

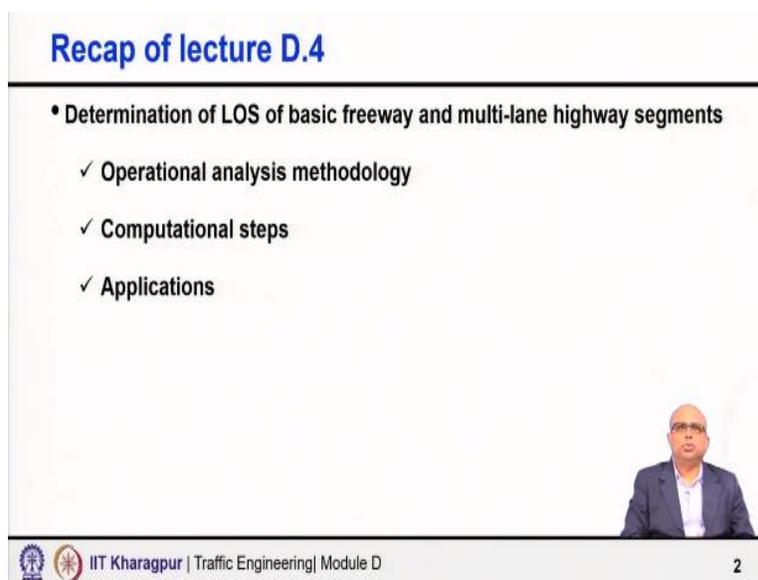
Traffic Engineering
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Lecture 20

Analysis of Two-Lane Highway Segments (As per HCM, 2016) -I

Welcome to module four, lecture five, in this lecture today we shall discuss about analysis of two lane highway segments with respect to capacity and level of service.

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The slide is titled "Recap of lecture D.4" in blue text. Below the title, there is a bulleted list of topics covered in the lecture. At the bottom right of the slide, there is a small video inset showing a man in a blue suit and glasses. At the bottom left, there is a logo for IIT Kharagpur and the text "IIT Kharagpur | Traffic Engineering | Module D". At the bottom right, there is a small number "2".

Recap of lecture D.4

- Determination of LOS of basic freeway and multi-lane highway segments
 - ✓ Operational analysis methodology
 - ✓ Computational steps
 - ✓ Applications

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In lecture 4 we discussed about operational analysis methodology for analysis of level of service for basic freeway and multilane segments, the computational steps, two steps we discussed in details in lecture three, in lecture four we discussed about the remaining steps in details, computational steps and then also took two example problems to demonstrate you the application that how the LOS can be analyzed for freeway segment and one more example problem on multilane highway segments.

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Background

- Analysis of Two-Lane highway segments as **uninterrupted flow facilities**
- Segments where **no traffic control devices** exist to interrupt traffic externally, and where **no platoons** are formed by traffic signals
- Passing maneuvers take place in the **opposing lane of traffic: A major difference** from other uninterrupted-flow facilities
- Passing maneuvers are limited by the availability of (i) **gaps** in the opposing traffic stream, and (ii) **adequacy of available sight distance**



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With this background today we shall focus on two lane highway segments, as you know the two lane highway segment means there are two traffic lanes, one for upstream, one for downstream and these roads are undivided roads and what we want to do here in this lecture and also the next lecture we want to show you how the capacity analysis and level of service analysis can be carried out for two lane segments.

Considering two lane highway segments as uninterrupted flow facilities, you know what is uninterrupted flow facilities we have discussed it earlier, freeway also uninterrupted flow facilities, multilane highways also uninterrupted flow facilities, we analyzed them and now we shall analyze the segments of two lane highways which can qualify to be analyzed as uninterrupted flow facilities.

Which are the segments which can qualify to be uninterrupted flow facilities? These are the segments where no traffic control devices exist, particularly stop sign, yield sign etcetera, to interrupt traffic flow externally, that is the fundamental basis for defining uninterrupted and interrupted flow facility.

So, no traffic control devices such as traffic signals, stop sign, yield signs which can interrupt traffic externally and where no platoons are formed by the traffic signals, if there are adjacent signals and because of that the vehicle platoon is formed, so that platoon especially upstream, if upstream signal is there and the platoon is formed then the vehicle will move in platoons which is not as per uninterrupted flow facilities.

So, where no traffic control device exists to interrupt traffic externally and where no platoons are formed by traffic signals those segments of two lane highway can be analyzed as uninterrupted flow facilities.

