Drilling and Blasting Technology
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Lecture – 08
Drilling Mechanism

Let me welcome you to the 8th lecture of Drilling and Blasting technology. In this lecture we will discuss about the mechanism of rock breakage while we are carrying out drilling, but like every class let us retrospect our previous lecture.

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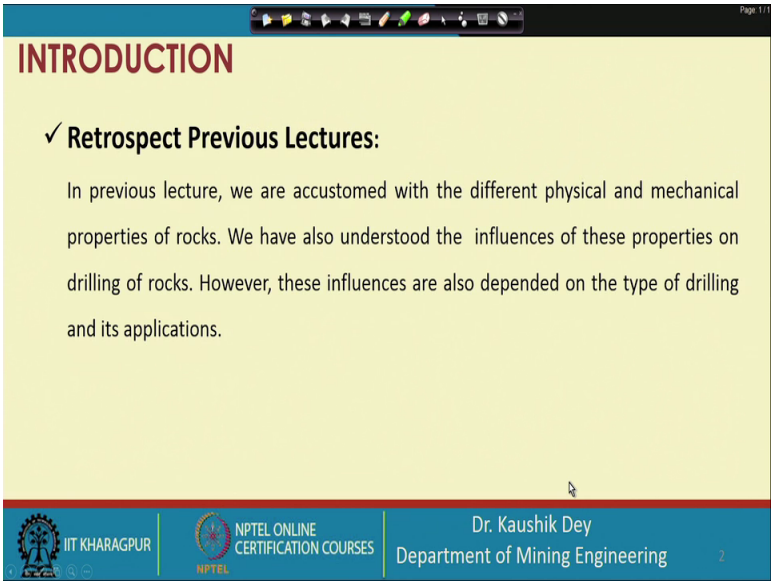

Previously we are accustomed with the different physical and mechanical properties of rocks. We have also understood the influence of these properties on the drilling of rocks. However, this influencers also dependent on the type of drilling and it is application.

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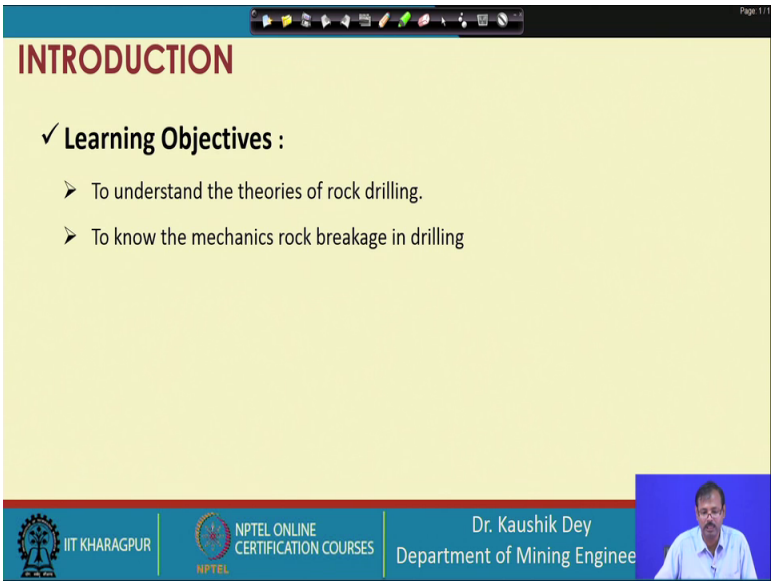

So, what we will do in this? This class we will mostly discussed about the theories of rock drilling; that means, how in a during our drilling we are failing the rock. And the mechanics of that rock breakage while we are applying force from the drill steel or drill bit. So, this is our learning objective, we will try to understand these things in this lecture. So, first before understanding the mechanism first let us have some look into the Drilling methods.

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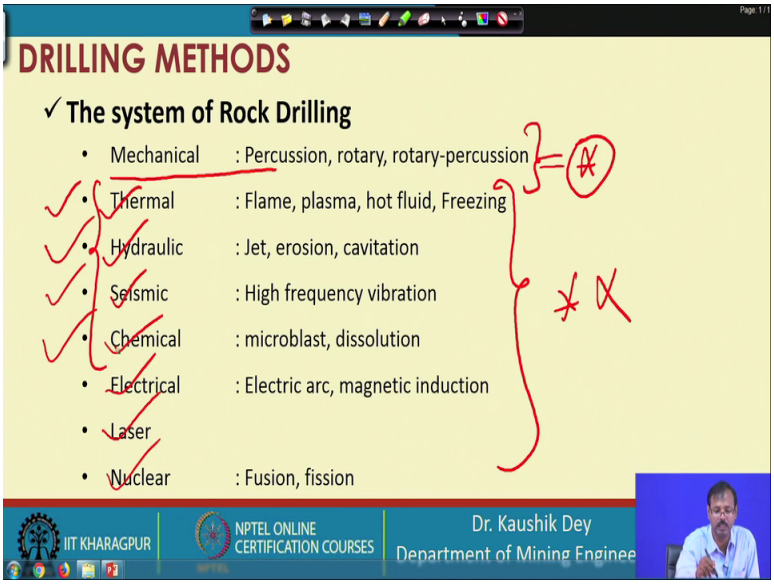

Basically the system of drilling may be carried out in different, different way. First is the mechanical one, first is the mechanical one where we provide mechanical force using some drill bit or drill steel so that; on repeated hammering or repeated abrasion the rocks can fail. There are other systems in our mostly drilling while we carry out for our blasting purpose, this is the most common one the mechanical drilling system we use for drilling a hole in the rock mass.

Apart from that there are other drilling systems, where thermal behavior of the rock is utilized for fragmenting the rock. If here, flame plasma hot fluids freezing these technologies are adopted. It can be hydraulic force can be used for piercing the rock fragmenting the rock so these are basically different where cavitation and erosion is carried out for creating a hole. Seismic is carried out, where the seismic energy or the wave propagation is utilized for fracturing the rock and creating a hole.

Hole can be created chemically where the rock is made soluble with the chemical and take it out for creating a cavity. Electrically rock can be allowed to be fragmented by electrical arc, magnetic induction. In fact, microwave techniques are also used for that, laser cutting also be carried out and nuclear fission and fusion is also carried out.

