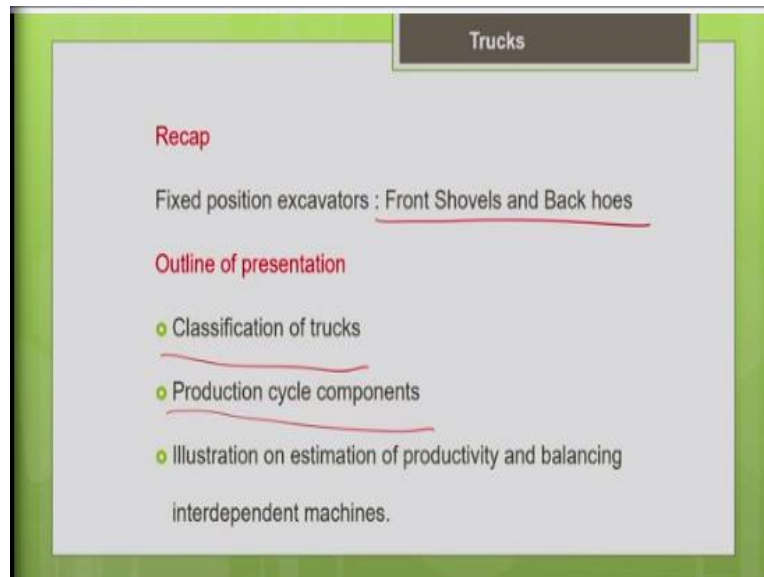


Construction Methods and Equipment Management
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Lecture-15
Earth Moving Equipment-Trucks

Hello everyone I welcome you all to the lecture 15 of this course construction methods and equipment management. So, in this series of lecture on the earth moving equipment today we are going to discuss about the trucks.

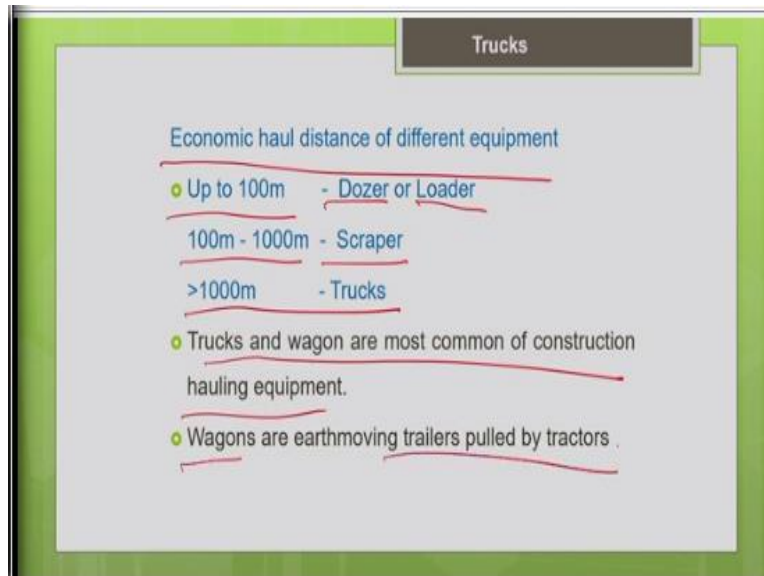
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So, in the last lecture we discussed about the fixed position excavators that is front shovels and the backhoes. So, let us look into the outline of today's presentation, in today's presentation we will be discussing about the types of trucks and we will define what is the production cycle of the truck, what are all the components of the production cycle, let us see how to estimate the productivity of trucks.

And we will work out some problems on how to balance the interdependent machines. So, as you know that the trucks and the loaders are going to work together, how to balance size of the machines and how to balance the number of trucks for the loader? So, we will work with some examples in this regard.

