Traffic Engineering
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Lecture No. 02
Mobility and Accessibility, Traffic Engineering Elements and Components of Traffic System

Welcome to Module A lecture 2. In this lecture, we shall discuss about mobility and accessibility, also various elements of traffic engineering and component of traffic systems.

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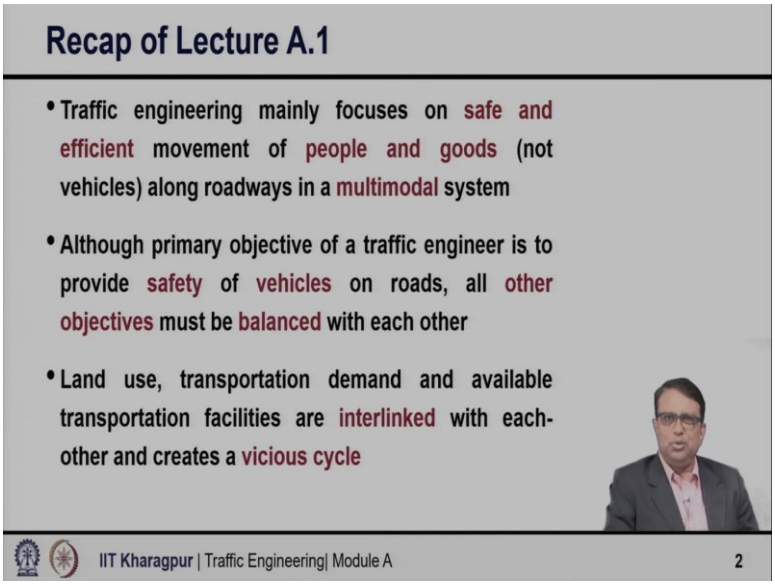

But before we go ahead, let us quickly remember some of the key points from the lecture 1. We said that traffic engineering mainly focuses on safety and efficiency of movement. So, that is one part, number 1, safety and efficiency. Second, we said movement of people and goods, both are important.

Third, along roadways, so, we are talking about road transportation systems related to road transportation systems. And fourth, we said that it is in a multi-modal system that means not one mode of transport within the road transport, but maybe car, bus, intermediate public transport 2-wheeler, even non-motorized mode like bicycle, so, multiple modes we are considering.

And also said that our basic objective is not movement of vehicles, although we traffic engineers often refer to vehicles, but our primary objective is movement of safe and efficient movement of people and goods. Second, we said that the primary objective of the traffic

engineer is to enhance safety. Safety is always the highest importance and the primary objective of a traffic engineer.

But all other objectives are also important as they are kind of self-desire of the road users or transport users. And the key challenges what we face often as traffic engineer, how to balance these objectives with each other, the secondary objectives within themselves and also with the primary objective of safety.

The third point we said that land use transportation and available transportation facility transport demand and available transportation facilities are actually interlinked with each other and therefore, create some kind of a vicious cycle. So, we must understand these interactions that if we are improving transportation systems, then what is going to be the impact of that on the land-use and thereby subsequent impacts.

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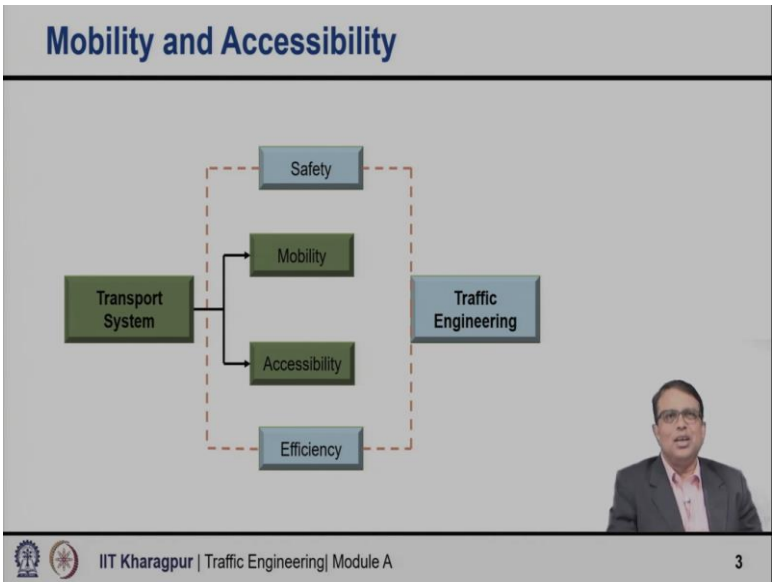

Now, as I said, the traffic engineering the two key objectives are safety and efficiencies. But then, if we look at the transportation systems, what are the objectives or what the transportation systems aims to provide? Transportation systems aim to provide two things, mobility and accessibility.

So, while the transportation system aims to provide mobility and accessibility, traffic engineering is aim to ensure safety and efficiency. So, these are again coming to one common area. Let us talk about then mobility and accessibility.

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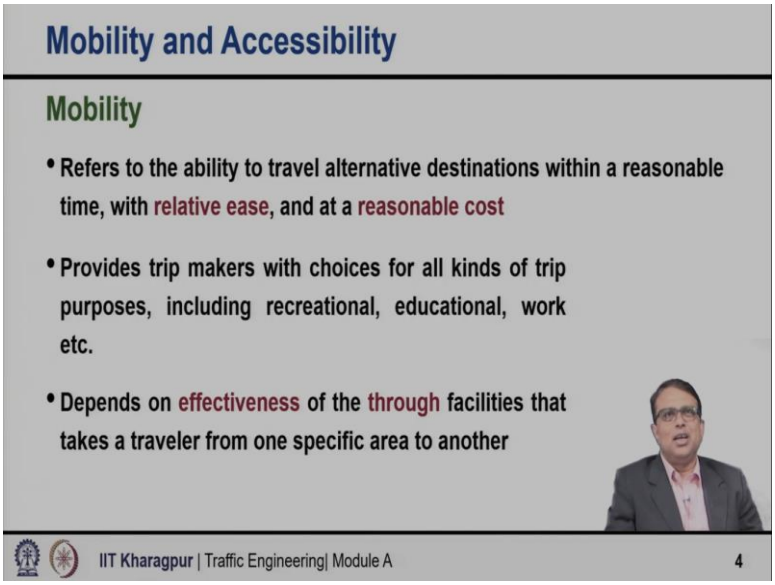

So, what is mobility? It refers to the ability of to travel alternative destination within a reasonable time with relative ease and at a reasonable cost. That means how quickly we can travel from one point to another. Of course, with a reasonable cost and with relative ease. In general, mobility refers to in this sense, mobility more refers to how quickly we can travel from one point to another.

