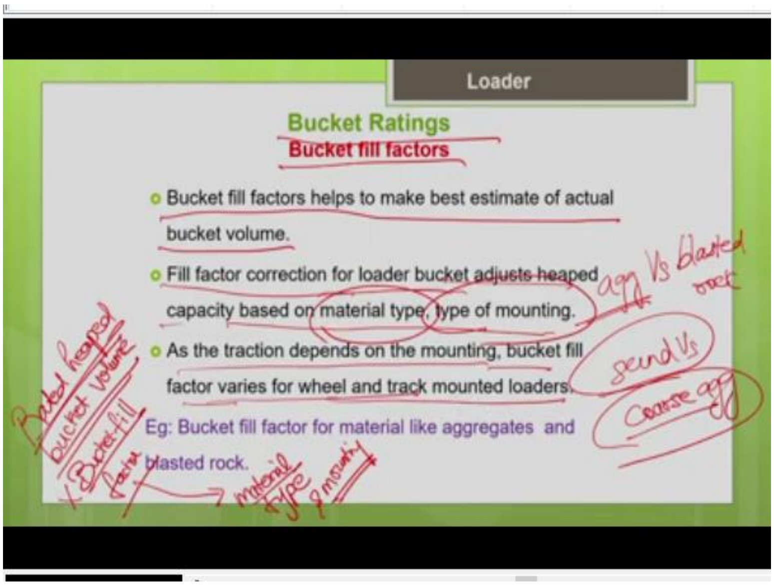

Now, let us see about the bucket ratings, see the manufacturer provide you the information on what is the heaped capacity of the bucket. So, this bucket rating is done by the manufacturer in a standard manner with a particular material, say they heap the material at a standard angle of repose say is 2 to 1 and then rate the bucket based on that. So, that bucket rating, we are going to use it for the estimation of the productivity of the loader.

So, but in your actual project site, the material which you are going to handle that may be of different from the material which was used for the rating of the bucket by the manufacturer. So, you know that different material will have different filling ability. Say for example, we are going to handle sand. Sand has a particular filling ability, if we compare sand and if you compare the coarse aggregate, if you compare bigger size coarse aggregate, sand has better filling ability when compared to the coarse aggregate.

Similarly, when I compare the aggregate versus the blasted rock or the short rock obviously, aggregates will have the better filling ability. So, the filling ability of the material into the bucket will vary from material to material. So, that is why according to the material which you are going to handle at your project site you have to apply the correction factor to the rated bucket volume by the manufacturer.

So, the manufacturer would have rated the bucket. So, that is the heaped bucket volume. This data, I can get it from the manufacturer for different bucket capacities, for different bucket sizes, I can get it from the manufacturer, this value, I have to adjust according to my material type, which I am going to handle at my project site. So, I have to multiply this rated bucket volume given to the manufacturer with a bucket fill factor, which depends upon the material type.

So, this value also I can get it from the literature for different materials, depending upon the size of the material, the filling ability will vary. So, the bucket fill factor will also vary. So, it not only depends upon the material type, it also depends upon the mounting of your machine. So, your machine will be either wheel mounted or it can be either track mounted. So, generally as you know, the track mounted machine will give you better tractive effort, it will be able to generate more amount of breakout force.

So, say it can easily loosen the material and it can easily fill the material into the bucket. So, the filling ability will be more when we go for the track mounted machine when compared to the wheel mounted machine. So, that is why the type of the mounting will also affect the bucket fill factor. So, this bucket fill factor helps to make the best estimate of the actual bucket volume.

So, the fill factor corrections for the loader bucket adjust the heat capacity given by the manufacturer, based on the material type and the type of mounting of your machine. So, the material type which you are going to handle the material, which you are going to handle at your project and the type of mounting of your machine, according to that your fill factor will vary. With that fill factor you adjust the actual bucket volume rated by the manufacturer.

As the traction depends upon the mounting the bucket fill factor also varies for the wheel and track mounted loaders. So, the track mounted loaders will give you better traction. So, it can easily loosen the material and it can easily fill the material into the bucket. So, the bucket fill factor will be better, will be different for the track mounted loader and wheel mounted loader.

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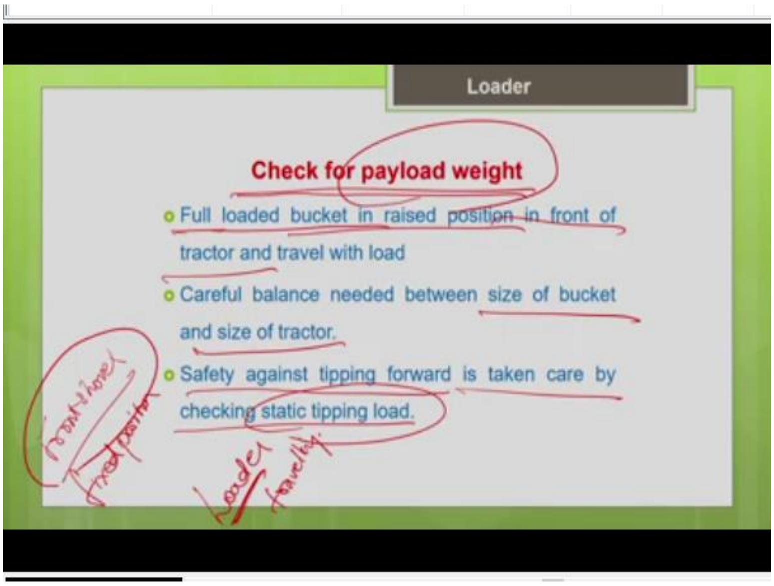

Now another important thing which we need to check particularly for the front end loaders is way to check for a payload weight from the stability point of view. So, you know that your front end loader is going to carry the material in the bucket in the front end and it has to travel for some economical haul distance. So, unlike the other excavators, which I discussed earlier, say your front shovels see if you compare this machine with your front shovel, which is also an excavator machine.

