Surface Mining Technology
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Lecture 13
Drilling Technology for Surface Blasting- III

Let me welcome you to the 13th lecture of surface mining technology. This is the third lecture of drilling technology for surface blasting. We discuss the drilling technology mainly required in the surface mines to carry out bench blasting.

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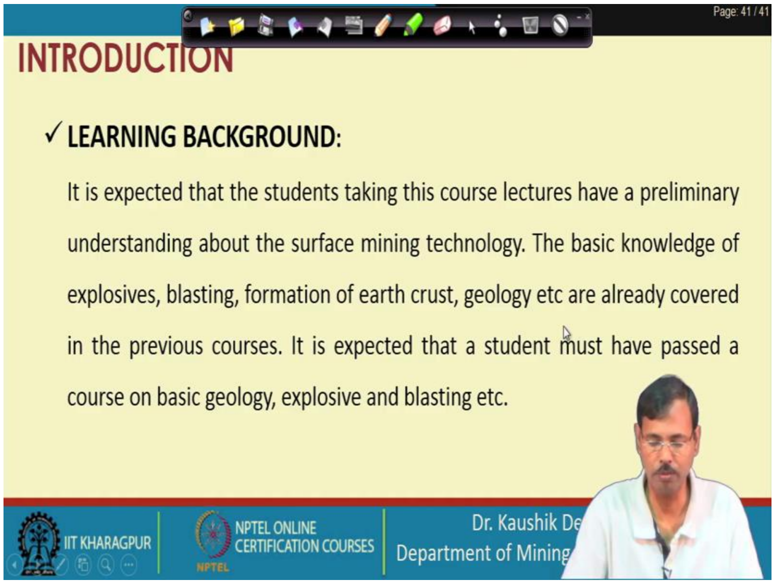

So, in this lecture, this is the third lecture; let us show you a glimpse of the learning background required for the surface mining technology course.

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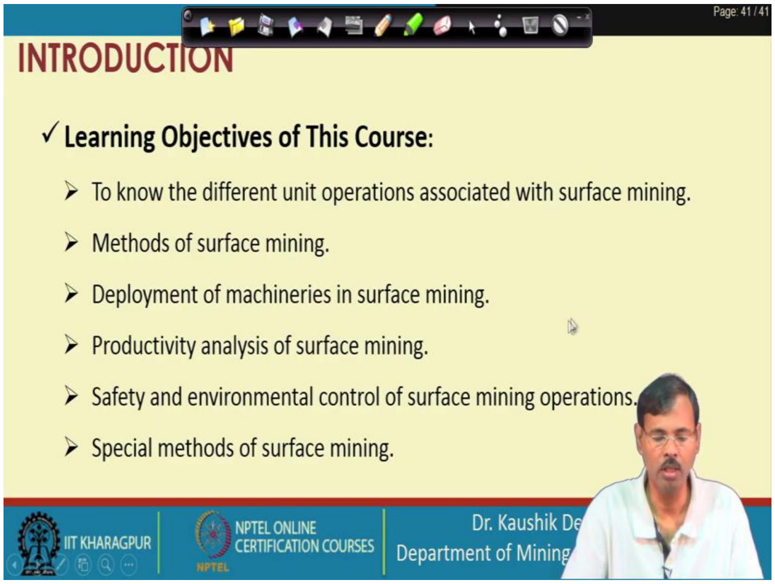

The learning objective of the surface mining technology course.

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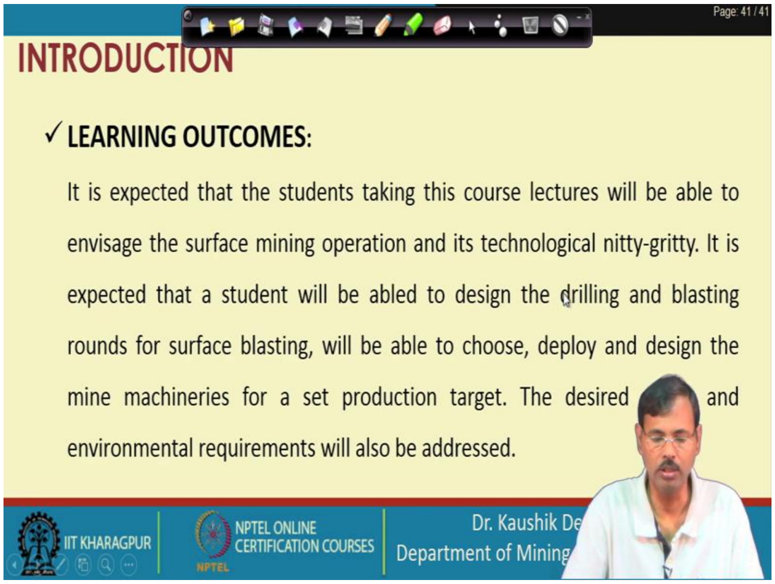

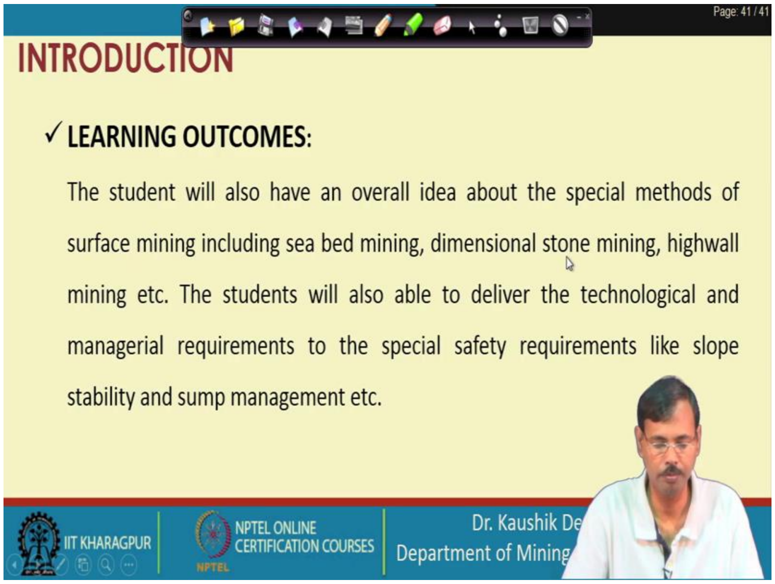

And this is the learning outcome expected from the participant of the surface mining technology course.

