Traffic Engineering
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Lecture 41
Signal Coordination - II

Welcome to Module E, lecture 15. In this lecture, we shall continue our discussion about Signal Coordination.

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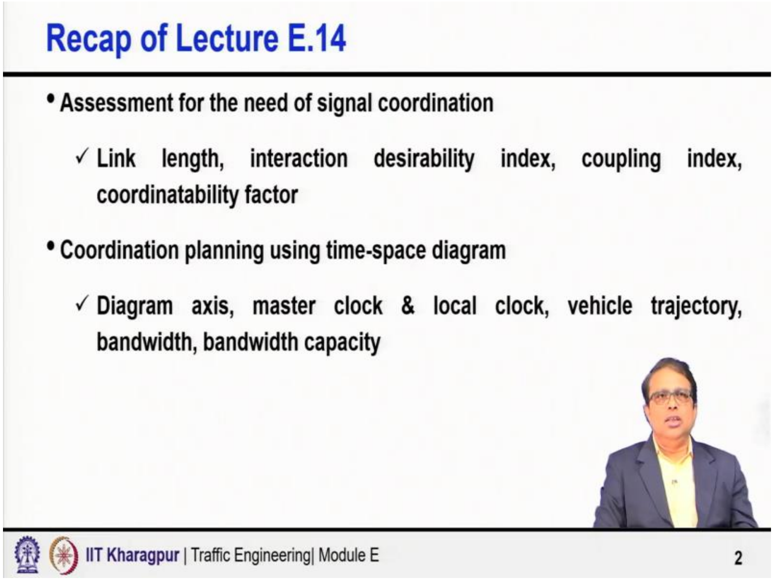

In lecture 14, I discussed about 2 specific aspects of signal coordination first, about the assessment for the need of signal coordination using different parameters. So, for example, Link length, interaction, desirability index, coupling index, coordinatability factors and then I also, mentioned to you and explained the use of time space diagram for the signal coordination planning. Diagram axis, the concept of master clock, local clock, vehicle trajectory what all information we can extract from vehicle trajectories, the concept of bandwidth and the bandwidth capacity.

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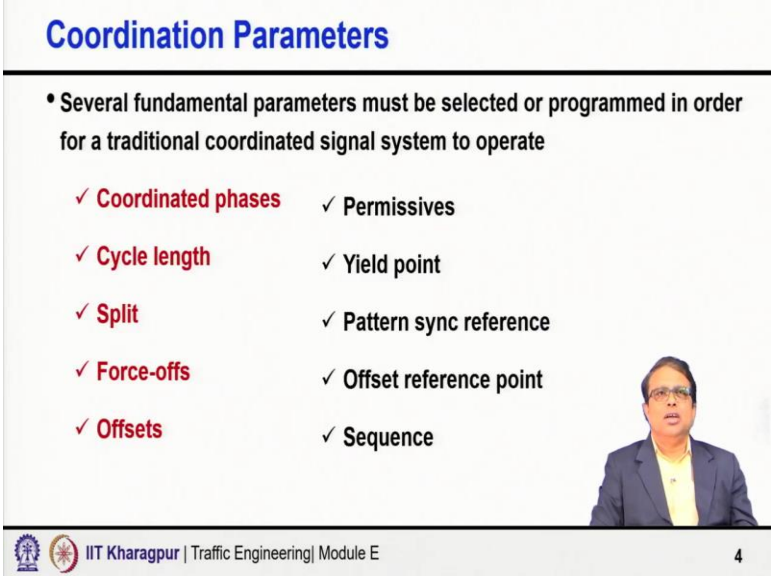

Today, first we shall focus on some of the important coordination parameters. There are several coordination parameters which are extremely important in the context of design of coordinated signal systems. Some of the parameters I want to discuss today for example, coordinated phase, cycle length, split, force off and offsets these are the 5 parameters which I would like to discuss in today's class. There are also, other coordination parameter for example, permissive, yield points, pattern synchronization reference, offset reference point, sequence you may refer to signal design manual to know more details about all such parameters.

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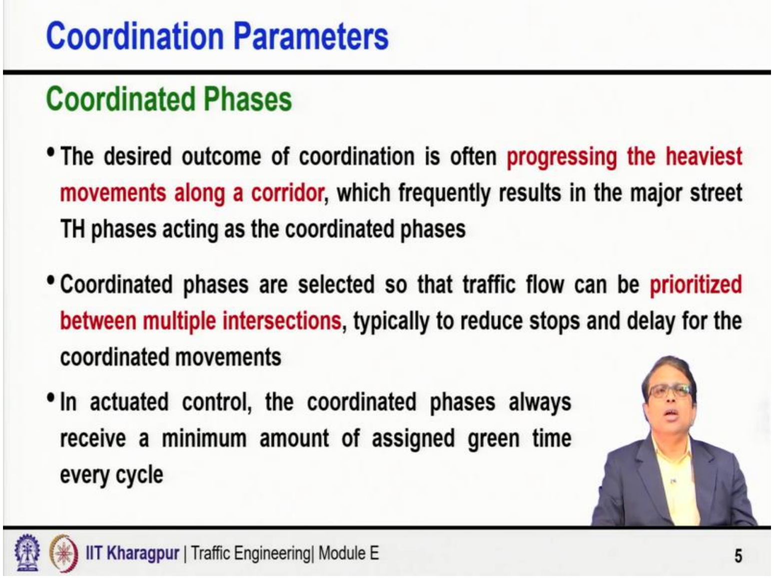

First coming to coordinate phase which phase to coordinate primarily in an urban area for example, a morning peak it is all vehicles are running towards the CBD area. So, if we are coordinating mostly, we would like to coordinate the through movements which are passing through several intersections along the major arterial and traveling towards the CBD. So, that desired outcome of coordination is often progressing the heaviest movement along a corridor and this frequently results this kind of movements in major street through phase and therefore, we try to coordinate this particular phase which is surfing the through movement.

And once coordination is done, the traffic flow in that process will be prioritized between multiple intersections it could be 2, 3 or 4 depends on again several factors, the intersection traffic volumes, the traffic patterns, the length or the distance between successive intersections, all this will govern.

And if we are using actuated control, then the coordinated phase always received a minimum amount of assigned green time every cycle because as you understand if we are designing a fixed time signal, then obviously, the cycle length is fixed and every phase is well defined including the coordinated phase or phases and obviously, they will get the predefined green time, but in actuated control, Sometimes Some of the phases may not even receive the green time.

It depends on whether the demand is there which is how many how many movements we are trying to bring into the actuation system or in the actuated under actuated control all this will govern but even when we are operating with actuated control, since the signal coordination we are doing obviously, the coordinated phases will always receive a minimum amount of assigned green time in every cycle that is what is that point.

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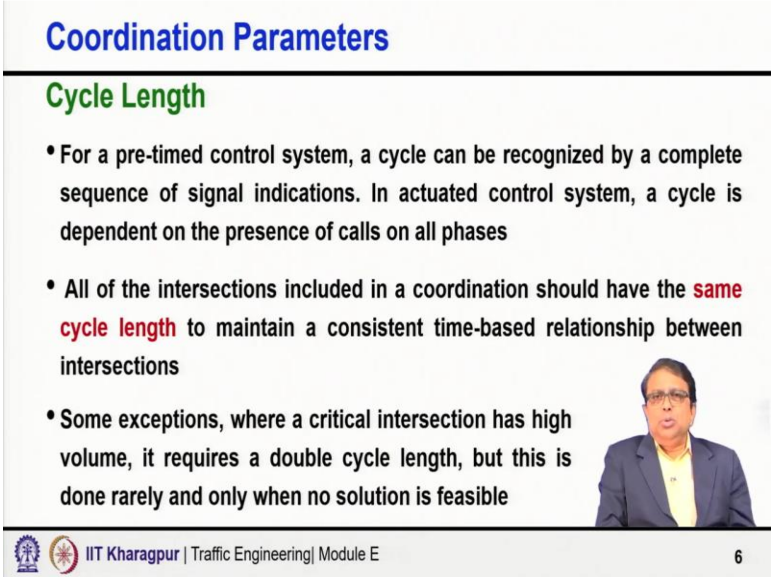

Coming to the cycle length, all of you by this time understand what is the cycle length we have discussed also. So, many times for a pre timed control system, a cycle can be recognized by complete sequence of signal indication for example, if just a 2-phase signal, then phase A receive some green time then also, receive some green time then again green comes back followed by Amber, all red and red again, the green will come back. So, like that the cycle will continue.

