Surface Mining Technology
Professor Kaushik Dey
Department of Mining Engineering
Indian Institute of Technology, Kharagpur
Lecture 12
Drilling Technology for Surface Blasting- II

Let me welcome you to the 12th lecture of surface mining technology. This is the second lecture on drilling technology for surface blasting. In the last class, you also discussed the first lecture related to drilling technology for surface blasting. So, we will continue that lecture for this class also.

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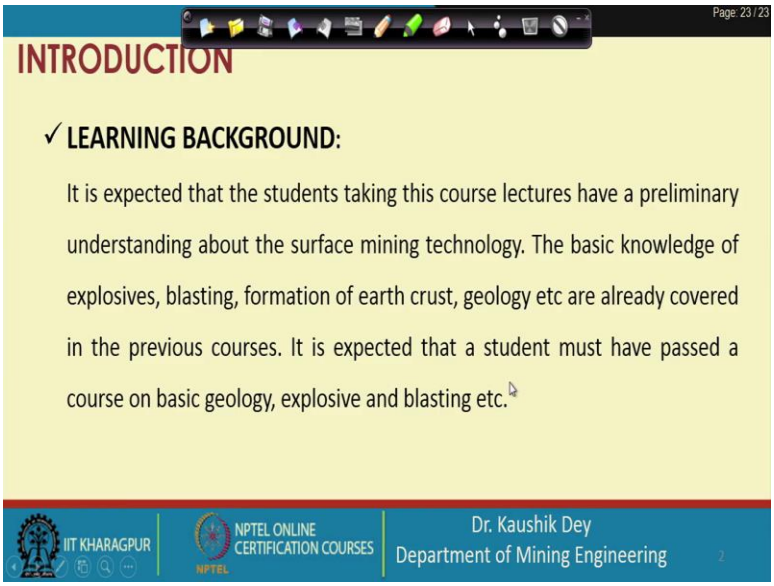

So, as we discussed every time, this is the learning background required for the surface mining technology course.

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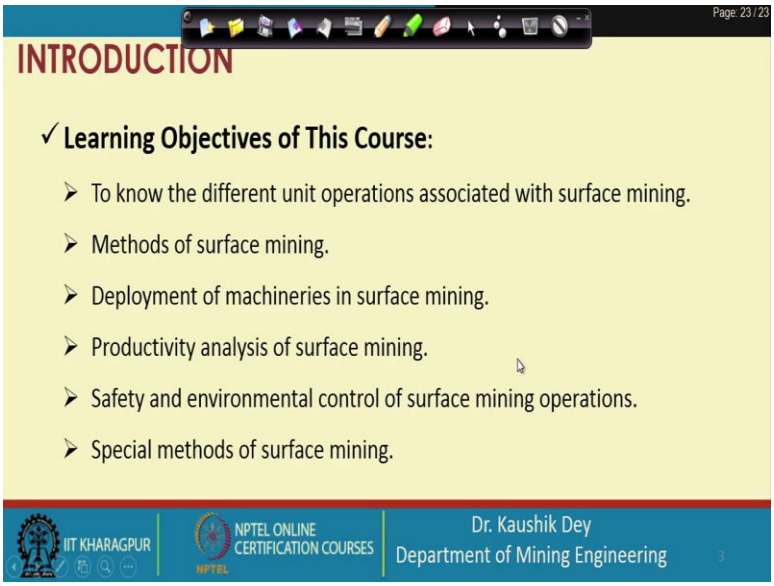

This is the learning objective for the surface mining technology course.

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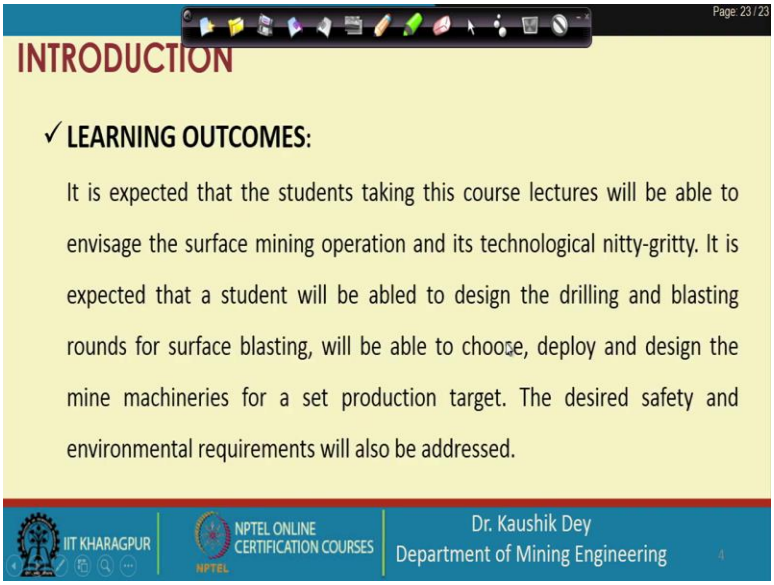

And there is the expected learning outcomes from the surface mining technology course participants.

