Surfacing Mining Technology
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Lecture – 30
Transportation in Surface Mines - 3

Let me welcome you to the 30th lecture of NPTEL online certification course of Surface Mining Technology. The topic of this lecture is transportation in surface mines. This is the third and final lecture in this series, and in this lecture, we will continue with the shovel dumper combinations and how the shovel and dumper can be matched; we can discuss related to that.

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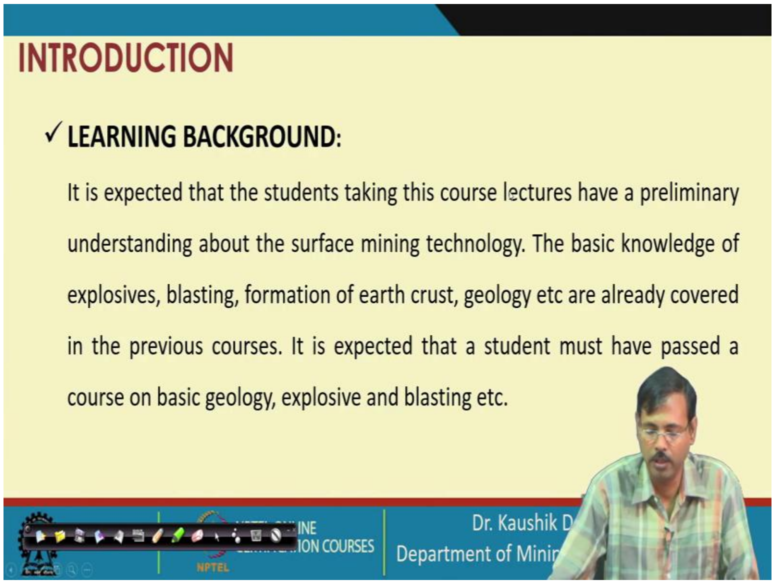

But before starting that, let us look into the learning background required for the Surface Mining Technology course.

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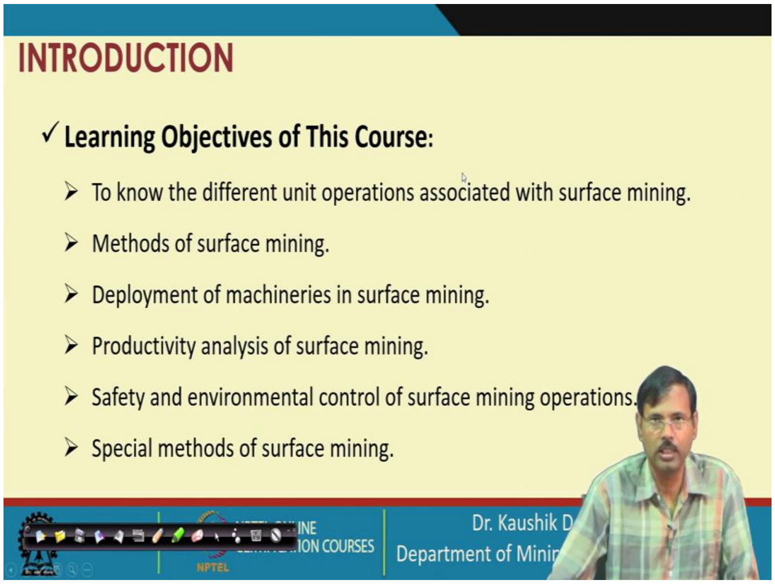

These are the learning objectives for the Surface Mining Technology course.

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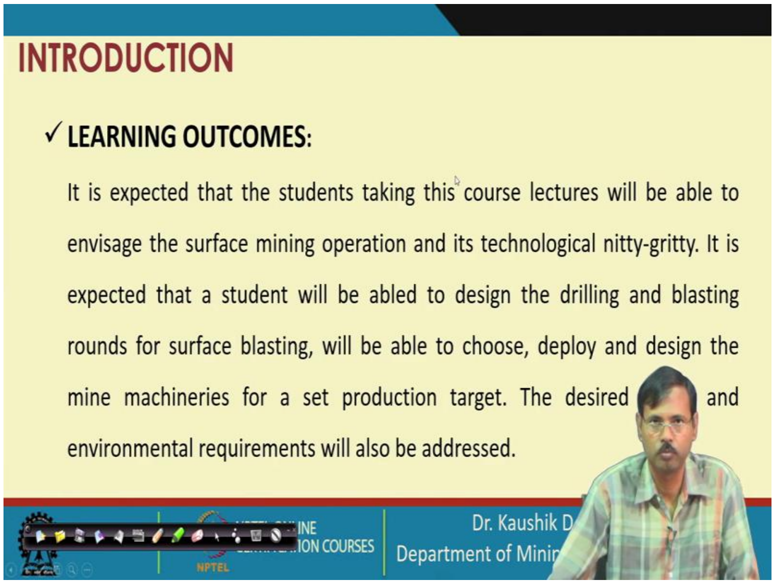

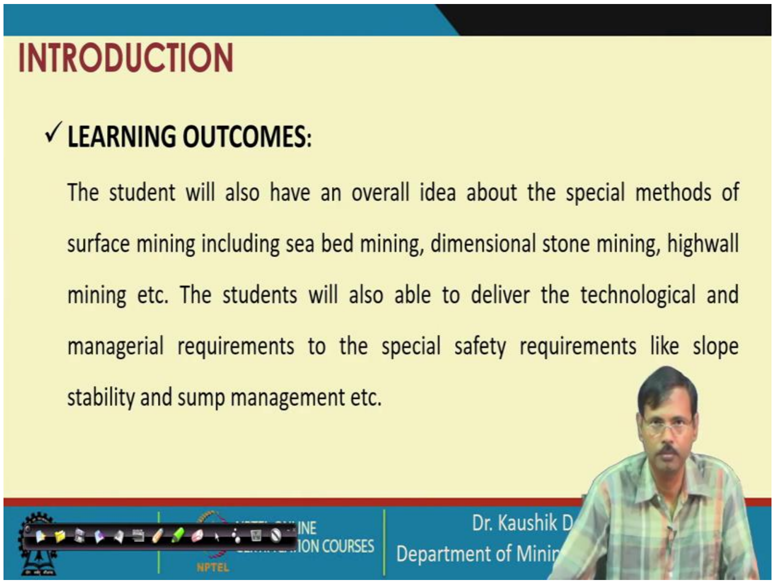

And these are the expected learning outcomes.