But these technologies are not commonly used in drilling, in drilling for blasting purpose. However, some of these technologies are utilized for rock excavation where rock are fractured prior to excavate from the in (Refer Time: 03:38) in those cases these are the technology Thermal, Hydraulic mining, Seismic fracturization or Seismic fracturing in case of gas extracting, these chemicals where some mining is carried out by chemical solutions, these are commonly used in rock excavation purpose, but not for our drilling purpose.

So, in drilling for blasting purpose mostly we use this mechanical drilling and we will discuss about this one in our future slides. However, at the end of this drilling part we will try to discuss some of the special techniques of drilling in those cases some of these techniques will be also discussed.

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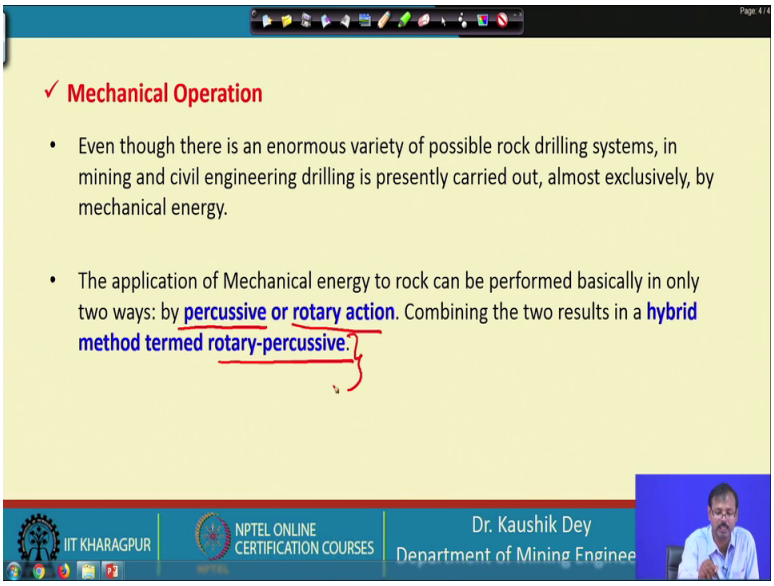

Now, let us understand how we are mechanically carrying out the drilling. The mechanical orientation this is carried out say there is an enormous variety of possible rock drilling system in mining, and civil engineering, and exclusively it is carried out by using the mechanical energy, this we have already discussed. This mechanical energy from the drill to the rock is transferred basically from 2 by 2 way one is by percussion or by rotary action.

And using where we use both the system, there we use hybrid system which is called rotary percussive. Basically none of these systems are stand-alone all the rotary drills are basically carrying out rotary action under a very little percussive actions. All the percussive drills are carrying majorly percussive action a little rotary action. And in rotary percussive drill that is hybrid drill carrying most both the action in a major manner, but always the percussive in rotary percussive is the major action carried out for drilling purpose.

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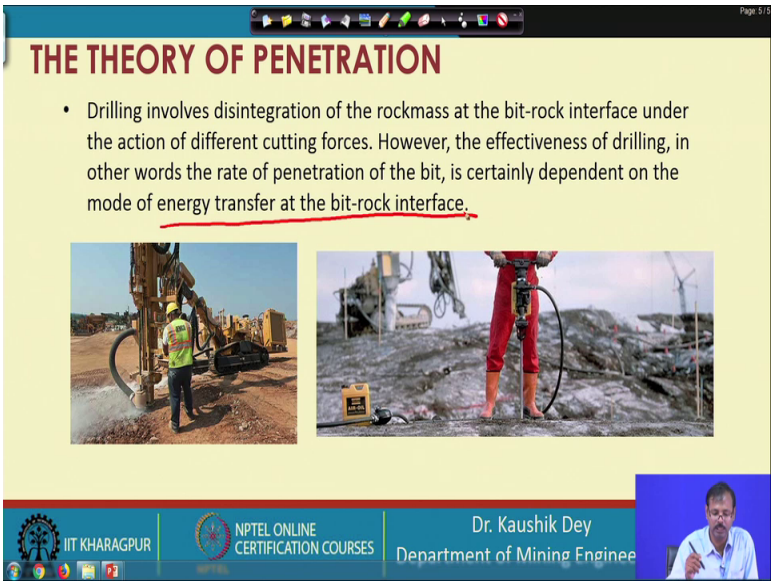

So, let us see about the theory of penetration, drilling involves disintegration of the rock mass where the bit, and rock are interacting bit is basically fracturing the rock under the percussive or rotary action, and the effectiveness of drilling is measured as the rate of penetration of the bit. That means the speed at which the bit is traveling inside the rock mass. So, basically the bit will travel in the rock mass very fast; if the energy transfer is efficient.

So, basically drilling is basically the bit the bit and rock energy transfer between the bit and rock interface which is very very important in the drilling. So now, let us look further details of this.

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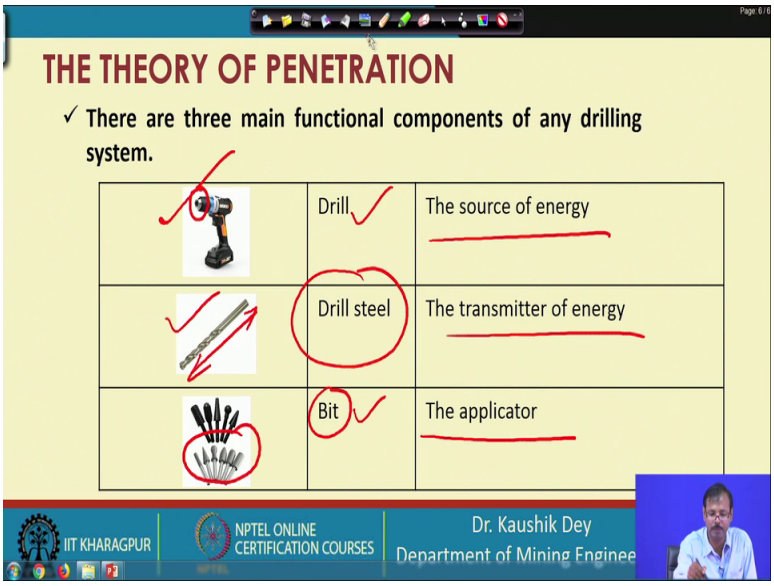

If you see the drill machine drill machine basically comprising 3 things: first is the drill that is the machine second one is the drill steel. That means, the energy developed in the mouth of this drill machine is transport to the bit through this drill steel, and bit is the element which is interacting with the rock to fracture the rock.