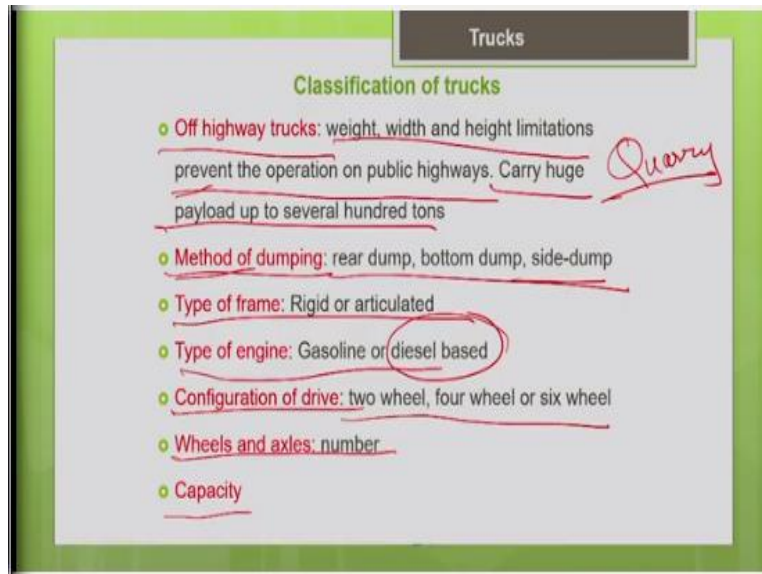
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So, basically for any earth moving equipment we are more concerned about the economic haul distance of the equipment. So, as you know that different equipment has their own economic haul distance. So, in the early lectures I have discussed that with bulldozer has an economic haul distance up to 100 meters. And your loader is say, crawler mounted loaders will have an economic haul distance of less than 100 meters.

So, but your scraper has a better economic haul distance say it is good in loading as well as in hauling, so it can have a haul distance up to 1000 meters. But for haul distance greater than 1000 meter we are supposed to select the truck. So, truck and wagons are the most common of the construction hauling equipment, so they are the commonly used hauling equipment. So, what is this wagon, wagons are nothing but earth moving trailers which are pulled by tractors.

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So, let us now look into the classification of trucks. So, in different context we can have different types of classification of trucks. So, basically some trucks are permitted on the highways but some trucks are not permitted on the public highways. So, those which are not permitted on the public highways we call it as off highway truck, why they are not permitted because their weight, width and height.

So, or beyond the limitations which is the permissible for the public highway, these are very huge trucks whose weight, width and height are too high. So, that prevents it is operation on the public highways. But obviously the advantage will be it can handle huge capacity, it can carry huge payload up to several hundred tons. The productivity of this truck is going to be very high, so very commonly you can see these trucks in quarry, so that is why it is also called as the quarry truck.

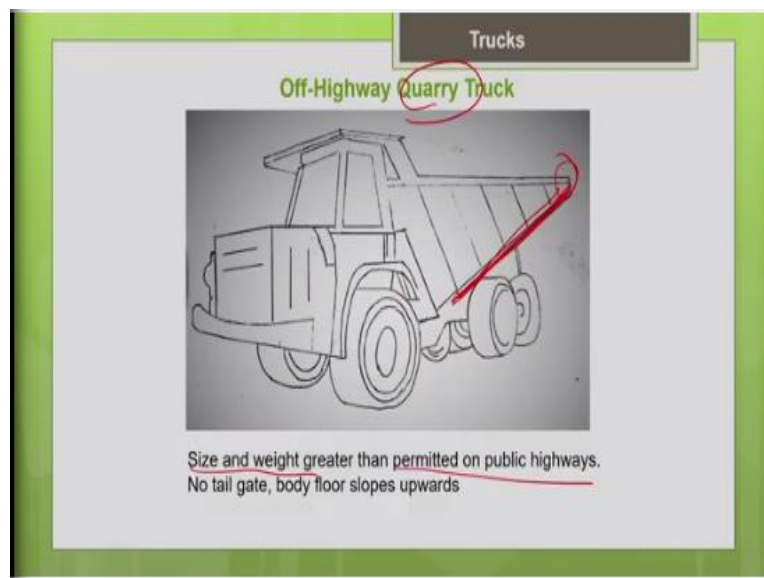
So, these trucks are very huge in size as I mentioned just now. So, commonly you can find it in the quarry, I will show you the pictures later. So, based on the method of dumping you can classify the truck into rear dump, bottom dump and side dump. Some trucks can dump the material at the rear end, some can dump the material through opening at the bottom, some can dump the material through the sides, so depending upon that we can classify.

