Surface Mining Technology
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Lecture 26
Excavation with Shovel - III

Let me welcome you to the 26th lecture of surface mining technology. We are continuing with excavation with shovel, this is the third lecture in this series. And in this lecture we will discuss about the performance analysis and layout. So, let us continue in this lecture.

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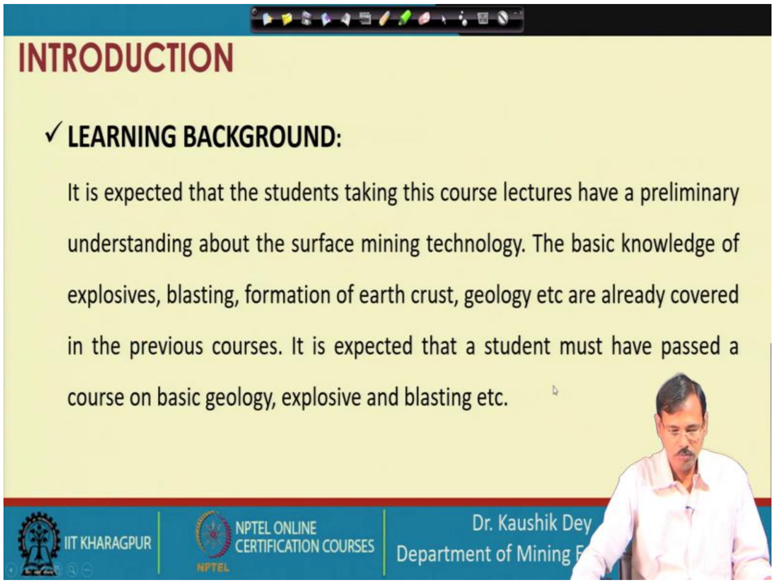

So, as the let us take a glimpse of the learning background of surface mining technology course.

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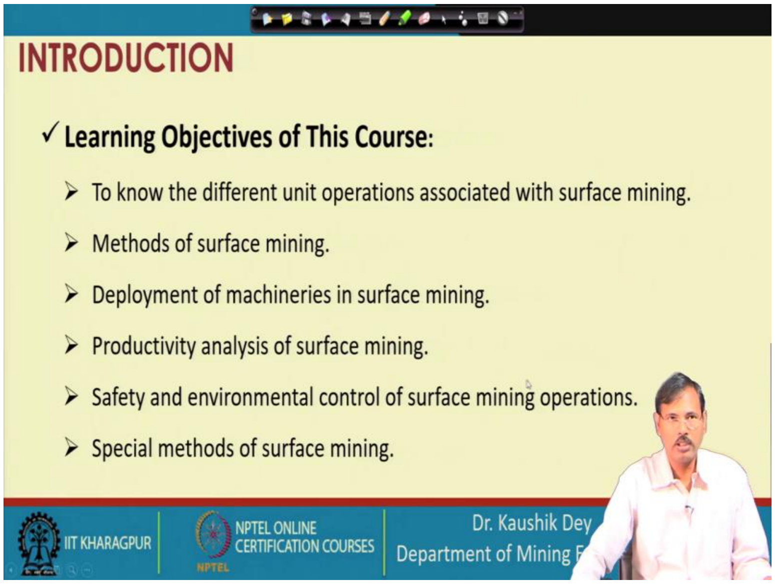

Let us look into the learning objective of surface mining technology course.

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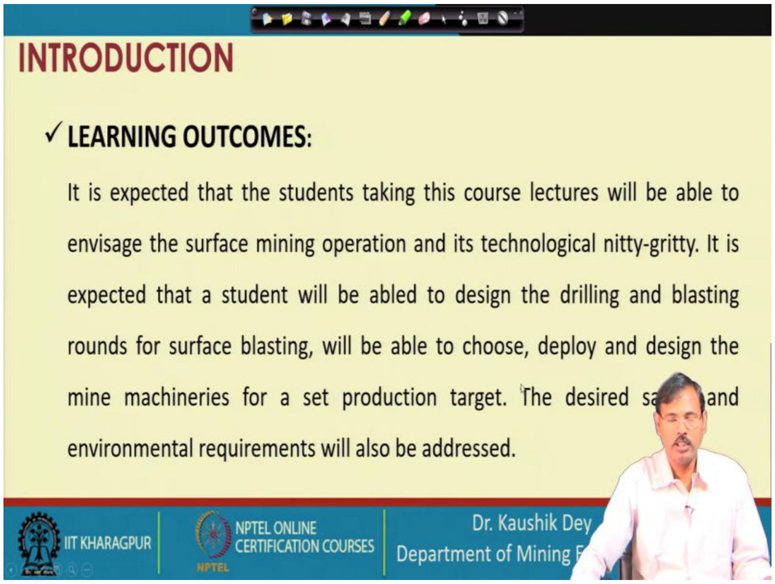

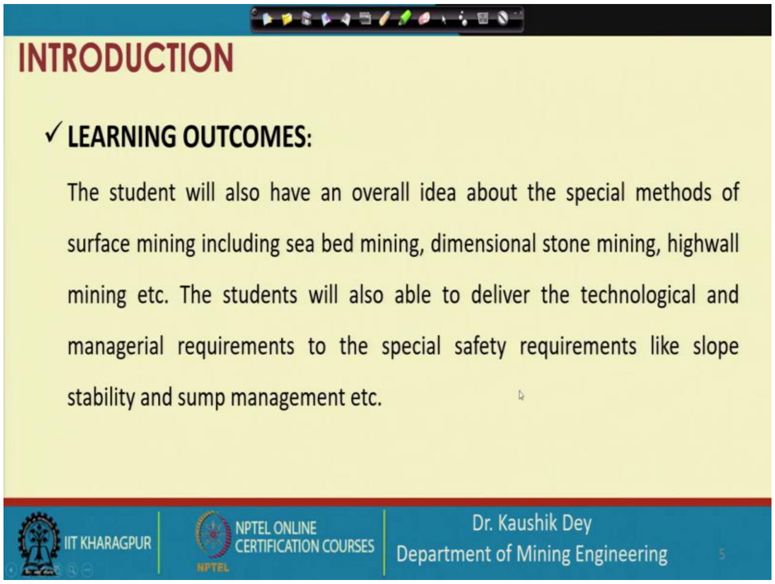

And this is the expected learning outcomes of surface mining technology course.