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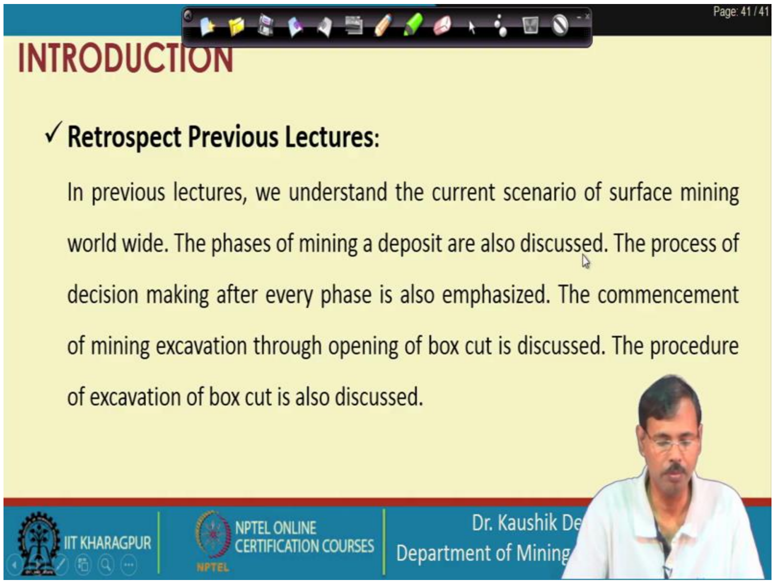

And these are the retrospect of previous lectures just before the drilling technology. The portion discussed herein is drilling technology for surface blasting in lecture one and lecture 2? We have covered the different types of drill machines and different types of drill bits; they are requirements and the properties that are basically dictating the penetration rate of a drill machine; penetration rate is basically the speed of the drill bit while it is carrying out drilling.

So, the speed of the drill bit inside the rock mass during drilling is called the penetration rate. So, different factors influencing penetration rate are discussed in the last class. So, we have seen the different types of drill machines and different types of drill bits penetration rates. These are discussed in the previous lectures of the drilling technology for surface blasting.

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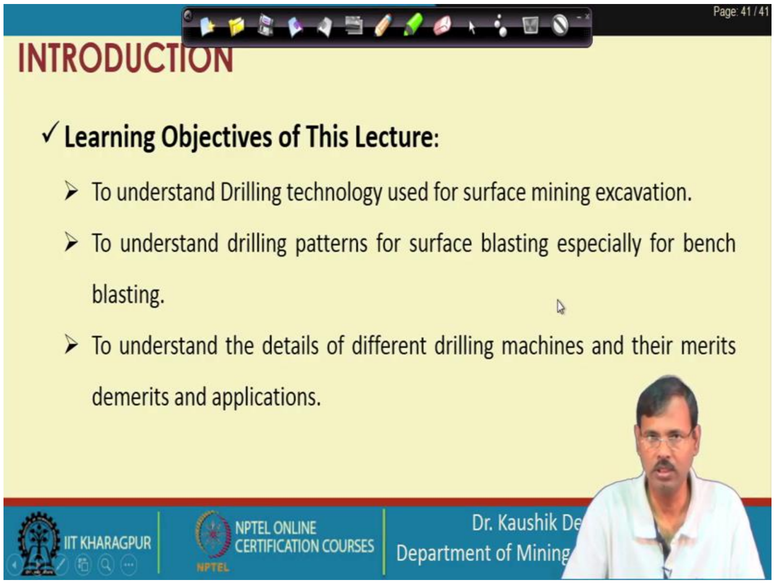

The objective of this lecture is basically to analyse the performance of drill machines, how that is basically governing the drilling, and you understand that performance of the drilling is very, very important because based on that, you have to decide how many drill machines are to be procured for achieving the production target and what would be the cost all these are related to that. So, that is why this performance calculation of a drill machine is required to be calculated. So, this is the main objective of this lecture.

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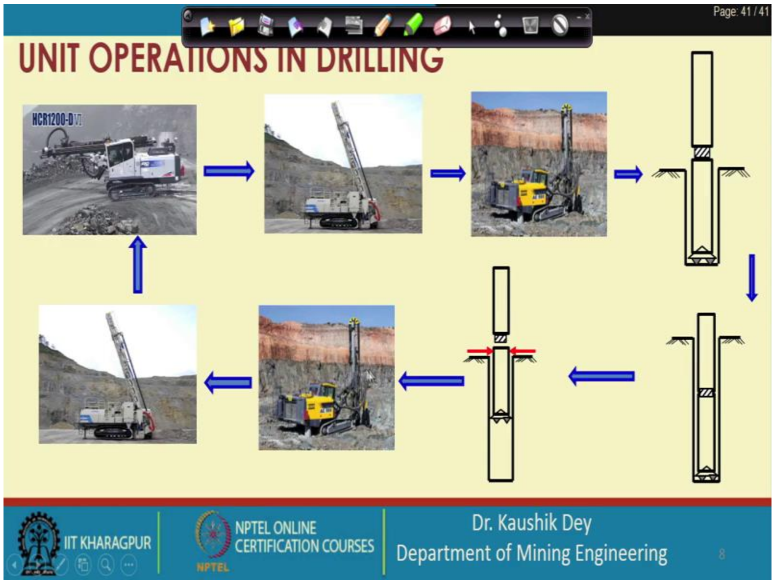

This part we have discussed in the last class shows the different unit operations of the drill machine and how this is propelling; then, it is set. It is started drilling; then the rods are inserted, then the drilling is completed, then the rods are dislodged, then they are taken out, then again the drilling is complete the machine is moving. So, this is the normal drilling cycle.

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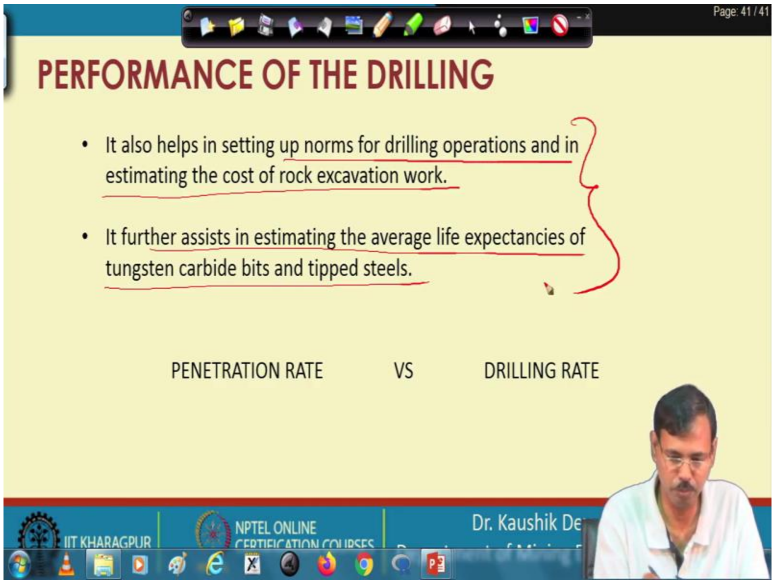