So, a cycle can be recognized by complete sequence of signal indication, in case of the actuated signal control a cycle is dependent on the presence of calls on all phases, every cycle every phase may not receive green the phase may change even the cycle length may change it depends on what is the present traffic state and what kind of rules we have in built into the controller for doing the coding actuation or for doing the actuated control.

So, in that case a cycle depends on the presence of calls on all phases that will govern that cycle. And it also, depends on what kind of coordination we are doing traditional coordination system again the cycle length is fixed, the phasing also, may be fixed, but in kind of advanced control everything may change also. So, it is coordinated, but based on the real traffic state all of the intersections included in coordination should have rather must have the same cycle length to maintain a consistent time is relationship between intersections.

I mentioned to you about the master clock and the local clock and instead the role of master clock mainly for defining the offsets. So, whatever maybe the offset if the offset is again between signal 1 and signal 2, then every cycle whenever the green is initiated after t seconds, the signal to the green will be there for the same movement. So, the signal cycle length has to be same otherwise, it will not be possible that every cycle after t seconds the green will happen initiation of green will happen in the subsequent or the downstream signal.

So, this is one requirement which is very clear and we need to keep that in mind and that will control many other decisions related to coordination. So, we need that means that kind of operation of signals where more or less same cycle length will work. If the cycle length differs very significantly, then the coordination may be challenging and the coordination may not even bring the expected benefit. So, the next point some exceptions, where a critical intersection has high volume, it requires a double cycle length, but this is done rarely and only when no other solution is feasible. It is a possibility but not so common.

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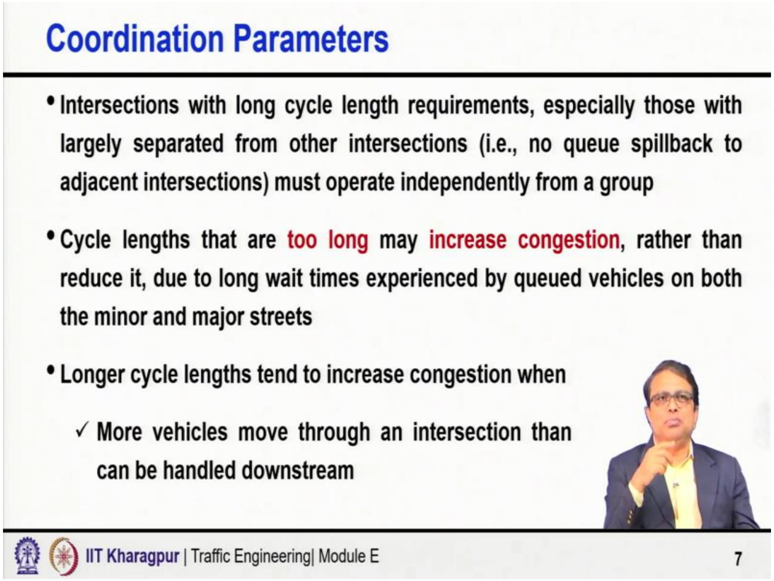

In the same spirit. I would like to mention about the following points. Next point intersections with long cycle length requirements long as compared to other signals which we are trying to coordinate. So, intersections with long cycle length requirement, and especially those with largely are largely separated from other intersections and when there is no queue spill back to adjust and intersections, such kind of intersection must operate independently from a group from a group of signals, which we are trying to coordinate.

As I said, since the cycle length should be common, it is important that the intersections are somewhat similar, no two intersections will be exactly the same in terms of traffic volume to geometry and requirements exactly same, it may not be there, but it should be somewhat similar. So, that if you are operating with the same cycle length in case of regular coordination not for very advanced coordination, then it should actually end up the day it should benefit the traffic it should serve the objectives of doing the coordination.

Cycle lengths that are too long may increase congestion that is another point when we are deciding the cycle lengths, we have to bear in mind that if the cycle lengths are too long, eventually the congestion may get aggravated, rather than you know getting elevated or getting reduced. And this could be due to the long wait time experienced by queued vehicles on both minor and major streets, because since your cycle length is longer, therefore, the key will be formed on minor road and also, the measured approach.

Longer cycle lengths tend to increase congestion when more vehicles move through an intersection then can be handled downstream signals are there traffic is moving through a series of signals more vehicles move through from an upstream but then the number is really more as compared to what can be handled by the downstream intersection, then the congestion may occur increase congestion may increase with longer cycle length.

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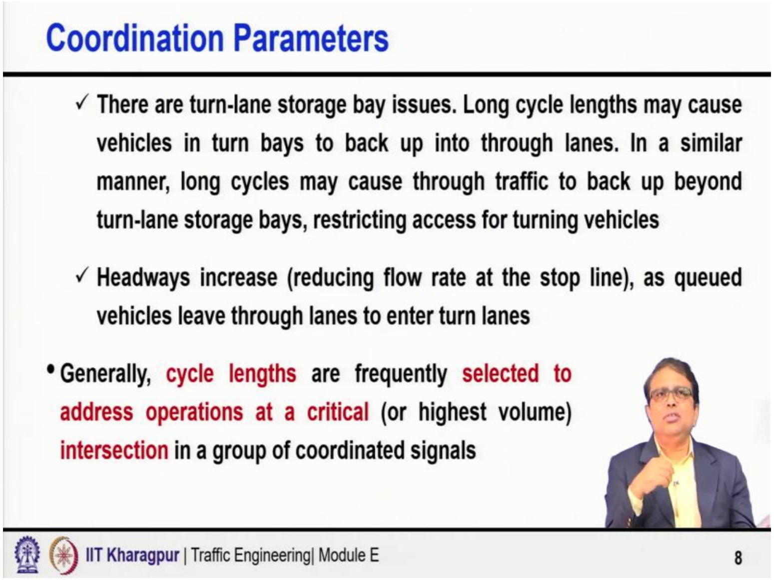

Second, there are turn lane storage bay that are also, used for say right turning lane we create an additional storage layer that is for turning traffic. Now, if we are using long cycle lengths, sometimes what happens vehicle in turn bays to back up into through lanes. Suppose you have kept it for turn storage you have kept it for 6 or 7 vehicles. If there are more than that number of vehicles then what will happen now right turning in that case, if there are more right turning vehicles, then in that case, since the turn storage, turn-lane storage is full, these turning vehicles also, will occupy the through lane.

So, in the similar manner, long cycles may also, cause through traffic to backup beyond the turn storage bays restricting access for turning vehicles, it will happen otherwise also. The through traffic queue is long enough. So, the vehicle which is actually maybe your right turn storage lane is fine. It is available, but the vehicle cannot reach up to that because the straight or the through movement queue, through vehicle queue is long enough and blocking the access for the turning vehicles.

Headway may increase as queued vehicles leave through lanes to enter turn lanes. So, when the vehicles you are discharging the vehicle, the headways may increase or the discharge may reduce or decrease Because queued vehicles they have to actually leave through lane to enter into turn lanes. Generally, cycle lengths are frequently selected to address operations at a critical or generally speaking highest volume intersection in a group of coordinated signals.

So, if I am trying to coordinate some 3 or 4 signals, obviously, the cycle lengths common cycle lengths will be selected generally, based on the requirements are at a critical intersection, which is the heavily loaded intersection or highest volume intersection, because that if not, then these critical intersections requirement will not get satisfied. So, that is the key that cycle length are frequently selected to address operations at a critical intersection in a group of coordinated signals.