So, that is not going to travel from loading to dumping position, they are fixed position machines, but this loader will be travelling, loader can move material from the loading to the dumping point, that is why in this machine, we are more concerned about the stability, there are more chances for the tipping of the loader machine if you overload the bucket.

So, that is why we have to check for the payload weight. So, these machines are basically travelling with fully loaded bucket. And the bucket will be in the raised position in the front of the tractor and it will be travelling. So, that is why there are more chances for instability. So, we have to carefully balance, we have to match the size of the bucket and the size of the tractor, for a very small tractor, we should not put a bigger bucket.

So, that will affect the stability of your machine, safety against tipping forward is taken care by checking these static tipping load. So, how this static tipping load is determined we are going to discuss in the next slide. So, we have to check whether the payload weight, the actual load in the bucket is within the static tipping load prescribed by the manufacturer.

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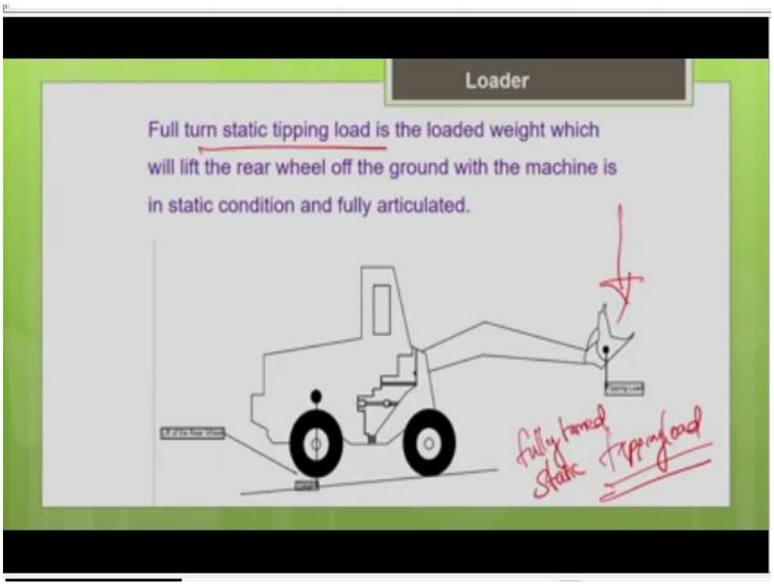

What is this tipping load? See just like you imagine you see some like if you are going to put more material into this bucket as you keep on adding material into the bucket. So, at one point of time, you can see that if the bucket is overloaded, the rear wheel will be lifted off the ground. So, that is what is called as a tipping of the bucket. So, your rear wheel will be lifted off the ground as you put more and more material into the bucket.

So, this static tipping load is determined by the manufacturer under standard conditions. So, how do they do this test? So, basically, what they do is they carry out the test by putting material into this bucket, they look for that particular point of time at which the rear wheel will be lifted off the ground, that particular load is called the tipping load.

So, how much load we need to add into the bucket which will cause the lifting of the rear view of the ground that is called as a tipping load. So, this test will be done to the manufacturer and they do this test to static condition to avoid the variability and the machine will be fully turned condition or articulated condition that is going to be highly risky.

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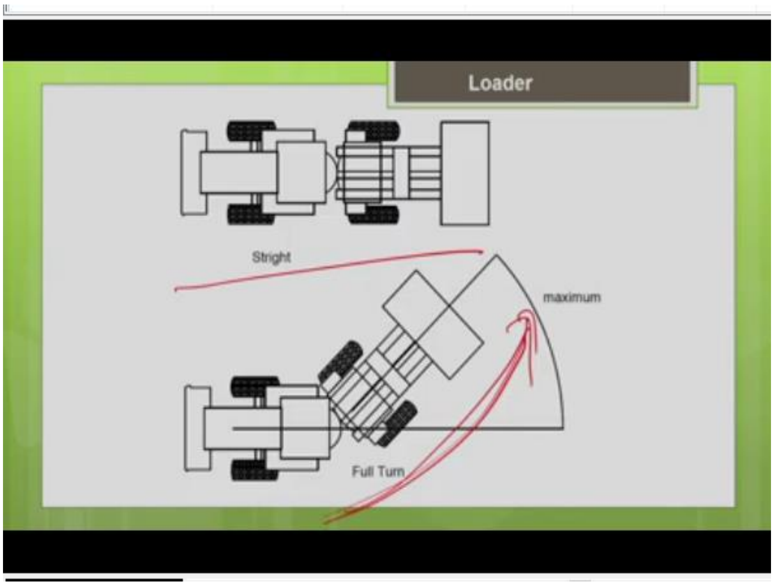

So, the machine will be in fully turn condition when they do the test. I hope you understand the difference between straight and fully turn. So, when it is fully turn it is going to be more risky. So, they carry out the test in the fully turn condition. So, basically full turn static tipping load is the loaded weight which will lift the rear wheel off the ground with the machine in static condition and fully articulated state.