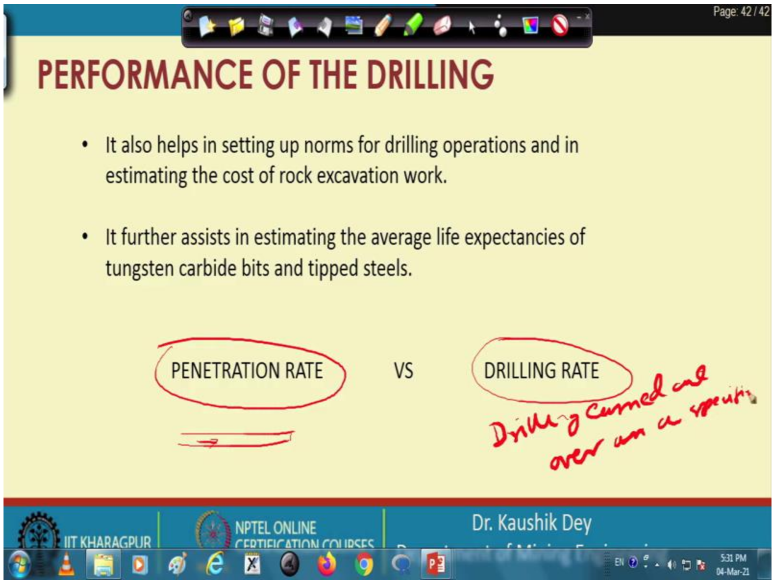

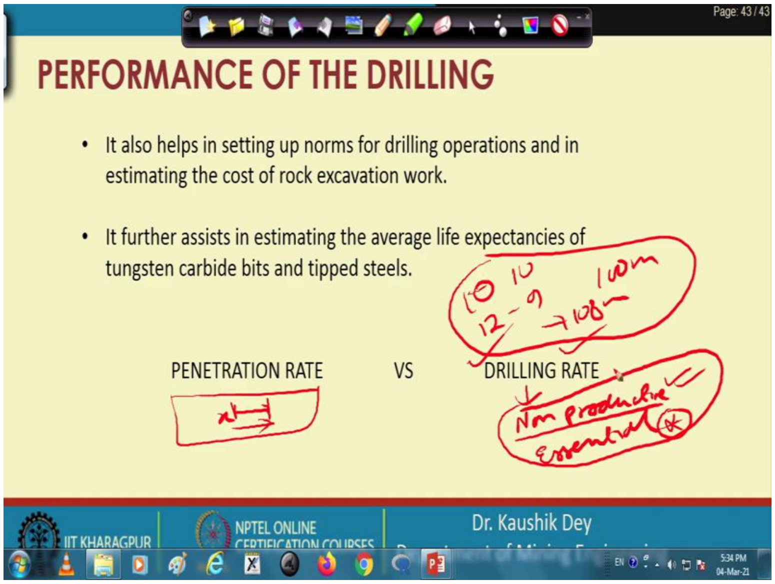

Then the drilling performance is considered the drilling rate, and this performance is important for finding out the setting of the norms for drilling operation estimation of is cost. It also assists the average life expectancies of tungsten carbide bits and tips steels.

So, these are the very, very important performance of a drill machine. In this place, we would like to draw your attention to this two-term penetration rate and drilling rate; the penetration rate is already discussed. This is the rate at which the drill bit moves inside the hole while it is drilling. But the drilling rate is a little bit different. It is basically the drilling carried out over a specified period.

What is the meaning of this? The meaning of this is drilling rate is the rate of drilling considering all the non-productive operations but essential operations; what are the non-productive operations? Non-productive operations mean in the previous slide, we have shown you are inserting the second rod. So, while you are inserting the second rod during that time, you are not caring about drilling, but you are adding the second rod with the first rod; this is non-productive because you are not caring about drilling.

But this is essential because without inserting the second rod, you cannot complete the drilling because you cannot reach the depth. So, whatever is the non-productive, but essential jobs that need to be taken care of to control the drilling, penetration rate is not considered all this time rod time with the speed of penetration, it is just at x moment drill bit at this position at y moment drill bit at this position, and in between that it is the continuous drill cutting there is no in-between that you are inserting the rod.

So, this is the penetration rate at which the drill bit is penetrating the rock is penetration there. Still, the drilling rate considers all the non-productive settings of the machine tying up the rock, untying up the rod changing the drill bits. All this unproductive part is essential because that cannot be avoided. Those hours are also considered in this.

So, that is why your drilling rate is considering non-productive hours, and in drilling rate, you are basically saying in a shift in the shift we have drilled say 100-metre hole total 100-metre hole five maybe a ten holes of 10 metre or maybe 12 holes of 9 metre that is 108 metre. So, as we expressed and in this case, we are considering all these non-productive hours in this calculation.

So, that means our drilling rate you can understand drilling rate is a little bit lower than the penetration rate if you are considering the metre drill per unit time. The drilling rate is lesser than the penetration rate. But you need both this one is the same metre per minute.

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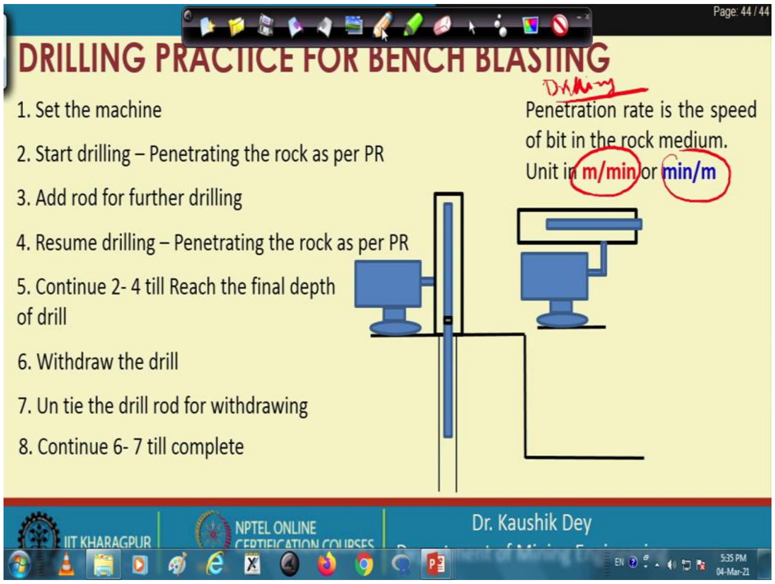

So, this part is also what you have discussed in the last class; the penetration rate and drilling rate are both expressed in terms of metres per minute or minute per metre. So, you must be very careful while using the penetration rate and drill rate terms.