So, basically bit is acting, drill is generating the power, and drill steel is the transmitter. So, drill is the source of energy drill steel is the transmitter of the energy and bit is the applicator of the energy.

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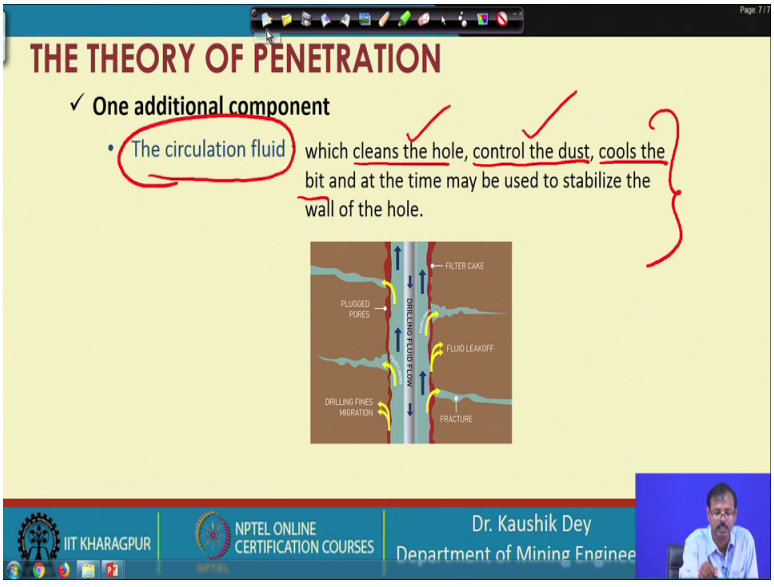

And we meet another thing along with this main one that is, auxiliary one, but this is very very important that is the circulation fluid it is important, because the purpose of circulation fluid is to clean the hole. That means whatever fractured rock is there the fractured rock has to be taken out from the drill hole. So, we have to clean the hole so circulating fluid is basically cleaning the hole. This is also suppressing the dust as it is a fluid and these also cool down the bit. As the repeated hammering action or the rotary action the temperature on the bit is trying to increase a lot the purpose of this circulation fluid is to cool down this a bit.

So, that the temperature of the bit will remain less and the disintegration of the fracturing of the bit material will not occur. So, that is why this circulation fluid is very very important in the drilling.

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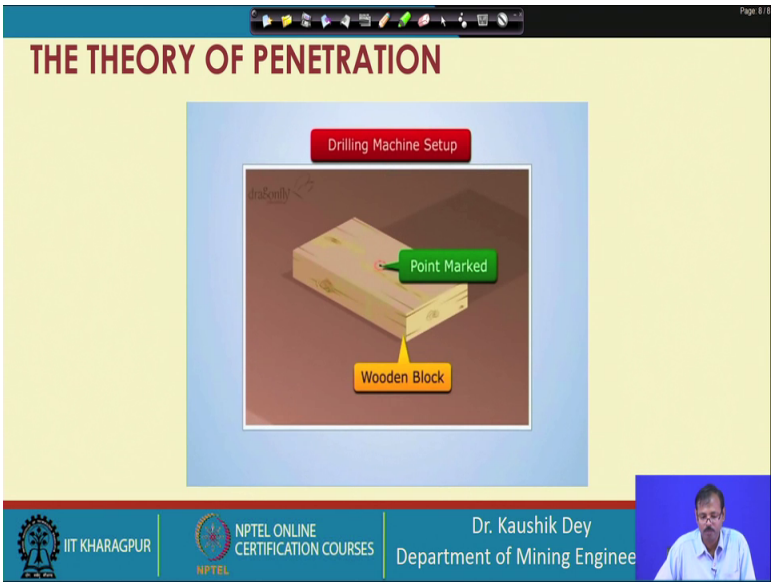

Now, let us look into this video, this video basically will give you some idea. Here a rotary drill normal a handheld drill which is used in the household purpose that drill is used to drill an wooden piece. So, you just look into that you just look into this.

As you has a thought.

Video.

How the holes are made in a work piece without damaging it.

So, that you can understand little bit of axe some of drill machine

To understand this let us consider a wooden block.

How it is carrying out the drilling?

And mark a point on it.

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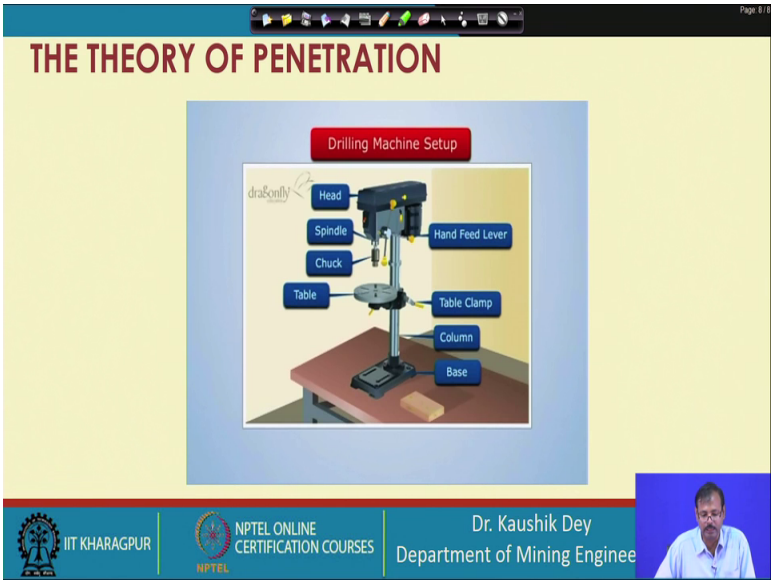

So, they basically this is the drilling of the wood under a household machine and this is a complete rotary drill machine.

