**Analysis and Design of Bituminous Pavements**

**Dr. Neethu Roy**

**Dean (R&C), Professor**

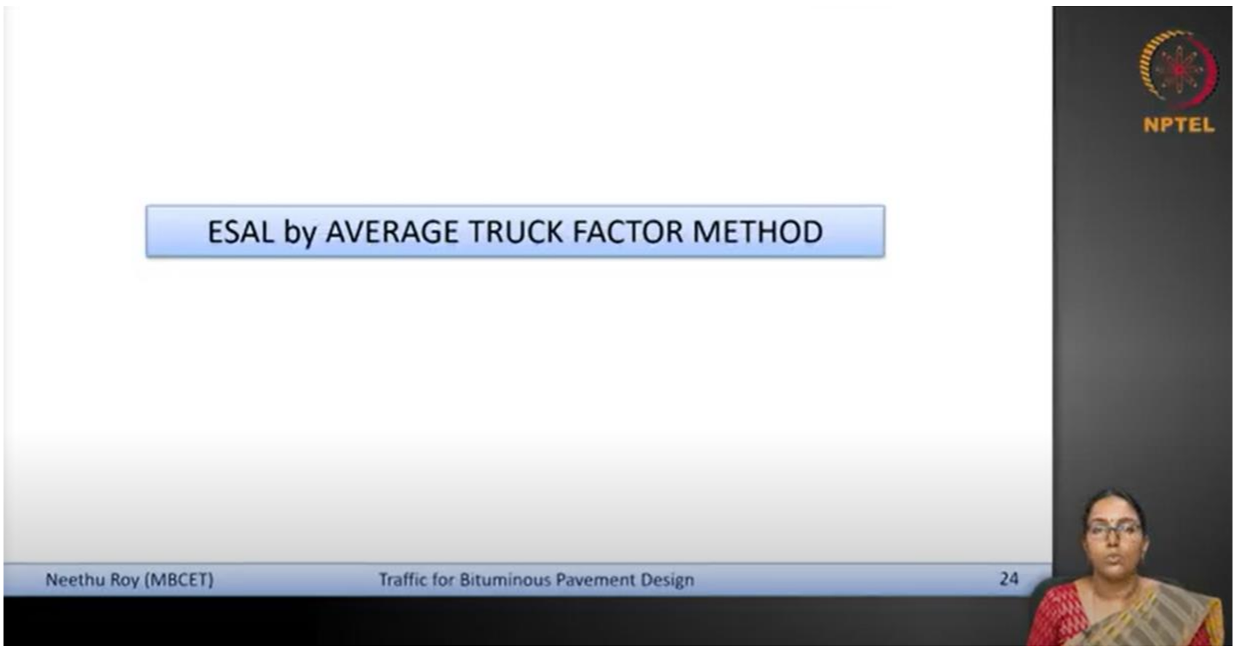
**Department of Civil Engineering**

**Mar Baselios College of Engineering and Technology Thiruvananthapuram**

**Lecture -17**

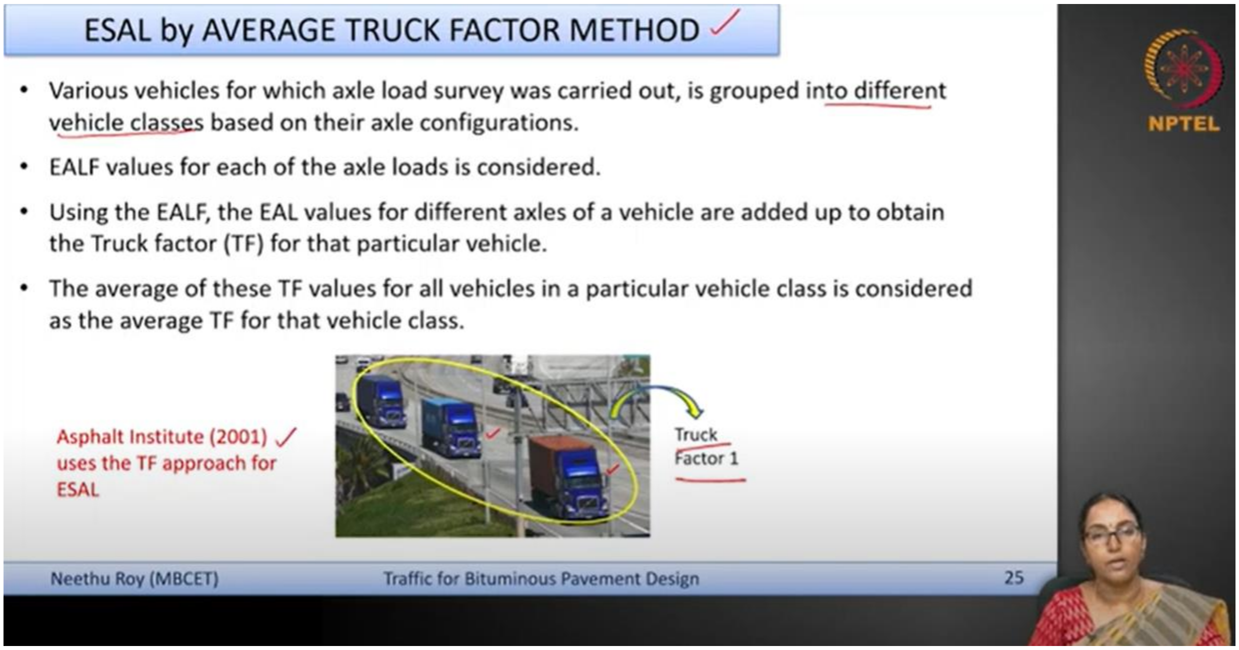
