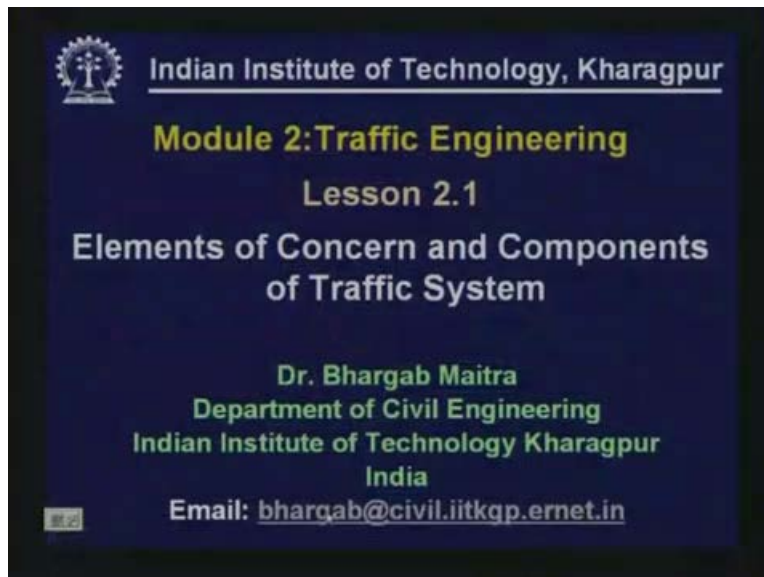


**Introduction to Transportation Engineering**  
**Dr. Bhargab Maitra**  
**Department of Civil Engineering**  
**Indian Institute of Technology, Kharagpur**  
**Lecture - 2**  
**Elements of Concern and Components of Traffic System**

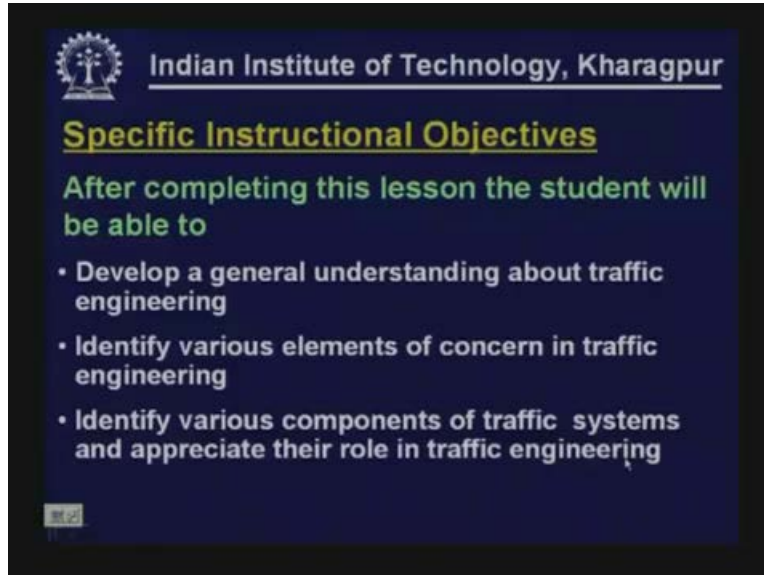
Module 2 Traffic Engineering lesson 2.1 Elements of Concern and Components of Traffic Systems


(Refer Slide time: 01:09)



The slide features a dark blue background with white and yellow text. At the top left is the IIT Kharagpur logo. The text is centered and reads: 'Indian Institute of Technology, Kharagpur' (underlined), 'Module 2: Traffic Engineering' (in yellow), 'Lesson 2.1', 'Elements of Concern and Components of Traffic System', 'Dr. Bhargab Maitra', 'Department of Civil Engineering', 'Indian Institute of Technology Kharagpur', 'India', and 'Email: [bhargab@civil.iitkgp.ernet.in](mailto:bhargab@civil.iitkgp.ernet.in)'. A small '17/2' icon is in the bottom left corner.

(Refer Slide time: 01:14)



 Indian Institute of Technology, Kharagpur

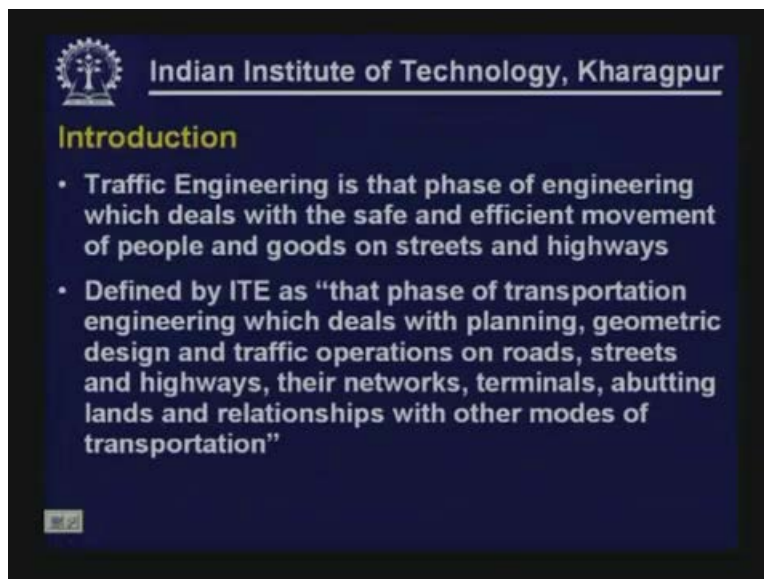
**Specific Instructional Objectives**


After completing this lesson the student will be able to

- Develop a general understanding about traffic engineering
- Identify various elements of concern in traffic engineering
- Identify various components of traffic systems and appreciate their role in traffic engineering

After completing this lesson the student will be able to develop a general understanding about traffic engineering, identify various elements of concern in traffic engineering and the student will be able to identify various components of traffic systems and appreciate their role in traffic engineering perspective.

(Refer Slide Time: 01:51)



 Indian Institute of Technology, Kharagpur

**Introduction**

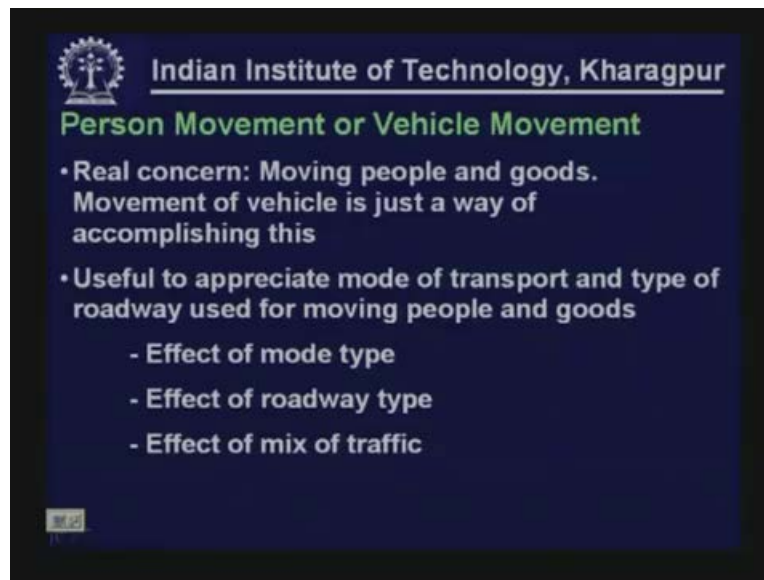
- Traffic Engineering is that phase of engineering which deals with the safe and efficient movement of people and goods on streets and highways
- Defined by ITE as "that phase of transportation engineering which deals with planning, geometric design and traffic operations on roads, streets and highways, their networks, terminals, abutting lands and relationships with other modes of transportation"

Introduction:

Let us first of all try to understand the subject area traffic engineering. What is traffic engineering?

Traffic engineering is that phase of engineering which deals with safe and efficient movement of people and goods on streets and highways. So it deals with safety and efficiency of movement of people and goods on road system that is street and highways. Institute of transportation engineers define that phase of transportation engineering which deals with planning, geometric design and traffic operations these three major aspects on road system that is roads, streets and highways then networks, terminals, abutting lands and relationships with other modes of transportation. that's the way ITE Institute of traffic engineer defines traffic engineering subject. With this background definition let us now try to address some of the basic issues in traffic engineering perspective basically to create our mind set about the traffic engineering elements.