Now, a major difference between two lane highway segments, such two lane highway segments and other uninterrupted flow facilities. For example, multilane highways and freeway segments is that in two lane highway segments passing maneuver takes place in the opposing lane of traffic, passing maneuvers take place in the opposing lane of traffic.

Because there are only two lanes so upstream one lane, downstream one lane, so if you are driving a vehicle and you want to overtake you have to actually go to the lane which is actually for otherwise for opposing traffic of course, looking at reasonable gaps and available side distance and so and then you will do the maneuver.

Whereas, in all other uninterrupted flow facilities vehicles can overtake without encroaching to other lanes and obviously most of the other facilities are divided, whereas two lane highway undivided facility. Obviously, because of that passing maneuvers how much passing one can do for a given two lane highway segments depends on availability of gaps in the opposing traffic stream because unless there is significant gap you cannot go and occupy that lane to do the overtaking and come back, so the gaps must be available so how much the gaps are available.

And second is what is the adequacy of available side distance why because you need to follow the vehicle in front for some time then you will take out your vehicle, go to the opposing lane, complete the maneuver and then you will again come back to the original lane, so all these side distance for all these operations should be available to you, you should be able to see adequate side distance must be available in front of you. So, it depends on the adequacy of available side distance. If adequate sight distance is not available for overtaking then that will be designated normally as no overtaking zone or no passing zone, so that is what it is.

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Background

- As demand flow and geometric restrictions increase, **opportunities to pass decrease** creating platoons and **causing additional delays** to trailing vehicles
- The relationship between passing demand and passing capacity is complex:
 - ✓ In any given direction, passing demand **increases** as flow **increases**
 - ✓ Passing capacity **decreases** as opposing flow **increases**
 - ✓ Operational quality deteriorates at relatively low flows in comparison with multilane facilities



Next, as demand and geometric restrictions increase, demand is going more and geometric restrictions are increasing, obviously the opportunity to pass will decrease and what that will mean, that will mean the slow moving vehicle in front you have to follow that, so the platoons will get created and platoon will increase and this will cause additional delays to the trailing vehicle which are forced to follow the slow moving vehicle in a platoon, simply because the passing opportunities was not there.

The relationship between passing demand and passing capacity, these two terms are also important and the relationship between these two is actually complex in two lane highway segments. In a given direction if you are considering northbound, then in northbound direction passing demand increases as flow increases, how much vehicle, how many vehicles want to overtake, will that number increase, will increase as the overall traffic volume in that direction will increase, this is quite logical.

The passing capacity, how much opportunity will exist and how much capacity will exist to facilitate this passing opportunity or to facilitate the passing maneuver that will decrease as opposing flow, southbound flow will increase, because if the southbound flow is heavy then you will not get adequate acceptable gaps to occupy that lane which is for the southbound traffic and to do the maneuver and come back to your original lane.

So, remember that passing demand increases as flow increases in the same direction and passing capacity decreases as opposing flow increases, obviously operational quality therefore, deteriorates at relatively low flows when you compare these two lane highway segments, uninterrupted

segments, facility segments with other multilane facilities, such as multilane highways or freeway segments.

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Background

Functions

- Two-lane highways are located in many geographical areas and serve a variety of traffic functions
- **Efficient mobility** is the principal function of major two-lane highways that **connect major trip generators** or serve as **primary links** in state and national highway networks
- ✓ Serve **long-distance** commercial and recreational travelers
- ✓ **Long sections** may pass through **rural areas** without traffic control interruptions



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Let us look at the functions of two lane highway segments, two lane highways are actually located in many geographical areas in any country, any region you go you will find two lane roads, two lane highways, probably the most common among the highways, different cross section of highways if you say the most common would be probably two lane highways.

The other lower order roads could be sometimes single lane, sometimes depending on the country intermediate lane road but among highways you go to any geographical region, the majority of the roads you will find probably two lane roads and this serve this is very important, because subsequent what measures we use for defining the level of service will depend on that, because the function wise a variety of traffic functions they serve, not all two lane highways.

Like if you consider all the multilane highways or all the freeway segments, mobility is the only basic and primary objective, the major focus is only on mobility, but not all two lane roads have the same functions, they serve different regions, everywhere you will go you will find the majority of the highways in most of the countries will have two lane configurations and they serve different functions.

For example, efficient mobility is the principal functions of major two lane highways which are connecting major trip generators or serve as primary link in the state and national highway network,

primary network, part of the primary link in the state and national highway network, because these are the major mobility corridors, long distance corridor, maybe they are still having two lane for some reasons or other but they are the major mobility provider basically.