So, this is how they determine the full turn static tipping load, this value you can get it from the equipment handbook, the manufacturer will provide you for different bucket capacities, what is the full turn static tipping load of the machine that value I can get it.

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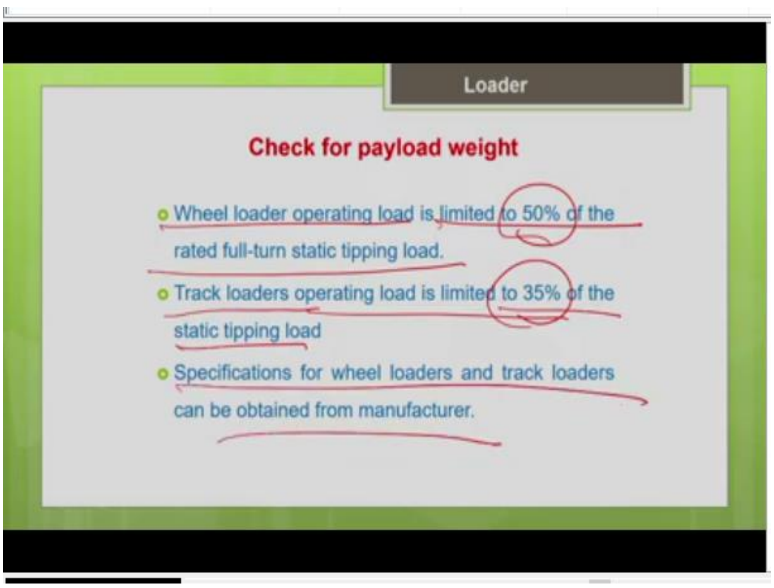

And we have to check whether the operating load of your machine that is the load in the bucket should be well within the full turn static tipping load prescribed by the manufacturer for that particular machine. So, the load in the bucket should be well within that. So, we should go for a very high factor of safety. The factor of safety depends upon the mounting of the machine.

So, the guidelines are available in the literature, say if it is going to be wheel loader the operating load in the bucket is limited to 50% of the rated full turn static tipping load defined by the manufacturer. Similarly, if it is going to be track loader, the operating load is limited to 35% of the static tipping load. So, you have to ensure that the loads which are going to put in the bucket of the loader should be well within the full turn static tipping load.

So, the factor of safety will depend upon the mounting of your machine. So, as I told you the specifications I can get it from the manufacturer.

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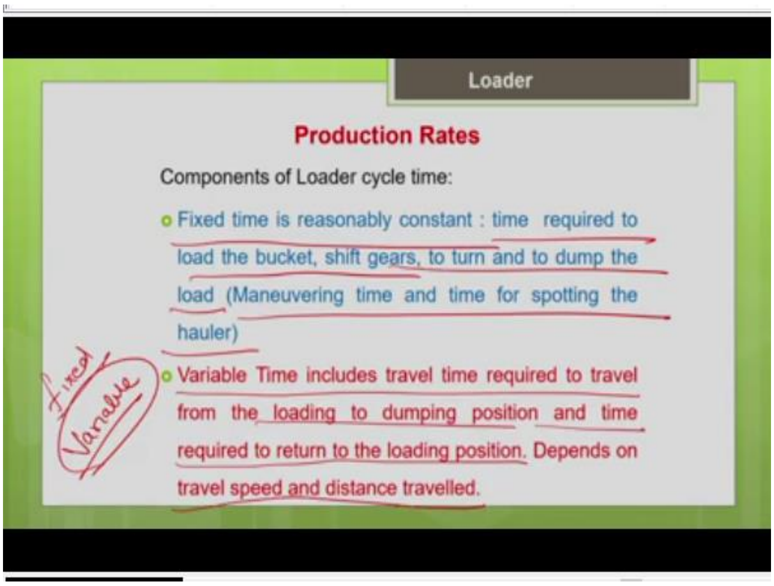

Now, let us define what is the production cycle of the loader? So, what are all the components of the production cycle as we discussed earlier the same way we can split the production cycle time into 2 components, one is fixed time, other one is variable time. The fixed time does not depend upon the haul distance, say the time needed for the loading, dumping, turning, your maneuvering the changing gears and also for spotting your truck.

So, the loader has to spot the truck, then only you can dump the material, if it is not able to spot the truck, the truck is not really available even that will increase you cycle time. So, the fixed time is reasonably constant the time required to load the bucket, shift the gears, to turn and to dump the load. The maneuvering time and the time for spotting the hauler also come under the fixed time.

So, obviously the variable time will depend upon your haul distance and the speed of the machine. The speed of the machine, you can get it from the performance chart as we discussed earlier or you can get it directly from the manufacturer, manufacturer may provide you the possible speed for different capacities of the loader or different capacities of the bucket, what is the maximum possible speed the first gear, second gear, third gear, all these information are provided by the manufacturer.

So, based upon that also, you can estimate your variable time. The variable time includes the travel time, required to travel from loading to the dumping position and the time required to return to the loading position. So, obviously it depends upon the travel speed and the distance travelled.