So, generally relates to the speed in this sense, when we are talking about accessibility and mobility functions of road systems or transportation systems. Mobility provides trip makers with choices for all kinds of trips including recreational, educational, work, etc. For various trip purposes people travel and mobility provides them choices.

Mobility depends on the largely the effectiveness of the through facilities that takes a traveler from one specific area to another area. Maybe, if you are traveling from point A to point B, maybe it is 50 kilometers or 60 kilometers, 100 Kilometers, then the mobility generally will depend largely on that long distance segments.

How effective the through facilities. Because obviously, when you start from your home, the local roads, residentials areas, the roads and at the destination and also it may be the local roads, where, which are primarily providing the connectivity. So, you do not expect to travel very fast in those roads or those facilities, but what will be the travel time, overall journey time, will largely depend on the how good or how effective is that through facility.

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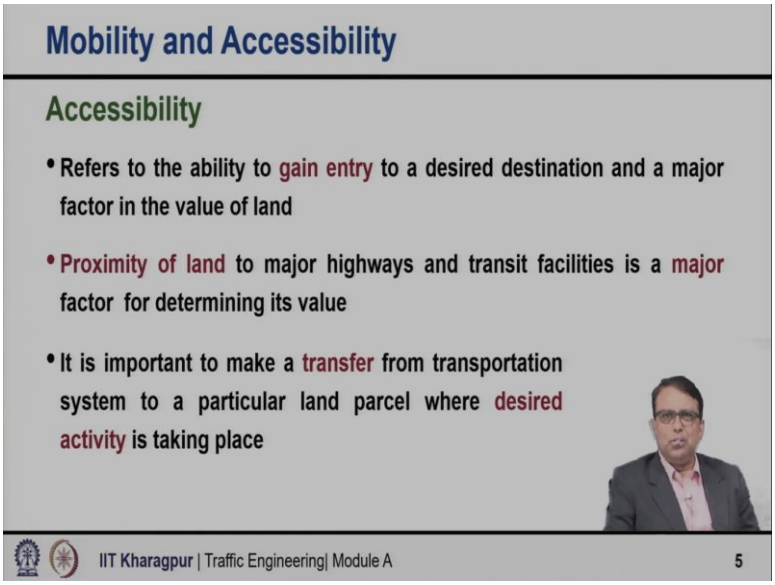

On the contrary, accessibility refers to the ability to gain entry to a desired destination and a major factor in the value of land. Suppose, you are living somewhere from your home. You have to get that connectivity or the connectivity should be there through the road system, so, that once you come out of your home, you should be able to travel up to the higher order road and maybe the primary road network, will be able to get connected to the primary road network and then the mobility gets dominated.

Mobility becomes the primary thing. But, this connectivity is very important. So, if a place is not connected, if you cannot reach to your destination up to the point, right, then the trip is not completed, the trip cannot be done also in that sense. So, it refers to the ability to gain entry to a desired destination and proximity of land to major highways and transport facility, is a major factor for determining its value.

All of us know, if a major road is there, or if a good road is there, and the land is adjacent to that, obviously, that accessibility is much better for those land parcels because they are easily can get connected to the road, or the higher order road. So, the land value directly depends on the accessibility.

Or if you consider a land piece of or the parcel of land, which you cannot go by car, simply the road is not there, maybe very narrow road, very congested road connecting the land. Vis-a -Vis it is a nice road, which is just passing through by the next to that land and you can directly get entry. So, where the land value will be higher, you can imagine? So, that is the say the proximity of land to major highways and transit facilities. The bus stop is just two minutes walking distance from your home, obviously, the land value will be much higher.

So, it is important to make transfer from transportation system to a particular land parcel where the desired activities taking place. The road system or the overall transport systems aims to provide both, accessibility and mobility functions. And these are the two very important functions of road system or transport system as a whole.

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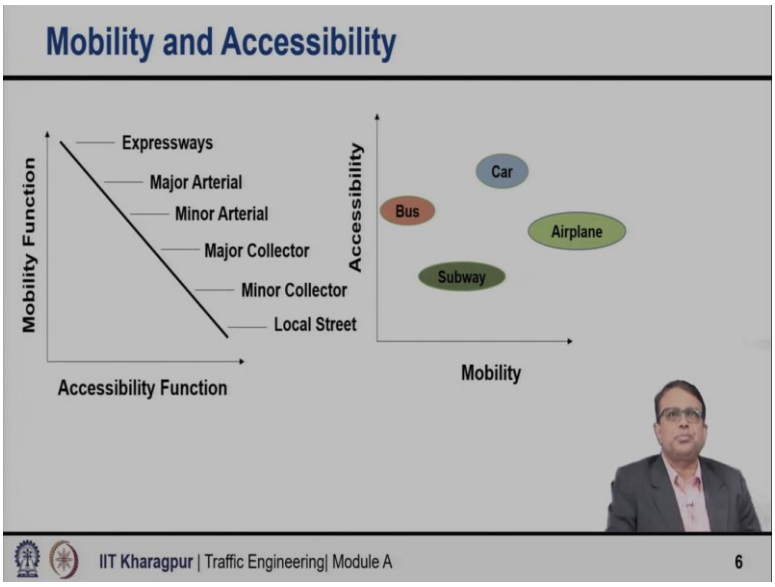

Based on these, the whole functional classifications of road has been developed. If you take the urban road system then the highest order road is expressway followed by arterial, collector streets and local streets. Again of course, you can arterial again major arterial, minor arterial, major collector, minor collector, all this you do. But these are, the top is expressway, collectors then, and the lowest end, it is the local street.