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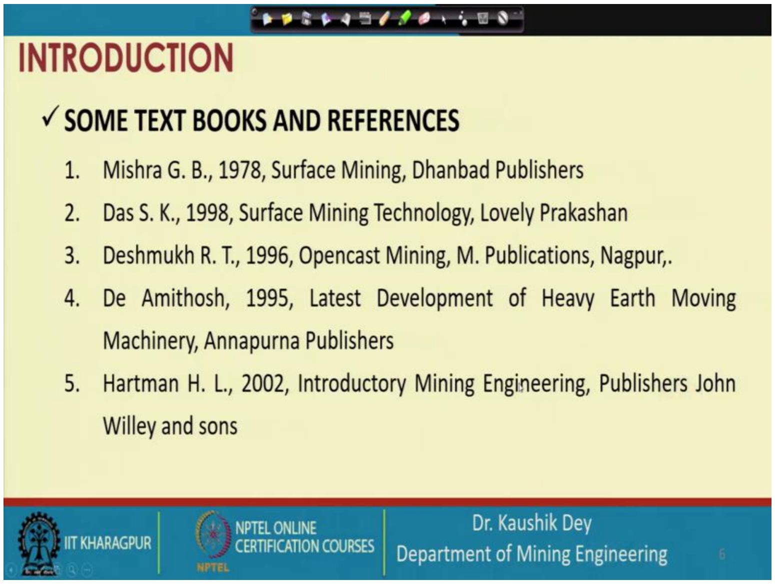

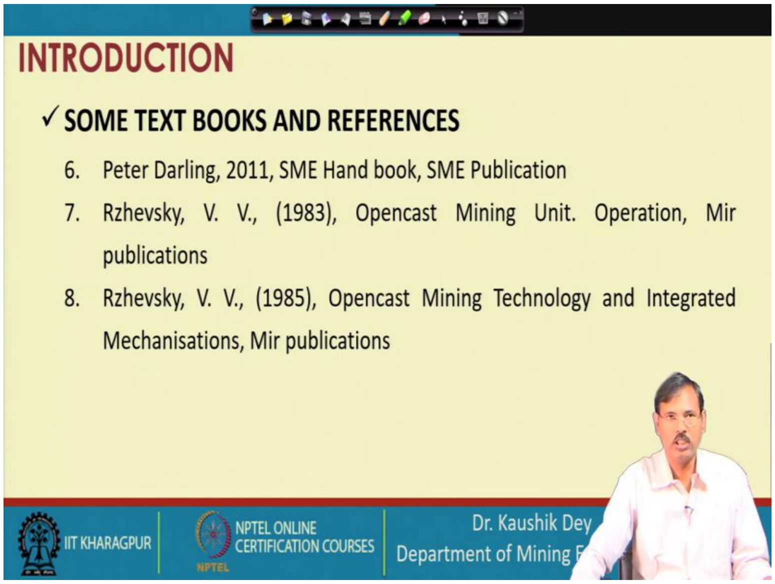

And these are the textbooks and the references, these are some more references.

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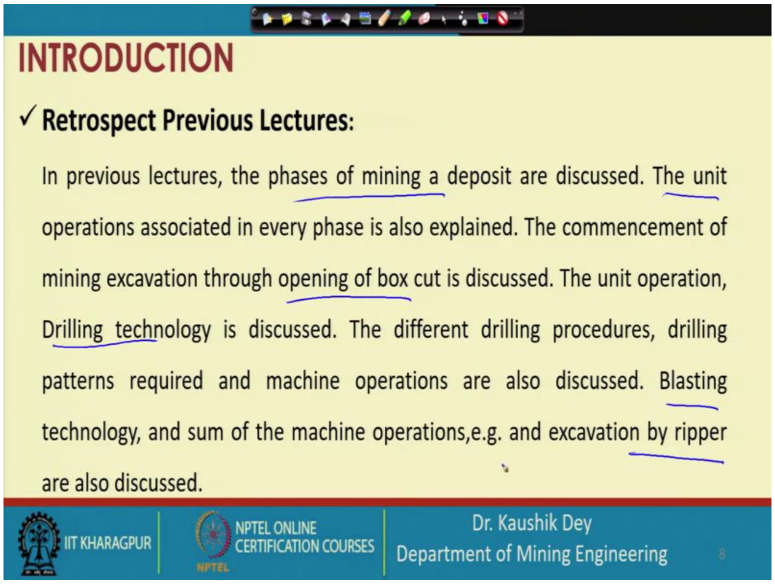

And so, far we have and so, far we have covered the phases of mining a deposit by surface mining technology. We have also discussed the unit operations associated with every phase. We have also discussed the starting of surface mining through the box cut, we have covered the drilling technology we have covered the blasting technology. And as we have discussed in the few class related to blasting technology, ripper is used for excavation or loosening the rock material.