So, the mobility function is the principal function and most such roads serve long distance commercial and recreational travelers, long distance travelers, so the mobility will be of high priority and long sections may pass through rural areas without traffic control interruptions.

If you go to the rural area not many intersections will come, not so much inflow, outflow will happen from minor roads, there may not be any signalized intersections also, so there are long sections which are uninterrupted sections, primary purpose is mobility and serving the long distance commercial and recreational travelers, it is needless to mention that the mobility function is the primary function for all such two lane roads.

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Background

- ✓ Consistent **high-speed operations** and **infrequent passing delays** are expected for such facilities
- **Accessibility** to remote or sparsely populated areas is the major function of several two-lane highways
- ✓ Provide reliable all-weather **cost-effective access** and often serve low traffic demands
- ✓ High speed, although beneficial, is not the principal objective
- Two-lane roads also serve **scenic and recreational areas**: Vista and environment are to be experienced and enjoyed without traffic interruption or delay



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But is it that only type of two lane roads that are there? No, and obviously as I said that high speed operation and infrequent passing delays are expected for such facilities. Coming to other types of road the accessibility may be the prime or the major functions, accessibility to remote and sparsely populated areas may be the major functions of several two lane highways, not so populated areas, different specially distributed and the connections are maintained, so their main function is ensuring accessibility or connectivity.

So, these are the roads which provide reliable, all weather, cost effective access and often serve low traffic demand, the demand may not be very high, many of these road segments but they are actually providing the accessibility to sparsely located population areas and they are providing also reliable all weather cost effective access. Therefore, high speed although beneficial, people always would require high speed but that is not really the primary functions or primary objective.

Third, two lane roads also serve scenic and recreational areas, in India we may not have so many roads like this, but in many other countries there significant proportions of the overall two lane roads. So, there the vista and environment are to be experienced and enjoyed, that is the basic objective without traffic interruptions or delay, so if the traffic is interrupted and too much delayed, then you cannot really enjoy the vista and environment, so their basic objective is to ensure or to provide, to facilitate people to enjoy the vista and the environment.

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Background

- ✓ High-speed operation is neither expected nor desired
- ✓ Passing delays should be minimized as they significantly distract from the scenic enjoyment of trips
- Two-lane roads may also pass through and **serve small towns and communities**
- ✓ Higher-density development than would normally be expected along a rural highway
- ✓ Speed limits in these areas are often lower and drivers expect to be able to maintain **speeds close to the posted limit**



Obviously, high speed operation is neither expected nor desired here, because people want to enjoy the travel, they want to really see, enjoy the scenic beauty but passing delays should be minimized as they significantly distract from the scenic enjoyment of trips, that we should try to minimize.

So, passing delay need to be minimized, but then high speed operation is neither expected nor desired. There are also two lane roads which may pass through and serve small towns and communities, these are the roads may be part of this so called rural roads but passing through small towns or habitations, there are many, many examples of this kind of segments.

So, there the function is very different because it is serving small town and communities, so higher density development that would normally be expected along a rural highway, that means what I would say that the type of habitations or the land use is something which have high density development that we normally do not expect otherwise along a rural highway because the interruption, site friction should be very less in other places and we do not expect so many habitations, so much development around the roads, but since these are passing through the towns or communities, small communities so there are higher density development than what we normally expect to face along rural highways.

Therefore, these roads often will have speed limits and the speed limits will have lower values considering the safety perspective, because non-motorized vehicles users will be there for pedestrians, bicyclists like that and therefore, drivers generally expected to be able to maintain the speed close to the posted speed limit, posted speed limit often will be lower, so if I am able to drive at the posted speed limit I am happy.

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Background

- ✓ Segments serving such developed areas are usually of limited length, and passing delays are not a significant issue

Classification

- Because of the wide range of functions served by two-lane highways, they can be divided into **3 classes**: Two classes (**Class I and Class II**) include **rural two-lane highways** and another class (**Class III**) includes two-lane highways in **developed areas**
- Most rural **two-lane arterials** and **trunk roads** would be included under Class I highways, while most **two-lane collectors** and **local roads** would be included under Class II or Class III highways



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Background

- ✓ High-speed operation is neither expected nor desired
- ✓ Passing delays should be minimized as they significantly distract from the scenic enjoyment of trips
- Two-lane roads may also pass through and **serve small towns and communities**
- ✓ Higher-density development than would normally be expected along a rural highway
- ✓ Speed limits in these areas are often lower and drivers expect to be able to maintain **speeds close to the posted limit**



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As different types of two lane roads have different functions, therefore it is necessary to classify the two lane highway segments as per their expected functions. As I said because of the wide range of functions served by the two lane highways, two lane highways are actually classified under three classes, two classes include rural highway segments, these are called class one and class two and another class includes two lane highways primarily in developed areas, that means what I said here that some of the two lane road may pass through small towns and communities primarily those segments.