(Refer Slide Time: 03:45)



First issue is whether it is person movement or vehicle movement. Often we face this confusion in traffic engineering what is our primary concern or real concern? Whether it is person movement or movement of vehicles? It is worthwhile to mention that the real concern is the movement of people and goods. So moving people and goods is the real concern. Obviously movement of vehicle is just a way of accomplishing this. Therefore primarily people need to move from one place to another place so there is movement of people and also goods are to be transported from one place to another place. Hence the primary concern is movement of people and movement of goods and how these people or goods are transported and vehicle is the means for that, they are transported in vehicles. So vehicle comes afterwards and it is the resulting volume that is creating road congestion and creating many peripheral problems in traffic engineering. But let us not forget that the primary concern is movement of people and movement of goods.

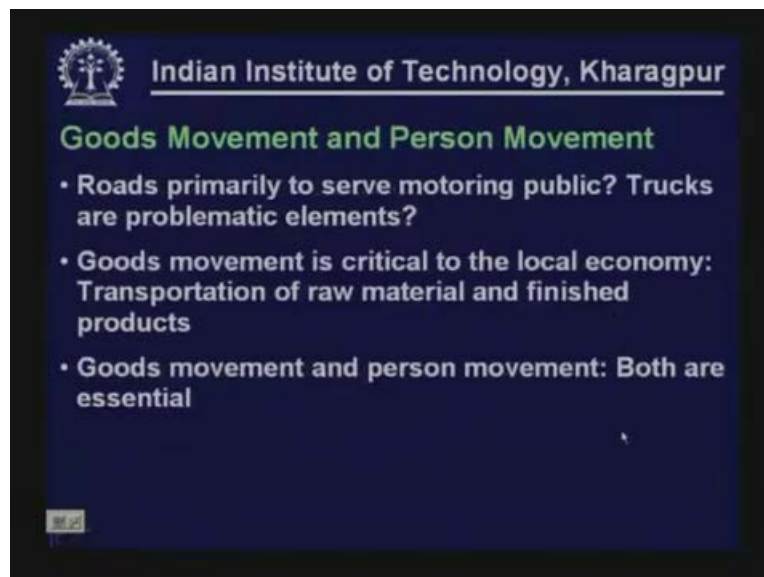
Of course it does matter the way it is transported in vehicles. So we cannot really deny the role of models played that means how the demand is distributed in different modes and other model characteristics. Therefore it is worthwhile to mention that it is necessary to appreciate the mode of transport and type of roadway used for moving people and goods.

What is the effect of mode? What is the effect of road way type? What is the effect of mix of traffic? All three aspects are also important. A road system if it is carrying say in terms of let us consider the movement of people so some k number of people are to be transported and if all of them use a car obviously that means there will be very large number of cars on the roads and highway systems and probably that means very high level of congestion. But all the people if they use public transportation system say bus transportation system obviously relatively much lesser number of buses will be required and probably the road will apparently appear free and not suffering with acute congestion level.

So definitely the models played or the way the demand is distributed into different modes that have a very vital role to play in the overall traffic engineering perspective. Similarly all the roads they do not share the same purpose. The way the road systems function it has really got an impact on the overall performance or quality of service that is offered by the road system. Some roads may be providing multiple access from any place you can enter into the road so that creates substantial disturbance to the moving traffic stream. So obviously in a system you are allowing entry and exit at any point where you have lot of pedestrian activities around, vehicles parked on street etc has got all these elements and they will affect quality of traffic operation on road system. So obviously effect of road way type is also important and we cannot also deny the effect of mix of traffic or the traffic composition in the overall traffic engineering perspective.

The way the demands are distributed is the same road space which is used by cars, buses, by commercial vehicles, by light commercial vehicles, heavy commercial vehicles so the way the road system accommodates the traffic, the nature of traffic, the mix of traffic it really matters or it really influences the performance or the overall characteristics of traffic operation. So effect of mode, effect of roadway type and effect of traffic mix all these three are very important in traffic engineering perspective.

(Refer Slide Time: 09:18)

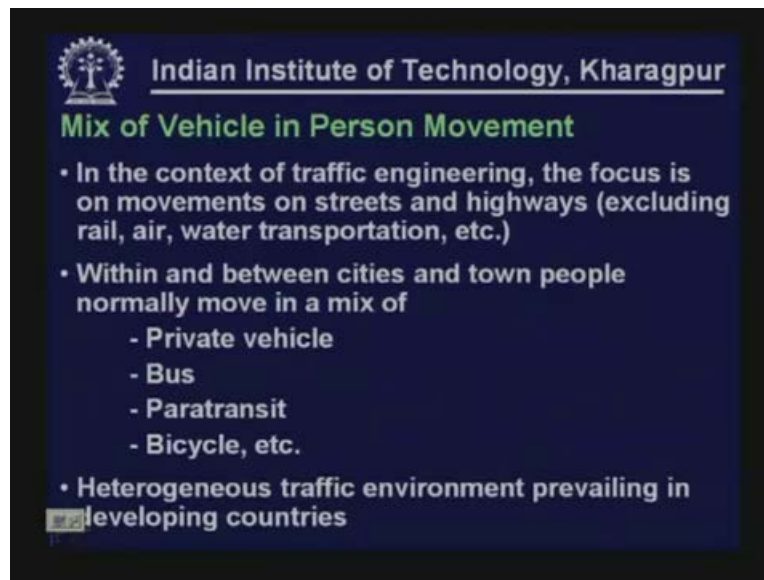


Now the second question is goods movement or person movement.

In many occasions we think that road is primarily for passenger movement. That means we see often cars are getting congested and with the volume of more cars the roads are getting congested and the presence of a few commercial vehicles like trucks or other heavy types of vehicles, their presence even aggravate the traffic congestion problem. So we apparently think that the road is primarily for movement of passengers and trucks or goods vehicle are some sorts of disturbing elements in the overall system because really they do create problems. But let us not forget the fact that goods transportation provides the lifeline to any community. It directly adds to economic development.

It is necessary to the transport raw materials and it is also necessary to transport the finished products, both are important. So we must not forget the role of goods transportation in the overall transportation engineering sphere and their contribution in the overall economic development. So we have to consider and we have to take care of passenger transportation as well as goods transportation, both are important. So I have indicated like this; roads primarily serve motoring to public and the trucks are problematic elements, the answer is no because goods movement is critical to the local economy, transportation of the raw material and the finished products both are important therefore goods movement and person movement both are essential.

(Refer Slide Time: 12:03)



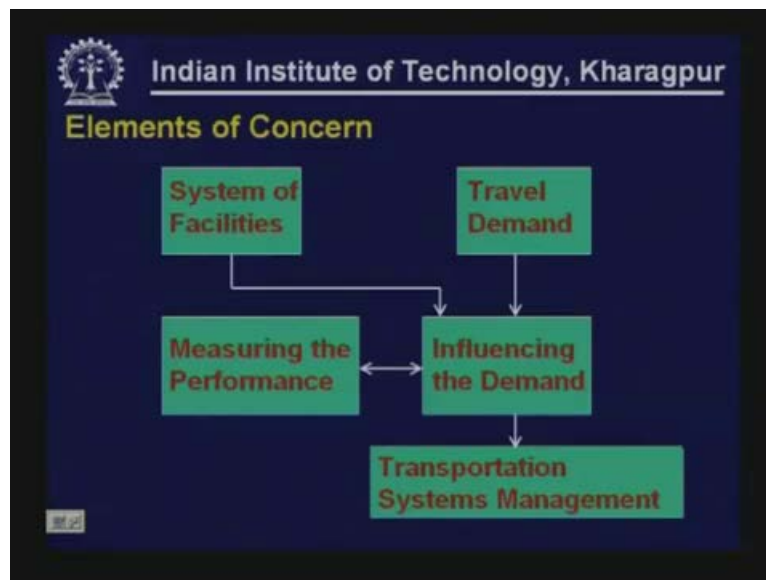
Mix of vehicle in Person Movement:

Person movement is normally accomplished by sharing the demand into different types of modes. So in the context of traffic engineering our focus is generally on movement on streets and highways. That means we are excluding for the moment the rail transportation, water transportation and air transportation scenarios. So within and between cities and towns people normally move in a mix of vehicles namely private vehicles, buses, paratransit systems, bicycles and even walking so different modes of transportation do exist.