Then we are continuing with the excavators in which an excavator is used to excavate either the blasted rock mass or very loose insitu rock mass or the rock mass which is ripped for the loosening. That of mass can also be as excavated using an excavator. So, this is the excavation by a shovel we are continuing here.

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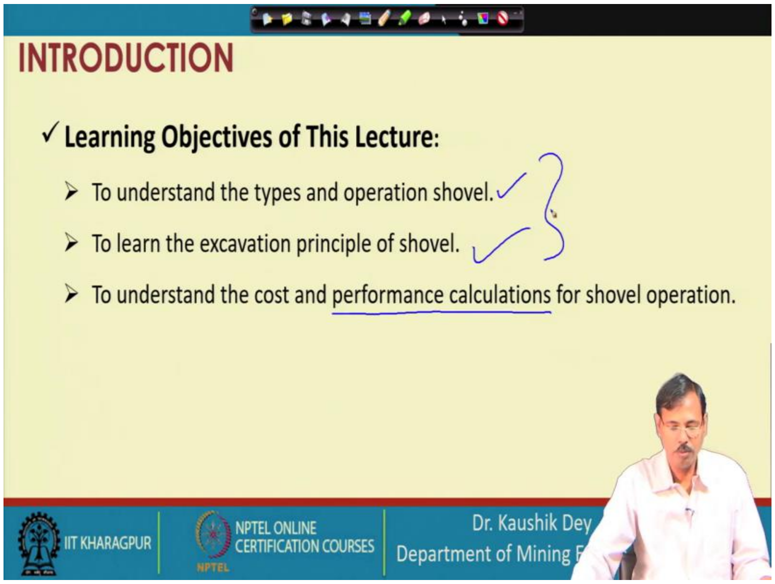

So, the objective of this lecture series on excavation by a shovel is to understand the types of operations of a shovel to learn the excavation and principles of the shovel. These are already discussed and over, and we are in this lecture, we will try to understand the performance calculation of shovel will also solve some tutorials related to this, and this is the main objective of this lecture.

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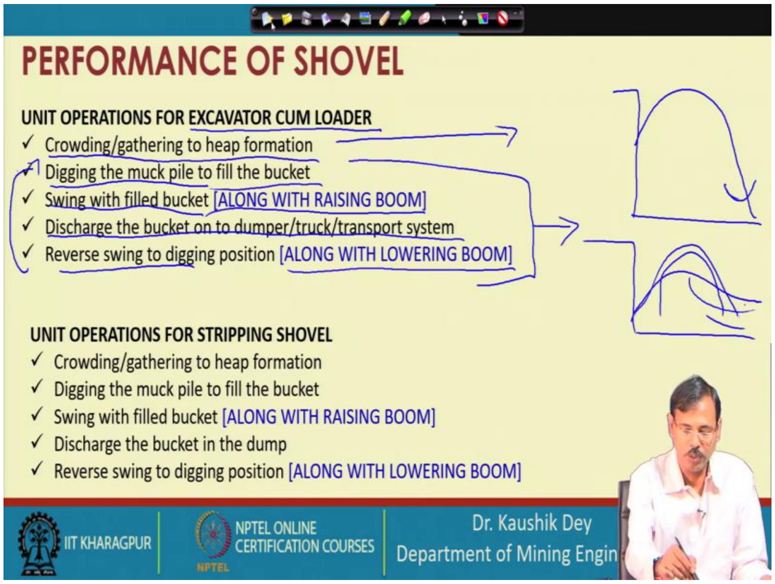

