the rear-end collision may increase. Sometimes due to installation of signals, the rear-end collisions may increase. So, if there are certain experiences you know of increased rear-end collision, you have to rethink. I am not saying always that remove the signal or removal of signal is the only solution. Not at all. But such kind of you know potential disadvantages also one may have to face.

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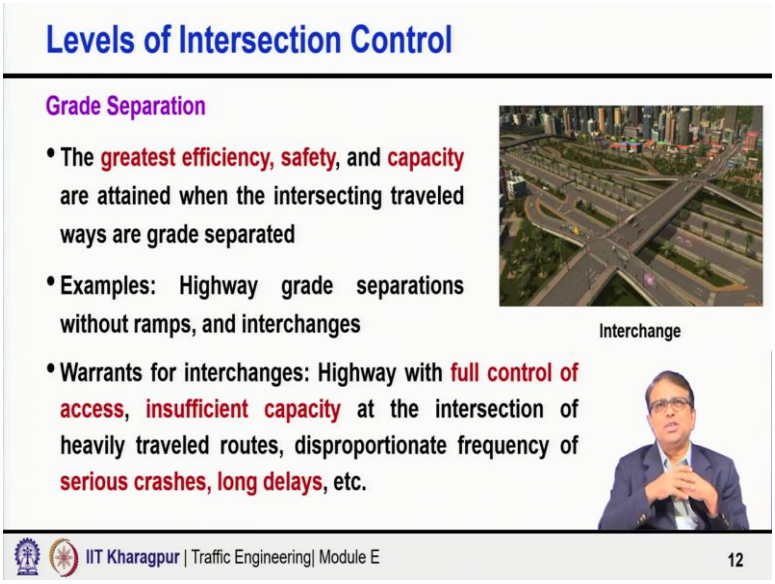

Now, even if it does not work, signalization also does not give the required result, then you go to the next higher level of control. Probably the best level is grade separation. You can see the video. You can see how the traffic moves in a grade separated intersection. Conflicting movements are happening sometimes. But they are happening, conflicting movements are happening. But happening at different grades, different levels. So, actually, there is no conflict.

Because we have separated the conflicting movements by grade. So, the greatest efficiency, safety and capacity attained when the intersecting traveled ways are grade separated. But remember that it is expensive solution. So, not that always we will go and make the intersection grade separated. It may look nice such things but the use of this kind of facilities are to be justified properly. So, it could be highway grade separated without ramp, with ramp, with interchanges. All different possibilities are there.

Now, where typically we would like to go ahead with the grade separation? Particularly for highway with full control of access. You want to develop completely access control facilities. So, obviously you want to remove at-grade intersections. Because at-grade at intersection, the traffic entry and exit will really influence or inter, cause interference to that traffic on the control access facility. So, all the intersections are to be actually access control. You do not allow anywhere and everywhere creation of intersections. Maybe service road other alternative facilities. But only at selected locations, you may create grade separator.

Wherever the existing capacity of the intersection at-grade intersection is insufficient and the overall level of service or quality of service is not acceptable, much below the required level

of service, such kind of things or such cases you can; in such kind of situations, you can use grade separated facility.

Or even disproportionate frequency of serious crashes. Even at intersections also, lot of crashes are happening. Delays are happening also. So, under typical that kind of situation where nothing else is working in terms of safety and or efficiency, there you will go for grade separation. But you require larger land. So, land requirement is one issue. Cost is another issue. So, not that always we will go for grade separator. It has to be a step wise improvement. Start with level 1. It does not work, go to level 2. Then go to level 3. First, signalization. Still it does not work, then go for grade separation.

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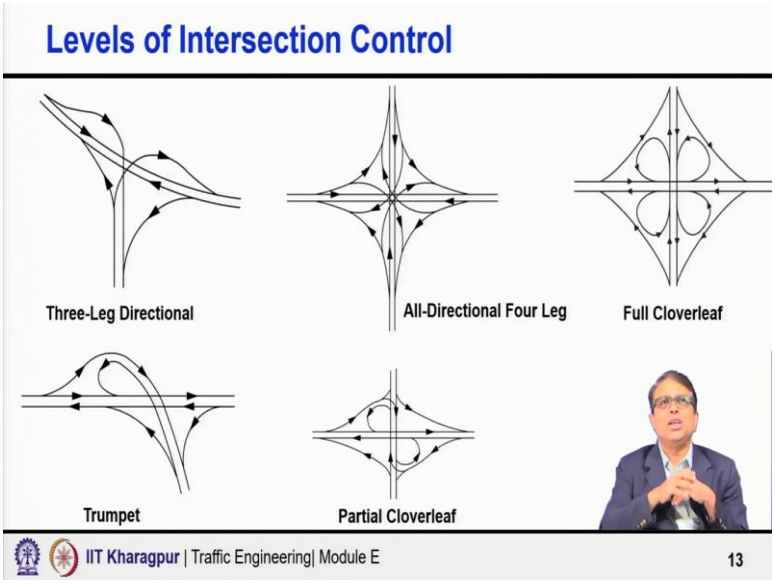

Now, here I am showing a few grade separated facilities, layouts typically. You can see it could be full cloverleaf like. All movements are permitted with full segregation. No conflicts, nothing. But some cases it could be simply two roads crossing each other, just a simple flyover, typically what we see. Without any even exchange also, some cases.