Most of the two lane arterial and trunk route would be included under class one highways, where the mobility is the primary function, while most two lane collector and local streets mixed functions, range is reasonable range and therefore they may be included either under class two or class three.

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Background

Class I Two-Lane Highways

- Motorists expect to travel at relatively high speeds
- Include two-lane highways that function as primary arterials, daily commuter routes, or major links in state or national highway networks
- Serve mostly long-distance trips or connect facilities that serve long-distance trips

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Now, let us look at the classifications in more details so that we can easily identify where what road segment should be included. Coming to first class one two lane highways as I said these are the segments where mobility is the primary requirement. So, motorist expect to travel at relatively high speeds and which are the segments where the speed is of primary importance, these are the sections which functions as primary arterials daily commuter routes, mobility always will be high and major links in state and national highway network.

Major backbone of the national network or the state highway network, maybe they are still two lane roads but they are the mobility corridors in the state or within the country and all such sections class one two lane sections serve long distance trip because long distance trip and mobility are highly related and or connect facilities that serve long distance trip. So, I have clarified that why and which segment should be included and considered under class one two lane highways.

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Background

Class II Two-Lane Highways

- Motorists **do not necessarily expect to travel at high speeds**
- Include segments which (i) act as **access routes to Class I facilities**, (ii) serve as scenic or **recreational routes** (and not as primary arterials), or (iii) **pass through rugged terrain** (where high-speed operation not possible)
- Often **serve relatively short trips**, the beginning or ending portions of longer trips, or trips for which sightseeing play a significant role



Next, going to class two, two lane highways here motorists do not necessarily expect to travel at high speed, mobility is not the primary objective or primary function, so which are the segments, those segments which act as access route to class one facilities, they are not class one facilities, same two lane may be connected to class one facilities but here the function, here we do not expect high speed as motorists.

So, act as access route to class one facilities, serve as scenic or recreational routes, I have already mentioned the speed is not the primary objective and we also do not want high speed on the scenic and recreational route, because people want to enjoy the vista and scenic beauty and obviously these routes are not the primary arterials, generally not because the primary arterials means the mobility will be again very important or these are the routes or segments which are passing through rugged terrains which are not suitable generally for offering high speed.

And often these segments serve relatively short trips, the beginning or ending portion of the longer trips and trips for which sightseeing play in significant role. So, these are the descriptions of class two highway segments, so you can easily identify which are the segments on rural highways that are to be included under class two, two lane highways.

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Background

Class III Two-Lane Highways

- **Serve moderately developed areas:** Include portions of a Class I or Class II highways that pass through **small town or developed recreational areas**
- **Local traffic often mixes** with through traffic on these segments, and the number of unsignalized driveways and cross-streets is noticeably higher than in a purely rural area
- Such segments are often accompanied by **reduced speed limits that reflect the higher activity level**



Third, class three two lane highways, these are the roads or highways or highway segments which serve moderately developed area, as I am saying the road is passing through rural areas but a short stretch is actually passing through small habitations on small towns, so this may include portions of class one or class two highways that pass through small towns or developed recreational areas.

Obviously, in all such sections local traffic often mix with through traffic, there will be local traffic which is the slow moving traffic, they mix with this long distance traffic and the number of unsignalized driveways and cross streets is noticeably higher than in a purely rural area, the way we face it normally we expect to face it in rural areas or rural segments, here the number of unsignalized driver and cross streets will be significantly higher than what we normally expects in purely rural areas.

Such segments often accompanied by reduced speed limits, because they are passing through habitations and populated areas and therefore the speed limit will be lower that reflect higher activity level, pedestrians are there, bicyclists are there and residential areas may be there in the nearby, so speeds are normally low, speed is not the primary objective in any case.