And you can see here clearly, how the mobility and accessibility functions are changing. So, if the mobility for expressway, major arterial, the mobility function is main. The main purpose is to provide mobility. So, we expect vehicles to travel faster, the speed will be higher. Of course, not compromising the safety aspect. On the other hand, if you come down lower order road, minor, collector or Local Street, the primary objective is to provide connectivity to the land. So, there we do not expect vehicles to have high mobility function.

And this is very important because often we confuse these two functions and try to achieve both. That means, the road you widen that is where the conflict come and that is why the safety is such a burning issue today in India and many other developing and emerging nations. We try to achieve high mobility because simply widen road, make it 2 lane to 4 lane to 6 lane, 8 lane, dual carriageway, make good roads, but also every village is connected to that highway system.

So, you want high mobility functions, also high accessibility functions. Both you cannot achieve simultaneously. So, there will be conflict and you will neither be able to achieve mobility nor accessibility or you will be able to achieve both at the cost of safety. So, a lot of accidents will happen.

Because, the long distance, vehicles will be there, good road, high speed, they will try to travel, but then villagers somebody from (bike) taking a bicycle will also come from the adjacent village and directly enter into that highway system or the road system. If you look at the different modes of transport, they also they have different accessibility, mobility functions.

Bus, as some level of accessibility, if in a good if there is a good bus network, spread along the length and breadth of the city, then you can clearly see that the bus will have high accessibility. Because from anywhere probably within a reasonable walking distance you can get the bus. And mobility functions will be slightly lower because bus will stop at every stops for boarding and alighting of passengers.

Compared to the bus, if you take car, both your accessibility and mobility will be higher. Because car is a private mode, if you can, it can go up to your home, probably will be the car will be in your garage, or in nearby parking area, parking lot. So, if the accessibility will be higher also the mobility will be higher. To similarly different transport modes also have different accessibility mobility functions. So, this is very important.

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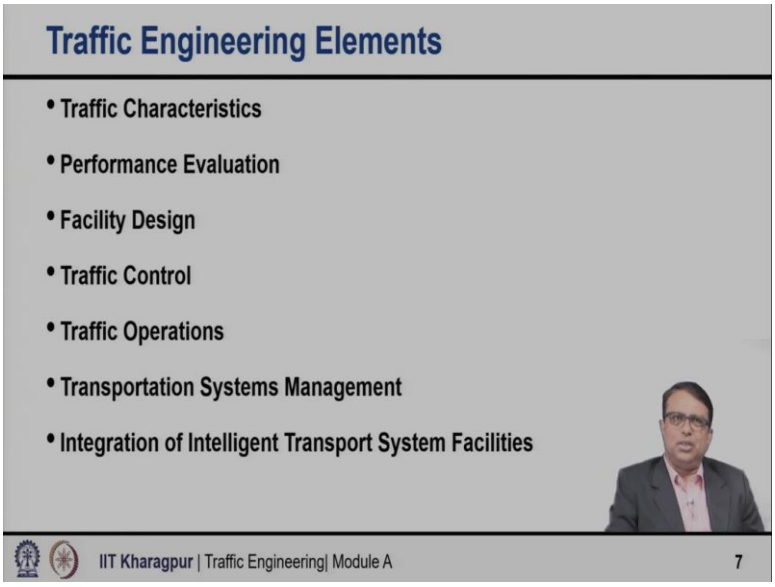

Next coming to the various elements of traffic engineering, when we talk about the traffic engineering, several elements are important, namely traffic characteristics, we must know the traffic characteristics, what is the volume, how is the composition of different vehicle types in the traffic stream and particularly in emerging, developing and emerging nations the traffic most cases is highly heterogeneous.

So that traffic characteristics is very important. Then the evolution of performance, facility design, traffic control, traffic operations, transportation systems management and integration of Intelligent Transportation Systems facilities. Now a little bit of discussion about each of these elements.

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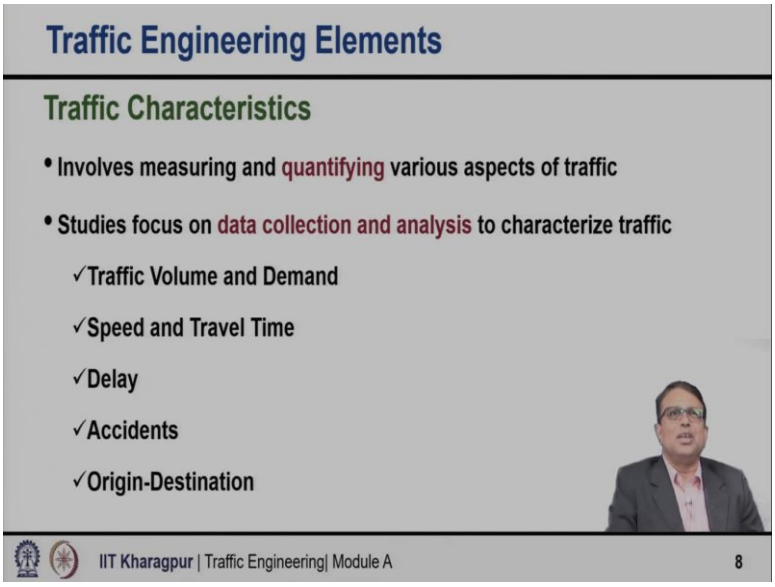

Traffic characteristics involved measuring and quantifying various aspects of traffic. So, we need various traffic studies. We need to collect data through these traffic studies and then analyze the data to characterize the traffic stream. So, various types of studies what we carry out and what are really meaningful may include traffic volume and demand studies. Speed and travel time, delay, accidents, origin-destination, all these are important information.