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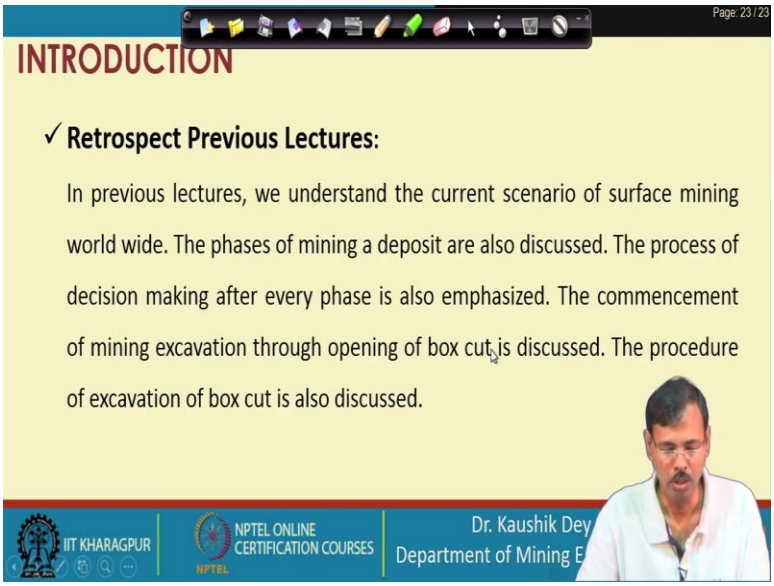

Let us retrospect our previous lecture; in the previous lecture we discussed about the current status of surface mining we have discussed about the phases of surface mining, we have discussed the box cut and the procedure of excavation of the box cut, which is the first cut for the surface mining technology.

And we have started the drilling technology for the surface blasting. In that, we have discussed about the different types of drill machines available and how those drill machines work and how what are their applicability considering the rotary percussive drilling machines and rotary drilling machines, and we have seen the rotary percussive drilling machine is classified into a top hammer or down the hole hammer type. There are applicability merits and demerits are discussed in the previous class.

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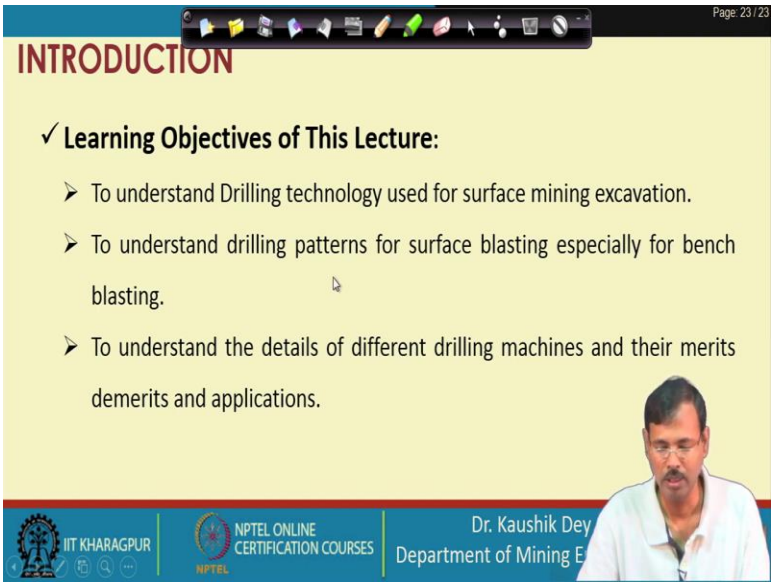

So, the objective of this is the objective of these four drilling lectures. So, the objectives are the same, but in this class, we will mainly discuss the different types of drill bits and how the drilling is carried out are the phases of unit operations associated with the drilling. We will discuss that in this class.

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So, at the very first, let us discuss the drill bit. In the last class, we have discussed the rotary percussive and rotary drilling. These drill bits shown in this figure are primarily applicable for the rotary percussive drilling system this drilling; you can see this is called a button bit in the button bit. You can see these tungsten carbide buttons are impregnated in the mouth of the drill bit.

So, the drilling is carried out by using these bits only. So, these bits are hammering onto the rock surface. So, if this is the rock surface, these buttons are basically provided, which are hammered through this button. So, this as tungsten carbide is a very hard material. So, it allows the propagation of the seismic waves, which breaks the rock and make it into a number of small fragments.

So, this is the button bit is in general applicable for the softer formation where a little bit of energy is required for the cracking of the material. Where a little bit of hard material is there or there may be a little bit of abrasive material is available in those cases, cross bits are used. The cross bit you can see a more significant size tungsten carbide tip is deeply impregnated in the drill bit.

So, that is why these tungsten carbide tips which are deeply impregnated in the beats, gives better resistance, and in the case of abrasive material, it is not eroded very easily in button bit in abrasive material it is eroded very easily this part is eroded very easily. So, in abrasive and hard materials generally, we go for opting of the cross bits. So, cross bits are very very commonly

used in the hard rock conditions, and these are the anchor type drag bits in different cases these are the different types of bit where the tungsten carbide variations are provided. This is the chisel bit most commonly used for the jackhammer.

Here also similar to the cross bit cross bit a number of tips are provided. But in this case as a single tip is provided and which is deeply impregnated. This is deeply impregnated with the drill rod itself. So, sometimes it is also the bit also. So, that is this is the chisel bit, it is commonly used in the handheld drill machines or the wagon drill machines using the jackhammer type drill machine operations. So, this is very commonly used in this cases.

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And these are the bits most commonly used for the rotary drilling system this is commonly used for the rotary drilling system you can see this is the diamond drill bits. So, these diamonds, these diamonds are impregnated into the mouth of the drill bit and you know the diamond is the hardest material.

So, when this is rotating along with it is cutting the rock also or eroding the rock along with this. So, this is the different way we are placing the diamond in the mouth of the drill bit. So, this is one common rotary type of drill bit very commonly used but as diamond is precious generally, these are used for various special cases, because the price of these bits is very high.

This is the second type of rotary drill bit which is called a tricone roller bit and you can see there are three rollers, one roller, two rollers, three rollers are placed at a 120-degree angle to each other and they rotate at a complimentary direction as this one is rotating. So, these rollers are also self-rotating type and have as it is instructed with the rock this one is rotating this is also rotating in complimentary direction and by rotation of this that tungsten carbide tips provided in the mouth of this tricone roller bit that is rolling with the rock and on rolling with the rock it is shearing the rock and failure the rock in abrasion.