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Capacity and Level of Service

Base Conditions

- Lane widths greater than or equal to 12 ft
- Clear shoulders wider than or equal to 6 ft
- No no-passing zones
- All passenger cars (i.e. no trucks) in the traffic stream
- Level terrain
- Equal volume in both directions
- No impediments to through traffic (ex. traffic signals, turning vehicles)



Now, with this understanding of the functions and classifications of two lane highways let us go to the capacity and level of service for such segments. As you know already for freeway, for multilane highway segments and all uninterrupted facilities we always define a base condition, same is true here also for two lane highway segments all classes.

So, the base conditions are defined based on several attributes, say lane widths equal to greater than 12 feet, clear shoulder width wider than or equal to 6 feet, no passing zone, all are passenger cars in the traffic stream, level terrain, equal volume in both directions and of course, no impediment to through traffic due to external reasons like traffic signals, standing vehicles, etcetera.

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Capacity and Level of Service

Capacity

- A two-lane highway's capacity under base conditions is **1,700 pc/h in one direction**, with a limit of **3,200 pc/h for the total of both directions**.
- Capacity conditions are rarely observed except in short segments: Service quality deteriorates at relatively low demand flow rates, and most segments are upgraded before demand approaches capacity
- Two-way flow rates as high as 3,400 pc/h can be observed for **short segments of tunnels or bridges**: Cannot be expected over extended segments



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Now, a two lane highway capacity under base condition is recommended as per highway capacity manual 2016 is 1700 passenger car per hour in one direction, so obviously this is per lane in one direction, so one direction there is only one lane, so 1700 passenger per hour in one lane which will obviously mean the another maximum cap of 1500 making for the other direction, making the total as 3200 passenger car hour for the total of both directions upstream and downstream.

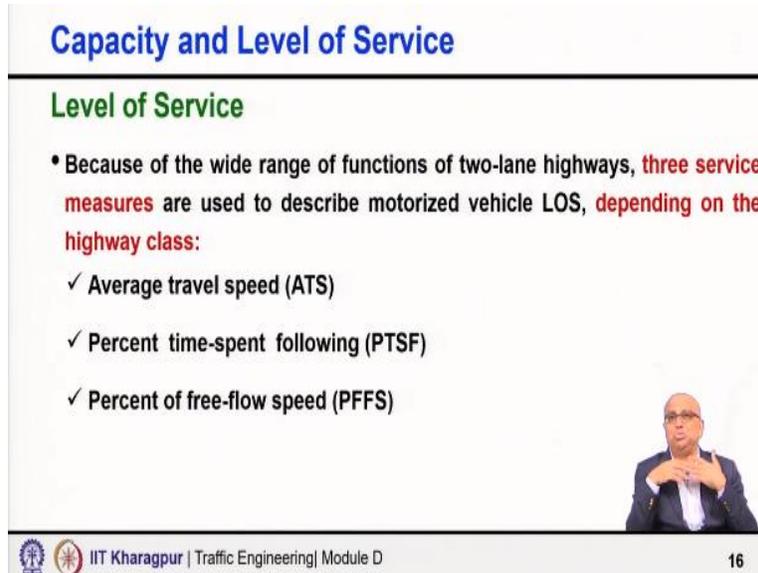
So, two way movements together a two lane road capacity is 3200 passenger car per hour, if you take one direction it could be maximum 1700 but if in one direction it is 1700 the other direction cannot be 1700 get restricted to 1500, this is very important. Capacity conditions we may not be able to observe on all two lane highway segments because service quality as I said the passing opportunities and all other issues are linked.

And therefore the quality deteriorates at relatively low demand flow rate as compared to what you get normally the flow rate per lane in other multilane facilities and therefore most such segments may be upgraded to higher order roads, may be full and dual carriageway or so before the demand approaches capacity, so you may not be able to observe capacity flow on all two lane highway segments.

Now, let me also mention you another important point, although we said that two lane capacity is 3200 passenger car per hour both directions, but for some cases specially for short segments of tunnels and bridges, the cross section is really very different, so there you can get for short segments of tunnels and bridges you may get maximum value of 3400 instead of 3200 but this 3400 passenger

car per hour cannot be expected over extended segments, they could be only for short segments of particularly tunnel and bridges.

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Capacity and Level of Service

Level of Service

- Because of the wide range of functions of two-lane highways, **three service measures** are used to describe motorized vehicle LOS, **depending on the highway class:**
 - ✓ Average travel speed (ATS)
 - ✓ Percent time-spent following (PTSF)
 - ✓ Percent of free-flow speed (PFFS)

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Coming to the level of service, as you know the so many types of two lane roads are there and their functions are also different, not all two lane highway segments are the same function. So, therefore the service measures what we would use also cannot be just one service measure for all types of road. So, three service measures are normally under consideration or considered.