There are specific studies, procedures, how to carry out these studies and then through the studies, we collect the data and then we extract the data as appropriate, create a digital database and then analyze the data to understand the traffic characteristics. So, you will say this is the volume, this is the speed and so, so many accidents are happening and this stretch is mostly serves long distance traffic or a combination of long distance and the local traffic and so on so forth. So, that is one thing it is very important.

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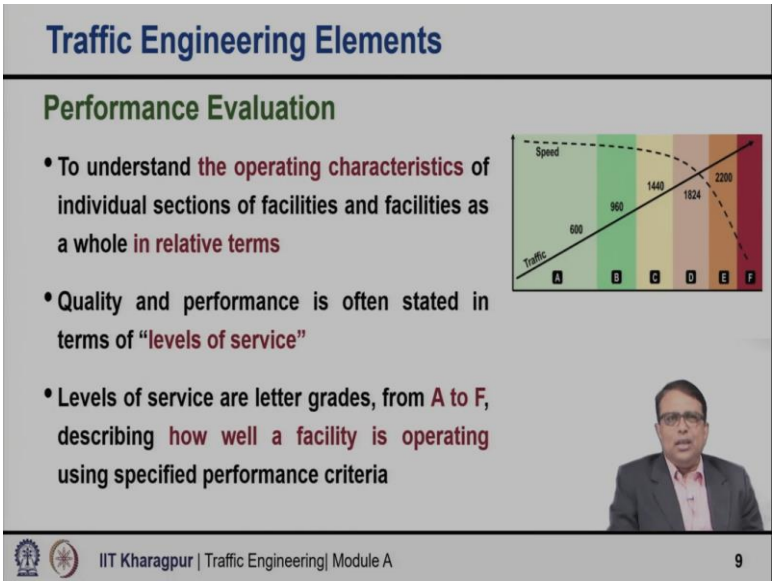

The second we also need to carry out performance evaluation. It is always important, how good or bad the existing system is performing or once you take some intervention, then how this intervention is really affecting the performance of the system. So, we carry out performance evaluation to understand the operating characteristics of individual section of facilities or sometimes the facilities overall facilities as a whole. So, different element wise also you can see, how they are performing and the overall system also, how it is performing.

Now, the quality and performance is often stated in terms of the level of service. It is a qualitative measure, which includes comfort, convenience, so, many other aspects of travel. And normally expressed using letter grades A to F, 6 level of service are generally accepted worldwide.

In every country probably the similar kind of things are taken, 6 level of service are very common and they are designated as A to F. LOS A to LOS F, indicating how well a facility is operating. So, A is the best F is the worst. So, here in the figure I have said also that for a given facility, what will mean different traffic volume, so, traffic volume in the range of say 600 for a given facility example only said that we will be in probably that the level of service is A and then more than that, it is going to B, maybe up to 960 it will be B.

Then beyond that level of service will be C. Because the condition is increasing the world volume to capacity ratio will increase. Because capacity is fixed. So, as the volume is increasing, the volume to capacity ratio also will increase. And that is why, and also the speed will come down. So, speed will come down with increase or using the speed, using the

traffic volume, a domain of operation is considered as a particular level of service A or then more than that volume or further reduction in speed level of service B and so on so forth.

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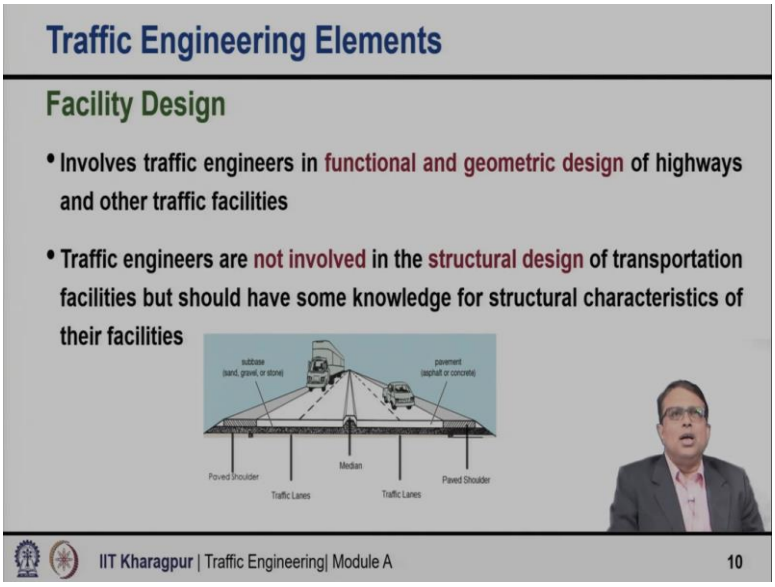

Third element is the facility design. Yes, you have to design the facility. So, road designing also is included as a part of traffic engineering. So, it involves traffic engineers in functional and geometric design of highway and other transportation facility. So, very much the geometric design is part of the traffic-engineering task. So, traffic engineer knows the safety aspect, how the elements are influencing, so, accordingly it suggests design, which is safer.

Traffic engineers normally are not involved, not expected to be involved in detailed structural design of the facilities. That means what will be the thickness of the pavement or what material you are going to use and all such kind of things that probably will be done by, if it is pavement, it is pavement engineer, if there is other facilities like bridge, culvert, other kinds of cross-drainage structures in general, then it will be done by structural engineering, but these are expected to have some basic knowledge of those.

Because then when you are seeing something and the back of the mind, you also understand you may not do that in details, but you understand the requirements and some ideas about the structural design, also. But, as I said, most cases we traffic engineers, we will do the functional part and also the geometric design part.

That means, here I have shown it will decide probably the cross section, it will say how much will be the width of the shoulder how much will be the how many traffic lanes will be required, very much comes from the traffic engineer, from the traffic engineer only and then

what would be the width of the median and then overall cross section, in some cases maybe some pedestrian work, some bicycle tracks, so, all this layout it has to come from the traffic engineer.