So, this is the way the tricone roller bit is working in a rotary drill machine. So, this is a very common drilling machine, in fact, in most of the cases where the rotary machine is used especially for the accuracy rock et cetera you will find out tricone roller beat is a very common bit used for the abrasive material like sandstone sail et cetera in those cases tricone roller bit is used for rotary drill machine.

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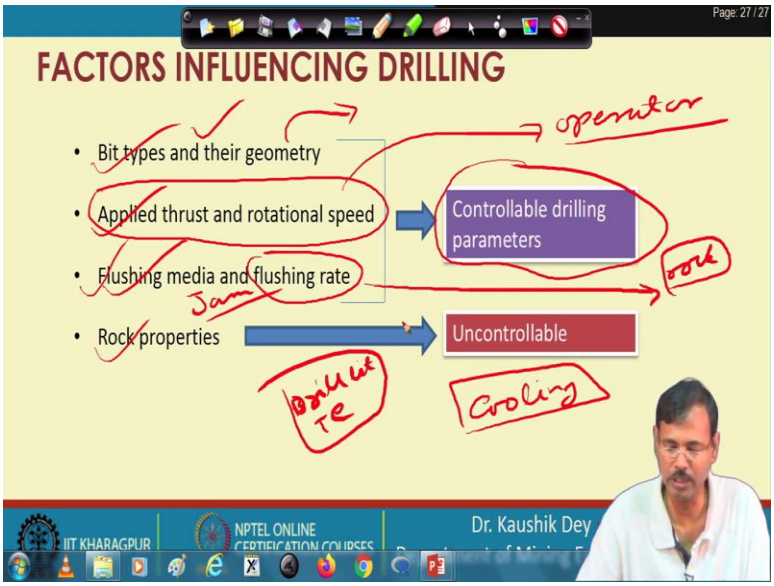

The factors influencing drilling are considered as the bit type and their geometry applied thrust and rotational speed. Flushing media and Flushing rate and rock properties. Among these three are controllable, the operator can control the bit-type can be controlled one time, so, this is one-time control of the drilling system.

So, depending on the rock type, you have to choose the right type of bit often the manufacturer helps you to do that one, but you have to think of the basically few rock properties for which you are considering this bit that is the hardness of the rock property, strength of the rock property abrasivity of the rock property these are the important rock properties you must consider when you are choosing the bit type.

Second is the applied thrust and rotational speed this is under the control of the operator, the operator has to choose the right thrust and right rotational speed so that the proper penetration rate is achieved. Otherwise, it is creating overloading to the drill bit drill rod that may lead to the loss of the drill bit cracking into the rock drill rod those are creating those will create a problem and that wear and tear to the machine is a must be avoided.

And flushing media is very important. The first aspect is that you have to take out the rock cuttings otherwise it will not allow the penetration of the rod or it will create the jamming of the rod. This will jam the rod inside the hole. To avoid that one flushing media must work properly. So, this proper flushing media is very very important and proper flushing rate so that the density

of the medium can be controlled very easily. The second important part important activity carried out by the flushing media is cooling.

Generally, to cool down the drill bit a good quantity of flushing media should be provided so that the temperature of the drill bits should be kept low at a low point so, that the drill bits and tungsten carbide tips these two are having different thermal expansion coefficients and there should not be the temperature should not reach such a point so, that attached in carbide tips will be lost from the bit. So, that is that should be avoided and for that, temperature control is very very important. So, that control must have cared for properly while one is selecting the flushing media and the flushing rate.

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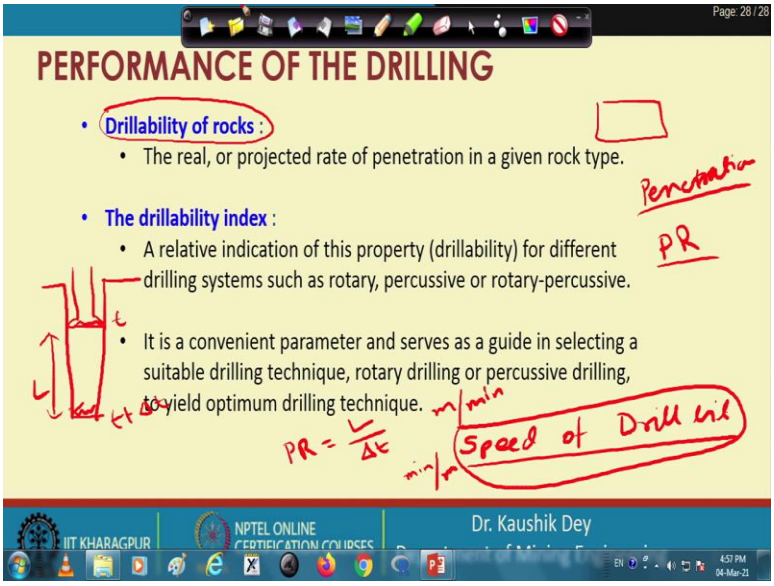

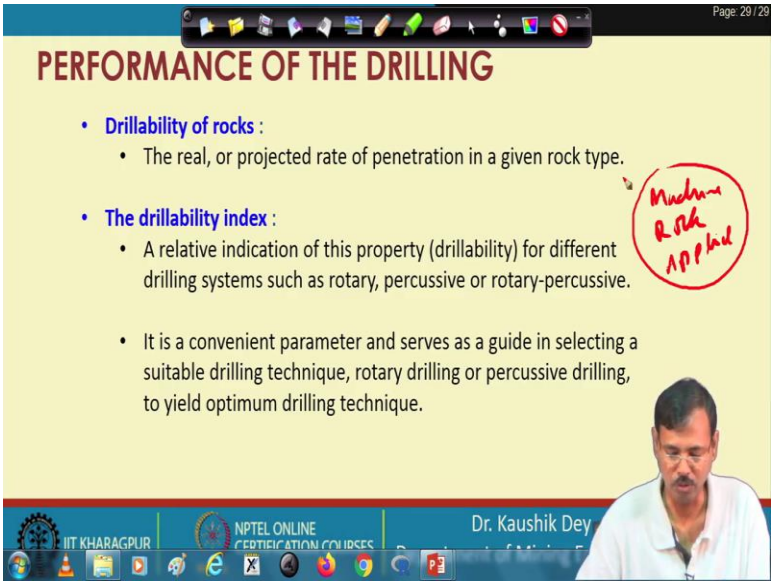

The rock that is the uncontrollable parameter is defined with the term called drillability, how rock is easy to drill is basically given by this term drillability that is if the rock is this is how much strong how much abrasive what is the hardness depending on that it is predicted if a certain machine is deployed in the rock, what is the penetration rate will be achieved what is penetration rate?