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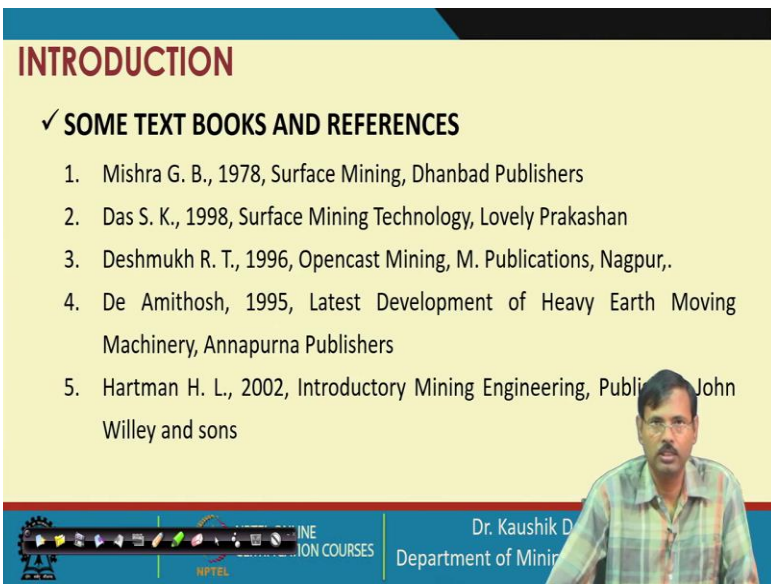

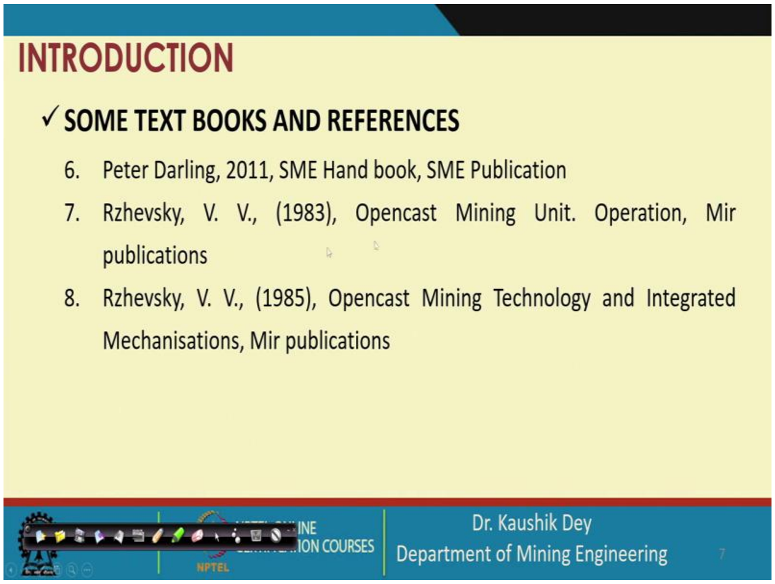

And these are some of the texts and reference books the participant can follow for this particular shovel dumper combination. This book may be a bit useful; this can be referred apart from that the books on this opencast mining unit operations and opencast mining technology and integrated mechanization. These two books are also very good pertaining to this shovel dumper combination.

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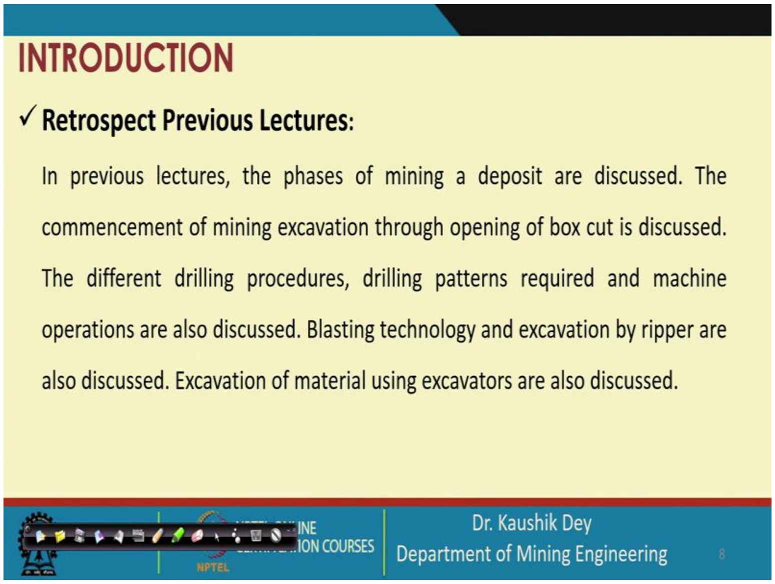

Now, let us say retrospect so, far what we have covered, we have covered the phases of mining and deposit, we have covered the commencement of mining excavation through opening a box cut, the different drilling procedures, drilling patterns required and machine operations are also discussed. Blasting technology and excavation by ripper are also discussed. And blast fragmented rock moss and the ripper excavated rock mass, how the excavator can be engaged to load those to the transporting system is also discussed.

Now, we are continuing with the transportation system. This is the third and final lecture on the transportation system in the surface mine. In transportation systems, we have seen many transportation systems available, continuous systems, and discrete systems. So, we have discussed all those systems. We are now continuing in this discrete system which is the dumper transportation system, and in this lecture, we will cover the shovel dumper combination.