**Traffic Analysis - ESAL using TF**

(Refer Slide Time: 00:16)




Let us see how this equivalent standard axle loads are calculated by an average truck factor rather than a VDF factor.

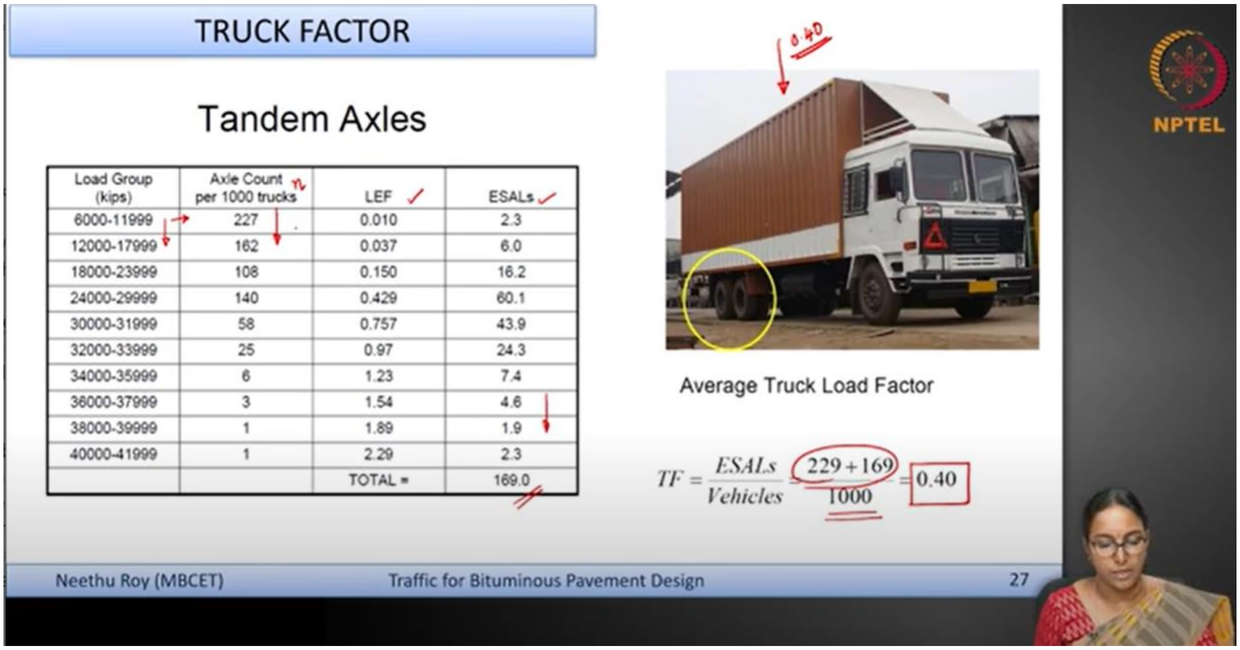
(Refer Slide Time: 00:27)