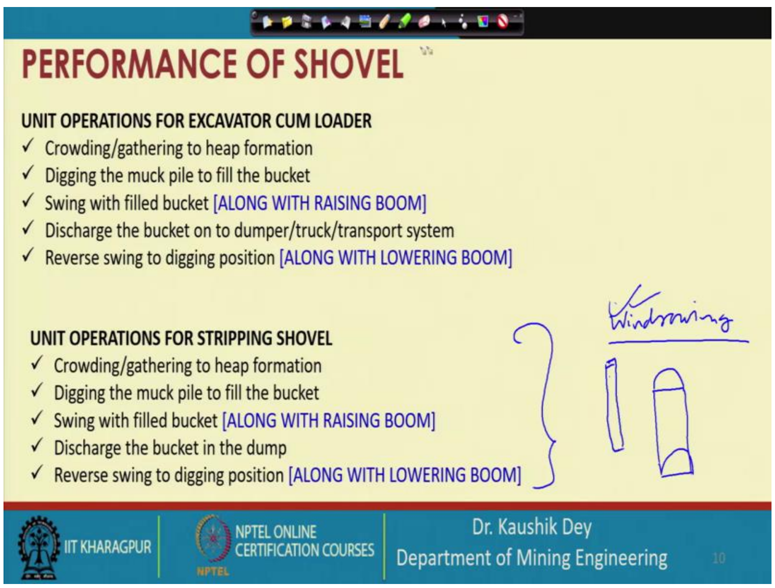

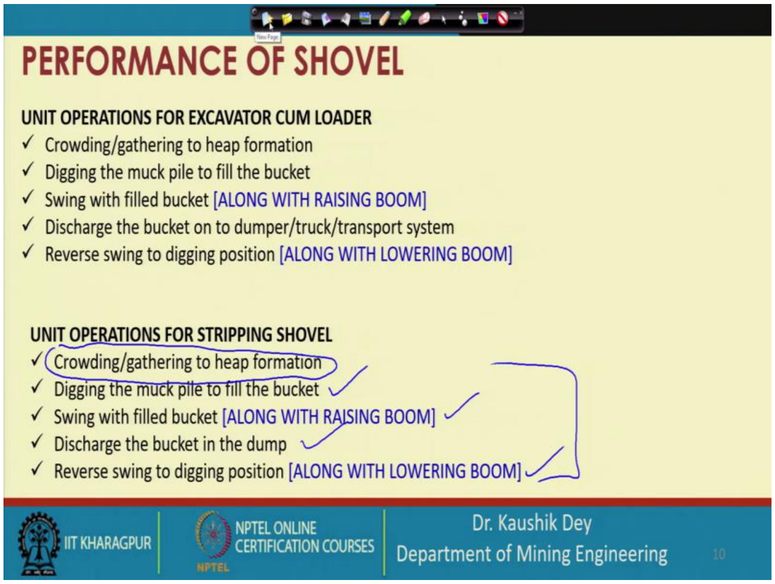

So, to analyze the performance of a shovel, we have to understand the unit operations carried out by shovel every time it loads a bucket. So, you can see when this excavator is just shovel is operating as excavator cum loader so, it is excavating the blasted mark and loading that to your transporting system say dumper in this case. So, it needs to first go for crowding or gathering to form a hap.

Then he has to dig the muck pile to fill the bucket; then, he has to swing with the filled bucket. And during the swinging, he has to raise his boom to the height from which it can dump to the dumper, and then it discharges the bucket to the dumper truck or whatever transportation system is there. Then he must return to digging the muck pile again at this position. So, this is the reverse swing to the digging position, and he has to lower the boom automatically during this time.

So, he must complete this cycle before dumping a bucket into the dumper each intome. So, from time to time, he has to complete this second every time it is filling a bucket, and from time to time, he has to count the fragmented material and gather the fragmented material to provide a heap so that its bucket filling efficiency will increase. So, if the blasted muck profile we have already discussed is like this. So, the digging efficiency of the soil is increasing.

But if the blasted muck pile becomes like this, then the efficiency will not be that much. So, the shovel has to create its own heap like this so that it can carry out a better performance. So, this is carried out. These are the operations in general carried out by an excavator, or you can say shovel, but if the shovel is not dumping the material onto the dumper, it is making a hip say like stripping shovel is doing.

Sometimes this shovel is also made to go for windrowing; this term is new windrowing, windrowing means make a heap in a row makes a heap in a row. So, this is a heap; this is a heap like this set. So, if you make a heap in a row like this, that is called windrowing, often you can see them when the drainage is being dug. So, that time that material is heaped at the side of the drain, it can be later on-field or some underground excavation work is carried out for laying cable, etc.

So, the material is dug and kept in the side of that opening. So, that is called windrowing. So, making a heap in a row is called windrowing. So, often shovel is also going for that one, if that type of excavation is carried out, then our unit operations will become this part will be common. So, the digging the muck pile, swing the bucket with raising boom discharge material on the dump, and returning to the first position. So, it will remain only this part.

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So, let us look at how this is being operated once in a video. So, this is a loading operation. You can see this is the dumping. So, this video starts with dumping. Now, see bucket is being moved along with it is lowered. Now, it is the material dig material is being dug. And now it is moved with raising boom you can see the boom is being raised and dumped onto the truck. So, this is a smaller size truck.

So, now see it is started gathering the material, it is started gathering the material. So, when the dumper is being pushed, it is picking the material. Now it is loaded loading the material into the bucket and swinging with the loading, raising the boom then dumping the material onto the truck. Again, lowering the boom swinging with lowering the boom filling the bucket and now filling the bucket again it is now swinging with the raising boom see singing along with it is raising the boom also.

So, it is swinging and raising the boom. So, we consider some of these the control system was given to the operators is such that in one hand in the joystick, the swinging system is given in another hand of the joystick the boom lowering and raising system is given so that the operator can control both the operation simultaneously. So, this system is used for shoveling for filling the trucks.

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So, now let us look once this video we have already seen see this is moving along with you see the bucket is being lowered and this is filled bucket is being moved along with raising the stick. So, this is the same case only here. It is not the only one here. It is not that it is filled with the material, but it is you can see it is dumping the material. So, it is dumping the material instead of filling it. So, that is the difference in the stripping that we have seen already seen in the previous class.

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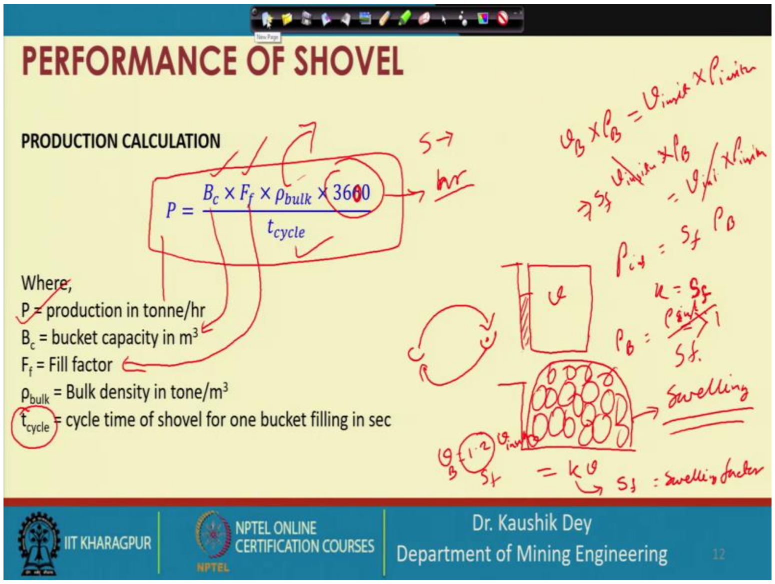

Now, how you can calculate the performance? The performance can be calculated using the formula P is equal to Bc into Ff into rho bulk into 3660. This is actually, I think, 3600 to convert the seconds to an hour, seconds to hour 3600, and this is the cycle time. So, you can see P is the production in tonne per hour, Bc is the bucket capacity in meter cube Ff is the Fill factor. That means the proportion of the bucket is filled in the Field factor and rho bulk is the bulk density of the fragmented material.