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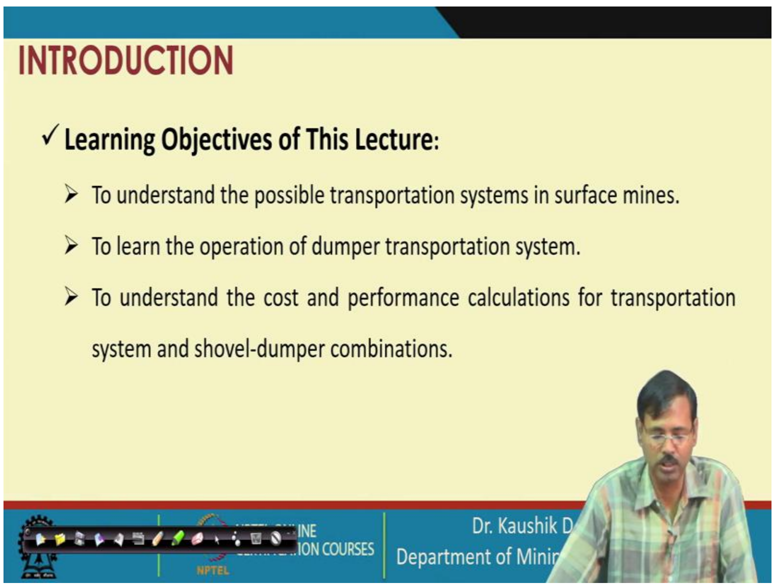

The objective set for this transportation system lecture is to understand the possible transportation systems in surface mines, to learn the operation of the dumper transportation system, and to understand the cost and performance calculation of the transportation system with particular reference to the shovel dumper combinations.

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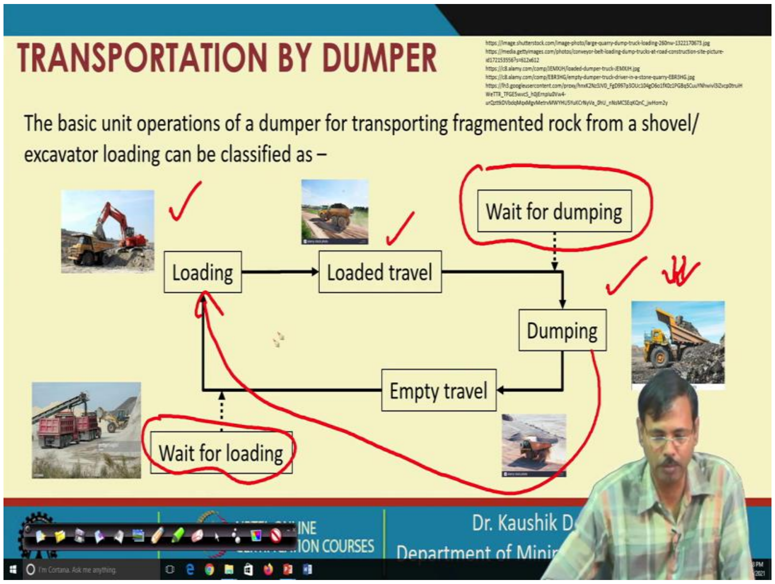

In the last class, we have also seen the dumper's different unit operations in its lifecycle: loading, loaded travel and dumping. There may be some waiting time if conditions are in the loading or dumping site. Then after dumping, it has to move to the loading point, and there may be some unwanted waiting time if the excavator is engaged with loading the other dumpers. Then there may be some waiting time during the loading is possible. So, this is already covered in the last class.

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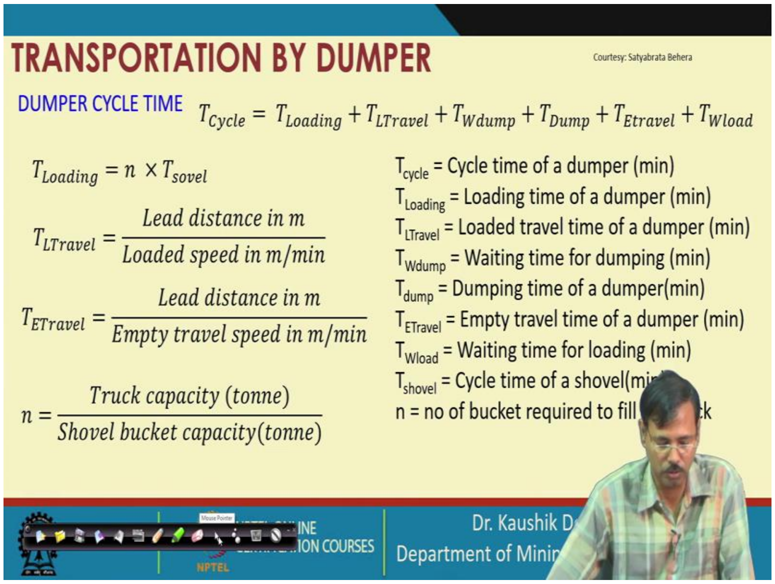

And we have seen how a dumper's cycle time can be calculated, and this formula is well expressed.

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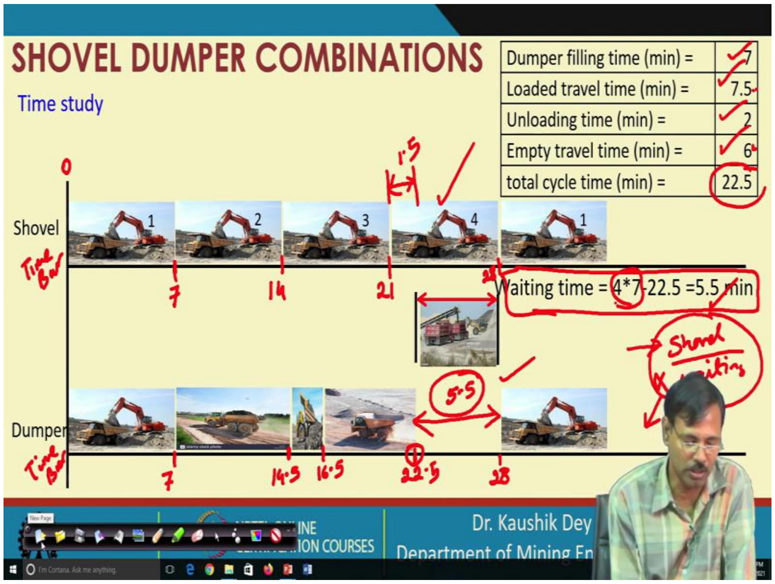

Now, let us look into the whenever we are considering the shovel dumper combinations. Now, let us look at the last problem we have solved: dumper filling time is 7 minutes, dumper loaded travel time is 7.5 minutes, unloading time is 2 minutes, and empty travel back is 6 minutes. So, the dumper cycle time has been found it is 22.5 minutes, but we have to check whether there is any waiting period possible with this or not. For this, we have to look into the cycle time of the shovel.