So, the penetration rate is basically the speed of the drill bit at which as it advances in the hole. So, that means, if you are carrying out drilling and at time t your drilling bit is at this position and at time t plus delta t the drill bit it at this position and this length you consider this length is L then the penetration rate is called L by delta t. So, this is expressed in metres per minute sometimes often in reverse.

So, you can also express it that is the minute required for penetrating a 1-metre length in that case it is the inverse of this and then the unit will become a minute per metre. So, often sometimes penetration rate is defined in this way also. So, both are penetration rates you must be very very careful about the unit by which it is being expressed. So, that is a very, very important aspect.

So, the penetration rate is governed we have discussed, by the machine parameters, rock parameters and obviously, application parameters. So, as we have discussed earlier that what flushing media we are using, how much thrust we are providing what is the rock these are some of the controllable. So, what bit you are using. So, depending on that those parameters are

governing your penetration rate and basically drillability of the rock means it is basically searching for the penetration possible penetration rate depending on the rock and the machine.

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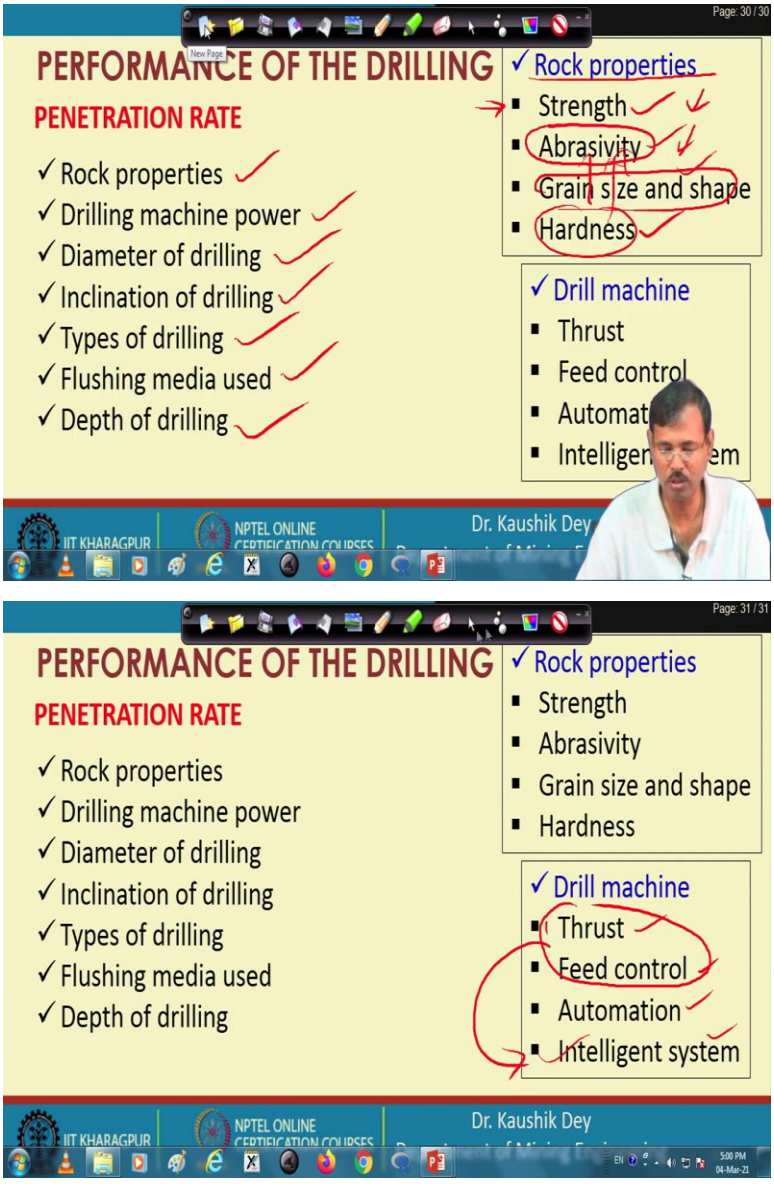

So, you can understand the rock properties govern the penetration rate. It is governed by the drill machine power governed by the diameter of the drilling governed by the inclination of the drilling, types of drilling, flushing media used and depth of drilling. So, if you consider the rock properties, the main key rocks that we consider as the influencing parameters of the penetration rate are strength, abrasivity, grain size, shape, and hardness.

So, if the strength of the rock is very high, obviously, it takes more time to be fragmented more time to be cracked. So, that is why the if the rock, rock strength is high, the penetration rate you will obtain is less so; it is inversely proportional. Similarly, abrasive is basically the measure of the loss of drill bit that depends on how much the drill peak will be eroded. This is because of the abrasive of the rock that is basically governing.

At the moment, if the peak is becoming eroded, that means the tips of the drill bit iarebeing eroded its sharpness will go, and it becomes blunt. So, the blunt tip means the penetration rate will be suffered. So, if the abrasivity is high, then your tip loss is more. In that case you will receive you will get the penetration rate less. Similarly, grain size is also dictating the abrasive the strength of the grain angularity of the grain are basically the governing the higher abrasivity; similarly, high hard means it is also highly abrasive. So, these are basically controlling the aggressivity of the rock.