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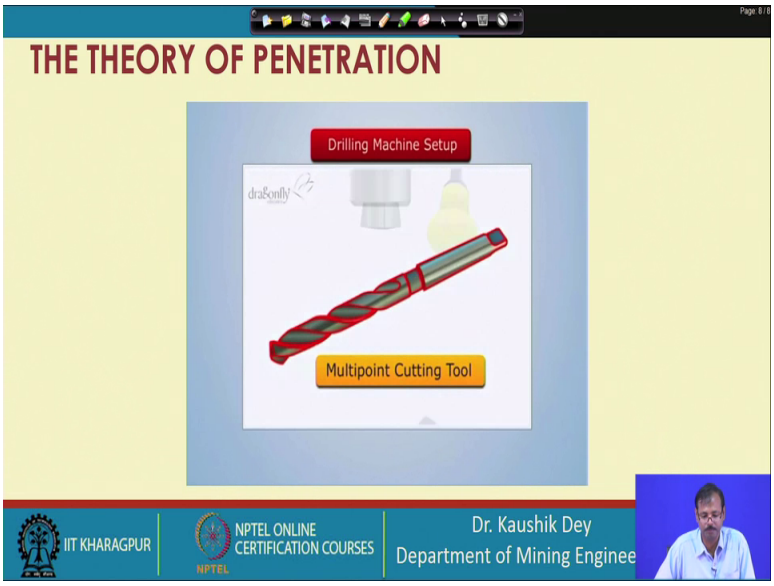

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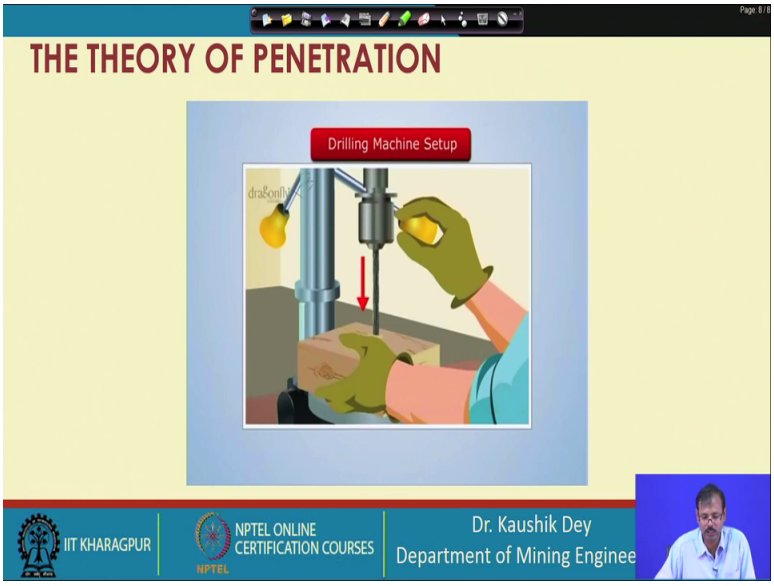

So, you can see it. So, that is the machine this is the drill steel in the mouth of the drill steel the rotational part that is the bit is there, so these are 2 point.

Now, let us rotate the hand lever manually, this makes the rotating tool to move linearly towards the wooden block until the tool gets touched to the block as we rotate the lever further we see the 2.

So, first is given manually to the rotary action.

Into the wooden blocks.

The wooden blocks are.

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Cutting into to the pieces we can see the cut pieces are coming out.

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You see in this case there is no circulation fluid.

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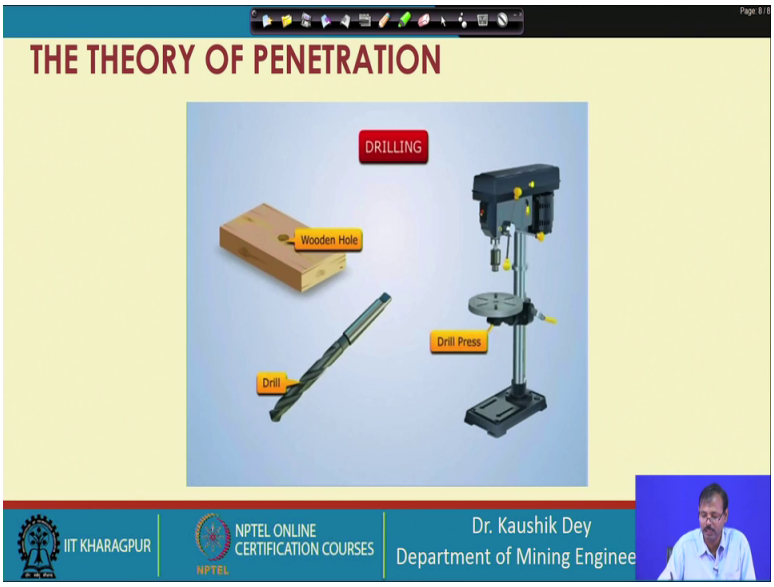

Only by as it is a short length drilling and it is manually operated. So that is why the wooden pieces are coming out in the rotary action only cut pieces are coming out in the rotary action only more circulation fluid is available in this case.

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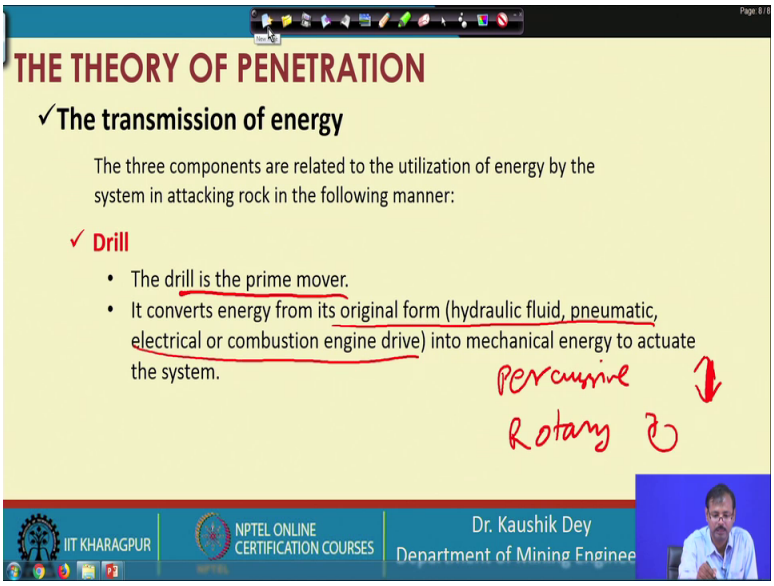

So, basically you can understand the drill is basically the prime mover which is the source of the energy. It converts the energy from it is original form which may be hydraulic, pneumatic, electrical, diesel anything into the mechanical energy either by percussive or rotary.