Now, let us consider this time bar, this is the time bar for the shovel, and this is the time bar for the dumper. Now, let us consider this is the 0 time that is t is equal to 0 from which we are starting our time study, and what is the time we are considering this dumper number 1 is under just for the commencement of the loading of this dumper is started at t is equal to 0.

So, a t is equal to 0 shovel started loading this dumper, the dumper number 1 which is we are interested to study its time cycle, and this dumper is now being loaded up to this point that is the 7 minute. So, if this is the 0, this is the 7 minute, 7 minutes the loading of the first dumper is complete. Now, what will this dumper do? The dumper will start loaded travel, traveling in loaded condition for up to 7.5 minutes.

So, it is completing its loading, loaded travel at 14.5 minutes, then what will happen? We are considering there is no waiting time for the unloading or dumping. So, immediately the dumper is unloading. So, the dumper is unloading the material, and the unloading is complete at 2 after 2 minutes. So, at 16.5 minutes, the unloading of the dumper is complete. Now, the dumper is starting its empty travel returning phase and is open traveling for 6 minutes.

So, it reaches the shovel position, completing its empty travel at 22.5 minutes. But whether it will be immediately started for the loading as we have seen in the last video of the previous class, where we found the shovel immediately after returning, is ideal. So, the dumper is immediately allowed to take the load there. Now, for this, let us look into the shovel cycle time. So, at the 7th minute shovel has completed loading this dumper, then the second dumper, which was waiting, has come, and the shovel started its loading, which is also taking 7 minutes.

So, at 14 minutes, it has completed loading the second one, and immediately, the third dumper is coming. So, it is loading the third dumper. So, that is completed in 21 minutes, but do you see at 21 minutes its empty travel is not back. So, this dumper is not available here. So, mine management has provided this fourth dumper. So, he has started loading this fourth dumper, which will take up to 28 minutes.

Now, at 28 minutes, when the fourth dumper loading is complete, before that, at 22.5 minutes, the dumper number 1 has returned and is now waiting close to the shovel for its loading. So, from this, the shovel has takeretaken this first dumperk for loading at 28 minutes. So, up to that time, the dumper has to stand on waiting. So, stand on waiting for loading, which is 5.5 minutes. So, the waiting time for the dumper at this position is coming at 5.5 minutes, which is found from this.

Because we have taken the fourth dumper, the loading time of the fourth dumper is 4 into 7, 28 minus 22.5 is 5.5 minutes is the loading time required for this dump; the waiting time has to be considered for this dumper cycle time. So, this is unwanted but an essential part of the dumper cycle that cannot be avoided. But how that can be expressed in a mathematical formula. It is now clearly understood if we are not providing the fourth dumper, the shovel will be under waiting; in that case, the shovel will be under waiting for 1.5 minutes.

And if we provide the fourth dumper, the dumper will be under the waiting of 5.5 Minutes. Now, as in mining, we, in general, consider the shovel cannot be allowed for waiting because if the shovel is under waiting, then the productivity calculation which is made that is the target production which is made considering the shovel that will not be insured and that is why this shovel is waiting is not allowed.

Instead, we asked for the dumper to wait that is another factor is that as the dumper is mobile equipment, so, it has a more unpredictable cycle duration. But the shovel is a stationary one that is not facing all those problems, dumper may face traffic problems, dumper may face the waiting time in the dump yard. All these are problems associated with the dumper, but the shovel does not have those problems.

So, that is why the shovel should not be allowed for the waiting, dumper may be additional dumpers. This fourth additional dumper is given so that the dumper can be allowed to wait for 5.5 minutes, but the shovel is not allowed to wait for 1.2 Minutes.

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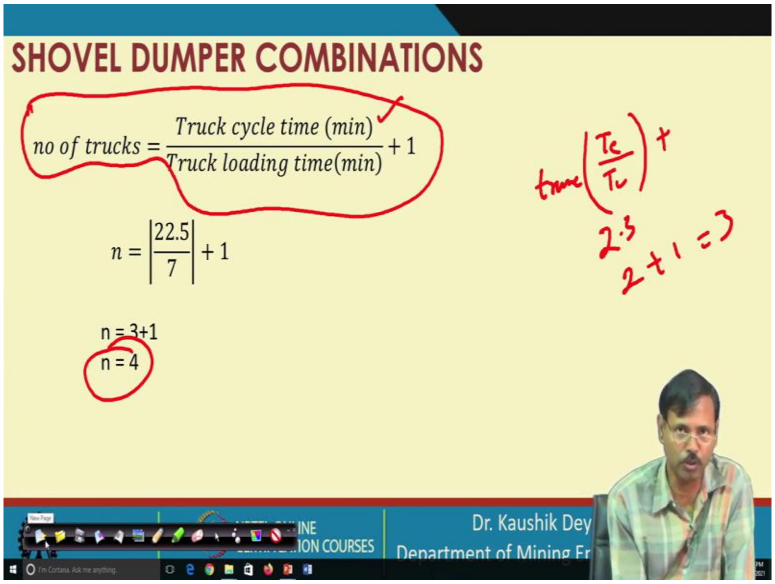

