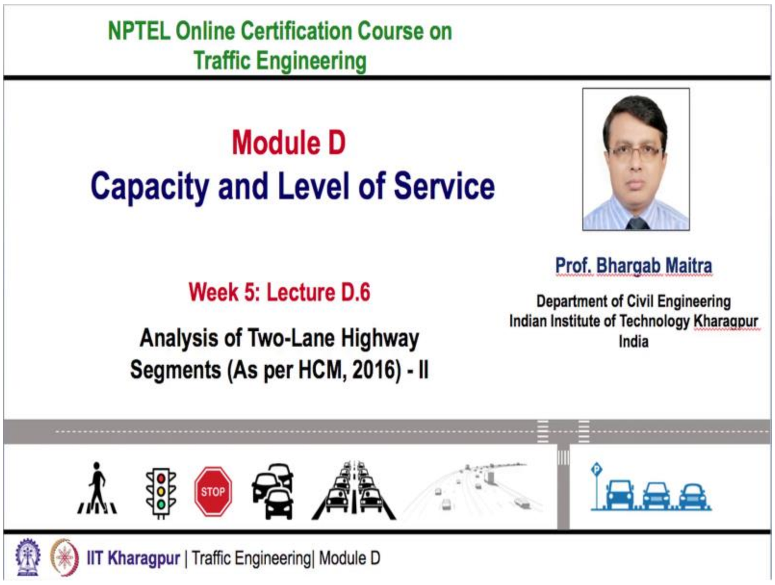
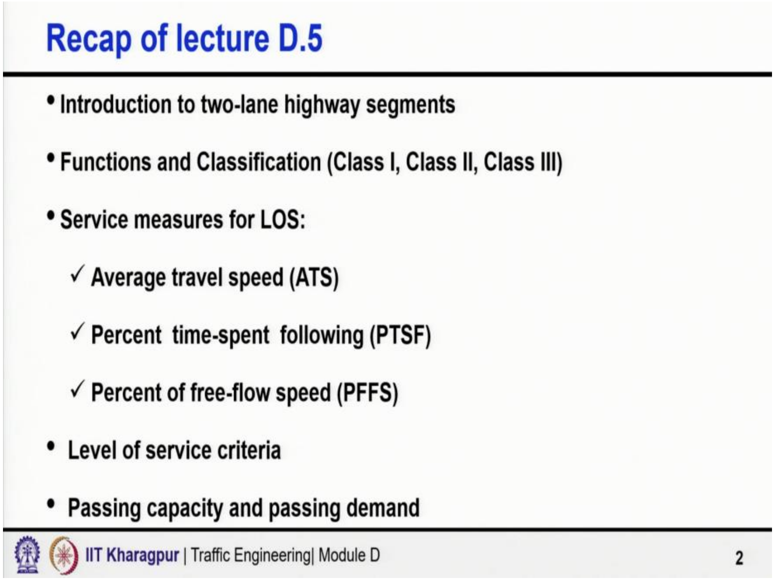
Traffic Engineering
Professor Bhargab Maitra
Department of Civil Engineering
Indian Institute of Technology, Kharagpur
Lecture 21
Analysis of Two-Lane Highway Segments (As per HCM, 2016) - II

(Refer Slide Time: 0:20)



Welcome to Module D, lecture 6. In this lecture also, we shall continue our discussion about analysis of two-lane highway segments as per Highway Capacity Manual 2016.

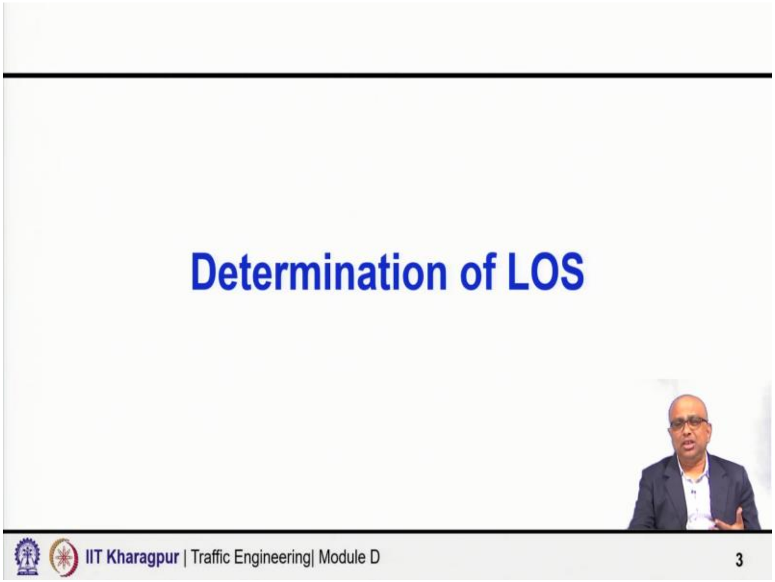
(Refer Slide Time: 0:31)



In lecture 5, I introduced to you about the basic characteristics and uniqueness of two-lane highway segments as compared to other uninterrupted flow facilities for example, multi-lane highways or freeway segments. Then, two-lane highways serve different functions wide range of functions. And therefore, there are 3 types or 3 classifications of two-lane highway segments, class 1, class 2 and class 3.

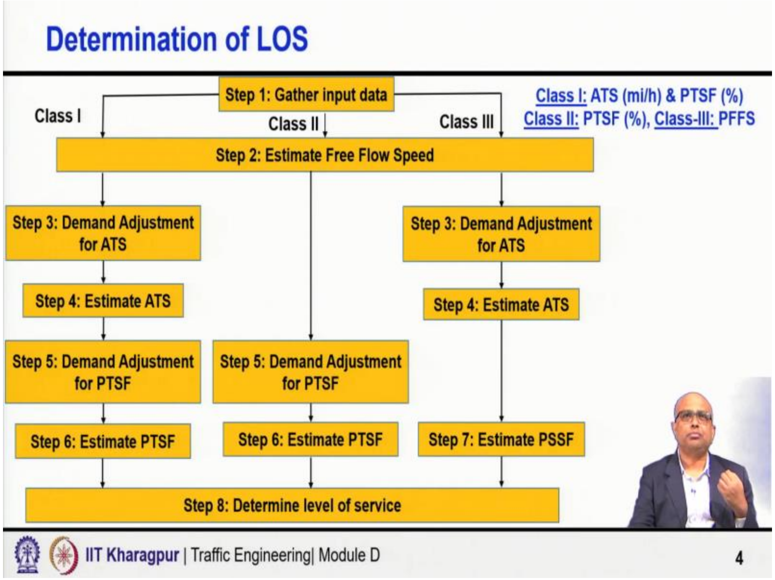
We also discussed about various service methods, which should be used to define the level of service for different classes of road. The 3 service measures which were discussed include average travel speed, percentage time spent following and then percent of free flow speed. Then, the level of service criteria this was discussed and the role of passenger capacity and passenger demand in the context of level of service was highlighted.

(Refer Slide Time: 1:53)



With this background, today, we shall see how we can determine the level of service for different classes of highway particularly two-lane highway segments.

(Refer Slide Time: 2:05)



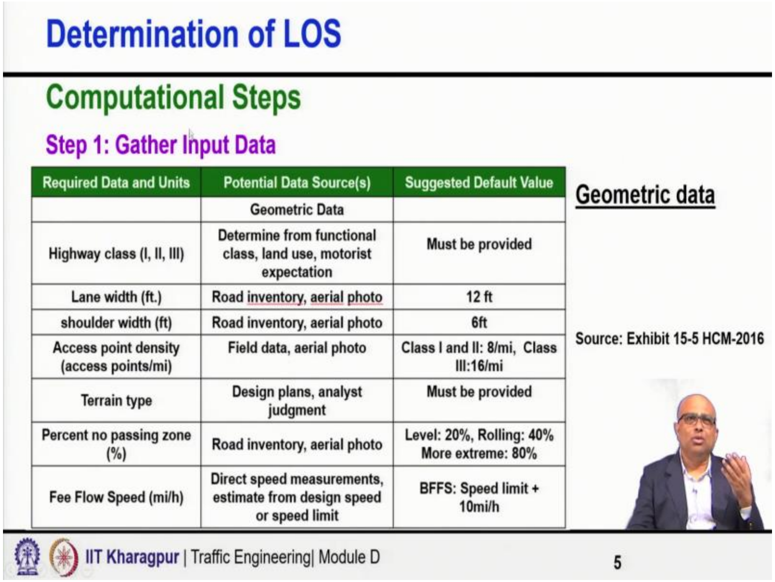
As for class 1 road, the service measures average travel speed in miles per hour and percentage time spent following expressed as a percentage. For class 2 road it is only percentage time spent following and class 3 road which are passing through local cities or towns or urban settlements, there we only use percentage of free flow speed. Now, according to that, the flow chart shows how stepwise we can go ahead to determine the level of service for a given two-lane highway segments.

It starts with step 1, gather input data, then the step 2 is estimate free flow speed. These 2 steps are common for all classes of road then as class 1 road we need to calculate ATS and PTSF. So, what we do, step 3 and 4 are related to ATS and 5 and 6 related to PTSF. In step 3, we adjust the demand by applying necessary corrections with respect to the ATS which are necessary, then estimate the average travel speed. Similarly in step 5, we adjust the demand keeping in mind the objective of doing that is calculation of PTSF. Then estimate the PTSF.

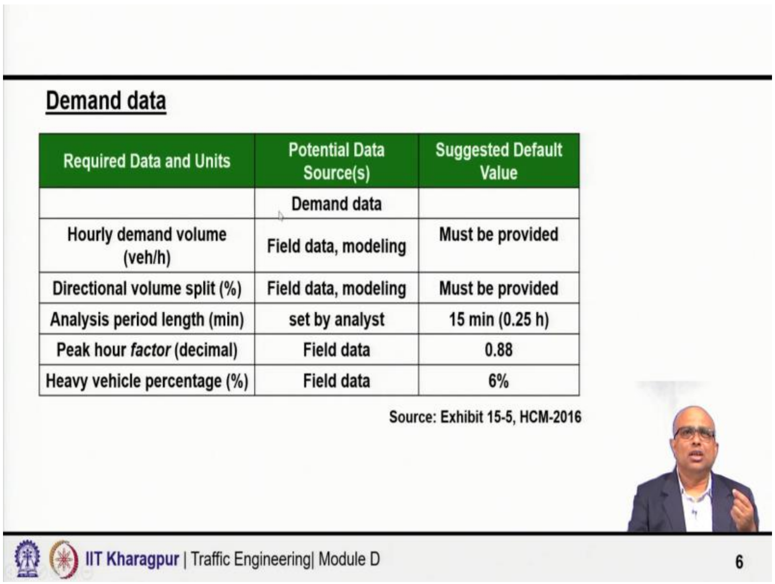
And once the PTSF and ATS are known, then you determine the level of service. For class 2 roads it is only PTSF. So, step 5 and step 6 are only done. And then step 8. Class 3 road, we need ATS because if you want to calculate percentage of free flow speed or PTFS then actually you need to also calculate the average travel speed. So, here step 3 and 4 as we did for class 1 road, 5 and 6 are omitted. But then using the 3 and 4 and with the knowledge of free flow speed, we can calculate the percentage of free flow speed.