Then depending upon the type of frame, as we discussed for the earlier missions also, here also we have rigid frame and articulated frame. And based upon the type of engine either it can be gasoline

or diesel-based engine, but more commonly you can see that most of the trucks are diesel-based engines. Then based upon the configuration of drive, this also we have discussed earlier, like how many axles are powered and the corresponding wheels will be driving wheels.

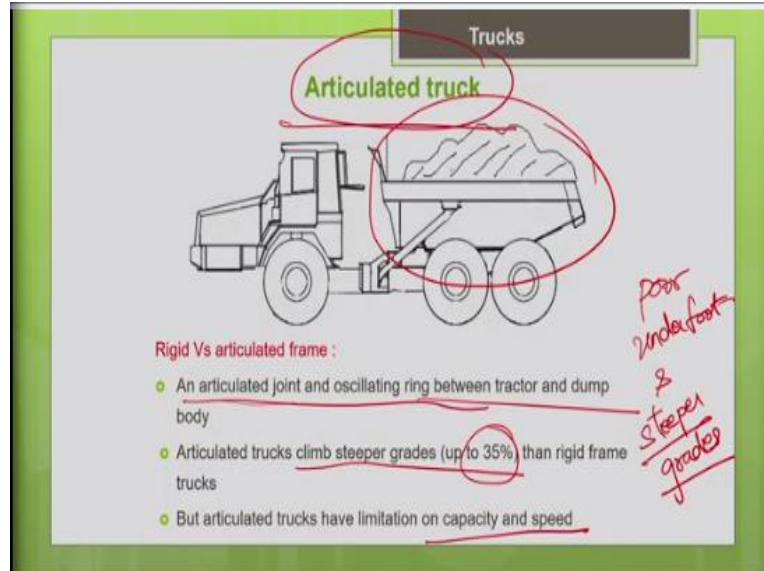
So, based upon how many wheels are driving, you can call it as 2-wheel drive, 4-wheel drive or 6-wheel drive. And depending upon the number of wheels and number of axles in the truck also you can classify. And depending upon the capacity of the truck, that is a capacity of the dumb body you can classify the truck. So, there are different means by which you can classify the truck.

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So, this is the picture of the off-highway quarry truck. As I told you it is commonly used in quarry, it is not permitted on public highways because its size and weight is greater than the limitations allowed for the public highways. And one thing you can note that is, it will not have a tailgate, so that is why you can see that the body floor will be sloping upward, you can see it is sloping upward. This kind of arrangement facilitates easy loading of the truck with the loader, so that is why it has this shape.

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So, the next type is based on the frame. As we mentioned earlier, we have rigid frame and articulated frame. Basically articulated frame is there will be a pivot joint, so the machine will be hinged between the front part and rear part, that permits the articulation, it will have a better turning ability when compared to the rigid frame. So, you have a articulated joint and an oscillating ring between the tractor and the dumb body, so this is the dump body.

So, between the tractor and the dumb body you have the articulated joint, so that will facilitate better articulation. So, this is commonly used for poor underfoot conditions, so poor underfoot conditions in the sense the terrain is very bad and you have to climb steeper grades. In that case you have to go for this articulated truck for tough conditions if the mission has to climb steeper grade or the terrain is to it is a clay area.

So, which is not possible for a rigid frame to maneuver, in that case you can go for the articulated trucks. They are basically designed for tough underfoot conditions, so they can claim steeper grades up to 35% while the rigid frame is commonly used for only up to 10% slope, I am talking about the slope. But another limitation of this articulated truck is, it is designed for poor underfoot conditions, so these trucks will have a limitation on it is capacity and the speed.

So, it is capacity as well as the speed will be lesser than the rigid frame truck, so depending upon your requirement whether it can go for rigid frame or articulated truck. And also, in confined areas

it is easy to work with this machine which has a better turning ability. So, based upon your requirement you have to make the selection but obviously articulated trucks are costlier when compared to rigid frame. So, but you have to justify the cost based upon the application.