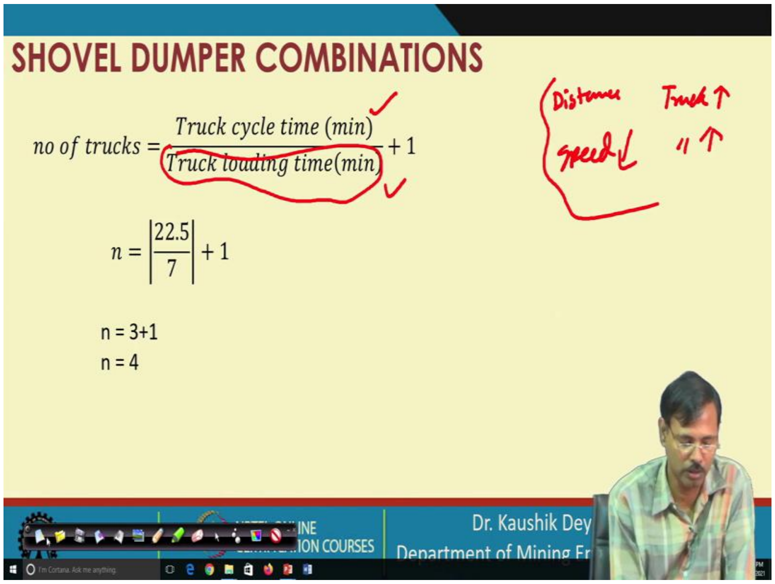

Considering this, the number of dumpers required for a Shovel can be expressed in terms of a mathematical formula that the number of trucks to be assigned with the shovel. Depending on this formula, the truck cycle time divided by the truck loading time is considered as the number of trucks required plus 1. So, we need to truncate the truck cycle time then truck loading time, and after this, whatever, if it is 2.3, then we will truncate it to 2 plus 1.

So, the number of trucks required is 3. So, this plus 1 is added for that. So the number of in our case we can find this is now a number of track required is 22.5 by 7 so 3 plus 1. So, the number of trucks required to combine with the shovel is considered the 4. So, this is the mathematical formula, in general, we use to express the number of trucks to be assigned with the shovel, and obviously, it depends on to see it does not depend on the shovel cycle time. It is shovel cycle time is a part of this one truck loading time.

But basically, it depends on the truck cycle time and the truck loading time. And if we find that the distance is more, we need to provide more trucks; if the speed is less, trucks should be increased so all these are required to be considered while considering the number of trucks.

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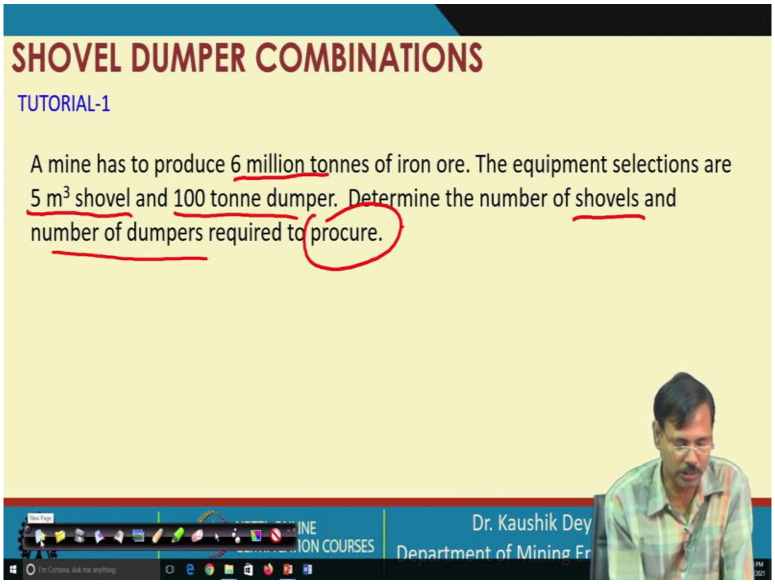

So, now let us have one solve-one tutorial. In this tutorial, we are considering a mine that has to produce 6 million tonnes of iron ore. And we have to find out the number of equipments if we are using 5-meter cube shovel and 100-tonne capacity dumper. Find out the number of shovels required and the number of dumpers required to produce 6 million tonnes. So, we need to purchase these dumpers. So, we have to assume all other data.

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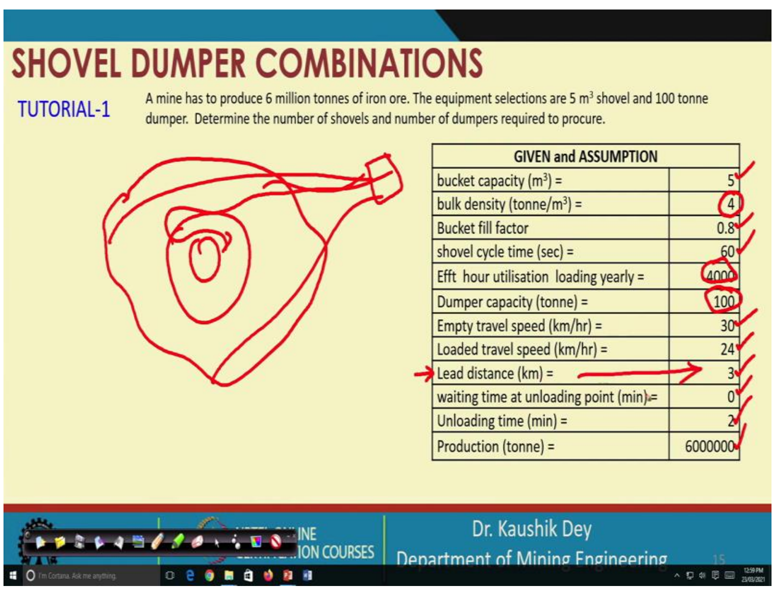

SHOVEL DUMPER COMBINATIONS

TUTORIAL-1

A mine has to produce 6 million tonnes of iron ore. The equipment selections are 5 m^3 shovel and 100 tonne dumper. Determine the number of shovels and number of dumpers required to procure.

GIVEN and ASSUMPTION	
bucket capacity (m^3) =	5
bulk density (tonne/m^3) =	4
Bucket fill factor	0.8
shovel cycle time (sec) =	60
Efft hour utilisation loading yearly =	4000
Dumper capacity (tonne) =	100
Empty travel speed (km/hr) =	30
Loaded travel speed (km/hr) =	24
Lead distance (km) =	3
waiting time at unloading point (min) =	0
Unloading time (min) =	2
Production (tonne) =	6000000