So, let us see how the equivalent standard axle loads can be arrived at by making use of truck factor. Now, in this case, the various vehicles for which the axle load survey is carried out will be first grouped into different vehicle classes. For example, you can have trucks with single axle and a tandem axle, trucks with a single axle and a tridem axle, and you can group them into different vehicle groups. Now, for each vehicle group, you can divide them into different axle loads based on the axle load spectra of this vehicle group alone. As you see in this picture, I have considered all the identical vehicles as one vehicle group and then you determine the EALF for the various axle load groups of this vehicle group alone and using those EALF values, you can determine what is the equivalent axle loads for the different axles of this vehicle and for each vehicle, you can add them together to get the truck factor for that particular vehicle.

Now, you have a truck factor for each of the vehicles. You can then average out the truck factor for all the vehicles in that particular vehicle class to get an average truck factor for that particular vehicle class. All these blue trucks belong to one vehicle class, you will essentially get a truck factor for that vehicle class. Similarly, if you have another vehicle class, you will get a separate truck factor for that vehicle class. Now, using this truck factor, the equivalent single axle loads is determined in the case of Asphalt Institute method of design.

(Refer Slide Time: 02:13)

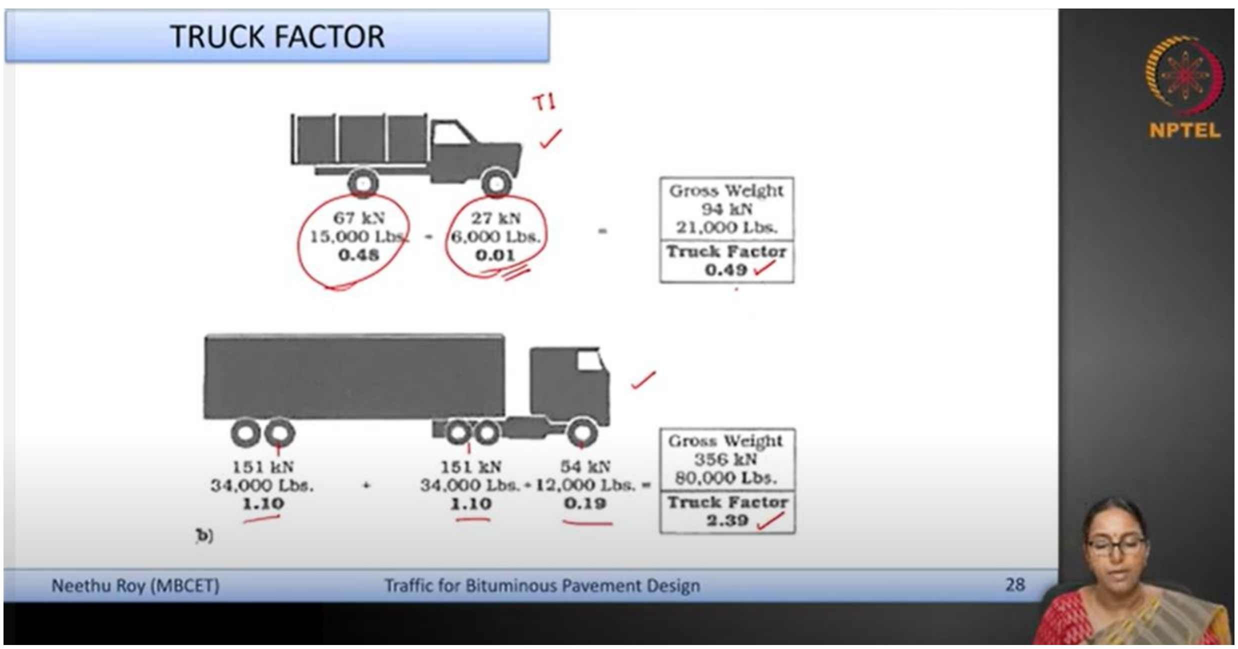



Now, I will just show one example. This is one truck with a single axle single wheel at the front and a single axle dual wheel at the rear. You are conducting an axle load survey of 1000 trucks. So, first of all, you will measure the axle loads on the front axle as well as the rear axle on all the 1000 trucks. Then they will be grouped together, the single axles will be first grouped together. And as you see that, you put it in different axle load bins such as 3000 to 7000 is 1, then 7000 to 8000, 8000 to 11000 and so on. So, you have divided it into different load groups and you count how many number of axles come under each of these load groups. So, this essentially is the frequency.

Now, for each of them the load equivalency factor will be determined for the mid value of the load group. Say if you have 3000 to 4000, 3500 becomes the mid value, for that mid value you take the load equivalency factor as per the fourth power approach. The load equivalency factor multiplied by the frequency of that group will give you the ESALs. So, what you are doing is that all the axles that are coming under that load group are now converted to equivalent standard axles. Now, you sum up all this equivalent standard axles together to get a total equivalent standard axles of 229 for the front axle. Likewise, you consider the rear axle which is a tandem axle. So, we have 1000 vehicles, for all 1000 vehicles you have determined the tandem axle load and the frequency is put in axle load groups like this. These are the axle load groups, and the frequency under each group load group is determined. And for the mid value of each load group you find out the load equivalency factor and multiply the load equivalency factor with the number of vehicles on that group to get the equivalent standard axle loads. So, we got a total ESAL at the rear axle as 169. The front axle has a total of 229 ESALs and the rear axle has given a ESAL of 169. So, you add them together to get the total equivalent standard axles due to this class of 1000 vehicles. Now, divided with 1000 you will get 0.4. This means that this truck class has a truck factor of 0.40.

Now if in your traffic stream, there are 2000 of this truck coming. You can just multiply it with this 0.4 which will convert those 2000 vehicles into equivalent standard axles. In this method, each truck class is given a truck factor. Whereas in the last VDF method you have seen that all the vehicles put together you are finding one vehicle damage factor.