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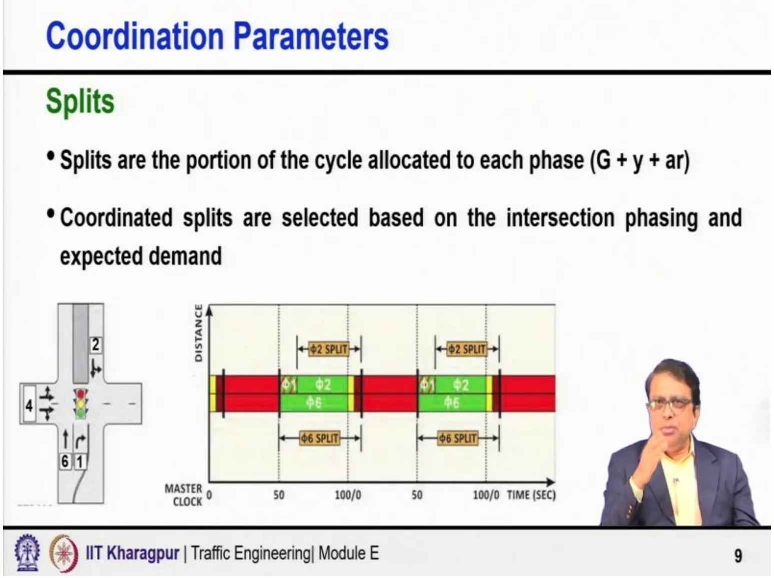

Coming to the concept of splits, you already know splits are the portion of the cycle allocated to each phase, how much green time we are giving what is amber, all red time, because every phase will receive some amount of green time along with followed by yellow time and all red time. So, that will be decided and that is what we call as splits, coordinated splits are selected based on the intersection phasing and expected demand when we are doing the coordination of signals, then the splits are selected based on intersection phasing what is the phasing that we are going to use, and what is the expected demand.

Here I have shown here, suppose, if you consider these intersections, you can understand it clearly. The first say let us say it is red, then it gets green, green, who gets green phase movement 1 and 2. So, they get green movement 1 and movement 6. So, phase 1 gets green, movement one gets green, that is the turning, that is what is the leading movement here 1 and 6 straight they are getting green, but then after some time, we stop 1 right turning and we start allowing to straight and left from the opposite direction. So, this is the split here for movement 2 and this is the split for movement 6 then followed by Amber followed by all red and then the conflicting movements starts. So, that is the way the signal is operating. So, you understand the concept of splits.

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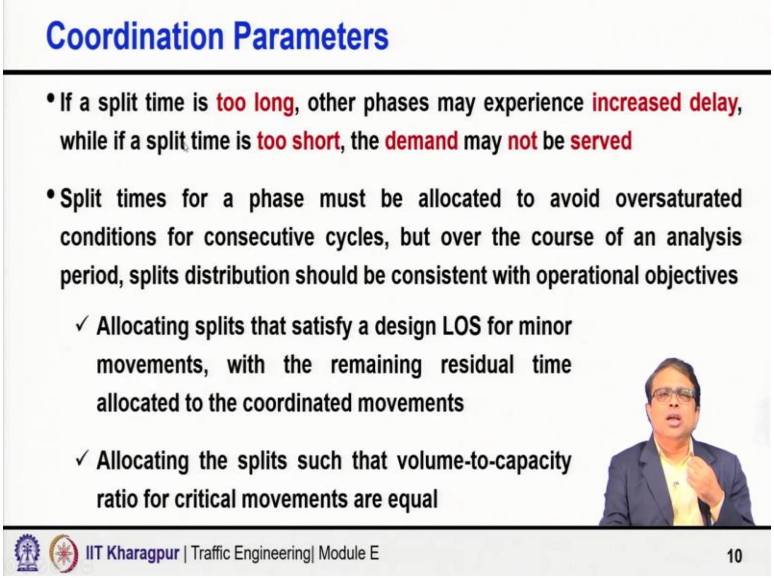

Now, if a split time is too long, then also, there is a problem. If split time, a split time is too less then also, it has a problem. So, if the split time is too long, then other phase may experience increased delay because your overall cycle length is same. So, if you are giving too much of green for one moment, say that one phase the other phase may not get adequate green. So, therefore, the delay may increase on other phases. While if a split is too short, then the demand may not be served at all.

So, whatever is the demand that is to be served. So, if my split is too short, I may not be able to serve the demand, split times for a phase must be allocated keeping in mind a few things for example 1, to avoid oversaturated condition for consecutive cycles. So, if it should not lead to oversaturation in consecutive cycle, then there will be many consequences. The queue length will you know grow and there will be other issues but over the course of an analysis period split distribution should be consistent with operational objectives.

So, one way it must be allocated to avoid oversaturated condition for consecutive cycles, but over the course of an analysis period, split distributions should be consistent with operational objectives. What I mean by that operational objective? Say allocating splits that satisfy a design level of service for minor movements, you have designed the signal I have discussed earlier also, in my lecture about the traffic signal control, that planning level analysis operational level analysis. So, LOS is very important.

So, allocating splits that satisfy a design LOS for minor movement with the remaining residual time allocated to the coordinated movement. So, we try to satisfy that objective. Second allocating the split such that this is again very important and I mentioned this thing to you, when I discussed about the planning level analysis of signalized intersection allocating the split such that volume to capacity ratio for critical movements are equal. Please recall my discussion about the planning level analysis of signalized intersections and there that was the aim that we allocate the green time or allocate the split in such a way or in such a manner that the volume to capacity ratio for critical movements are equal.

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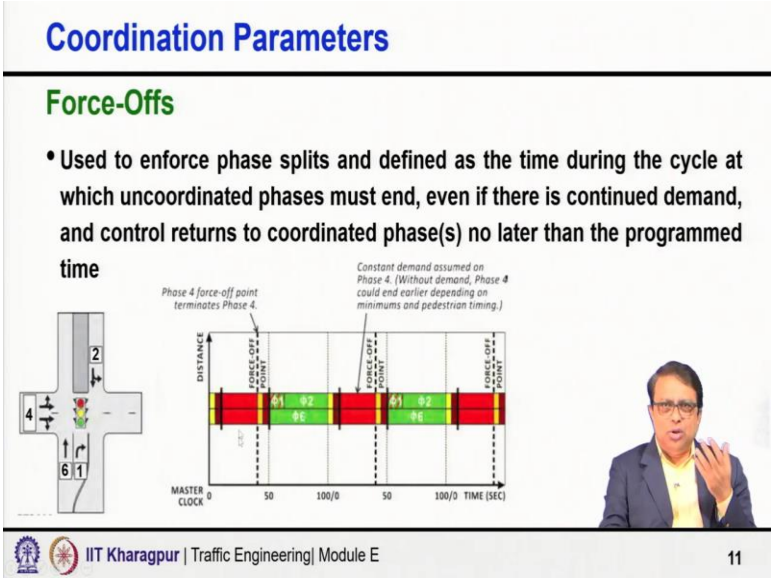

Now, coming to the concept of force offs, force offs is used to force and this is applicable for actuated control in actuation or actuated control what we do as long as the green given is less than the maximum green and within the PT within the passage time, if another vehicle arrives and the sensor or detectors tells me that the vehicle has arrived, then we extend that green and we keep on extending the green till the green is within the maximum green.

So, always the allocated green is more than the minimum green and less than the maximum green. But if there is coordination along with this vehicle actuation, then the coordination is also priority, coordination gets even higher priority than actuations. So, what we will do the coordinated phase as per the master clock must get and the decided offset must get green, the coordinated movements that phase must get green.

So, even if a vehicle is present, and even though the maximum green time has not been reached, still I should do force off and give green to the coordinated phase as per the master clock and as per the offset. That is what is said here, used to enforce phase splits to enforce phase splits and defined as the time during the cycle at which uncoordinated phases, uncoordinated phases, because we want to go back to the coordinated phase.

So, the uncoordinated phases must end even if there is a continued demand and control returns to coordinated phases no later than the program time, program time is what I said as for the master clock and as per the offset, you know, that this coordinated phase must get green at this time. So, we will do force off and green to the coordinated phase.