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And the next one is your highway rear dump truck. So, you can see the picture the material is being dumped through the tailgate in the rear end. So, you can see the machine will be having a hydraulic jack system with that you can lift the dumb body and dump the material at the end. So, this is the one which is commonly seen, the commonly used one is rear dump truck. But if you look into the dump time, so basically when you go for real dumping, so it takes little bit more time.

This is because since you are dumping at the rear end you have to correctly locate the location where you have to dump it. Sometimes you have to travel some back distance to exactly locate the place and then dump it. So, this may increase the dump time, so for the rear dump mechanism the dump time is slightly higher. Obviously, it depends upon your type of material also, some material maybe easily flowing, in that case dumping will be relatively easier.

It also depends upon the capacity of your truck your truck capacity, the type of material all these things will influence the dump time. But basically, rear dumping takes more time because you have to exactly locate the location and then you may have to even travel in a backward direction to locate that location and then you have to dump it. **(Video Starts: 07:58)**

This video shows you the how the rear dump truck unloads the material you can see that with the help of this hydraulic jack system. So, the dumb body is lifted, so this is lifting it you can see that, it is lifting the dump body and the material can be unloaded through the tailgate. **(Video Ends: 08:24)**

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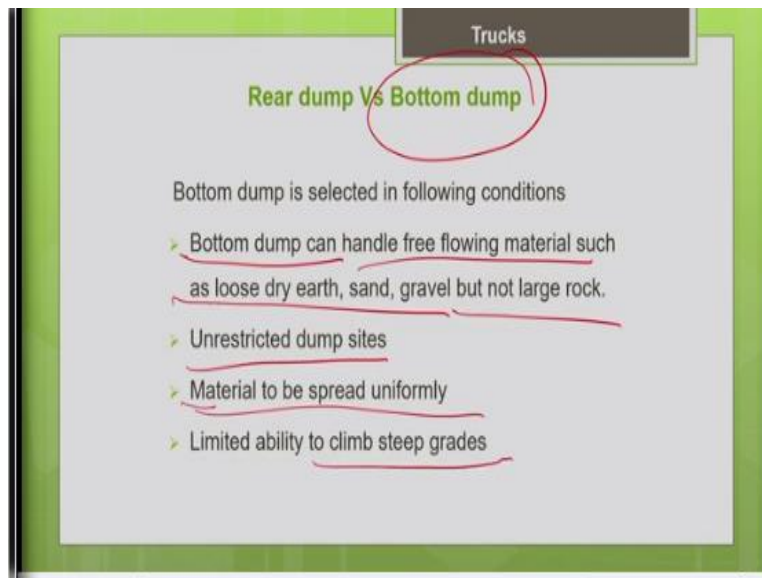
So, the next is about the bottom dump trailers. So, here you can see that dumping will be from the bottom opening. See you have a facility to unload the material to the bottom opening, so when compared to rear dumping this bottom dumping it will have a lesser time. So, this is because basically we go for these trailers this bottom dump trailers when you have to dump the material over a large area, you have to dump it and as well as spread it.

Actually, the machine will be moving and dumping together, the machine will be traveling and dumping together both the operations will be done in one stage. So, the machine will keep on moving as well as it will keep on dumping the material through the bottom end. So, for that you need a larger dumping area, so that this trailer can easily deposit the material in windrows they call it as windrows.

So, you can deposit the material in layers uniformly with this bottom dump trailers. Wherever you want to dump the material over a larger area and spread it uniformly and spread it in layers then

you can go for this bottom dump trailer. Since it is moving as well as dumping you can see that the dumping time is relatively lesser when compared to the rear dumping trucks.