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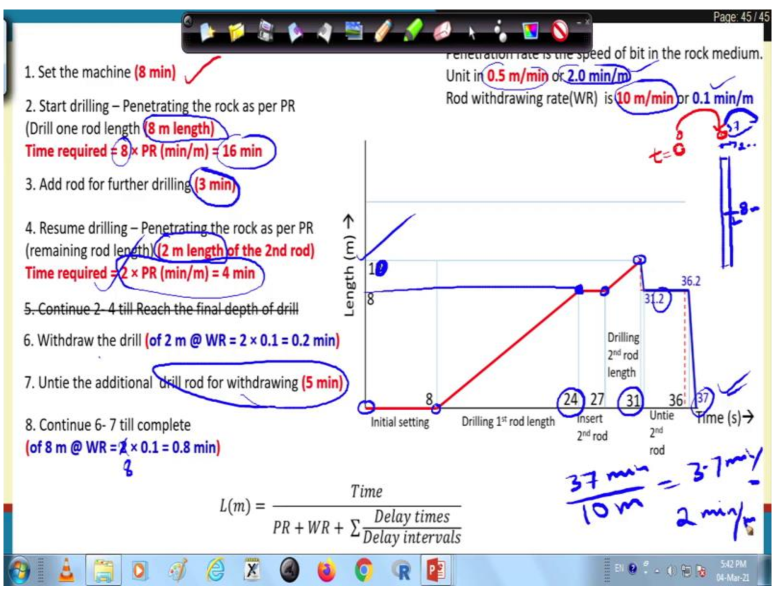

Now, let us look for one case of how this penetration rate and drilling rate govern our total in a full-time study that is being controlled. So, consider a machine is at this position machine is in the first drilling hole position it has to drill the second one at this position. So, the machine is moving from this to this, coming at this position. Say the machine at this position at time t is equal to 0, and it is then coming to this position that is the movement of the machine occurs at this position and let us consider this is taking 8-minute time.

So, the initial setting time is 8 minutes. So, the machine was at this position, and after 8 minutes, it was rating at this position. So, after 8 minutes, the machine is at this point. Now, you can see that we have not drilled any holes. This is the length of drilling. Only the machine has moved from this place to this, and this is taking 8 minutes this 8 minutes is a non-productive time. But you cannot avoid it because it is essentially required.

Then the machine set it to start drilling. So, the machine is taking, or that machine is drilling the hole as per the penetration rate and machine you consider the machine is utilising an 8-metre long drill rod and say our penetration rate is 2 minute per metre or half a metre per minute that means in 1 minute the machine can drill 0.5 metre that means it is taking 2 minutes to drill 1 metre.

So, the machine has the first rod, the first rod the machine is having that is 8 metres long and carrying out this 8-metre drilling, so, this is 8 metres. So, carrying out this 8-metre drilling machine takes 16 minutes. So, because it is 2 minutes per meter, it takes 16 minutes. So, your bit drill bit position will be at an 8-metre depth. From this place, your drill bit position will be at 8-metre depth. If it is 16 minutes, you can drill with that bit.

So, 8 plus 16 is the 24. So, at the 24th minute, if this is the hole you are drilling at 24 minutes, your drill bit at this position is at the 24th minute from starting if it is 0 here,, t is equal to 24 at this position. Now, we have to add the second rod with this first rod. So, that is considered that it takes 3 minutes.

So, you have to spend 3 minutes again. That 3 minutes is a non-productive hour. So, that 3 minutes has to be spent at this position. So, the second rod will be added to this. So, the second rod you are adding now, the second rod is now added. So, you will start your drilling again, but these 3 minutes are added. So, in these 3 minute,s, you add the second rod that is non-productive hours. So, it is not the 27th minute at this position.

So, add this 27th minute you have started to drill the hole with the first and second rod both, and you are drilling length say required this drilling length is 2 metre you are going for drilling of the 10-metre hole. So, for the 2-metre drilling, you need to spend 4 minutes drilling because the penetration rate is 2 metres. So, 2 into 2. So, the 4 minutes you have spent reaching this will be 10.

So, to reach up to this point, this is 10 metres in depth. So, it takes 4 minutes more, so 27 plus 4 is 31 at this position. Now, let us consider it is taking withdrawing speed rod withdrawing rare is 10 metre per minute. So, you have to remove the rod; first, how much rod length must be withdrawn? The rod length has to be withdrawing is 2 metres because the second rod is 2 metres. This 2 metre was the depth of the second rod.

So, you have to withdraw 2 metres and that withdrawing time is 0.2 metres 0.2 minutes because it is 0.1 minutes per metre. So, it is 0.2 minutes. So, at 31.2 minutes, your rod is again at this position; you have to withdraw the rod. Say untying the rod time taken is 5 minutes. So, you have to give 5 minutes at this position. So, from 31.2 to 36.2,, this is the untying time, and at 36.2,, you have just untied the rod, and are ready to withdraw the first rod.

The first rod is 8 metres, so the withdrawing time required is 18 to 0.1. Again, this is 8 into 0.1. So, that is 0.8 metres, so it is 0.8 metres 36.2 plus 0.8 so 37 metres, so you are drilling will be complete, and your are machine is now set at this position to move to the next hole. For this, it is now the 37th minute. So, from this point to this point, one drilling cycle is possible with 37 minutes of operation. Now, what drilling you have carried out the 10-metre drill. So, now 37 minutes are required to carry out a 10-metre drill. So, your drilling rate is 3.7 minutes per metre, whereas your penetration rate is 2 minutes per metre.

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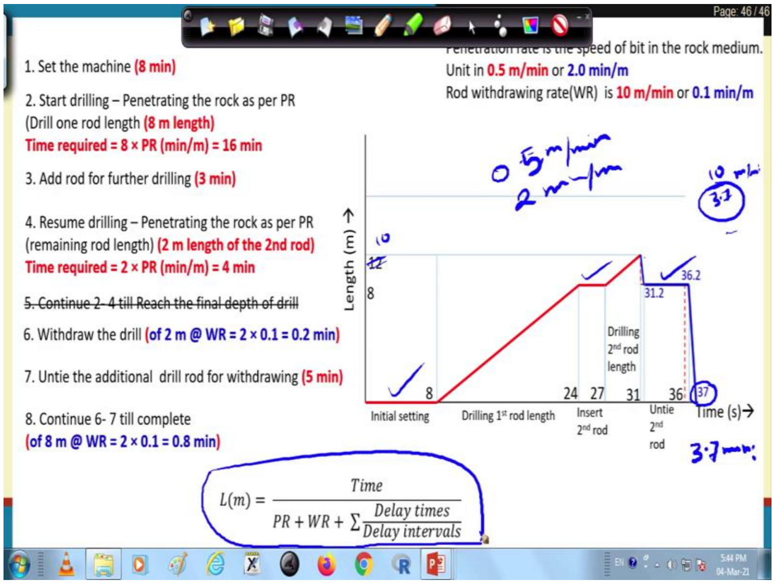