So, this is the insitu hollow before blasting after blasting. As the new surface area is created here, this portion will become a fragmented rock mass. So, this portion is increased in volume. This is called swelling. So, as the swelling occurs, this increases in volume, so this volume p will become k into v. Let us give this term k as Sf, which is the swelling factor so, as this is increased. So, k is equal to the swelling factor and should always be greater than one as it is increased in the volume.

So, in general, if it is v is say 1.2 of sorry, this v bulk will become 1.2 or maybe something else Sf into v insitu. So, in another way, if you are instead of volume, looking into the density, the mass will remain the same. So, vB bulk multiplied by rho bulk then equal to v insitu into a rho insitu. So, we know that vB is similar to Sf into v insitu into rho v is equal to v insitu into rho insitu.

So, v insitu, v insitu will cancel. So, rho insitu is equal to Sf into rho bulk. So, if rho bulk is given, that is rho insitu by Sf. So, generally, as Sf is more than 1 bulk density is less than the insitu density that is understood. So, we have not considered that part here because we have already taken the rho bulk if insitu density is given then we have to consider insitu density divided by the swelling factor in this case.

So, this is the fill factor this is bucket capacity, this is rho bulk, this is second to this and t cycle is the cycle time of shovel to fill one bucket. So, basically this cycle time means filling the bucket turning the bucket with raising then dumping onto the bucket dumping onto the truck then returning with the lowering for filling. So, together this is called one cycle which we have already seen in the video. So, let us go for completing one tutorial here.

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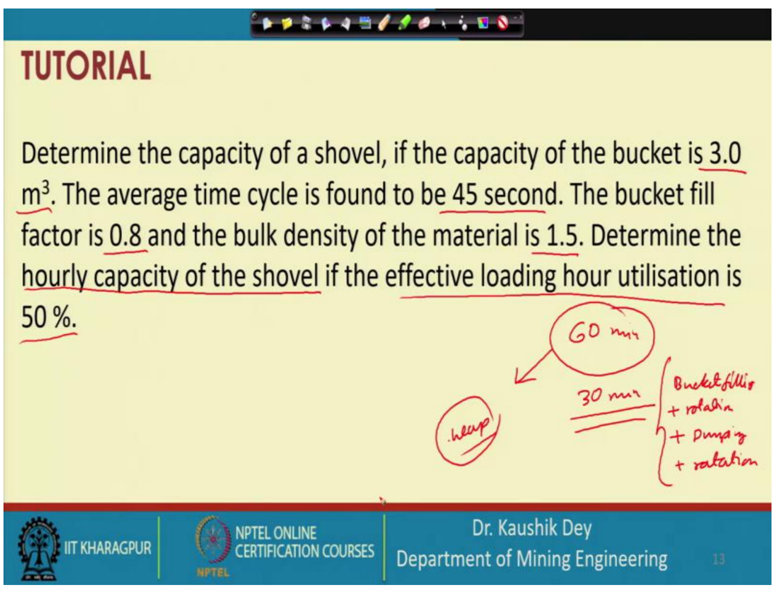