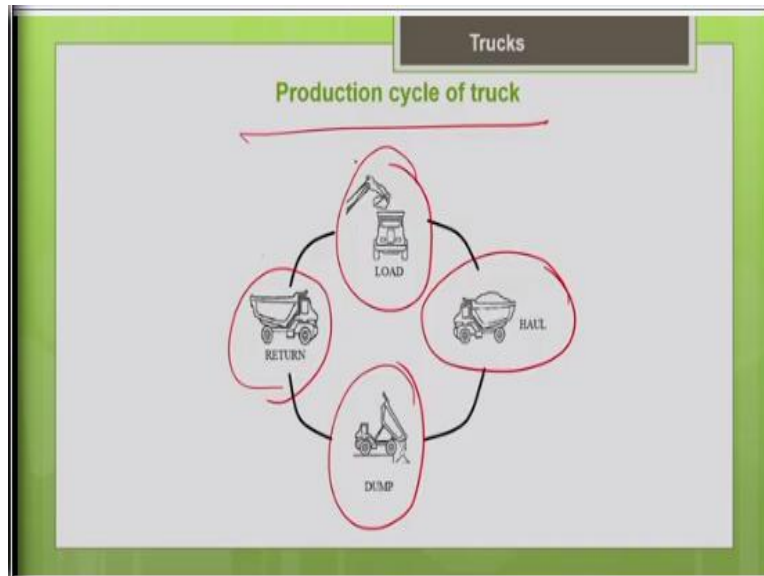
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But it has some certain conditions like as I told you the material should be free flowing in nature for the bottom dump. Like your loose dry earth or sand or gravel it should be loose material and it should not be large rock, so that can be handled with the bottom dump trailer. So, the material should be free flowing in nature and it should be unrestricted dump site.

That means we need a larger dumping site where you can uniformly travel and deposit the material in windrows. So, wherever you want to spread the material uniformly this will be the right choice, a bottom dump will be a right choice. But it has its own limitation it cannot climb steeper grades. These kinds of trailers cannot climb steeper grades.

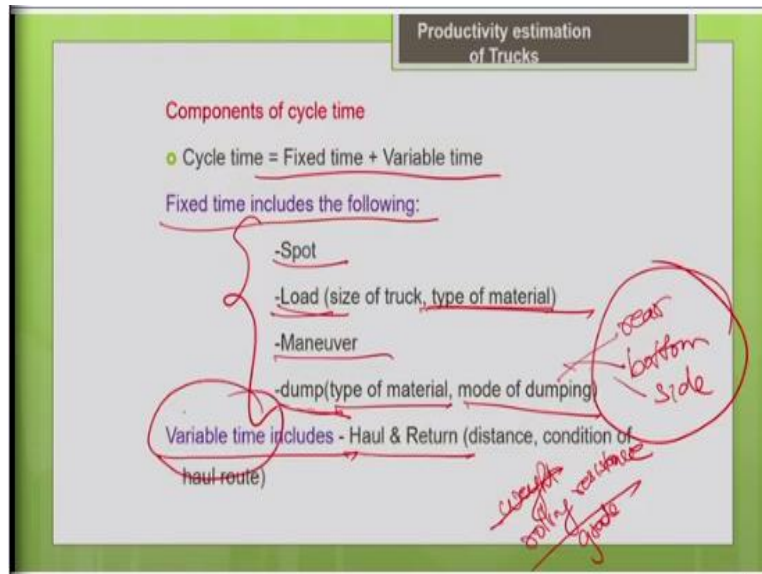
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So, now let us look into the production cycle of the truck we have discussed so far about the different types of trucks. Now let us move on to what is the production cycle of truck and what are all the different components of the production cycle? So, the first thing is your truck should spot the loader, so the truck is helping the loader, the loader should be spotted by the truck, so that spotting time is also included.

Then the loader will be loading the truck that is loading time, then your truck will be traveling with the load that is hauling. Then at the required dumping site it has to dump the material, then it will be returning in the empty condition get ready for the next cycle. So, all these things make up the one production cycle of the truck.

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So, as we discussed earlier some are fixed and some are variable. Some of the components are fixed and some are variable. So, what comes into the fixed time? So, under fixed time you are spotting of your loader, loading the truck obviously it depends upon the size of the truck and also depends upon the material. Some materials are easy to load, dry earth your sand and gravel are easy to load.

But blasted rocks, clay material are difficult to load so all these things will affect the loading time. Then whatever maneuvering changing gears and other things turning then dumping also comes under the fixed time. So, as I told you dumping will depend upon the type of material, some material can easily flow out there the dumping time will be less. Then it also depends upon the mode of dumping, in the sense whether you go for rear dumping or you go for bottom dumping or you go for side dumping.