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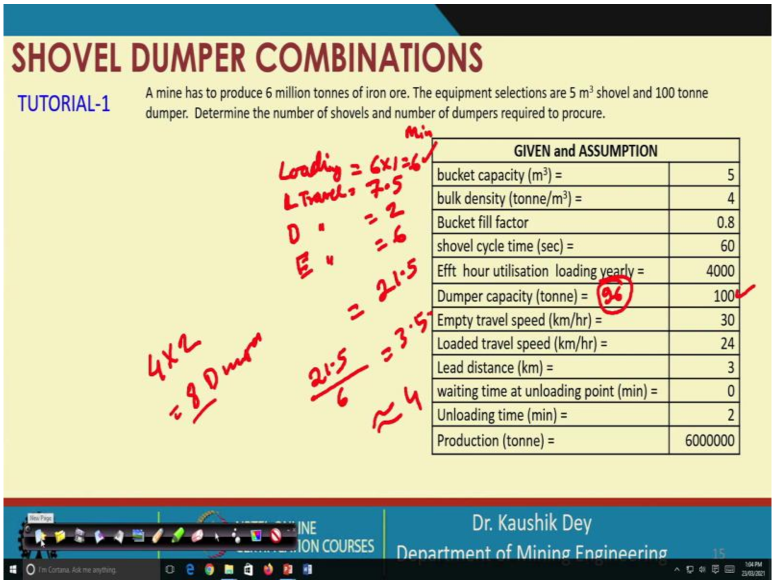

Now, let us look at what our assumptions are. So, we assume the bucket capacity is given a 5-meter cube, and the bulk density is 4 for the iron ore. Now bucket fill factor we have assumed 0.8, we are assuming shovel cycle time is 1 minute, we are considering the effective available utilized hour for loading is 4000, dumper capacity is given 100 tonnes, the empty travel speed we have considered 30, loaded travel speed we have considered 24, the lead distance we have considered 3, waiting time is 0, dumping time is 2 and production target is this.

Now, a little bit of discussion I should give on this lead distance is obviously understood if a mine is working like this. And our said destination is at this point, so lead distance from this place, lead distance from this place, lead distance some from this place will be different. Similarly, the lead distance from the lower bench to the upper bench is also increasing. So, this lead distance is variable. And with consideration of that, the number of dumpers has to be considered tough it is not affecting the number of shovels.

But as the lead distance is variable, we are considering the number of dumpers has to be considered and that, in general, a few dumpers are kept additional for utilization in those conditions. Apart from that, this lead distance is generally considered the average one while these mathematical calculations are made. So, now let us try to find out that the bucket's capacity is a 5-meter cube, bulk density is 4, and the bucket fill factor is 0.8.

So, this bucket load is 16 tonnes, and a shovel handles this 16 tonnes in 1 minute. The available hour is 4000 into 60 minutes. So, in that, the load is into 60. So, this is 64 into 6, so it is coming so, this is the total production can be handled, this is 5-meter cube excavator can load the volume. So, 3.84 million tonnes of material can be handled by one shovel. So, our target is 6 million tonnes.

So, if we are dividing this 6 by 3.84, that is 1. something so, we understand we need to have 2 shovels of the 5-meter cube to achieve the production target of 6 million tonnes. So, this is now clear, and this can be easily calculated. Now, let us look for the next one; our dumper capacity is 100 tonnes; we have seen in that bucket capacity is 16 tons in the last if we are dividing with this, we will get 6 points something, but if we provide the 7, then it will increase it will become 112 that is the overloading condition.

So, 6 into 6, 96 tonne. So, we can allow the 6 buckets in 1 dumper, which means the dumper is carrying 96 tonnes on average basis 96 tonne is the capacity of the dumper. So, now dumper capacity is reduced to 96 tonne and ,dumper is taking 6 passes. So, the loading time. Now, let us find the cycle time loading time is 6 into 1 minute. So, that is 6 minutes these all are in minutes.

Now, our empty travel time sorry loaded travel time, loaded travel is again this 3 by 24. So, 3 into 60 by 24 which is again coming 7.5, and dumping time is 2 minute and empty travel time is 6 minutes this we have carried out earlier. So, our total cycle time is coming this is now 21 because 1 is reduced here. So, 21.5 minute so, 21.5 minute is the dumper cycle time and our shovel cycle, loading time is 6 minute. So, it is coming at 3.5 or something like that.

So, we have to give 4 dumper to 1 shovel. So, as we have 2 shovels, we need to procure 4 into 2, 8 dumpers of 120 tonner must be provided, which will take 96 tons of load each time, and 8 such dumpers need to be procured. So, now we can say the mine management you procure 2 shovel and 8 dumpers that will serve your purpose of the target production achievement of 6 million tonnes.

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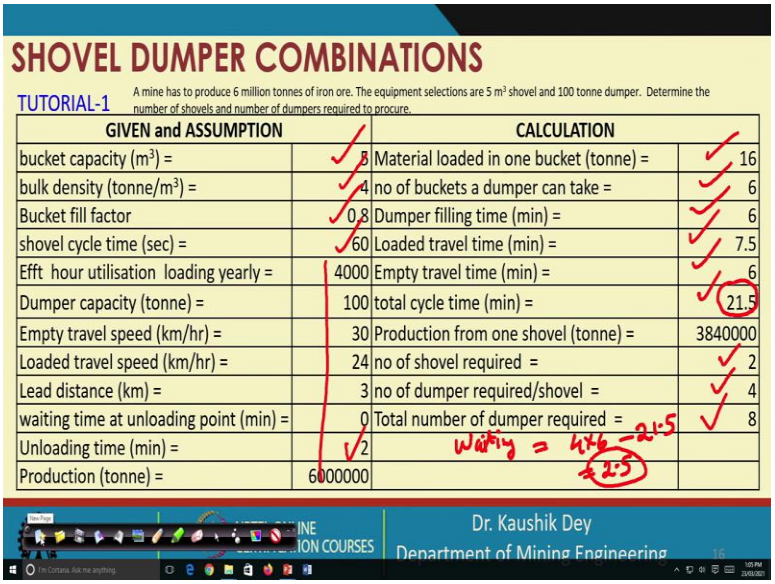

So, now this is the calculation. So, these are the assumptions we have already discussed, and we can see the material load in 1 bucket. This number of buckets a dumper can take 6, dumper filling time 6, loaded travel 7.5 minutes, empty travel 6 minutes, dumping time 2 minutes, then total cycle time is 21 minutes, number of shovel 2, number of dumper per shovel 4, the total number of dumper 8.