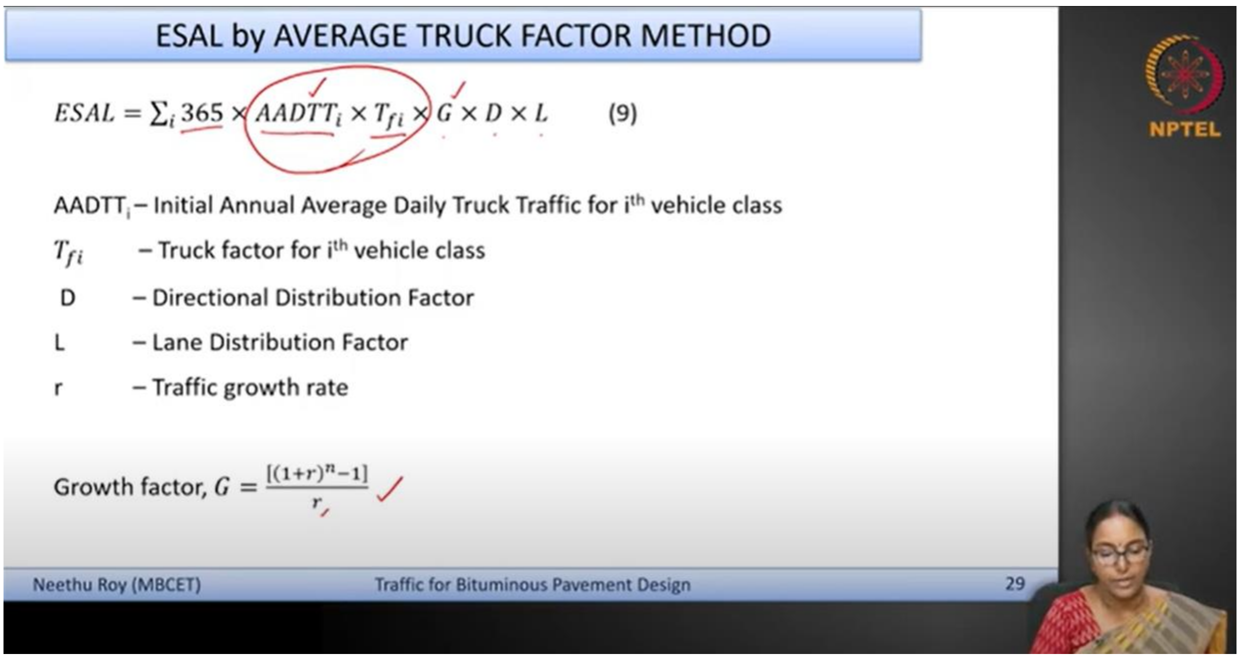
(Refer Slide Time: 05:24)




This is one more example which is shown here. You can see that this is one truck type T1. For the front axle, you see that its load is converted to ESAL by multiplying with equivalent axle load factor. And for the rear axle, you have to determine the equivalent standard axle. So, adding them together divided by 1, if it is only one truck will give you the truck factor for this class of truck.

Similarly, you can see that this is another class of truck which has 3 axle groups. So, for each axle group you find the equivalent standard axle loads, add them together divided by the number of vehicles will give you the truck factor. The first truck shown here has a truck factor of 0.49. The second truck has a truck factor of 2.39. So, for every class of truck, you have to separately find the truck factors.

(Refer Slide Time: 06:47)