One is average travel speed, another thing percent time spent following, when you are not getting an opportunity to pass you are forced to follow the slow moving vehicle in front of you till you get an opportunity to do the passing maneuver, so how much percentage of time vehicles are spending on following a slow moving vehicle or being a part of the platoon. Third, is percentage percent of free flow speed, not the actual travel speed but whatever is the free flow speed or posted speed limit, what is the percentage of free flow speed.

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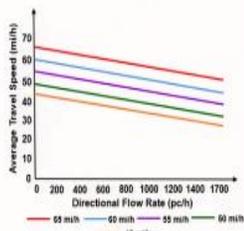
Capacity and Level of Service

Average travel speed (ATS)

- Reflects **mobility** on a two-lane highway
- Estimated using the highway segment length and average travel time for vehicles to traverse it during the analysis period

Percent of free-flow speed (PFFS)

- Represents the **ability of vehicles to travel at or near the posted speed limit** i.e. the **ratio of ATS to FFS**
- The exact relationship between FFS and speed limit **depends heavily on local policies on setting such limits and on enforcement practices**



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Coming to average travel speed reflects obviously the mobility on a two lane highway, speed is important and you can say this average travel speed, how it is coming down depending on different free flow speed, how the lines are expected to happen or the relationship is expected to vary with different flow level and it will obviously since the capacity is 1700 it is up to the 1700 passenger car per hour in one direction.

These are average speeds you can estimate using the highway segment length, what is the length and how much is the average travel time of vehicles to traverse it during this analysis period, so during this analysis period you take the average travel time and you know the length, so you can calculate the average travel speed, so this is one measure.

Second, percentage of free flow speed, it is not the travel time but what is the percentage of free flow speed, so this represents the ability of vehicles to travel at or near the posted speed limit, particularly as I said that you are class three type of road where it is going through, passing through habitations or small towns or populated areas, the posted speed limit often will be there, so what percentage of posted speed limit you are able to achieve.

So, it may be calculated simply using the ratio of average travel speed to free flow speed, so note the absolute value of average travel speed because the speed restrictions could be different in different areas that is what I say the exact relationship between free flow speed and speed limit depends heavily on local policies, on setting up such speed limit and also most importantly the enforcement policies, what is the level of enforcement.

In many countries just putting a posted speed limit, just putting a sign may not really mean much unless there is proper enforcement and that enforcement is actually necessary across all regions and across all countries, very important, maybe it is more important in some countries as compared to other countries but it is important in all cases, so it depends on setting up this speed limit, what is the local policy and also on enforcement practice.

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Capacity and Level of Service

Percent time spent following (PTSF)

- Represents the **freedom to maneuver** and the **comfort and convenience of travel**
- Expressed as the average percentage of time that vehicles must travel in platoons **behind slower vehicles** due to the inability to pass
- Since PTSF is difficult to measure in field, a **surrogate measure** is the percentage of vehicles traveling at **headways less than 3.0s**

Directional Flow Rate (pc/h)	200 pc/h opposing flow	400 pc/h	600 pc/h	800 pc/h	1000 pc/h
0	0	0	0	0	0
200	10	15	20	25	30
400	20	30	35	40	45
600	30	40	45	50	55
800	40	50	55	60	65
1000	50	60	65	70	75
1200	60	70	75	80	85
1400	65	75	80	85	90
1600	70	80	85	90	95
1700	75	85	90	95	100

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Then the other measure which is also important is the percentage time spent following, so it represents the freedom to maneuver and the comfort and convenience of travel because two lane mixed traffic will be there nearly all prevailing situation, so even otherwise also there will be differential speeds, not all the same vehicle, all cars also may not travel at the same speed.