So, if in a nutshell if the rock is strong, aggressive, et cetera the penetration rate will be suffered, you will get a less penetration rate. Similarly, if you are looking into the drill machine, the thrust, feed control, automation, and intelligent system these are basically governing the penetration rate. If the machine is automated, the drill bit is automatically inserted or released. In those cases that time will not consume a lot.

Feed control, if the proper thrust proper feed is given in those cases, you will get a better penetration rate. If the low thrust is given, then the penetration rate will suffer, and intelligent system means you are controlling the feed thrust all these parameters depending on the resistance received by the rock. In those cases, that is an intelligent system developed for the different modern machines, the thrust and feed et cetera are controlled using those cases. So, those machines are better for getting a better penetration rate.

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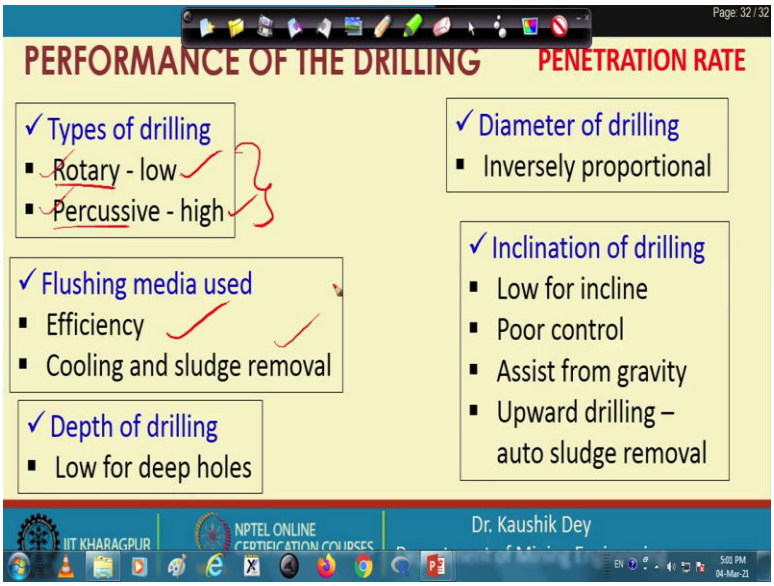

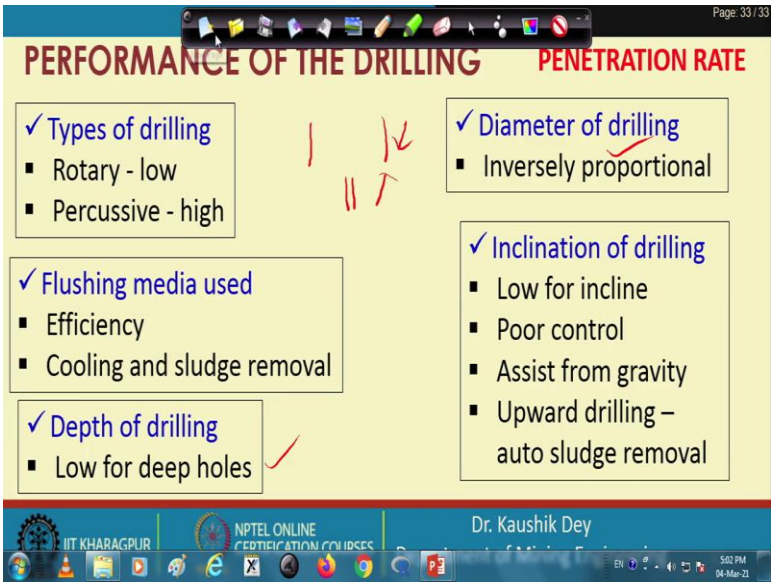

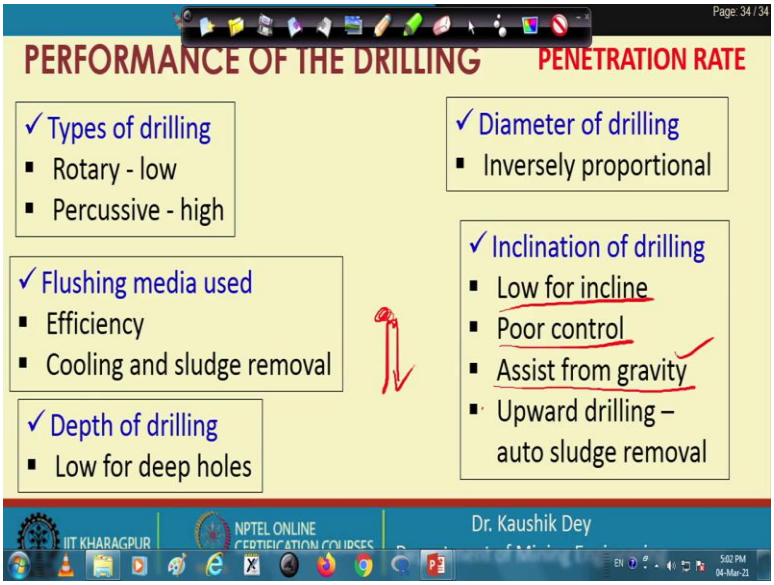

Similarly, if the drilling is carried out rotary, the observed penetration rate is a little low. In the case of percussive, the penetration rate is observed to be a little bit high. But if you consider the very strong rock cases, it may often differ. So, this depends on the type of rock and the interaction between the machine with that.

So, depending on that, the rotary or percussive also governs a lot of roles. The flushing media its efficiency, how much cooling is required, sludge material is being generated if that has to be removed, the proper quantity of flushing is being provided, or not the flu pump is basically giving the proper pressure or not all these are basically governing a lot to achieve the penetration rate.