So, either it is giving a percussive action like this or it is giving a rotary action like this or both. So, basically drill is converting the prime energy into the mechanical energy in form of either percussion or rotary action.

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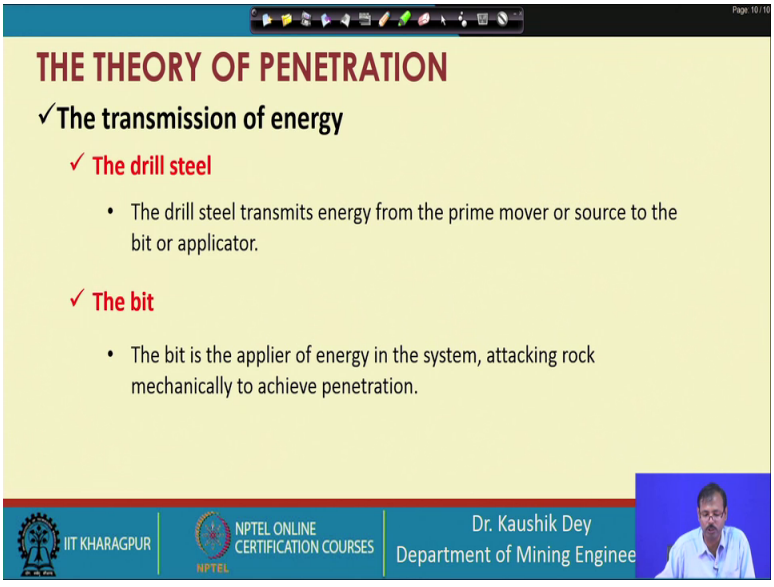

Then the next one is the drill steel. So, drill steel is the basically the drill rod, which is transferring the energy in same and equal manner to the drill bit, which is the applicators. And the next one is the bit which is applying this energy to the rock. That means, if it is a percussive energy. So, drill bit is basically hammering the rock, if it is the rotary energy then drill bit is abrasing the rock and on it is point of contact.

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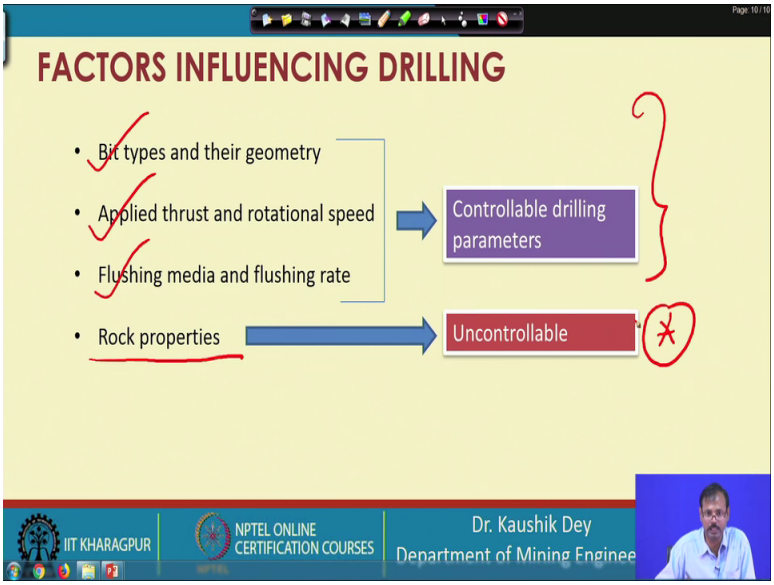

Now, fracturing is fracturing of rock by the drill is basically influencing by 4 major properties. You can see the first is the drill bit and it is geometry. Second one is the applied thrust and it is rotational speed; that means, the rotary force abrasive force, applied thrust means the percussive force. Flushing medium is how first we are taking out the cut pieces, and finally the rock properties. Basically if you look into these the first 3 are controllable; that means, we can change we can choose our drill machine, we can choose our drill bit, we can choose our drill steel, we can choose our flushing media, we can increase or decrease the force of the drill bit you by a manually operating our drill machine.

So, these are controllable parameter for us; however, we cannot change the rock because this is in situ and it is uncontrollable. We have to drill a hole in that media whether we like it or not we cannot change this media. So, basically we have to select a suitable drill machine or you have to select these properties in the drill machine so that we can achieve the foster drilling rate.

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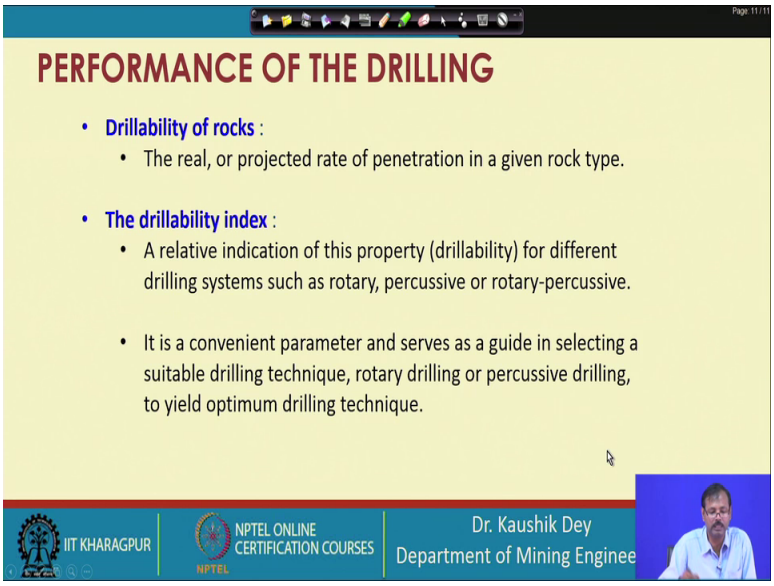

So, basically drillability is the drillabilty of the rock is defining it is how easy to drill a rock and we, there is a drillabilty index which defining the drillabilty of the rock under different condition rotary or percussive or rotary percussive condition.