Each mode of transportation has its own utility in the overall system starting from walking to movement by bicycle or non-motorized transport to faster travel even the car movement, the bus movement and so on. So every vehicle type every movement has its own utility and contribution in the overall transportation system so we have to consider all of them. And the beauty of the road system is the same road space or whatever is the available road space we have to use them for movement of various types of vehicles. In certain context we may restrict some type of vehicle movement on certain roads during certain periods but that's a different question. But all types of vehicles are to be accommodated.

And if we look at the developing country context in particular in developing country context heterogeneous traffic movement is very, very common. In most of the developing countries the traffic movement is heterogeneous and heterogeneous traffic movement adds to the complexity operation and it makes traffic engineering a more complex task in developing country context.

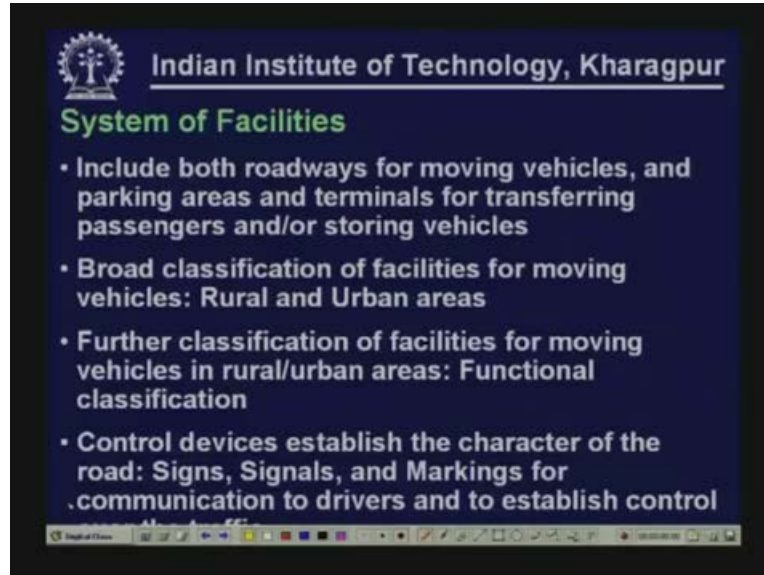
(Refer Slide Time: 14:18)



Now with that background let us look at the various elements of concern. Basically through this part we would like to develop our understanding about traffic engineering. Now it is probably easy to develop a concept and understanding if we discuss the major concerns or the elements of concern. Five major elements are shown in this flow chart. You have system of facilities basically the road system, we shall discuss in detail about each of these components. We have supply site or the system of facilities, we have demand and they interact with each other in transportation system in the interface of control and this interaction creates operational performance, congestion and all sorts of other things.

So, influencing the demand is another aspect, can we influence the demand, should we influence the demand, if so then in which ways, then measuring the performance of the overall transportation systems and then transportation systems management. So these are the five major element of concern and let us try to understand each of these elements in detail.

(Refer Slide Time: 16:04)



First is System of Facilities:

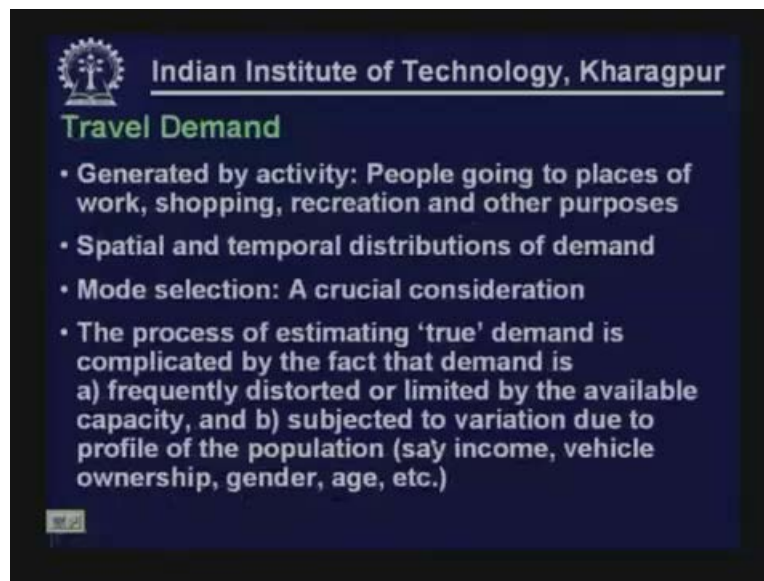
System of facilities normally includes the physical root system. It is essentially the supply side of a transportation system. So it includes roads which are used for moving vehicles, parking areas, terminals and all other physical facilities and it also includes the control devices which are present on roads. For example, signs, signals, and markings are all physical facilities so they come under system of facilities. So, system of facilities includes both roadways for moving vehicles, parking areas and terminals for transferring passengers and or storing vehicles. Now in this context also we know that road systems in urban areas, in rural area they are different, fundamentally they are different. The type of the system the purpose they all may be different. So primarily we consider two types of road system urban areas and rural areas. Rural means essentially non urban areas so normally we call them as highway roads in rural areas.

Now, further classification of facilities for moving vehicles in rural and urban areas is done based on functional classification that is again an important aspect. Not that all roadways even in urban area or even in rural area serve the same purpose. Two aspects are important. A road may serve the purpose of providing access and then it may also serve for the true traffic movement that means faster movement of long distance **traffic, through traffic**. So often these two aspects are important, how much road is available for providing access and to what extent it is supposed to handle the through traffic movement. Therefore these two major functions and their level of influence may define functional classification of roads. We define a hierarchy of roads wherein some cases the whole objective is through traffic movement and at the extreme end the whole purpose may be providing access and there could be other types of roads which serve as a combination of both these aspects, some may be more and some may be less.

Therefore functional classification is important, we shall also learn functional classification in due course of time. Then we have control devices, these generally establish the character of the road. These control devices include traffic signs, traffic signals, road markings and all these are

essentially for communication to diverse and establish control over the traffic. Controlling the traffic or looking at the operational aspects of the traffic is also important when we look at how to improve the efficiency of the traffic operations for a given facility and a given demand system. Hence there the control devices will play a vital role so this also includes or defines the system of facilities.

(Refer Slide Time: 20:11)



Then the second aspect is the travel demand. We all know that demands are generated by activities. people live somewhere they need to travel to various places, places of work, places of shopping, places of recreational facilities so for different purposes they need to travel and there is a special distribution, residences are located somewhere, activities are located somewhere and that's what generate the travel demand. The spatial distribution of activities they generate demand. Thus there is demand and because there is demand we need to provide supply and supply also influences the demand pattern, so it is a two way interaction. So it is basically generated by activity and both spatial and temporal characteristics of distribution of demands are important. Let us try to understand the spatial and temporal distributions of demand.

As I have already indicated because the facilities are located in different places it has got a special characteristic. Thus naturally demand has also got a special dimension. if offices are located somewhere in the vicinity and if residents are located in the suburb then it is obvious that during the morning hours the peak hours the travel will be from residences to the vicinity area or the office area and in the evening people again need to comeback so again there will be demand between office areas or the vicinity to the suburb.

Obviously not that all places are equally loaded over the whole period of time some roads are loaded some are free and at some other time may be there is congestion and may be sometime there is no congestion on the road so it varies over distance, over space, space means the area and also it varies over time. If you again think of the earlier example people are going to office. May be between 9 and 10 all the roads towards the CVD area they will be congested. If you see may



be at 12 O'clock those roads are not congested because primarily the sharp demand is towards the **CVD** area or where the main offices are located. So the same road whatever you find at 9 O'clock it is highly congested at 12 O'clock there may not be any congestion on that road so demand has got both special and temporal characteristics and this is to be understood very clearly if we have to address the traffic engineering and related issues.

As i indicated earlier mode selection is a crucial consideration because for the same person demand or the passenger demand mode selection or mode split decides the actual traffic volume and therefore the actual level of congestion on road at a given time. Remember that the process of estimating true demand is often complicated by the fact that demand is frequently distorted or limited by the available capacity. All physical facilities are capacitated. If you think of a road it can handle only certain number of vehicles or certain volume of vehicles. So even if the demand is more the road cannot accommodate any traffic volume higher than its capacity. So demand may be distorted or limited by the available capacity. And also demands are subjected to variation due to profile of populations say income, vehicle ownership, gender, age and other socio economic attributes.

(Refer Slide Time: 24:56)

**Indian Institute of Technology, Kharagpur**

### Travel Demand

- Generated by activity: People going to places of work, shopping, recreation and other purposes
- Spatial and temporal distributions of demand
- Mode selection: A crucial consideration
- The process of estimating 'true' demand is complicated by the fact that demand is a) frequently distorted or limited by the available capacity, and b) subjected to variation due to profile of the population (say income, vehicle ownership, gender, age, etc.)