The penetration rate is often low for deep holes; it is high for the initial part. So, the depth of the hole also governs a lot. The diameter of the drilling on which the penetration rate is inversely proportional because it is easily understood that if the diameter is more the penetration will be less. If the diameter is small, the penetration will be very easy because the rock resistance is less.

So, that is why the penetration rate here will get less here. It will get it more. And this inclination of drilling low for incline home, because poor control and if you are carrying out drilling vertically downward, the drilling is being assisted by the gravity, so that is the better option. But if you are carrying out drilling in the upward direction in that case, the drilling is carried out against gravity. Still, it has a benefit that the sludge, whatever drill cuttings are there, is automatically released from the hole because of the gravity. So, in some way, it is also

beneficial. But overall, the drilling against gravity is troublesome and difficult to control. In general, that is why it is avoided in most cases and is not available for surface mine cases.

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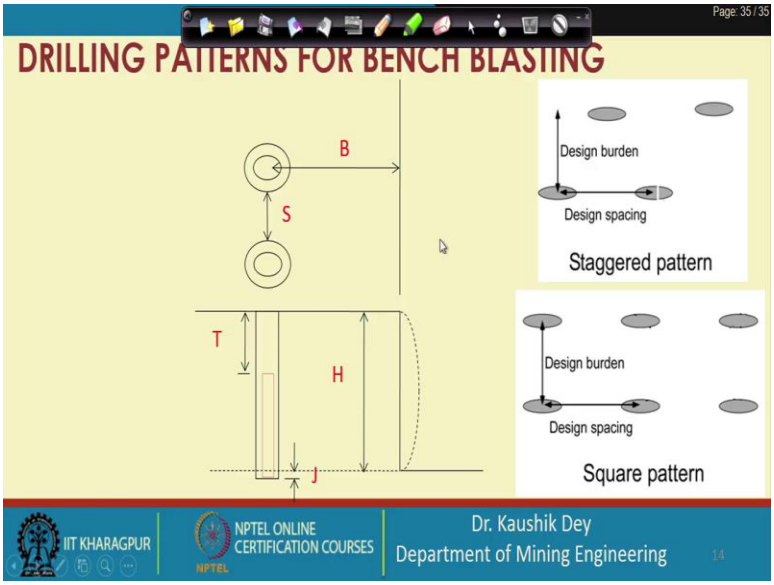