And then in all cases, once the measures are known, we know the criteria what measures what value or values and what they will mean in terms of the actual LOS from ATF, so, we can determine the level of service.

(Refer Slide Time: 5:04)



Required Data and Units	Potential Data Source(s)	Suggested Default Value
	Geometric Data	
Highway class (I, II, III)	Determine from functional class, land use, motorist expectation	Must be provided
Lane width (ft.)	Road inventory, aerial photo	12 ft
shoulder width (ft)	Road inventory, aerial photo	6ft
Access point density (access points/mi)	Field data, aerial photo	Class I and II: 8/mi, Class III:16/mi
Terrain type	Design plans, analyst judgment	Must be provided
Percent no passing zone (%)	Road inventory, aerial photo	Level: 20%, Rolling: 40% More extreme: 80%
Fee Flow Speed (mi/h)	Direct speed measurements, estimate from design speed or speed limit	BFFS: Speed limit + 10mi/h



Required Data and Units	Potential Data Source(s)	Suggested Default Value
	Demand data	
Hourly demand volume (veh/h)	Field data, modeling	Must be provided
Directional volume split (%)	Field data, modeling	Must be provided
Analysis period length (min)	set by analyst	15 min (0.25 h)
Peak hour *factor* (decimal)	Field data	0.88
Heavy vehicle percentage (%)	Field data	6%

Now, let us go ahead with the computational steps. So, each step we want to discuss in details as the step 1, we gather in step 1, we gather the input data, mainly 2 types of data we required 1 is the related to geometric data. The second 1 is related to demand data. So, what comes under geometric data? Obviously, the highway class we need to know whether it is class 1, class 2 or plus 3 and this must be provided there cannot be any default value for a that.

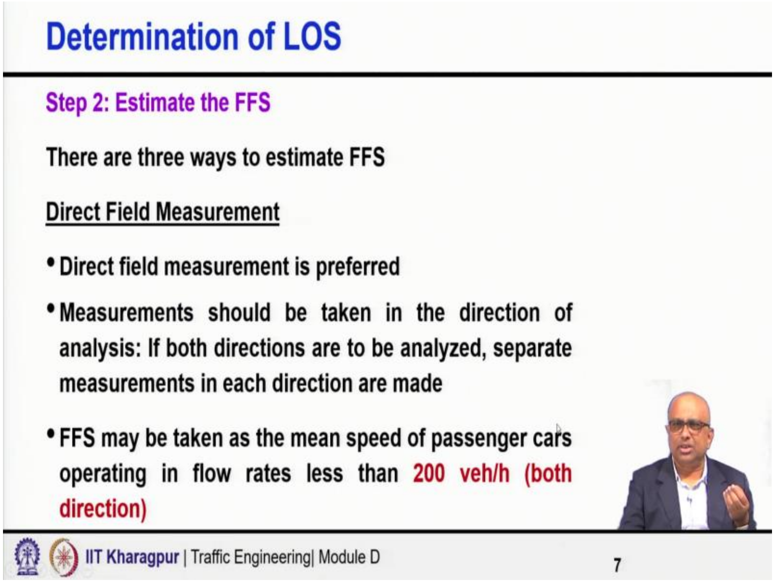
Lane width, we can get it from road inventory or aerial photograph. You may also assume a default value of 12 feet is nothing is given. Shoulder widths, we can actually measure based on road infantry, aerial photo and if you want to assume or if you want to assume you may assume a default value of 6 pit. Access point density again from the field data or aerial photo we can calculate. And if not, default values are given here for class 1 and class 2, 8 per mile and class 3, 16 per mile. Obviously, for class 3, it is higher.

Terrain type, it has to be based on design plan or analyst judgment and it must be provided there cannot be any default values which we can assume in this case, percentage of no passing zone based on the road inventory and aerial photo we can get it if not a default value may be assumed as for level 10 and 20 percent, rolling terrain higher 40 percent and more extremes even 80 percent in extreme situation, very difficult terrain.

Free flow speed it can be from direct measurements or estimated from the design speed or speed limit. And if nothing is known, then BFFS maybe based free flow speed maybe assumed as speed limit plus 10 mile per hour. Going to the demand data, you will need the hourly volume, demand volume this must be obtained from filled data or from modeling or from projection or future forecast and this must be provided.

Directional volume speed again may be assumed or may come from model, may observe from the field. Analysis period normally, it is maybe default values of 15 minute that maybe assumed. So, hourly rates are calculated based on 15 minute count. Peak hour factor normally should come from the field data but if nothing is known you may assume as 0.88. Heavy vehicle percentage also come from the field data and if not in a default value of 6 percent may be issued and these are as per exhibit 15-5 of Highway Capacity Manual 2016.

(Refer Slide Time: 8:15)



The next step or the very next step is basically estimation of free flow speed, there are 3 ways the free flow speed can be obtained. One and the most desirable one is to get from direct field measurement. So, this is the most preferred one, you simply go to the field and directly measure it. Now measurement must be taken in the direction of analysis. So, if you are analyzed trying to analyze the northbound direction, then we must collect the free flow speed in the northbound direction.

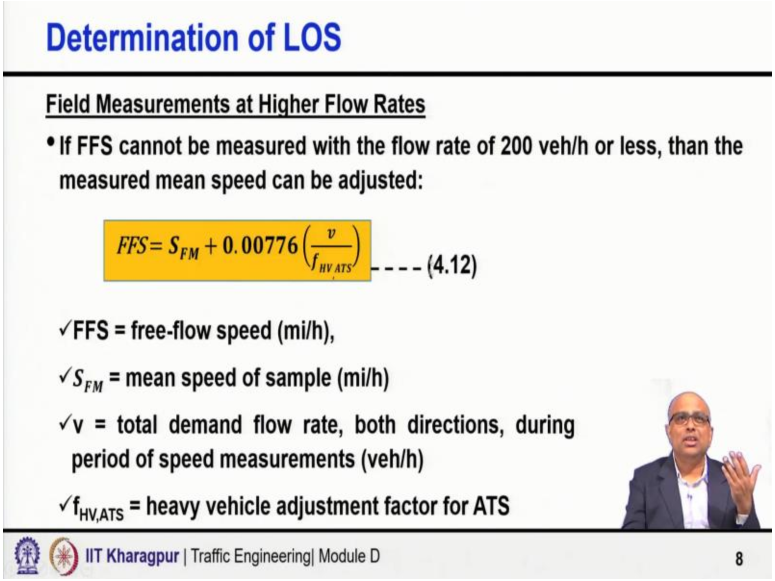
And if both directions are to be analyzed, then we need separate measurements in each directions, because the same free flow speed may not be there for both direction upstream and downstream. And because since we are telling that is free flow speed and that too for two-lane roads, so two-lane roads the speed may not remain same for a long or for a heavy up to heavy vehicle volume, the speed drop happens more early speed drop is expected.

So, we have to really be careful about the flow rate and as set are as prescribed in highway capacity manual 2016. This must be measured with the flow rate less than 200 vehicle per hour considering both directions because these are two-lane roads with the operation or speed get influenced at a early stage at even a lower value of the flow to a flow.

So, 200 vehicle per hour is the cap we must try to measure the free flow speed if we are actually measuring the free flow speed, then it must be done with the flow level less than 200 vehicle per hour both directions. Now, the second alternative method is, again a field measurement. But suppose for some roads see we are not getting this range of flow, we are not able to observe because the traffic demand because a variety of purposes and functions, the two-lane highway segments they serve.

So, there could be some two-lane highway which are really busy and you may not be able to observe a flow level and go and measure the speed with the flow level less than 200 vehicle per hour.

(Refer Slide Time: 10:45)

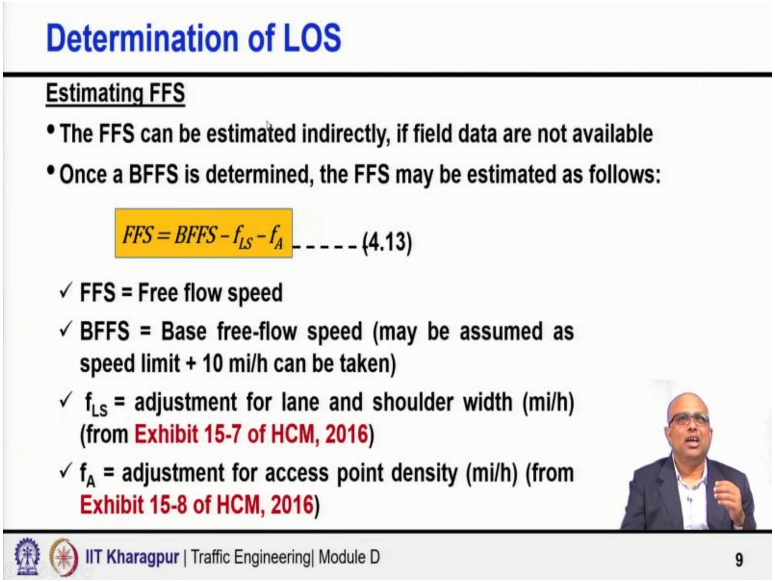


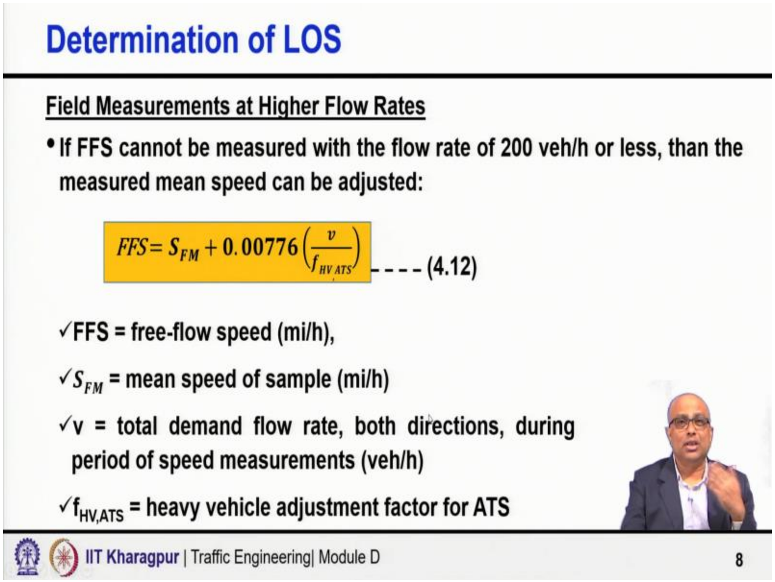
So, in that case, the actual field measurements is done at higher flow rates, what we do and then how we can use it, we can still use that measured speed and estimate the free flow speed by applying necessary corrections. So, that is what is shown here in this equation. If the FFS cannot be measured at a flow rate of within 200 vehicles per hour, then the measure speed need to be adjusted using this equation.