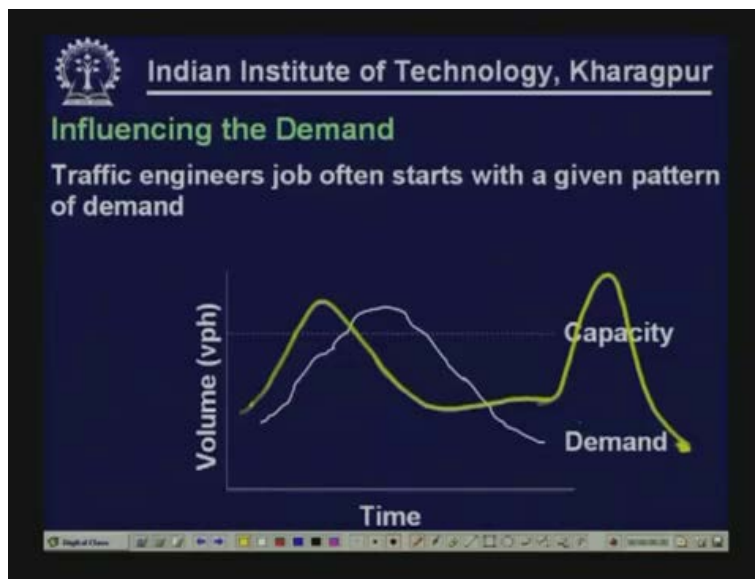
If you see the trip rate the way or the per capita trip made in a day, the number of trips it is influenced by income, it is influenced by car ownership. Normally may be high income households they make more trips, high personal income means more trips, higher vehicle ownership means more trips so all these socio economic characteristics also do affect or influence the demand pattern and that makes the whole demand estimation a complex task.

(Refer Slide Time: 25:46)



Next is influencing the demand. Now traffic engineer job often starts with a given pattern of demand. This is just an example. If you see it is the volume of traffic in a road that versus time. You normally get a pattern like this. Sometimes you may be getting a pattern like this also, may be two peaks.

(Refer Slide Time: 26:14)

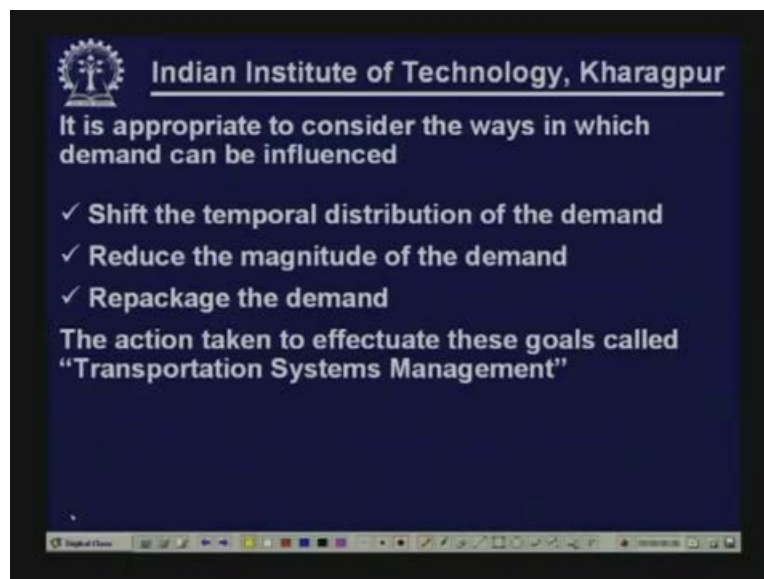


Morning when people are going to offices that time you find the traffic volume is more the road is congested and then the traffic volume comes down and then again in the evening when people are coming back or going to shopping or recreational places then again the demand is more. It is interesting to note that the capacity of the system is fixed as shown by this dotted line, this is a

fixed value. So capacity is fixed and demand most of the times it is lesser than the capacity. And at night time the demand is practically nil but the capacity does not change but it still remains so it is only at certain hours of the day that demand is becoming more than capacity and the congestion is created. So it may be worthwhile wherever it is possible wherever it is applicable to think of or to influence this demand pattern to make a better use of the available capacity. Say only during one hour in the morning and one hour in the evening the demand is more than the capacity and we start thinking of widening the road to have a capacity level here.

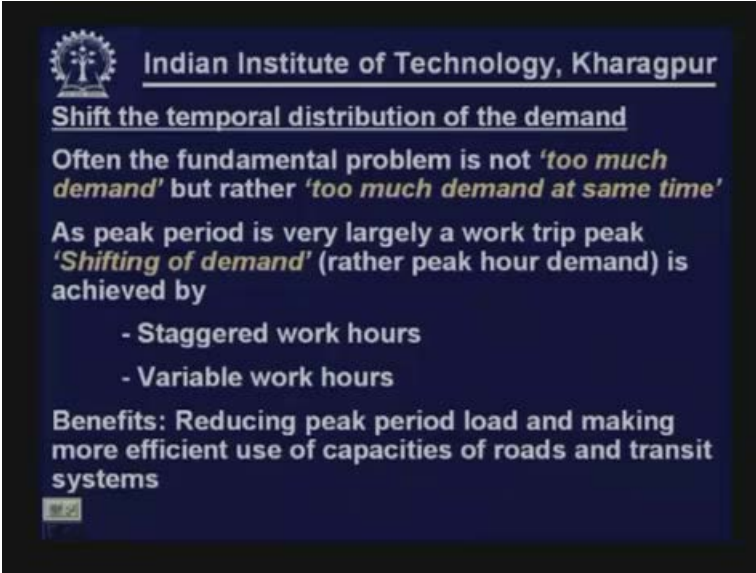
Now, problem is only for the two hours, one hour in the morning say for example and one hour in the evening and for that one why to increase the capacity of the road system, why to add more capacity because adding capacity building roads is a very, very capital intensive solution. Rather than that can we touch or can we influence the demand so that within the road system within the available capacity we can have a better utilization of the capacity. So that way it is meaningful and it makes sense to influence the demand.

(Refer Slide Time: 28:31)



There are three different ways we can influence the demand. One is shifting the temporal distribution of demand. I have already mentioned the demand has got a temporal nature. At nine o'clock the road is highly congested and at 11 O'clock the road is relatively free. So basically we can shift the temporal distribution of demand and that is one way how we can influence the demand. The next one is to reduce the magnitude of the demand, can we really reduce the magnitude of the demand itself and that will be very much meaningful in the overall perspective. The other one is repackage the demand. We shall discuss in detail about all these three approaches. Now the decision taken to effectuate these goals of influencing demand is called transportation systems management the other elements of concern that I have mentioned.

(Refer Slide Time: 29:33)



The slide features the IIT Kharagpur logo in the top left corner. The text is centered and reads: 'Indian Institute of Technology, Kharagpur' followed by 'Shift the temporal distribution of the demand'. Below this, it states: 'Often the fundamental problem is not *'too much demand'* but rather *'too much demand at same time'*'. It then explains: 'As peak period is very largely a work trip peak *'Shifting of demand'* (rather peak hour demand) is achieved by'. This is followed by a bulleted list: '- Staggered work hours' and '- Variable work hours'. The final line states: 'Benefits: Reducing peak period load and making more efficient use of capacities of roads and transit systems'.

Shift the temporal distribution of demand. By this time I am sure you all will appreciate the problem may not be really 'too much demand' but the problem may be 'too much demand at the same time'. If you see in the mid night, early hours in the morning, late hours in the night the demand is practically nil. So it is not that if you consider 24 hour span in a day not that the demand is very high as compared to the capacity rather the problem is too much demand at the same time.

So it does make sense to influence a demand by trying to shift the temporal distribution of demand. So the peak period is very largely a work trip peak because most of the time morning and evening peaks constitutes of largely vehicles which are for work trips or people using vehicle for work trips. So shifting of demand is really meaningful. What I mean by shifting of demands rather shifting the peak hour demand, mitigate the peak hour demand let the total demand be even same but can we distribute the peak hour demand over a larger period of time so that at no hours the demand is more than the capacity. Reduce the peak and spread it over longer hours and that can be achieved by staggered work hours, variable work hours and so on.