With this time study, I think it is clear that the penetration rate here for the 10-metre hole considered is 10 metres. So, for the 10-metre hole, you are drilling time required is 37. So, that is why your drilling rate is 3.7 minute per metre, or if you are expressing it, it is 10 by 37 metres per minute. The penetration rate is 0.5 metres per minute or 2 minutes per metre. So, almost you can see non-productive hours of 17 minutes are added here 8 minutes here, then, 3 minutes here 11 plus 5 16, then withdrawing rod withdrawing time of almost 8 0.2 plus 0.8 almost 1 minute. So, 17 minutes of non-productive hours are included here, and that is why the delay time is inserted, and you are getting the actual drilling rate is lower than the penetration rate. Now, just look into how you can express this in a mathematical formula.

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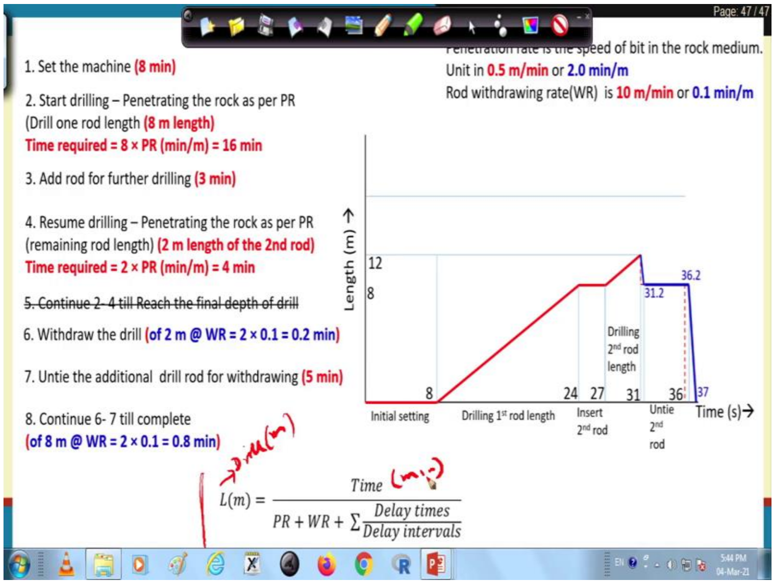

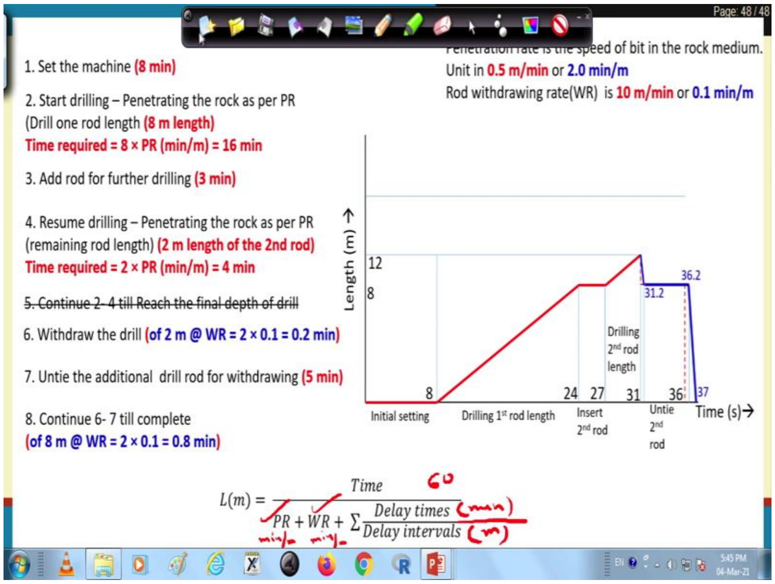

Suppose you would like to calculate for 1 hour time, then the penetration that drilling rate L is the drilling that is the actual drilling you can find in metre, and this is that time in a minute. So, if you take this position, it will give you the drilling rate. So, if you would like to express it in 1 hour, that means you are interested in 1 hour how much length can be drilled. In that case, you take the time as a 60-minute penetration rate expressed in minutes per meter, withdrawing rate again minute per metre and then it is a summation of delays plus delays divided by the delay interval and these delays are given in minutes, and delay intervals are given in meter.

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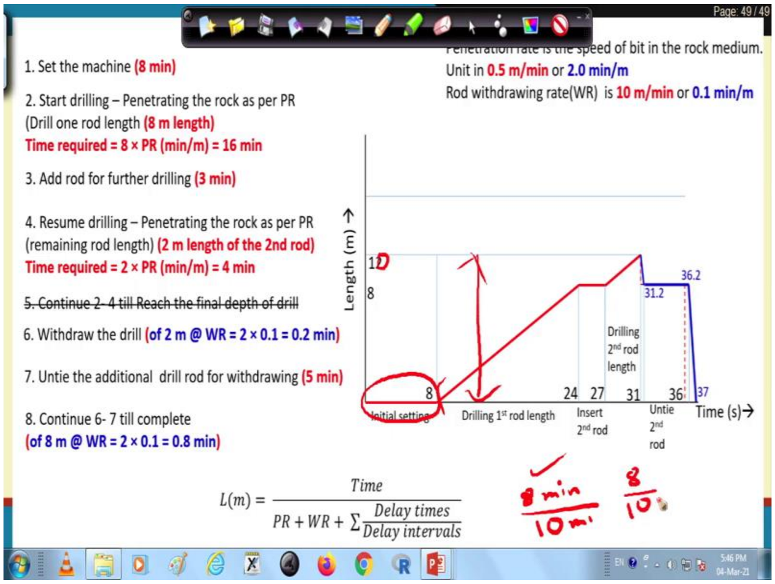