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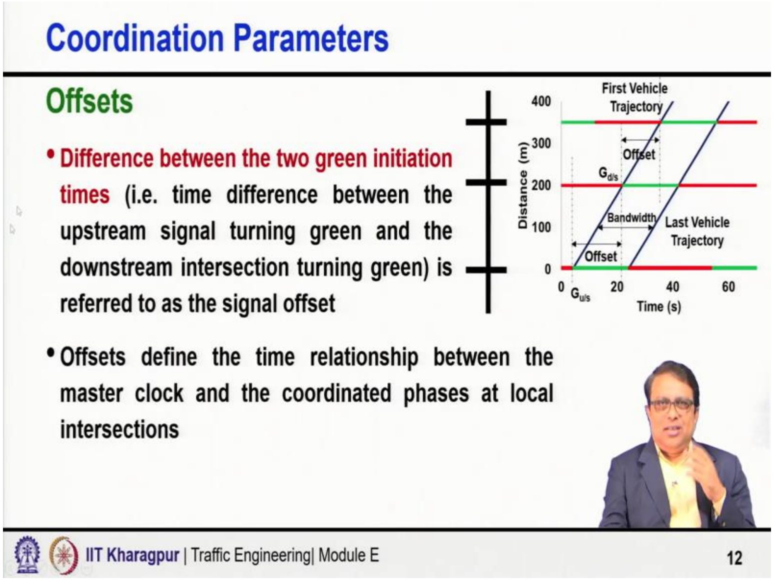

Coming to the concept of offset. As you know, it is the difference between the 2 green initiation times I have discussed earlier. So, these 2 lines in this particular diagram is showing what is the offset you have a signal here and he will also, signal that 200-meter distance and other signal at 400-meter distance. So, what is the difference between the 2 green initiation times I start green here after how much time or after how many seconds I will start the green for the next signal.

So, it is the time difference between the upstream signal turning green and the downstream intersection turning green and that is referred to this difference in time is referred to as the signal offset. So, as per the offset signal will start becoming green. Offsets define the time relationship between the master clock and the coordinated phases at local intersections. So, that the connection that is maintained.

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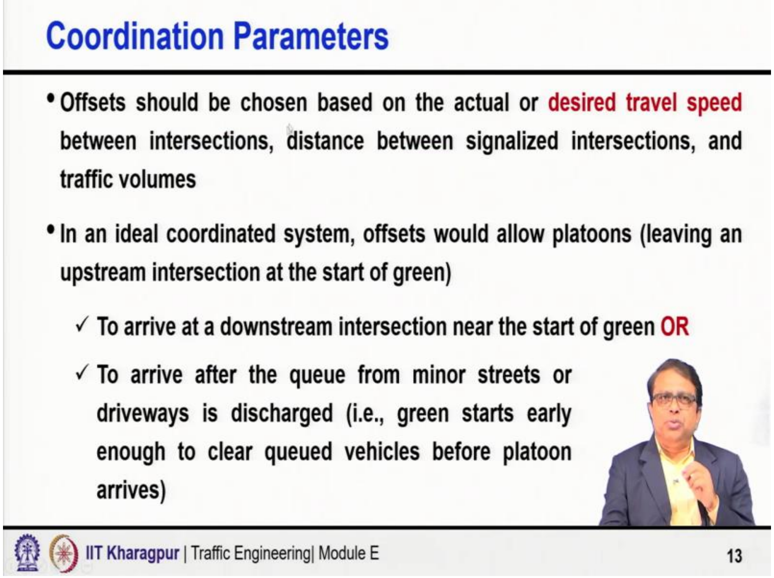

Offset should be chosen based on the actual or desired travel speed between the intersections what is the speed that we expect the vehicles to travel or to achieve what is the distance between 2 signals and how much is the traffic volume because the volume will also, influence the travel time in an ideal coordinated system offsets should allow platoons which are leaving an upstream intersection at the start of the green to arrive at a downstream intersection near the start of the green.

So, bunch of vehicles getting released the first vehicle which is getting discharged as soon as the signal turns green, when that vehicle reaches to the next intersection in the downstream when the vehicle reaches to the downstream intersection the signal turns into green for the downstream intersections. So, that is the first case to arrive at a downstream intersection near the start of the green or to arrive after the queue from minor streets or drivers is discharged. Sometimes the traffic is entering not only based on the through movement, but from the side roads also, the turning traffics are coming in entirely in other phases.

So, if those vehicles may be queued up in the downstream intersection. So, the green is initiated in such a manner that those queued up vehicles are cleared. And eventually when the first vehicle with is getting discharged in the green as per the coordinated movement when that vehicle reaches to the intersections, all the queues queued up vehicles are cleared and that vehicle is able to proceed without stopping or without any interruption.

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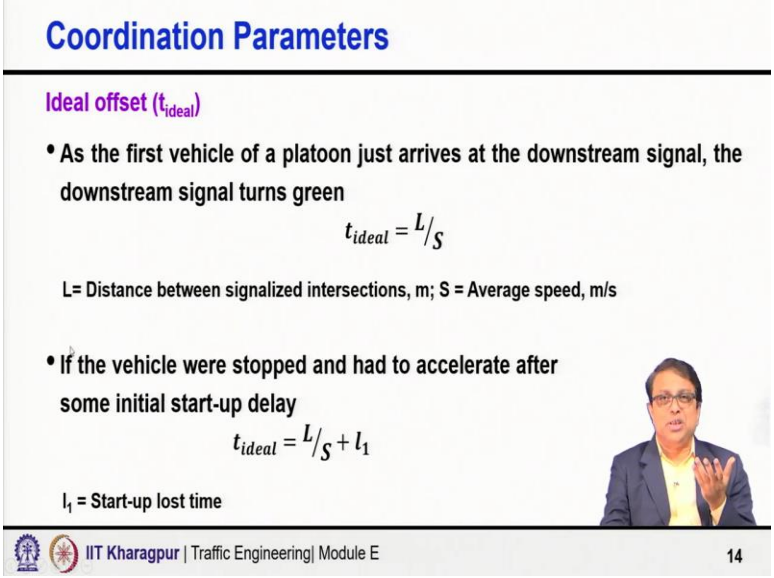

So, the concept comes here ideal offset. What is the ideal offset? As the first vehicle of a platoon just arrives at the downstream signal, the downstream signal turns green. So, L is the length in meters between 2 signals, and if S is the average speed, then what will be the ideal offset L by S.

$$t_{ideal} = L/S$$

So, if the vehicles were stopped, and had to accelerate after some initial startup delay, if the vehicle in the first intersection, it was in stopped condition, obviously, the offset will also, include the startup last time. So, L by S plus l1, where l1 is the startup last time.

$$t_{ideal} = L/S + l_1$$

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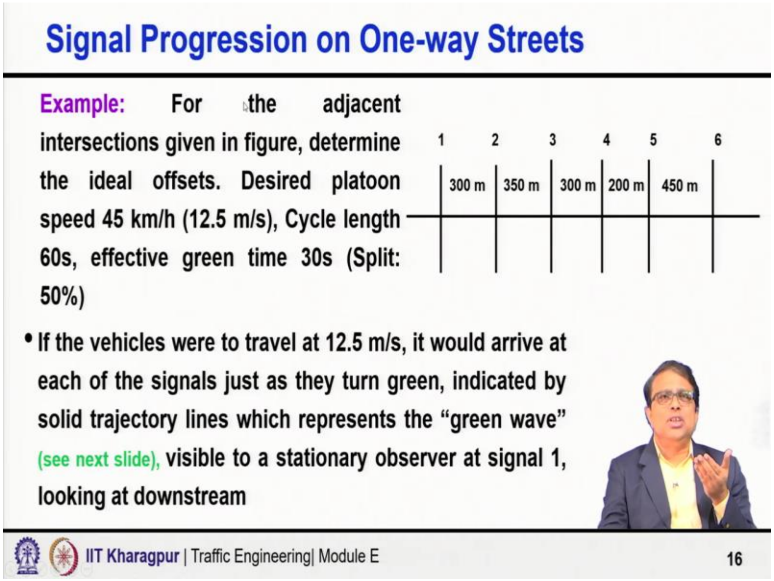

Now, let us see how the signal progression happens on one-way streets. Let us consider this example you have 1, 2, 3, 4, 5, 6. These all are signals, the distance between 2 signals are giving here 1 to 2 - 300 meter, 2 to 3 - 350 meter, 3 to 4 - 300 meter and so on. And what is said here the desired platoon speed at 45 kilometer per hour or say 12.5 meter per second and the cycle length is 60 seconds and effective green times 30 seconds. That means split is 50 percent. So, total cycle length is 60 seconds, 30 second is green and 30 second is red in general.

So, if the vehicles were to run at 12.5 meter per seconds, it will arrive at each of the signal just as the turn green indicated by solid trajectory lines, which represents the green wave, I am showing it in the next slide visible to a stationary observer at signal one. So, means if is stationary observer at Signal 1 is watching the movement observing the movement, he or she will feel that as vehicles are moving and reaching to the intersection it just becomes green, then it moves further reaches to the next intersection, it just reaches near the intersection it becomes green. So, it is like a green wave that is going and the whole bunch of vehicles is passing through a series of intersections without stopping.