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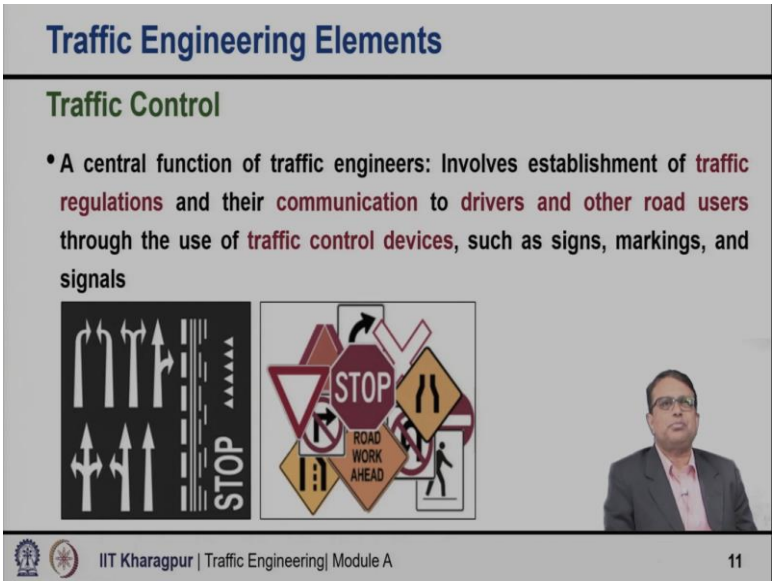

Then the traffic control is very very important, it takes a central function for traffic engineers. Why? Because, traffic control involves establishment of traffic regulations, how the traffic will move, which route will be one way, where the signals will be installed, where the stop signs should be given? Where the speed limit should be imposed? All such kind of things, using traffic control devices, how you communicate, they are the friends.

So, you do not have to ask anybody. The well designed and where the traffic control is very good with use of appropriate signs, markings, signals, user get all the information that has required, that are expected or what they require, they get all the information. So, to establish traffic regulations and the job is not completed only by establishing regulation, but also they have to be communicated to the drivers and other road users, where pedestrians should cross, when pedestrians should cross, what speed limit should be there.

So, drivers know that they should not drive beyond that speed limit which is prescribed. How you communicate to driver? So, establishing traffic regulation is important, but also communication of that to drivers and other road users, are equally important, if not more. So, the traffic control devices help us to do that, using science, using markings, using traffic signals and so on.

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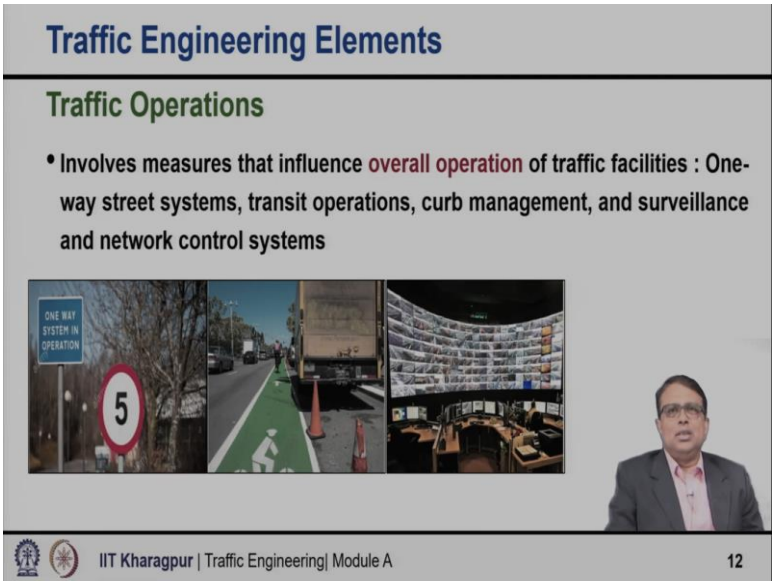

Then the overall traffic operation involves measures that influence overall traffic operation facilities, a traffic engineer has to decide that many decisions such as one way streets, when and how you do it, why you do it, the decision has to come from the traffic engineers. Then the transit operations, which will be the route? And, what kind of priority to be given if required? Then how the overall curb management to be done? Where the parking should be allowed? Where the parking should not be allowed?

And overall the network control, whether the signals will operate at isolated signals or they should operate as a coordinated signal systems to move the traffic along certain priority corridors. So, all such kind of decisions, anything related to traffic operations, those are to be taken by the traffic engineer.

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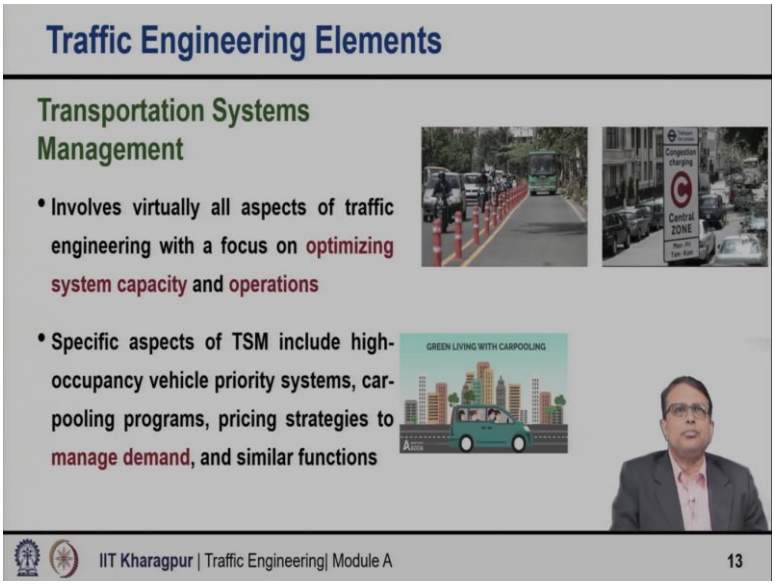

Then transportation systems management. What is transportation system management? It is very interesting, involves virtually all aspects of traffic engineering, any intervention, which focus on optimizing system capacity and operations. That means, I have this infrastructure, I have this much, this much road, and that is what all what I have. How best I can utilize that for a given transport demand.