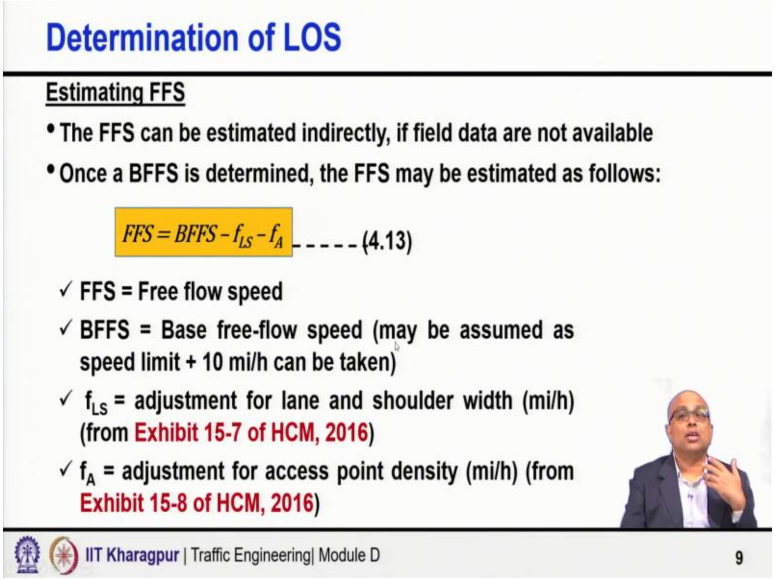
As you can see here, whatever we are getting FSM is the mean speed of the sample whatever you have collected, and then we are applying some correction and obviously, it has to be with positive sign because they officially will be higher in that case than what we have measured in the field at higher flow level.

So, this correction is applied 0.00776 into v by $f_{HV\ ATS}$. So, v is the 2 way traffic volume. And FH_{ATS} is basically the corrections in that volume for heavy vehicle and this will be done as the corrections I shall explain you in the subsequent slide for the calculation of average travel speed the same correction will be applied here.

(Refer Slide Time: 12:11)







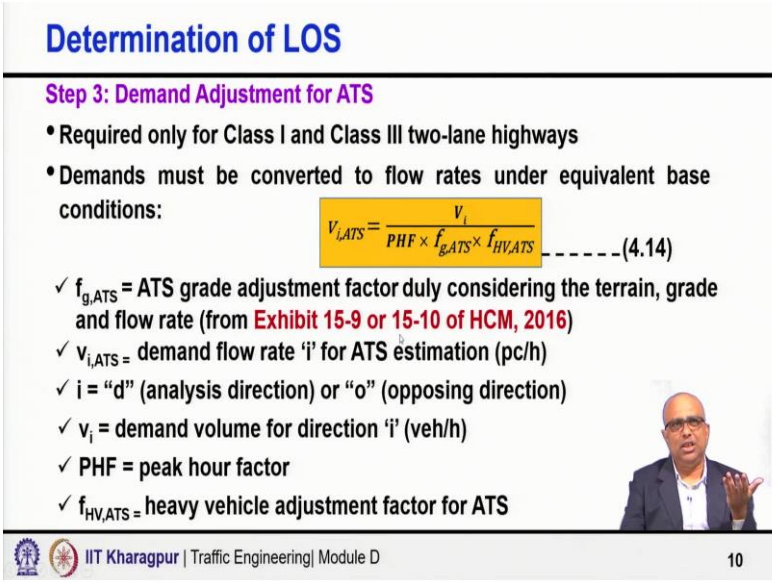
Then the third method, you can directly estimate FFS if you were unable to measure it neither up to 200 vehicle per hour or even higher than that. So, you will not be able to measure it in the field. In that case, this can be estimated, how that is shown here in equation 4.13. So, you take the base free flow speed and apply 2 corrections here, 1 with respect to lane and shoulder width. And what would be the correction based on lane and shoulder width that values are given in exhibit 15-7, Highway Capacity Manual, 2016.

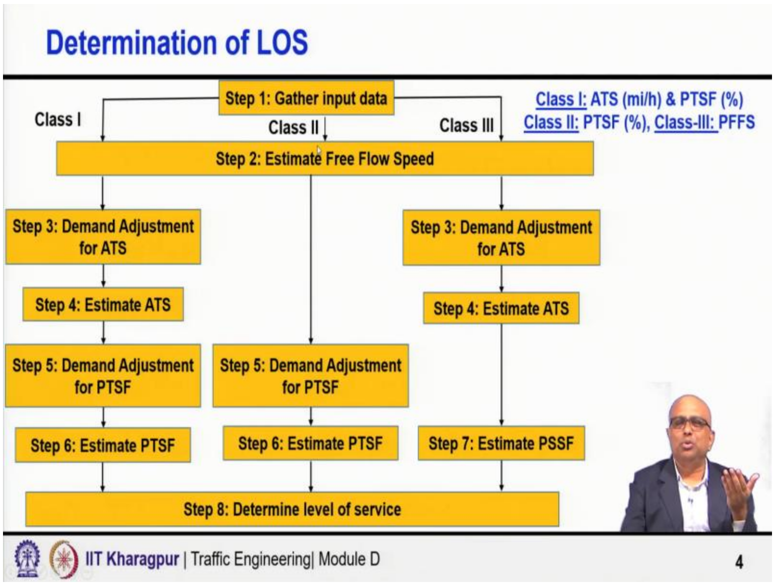
And the second correction relates to access point density, how many access points are there average on an average per mile and necessary adjustment in mile per hour speed BFFS to be reduced to account for the prevailing condition and how much the speed to be reduced you can take it from exhibit 15-8 of HCM, 2016.

Now coming to the BFFS, BFFS, if you do not know, but if we know suppose the speed limit, then it may be assumed I have mentioned it earlier also that it is the speed limit plus 10 mile per hour that value may be taken as BFFS and BFFS minus some speed reduction due to lane and shoulder width correction minus further speed reduction because of the access point density.

So, these are the 3 ways you can actually, estimate the FFS either direct measurement of FFS or measurement of speed, but at a high flow rate, then apply necessary correction or you can completely estimate it without any field measurements.

(Refer Slide Time: 14:12)





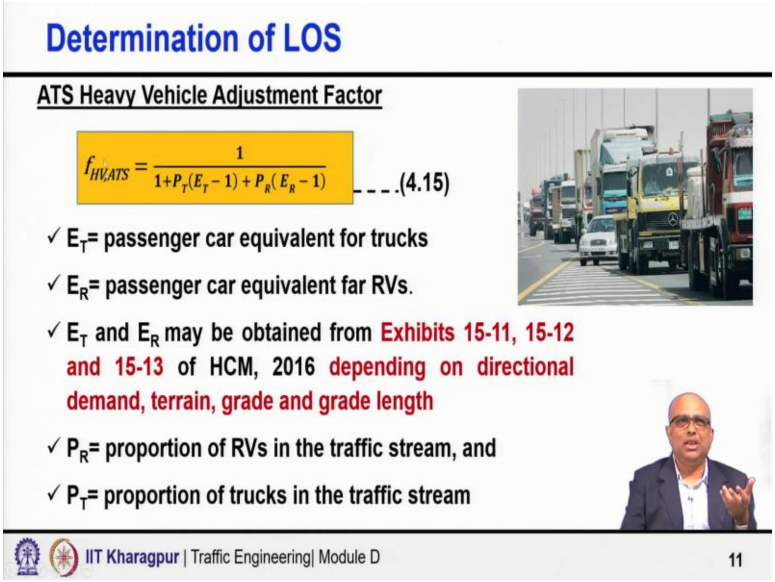
Then the step 3, relates to demand adjustment for ATS, if I can go back quickly to the master flowchart, so 1 and 2 are common for now. For class 1 and class 3, we need to calculate ATS. So, how to do the adjustment the demand for ATS and then how the how to estimate the ATS step 3 and 4. So, step 3, it relates to demand adjustment for it is and as I said, we require it only for class 1 and class 2 for class 1 and class 3, class 2 we do not require it. So, demand must be converted to flow rates under equivalent base conditions.

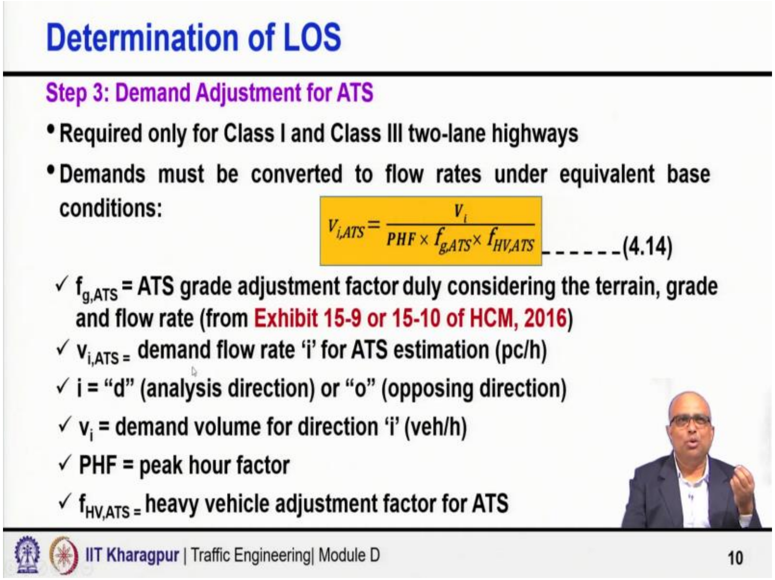
So, what are the corrections we need to apply? One is the peak hour factor to account for the big 15 minute flow rate, if the overall hourly demand is there as Vi. Then apply application of correction factor with respect to the FGATS that means, adjustment factor dually considering the terrain grade and flow rate, it is primarily the grade adjustment factor, but we also considered the flow rate and also considered the type of terrain and these corrections may be done as for exhibit 15-9 or 15-10 High Capacity Manual and then 1 more adjustment factor is to consider the effect of heavy vehicle.