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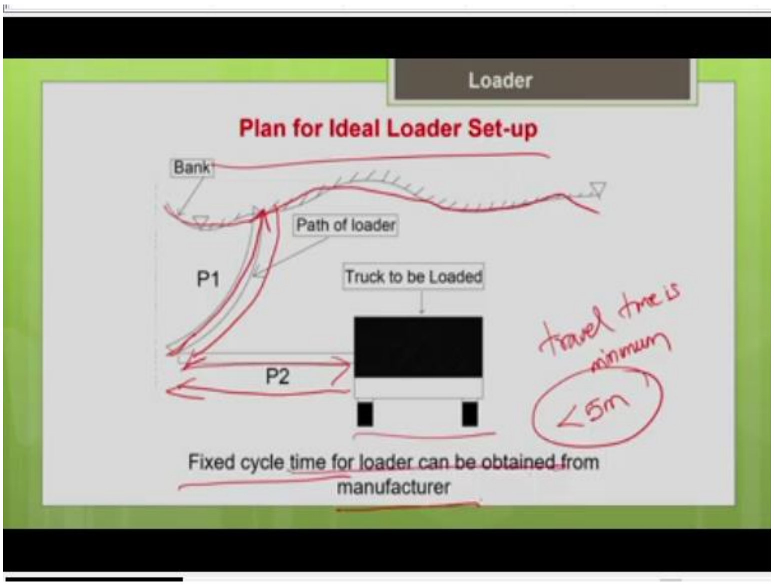

So, this picture shows the plan for the ideal loader setup. So, basically though the loader is able to transport the material for certain haul distance, it is always preferable to place the truck as close to the loader as possible particularly for the track mounted loader for which the economical distance is less than 100 meter, it is always preferable to have the truck as close as possible, so that we can improve the productivity of your loader.

So, that is what we call it is ideal loader setup. So, you can see the production cycle here, this is your truck and this is the bank to which the loader is excavating. So, this shows the path of the loader. So, the loader is first moving to the back excavating the material, then it will take apply the reverse gear and move in the reverse direction. Now, it will move forward to the truck and dump the material into the truck, again take the reverse gear move in the reverse direction and get ready for the next cycle**.**

This is how the production cycle gets repeated. This is called the ideal plan. This is because the travel time is minimum here particularly the crawler loaders are also not designed for a very high haul distance. So, it is preferable to minimize the travel time of the loader, but everything depends upon your actual project condition or the site requirement. And another important thing to note that is when the travel time is minimum say if the truck is placed very close to the loader say less than 5 meters or approximately 15 feet.

So, in that case, the travel time is going to be travel distance is negligible, I can see the travel distance is negligible and the travel time is minimum. So, in that case directly I can take the fixed cycle time for the loader from the manufacturer because for distance is less than 5 meters, there is not much variation in the fixed cycle time. So, that is why you can take it directly from the manufacturer the fix cycle time based upon the bucket capacity of your loader.

That itself will give you the total cycle time of the loader then the travel distance is negligible. That means when the truck is placed very close to the loader say within 5 meters.

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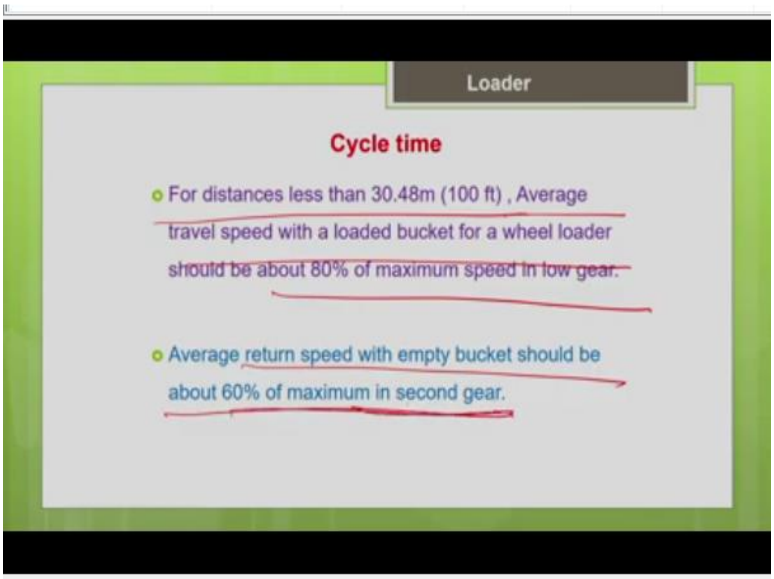

But if the travel distance is not negligible, so in that case, you have to estimate your variable time. So, how to estimate the variable time, there are some guidelines given in the literature, you can follow the guidelines. Say obviously, you know that when the machine is travelling with the loader during the onward journey, then the speed is going to be lesser, when compared to the return journey, where the bucket is going to be empty.

And also the speed possible depends upon the haul distance, if the haul distance is going to be lesser, in that case, the travel speed is going to be lesser, for distance is less than say 30 meters, your average travel speed with a loaded bucket for the wheel loader should be 80% of the maximum speed in the low gear. So, this is a guideline available in literature which we can use it in the estimation of the speed when you estimate the productivity.

So, for the onward journey with the load for the wheel loader you should take the travel speed as 80% of the maximum speed in the low gear as given by the manufacturer. So, as I told you for different bucket capacities what is the maximum speed possible the first gear, second gear, third gear and the top gear is given by the manufacturer. So, you can use it and find this and similarly, for the return journey when the bucket is empty, the return speed should be about 60% of the maximum in the second gear. So, you can see that the return speed is high in the second gear.