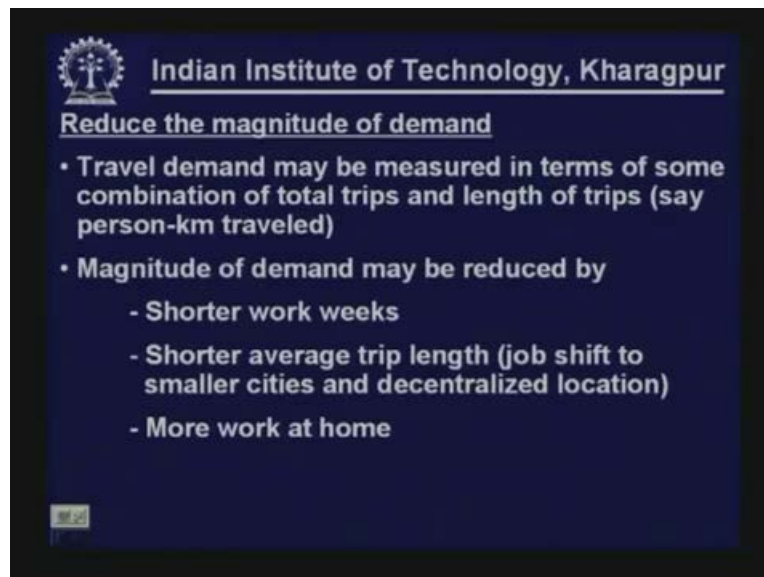
Now again let us try to understand this concept. In most of the cases you will find that in a city or in a town all offices may be start at 9 O'clock so you find if it is so all offices are starting at 9 O'clock you will probably expect that everybody is going to office between 8 to 9 O'clock. So 8 to 9 probably is giving generating maximum demand the time demand is maximum and all the road systems are congested. Can you not think of a system where some offices may be starting at nine o clock, some are starting at eight o clock, some are starting at 10 O'clock and accordingly the closing time also will change, instead of 4 O'clock or 5 O'clock some will close at 4 O'clock, some will close at 5 O'clock, some will close at 6 O'clock but still there will be enough common time, enough common working hours for interaction, exchange of ideas, meetings and all sorts of other works. So keeping sufficient gaps sufficient overlaps we can still stagger the time. if we do that then there is tremendous benefit because complete demand is shared in a better way with the

same road system, same facilities and capacities and people enjoy a better quality of service then roads will definitely become lesser congested by this mechanism.

Flexible working hours: In an office also there could be different slots. Somebody may pick up a slot from eight to four, somebody may pick up a slot from nine to five, and somebody may pick up a slot from ten to six. So often these kinds of flexi hours it gives advantage or benefit to the job makers and also to persons who are employed because they can accordingly schedule other activities, may be husband and wife both are working one can go bit early in the morning and he or she will come back early and the other can go at late hours may be they will start to work at ten o clock and he or she will come home late. So that way it is beneficial for the employee and it may bring tremendous benefit on the traffic operation, road system and the overall performance of the transportation system.

So, if you look at the benefits it is reducing peak hour load through all these mechanisms and making more efficient use of capacities of roads and also the transit systems. So transit systems also most of the times you will find during the peak hour that transits are overloaded, buses are completely loaded. so if we can stagger the demand rather than the load on transit system will also be reduced will also spread over longer time so the benefit will be less crowding on transit and better utilization of capacities.

(Refer Slide Time: 35:28)



Reduce the magnitude of demand: how can we reduce the magnitude of demand. Remember that travel demand may be measured in terms of some combination of total trips and also length of trips say person to kilometer traveled. In fact this is a more rational quantification of demand. If we say only how much number of trips we may ignore whether they are short trips or long trips. So if we consider a combination of total trips and length of person to kilometer then that gives a rational and balance measure of the magnitude of demand. So magnitude of demand may be reduced by the following ways:

- shorter work weeks
- shorter average trip length and
- more work at home

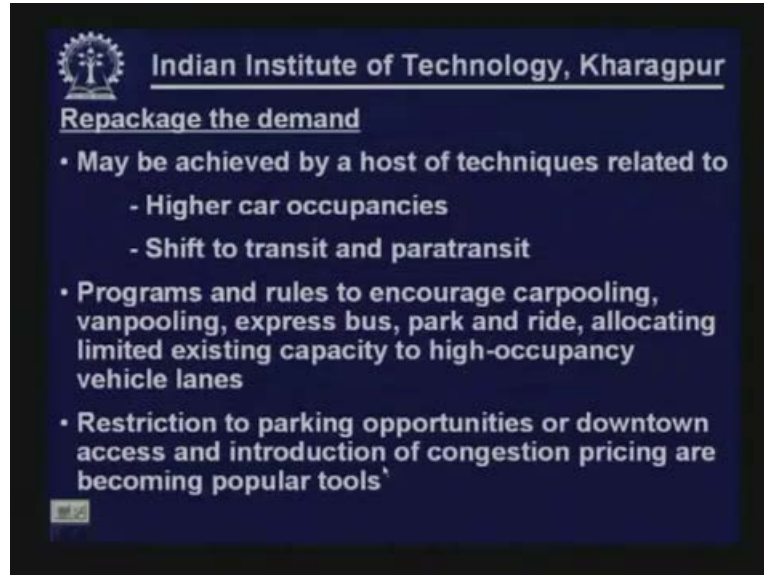
All these are possible, nothing is impossible.

Shorter Work Weeks: Instead of may be a six day week it may be a five day week. the total working hours in a week still remains the same. if some offices operate on a five day schedule and some offices operate on a six day schedule obviously the starting and the closing times will be different. Five days week means longer working hours in every working day and six day week means relatively shorter working hours in every working day. Hence **all the people** will not go to the office in the same time so that will again bring benefit. Thus we are reducing the demand during the peak hours and there are number of benefits from that.

Shorter average trip length: Job shift to smaller cities and decentralized locations. in many cases in most of the cities in developing countries you will find all offices all head offices are located in the capital city may be majority of them are required to be located in capital city but in many cases probably all the people from different states they need not come to the capital city you can have district head quarters or zonal head quarters decentralize it so that all people do not require to travel to the CVD area or to the same town for each and every work so that may reduce the total demand.

More works at home: this is also a feasible option. Because with the development of computer, networking facilities many things can be done in home also and that can substantially reduce the overhead cost for physical facilities. A big office in a very expensive area or in a zone where the land is used the rental is very high. a smaller office can be there but the productivity can still be comparable. people can work in home, they can exchange ideas, they can interact and not that everyday everybody will go to the office, it may sound very surprising but it may be possible because if you have computer if you have network not that for every office for every system every type of industry it will be possible but it may certainly work for some of the industries and some of the types of job at least for some employment. So if we try to make use of this computers and networking facilities certainly we may be able to reduce the travel demand at least to some extent.

(Refer Slide Time: 39:09)



Repackage the demand:

Remember that we are talking about repackaging that means the total demand still may be the same in terms of person movement but we are trying to repackage the demand. let us see how we can repackage the demand. It can happen through the following:

- Higher car occupancies
- Shift to transit and paratransit

So what will happen is same volume of passengers may be transported but with lesser number of vehicles. that means it may be possible that you allow a vehicle to take a shorter route when the occupancy of the vehicle is higher may be for a car at least there should be three persons if you want to use the shorter route. if it is only one person or less than three persons the vehicle will be forced to take a longer route. so people will be encouraged to use higher occupancy or make higher occupancy of the vehicle. The result or the benefit to the community is substantial, three persons are traveling in the same vehicle so instead of three vehicles it is now one vehicle.

More people switch over to mass transportation system or public transportation system so again there is reduction in the vehicle volume so there is lesser congestion on roads. Thus the benefits are multidimensional. Benefits in terms of capacity utilization, benefits in terms of better mobility, better travel speed, better environmental aspects and so on.

Programs and rules to encourage carpooling, vanpooling, express bus, park and ride, allocating limited existing capacity to high occupancy vehicles are the different ways and means for repackaging the demand.

Carpooling is, instead of three persons taking three cars and going to the same office area from the same residence area say it is a six day **per week schedule** everybody is taking their own car to

the office but instead of that if the three of them use carpooling and they decide every two days in a week one person will take his car and all three of them they will travel in the same car because they start at the same time they go to the same area. So instead of three cars it is one car now so congestion is reduced and again all sorts of benefits may be achieved. Similarly, we have the vanpooling where in one vehicle so many people are traveling. This kind of repacking may be encouraged by putting restriction to parking opportunities. if you take the vehicles parking space is limited you may not get a parking space or you may have park your vehicle at a much distant place or there may be some kind of parking charges these are all indirect ways and means to encourage people to use mass transportation system or use some sort of repacking facilities like carpooling, vanpooling and other things. So, congestion pricing also could be taken as an instrument to encourage this kind of achievement.