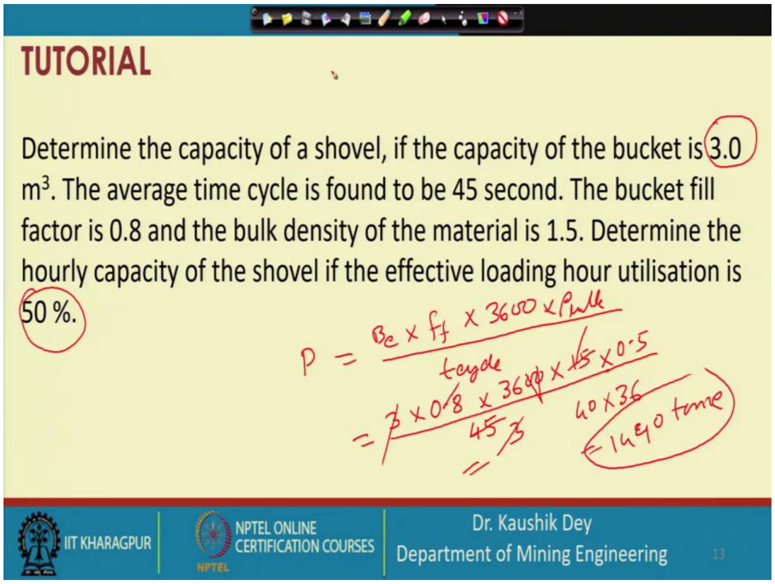

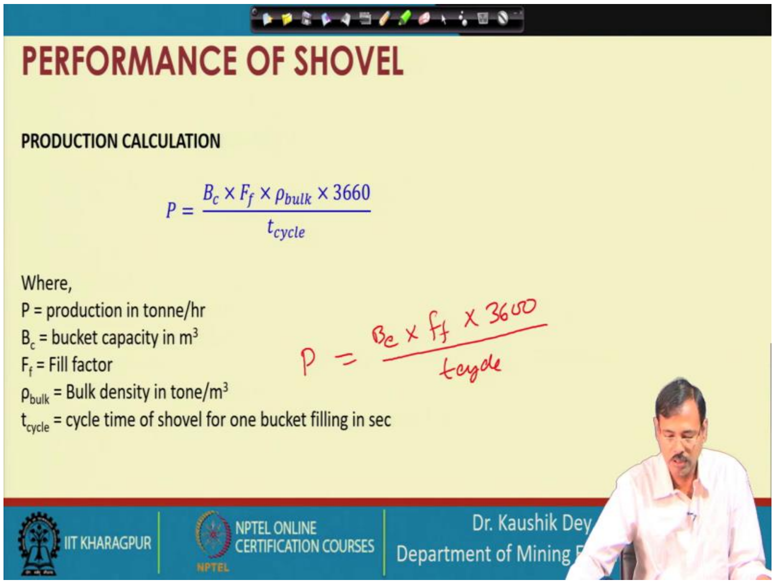

So, consider the capacity of the shovel is determined the capacity of the shovel, it is given that bucket size is 3 meter cube cycle time is given 45-second fill factor is pointed bulk density of the material is given, and we have to find out the hourly capacity of the shovel if the effective loading hour utilization is 50 percent that means, we are considering in one hour if 60 minutes is there, we are only having 50 percent of the time that means 30 minute is only available for the loading purpose that is means bucket filling plus rotation with raising boom plus dumping onto the truck plus the rotation to the refilling rotation for bucket filling.

This is for this the time available is 30-minute rest 30 minutes is required for heap formation, or you can say the making the proper or cutting the material from the bench all these things are required only in that case. So, this is the requirement it is given. So, let us solve this problem. So, the bucket capacity, we have to find out the production. So, we know the formula bucket fill factor into 3600 divided by the t cycle as this formula is given earlier.

So, this is rho bulk have missed so, into rho bulk is there. So, let us calculate it. So, Bc is given 3-meter cube fill factor is given 0.8 this is 3600 and rho bulk is given 1.5 and t cycle is given 45 seconds and in this 3 6, we are having the efficiency of 50 percent So, only 30 minutes is available. So, 50 percent is considered here. So, if we are doing this so, these are removed. So, this is 40 into 36. So, this is the answer. So, this is the hourly capacity of this 3-meter cube shovel. It will load 1440 tons of material onto the truck. So, that is the possibility. Let us look into the solution here.

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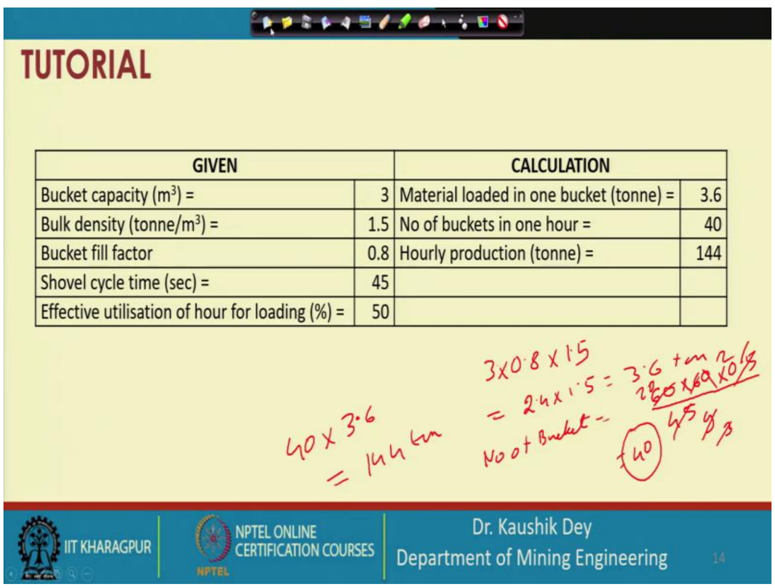

So, I think I have created some problems with the 0 probably. So, as it is calculated 3, meter cube material loaded in one bucket is three into 0.8 into 1.5 2.4 into 1.5 is equal to 3.6-ton number of buckets per hour. In one hour, there are 60 minutes, 60 into 60 seconds, and we are having the second time of 45 seconds, and this is only 30 minutes is available. So, that is 0.5. So, 40 buckets we can load in 30 minutes. So, the 40 into 36 3.6, 40 into 3.6 that is 144-ton material can be taken out. So, probably in the previous one, I missed a 0 in the calculation. So, that is why 1440 has come, but this is the right calculation. So, it will become 144 tons of material that can be taken out in 1 hour.

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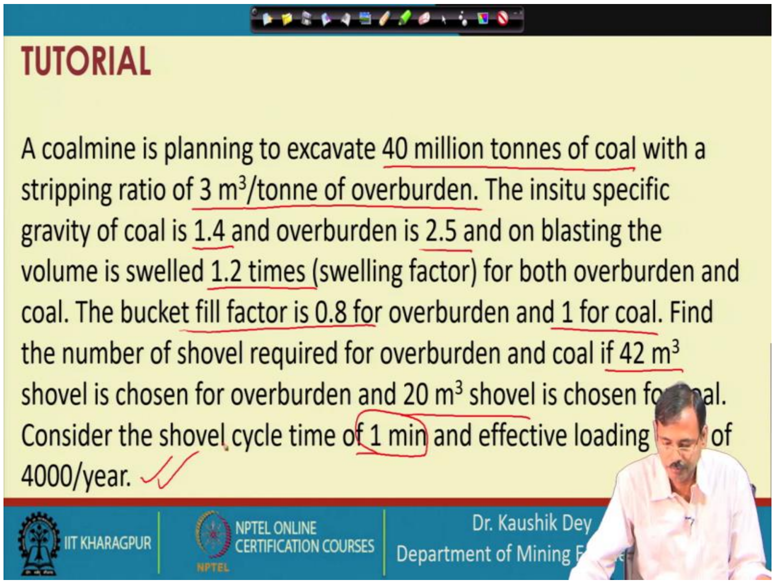