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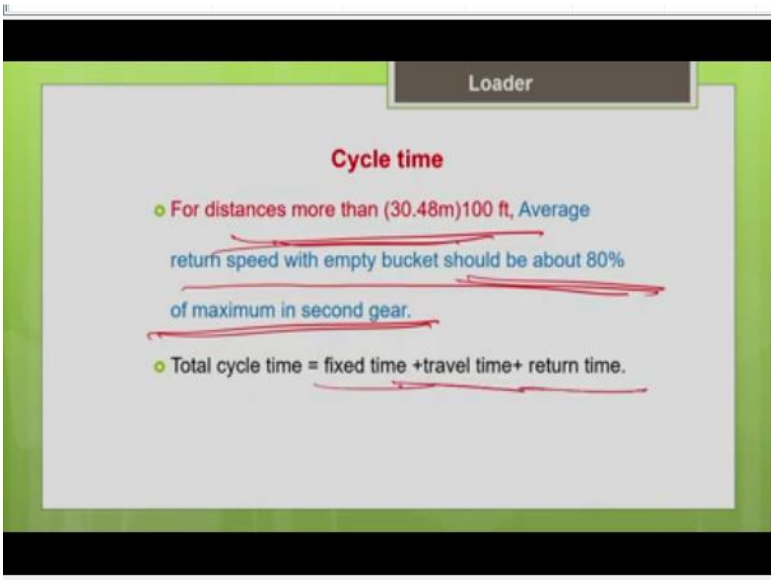

So, if the distance is more than 30 meter in that case the return speed will still more, the return speed will be for the empty bucket, it will be 80% of maximum speed in the second gear, remember when the distances are less than 30 meter, the return speed was only 60% of maximum in the second gear, but for distances greater than 30 meter, the return speed will be 80% of maximum in the second gear, it is greater for the greater haul distance. So, the total cycle time we have to add the fixed time plus your onward journey time as well as a return time.

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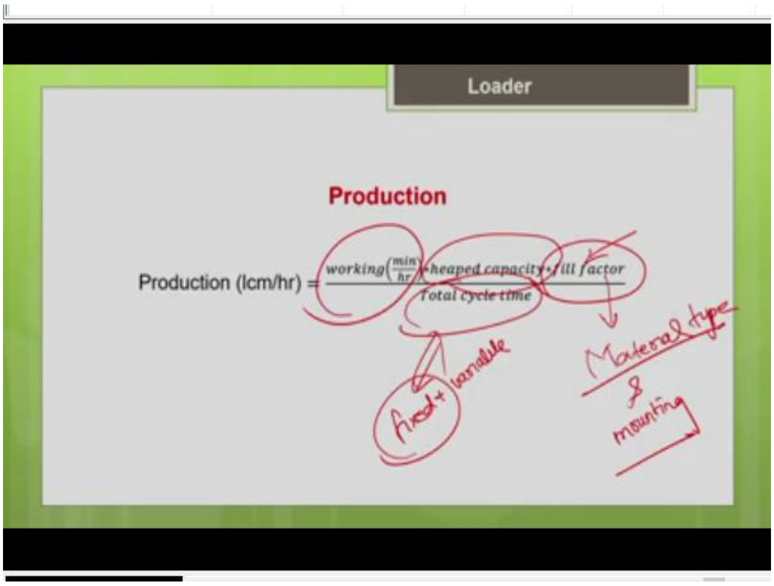

Now how to estimate the production? So, the production estimation is going to be similar for most of the machines. So, you know the heaped bucket capacity for the particular bucket given by the manufacturer, that bucket capacity, you are going to adjust with the help of the bucket fill factor. So, the bucket fill factor will depend upon the material type, which you are going to handle at your project site and the mounting of your machine, whether it is wheel mounting or crawler mounting depending upon that you have to apply the bucket fill factor.

And that value is also available from the literature. Then divided by the total cycle time it is nothing but your fixed time plus variable time. If the travel distance is negligible, you can take the fixed time itself as a total cycle time, that you can directly take it from the manufacturer and you have to multiply with the job efficiency like how much time the machine is working in a hour. So, with this it can give you the productivity value for the front end loader. Productivity can be represented by following equation:

$$Production\ (lcm/hr)\ = \frac{Working\left(\frac{min}{hr}\right) * heaped\ capacity * fill\,factor}{Total\ cycle\ time}$$

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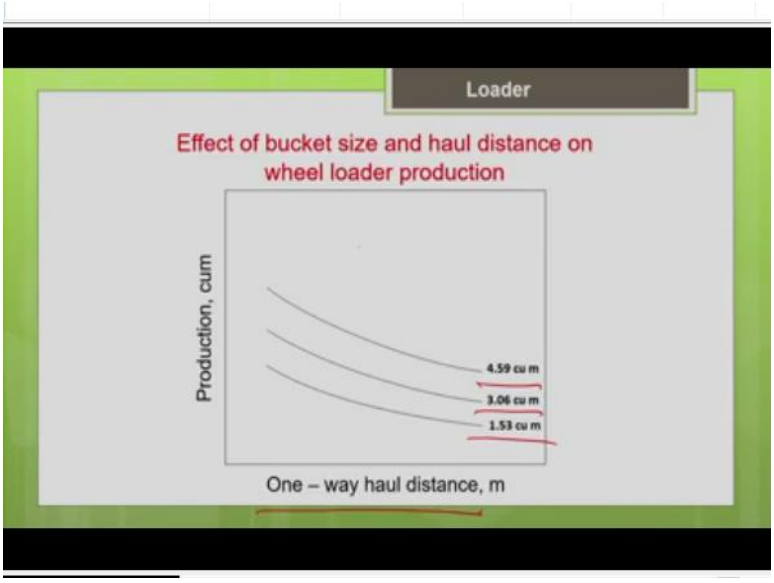