So, all these things are going to affect your dumping time. But all these things make up your fixed time, because these are not going to vary with your haul distance. Then the variable time that is going to depend upon your haul distance your haul time and the return time that depends upon your distance as well as the speed. Speed you can get it from the performance out of the machine.

So, if you know the weight, if you know the resistances, that is a rolling resistance in your project side and the grade resistance in your project site, if you know this input data you can find the speed

of the machine. So, once you know the speed and once you know the distance I can calculate the variable time.

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Productivity estimation of Trucks

Determination of number of bucket loads

- Match truck and excavator capacity – maximum loading efficiency and reduced total costs.
- Use trucks having 4 to 5 times the capacity of excavator bucket.

$$\text{No. of bucket loads} = \frac{\text{Truck capacity (lcm)}}{\text{Bucket capacity (lcm)}}$$

Handwritten notes: = 4 to 5 (Ideal), 4 bucket loads, 5 bucket loads

So, now let us see how to estimate the productivity of the truck. To estimate the productivity of the truck these are the steps to be followed. First, I need to find what is the number of bucket loads needed to fill the truck, how many bucket loads are needed to fill the truck? That depends upon the capacity of your truck and the capacity of your bucket of the loader. So, as I told you these are interdependent machines we should go for compatible capacities.

That means you should not go for a small truck and a bigger loader or a bigger truck and a smaller loader. In both the cases your cycle time will be longer there will be unnecessary wastage of time. So, that is why you need to balance the capacity of the truck and the loader or the excavator. So, as we mentioned earlier it is based on the studies they have found out the truck capacity should be at least 4 to 5 times the bucket capacity.

Use trucks having 4 to 5 times the capacity of the excavator bucket, so this is the ideal case. So, this will give you a maximum productivity. So, match the truck and the excavator capacity that will result in maximum loading efficiency and reduced total cost. Because your cycle time will be reduced, your productivity will increase, so unit production cost will reduce. So, that is why we have to match the size of the interdependent machines.

Now let us determine how many number of bucket loads are needed to fill a truck. That depends upon the truck capacity and the bucket capacity, divide truck capacity by bucket capacity you will get the number of the bucket loads needed to fill the truck. This is the balance number, hopefully you should get between 4 to 5 for the ideal case. See if you get a whole number it is fine you can either go for the 4 buckets or 5 brackets.

But if you are getting some decimal numbers say 4.2, in that case you have to round the bucket load either I should round it to 4 or I should round it to 5. But basically, when it is less than 4.5 we round it to 4, but if it is greater than 4.5 in that case it is better to work out the economics of both the cases. Then if I go for 4 bucket loads what will be the unit production cost? If I go for 5 bucket loads what will be the unit production cost? It is always better to work out the economics of both the cases and make the choice.

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Productivity estimation of Trucks

Load time & truck load volume

- If no. of bucket loads rounded to next lower integer lower than balance number of loads
- Load time = no. of bucket loads x bucket cycle time
- Truck loads (short) = no. of bucket loads x bucket volume.

Handwritten notes:
 no. of bucket loads
 < balance no. of loads

Now let us see the cases like one thing is say for example if I am going to round the bucket load to the lower number. Say I got a decimal number and I am rounding it to lower number.

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Productivity estimation
of Trucks

Determination of number of bucket loads

- Match truck and excavator capacity – maximum loading efficiency and reduced total costs.
- Use trucks having 4 to 5 times the capacity of excavator bucket.

$$\text{No. of bucket loads} = \frac{\text{Truck capacity (lcm)}}{\text{Bucket capacity (lcm)}} = 4.2$$