And obviously, we can understand if we are having this, then a waiting time for the dumper at shovel is 4 into 6 minus 21.5. So, that 2.5-minute waiting time is required at the shovel for the waiting time of the dumper. So, this is the solution.

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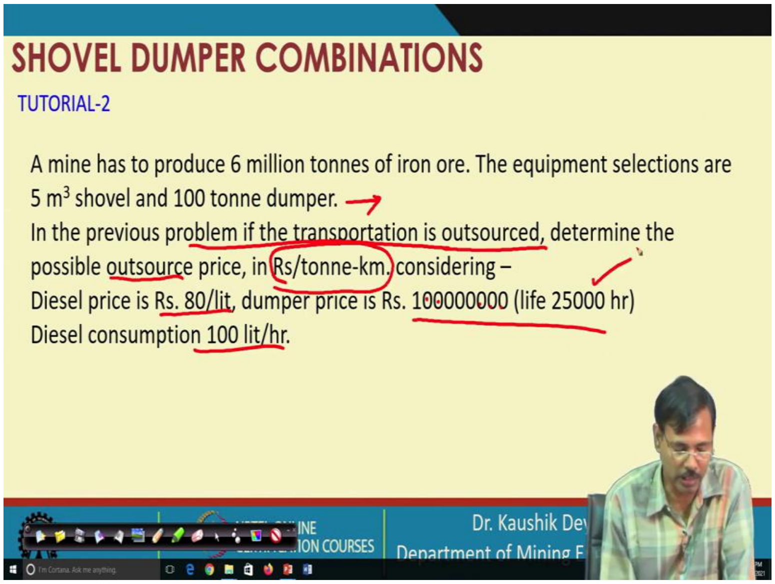

Now, let us look into another problem in which you will estimate the cost of transportation. Suppose, the mine the earlier we have discussed that mine is now thinking that it will transport, give the transportation in the outsource that means, it will ask some contractor to procure the dumper, and you go for transporting the material. So, we are not considering the shovel cost here because that is already solved in the previous lectures.

So, we are considering only the transportation cost, and the outsource bid has been asked; the transportation cost has to be given in rupees per tonne-kilometer. And what are the considerations? Some of the considerations given here are, diesel price is 80 liter, 80 rupees per liter, diesel consumption 100 liters per hour, dumper price is this is I think 10 crores. So, this is 10 crores and its life is 25,000 hours. And there are other assumptions. Let us look at what the other assumptions we are considering are.

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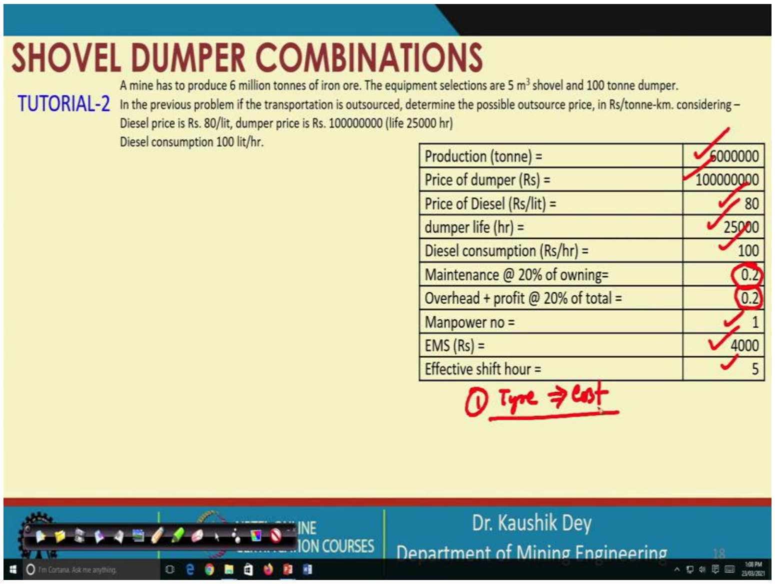