So, there are different ways to estimate the productivity, sometimes the equipment manufacturer may also give you directly the productivity value with respect to the haul distance and for different bucket capacities. So, these are just some sample curves to show you the trend. So, you can see that these kinds of curves are also available in the equipment handbook provided by the manufacturer.

From there you can directly choose the productivity value depending upon the haul distance of the bucket capacity then you have to adjust the value according to your project conditions.

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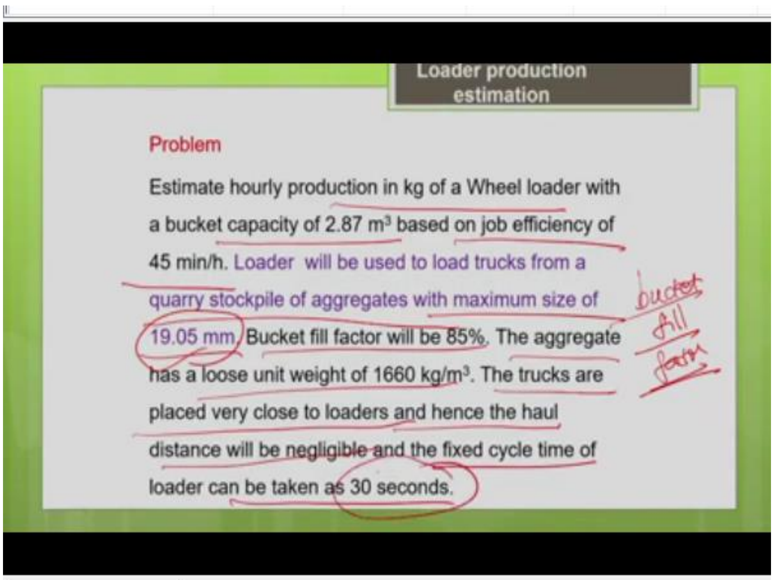

Now, let us work out the problem and see how to estimate the productivity of the loader. So, estimate the hourly production in kg of a wheel loader with a bucket capacity of 2.87 meter cube, the rated bucket capacity is given 2.87 meter cube, it is a wheel mounted loader, job efficiency is given as 45 minutes per hour, this loader will be used to load the truck from a quarry stockpile of aggregate with maximum size of 19 mm.

So, the loader is going to load your truck. So, from a stockpile of aggregate, the aggregate size is also given because depending upon your size, the filling ability of the material will vary the bucket fill factor will vary. So, that is why even the size of the aggregate is given, bucket fill factor will depend upon the size of aggregate. So, from the literature you are supposed to choose the bucket fill factor.

For this problem it is given to you directly as 85%, the aggregate has the unit weight, loose unit weight of 1660 kg per meter cube. So, this will help you in that weight estimation. The trucks have placed very close to the loader and hence a haul distance will be negligible it is a very ideal condition like the truck is placed very close. So, the travel distance is negligible. So, you can directly take the fixed cycle time from the manufacturer.

And the fixed cycle time is given to you in this problem is 30 seconds. So, that will include your time for loading, dumping, turning, changing the gears. So, mostly it will work in reverse gear as I told you the ideal setup. So, the time for the minimum travel involved for the minimum distance is given directly by the manufacturer and here it is found to be 30 seconds.

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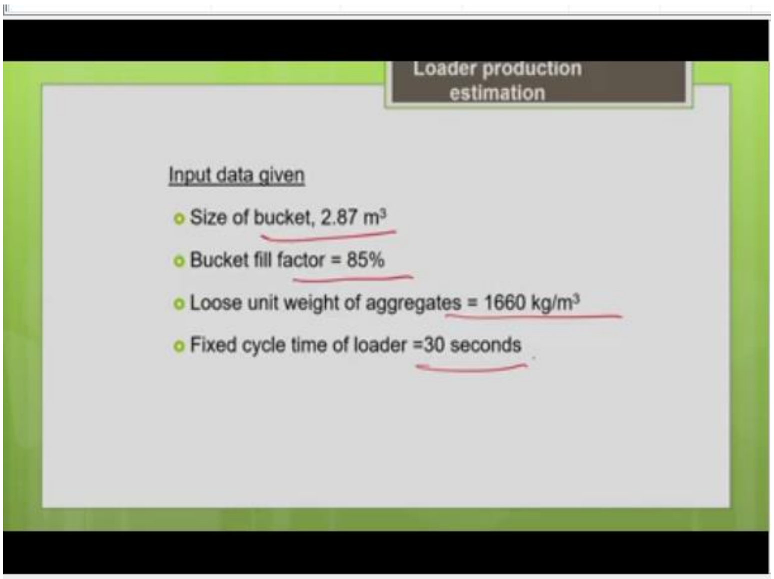

So, let me summarize the input data, size of the packet 2.87 meter cube, bucket fill factor is 85% and the loose unit weight is 1660 kg per meter cube and fixed cycle time of loaders 30 seconds.