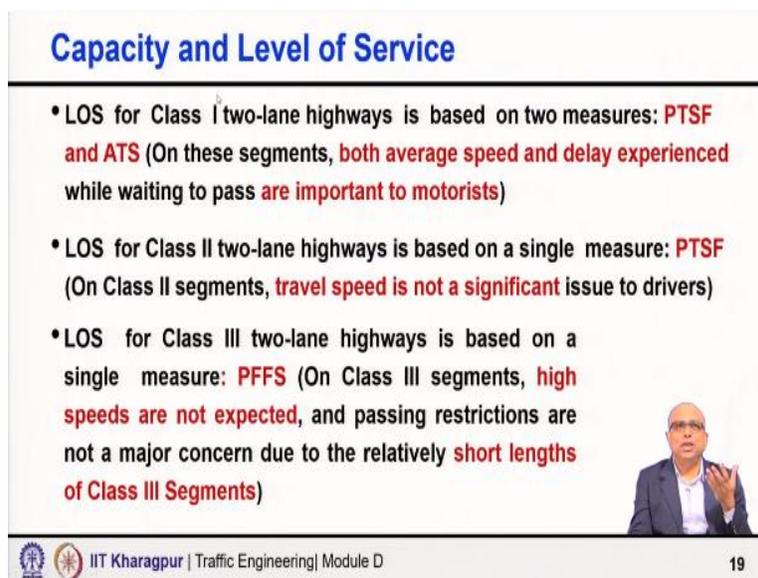
So, there will be requirement for overtaking and this opportunity is very important and this aspect is very important especially on two lane road because the overtaking or passing has to be done by going to the other traffic lane which is for the opposing traffic. So, the opportunity is very, very important and opportunity is quite influenced by the overall traffic volume and many other considerations.

So, it represents the freedom to maneuver and comfort and convenience, also expressed at the percentage average percentage of time that vehicles must travel in platoon behind slower vehicles, why they are travelling, due to inability to pass, passing maneuver that opportunity is not available, so they are forced to travel in a platoon following the slow moving vehicle, so how much percentage

of time, overall time the vehicle must travel in platoons behind a slower vehicle, as they are not able to get an opportunity to pass, that time is the PTSF.

Since, the PTSF is difficult to measure in the field directly so therefore a surrogate measure may be used and that is the percentage of vehicles travelling at a headway less than 3 seconds, so if the headway is less than 3 seconds you can assume that the vehicle is actually following another vehicle closely and which in all possibility will be a slow moving vehicle and therefore the vehicle is actually part of the platoons.

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Capacity and Level of Service

- LOS for Class I two-lane highways is based on two measures: **PTSF and ATS** (On these segments, **both average speed and delay experienced while waiting to pass are important to motorists**)
- LOS for Class II two-lane highways is based on a single measure: **PTSF** (On Class II segments, **travel speed is not a significant issue to drivers**)
- LOS for Class III two-lane highways is based on a single measure: **PFFS** (On Class III segments, **high speeds are not expected, and passing restrictions are not a major concern due to the relatively short lengths of Class III Segments**)

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Now, LOS for class one two lane highways based on the functions, now we know the functions, we know the measures, now which type of, which class of two lane highway should have what measures to get the LOS.

For class one two lane highways, two measures are used PTSF and ATS, average travel speed because mobility is very important and also because mobility is important the average travel speed is very important, now obviously the restrictions are the percentage overtaking, so therefore or passing therefore the PTSF percentage of time spent following vehicle is also very important.

So, on all this segment both average speed and delay experienced while waiting to pass in an queue, these both are important to motorists, so class one roads we use both PTSF and ATS. For class two road it is based on single measure because speed is not so important but percentage time spent following is important, so on this class segments travel speed is not important issues to drivers we

do not use the ATS but we use the PTSF and for class three, basically the urban segments pedestrians, motor, bicyclist the speed limit is very, very important here so there what we are using is PFFS percentage of free flow speed.

So, these segments high speed are not expected and passing restrictions are also not a major concern because the lanes are relatively short length, because this kind of small habitations or small urban areas, urban development or small towns it is passing through, so the length is not really very big, so passing is not an important thing, speed is not an important thing, what is really important is what is the posted speed limit if I am able to travel to that speed limit I am happy, so this PFFS is really the service measure for class three two lane highways.

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Capacity and Level of Service

Table 4.4: Motorized vehicle LOS criteria for two-lane highways

LOS	Class I highway		Class II highways	Class III highways
	ATS (mi/h)	PTSF (%)	PTSF (%)	PFFS (%)
A	>55	≤35	≤40	≤91.7
B	>50-55	>35-50	>40-55	>83.3-91.7
C	>45-50	>50-65	>55-70	>75.0-83.3
D	>40-45	>65-80	>70-85	>66.7-75.0
E	≤40	>80	>85	≤66.7
F	Demand exceeds capacity			

Source: Exhibit 15-3, HCM-2016

• A single definition of operating conditions at each LOS is difficult: Driver expectations and operating characteristics on the three classes are different

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Now, accordingly this highway capacity manual exhibit 15-3 of highway capacity manual 2006 provide this table. So, you know class one highway the ATS and PTSF are the measures service measures, for class two it is only PTSF and class three it is PFFS. So, these are the threshold values given for different levels of service and for different classes of two lane highway segments and obviously in all cases when the demand exceeds capacity, then it is a level of service A.