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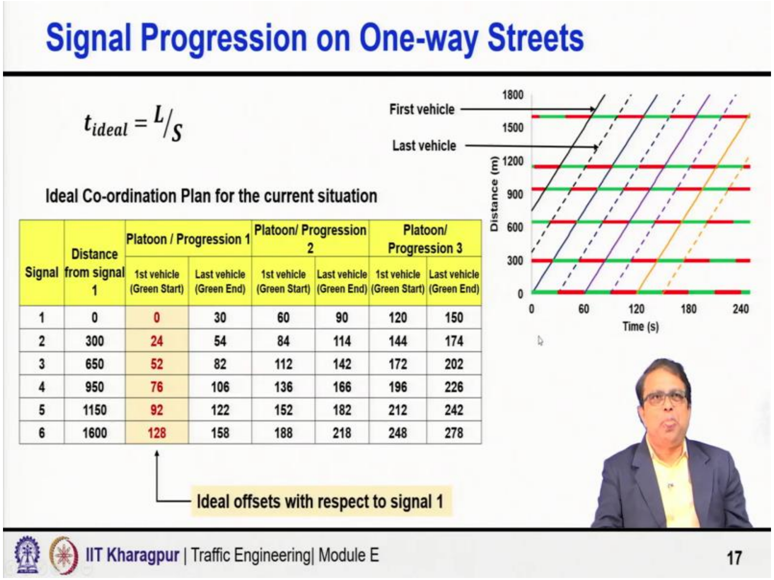

So, considering that it is ideal situation. So, the ideal offset is L by S, you can actually calculate once the distance is known for the first platoon or progression one, let us say here, it is the first probably starting at 0 and then when it reaches their L by S is you know, the 24 seconds, then 52 seconds, 3rd intersection, 4th intersection like that the first vehicle in the platoon will reach to the intersection 6 at 128 seconds.

So, my green should start if the green is starting at 0 for signal 1, green at Signal 2 should start at 24 seconds, 3 it should start at 52 seconds, 4 it should start at 76 seconds, in 5 it should start at 92 seconds and in signal 6 it should start at 128 second. Then the platoon leader the first vehicle will pass through all 6 intersections without stopping what will happen to the last vehicle obviously, the last vehicle since 30 seconds is the green time. So, the first intersection it crosses at 30 seconds.

Similarly, you add 24 seconds here 54 seconds and like that you can calculate all this. So, similarly, I have shown it for the second platoon or progression to second obviously we will start at 60 seconds. So, first one starting at 0 second, 2nd platoon starts at 60 seconds, 3rd platoon starts at 120 seconds and like that.

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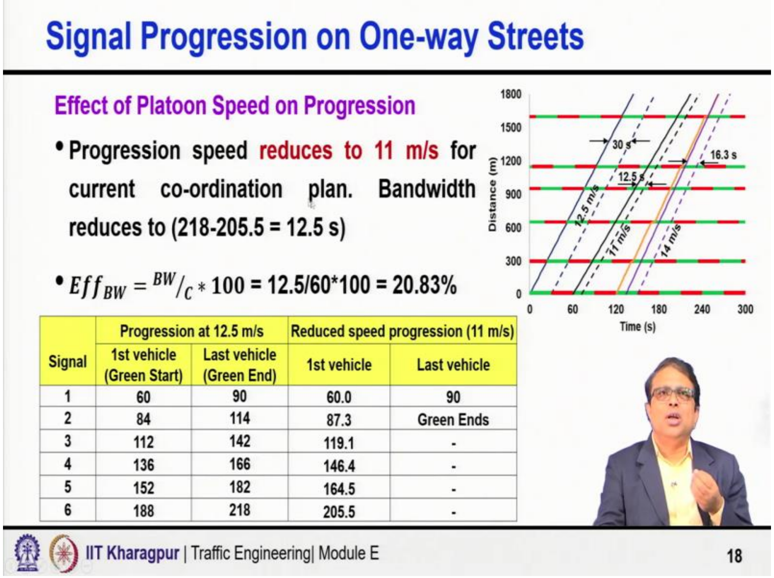

Now, let us also, understand the effect of platoon speed on progression, everything looked so nice here the whole green time whatever vehicles are entering through signal one, they are passing through all 6 intersections without stopping in an ideal condition if the vehicle travels really at 12.5 meters per seconds.

But suppose it does not happen that and the speed is different speed is lower than that and maybe let us consider the speed is 11 meters per seconds, then what will happen you will find that not all vehicles will be able to pass through all the signals without stopping as it happened earlier, the similar kind of thing is not happening, some of the vehicles will be able to pass through which are getting discharged during this 30 second green time in signal one, but all those vehicles will not able to pass through all subsequent intersections without stopping.

So, the bandwidth gets reduced and I have shown it here it will say now, the bandwidth reduces to only 12.5 seconds. Earlier it was 30 seconds because the whole green time was the bandwidth. But now, because the speed is different than what you actually programmed that means I did my coordination plan based on that previous speed that is 12.5 second, but actual vehicle speeds platoon speed is lower than that, then my bandwidth gets reduced. And I get the bandwidth efficiency of only 20.83 percent instead of the earlier 50 percent bandwidth efficiency.

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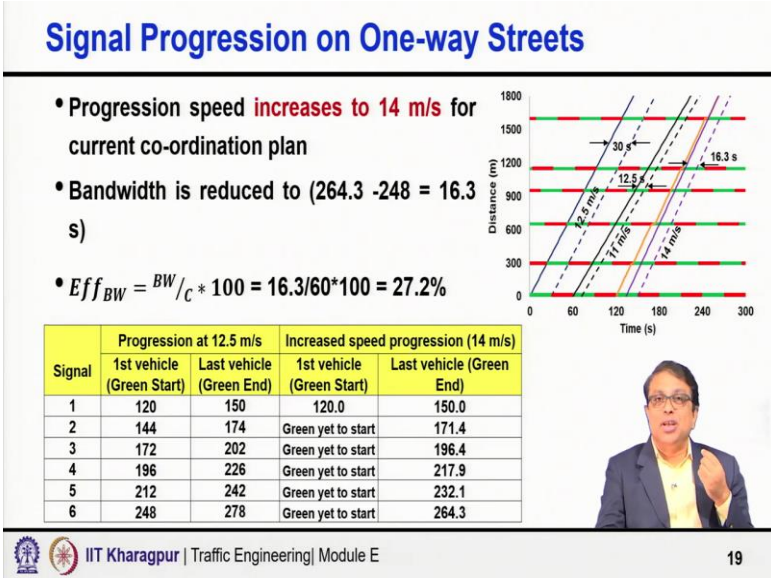

Now, what happens if the speed is even higher that is also, a problem. Then also, some vehicles will be able to clear through all the intersections without stopping, but not all the vehicles which are interfering during the green time from signal one you can see the vehicle trajectories and you will appreciate that not all the vehicles which are entering during these 30 second green times in from signal 1 will be able to pass through all these signals without stopping some of them will actually go and reach during red time. So, they have to stop. So, naturally the bandwidth again will get reduced here in this case you are getting bandwidth of 16.3 seconds. So, obviously, the bandwidth efficiency becomes 27.2 percent.

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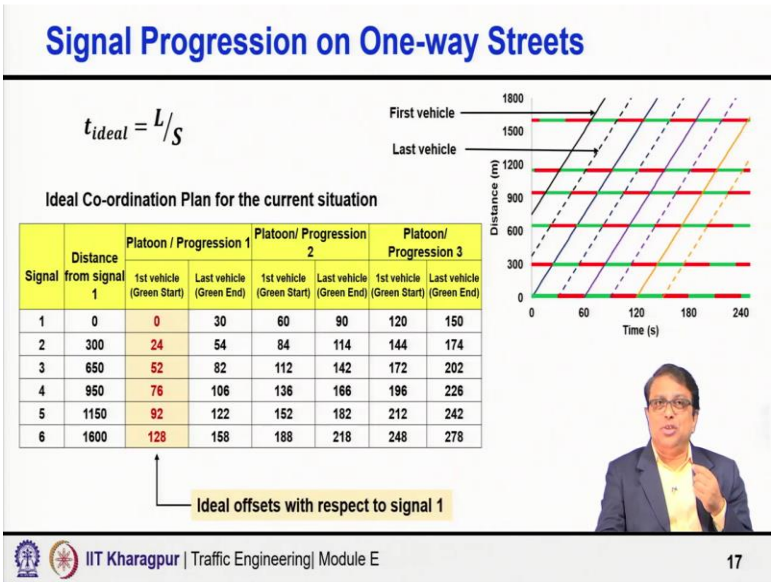

So, what it tells us that if the speed whatever speed you have considered for the design of this offset and overall design of this code in to signal if the actual platoon speed is higher or lower, then the efficiency will come down.