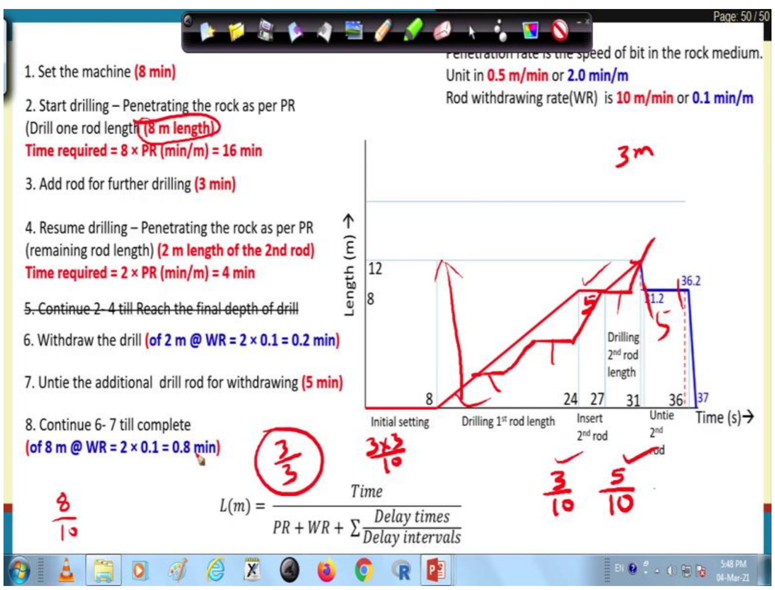

Now, let us examine how you express these delays, say your initial setting time. So, this is the initial setting time. Your initial setting time is 8 minutes. So, your delay is 8 minutes but what is the frequency of this initial setting? You do the initial delay initial setting that is carried out after each drilling of 10 metres. So after each drilling of 10 metres, you are carrying out one initial setting.

So, the frequency of this delay of the 8-metre initial setting is 10 metres. So that is why your delay interval is 8. Delay time is in 8 delay interval is 10, this is for the first one. So, for the first case, it is 8 by 10. Now, look into the second one-second rod insertion. We are inserting the rod for once only this is again 5 minutes and again see this 5 minute inserting rod inserting time is only carried out for drilling of a 10-metre hole.

So again, the drill interval is 10. The third one is this one that is rod untying, and this is 3. So, it is 5, so this is for rod untying, and three by 10 is for inserting the rod. This is for untying the rod, and this for both the cases, the delay interval that is once it is happening only for this 12 metre. Now, just look into this for further explanation.

Suppose, your drill rod length instead of 8 metre, you have a drill rod length of say 3 metres then what you would have to do you will do in 3 metre after drilling 3 metres there will be a 3 minute rod inserting time then again for after doing 3 metre drilling again 3 minute again after 3 metre again 3 minute. Finally, the fourth rod you will complete the drilling.

So, how many number of 3 minutes will be there 1, 2, 3 now, you can see in 10 metre interval you are having 3, 3-minute rod inserting time. So, in that case your delay interval will be 3 into 3 by 10 delay times will be 3 into 3 and the frequency will be delay interval is then 10. So, you must be very careful not to make it 3 by 3 because this is your carrying out after every 3 metre. So, you must be very careful while calculating for this delay interval.

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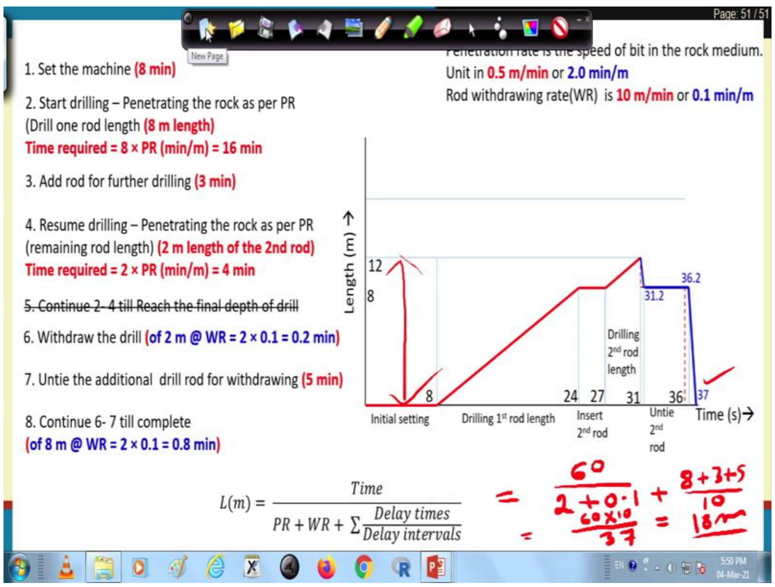

So, if you are doing this for this particular case,

$$L(m)= 60/(2+0.1) + (8+3+5)/10 = 60*10/37 \approx 18$$

So, you can find out. Say, they are maybe, I think 18 or something 18-metre drilling or something like that what about it is coming or instead of this if you place it 37 that means 10-metre drilling will be carried out that 37, 37 will be cancelled in that case 10 metre, which is the drilling length of one this the length of one that is taking 37 minute. So, this is how you can calculate the drilling rate for a particular rock with a particular machine and determine the performance.

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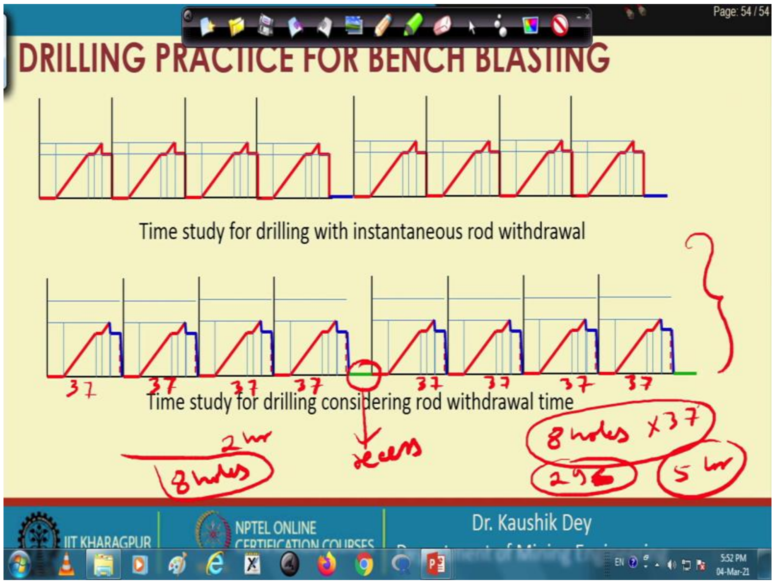