So, let us solve the next problem in this problem we have to excavate 40 million tons of coal with the stripping ratio of 3 meter cube per tonne of overburden. Now, 3 meter cube of overburden per tonne of coal insitu specific gravity of coal is given overburden is given and blasting for both the cases swelling of 1.2 times is assumed that means swelling factor is 1.2 bucket fill factor is 0.8 for overburden 1 for coal and the shovel deployed in overburden is 42 meter cube and 20 meter cube in case of coal. So, if the cycle time for both the shovel is one minute, the effective loading hour is 4000 per year. So, now 4000 hours are available for loading by this shovel, then we have to determine the number of shovel to be deployed in both the cases.

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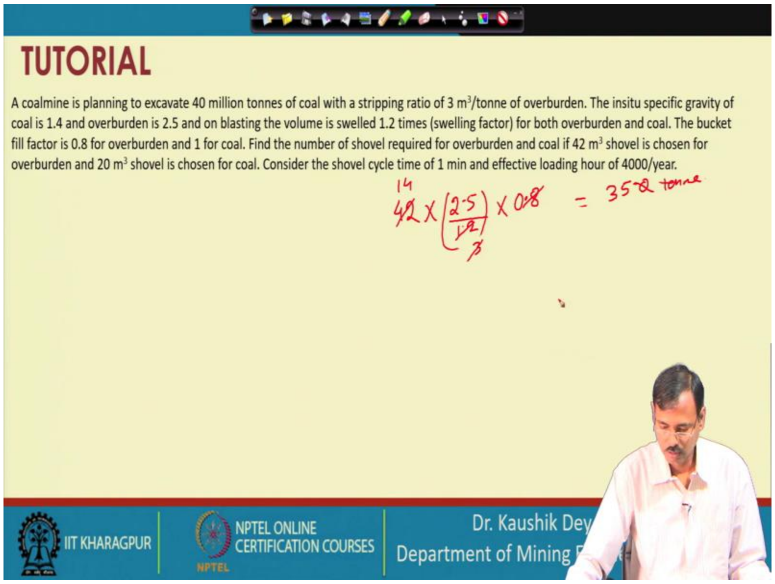

So, let us find out the capacity of one bucket. So, for overburden it is 42 meter cube and material density is 2.5 but that is having a swelling factor of 1.2 so, that is the material density and the fill factor is for is 0.8 and this is for overburden. So, bucket capacity fill factor bulk density, so, this is the capacity of one bucket. So, this is I think 3 so, this is 14 so, I think this is 25 so, this is I think 35 tonne if I am not made any calculation mistake here. So, that is the capacity of one bucket.

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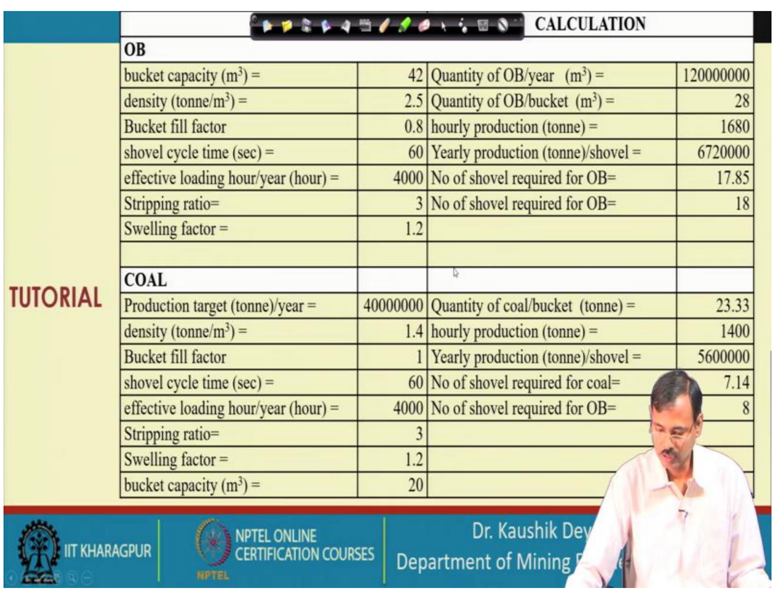

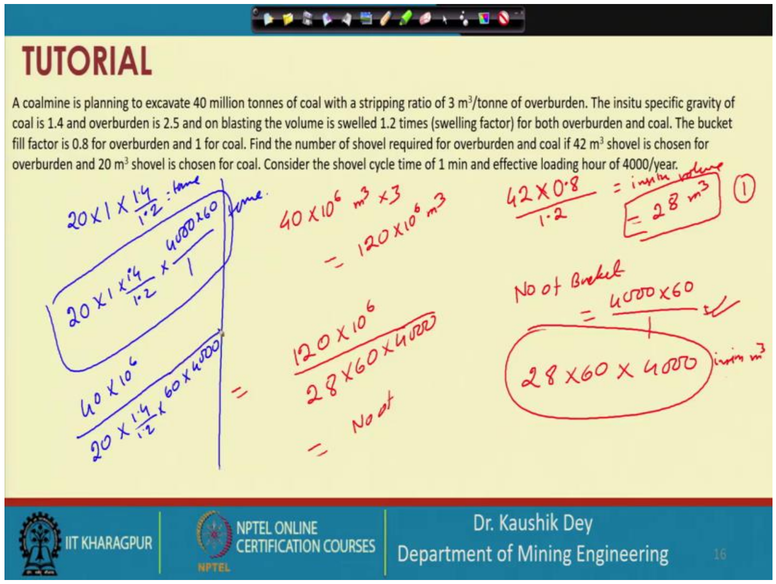

Let me check once otherwise, I will continue with the mistakes I think 28 tonne 42, 2.5 in 0.8 considering this 42 into 0.8 that is the fill factor and this is 2.5 into 1.2 that is meter cube. So, I have come out with the tonnage. So, 42 in 0.8 is in the meter cube. So, that is coming 28. So, we have come out with the densities actually we need not to go for calculation of tonnage. That is that actually we need not to have calculation of tonnage for overburden. So, for keeping overburden you can come out with the density only volume only.