That means, what all I can do keeping the primary objective, movement of people and goods, not movement of vehicles, as the primary objective. So, what all measures I do or what all measures can be done to optimize the system capacity and operations or to effective or to maximize the use of the existing capacity, that all come under. Various examples are there, say system aspects may include high occupancy vehicle priority.

So, you give priority to high occupancy vehicles that means, you in a way, you want or encourage, you want to encourage people to use more public transport system than traveling alone in a car. Because the car is taking away the road capacity and serving only one person whether a bus probably coming serving 50 people. So, movement of people than movement of vehicle, rather than movement a vehicle get the priority. So, the priority is on movement of people, right.

So, if my road system is not adequate capacity is not adequate, how I can do better capacity management, I would try to see the how I can transfer same number of people with less number of vehicle. So, high occupancy vehicle means also you promote car sharing three of us instead of using three cars, if we traveled together, we are saving in terms of fuel cost, we

are saving in terms of energy consumption, right, we are able to do some benefit in terms of the vehicular emission reduction.

And traffic engineer is giving them a big priority. So, there are certain short corridor which can be allowed only to this high occupancy vehicle, not to vehicles which are carrying a single passenger or where you were driving alone. So, then you are forced to travel a longer road.

Similarly, the carpooling program as I said pricing strategy, where the public transport should be given priority, all such kind of things come under the transport system management. Anything, how to make better use of the existing facilities to for movement of passengers and goods. So, these are again traffic engineering element, one of the traffic engineering element.

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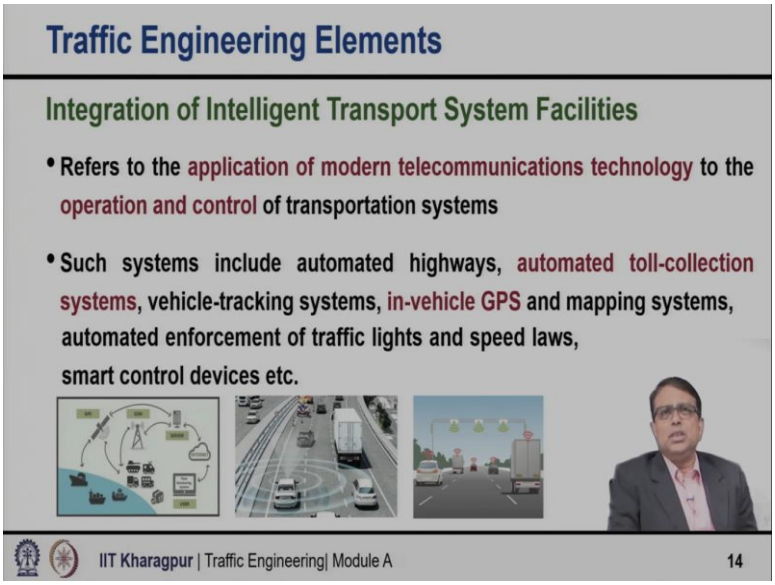

Then, integration of intelligent transportation system facility. This is this has emerged and slowly gaining more and more importance in the overall traffic engineering work. Refers to application of modern technology or communications to benefit the operation and control of transportation system.

How I can make the operation and control of transportation system more efficient by use of modern technology or modern telecommunication technology. So, all sorts of things special data infrastructure, IT applications and so, many other things, public transport, overall traffic control management, there is a vast scope.

So, anything may include like the automated highways, which is almost like a dream, automated toll-collection system very much in reality now, even in India you see that most

of the cases almost all the highways, the automated toll collection systems are working. Then vehicle tracking system, in vehicle GPS and mapping system, automated enforcement of traffic lights and speed laws, the police does not have to go and issue the fine ticket on road.

But, without any controversial you can find out, there is evidence, the camera is there, speed camera is there to detect, the cameras are installed at nearly all the traffic signals to tell you, if somebody has violated, the date, time, the vehicle number, exactly location, everything is available evidence based.

So, no controversy and you can search the database you can find out, where the owner of the vehicle is staying, where it is registered, everything is there, so, the challan can go, you do not have to stop people on road. If they have violated the traffic rule, they must be punished, as per the rule.

And you do not need to stop them on road and disturb the other traffic movement and so many other things can be avoided. So, anything you can say, enforcing the speed laws, smart control system, detection system of vehicles, so many things can come under this. Vast scope. And that is why it is the future of traffic engineering.

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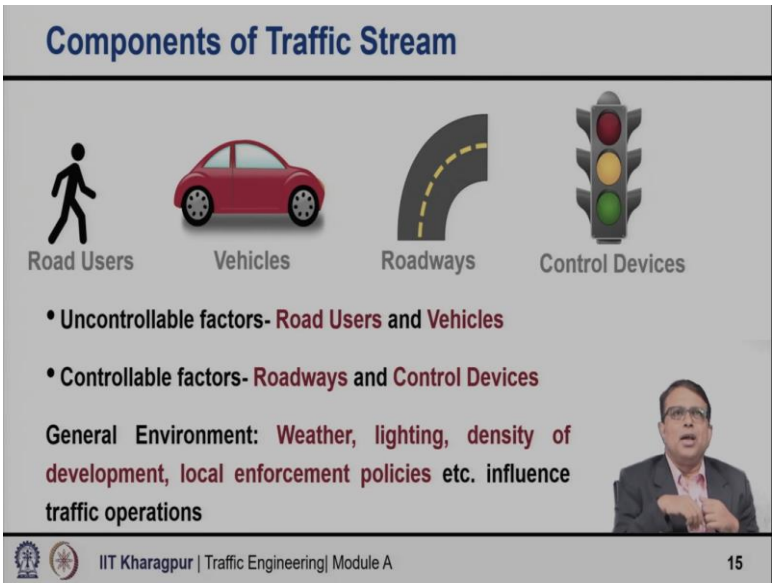

Now, let us look at the grossly, what are the components of traffic system. A traffic system generally, or simply have four components. Road users, vehicles, roadways and control devices. People are there, vehicles are there, road are there, and then the control system is actually dictating, how the operation will happen. So, they are the four major components.