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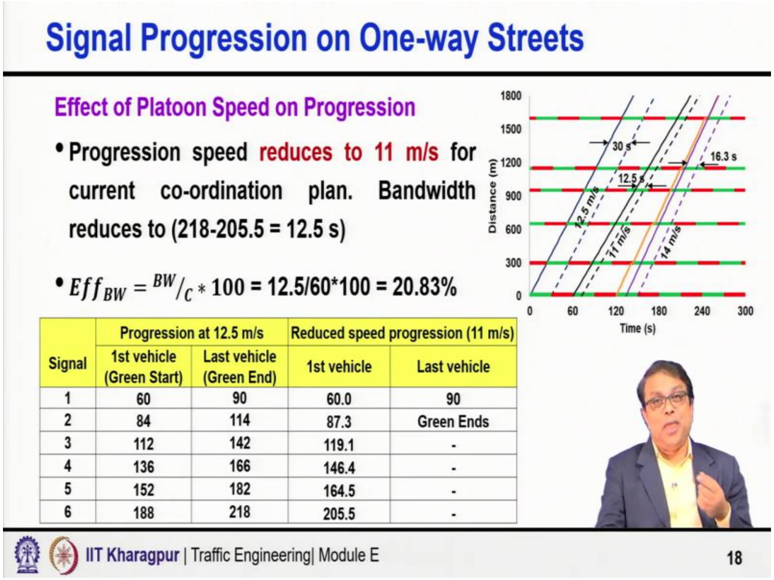

Now, the speed is very, very critical, because it depends on the roads, roadside environment, it depends on the traffic volume so many factors mix of vehicles. So, this is a challenge that how I can get maximum bandwidth efficiency, because if I get higher bandwidth efficiency, then I will also, get higher bandwidth capacity.

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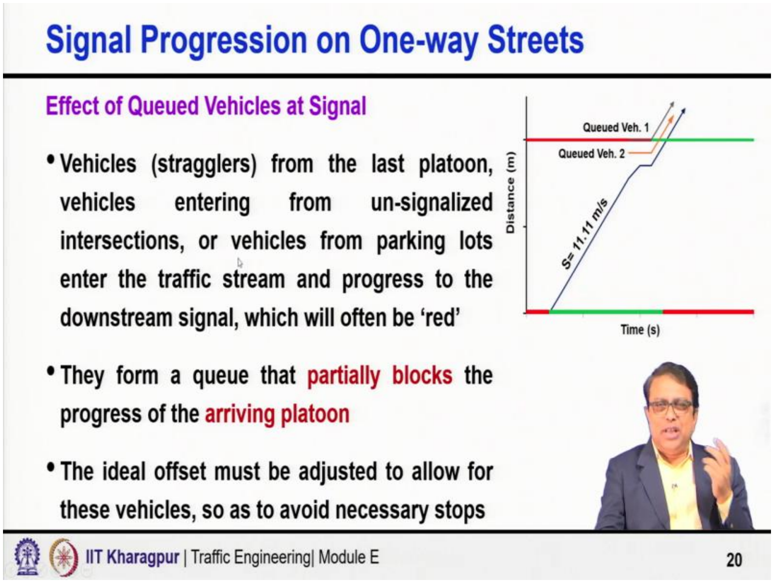

Now, that was ideal when the vehicle was just reaching and then there was no queued-up vehicles in the downstream intersection and it was all clearing. Now, if there are few vehicles which have entered during other phases from the upstream intersection, or might have come and joined from the side road or they were parked and then they started in between. So, it is quite possible that there will be few vehicles already waiting here.

In that case what we have to do, if we keep the ideal offset then this vehicle has to stop you can see the horizontal portion shows that the vehicle has to stop and only will be able to clear when the queued-up vehicles which were already waiting, they are they clear the intersection. So, in this case partial blocks will happen the progress of the arrival platoon.

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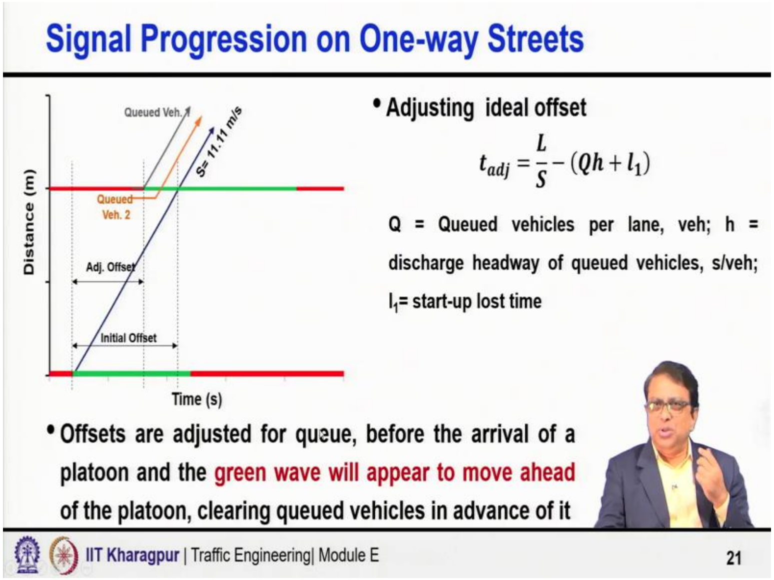

What to do and how to handle that then we should start green early. So, that and that match only just to clear the queued-up vehicles. So, if I know that there are 5 vehicles waiting. So, I know that how much time it will take for 5 vehicles to clear. So, that many seconds early I will start the green. So, by the time the 1st vehicle which is getting released during the green reaches to this intersection stop line the all queued up vehicles are cleared at the signal is also green.

So, what would be then the adjusted ideal offset or adjusted offset Sometimes people call it not ideal, but it is ideal is the previous one this is adjusted offset, it will be L by S that was time but I have to start early how much handy if I have Q vehicles waiting and if h is that discharge headway of queued vehicles, then how much time it will take to clear Q vehicles, Q into h plus these vehicles were waiting during the rate. So, I have to add the startup lost time. So, that way you can calculate the adjusted what will be the in the adjusted offset.

$$t_{adj} = \frac{L}{S} - (Qh + l_1)$$

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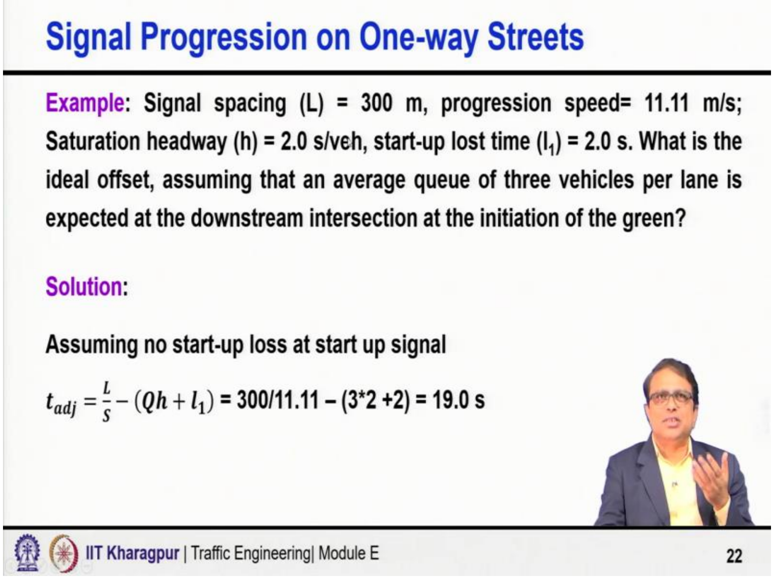

Let us take an example. Signal spacing is 300 meters. Progression speed is 11.11 meter per second, saturation headway 2 seconds per vehicle, startup lost time 2 second. What is the ideal offset, assuming that the average queue of 3 vehicles per lane is expected at the downstream intersection at the initiation of green? So, maybe from the survey we have seen that on an average 3 vehicle are queued.