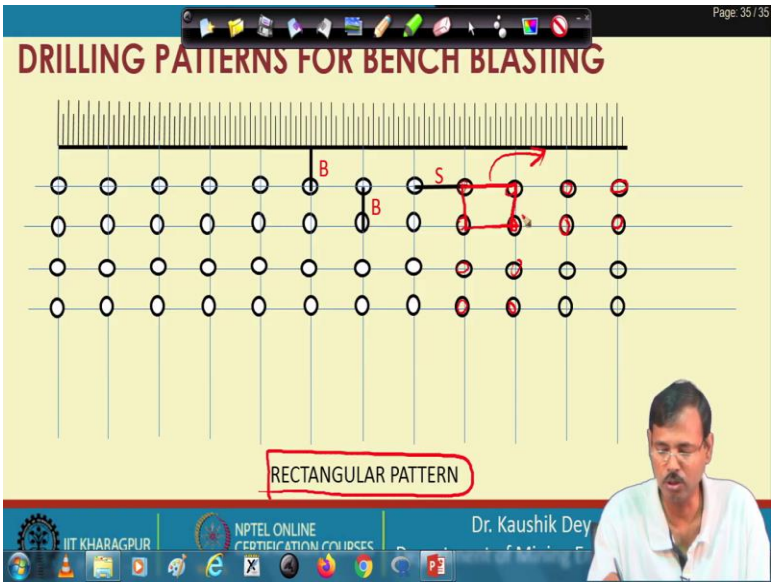

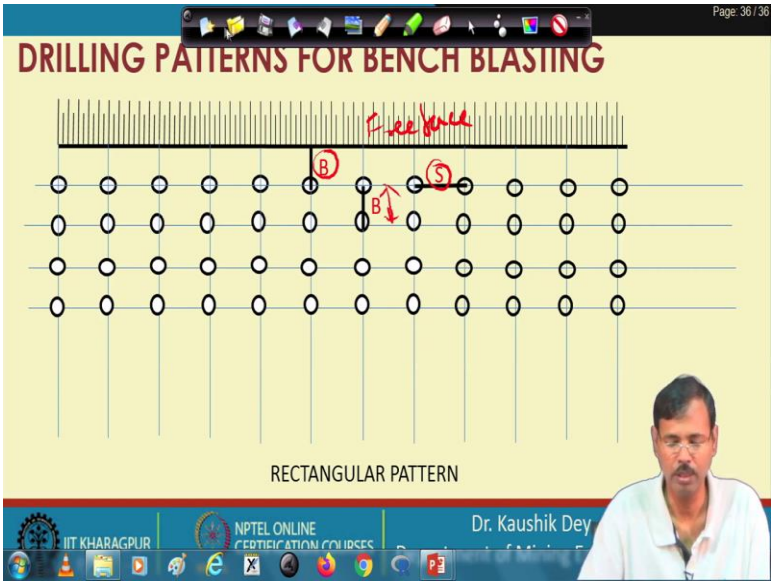

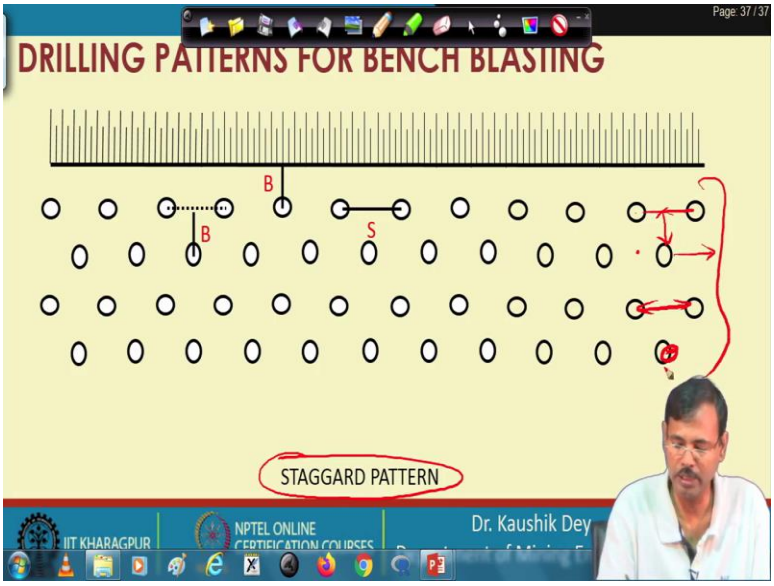

Now, let us understand the different terminology related to surface mine drilling. You would now go the for drilling to carried out the blasting. In blasting, while we are carrying out drilling, we are having options of drilling. we are having options of carrying out drilling the holes in which the second-row holes are drilled directly behind the first row holes. You can see the whole surface of the next row is drilled directly behind the front row holes, and in that case, this type of drilling is called a rectangular drilling pattern.

In a rectangular drilling pattern, you can see if you join four holes, then a rectangle is being formed. So, often you will find out in some textbooks that a square pattern is also discussed, but

the square is a special rectangle type. So, that is why I omit the square pattern. I consider a square pattern is also a rectangular pattern.

So, this is a rectangular pattern in which you carry out drilling the second-row hole just behind the front row hole. And you know the blasting terminology if this is the free face, this is called burden, and this is called spacing and for the second row also the distance from the first to the second row is considered as the burden.

Now, in the second type of dealing system, you can have the next row hole, you can have the next row hole, you can have this next row hole instead of just behind this one; you are just placing this hole between the two holes of the front row hole. So, the second role is placed in the middle of the first two-row holes. So, that is why here, the direct rectangle cannot be formed.

So, in this case, your drilling system is called a staggered drilling system in which the next row holes are placed between the two holes of the previous row holes. So, the next row hole is placed between the two holes of the previous row. So, this is called a staggered system, and in the staggered system, your concept of burden and spacing is the same. So, these are the two types of drilling systems in general available for the surface blasting carried out by the drilling.

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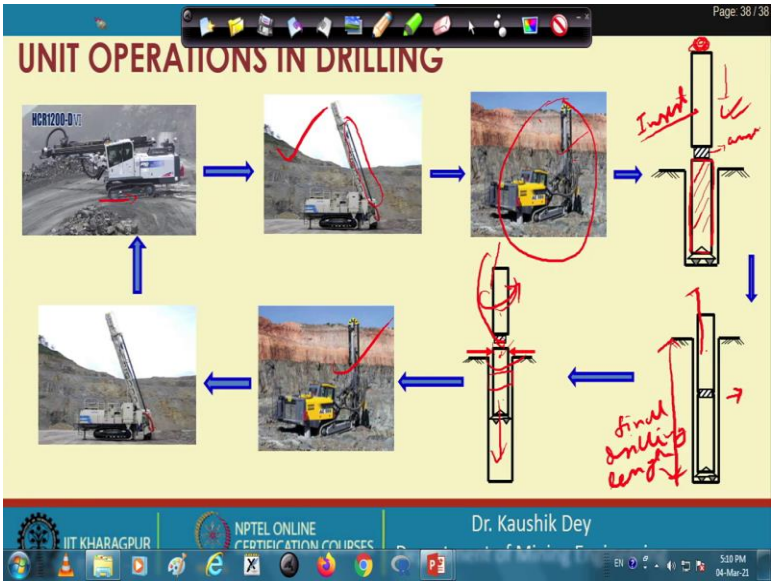

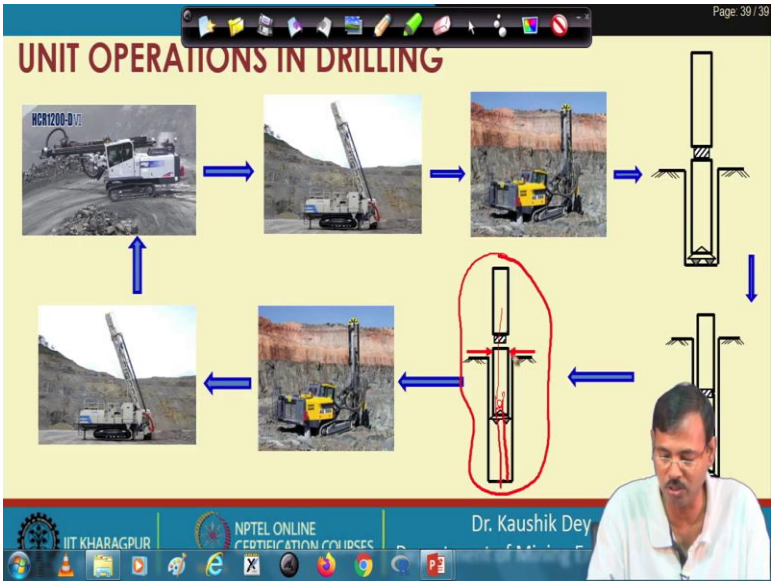

Now, if you look into the different unit operations possible with surface drilling, you can see the first job is positioning the machine or propelling the machine from the right to the right place. So, this is the position of the machine; we are now propelling the machine or allowing the machine to move to the right position.

So, this is the right position the machine has arrived at this right position. Now, the machine is placed at this position, and the boom is now lifted and trying to be trying it to place in the right spot. Now, it is the drilling is now started in the right spot. So, these photos are taken from Google photo. So, this is the right spot in which the machine is placed, and the drilling is started. Now, when the drilling is started, what will happen in the next phase? Suppose one drill length means rod; this is the rod that is placed at this position.