Some cases, the grade separator maybe to be segregate the major traffic, you take allow them to take elevated road. So, a good number of conflict is eliminated. The remaining traffic even maybe at-grade. You may even operate the remaining thing because half of the traffic volume is you know taken away because of the grade separated facility without any problem. Then, the remaining traffic is manageable. So, you may not go always for the all movement through grade separator and interchanges. It depends. So, varieties of layout, varieties of possibilities are there in terms developing the grade separated intersection.

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Data Requirements for Justifying Traffic Control Signals

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- The number of vehicles entering the intersection in each hour from each approach during 12 hours of an average day (greatest % of the 24-hour)
- Vehicular volumes for each traffic movement, classified by vehicle type, during each 15-minute period of the 2 hours in the morning and 2 hours in the afternoon (peak hours) (*Item B*)
- Pedestrian volume counts on each crosswalk during the same periods as the vehicular counts (*in Item B*) and during hours of highest pedestrian volume
- Stopped-time delay data and queuing information at important locations

Data Requirements for Justifying Traffic Control Signals

- Information about nearby facilities and activity centers that serve the young, elderly, and/or persons with disabilities
- The posted or statutory speed limit or the 85th-percentile speed on the uncontrolled approaches to the location
- Condition diagram showing physical & geometric features of intersection
- Collision diagram and crash experience (by type, location, direction of movement, severity, weather, time of day, date, and day of week)

Now, quickly before I close, I would like to discuss about data requirements for justifying traffic control signals. We need lot of data to check whether traffic signal installation is really necessary. One is typically 12 hours volume. 12 hours means, out of 24 hours the greatest percentage of 24 hours. So, when the 12 hours, that 12 hours span the traffic volume is maximum. So, there 12 hours traffic volume study we need. We need vehicular volume for each volume movement, classified by vehicle type, during each 15-minute period of the 2 hours in the morning peak and 2 hours in the evening peak.

Also, the pedestrian volume counts during the same periods. I have written as Item B. Item B means during the same period where you have actually carried out vehicle volume study. Also, maybe the stopped-time delay data, queuing information. So, to understand the basic performance and how under what circumstance the present signal traffic in junction or the intersection is operating.

Also, maybe information about nearby facilities and activity centers that typically serve the young, elderly or person with disabilities you may find nearby there is a school. Several hundred students are actually using this road to cross, for crossing purpose on their way to school or while they are going back home. Or maybe there are typically may be some establishments in the nearby area that attracts elderly people. So, you know that you have to take care. So, signalization may also consider that type of need. So, all these are important.

The posted or statutory speed limit and if that is not available then 85th percentile speed you can calculate on the uncontrolled approaches to the location. Then also you require maybe condition diagram showing all physical and geometric features of the angle. The complete details is available in the condition diagram.

Also, if crashes are happening, then in case of crashes, collision diagram and crash experience. What type of crash? Where it is occurring? What you know direction of movement actually are; what are directions of movement that are involved? What is the level of severity? What is the general weather conditions? What time of the day typically crashes are happening? Or which typical, is there anything on a typical day in the week the crashes are happening? All such kind of information you need.

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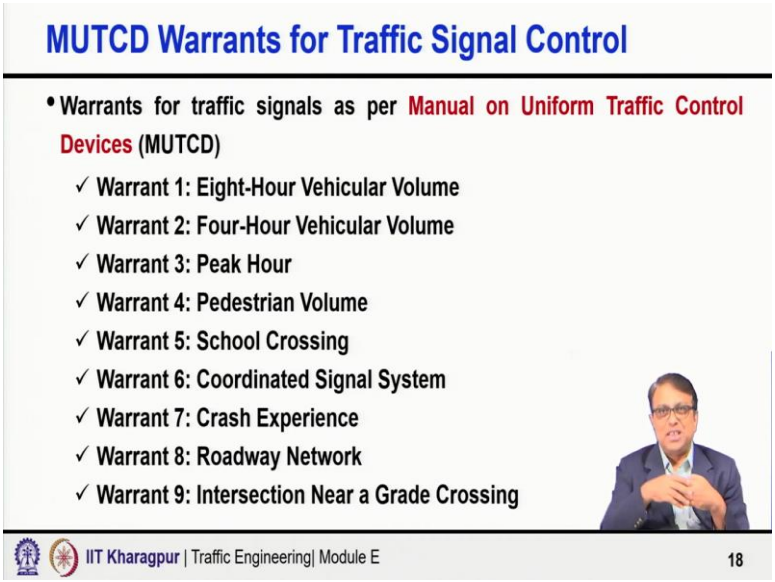

So, with all this information, there are several warrants which are popularly known worldwide by MUTCD Warrants for Traffic Signal Controls. We can then check this MUTCD warrants. What is MUTCD? It is called as Manual on Uniform Traffic Control Devices. Manual on Uniform Traffic Control Devices.