Now, this heavy vehicle adjustment factor and remember that I have written it heavy vehicle can adjustment factor for ATS. Demand Flow Rate, this is the adjustment for ATS estimation, because PTTS estimation also for PTTS estimation, similar corrections need to be done, the formula maybe looks very similar, but actually the values are very different. At least sometimes, they are different. So, that is why it is written.

So, similar heavy vehicle adjustment may be done for PTTS and that we will write as F HV PTTS and when we are doing the similar adjustment for ATS, we will write F HV ATS.

(Refer Slide Time: 16:30)



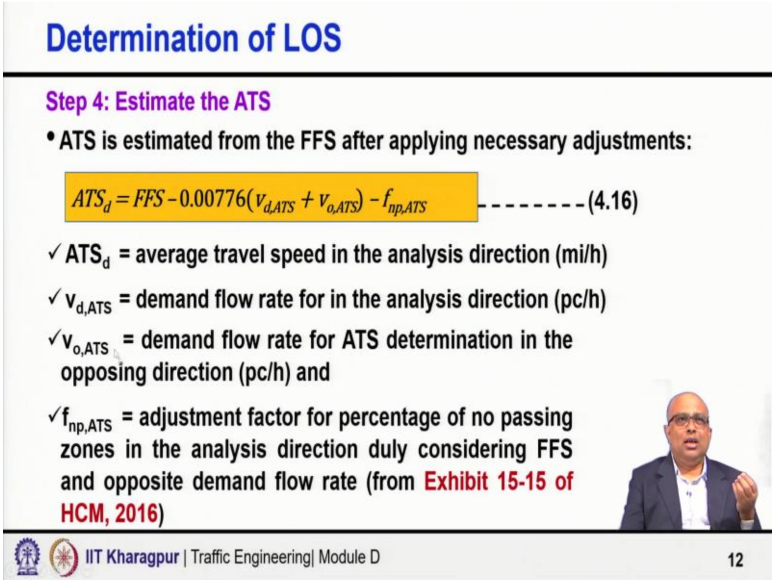


Now to do the F HV ATS, this is the equation you are familiar with this equation that we need to consider the passenger car equivalency and here 2 types of vehicles are considered, recreational vehicle and the trucks or the heavy commercial vehicles. Now wherefrom you will get the value of ET and PR that is the passenger car equivalency that the or passenger car unit or passenger car equivalency PCE or PCU value that to be obtained.

We can get it from exhibit 15-11 or 15-12 and 15-13 or 15-13 as the case may be depending on the context and we may have to also calculate or get the value using directional demand terrain, grade length all these factors may have to be considered depending on which exhibit is actually applicable and from what which exhibit we are actually taking them.

And then PR and PT are the proportion. So, you calculate get this PR and PT values proportions are known. So, you calculate this F HV ATS, once you calculate the F HV ATS and the FG ATS, the grid correction factors of course considering the terrain and flow rate as well and the peak hour factor is known then you can convert this volume Vi what you are given as input to an equivalent flow rate under basic conditions.

(Refer Slide Time: 18:10)



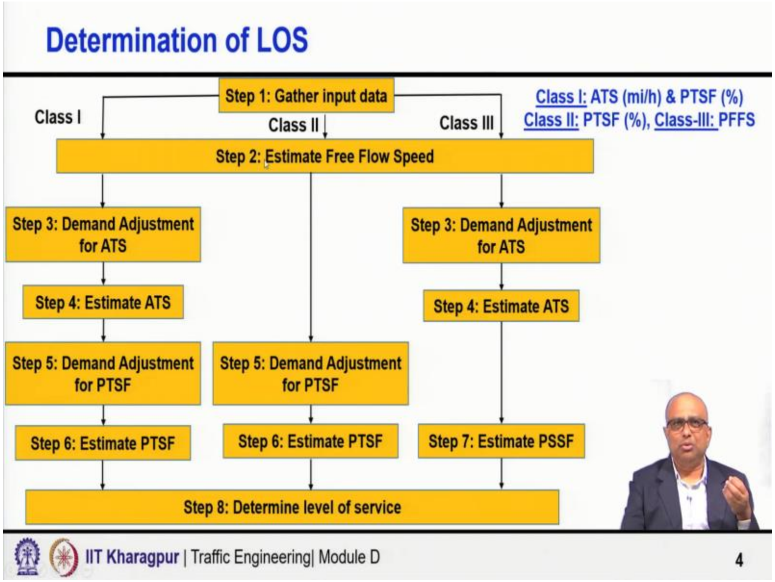
Then, estimate of we can do the estimation of average travel speed using this equation for 16 as given here, what are the corrections we need to apply, one is with respect to the volume. So, obviously FFS minus some constant or coefficient into volume. Now this since it is a two-lane highway, so that 2 way volume are to be taken.

So, we are considering the demand flow rate in the analysis direction that is indicated as this Vd ATS and also the opposite direction Vo ATS. Now, wherever in other cases this is for ATS calculation of ATS. So, everywhere these ATS is also mentioned. Not only Vd or Vo, but Vd ATS and Vo ATS.

So, this is the volume related correction and then another average travel speed will get impacted by the percentage of no passing zone that is very important for to lengthen. So, this is the F np ATS is the adjustment factor and the values will be LOS mile per hour because FFS minus this minus this. So, all these reductions are in miles per hour.

So, depending on the percentage of no passing zone, but here considering the FFS and also opposite Demand Flow Rate, opposite Demand Flow Rate matters a lot for the to get the number of no passing zone. So, these are to be obtained from exhibit 15-15 of HCM, Highway Capacity Manual.

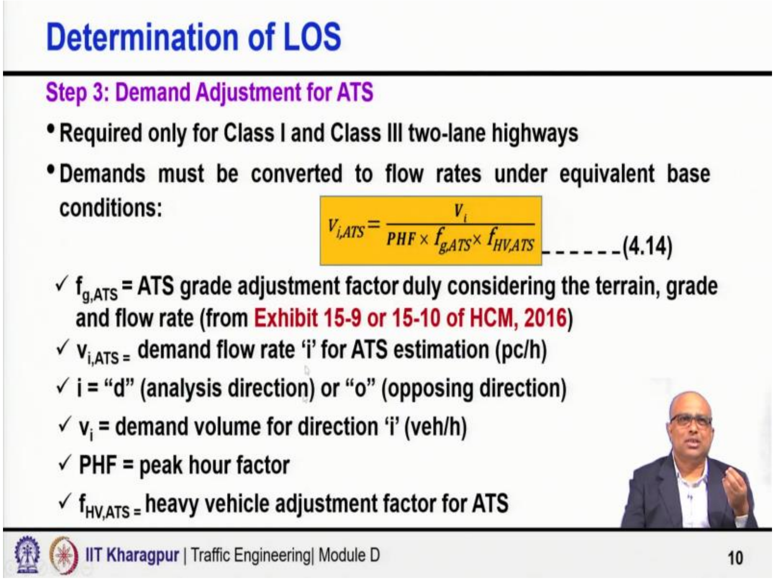
(Refer Slide Time: 20:00)

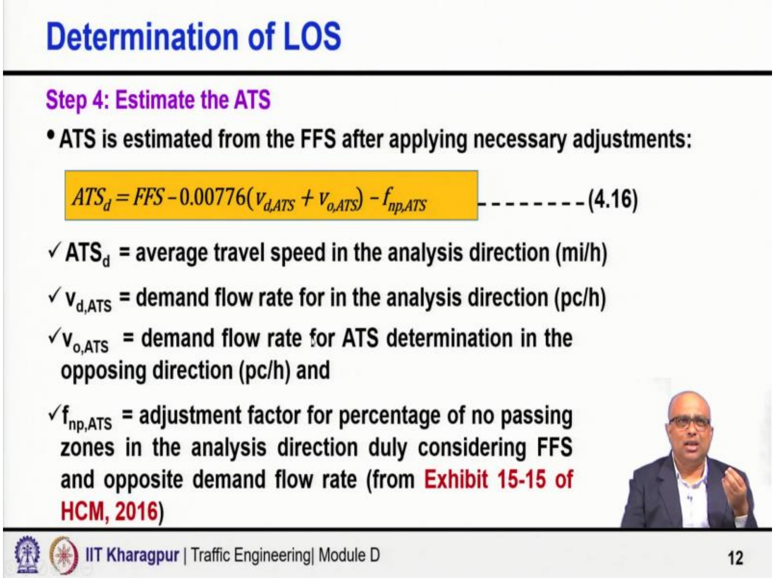


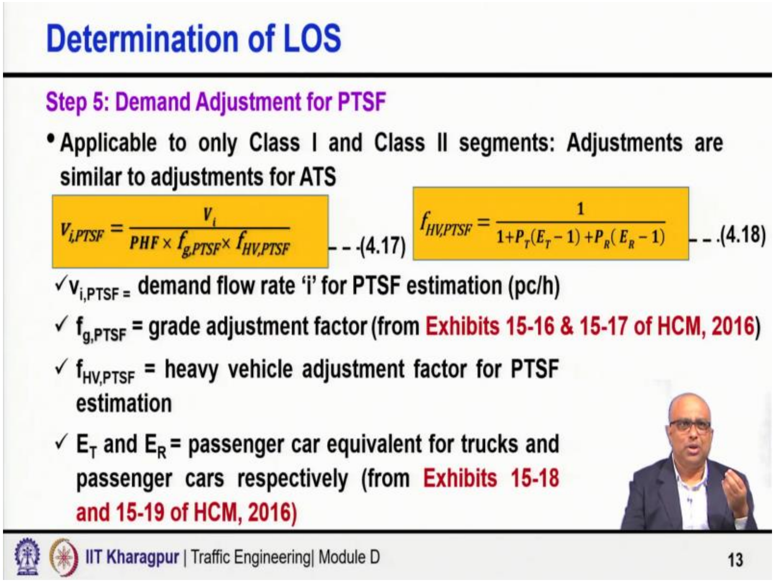
Now, that is 3 and 4. So, I if I go to the flowchart again. So, we have talked about step 3 and step 4, which is required for class 1 and class 3, highway two-lane highway segment. Now, we shall see how we can calculate PTSF percentage of time spent following and these are step 5 and step 6, and these are applicable for class 1 and class 2 road not required for class 3. So, here also again the demand adjustment has to be done following nearly similar procedure what we have described for the ATS calculation, but the correction factors will be different.