So, if we assume that is no startup lost at the Startups signals, startup lost time and the startup signals that means in their upstream signal then t adjusted will be L by S 300-meter speed is 11.11. So, 300 divided by 11.1 But that is the ideal offset minus I have 3 vehicles already queued up and saturation headway 2 seconds per vehicle. So, 6 second plus downstream intersection these 3 vehicles were waiting. So, obviously I have to add the startup lost time. So, I will add that. So, you get here as 19 seconds.

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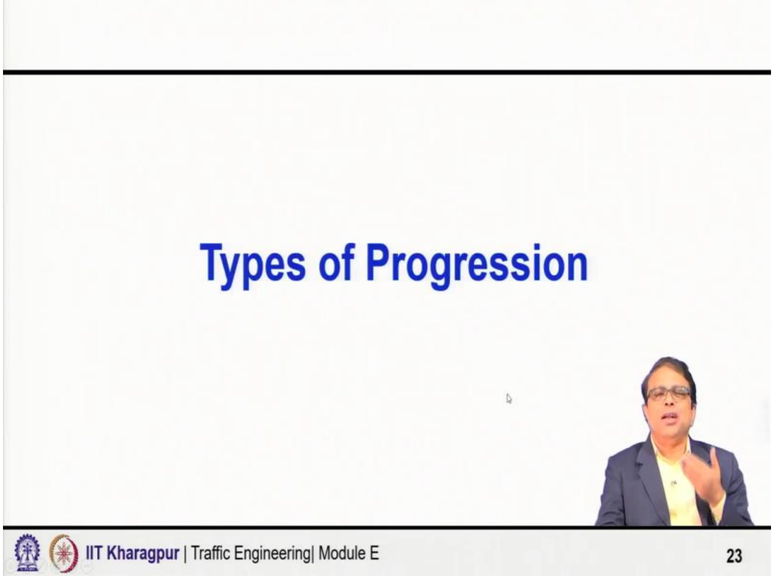

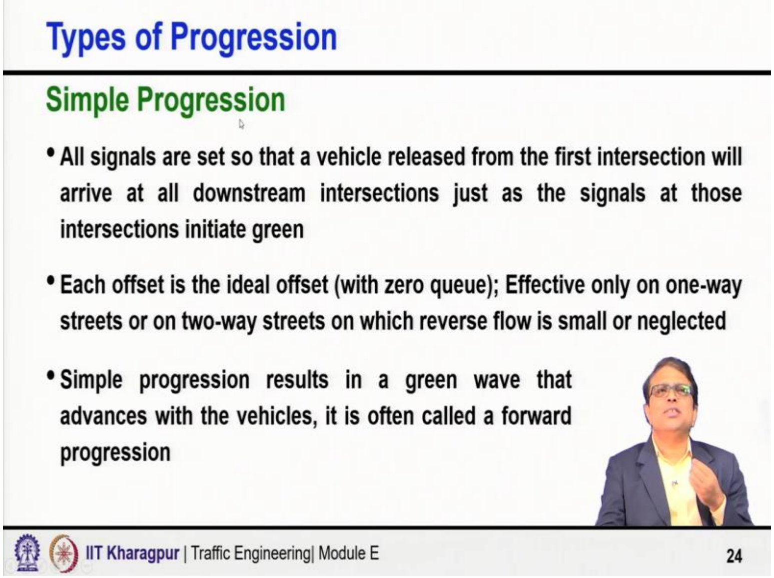

Now, let us quickly see various types of progression. First is the simple progression as I have just explained it, it was initiating green and then after some seconds you are initiating green for the downstream intersections and the vehicles are passing the first vehicle which is getting discharged in green from the upstream signals is passing the downstream signal without stopping.

So, all signals are set. So, that a vehicle released from the first intersection will arrive at all downstream intersections, just as the signal at those intersections initiate green that means the vehicle when it is reaching near the stop line. Everything is free no queued-up vehicle and the signal is green. So, that is what is the simple progression.

Each offset is the ideal offset for you have 0 queue effectively only on one-way streets or on two-way streets on which reverse flow is small or neglected. This you can appreciate even better as I proceed further to the next lectures that why I am saying which reverse flow is smaller neglected because you cannot get both ways north bound, south bound both ways you cannot get maximum upset that is not possible.

So, it may be that the other direction morning peak most of the vehicles are traveling towards CBD the other direction negligible number of vehicles are traveling that way the simple progression is very effective or if it is just one way street, if it is one way street, then the opposing vehicle does not come into picture, simple progression results in a green wave that advances with vehicles as the vehicle are going the green wave is also going clearing one after another signals making them green to ensure that the vehicles are able to pass through all these intersections without stopping. So, it is often also, called a forward progression. Because the wave is progressing forward this green, then next green, then next green, further green like that it is going so it is called sometimes called a forward progression.

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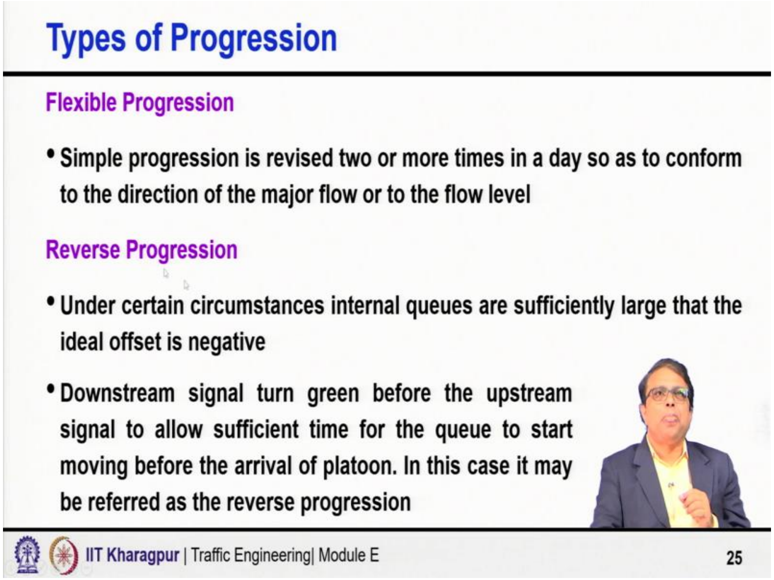

Forward progression also could be flexible. That means simple progression is revised two or more times in a day, because the traffic volume is different the direction wise also, the weightage or the vehicle volume is different. So, simple progression is revised 2 or more times in a day switch to conform to the direction of the major flow and to the flow level.

Also, sometimes it could be like a reverse progression, why? Because under certain circumstances, internal queues are sufficiently large that the ideal offset is negative. That means what you were doing, if the number of vehicles which are already in the queue, if the number is really high, then you need to give initiate the Greens sufficiently in advance to clear all those queued vehicles.

So, it may happen normally what happens signal one you are giving green after some time you are giving green to signal 2, after some time you are giving green to signal 3 like that. But if suppose signal to a lot of vehicles are already waiting in the queue and the number is such that timewise if you when you give the green to the 1st signal even before that you need to give green to the 2nd signal. The reason is, there is so many vehicles waiting in the queue that they should be able to clear and the vehicle, fast vehicle which is getting discharged from signal 1 during the green time should be able to get green in signal 2 as well.

So, what will happen earlier case you are feeling like green followed again green, green is moving forward signal wise as if one after another getting, but reverse progression, what will happen first signal 2 them signal 1 like that it may you may find that it is progressing in as if in a reverse direction. So, that is called reverse progression.