So, there are as many as 9 warrants. Based on eight-hour volume, four-hour volume, peak-hour volume. These are all about traffic. Then also based on pedestrian volume, based on the school crossing, based on requirement of coordination of signal system. Because the platoons maybe dispersing too much and you want to again bring them together. So, you install a signal. That may be a requirement. Based on crash experience, based on the roadway network requirements or intersection near or near a grade crossing. Or intersection near a grade crossing.

So, there are 9 warrants which I will discuss further details, in more details I actually discuss. There are 9 warrants which I shall discuss in details in the next lecture. So, but those are the data which I mentioned, all these data are actually useful, all these studies are actually useful to get the necessary data so that these warrants can be checked.

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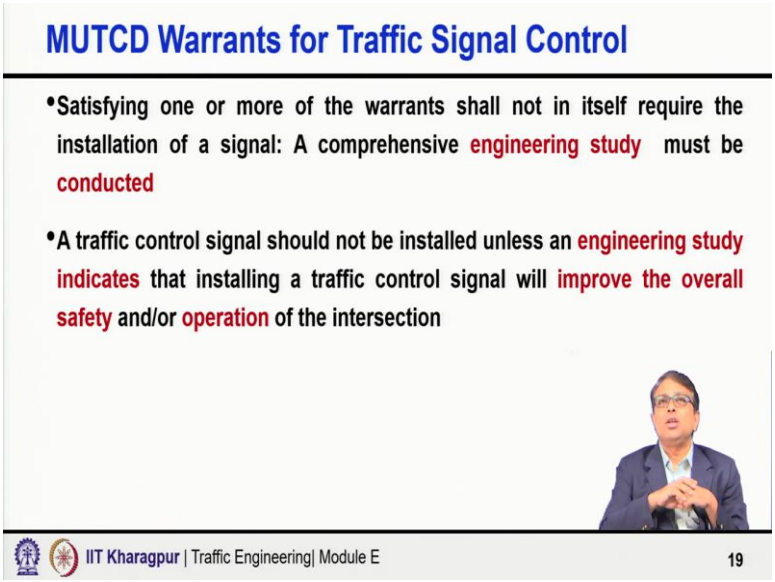

So, satisfying this is very important thing before I close. Remember that there are MUTCD warrants. But satisfying one or more warrants shall not in itself require the installation of a signal. It is not that the one or more warrants is getting satisfied so that means. Yes, install a signal. It may not be true.

You require a comprehensive engineering study to make a conclusion. But these are the warrants. That means it tells you warrants are, one or more warrants are getting satisfied, it is quite possible that the signalization is actually necessary. But not in 100 percent cases. So, that tells you that you need to go ahead with a detailed engineering study to really make a conclusion about that. So, traffic signal control should be installed only when engineering study will clearly indicate that installing a traffic signal will improve the overall safety and operation of the intersection.

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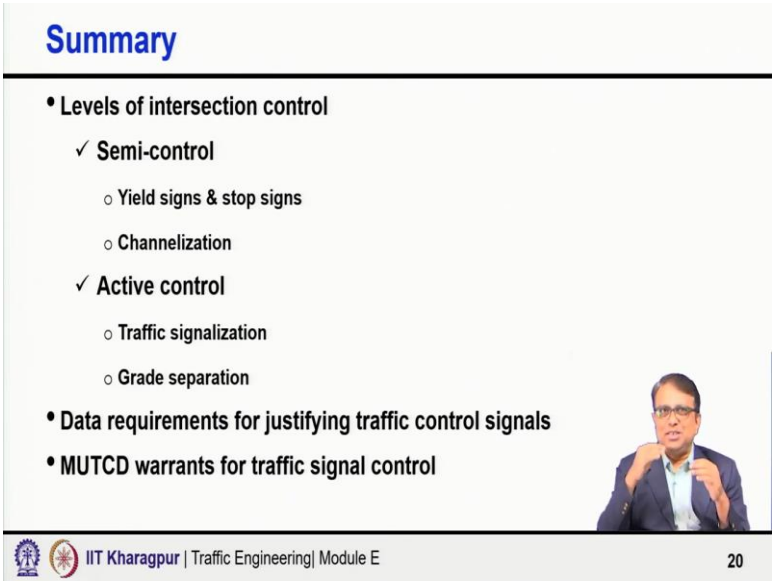

So, with this I close. But what we discussed today is: semi-control, level 2 control and then also about the active control. So, all three levels of control we discussed and then we went and discussed little briefly about the various data requirements which are useful or different studies and data which are useful for checking the warrants which are given by MUTCD. And in the next lecture, I shall discuss further details about the MUTCD warrants. Thank you so much.