Because the objective is different where we are trying to calculate the PTSF, and they are trying to calculate ATS. So, the way the heavy vehicles, grades and everything impact the ATS and the way they impact the PTSF exactly, it is not same, even the equivalency for the trucks and recreational vehicles are also not same.

(Refer Slide Time: 21:13)





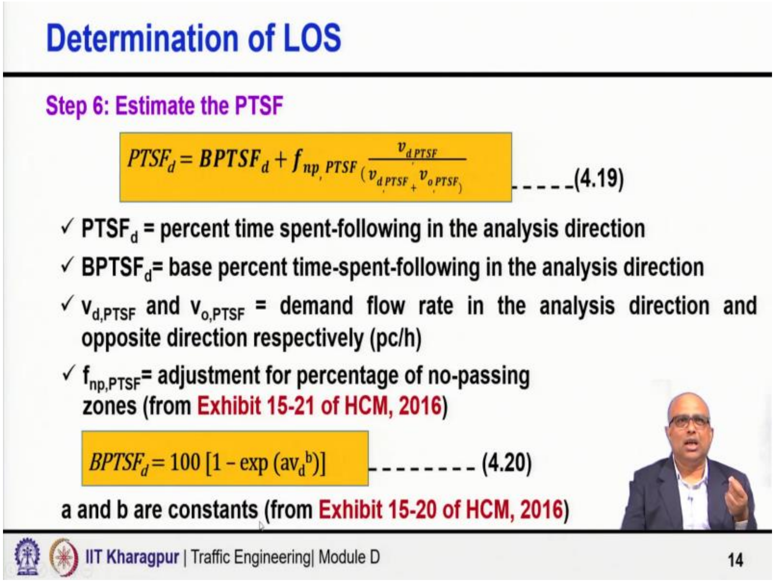


So, let us go back there and see how we can calculate it. So, that is the step 3, demand adjustment and step 4, we have done. Step 5 is demand adjustment for PTSF, as I said, it is only done for class 1 and class 2 segments and the formulas look very similar only here as you say Fg PTSF earlier case when we did it for ATS, it was Fg ATS that means the grade correction for the calculation of ATS.

Now the grade correction for calculation of PTSF. Similarly F HV PTSF, earlier case it was F HV ATS that mean that was for what is the effect of heavy vehicle how we considered that effect, when we are trying to calculate the average travel speed. Now same effect we have to consider, but the corrections values and everything, even the passenger car equivalency values also are not going to be same.

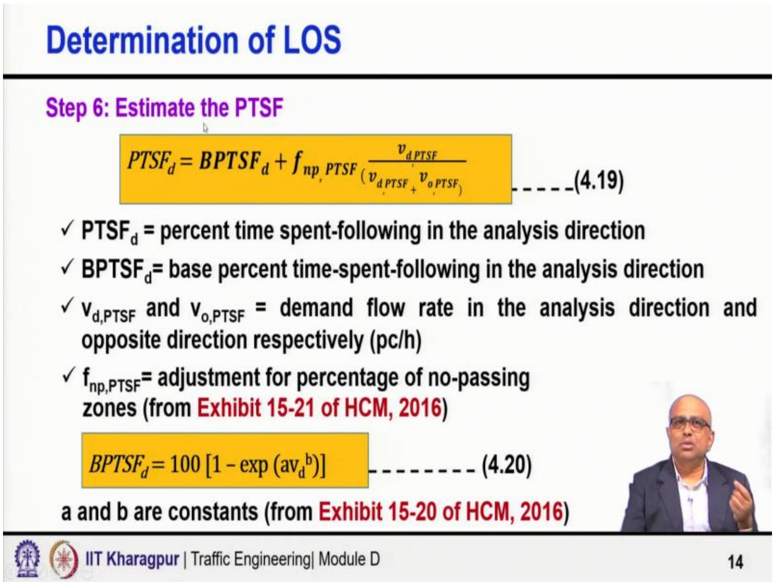
So, this correction actual value will be different. That is why it is called F HV PTSF. So, here also you can see the PHF peak hour factor directly you can get and F HV PTSF is the heavy vehicle adjustment factor for that we again use this equation 4, 18, here value this has to be used and PT PR proportion of truck and proportion of recreational vehicle to be used. And this PT PR you can calculate it from get it from directly from exhibit 15-18 or 15-19.

(Refer Slide Time: 22:54)



Considering other things and this Fg the grade adjustment factor that may be obtained from exhibit 15-16 or 15-17 which case is matching accordingly we will pick up that table.

(Refer Slide Time: 23:10)

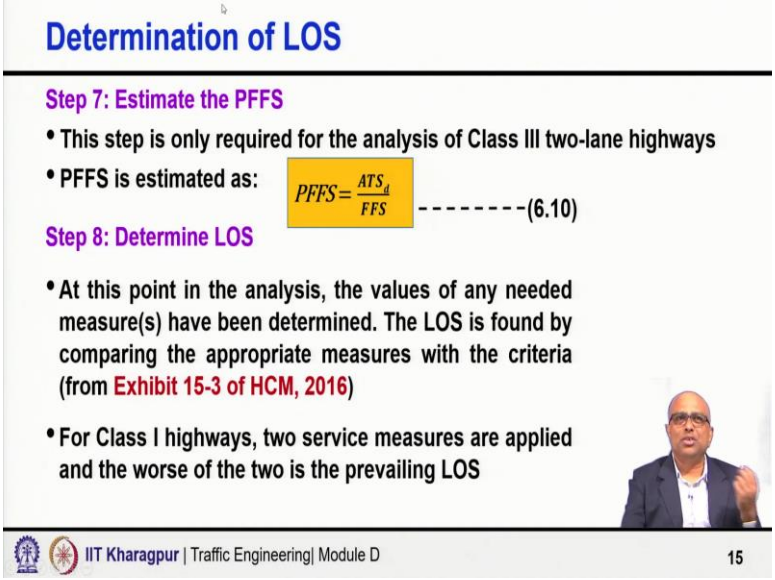


Now, estimation of PTSF, PTSF we are estimating, what will be the percentage time spent following it is what is the base percentage of time spent following there is a base value by default that has to be there plus there will be additional percentage time spent following. How this additional value can be calculated? It may be calculated depending on what is the percentage of no passing zone applying the necessary correction factor and considering the volumes. So, that is what is done here.

So, BPTSF d is the base percentage times spent following and the d indicates analysis direction and O indicates the opposite direction. And FNP as I said, PTSF is their adjustment factor for no passing zone, this can be taken from exhibit 15-21 and how we can get the base percentage of time spent following use this equation 4, 20. And where again you can see there are 2 coefficients, d is the direction of analysis.

So, a and b are that actual coefficient, Vd values can be calculated given the value of Vi. So, this is the 4, 20 is the equation that can be used here to calculate this base percentage time spent following. Now a and b are the constant, these values again maybe taken. So, exhibit 15-20 is there and you can get the value of a and b depending on the context.

(Refer Slide Time: 24:58)

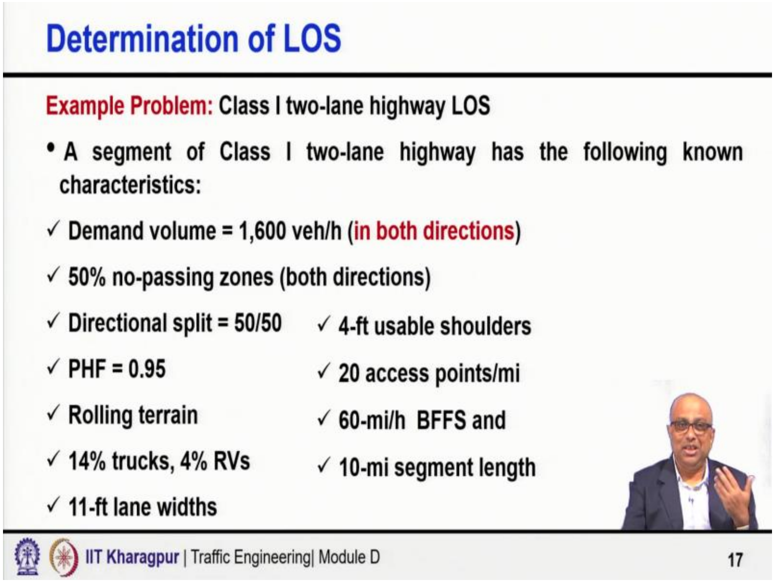


Now once you have done that, then you can calculate then PFFS also which is required for class 3 road and this is for class 3 highway because they are we use service method as PFFS. So, average travel speed is known divided by free flow speed. Now, in at this point step 8, all the service visits as relevant for the class of road, particular class of road, you have calculated measures or measures as the case may be class 1, 2 measures, other case 1, 1.

You have calculated, now, the threshold values are given, what value of service was there means, what LOS, so accordingly you can calculate this. One small confusion could be there that for class 1 highways there are 2 service methods. So, you may 1 service measure may indicate 1 LOS and the service may or may indicate another LOS. So, what value we will take and there we are saying the worse of the 2 is the prevailing LOS.

So, in 1 case if you are getting c, another case if you are getting d then you will assume the overall LOS will interpret it as d.