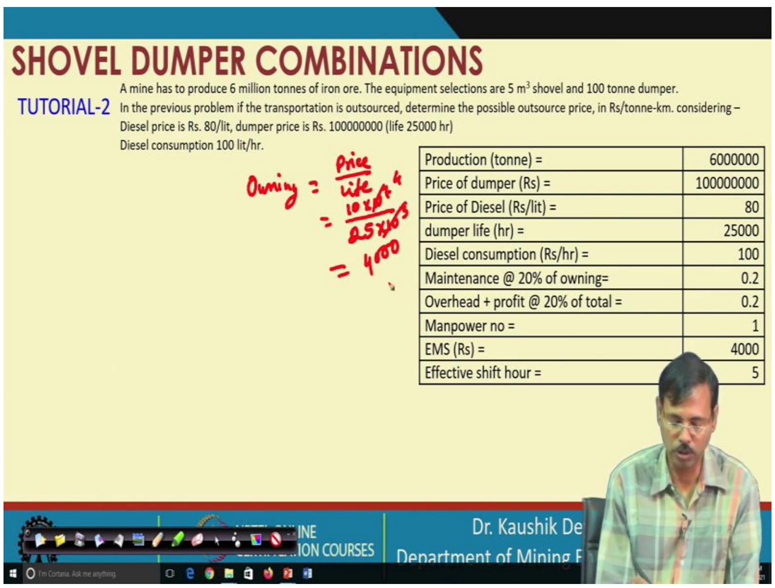

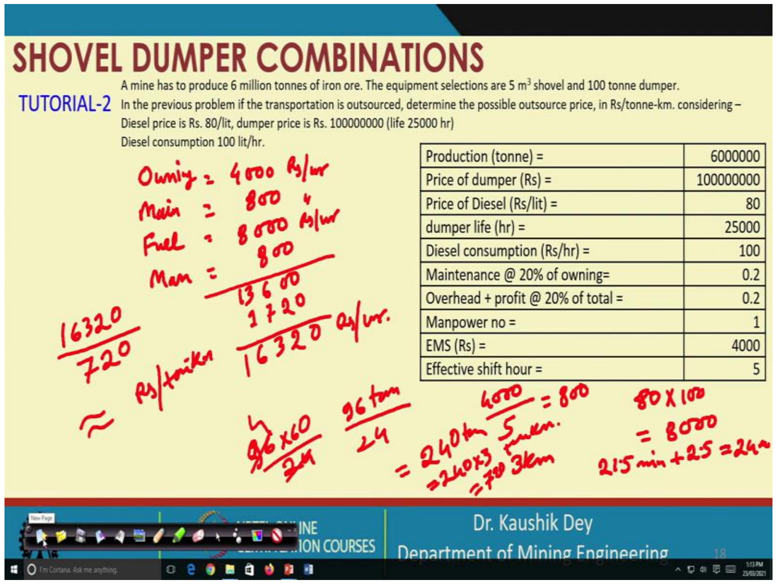

So, our production target is given, price of the dumper is given, diesel price given, dumper life given, diesel consumption rate given, we are considering maintenance is 20 percent of the owning cost and profit and overhead cost we are considering point a 20 percent of the total cost which is coming except this one, manpower one dumper you need one manpower only. DMS is considered 4000 rupees; effective shift hour is considered 5 hours available in 1 shift.

We have not considered a few critical parameters, but in general, while the cost calculation has to be carried out, those components are essentially looked for one is that tyre cost, tyre cost is a very, very significant cost. This tyre cost is a costly item that needs to be considered separately, but in this case, we have for simplification purposes, we have ignored that part. So, this is an important factor. There may be some considerations one can take.

So, this is one part; the second part is that we have not considered the interest part, we have not considered depreciation; all these are the essential components that are not considered in this calculation. So, let us calculate the owning cost for this we know we are having first. So, this is the price by life. So, this is 10 crore so, 10 into 20 power 7 divided by the life is 25,000. So, it is coming around. So, this is 4, 20 power 4, so, 20 power 4, and this is 25.

So, this is 4000, so; this is 4000 rupees per hour. So, let us directly write it, owning cost 4000 rupees per hour. We have considered maintenance is 20 percent of that. So, maintenance 20 percent of that is 800 rupees; then we have considered the diesel consumption. So, the fuel cost, we have seen the price of diesel is 80 rupees, consumption is 100 liter per hour. So, this is 8000 rupees, so this is 8000 rupees per hour.

Now, we have considered the manpower cost, manpower cost 1 person that is 4000 rupees per shift and effective shift hour is 5 so, it is coming around 800 rupees. So, manpower cost is 800 rupees, and the total cost is coming 006, considering 20 percent overhead cost, so we have to add 20 percent of this. So, that is 02 27 so; the total cost is coming so, this is the rupees per hour, total cost we can seek.

But we have to see what is the material transferred on this, and that has to be expressed in tonne-kilometer; we know our lead distance is now 3 kilometers, average lead distance is considered 3 kilometers, and we can see the dumper cycle time is last class we have found it is 21.5 minute but, as shovel has to engage with the fourth dumper. So, there is a waiting time for 2.5 minutes. So, the actual cycle time is coming 24 minutes.

And the dumper is handling how much; though it is a 100-tonne dumper, it is handling actually 96 tonnes. So, the 96 tonne material is being handled in 24 minutes. So, in 1 hour, it is handling 96 into 60 by 24, which means this is 4. So, 240 tons of material can be handled per hour by the dumper.

And this is 240 tons and if we are considering the lead distance is 3 so, it is 240 into 3 that is 720 tonne-kilometer is basically handled by this dumper. So, now, we are having the cost of 16320, and we have tonne-kilometer 720. So, if we are dividing this, we will get rupees per tonne-kilometer travel cost in this.

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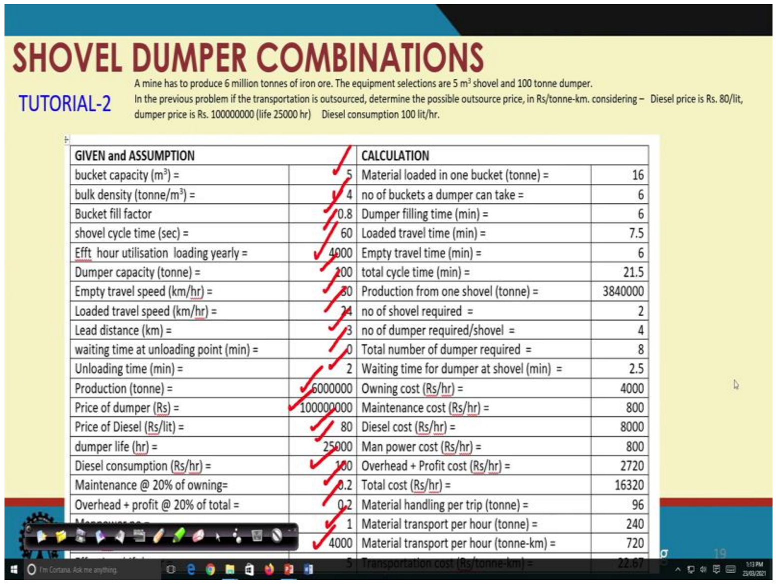

So, let us look into the solved values. So, now see, these are the bucket capacity, bulk density, bucket fill factor, shovel cycle time, effective hours, dumper capacity, empty travel, loaded travel, lead distance, unloading time, production target, price of the dumper, price of diesel, price dumper life, then diesel consumption, maintenance cost, overall profit, number of manpower, EMS. So, all these are available here.

So, all these are available here, and in consideration of that, we have calculated, so let me lift it a little bit so that it can be visible. So, now it can be seen that the material loaded is this much, a number of buckets are this much, dumper filling time, loaded time, empty travel time, and total cycle time. This is a production for a shovel, number of the shovel, number of dump per shovel, number of dumpers, now we have found waiting time for dumper is 2.5 minute.

Now, owning cost, maintenance cost, diesel cost, manpower cost, all together this is the overhead cost. So, this is the total cost of 16320, material handling per trip is 96 tonne. The material transport per hour is 240 tonne and tonne-kilom. If you are considering a 3-kilometer lead distance, it is coming 720 tonne-kilometers. So, this is divided by this one is giving us 22 rupees and 67 paise as the transportation cost in rupees per tonne-kilometer.

So, this is the solved example; you can solve similar problems. Many problems are available; you can design them and solve them. And this ends the lectures related to the dump transportation system on shovel dumper combination. Thank you.