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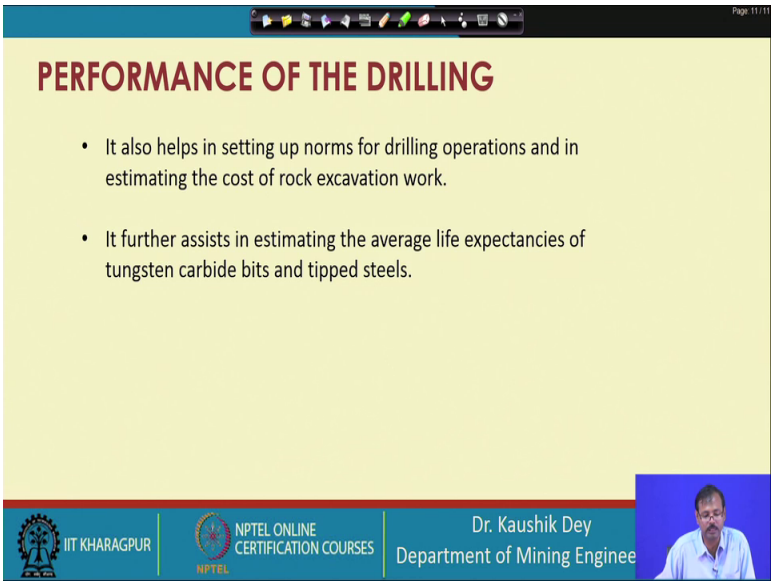

Performance of the drill machine also helps in setting up norms for drilling operations and in estimating the cost of the excavation. And it further assist the estimating the average life expectancies of the bits and the drill steels.

So, basically drillabilty index, drillabilty index is defining all these requirements from which we can assess or we can estimate the penetration rate, we can estimate the cost of drilling and accordingly we can choose our drill machine for our requirements.

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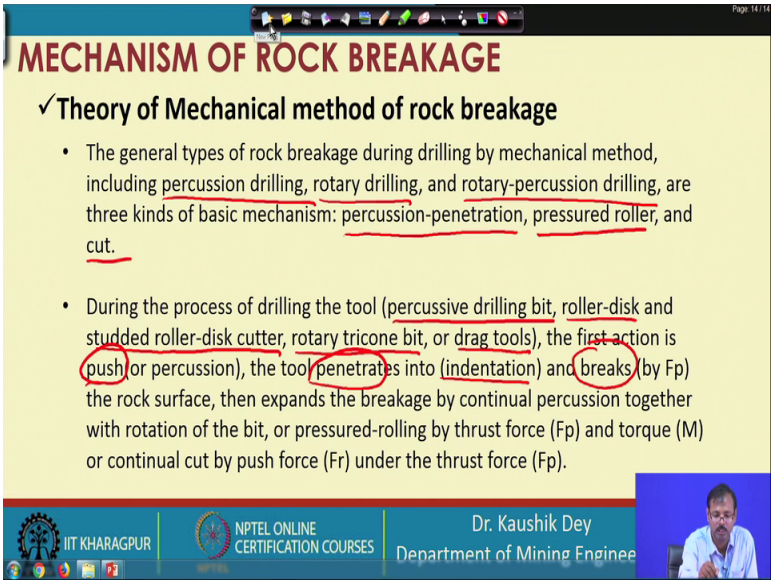

Now, let us see the theory of mechanical method of rock breakage. Generally, the during the drilling a rock is mostly fractured in percussion drilling or in rotary drilling or in rotary percussive drilling ok. So, this basic mechanism for the percussive drilling is the percussion penetration, which is nothing but the hammering and fragmenting the rock fracturing the rock. Then the pressure roller which basically a abrasive fails the rock on abrasion and finally, the cutting of the rock.

So, basically these 3 actions are considered while we are selecting a drill tool. Considering the percussive drilling bit rotter roller disk, studded roller disk cutter, rotary tricone bit or drag tools. The first action is basically push that is hammering carried out by percussion. Second action is penetration, which is the indentation we have already discussed in your indentation test third one is the breaking which is carried out.

So, the rocks this is basically we are converting our different force to the failure of the rock in the application part.

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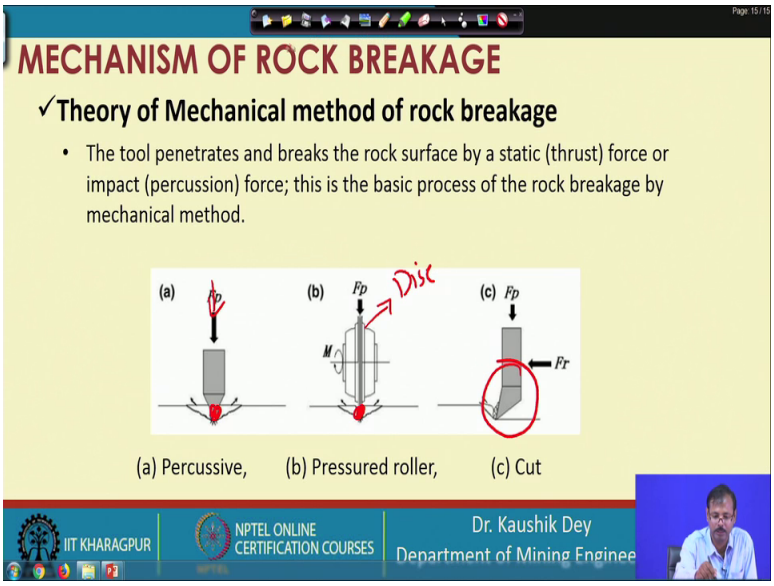

So if you look into this, this is a percussive this is a percussive action carried out on the rock. And in this case this portion the rock is fragmented or crushed in the percussive roller this is you can see this is a disk cutter, disk cutter. This percussive roller is basically crush or cut the rock in the mouth where the fracturing is occurred in the sharp nose of the roller cutter. And here, the shearing is carried out cutting of the carried out using the drag type of bits.