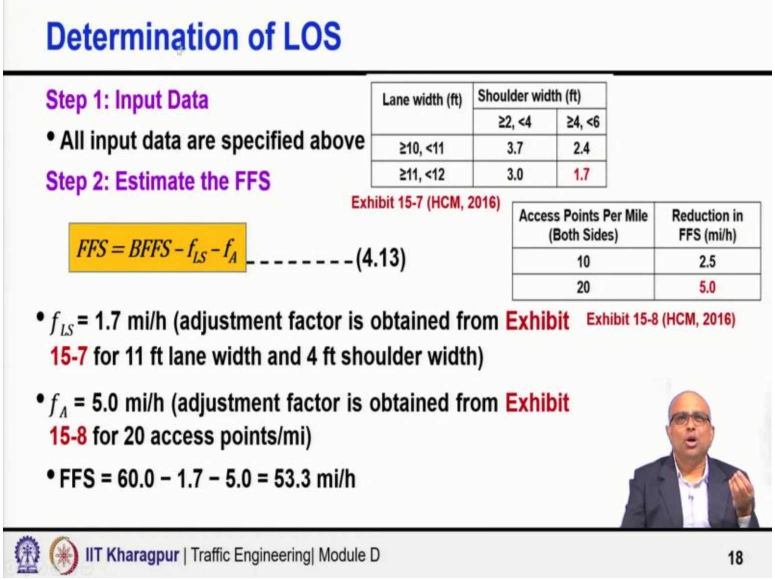
(Refer Slide Time: 26:14)

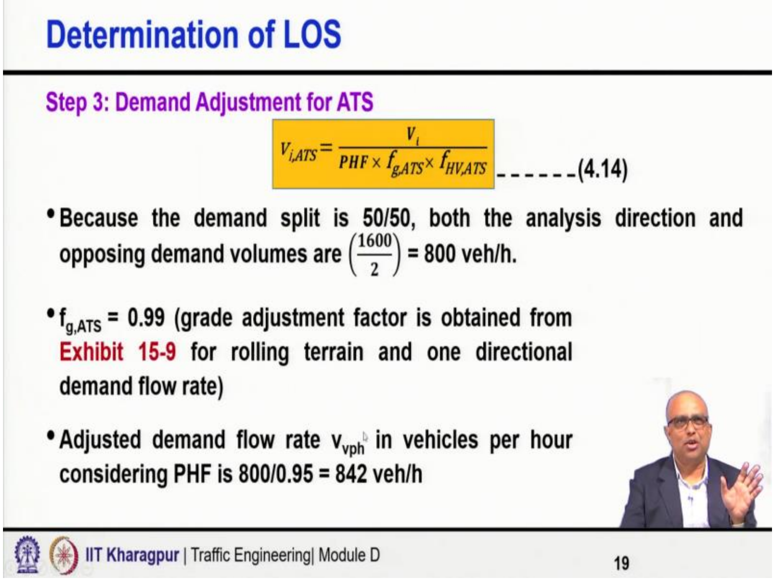


Now, let us take a small example to see how we can calculate it. This is an example of class 1, two-lane highways segment and every input is given demand volume is given in both directions with a 50-50 split. So, equal upstream and downstream. 50 percent no passing zone PHF value is given it said that is in rolling terrain that will be useful, the trucks and recreational vehicle percentage is given, 11 feet lane width, 4 feet usable shoulders.

So, lane and shoulder width are given, access point density is given, 20 access point per mile, what is the BFFS value, what is the base free flow speed value that is also given and it is a 10 mile segment length.

(Refer Slide Time: 27:08)

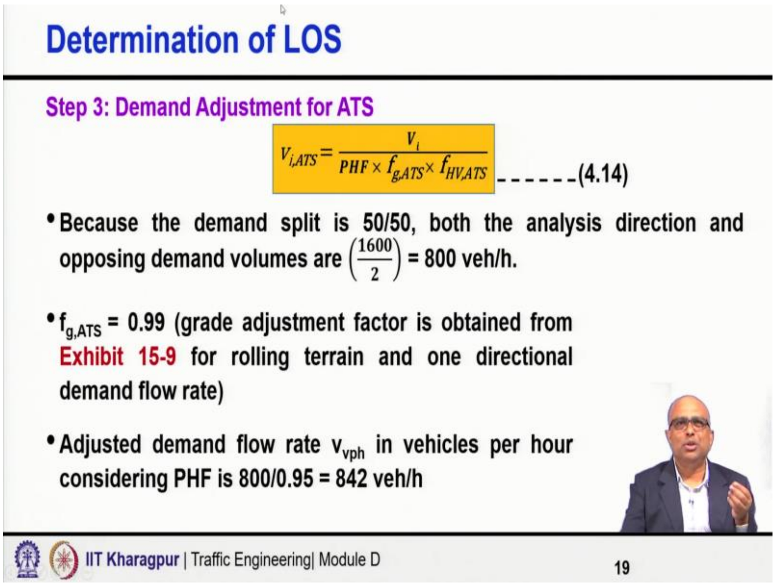


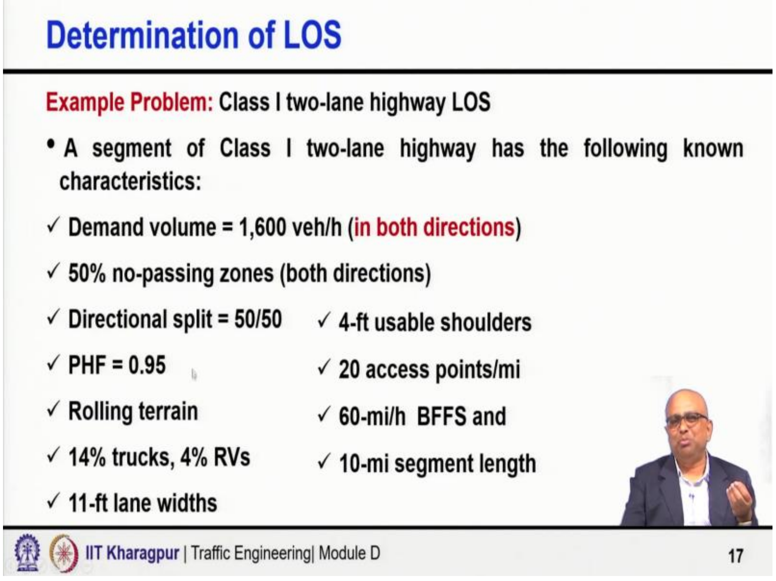


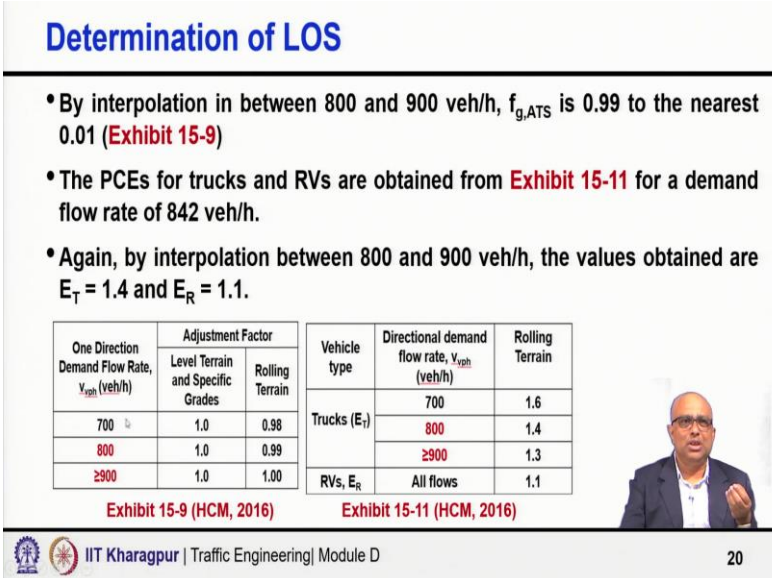
So, all input that are given, first is to estimate the BFFS straightway we are using equation 4, 13. Now, this BFFS value is 16, what we need to calculate FLS, we straightway go to exhibit 15-7 and we know the lane width and shoulder width. So, lane width is 11 feet, 4 feet is the shoulder width. So, we know that the speed reduction has to be 1.7. So, we get that 1.7.

Access point density we know 20 access point per mile. So, again go to exhibit 15-18 accordingly, and with 20 access points, we know that reduction is 5 mile per hour. So, we get that value. And once you have taken the value from exhibit 7 and 8, then we can calculate FFS equal to BFFS 60 minus 1.7 minus 5. So, you get it as 53.3 miles per hour, step 1 is to is done.

(Refer Slide Time: 28:08)





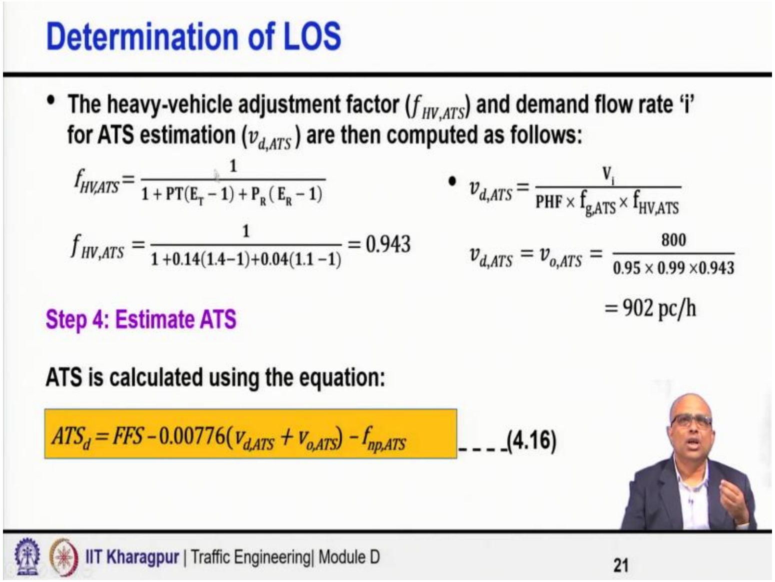


Then we go to step 3, equation 4.14, I have reproduced, but here the demand is 50-50 split and overall to a demand is 1600. So, 800 vehicles per direction and using exhibit 59 for rolling terrain and 1 direction and demand flow rate, what demand flow rate this is not 800. This demand flow rate is considering the peak hour factor.

So, we know that 0.95 is the peak hour factor if you go there, you see these peak hour factor is 0.95. So, considering the peak hour factor is 0.95, what is the equivalent vehicle volume per hour is 842. So, in exhibit 59, we need to give this value 842 not 800. So, 59 we give 842, we know for 800 it is and rolling terrain it is given 0.9 time and 0.01, so we rounded off to the nearest 0.1 and take a value of 0.99 only which is given here.

Now the other correction is the heavy vehicle adjustment factor. So, for that one, we know the flow is 842 and we go to exhibit 11. So, we take the passenger car equivalency value say for recreational vehicle rolling terrain, it is LOS 1 point a all flows 1.1 but for truck 801.4, 900 and number 1.3. So, our values are 842. So, we get the value as 1.4. Again, nearest 0.1.