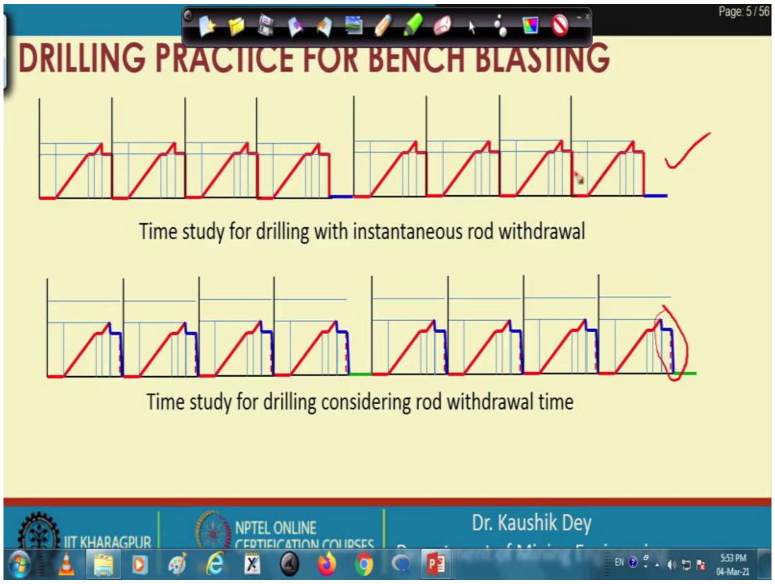

Now, what will happen if you look into this for a shift of operation you can say this is in a shift if say this much hours are required. So, this is taking 37 sorry, this is not this one this is without a say this is 37 this is 37 this is 37 this is 37. So, after drilling these 4 holes say 2 hour operation closely 2 hour something so, there is a recess time.

So, this is the recess time then again, the drilling is carried out 37, 37, 37, 37. So, effective you can consider the 8 holes each is taking 37 minutes. So, closely 5 hours are basically utilised to carry out the 8 holes. So, that means, from this you can find out if you are deploying a machine in that particular and operator is very very judiciously carrying out the drilling the operator can drill the 8 holes in that particular 5 hours available operations. So, this is from this you can find out what to do with the performance of a drill machine.

So, let us consider this concept in the above figure, which I have not shown you. So, now you can see, if this is the way you are calculating the performance, you are considering the withdrawing rate in this case the above this figure here we were not considering the withdrawing rate and in that case you are just considering it is instantaneous and you are neglecting the withdrawing rate.

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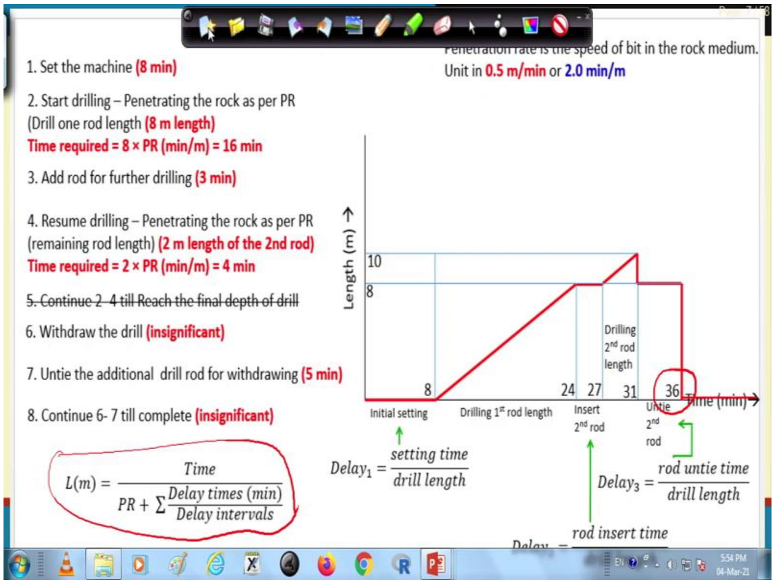

So, if that is the situation in that case, this will be your consideration, and your performance can be calculated using the same formula. Only the withdrawing rate is discarded here, and that withdrawing time of 1 minute you will find out that is not considered there and that is why the hole drilling of a hole of 10 metres is completed this 10-metre drilling hole is completed in 36 minute only.

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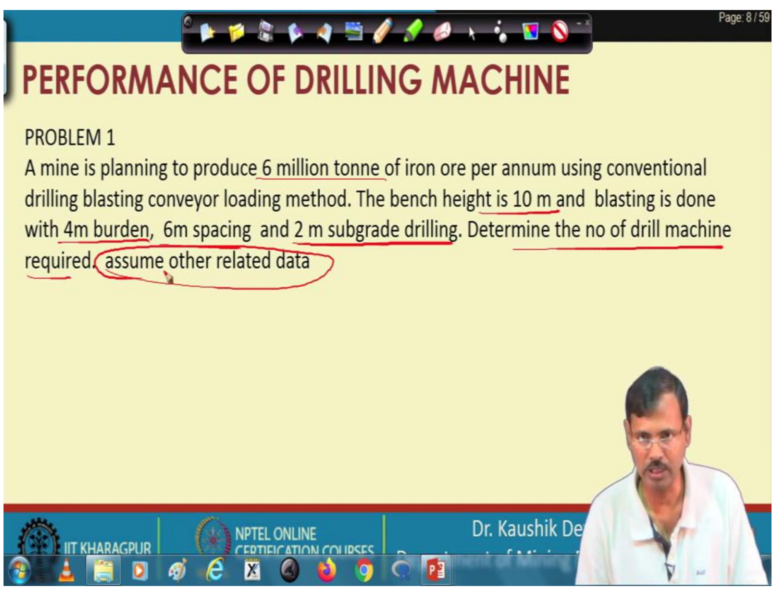

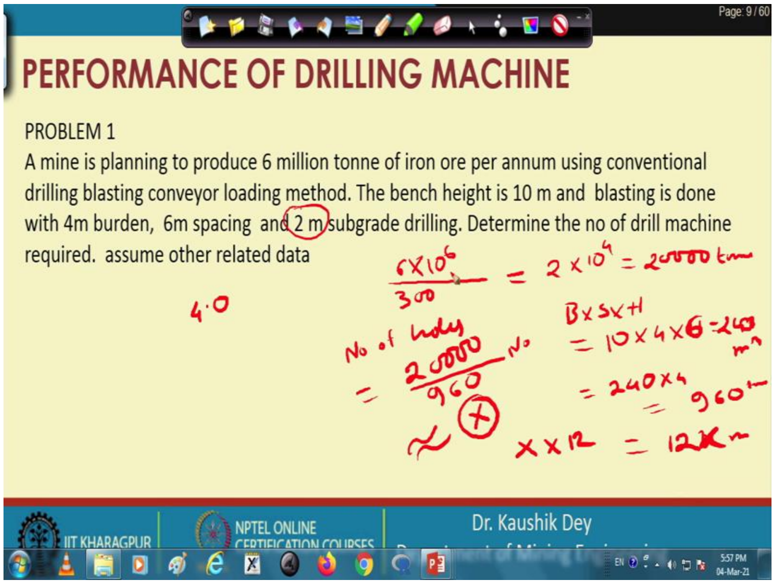

So, now, considering these, let us calculate for one practical case, where the mine is planning to produce 6 million tonnes of iron ore using drilling and blasting bench height. The 10 metres burden is given 4 metre spacing 6, and sub drilling is carried out 2 metres. So, we have to find out the number of drill machines required, and you can assume the other related data.