(Refer Slide Time: 42:35)

**Indian Institute of Technology, Kharagpur**

**Measuring the Performance**

- It is necessary to understand 'how well a facility or system is working' for the purpose of
  - a) assessing the existing condition
  - b) evaluating alternative improvements
  - c) quantifying associated costs and benefits
  - d) communicating the results to both technical and non technical audiences
- Facilities generally assessed by specific quantitative measures and by a qualitative index of 'quality of flow' termed as '*Level of Service*'

Measuring the Performance:

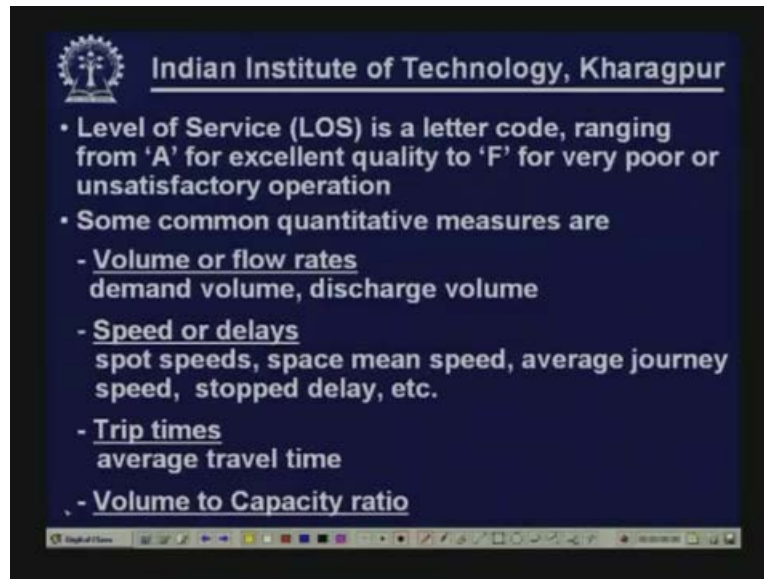
Yes, it is necessary to understand how well a facility or system is working. It is necessary to understand that. We need to understand this for various reasons. One is for assessing the existing condition, how good or bad the existing system is and how it is operating. So we must be able to measure the performance for assessing the existing condition, for evaluating alternative improvements. Suppose presently the situation is not that good and you are thinking of suggesting improvement measures there could be three different alternatives. Now how do you know which alternative brings maximum benefit to the community. We must be able to quantify it using proper measures. Hence it is also necessary for evaluating alternating improvements.

Quantifying associated cost and benefit, every alternative you say it will have some cost and it will bring some benefit to the community and road users. so for quantifying the cost and benefit also it is useful and for communicating results to both technical and non technical audiences, you need to observe this carefully, you may be doing lot of engineering, you might be doing a lot of other works but finally you have to communicate the results to technical and non technical



audiences. So if you can quantify it in a proper [not audible 44:10] and see that this is the benefit or this is the gain by this activity then it will be easy for others to appreciate your effort and accept the suggestion.

(Refer Slide Time: 44:55)



Facilities generally assessed by specific quantitative measures and by qualitative index of quality of flow are called the level of service. So mostly we use this term to describe the quality of traffic operation on a facility by level of service. Level of service has a qualitative aspect and it is not normally expressed by letter code ranging from A to F where A indicates the excellent quality and F indicates the worst or very poor or unsatisfactory operation, and B C D E R in between. Now we often use a quantitative basis also for defining level of service. Level of service is also a qualitative term so we often use a quantitative basis for defining the level of service known as measure of effectiveness. Measure of effectiveness is a quantitative basis for defining level of service. So they may be using many of these things as level of effectiveness.

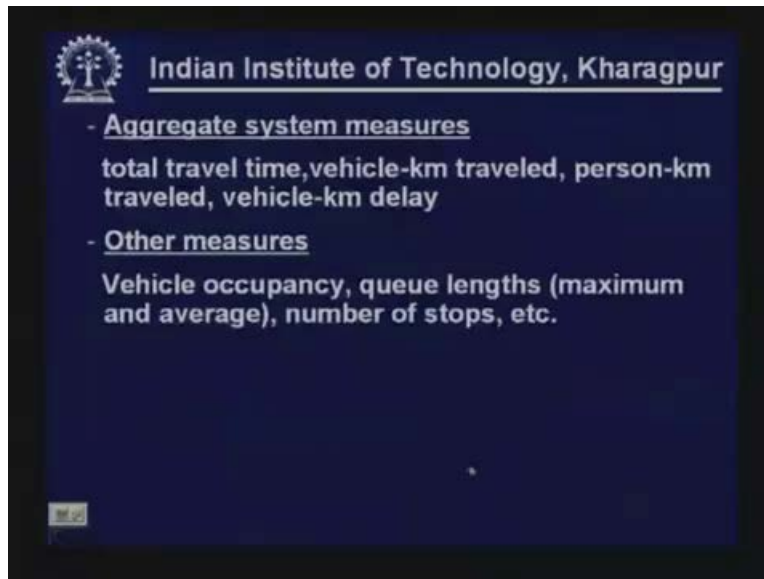
**Volume or the Flow Rates:** Traffic volume or traffic flow we can express it in terms of may be demand volume, in terms of may be discharge volume as to how much is coming out from the road system and so on.

**Speed or Delays:** For speed again we have various types of speeds, spot speed, space mean speed, average journey speed, stopped delays and so on. Thus many of these terminologies we have already discussed and many of these things we will also discuss again in subsequent lectures.

**Trip Times:** It may be the average travel time that is taking for the trips. We can use this one as a measure of effectiveness. Sometimes it is rational to use volume to capacity ratio rather than using only volume because if you say only volume that is two thousand vehicles, so two thousand vehicles on a single lane road or a two lane road or a three lane road the effect is totally different. So instead of using it only as the volume it is more rational and logical probably to use

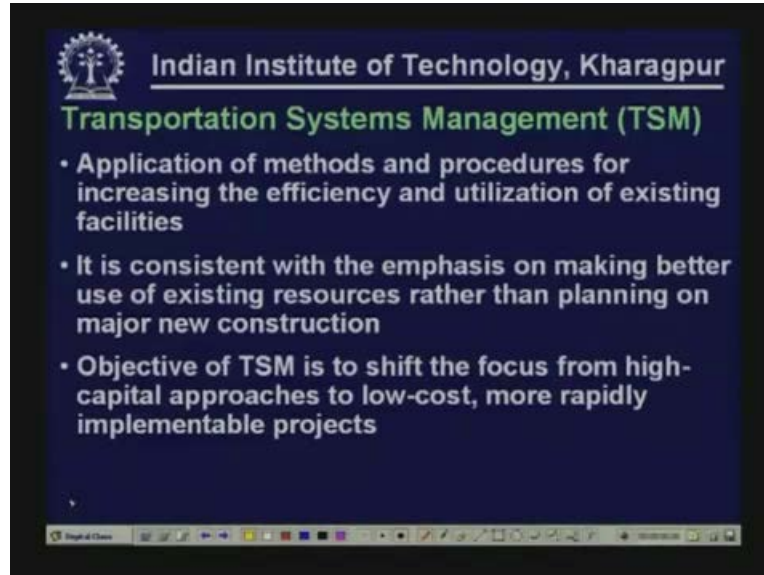
a measure like volume to capacity ratio. You will know what is the relative loading or what is the relative demand on that road as compared to the capacity or to what extent the road system is loaded.

(Refer Slide Time: 47:07)



**Volume to capacity ratio:** Sometimes one can use aggregate system measures like total travel time, volume to capacity ratio to total travel time, vehicle kilometer traveled, person kilometer traveled, vehicle kilometer delay so all these can be measured can be considered and they are basically indicating aggregate system measures. there are other measures for example vehicle occupancy, the queue length queue length is particularly relevant when you have signalized intersection may be the performance of the signalized intersection you can measure in terms of what is the queue length you are getting in peak periods. Again the queue lengths may be measured in terms of average queue length may be what the maximum queue length is and so on. Sometimes you use measures like number of stops that is made during a journey so all these are used as quantities or quantitative measures and many of these are also used for defining the level of service.