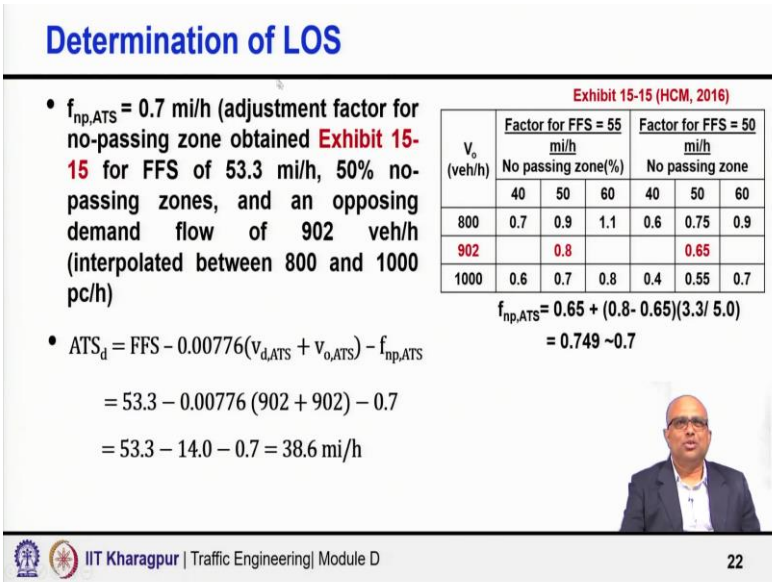
(Refer Slide Time: 29:57)



So, now we use this formula to get the F HV for ATS calculation put the values calculated as 0.943. And then we can get the volume adjustment in the direction of flow and also in the other direction H cases it is 800 divided by PHF 0.95, Fg 8 is graded adjustment factor is 0.99 and heavy vehicle adjustment factor we have just calculated 0.943.

So, you get 902 issue pc per hour. So, now we can calculate ATS for calculation of calculation of ATS, that we use equation 4.16. So, what we need to calculate here, Vd ATS and Vo ATS these are known 902, what we need to calculate is basically Fnp ATS.

(Refer Slide Time: 31:01)

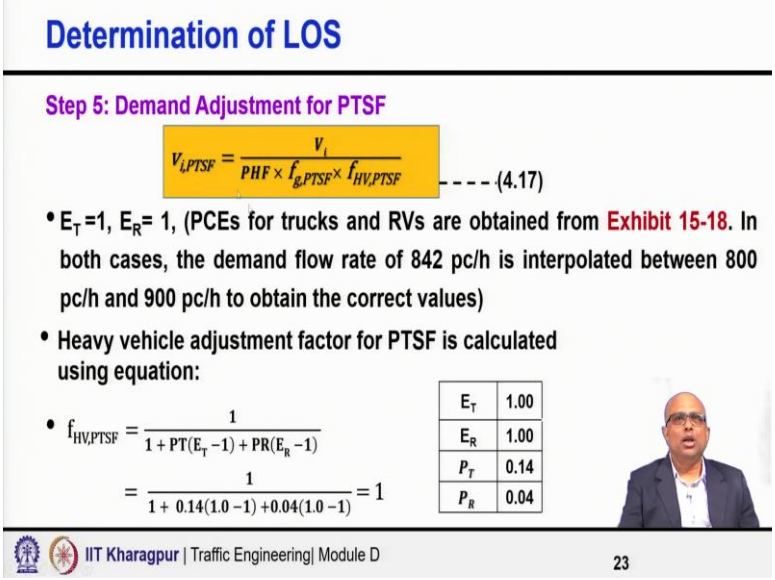


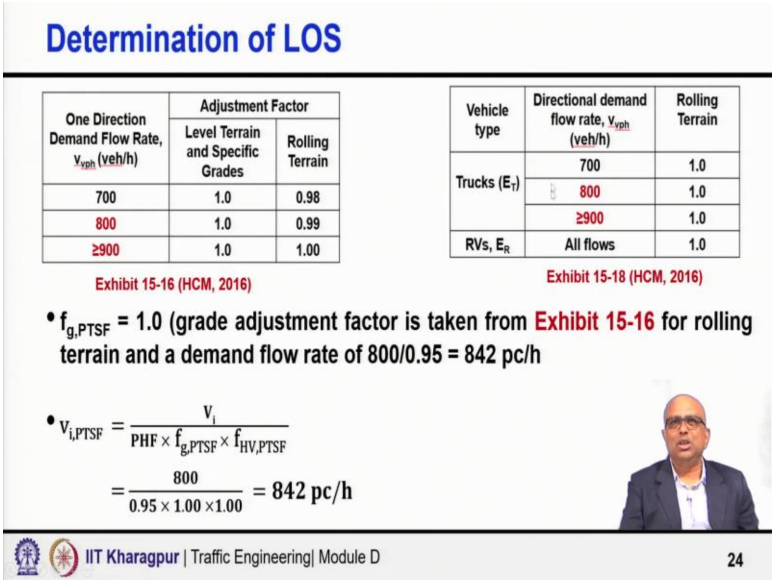
So, no passing zone. So, for no passing zone adjustment factor, we use exhibit 15-15 as I have shown here, and we know that FFS is 53 mile and we have 50 percent no passing zone, so there are one column which is for 55, one for 50. So, you have to take 2 hellos for 2 speed FFS value and then get it interpolated to get the value of for FFS 53.3. Similarly, no passing Zone 50 percent. But here we can get no passing zone 50 percent.

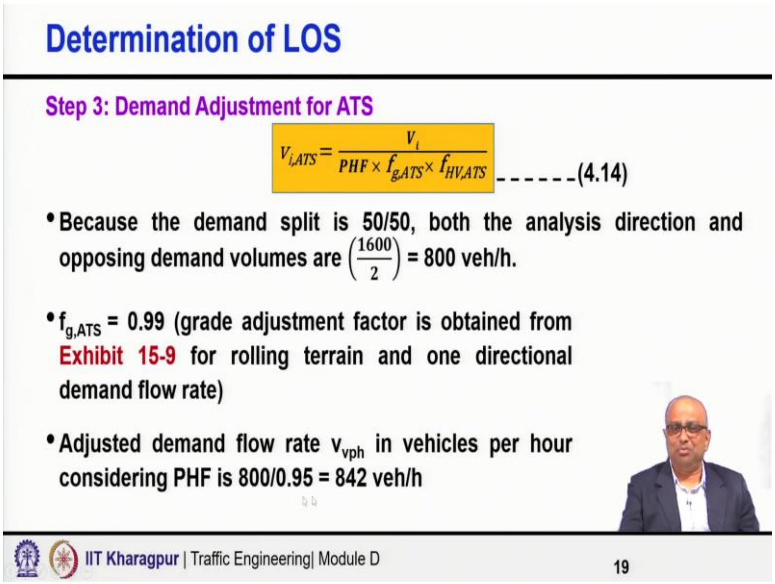
So, directly we can get it zone and the flow value is 902 is not given we know the flow value is given us 800, 900 and then 1000. So, we can interpolate it again get the value for 902. So, one first we do it for 55 FFS 55 mile per hour interpolate 800 and 100 with get the value as 0.8. Here again for 50 we get interpolate the value between 800 and 1000 to get the value for 902 as 0.65. Then we know for 55 it is 0.8, 50 it is 0.65.

So, for 50, 3.3, what would be the value and that altogether do you calculate it as 0.7. So, once it is known, so we know then Fnp ATS, no passing zone what adjustment to be done, volumes are known, 902 in each direction and same in both direction. So, simply use this equation and you can get it as 38.6 miles per hour.

(Refer Slide Time: 33:01)





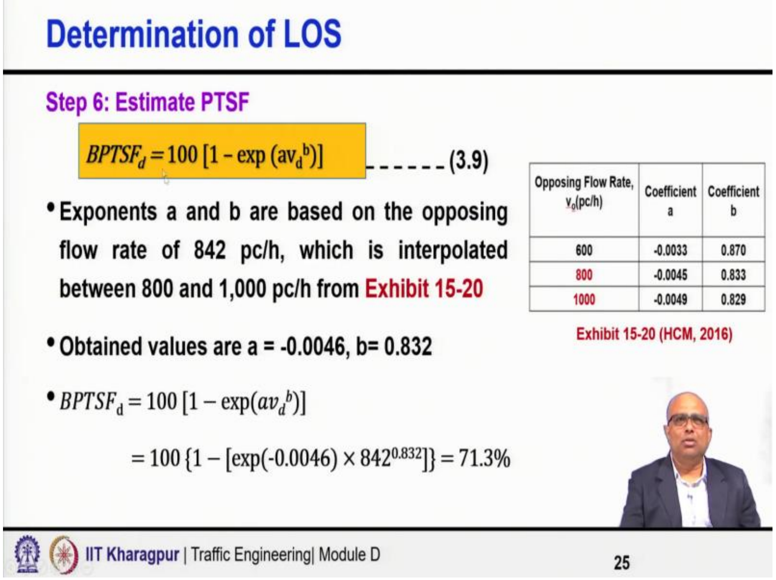


Now, the next step is determine a set up percentage time spent following. So, for that again we need to do the volume adjustment factor, very similar, but only the correction factors will be different and we have to refer to different exhibits to get the pick up the value. So, here also for exhibit 15-18. If you see, so the here I will say again for all flows here it is 1 and here 801, 900 greater than 900 is also one.

So, does not matter in between also for 842 where from 842 has come 842 you got it by applying the peak hour factor, zone 800 was the flow original and adjustment you have done based on 842. That is the value is to be which is to be used. So, you get it both cases it is one so, you get ET equal to 1, ER equal to one, you use this equation proportion is known percentage of truck and percentage of recreational vehicles are known.

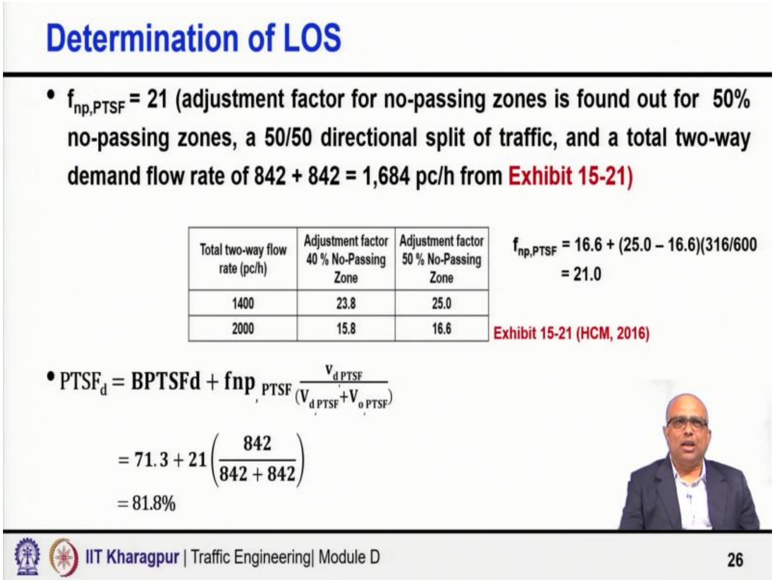
So, you can actually calculate this correction factor which is also coming out to be as 1. And then the Fg value for calculation of Fg value you can refer to exhibit 15-16. And here for 842, what is the value rolling terrain 0.99 and 1.00 so near is 0.1 up to that we take it so we again take the value as about 1. So, in this case, you are getting the equivalent volume as 842 passenger car per hour.