So, first, we have to find out our daily target requirement at this. So, we have some sample solutions in the next slide, but let us try to solve this in this place. So, as we have 6 into 10 to power 6 million tonnes of production is required. Let us consider we are having 300 days of operation, and this will lead to 2 into 10 to power 4 tone, which means 20,000 tone production is required daily.

Now, let us see what the yield we get from 1 hole if we blast 1 hole from there, we can get the yield is equal to the burden into spacing into bench height, which means our production from 1 hole is 10 into 4 into H that is 6 10 into 4 into 6 that is a 240-metre cube is. So, to convert it into the tone, we need to have the density say our density as it is iron ore considered the density is 4.0. So, this is 240 into 4. That is 960 tonnes of material can be produced from blasting one hole.

So, our number of holes to be drilled is 20,000 tones divided by 960, and this is the number of holes. Obviously, we have to express it in a whole number. So, what is the whole number you have to consider that and whatever number is obtained, say this is x, then the mid-range to be drilled is X into 12 because this 12X metre has to be drilled because you have 2 metres sub drilling. So, this 12X hole 12X metre has to be drilled.

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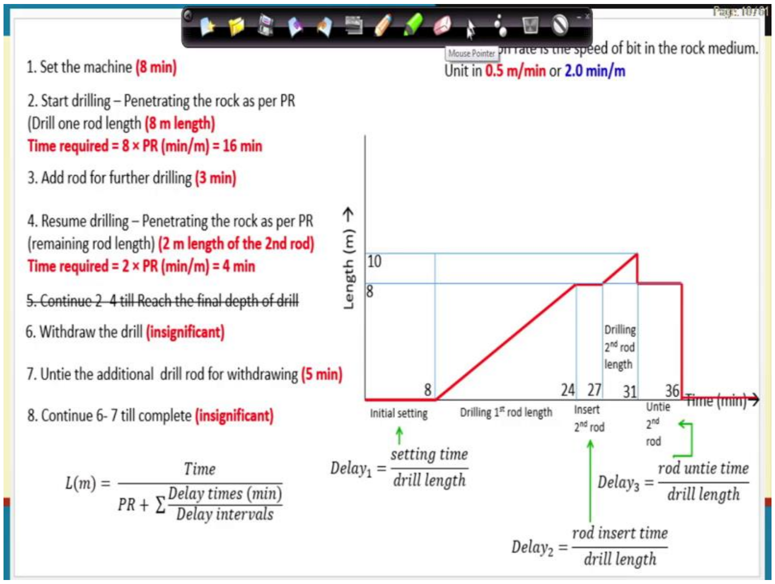

As per the requirement, our earlier let us look back and see what our drilling rate was. So, let us consider that this is our 36 minutes is required for the first case. So, let us consider something drilling rate at this position this is for 10-metre hole.

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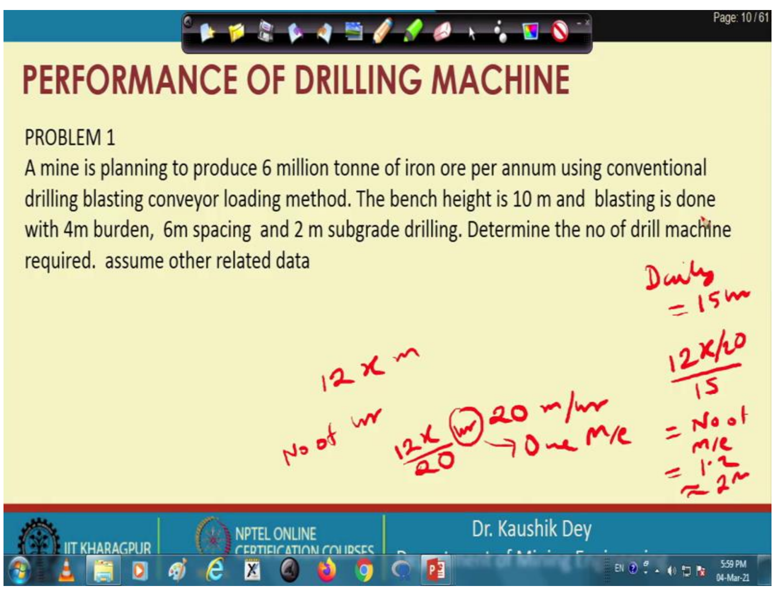

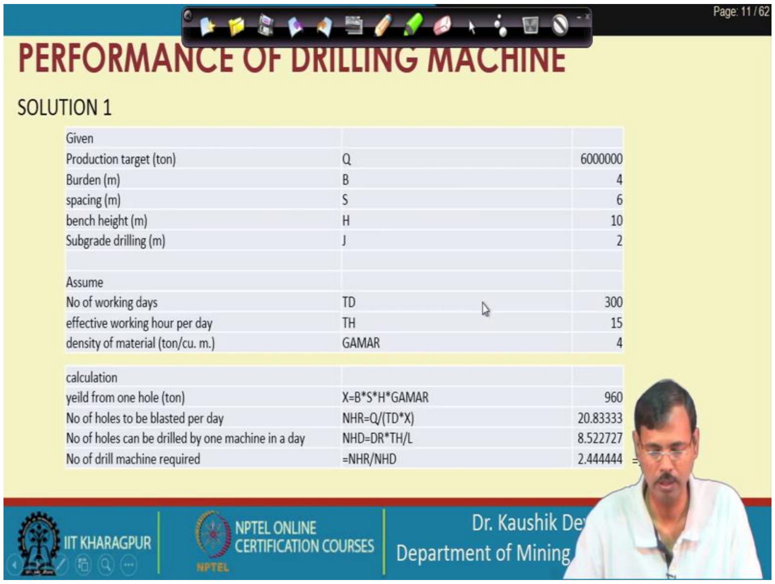

So, let us consider our drilling rate of 20 metres per hour. So, the total mid-range to be drilled is 12x metre. So, the number of hours required 12x by 20 is the number of hours requested for one machine. Now, considered daily available working hour is equal to 15 hours. So, dividing 12x by 20 with 15 will get the number of machines.

So, this is the number of machine you will obtain. Obviously, you must go for the next higher, that means 1.2 means it is you need to have 2 machines. You cannot conclude that you need one machine here. So, this is the solution here. So, the solution presented here we have found that the 3 machines are required in this particular case. So, this is the performance calculation for a drill machine. We will go for cost calculation for the drill machine in the next class. Thank you.