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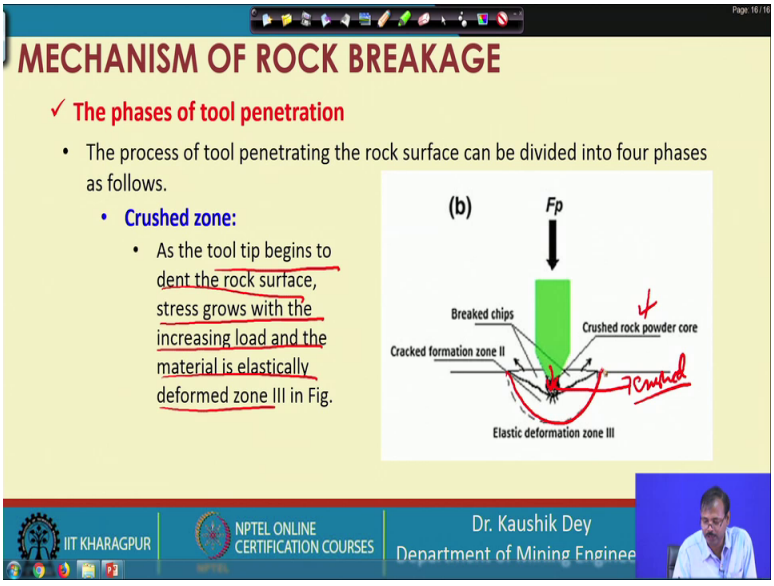

Now, let us see the phase of penetration of the rock say, while we are carrying out percussing a percussive action that time basically it is carried out in 3 phases first is the crushed zone. Say the moment for the first percussion is carried out at this position. So, this portion of rock fails under high hammering action and crushed and crushed into almost a powdery form.

So, first the tool tips begin to dent the rock surface stress, grows with the increasing load and material is elastically deformed in this part.

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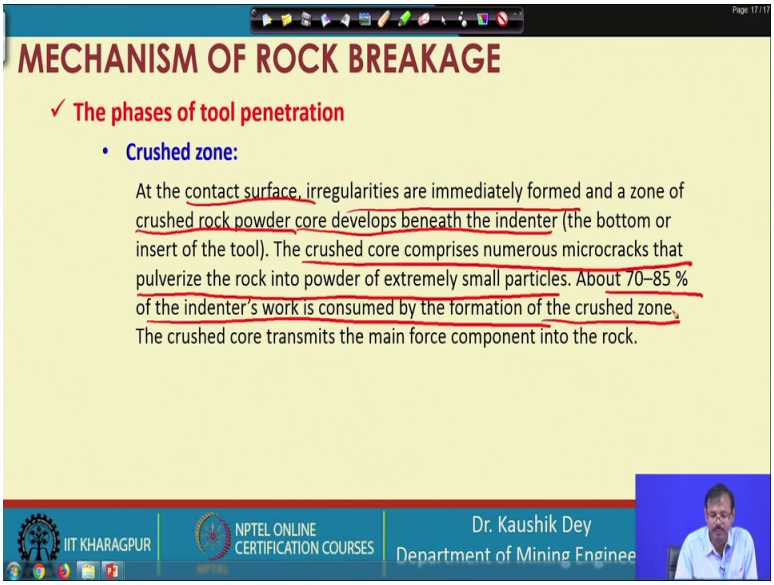

Then at the contact surface, irregularities are immediately formed a zone of crushed rock powders are developed beneath the indenter. So, the moment indenter is pressing the rock that time; the initial portion the rock fails under compression to a powdery form. Then the crushed core comprises numerous microcracks that pulverize the rock into the powder and extremely small particles.

So, about 70 to 80 percent of the indenter work is consumed by this formation of the crushed zone. So, initial in hammering the most of the energy is consumed by these then in the rest part the force is transmit to the through the rock and that formed that formed the cracks in the outer ward.

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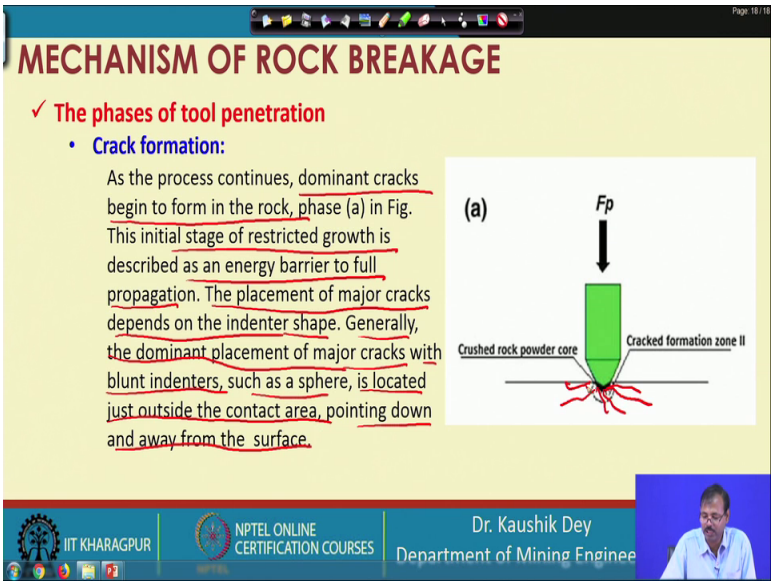

So, as the process continue; dominant cracks begin to form in the rock in the outside after this the cracks are formed after the crushed area. And this initial stage is a restricted the growth as energy barrier to full propagation. The placement of major cracks depend on the indenter shape. Generally, the dominant placement of major cracks with blunt indenters such as; sphere is located just outside the contact area pointing down and away from the surface.

So, from the crushed area the crack propagation to the outer direction is carried out in this phase.

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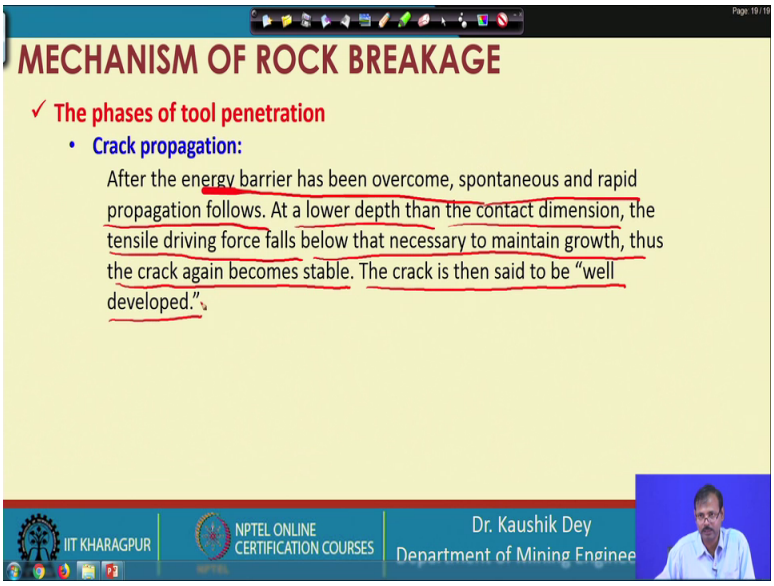

Then the crack starting propagating and energy barrier has been overcome and it propagates spontaneously and rapidly in the all direction. And at a lower depth than the contact dimension the tensile driving force falls below that necessary to maintain growth. Thus the crack, again become stable and the crack is then said to be well developed.