So, this rod is completely inserted; this rod is completely inserted in the hole. So, this is the rod's first rod that is completely inserted into the hole. This is the drill bit placed in the mouth of the first rod. Now, forgoing further drilling, we need to add the second rod at this position. So, this is the second rod either it is automatically taken or a manual it has to be placed at this position, and the sank adapter has to be again allowed to rotate and get fixed with this, then the further drilling has to be carried out.

So, you need to insert the second rod at this position. This is called coupling, which is basically joining rod one and rod two. So, you are inserting the second rod and again resume that drilling in here. You have started drilling here. You have completed the first-rod drilling and attached the

second rod here, then you have started drilling with the first rod that the second rod together now, you have increased that whole depth up to this.

Now, this is the completion of the whole depth, say or if you need to go for further addition of the rod, you can go for repeating this step again and in this case, let us consider we have stopped at this position, then this is your final drilling length. Now, you have completed the final drilling length if the requirement is to lift this rod up.

So, what you need to do you have to lift this rod in an upward direction. So, you are doing that now, when you have come out up to this then you have to untie the second rod, you have to untie the second rod you have to place that rod in the sideways then your sank adapter will come, and that will connect to it this one, and it will be lifted, but what will happen if you take out this one without holding this first rod, this first rod will drop into the hole then you cannot lift it up very easily again.

So, to avoid that one, you have to use a pipe jack and hold the first rod, then you have to untie this one. You allow your sank adopter to come here and join with this first rod which is now held in a hold with the pipe jack then you are taking it out lift it out finally, so, this is again you are lifting the rod finally. You are withdrawing from this position, and again you are moving to the next hole.

So, this is the basically cycle of the different unit operations. In general, you carry out a mining purpose; this part is very, very important. I would like to draw your attention to this holding of this one now it does with the modern equipment automatic systems are available to the machine is automatically having a pipe jack or you can say rod holder that will hold this one otherwise it has to be carried out manually and in that case any slipping of this on suppose if it is lost at this position, it is very difficult to lift it out because again say this rod has to send whether it will be appropriately aligned or it will tie it this properly or not that is a very difficult condition and that must be avoided in any such situation.

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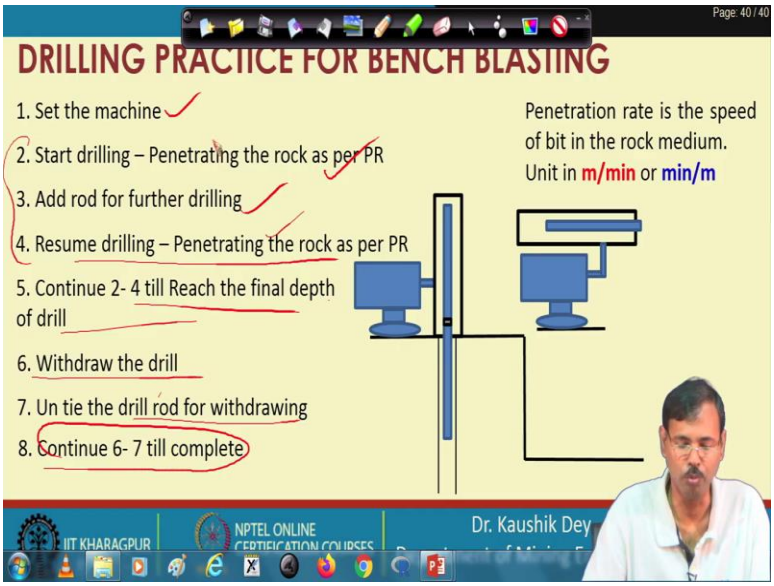

So, the whole process I have expressed in this slide. First, you need to set the machine; then you need to start drilling to penetrate the rock as per the penetration rate, then add the second rod for further delay; if you need to go for adding different rods in case of a bottomless hole. So, you have to resume drill and penetration carried out this one, this 2 to 4 will be repeated for the more number of holes then you have to complete the reach up to the final depth of drill then you have to withdraw the drill then, one by one you have to untie the drill rod and again take up the next part in that case very precisely you need to tie the and tie your hold the remaining rock portion which is there and from this 6 to 7 point you have to complete it unless and until you are moving out of the hole.

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So, this is the cycle of the whole operation. This is one video from YouTube I have taken here. Just look into this. This is basically the automatic rod changing. You can see this rod is being changed automatically. This is untying the sees the breast portion it is this sinking adapter is coming this is now again tying with the rod which is remaining in the lower part the first rod. So, it is now tying with that you can see the rod is being tied with the sank adapter now it is being lifted up see the second rod is now being lifted up.

So, the first rod was held hold with this pipe jack. Now, the drilling with this hole is complete. Now, the machine is moved to the next hole. See, it is now positioned down now the first road is completing that doing the drilling started drilling machine is position first rod started drilling at this position.

So, now the penetration, the drill bit penetrates the rock and goes inside the hole as per the penetration rate. So, now you can see the first rod is almost in the completion stage. So, the first rod is now, the first drill rod is now complete, and this is the first drill rod drilling is done. The hole is now trying to be flushed out, if anything is there or not.

Now, they are untying the sank adapter after from the drill rod see the sank adapter is nowt is taken up now automatically the second rod will be inserted through now, the sank adapter is this automatically the second rod is placed first the sand conductor is being tied with the second rod then the sank conductor will rotate this second rod now it is positioned.

Now, the second rod is further lowered annotated a little to tie with the first rod automatically rod. Now see, it is already tied with the first rod. The rod holder has now been released. The second-rod drilling is started at this position. So, this is a very, very interesting one. The complete cycle is shown at this position in this video. That is why I have taken this video from YouTube to show you properly. This is an Atlas Copco video; I think taken from YouTube. So, let us stop at this position. Thank you.