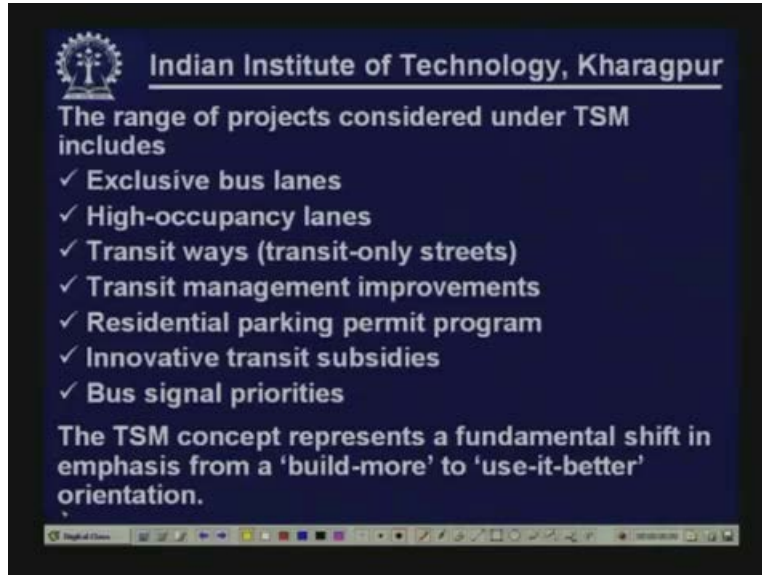
(Refer Slide Time: 48:22)



Now, coming to the concept of Transportation Systems Management already we have created a background for Transportation Systems Management. This essentially means application of methods and procedures for increasing the efficiency and utilization of existing facilities. Remember that it is consistent with the emphasis on making better use of existing resources rather than planning on major new constructions. because remember that if you are thinking of adding supply side as the only measure for solving congestion problem or transportation problem it is a capital intensive approach it takes money. So in majority of the developing countries we have serious financial constraints also. Thus these kinds of approaches may be more meaningful because they try to improve this, we can try to ensure utilization of existing facilities rather than just building roads and enhancing capacity. So objective of TSM is essentially to shift the focus from high capital approaches to low cost more rapidly implementable projects.

Let me tell you in the context of a developing country these kinds of transportation systems management TSM techniques have got a very vital role to play because we have limited resources, our cities in majority of the cases they are not properly planned so it is very difficult even to construct a road or to widen the road because of all other establishments, buildings and other permanent structures. So this TSM technique can really be very much instrumental for improving the overall traffic operations in urban areas and they are low cost techniques and are more rapidly implementable. You need willingness to accept and implement such techniques in reality.

(Refer Slide Time: 50:31)



The range of projects considered under TSM I have already given a background or understanding. So let us look at the some of the range of products that may be considered.

- Exclusive bus lanes
- High occupancy lanes
- Transit ways
- Transit management improvement programs
- Residential parking permit program
- Innovative bus subsidies: It has to be innovative bus subsidies basically to encourage the transportation system management strategies and
- Bus signal priorities

So you can see that majority of these types of projects are actually intended to encourage the use of mass transportation system through some measures either directly or indirectly. So encourage people to use more and more mass transportation systems rather than own personal vehicles. So the TSM concept represents a fundamental shift in emphasis from build more to use it better orientation. So it is a shift in approach from build more to use it better.

(Refer Slide Time: 51:50)

**Indian Institute of Technology, Kharagpur**

### Components of Traffic System

✓ Road Users	Traffic Engineers have little or no control
✓ Vehicles	
✓ Roadways	Traffic Engineers have more control
✓ Control devices	

Now let us quickly look at the components of traffic system. You have four components basically road users, vehicles, roadways and control devices. Traffic engineers normally have very little or control on the first two aspects road users and vehicles but certainly they have better control on roadways and control devices. Let us quickly go through these aspects.

(Refer Slide Time: 52:13)

**Indian Institute of Technology, Kharagpur**

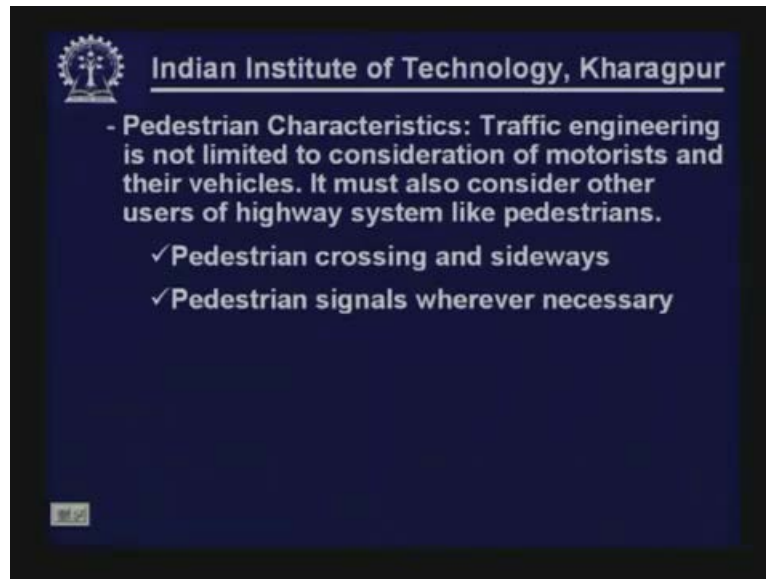
### Road Users

- Human elements separate traffic engineering from most other engineering: drivers, passengers, pedestrians, bicyclists, etc.
- Several critical characteristics of road users are quantifiable and can be taken into account in traffic engineering decision
  - Perception and reaction time
  - Visual acuity (Static and Dynamic)
  - Other driver characteristics like hearing and psychological factors. Design should account for driver characteristics

Road Users: Human elements separate traffic engineering from most of the other engineering because human elements are involved in it, the driver behavior and user behavior makes it different from most of the other traditional engineering disciplines.

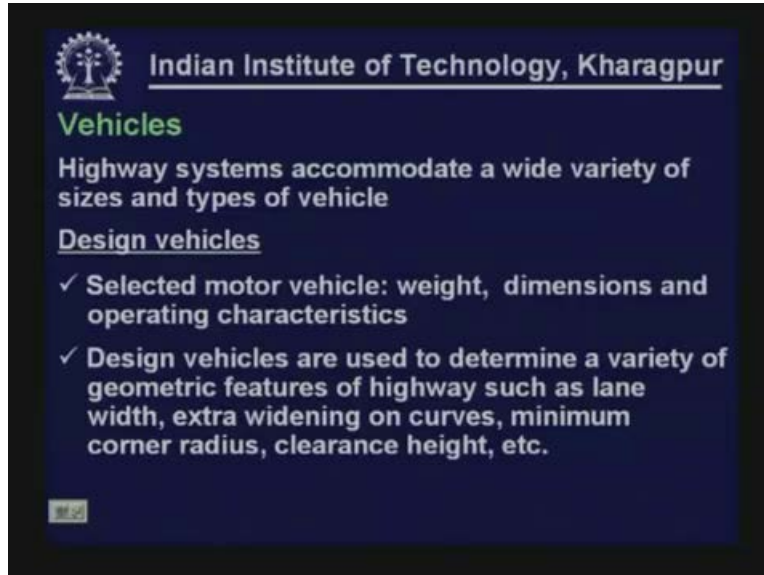
Several critical characteristics of road users may be quantifiable. We say we have no control on road user but we can certainly take the characteristics of road user and consider them in the road way design process or transportation engineering design process. For example, perception and reaction time of drivers, visual activity both static and dynamic, in most of the cases we check only static visual activity but dynamic visual activity also may influence the overall behavior then other driving characteristics like hearing, psychological factors so design should account for all these drivers' characteristics. You will see that in geometric design part we will discuss in detail how we can consider these aspects namely road users' aspects in the design process.

(Refer Slide Time: 53:22)



Pedestrian Characteristics: They are also important because traffic engineering is not limited to consideration of only motorists and their vehicles but it must also consider other users of highway system like pedestrian. They are the essential elements of the transportation system or traffic system. So pedestrian crossing sideways, and providing pedestrian signals phase wherever it is necessary and appropriate **comes into account**, then vehicles there are variety of vehicle sizes and different types of vehicles. So when we design the road we consider them in the design process in terms of taking into consideration all these characteristics to design vehicle. Design vehicle is normally the one whose weight dimensions and characteristics are used for deciding the geometric features. Again we will talk about the design vehicles during our discussion about the geometric design process.