Out of this four, road users and vehicles, we cannot control, as traffic engineering I have no control. Can I just control how many or what characteristics of car will come at a given intersection at a given time? I cannot control. I have got no control. Can I control also the road users completely and their behavior? No, I cannot control. And somewhere aged people will come, sometimes the young, kids will be there, sometimes, different varieties of road users will be there, I cannot control that.

So much variations will be there, right. So, road users and vehicles we cannot control. But, the design of roadways and control devices that is in my hand. So, I can control that right. And I can take care of various characteristics of road users and vehicles although I cannot control, I can take care of those characteristics, while I am designing my roadways and the control device, to make the overall system safe.

Also the general environment for example, weather, lighting, density of development, local enforcement policy, all this also will influence the traffic operations.

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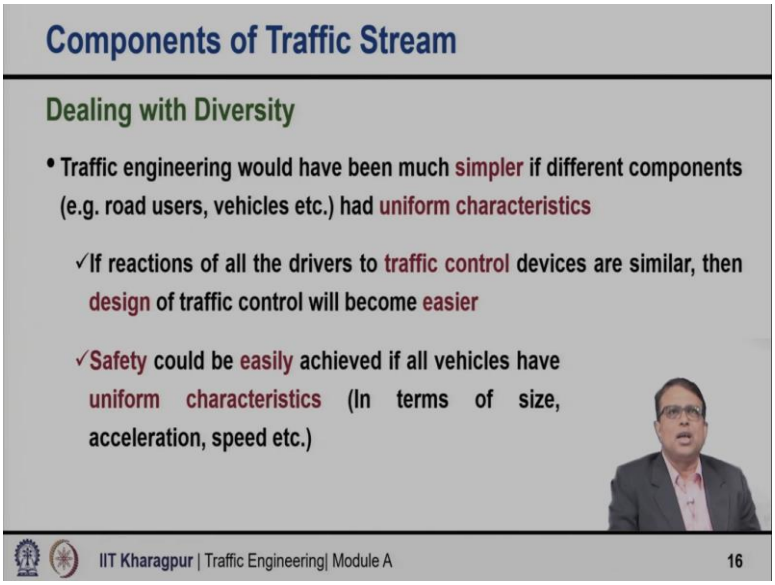

Now, in traffic engineering, things would have been very simpler, if different components had uniform characteristics. If suppose just imagine all users or all vehicles are same, every users behavior is same, the requirements are same, they react in the same manner or all vehicles are identical in terms of their characteristics in terms of in every sense, the things could have been very, very similar, it would have been very easy for us, uniform characteristics. But, that does not happen.

So that what I said, I said that if reactions of all the drivers to the traffic control devices are similar, then the design of traffic control will become very easy and can be made easily safer. Safety could easily be achieved if all vehicles have uniform characteristics, but it does not happen, does not happen. So, I am telling all this thing to tell you the complexity that comes because of this diversity.

Every human being is different. So many vehicle types are there on the road, there characteristics are different. They vary. You see, even the car also different cars, different characteristics, you have old technology car, you have also had the modern very up to date cars, up to date facilities and modern, all technologies are in built, that kind of cars are also there in the market.

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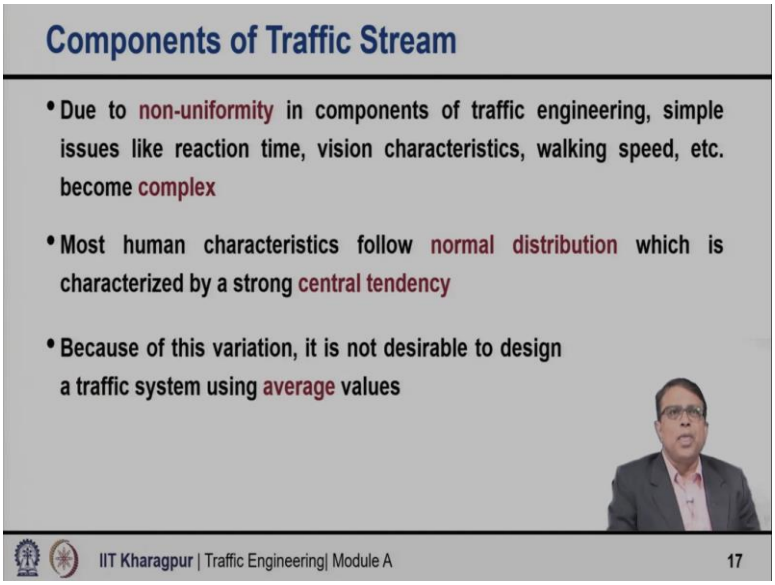

So, due to non-uniformity in components, traffic engineering, even simple issues like the reaction time, vision characteristics, walking speed, everything become complex, what you consider in the design. Now, most human characteristics in a way follow normal distribution, which is characterized by strong central tendency. So, because it varies, our life is so complicated, it becomes complex. Suppose if we take simple the average value, will it work? No, it will not work. Why?