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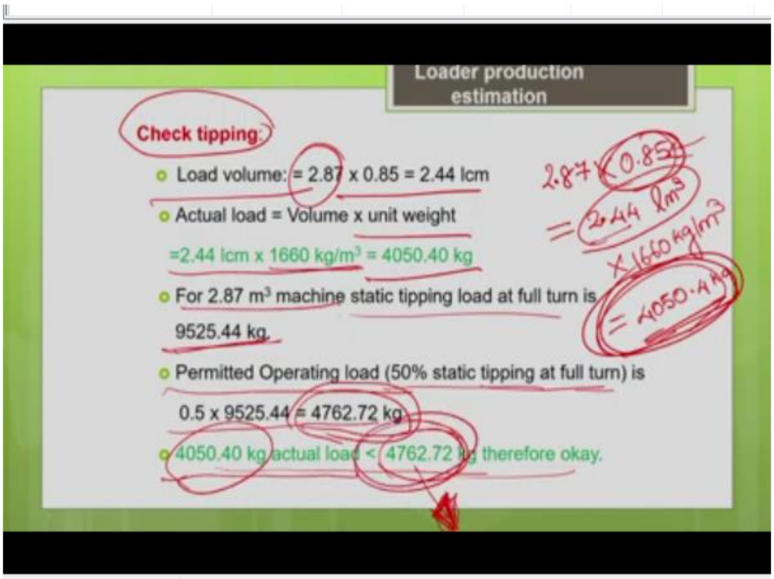

Now, let us work out a solution, the first step will be you have to do the checking for tipping. So, particularly for the front end loader as there are more chances for the machine to tip forward if you are going to overload the bucket. So, that is why we have to check for tipping. So, we have to make sure that the weight of the load in the bucket is going to be well within the full turn static tipping load defined by the manufacturer.

That is that should be first step. Now let me estimate the load volume. So, the bucket volume as rated by the manufacture is 2.87, multiply with a bucket fill factor 85%. So, that will give me the actual bucket volume, actual load volume of the bucket is 2.44 loose meter cube. So, you got the bucket volume as 2.44 loose meter cube, this bucket fill factor is based upon the material type, here we are handling aggregates and aggregate size is given as 19 mm.

So, depending upon the bucket fill factor is 85% and also depending upon the mounting, here it is wheel loader. So, corresponding bucket fill factor is 85% and the actual bucket load volume is 2.44 loose meter cube. Now, let me find the weight of the material in the bucket. So, for that I should use the unit weight of the material as given in the question as 1660 kg per meter cube.

So, multiply this by the unit weight of the material, you will get the weight of the material in the bucket in kg 2.44 multiplied by 1660 gives you 4,050.4 kg. So, this is the weight of the material in the bucket. Now, let me check for the tipping, for that I need to know what is the full turn static tipping load for this bucket capacity that is given by the manufacturer as 9,525.44 kg.

So, as per the guidelines the permitted operating load for a wheel loader is your load in the bucket should be within 50% of the full turn static tipping load. So, let me find what is the permitted operating load 50% static tipping load at the full turn is 0.5 into 9525.44 into 0.5 gives you 4,762.72 kg. So, this is a permitted load. Now let me check what is the actual weight of the load in a bucket?

Actual weight of load in a bucket is 4,050.4 kg. So, this is very much less I mean this is less than the permitted operating load is 4,762.72 kg. Since this is less than this the machine is going to be stable. Suppose if your material is going to be greater the weight is going to be more than the permitted operating load. In that case this will be the limiting value. So, you cannot go beyond it. So, that we have to take it as a guideline. So, you have to load the bucket only to this.

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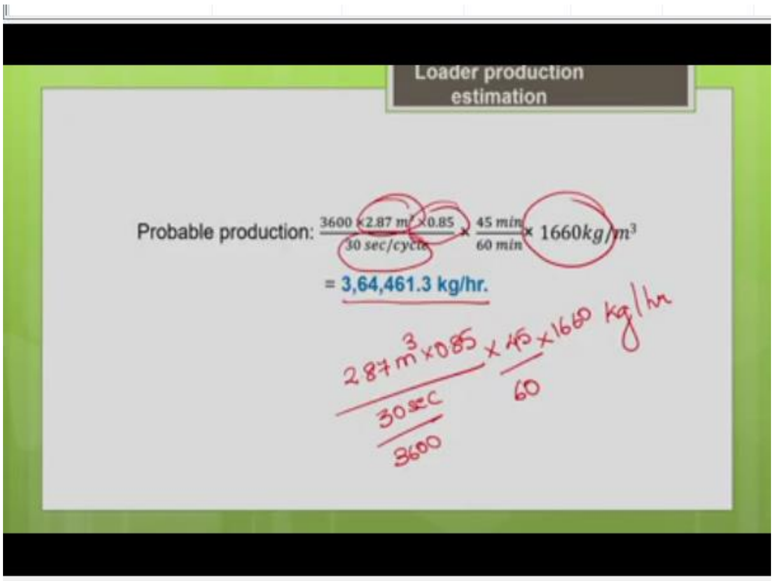

Now let us see how to estimate the productivity of the loader.

$$Production\ (lcm/hr)\ = \frac{Working\left(\frac{min}{hr}\right) * heaped\ capacity * fill\ factor}{Total\ cycle\ time}$$

$$Probable\ production = \frac{3600\ \times 2.87\ m3\ \times 0.85}{30\ sec/cycle} \times \frac{45\ min}{60\ min} \times\ 1660 kg/m^3$$

$$= \mathbf{3,64,461.3\ kg/hr}$$

So, we know the volume of the bucket. So, volume of bucket is 2.87 meter cube. So, you adjust it to the bucket fill factor which is nothing but 0.85. So, you know the cycle time, the cycle time is nothing but 30 seconds. So, here they asked you to estimate the productivity in kg per hour. So, they ask you to estimate the productivity in kg per hour.