ideal
 4 to 5
 4.2
 4
 5

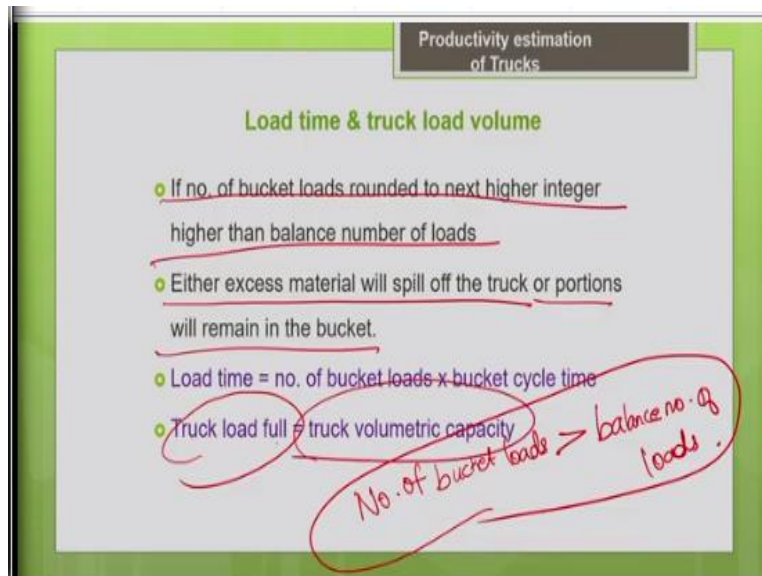
So, I got 4.2 and I am rounding it to 4 buckets. In that case how to work out the truck load and the load time, that is what we are going to see now. How to estimate the load time and the truck load volume? When the number of bucket loads are assumed to be lesser than the balance load. If the number of bucket loads rounded to next lower integer lower than the balanced number of loads, then what will be the load time?

Load time is nothing but your number of your bucket loads that is the number of cycles of the bucket loads multiplied by the bucket cycle time what is the per cycle bucket cycle time. So, number of bucket loads multiplied by the bucket cycle time will give you the loading time, loading time for your truck. Now how to find the truck load? In this case since the number of bucket loads is lesser, here we are taken number of bucket loads lesser than the balance number of loads needed to fill the truck.

So, obviously we are not going to fill the truck to it is full capacity the truck will be short load, truck load will be short. So, sometimes we prefer for short load say for example when you are climbing steeper grades we do not prefer loading the truck to it is fullest capacity we prefer short loads. So, in this case since the number of bucket loads is lesser than the balanced number of bucket loads it is called as short load.

So, the truck load is not equal to the truck full capacity, here how to calculate the truck load? It is nothing but number of your bucket loads multiplied by the bucket volume, number of bucket loads multiplied by the bucket volume will give you the truck load. And this is not going to be equal to the full capacity of a truck as you know.

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Now the next case is say the number of bucket loads which we are going to adopt is greater than the balanced number of loads. So, now we have rounded it to the higher end say instead of I got 4.2 and I am rounding it to 5, say for example I am rounding it to 5. In this case it means I am trying to load the truck beyond its capacity, so obviously there will be spillage of material.

So, if number of bucket loads rounded to next higher integer higher than the balanced number of loads either the excess material will spill off the truck or some portion of material will remain in the bucket of excavator itself. So, either way it can happen but one thing you should know that what you can load only to the truck capacity, we cannot load beyond that, excess material will definitely spill off. So, here you have to take the truck load is full and it will be equal to the truck volumetric capacity.

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Productivity estimation of Trucks

Load time & truck load volume

- If no. of bucket loads rounded to next higher integer higher than balance number of loads
- Either excess material will spill off the truck or portions will remain in the bucket.
- Load time = no. of bucket loads x bucket cycle time
- Truck load full = truck volumetric capacity

~~$\text{no. of bucket loads} \times \text{bucket volume}$~~

Your truck load is full here and it will be equal to the truck volumetric capacity, you should not take it as the number of bucket loads multiplied by the bucket volume as you did for earlier. Number of bucket loads by bucket volume you are not going to follow that earlier formula. This way you should not calculate for this, because here the number of bucket loads are more than the balance number of loads.

But even though it is more than the balanced number of loads I cannot load it beyond the capacity of the truck, truck maximum capacity will be the limiting capacity. So, in this case you should not go by this the truck load will be equal to truck volumetric capacity only, you have to follow that.

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Productivity estimation of Trucks

Load time & truck load volume

- If no. of bucket loads rounded to next higher integer higher than balance number of loads
- Either excess material will spill off the truck or portions will remain in the bucket.
- Load time = no. of bucket loads x bucket cycle time
- Truck load full = truck volumetric capacity

~~$\text{no. of bucket loads} \times \text{bucket volume}$~~