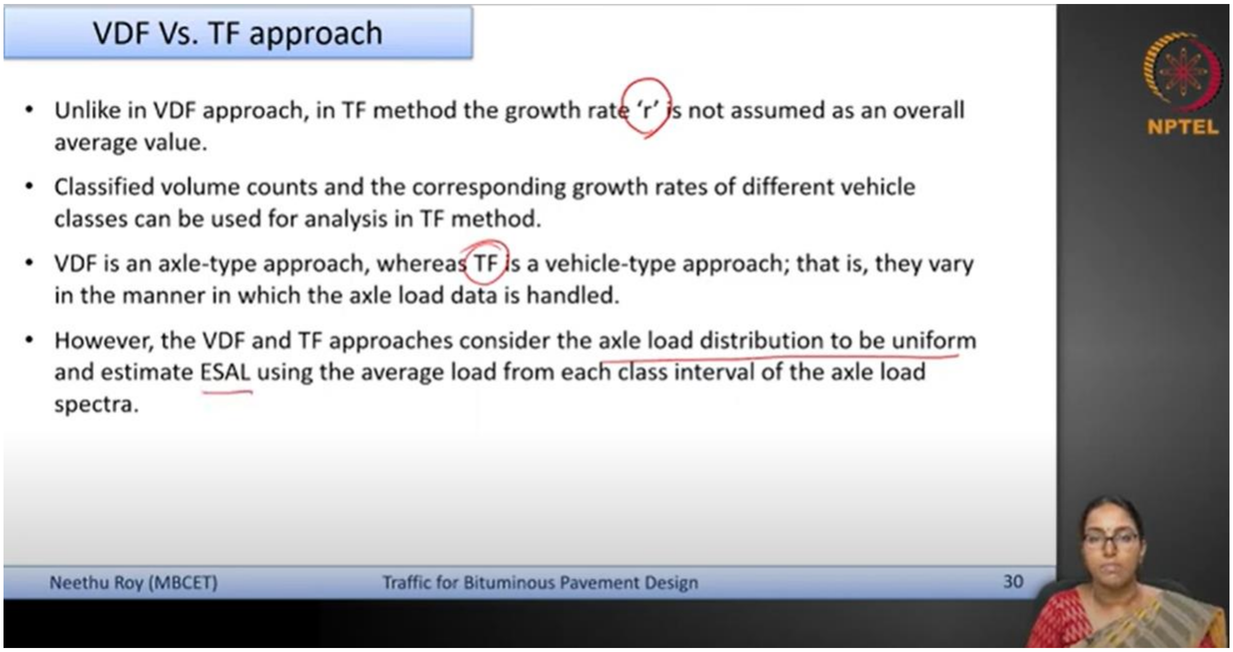



Now let us see how to get the total equivalent standard axles or the design traffic.

$$\mathrm{ESAL} = \sum_{\mathrm{i}} 365 \times \mathrm{AADTT_i} \times \mathrm{T_{fi}} \times \mathrm{G} \times \mathrm{D} \times \mathrm{L}$$

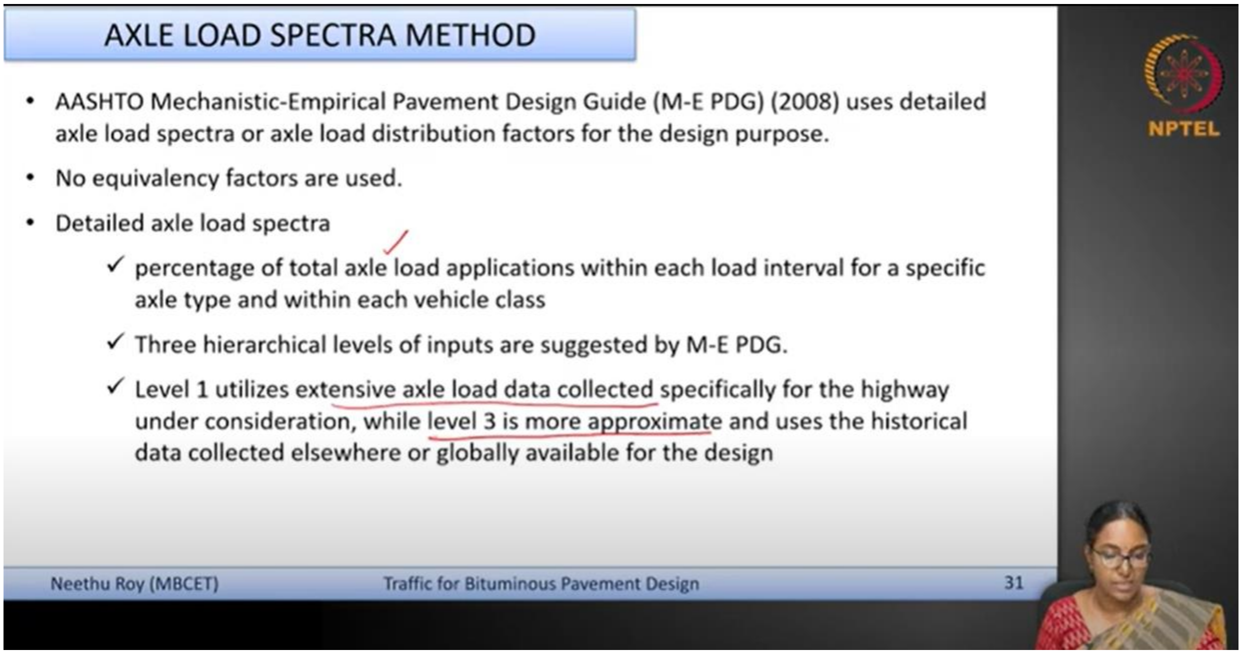
$\mathrm{AADTT_i}$ indicates the initial annual average daily truck traffic for the i$^{th}$ vehicle class. So, in the example that I have shown, there are three type of vehicle classes. For each truck type, you see the annual average daily truck traffic. Then for each truck type you have to determine the truck factor ($T_{fi}$). So, essentially all those trucks are converted to equivalent standard axles. Now you have to multiply it with 365 to get annual traffic then you multiplied with the growth factor (G) for that particular truck type. D is directional distribution factor and the lane distribution factor. So, this is how you will get the total ESALs if you are going for average truck factor method.