So, let me convert this second into hour, 30 seconds divided by 3600. The job efficiency is nothing but it is working for 45 minutes in a hour so 45 divided by 60. SO, as you need the productivity in kg per hour you have to multiply the volume by the unit weight of the material. So, the unit weight of the material is given as 1660 kg per meter cube. So, if you simplify this you will get the production as 3,64,461.3 kg per hour. So, this is the probable production of this loader. So, this how you have to estimate the productivity of the loader.

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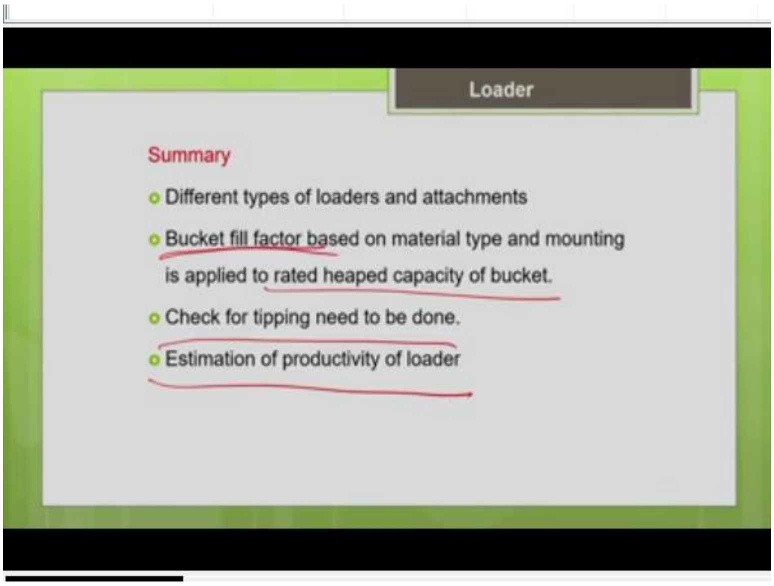

So, let me summarize now. So, we have come to the end of this lecture. So, we have discussed about the different types of loaders and their attachments and the corresponding applications and we discuss the significance of the bucket fill factor depending upon the material type which you are handling at the site. The filling ability will vary for the material.

So, not only it will vary with material type it also vary with respect to mounting. So, accordingly you have to adjust the rated heaped capacity of the bucket given by the manufacturer with the bucket fill factor. Then another important thing particularly for the front end loader we have to check for tipping, we have to check whether the weight of the material within the bucket is well within the full turn static tipping load for that machine as given by the manufacturer.

So, the factor safety is also given in the literature, so depending upon the mounting you have to check it. Then we have seen how to estimate the productivity of the loader we have worked out a illustration.

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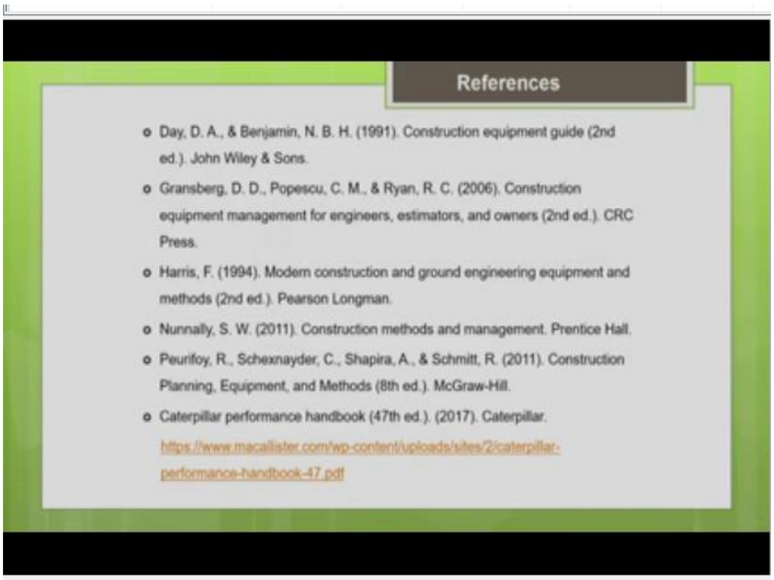

So, these are the textbooks which I have referred for this lecture preparation, you can go through that. So, in the next lecture we will be disusing about the other types of excavators say front shovel and the backhoe which are fixed position excavators. As I told you the fixed position excavators are have very poor mobility. They are not designed for travel from loading to dumping position.

So, they will just swing the boom from loading to dumping. So, we will be discussing about those fixed position excavators in the next lecture. Thank you.