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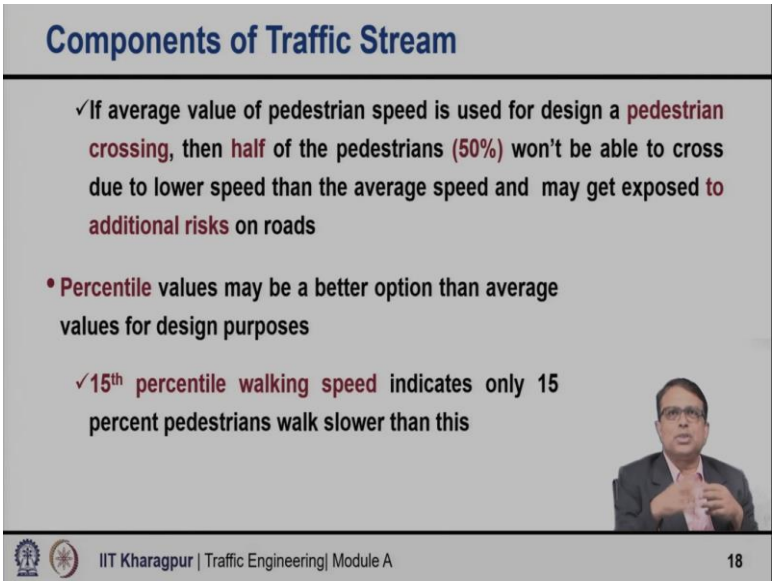

Because then 50 percent of the users or 50 percents of the vehicles, for 50 percent of users or 50 percent of the vehicle, things will not be adequate. Suppose if you take the average value of pedestrian speed, for design of pedestrian crossing, then half of the pedestrian only will be able to cross safely due to lower speed than average speed and therefore may get exposed to additional risks.

So, what is done, we use percentile. That means we cannot take the ever-highest thing or ever-lowest thing as appropriate. But we take suitable percentile value. What does it mean? A suitable percentile means which will, the value which will satisfy the requirement of most of the users under most operating condition.

So, for example fifteenth percentile walking speed, it means only 15 percent pedestrians may walk slower than what I am assuming at least I am ensuring 85 percent of the people will definitely have walking speed higher than this.

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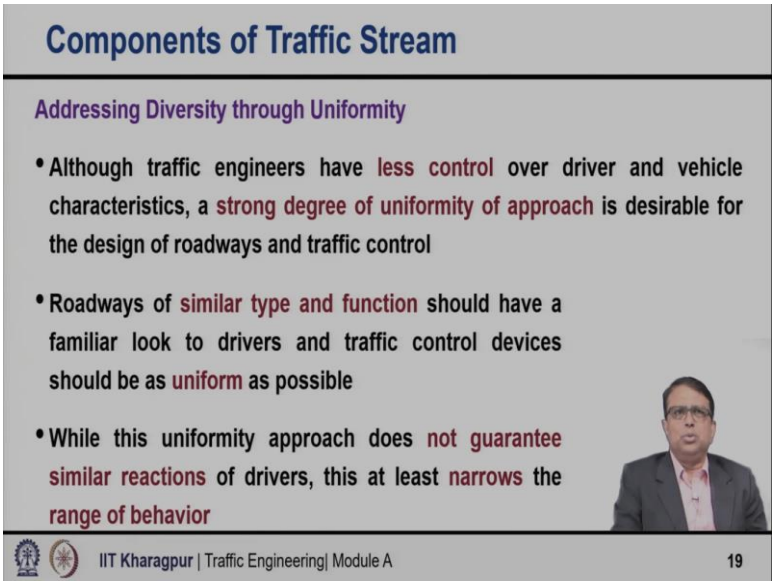

So, what we do, although the traffic engineers have less control over driver and vehicle characteristics, we still need a strong degree of uniformity approach is desirable. Every intersection is designed differently, everywhere the road looks different. So, just imagine, how the driver will feel. So, we need still although, they are so much of diversity, but we need still some kind of uniformity in our design, as far as possible, unless the requirements are very different.

Grossly the intersection should not look different, but yes, somewhere the pedestrians maybe there somewhere pedestrians not will not be there so much, or maybe nill even. So, the requirements are to be taken through appropriate design. So that way, not every intersection will be exactly the same, but grossly the layout and everything, if they also vary, then this will create utter confusion among the road users. So, they need to be uniform, as uniform as possible.

So roadways of similar type and functions should have a familiar look to drivers and traffic control devices should be as uniform as possible. The sign cannot change, the speed limit sign everywhere, every state, every locality need not to be different and it has to be uniform, but the requirement of different road users at different locations, maybe the additional facilities requirement may vary, but the basic thing has to be uniform.

Now, again, this uniformity will not guarantee that every driver's reaction will be same. No, it cannot happen. Because drivers have different behavior, users have different behavior, but at least uniformity in design will help to narrow down the ranges of behavior. That impact will be there.

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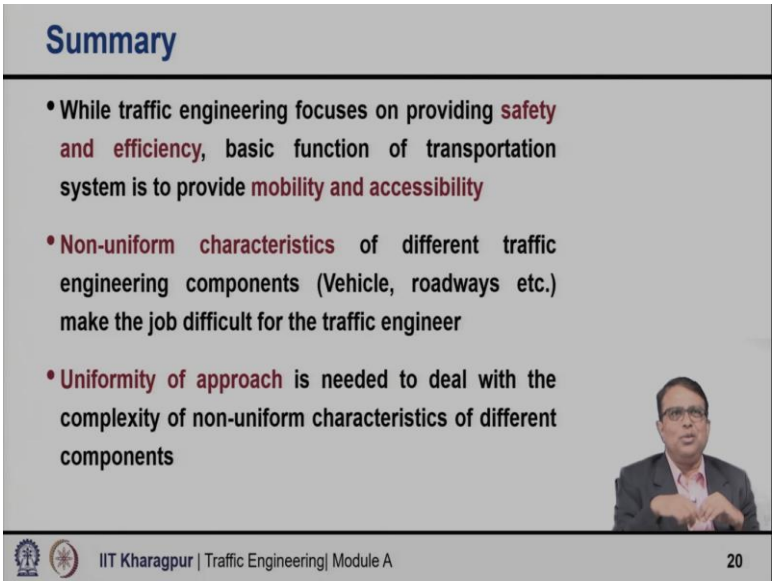

So, overall, if I have summarize to this lecture, we said that traffic engineering the basic objective is safety and efficiency. And for the transportation system, the basic functions are mobility and accessibility. The non-uniform characteristics of different traffic engineering components make the job extremely difficult and challenging for traffic engineer. Yet, uniformity of approach is needed to deal with the complexity of non-uniform characteristics of different components. So with this, I close this lecture. Thank you so much.