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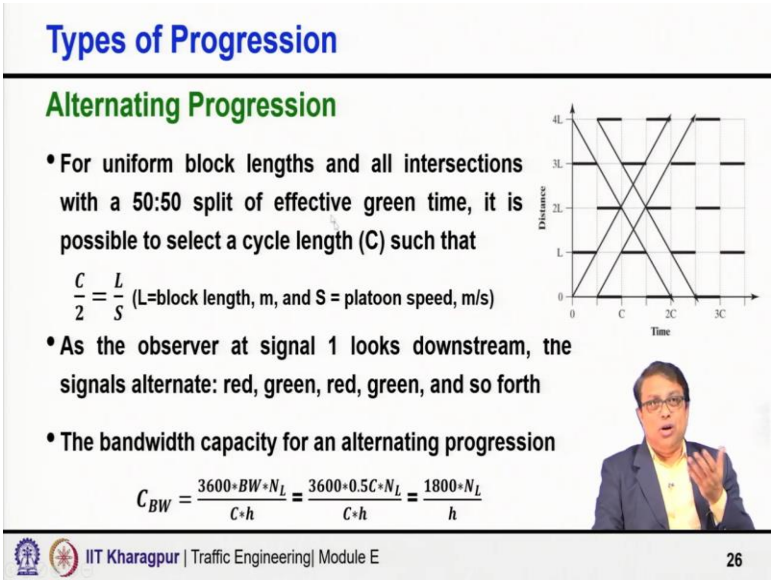

Alternating progressions is quite interesting for uniform block lengths and all intersections with a 50-50 splits of green time it is possible to select a cycle length such that C by 2, 50-50 splits in C by 2 if whatever is the cycle length green time is 50 percent of that. So, 50-50 split it is possible to select the cycle in such that C by 2 equal to L by S. What is the L? L is the block length that is what is L. And what is the S? S is the platoon speed. So, if the signals are like that zero at distance L, 2L, 3L, 4L and here most important thing is here actually, bandwidth efficiency is 50 percent.

$$\frac{C}{2} = \frac{L}{S}$$ **(L=block length, m, and S = platoon speed, m/s)**

So, bandwidth is actually 0.5C. Bandwidth is 0.5C. So, if an observer is at signal 1 looks what you will find green, red, green, red green red. So, if I look at this thing at a time I will find if my signal 1 is green, signal 2 is red, signal 3 is green, signal 4 is red like that, and that is called alternating progression and the bandwidth capacity you can calculate this formula is already known to you only thing here the bandwidth will be 0.5C into NL. So, C will cancel out denominator and numerator both will have C. So, you will get 1800 into NL by h.

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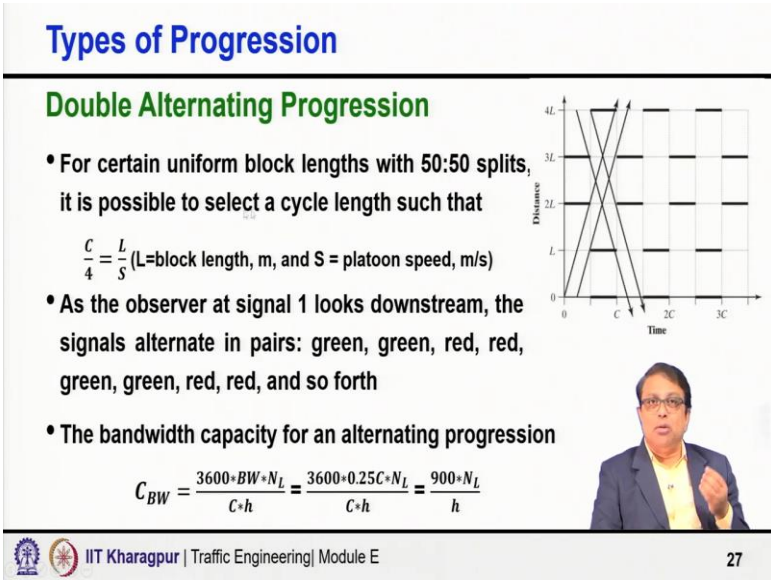

Double alternating progression very similar to the alternating progression, but why we are calling it double alternating progression here C by 4 equals to it is also 50-50 splits, but you are setting the signal length cycle length in such a manner that C by 4 equals to L by S. Earlier case it was C by 2 equals to L by S. Now, in this case C by 4 equal L by S. So, what will be different, different will be the bandwidth here the bandwidth will be 0.25C earlier 0.5C. Here you will get bandwidth 0.25C.

$$\frac{C}{4} = \frac{L}{S}$$ **(L=block length, m, and S = platoon speed, m/s)**

So, what will happen here again the same observer is standing here and signals are say L2, L3, L4 distance apart from the first signal. So, what the observer will see green, green, red, red, green, green. So, earlier green, red, green, red, green, red that was the thing here in this case green, green, red, red, green, green like that. So, obviously the bandwidth capacity also, you can calculate in this case it is 3600 into same formula but bandwidth will be point 0.25C. So, it will be 900 into NL by h.

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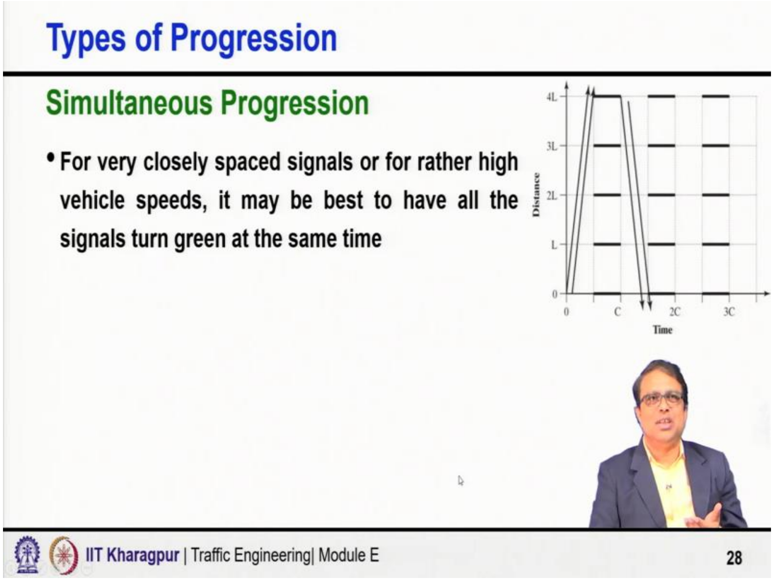

Last is the simultaneous progression here all the signals are given green at a time same time keep green to all signal when we do it particularly when very closely spaced signals the L the distance is really small practically you are operating these 2 or more intersections just like one intersection because they are so close that the same phase is used same green time the green is given to all red is given to all. So, what you will find here a person looking at it see all are green all the signal subsequently are green. So, that is called simultaneous progression.

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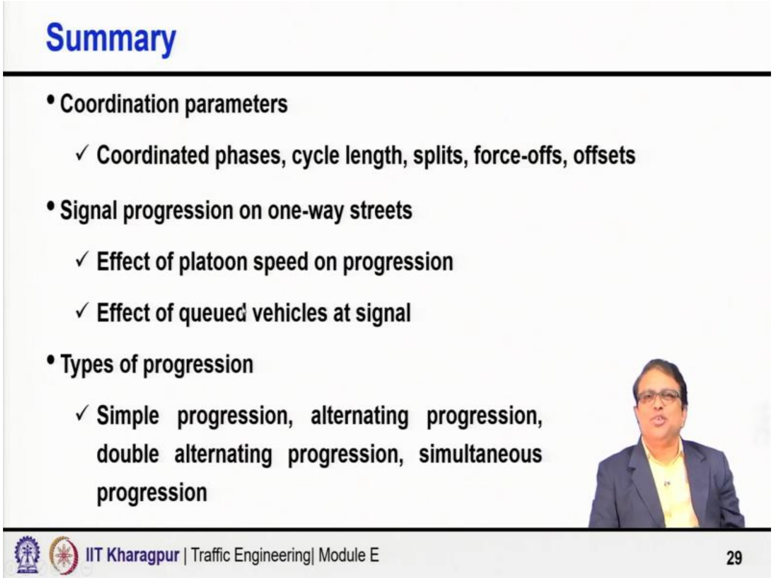

So, with this what we discussed today. Some of the coordination parameters, 5 coordination parameters, coordinated phase, signal length, split, force offs and offset. Then I discussed about the signal progression on one-way street also, mentioned to you how to handle the effect of platoon speed on progression, or what is the effect of platoon speed on progression and how to handle the effect of queued vehicle at signals. Then also, discussed various types of progression starting from simple progression, alternating progression, double alternating progression and simultaneous progression. So, with this I close this lecture. Thank you so much.