(Refer Slide Time: 08:21)




We will look at a quick comparison of VDF method and a truck factor approach. So, unlike this vehicle damage factor approach, in the truck factor method, the growth rate is actually not assumed as an overall average for all the vehicles. When you are doing the traffic survey you will be having the classified volume count for each class of truck that is annual average daily truck traffic. And also you can get the growth factor for each of these classes of vehicles separately. So, in the case of truck factor method, there is a possibility that if the different classes of vehicles have different growth rates, you can use it separately rather than using one growth factor for all the vehicle classes together as in the case of VDF method. So, VDF is essentially an axle type approach wherein you are just combining the axle types from all the vehicles together whereas the truck factor is essentially a vehicle type approach because each vehicle type is considered separately. So, essentially they vary in the manner in which you are actually computing the equivalent axle loads. So, in both this VDF and TF approaches they consider the axle load distribution to be uniform and the ESAL values are estimated for the average load from the each class interval.

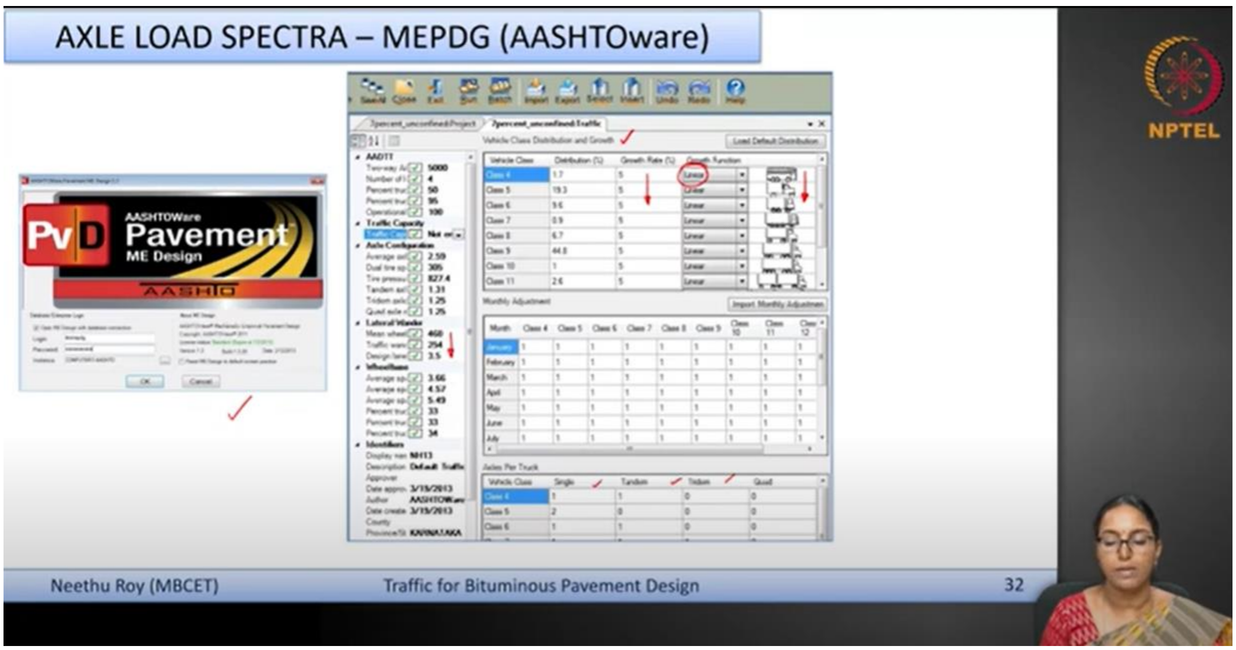
(Refer Slide Time: 09:45)