Now, one small and important issue is that a single definition of operating condition at each LOS is difficult because there are different types of highways, requirements are different, the service methods are different. So, driver's expectation and operating characteristics on all three classes are different.

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Capacity and Level of Service

Two characteristics have a significant impact on actual operations and driver perceptions of service:

- ✓ **Passing capacity:** Since passing maneuvers on two-lane highways are made in the opposing direction of flow, the ability to pass is limited by the opposing flow rate and the distribution of gaps in opposing flow
- ✓ **Passing demand:** As platooning and PTSF increase in a given direction, the demand for passing maneuvers increases. As more drivers are caught in a platoon behind a slow-moving vehicle, they will desire to make more passing manoeuvres

• Both passing capacity and passing demand are related to flow rates



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But two things are very important for all the types of segments, all the classes. One, is the passing capacity, since passing maneuvers on two lane highways are made in the opposing direction of flow, as I have mentioned earlier, therefore the ability to pass is limited by opposing flow rate and also the distribution of gaps in the opposing flow.

Because those are the opportunities depending on the how much is the flow rate, if opposing flow rate is high the passing opportunity will be less, so the passing capacity also will be less and also it depends on what is the distribution of gaps in the opposing flow.

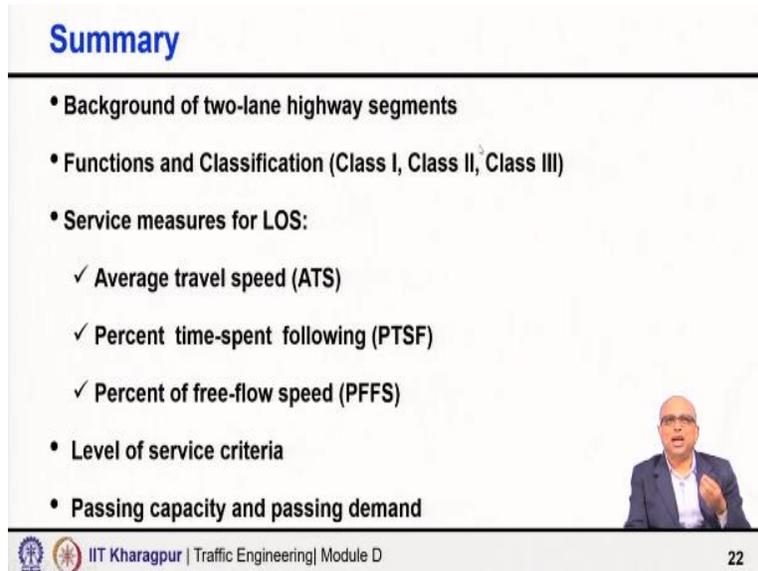
So, that is one thing which is important on all cases and also the passing demand that is the capacity, how much capacity is provided, so that how much capacity, passing capacity will be there that will get influenced by the opposing flow level or what is the opposing flow rate and what is the distribution of gap.

But the passing demand as platooning and PTSF increase in a given direction the demand for passing maneuver will increase and obviously as more drivers are caught in a platoon behind a slow moving vehicles they will desire to make more passing maneuvers, so generally I can say the flow in that same direction, if the flow is more, flow rate is high obviously the passing demand also will be high.

And therefore, both passing capacity and passing demands are actually related to flow rate which is very important and this flow rates passing demand depends on the flow rate in the direction we

are talking about where the vehicles in the direction vehicles are trying to pass the slow moving vehicles and the passing capacity depends on the flow rate of opposing direction, but both passing capacity and passing demands are related to flow rates.

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Summary

- Background of two-lane highway segments
- Functions and Classification (Class I, Class II, Class III)
- Service measures for LOS:
 - ✓ Average travel speed (ATS)
 - ✓ Percent time-spent following (PTSF)
 - ✓ Percent of free-flow speed (PFFS)
- Level of service criteria
- Passing capacity and passing demand

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So, with this we can summarize this lecture we discussed about the background and various characteristics of two lane highways, the functions and basically the classification, class one, class two, class three. We talked about three service measures, average travel speed, percentage time spent following and percentage of spread flow speed.

And then using this thing for all three class of road, three classes of road how the level of service criteria are developed and then we highlighted the role of passing capacity and passing demand in the context of level of service for all classes of two lane highway segments, thank you so much.