So, this is in 2.8 that is the fill factor and the insitu volume we have to convert that to soiling volume. So, this is if it is considered this has to be divided by 1.2 to have the insitu volume that is coming to 28-meter cube. Now, our insitu volume to be excavated is 40 into 20 per 6-million-meter cube into 3 as the stripping ratio. So, 120 into 20 power 6-meter cube has to be excavated.

Now, for excavation of this one we are taking this much of insitu volume with one bucket and as the cycle time is one minute in one-year number of buckets we can take that is 4000 into 60 divided by 1 that much number of buckets we can excavate. So, the one machine can excavate 28 into 60 into 4000 insitu meter cube of material. And now, if we divide it with this will give you the number of shovel required. So, we have already calculated this part.

So, we will see the whole calculation after doing it for the coal. So, for coal, if we are calculating we are having 20-meter cube shovel that is filled one is the fill factor is one and the density of the coal is 1.4 by 1.2. So, that much of tonne of material we are taking out by one bucket. So, this is coming around something is not calculating here. So, in one year, we are taking out 20 into 1 into 1.4 by 1.2 into 4000 in 260 by 1 tonne of material. Now, our production target is 40 into 20 power 6. So, the number of shovel required is divided by 20 into 1.4 by 1.2 into 60 into 4000. So, this is the requirement. So, this is 2. So, whatever it is coming let us see the calculation.

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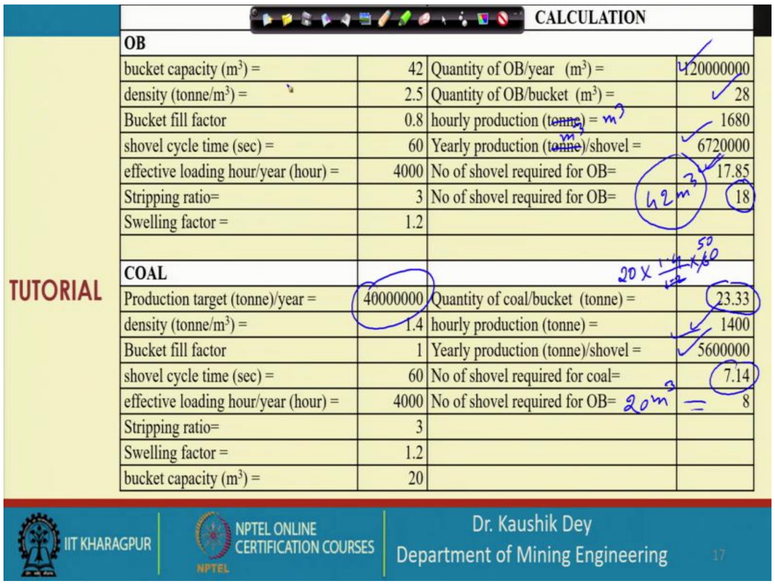

OB			
bucket capacity (m^3) =	42	Quantity of OB/year (m^3) =	120000000
density (tonne/m^3) =	2.5	Quantity of OB/bucket (m^3) =	28
Bucket fill factor	0.8	hourly production (tonne) =	1680
shovel cycle time (sec) =	60	Yearly production (tonne)/shovel =	6720000
effective loading hour/year (hour) =	4000	No of shovel required for OB=	17.85
Stripping ratio=	3	No of shovel required for OB=	18
Swelling factor =	1.2		
COAL			
Production target (tonne)/year =	40000000	Quantity of coal/bucket (tonne) =	23.33
density (tonne/m^3) =	1.4	hourly production (tonne) =	1400
Bucket fill factor	1	Yearly production (tonne)/shovel =	5600000
shovel cycle time (sec) =	60	No of shovel required for coal=	7.14
effective loading hour/year (hour) =	4000	No of shovel required for OB=	8
Stripping ratio=	3		
Swelling factor =	1.2		
bucket capacity (m^3) =	20		

So, see in this case, this is the overburden to be handled insitu overburden is the insitu volume we have come out with that calculation then this is actually not tonne, this is in meter cube insitu meter cube, this is into 60 this is also meter cube. So, this is the meter cube, so, number of shovel required is this one divided by this one that is coming 17.8. So, the number of shovel required in overburden is 18 42 meter cube, the shovel is required.

Similarly, for coal, we have seen, it is tonnage that is 20 into 1.4 by 1.2. So, that is coming 23.33 and our live production is coming this is into 60. So, you can come out in this, this is into 60. So, 100 into 1.4 so, that is coming. So, the yearly production, this is into 4000 to 60 and the number of shovel required. So, this is divided this divided by this.

So, this 7, so, number of 20 meter cube shovel is required 8 numbers for the coal handling. So, this is the population of the shovel expected for achieving that much production. So, this is considered since these are the simple capacity calculations we have carried out in a tutorial for the performance analysis of a shovel. So, let us stop at this position we will continue in the next class. Thank you.