Now in both these methods, what we have discussed which is normally followed in the IRC method and the asphalt institute design approach. The load is divided or each axle loads are converted into an equivalent single axle loads so that in the design we need to cater only to one parameter which is the $N_{design}$ or ESALs, equivalent standard axle loads. Whereas in the AASHTO mechanistic empirical pavement design guide method 2008 or MEPDG, you can use the entire axle load spectra or the axle distribution factors and different growth rates for the design purpose. You do not convert each one of these loads into its equivalent axle loads. The total axle load spectra as it is measured in the field can be utilized for analysis. So here the detailed axle load spectra are needed which includes the percentage of total axle load application within each of the load interval for a specific axle type and within each vehicle class.

The issue with this method is that such an extensive data need to be collected so that you can input it in for the analysis. But if that is not available so you have three hierarchical levels of inputs is mentioned in MEPDG. So level 1 utilizes this extensive axle load data which are collected for that particular highway or a similar highway under consideration. Whereas in the level 3 you can go for a more approximate method wherein historical data collected or the data that is globally available for identical approaches can also be used in the MEPDG analysis. But the idea is that, rather than converting the vehicle loads or the axle loads to some standard axle load, you are estimating the damages or the effect that is caused by the entire axle load spectrum as such on the pavement.

(Refer Slide Time: 11:54)




So this is just a screenshot of the AASHTOWARE MEPDG or the Mechanistic Empirical Pavement Design software. This is the vehicle configuration page. You can have the vehicle class distribution and its growth rate for different classes of vehicles. As you see here, you have different classes like class 4, 5, 6, 8, 10, 11 etc. For each of these classes, you can first determine the percentage of vehicles in the total vehicle data. So you give the two way annual average daily traffic and number of lanes and the total percentage of trucks in that and out of the percentage of trucks, how much percentage is present in each of these classes. This information can be given and different growth rates for each of the classes of vehicles can be given. And also the growth function you have mentioned here is linear. There are different ways in which this growth function can be considered. So the growth of a truck need not be always in a linear fashion.

It could follow any other trend. So accordingly that can be mentioned in the case of this MEPDG. And also there could be monthly adjustment factors because it need not be the same truck traffic, there may be wandering or the distribution need not be same in all the months. So you can have monthly distribution also. And the for each of these class, you have to mention the class of truck with the number of axles, how many single axle, tandem axle, tridem axle etc. are there.

And the other information such as the dual tire spacing, the tire pressure, the lateral wander, the traffic axle data that you get in the field can be input in the AASHTOWARE. It will use this information to compute the stresses, strains and other deflections which will be now linked to the distress transfer functions. So on a day to day basis, these distresses will be computed and the damage will be accumulated and then accordingly the design can be done.

We have seen that using the EALF factors, you can compute the equivalent single axle loads by two approaches. One is the truck factor method and the second one is the vehicle damage factor method and how the equivalent single axle loads is determined using both the methods. And we looked into how the axle load spectra can be as such given in MEPDG software. Now we will see some examples. I will use a excel template and show how an actual data is processed and how this ESAL or the equivalent single axle loads are computed.