(Refer Slide Time: 53:55)



The slide features the IIT Kharagpur logo in the top left corner. The title 'Indian Institute of Technology, Kharagpur' is centered at the top. Below it, the word 'Vehicles' is written in green. The main text discusses highway systems and design vehicles, with two bullet points.

**Indian Institute of Technology, Kharagpur**

**Vehicles**

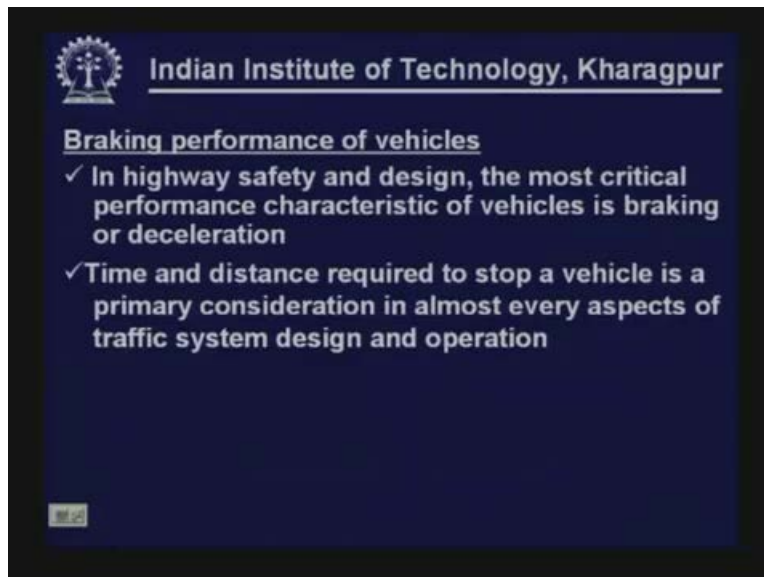
Highway systems accommodate a wide variety of sizes and types of vehicle

Design vehicles

- ✓ Selected motor vehicle: weight, dimensions and operating characteristics
- ✓ Design vehicles are used to determine a variety of geometric features of highway such as lane width, extra widening on curves, minimum corner radius, clearance height, etc.

Acceleration performance of vehicles is again an essential characteristic that comes into the design process.

(Refer Slide Time: 54:27)



The slide features the IIT Kharagpur logo in the top left corner. The title 'Indian Institute of Technology, Kharagpur' is centered at the top. Below it, the title 'Braking performance of vehicles' is underlined. The main text discusses highway safety and design, with two bullet points.

**Indian Institute of Technology, Kharagpur**

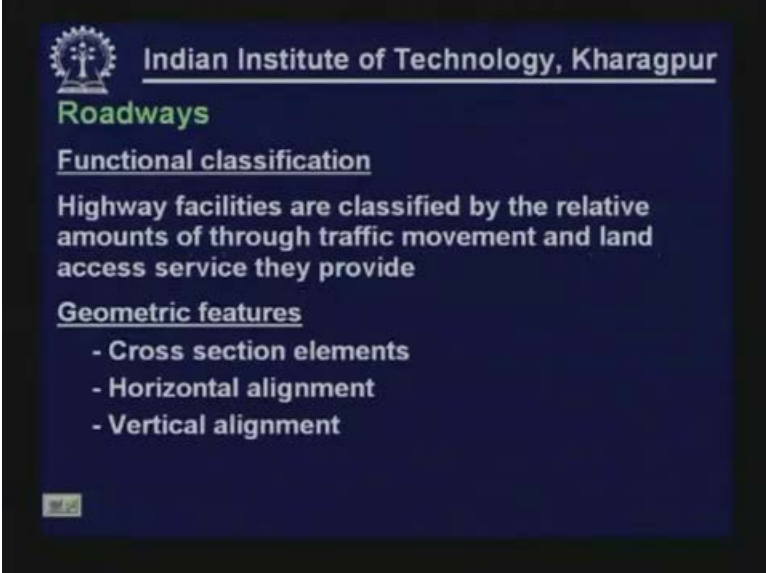
Braking performance of vehicles


- ✓ In highway safety and design, the most critical performance characteristic of vehicles is braking or deceleration
- ✓ Time and distance required to stop a vehicle is a primary consideration in almost every aspects of traffic system design and operation

Braking performance of vehicles: This is a very vital consideration. We consider the side distance. We will discuss again in detail all these aspects in the geometric design part and we will see how this braking performance is used for a making the design elements or design process particularly the stopping side distance requirement.

Coming to the roadways I have already discussed about the need for functional classification. We try to design roads for safe and efficient movement of persons and goods. Therefore we go for geometric design. We have a separate module under geometric design where we will discuss at length about each and every aspect. You will see that we design cross sectional elements, we design horizontal element, we design vertical elements considering the vehicle characteristic considering the roadway characteristics and try to make a safer design which will ensure safe and efficient movement of traffic on roads and highways.

(Refer Slide Time: 54:54)



 **Indian Institute of Technology, Kharagpur**

**Roadways**

Functional classification

Highway facilities are classified by the relative amounts of through traffic movement and land access service they provide

Geometric features

- Cross section elements
- Horizontal alignment
- Vertical alignment

(Refer Slide Time: 55:46)



 **Indian Institute of Technology, Kharagpur**

**Traffic Control Devices**

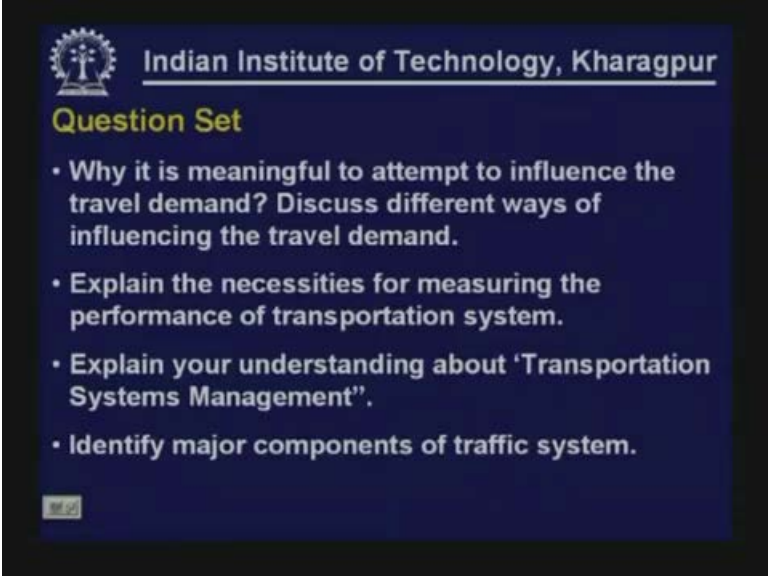
- Communication of traffic laws and regulations to drivers by means of control device
  - Road markings
  - Traffic signs
  - Traffic signals
- As control devices are the only measures of transmitting operational rules to drivers, they must be clear, easily interpreted and commanding of attention
- Regulatory aspects of traffic control must be enforced



## Traffic Control Devices:

Remember that they are for the communication of traffic laws and regulations to drivers. So through control devices we tell drivers about the laws like what they are supposed to do, what they are not supposed to do and there are different control devices like road markings, traffic signs, traffic signals etc. Remember that control devices are only measures of transmitting operational rules to drivers. When vehicles are traveling they all know about operational rules and regulations through the control devices. The signals will show the appropriate sign for the vehicle that it is supposed to stop, the other signs will indicate what they are supposed to do and what they are not supposed to do so they are the only measure of transmitting operational rules to drivers so they must be very clear, **easily interpreted and commanding of attention shape, color,** size of all the control devices are very, very important. Finally the regulatory aspect of control devices must be enforced so that people don't violate. If there is a sign they should obey that, if there is a signal they should obey that and that is again to be enforced, all these aspects are to be enforced which is again an essential component.

(Refer Slide Time: 57:13)



**Indian Institute of Technology, Kharagpur**

**Question Set**

- Why it is meaningful to attempt to influence the travel demand? Discuss different ways of influencing the travel demand.
- Explain the necessities for measuring the performance of transportation system.
- Explain your understanding about 'Transportation Systems Management'.
- Identify major components of traffic system.

Now let me quickly ask you some of the questions;

- Why it is meaningful to attempt to influence the travel demand? Discuss different ways of influencing the travel demand:
- Explain the necessities for measuring the performance of transportation system:
- Explain your understanding about transportation systems management: and the last question is;
- Identify major components of traffic systems:

The answers to these questions I will discuss after the next lesson or during the next lesson, thank you.