(Refer Slide Time: 34:53)



Now estimation of PTSF for that first we need to calculate base PTSF in the direction of analysis. So, base PTSF it is this equation. So, this equation number is wrong it is actually we are referring to this equation this will be this equation 4 dot 20. So, use equation 4 dot 20 to get this value, so, we know referred to exhibit 15-20. What is the opposite flow rate and accordingly what will be the coefficient of a and b, we pick up that, we calculate it zone, put it and calculate it, we get the base percentage time spent following is 71.3 percent.

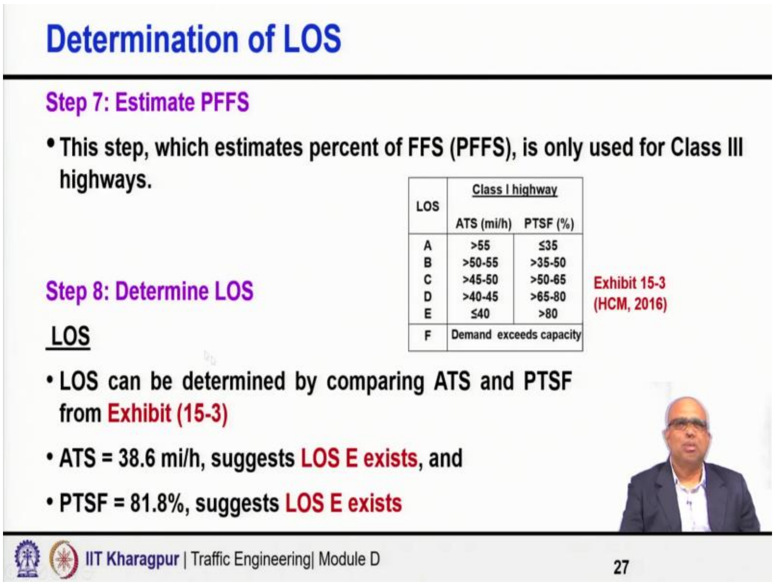
(Refer Slide Time: 36:01)

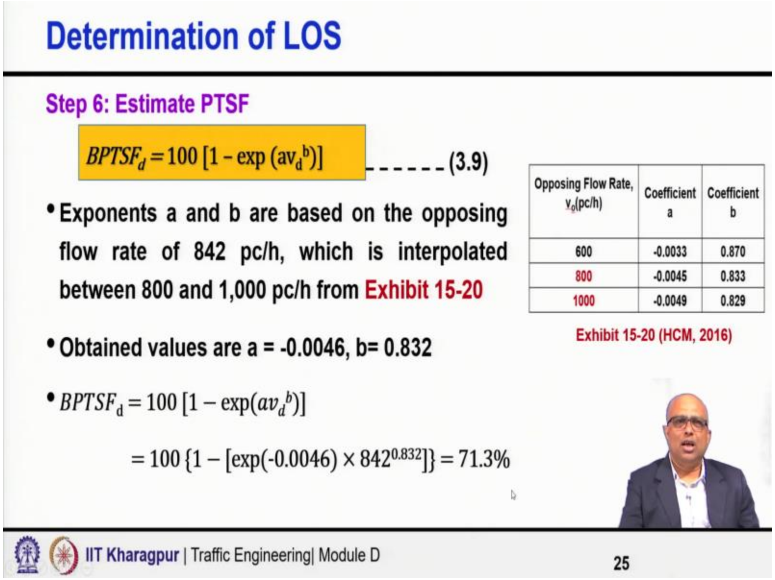


And once you have calculated that then this is the equation which we have to refer finally, and here we can have calculated this part as 71.3 and here we need to calculate this correction factor Fnp $_{PTSF}$. Now, what is the Fnp $_{PTSF}$ this is actually taken as 21 from you have get got it considering that 50 percent no passing zone and 50-50 split zone.

So, and the total two-way flow of 1684. So, two-way flow 1684 if you take and if you take 50 percent no passing zone, then 1400 and 2,000 to a flow rate so, we have taken interpolated and you calculate the value was 21. So, now, you get it PSF is 81.8 percent.

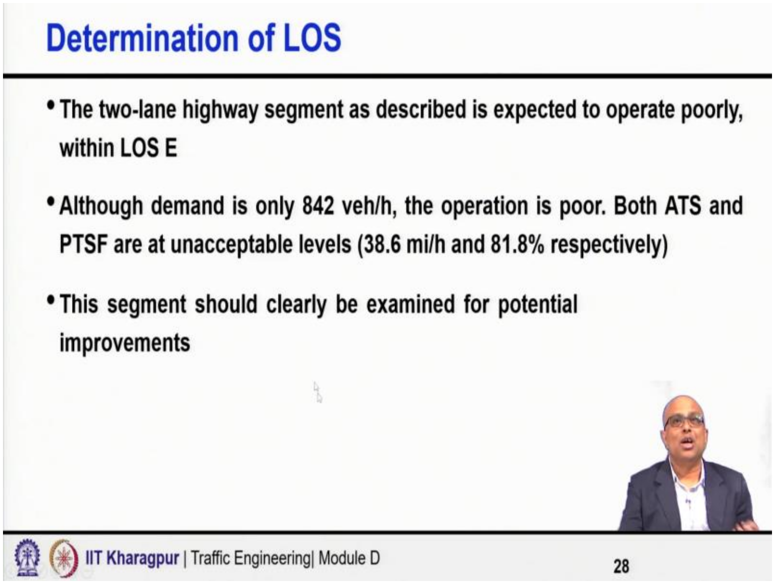
(Refer Slide Time: 36:56)

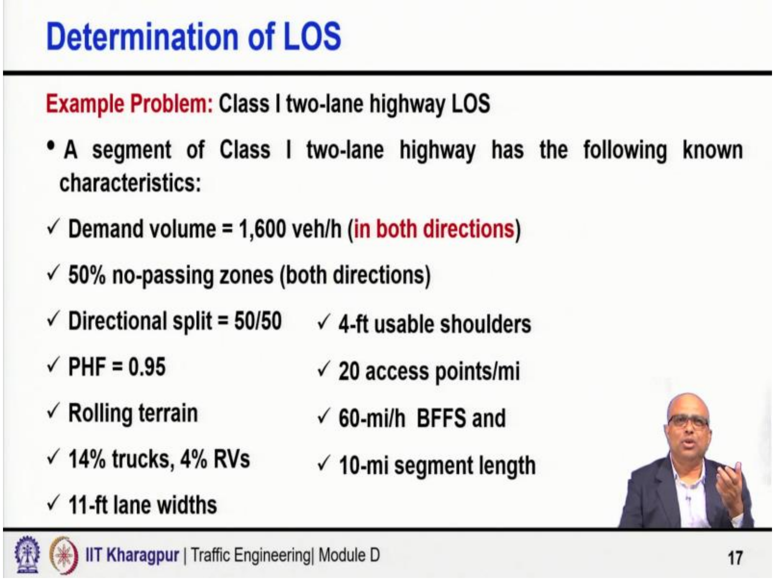




And then we can go to the next step is the LOS calculation and we can use this exhibit 15-3 HCM 2016 I have also mentioned this about this table in the previous lecture, lecture 5 of this module and you can pick up. So, if you take ATS as 38.6 average travel speed per mile per hour, then you can get it what is the it is the level of service E and PTSA was at 1.8 percent you get again LOS E. So, here actually this this is the place where we have calculated at 1.8 the same steps. So, both cases it is saying level of services. So, the overall LOS E is.

(Refer Slide Time: 38:07)

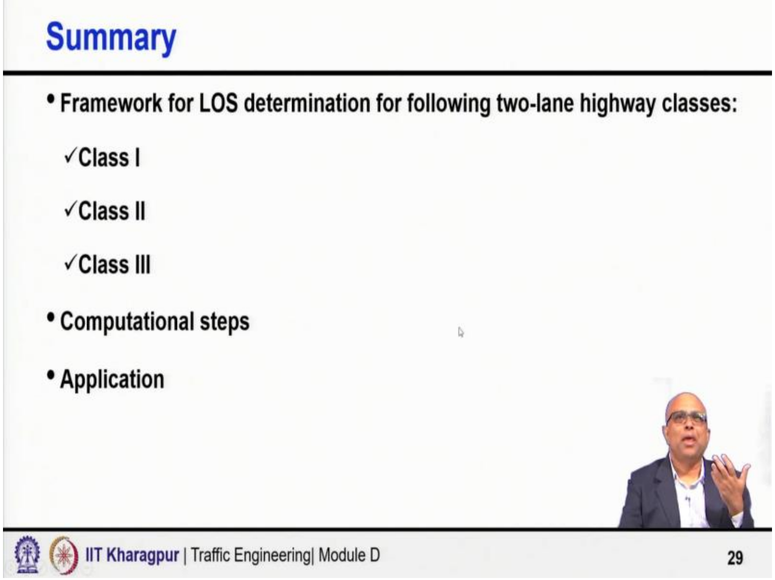




What you can notice that this to a higher segment as described is expected to operate poorly because level of services already E. But the demand is only 842 that shows that the two-way lane movement the level of service deteriorates very fast at a much lower volume only 842 vehicle per hour the volume. So, that is not very high.

The steel the operation is poor and both ATS and PTSF are at unacceptable level with 38.6 miles per hour and 81.8 percent. So, the directional flow we said 842 zone. So, with 842 this much direction flow in one direction itself the level of services deteriorated so fast. So, obviously the segments need to be examined for potential improvement that could be their recommendation because it is already operating LOS E.

(Refer Slide Time: 39:19)



So, what we discussed in this case is I explained to you the framework for a LOS determination for different classes, class 1, class 2 and class 3 and the computational steps in details I have described how you calculate, how you refer to different exhibits in highway capacity manual and pick up the appropriate values.

And then I have taken one example problem of class 1, two-lane highway segments to show you given all the data, how actually we can calculate the LOS and to conclude also that for two-lane two-way highway segment even at a much lower volume itself the level of service deteriorates very fast. With this I will close this lecture. Thank you so much.