So, around that a well-developed around the crush zone cracked is widened propagated, then propagated of propagation of the crack continues. Finally, it became stable after the well development of the cracks.

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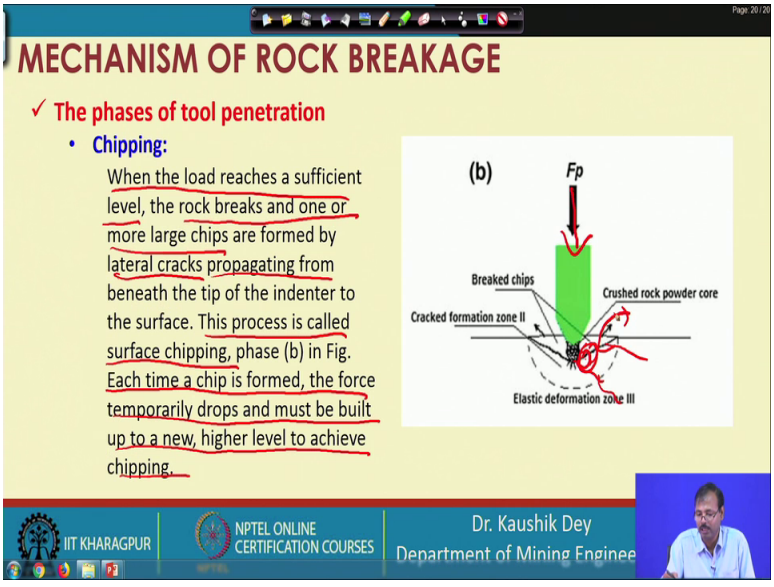

Then chipping action comes when the load, as we are also increasing this load as we are trying to forcing this inside this through our thrust. So, this load is increasing and reaches the sufficient level rock breaks into one or more large chips. So, this cracks crack generated here that breaks in the large chips and formed by which are formed by the lateral cracks propagating from this beneath. So, these are the propagation and this chip chips is formed, and this process is called surface chipping.

So, this is basically surface chipping occurs each time a chip is formed the force temporarily drops and must be built up to a new higher level to achieve the chipping. So, the moment one chip is coming out as you know the new formation of cracks or, new formation of the surface area, new surface area consumes energy. So, basically formation of one chip that is coming out it is basically the relief of energy. And again the next chip will come out when the again the thrust will be built up on the tip of the bit.

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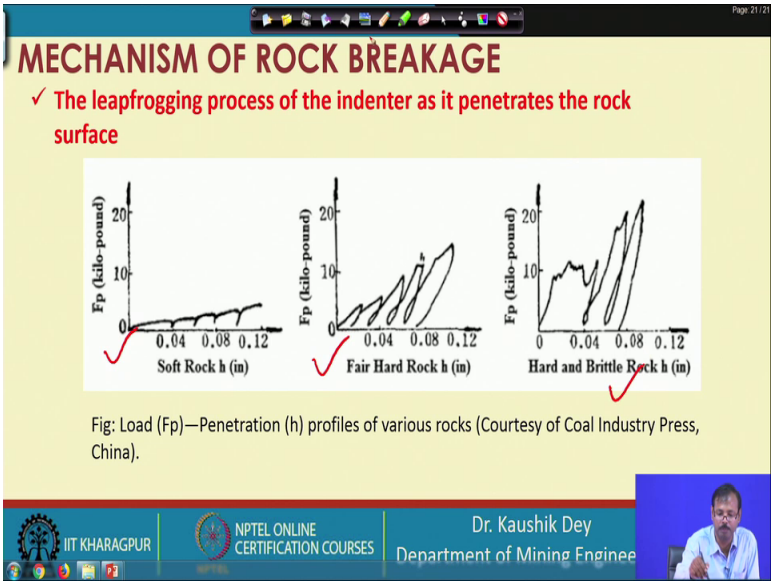

So, if you look into this figure, this is the leapfrogging process at the tip of the indenter occurs as it penetrates the rock surface. So, this one is for the soft rock, this one is little bit hard rock this is of very hard and brittle material, and you can see every time one chip is coming out some penetration is achieved it drops it is force again it the force built up in the tip of the a bit.

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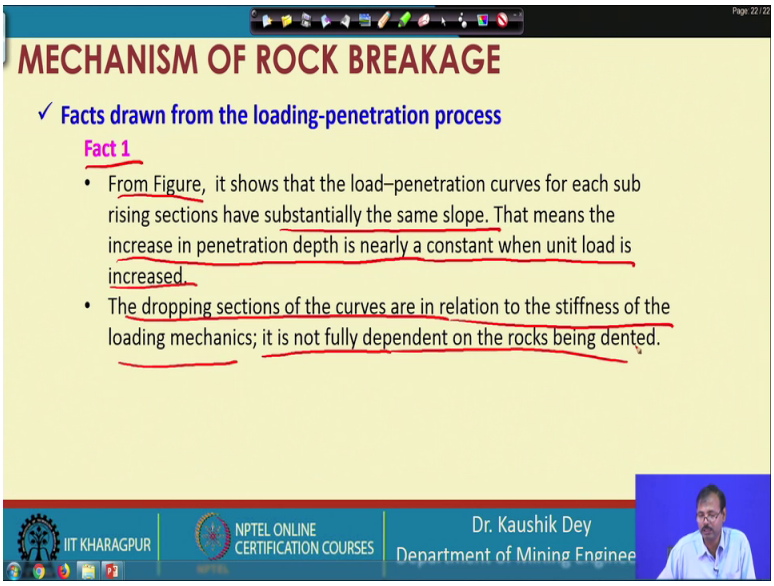

So, from this figure we can understand few things, first the fact one from the figure it shows that the load penetration curves for each sub rising section have substantially the same slope. That means, the when the load is build up the strain generated on the rock is having similar slope, and with the increasing penetration depth it is a nearly constant when unit load is increased.

Next the dropping sections of the curves are in relation to the stiffness of the loading machine and it is not always, always fully dependent on the rocks. So, basically this dropping sections depends on the machine also depends on the property of the rock also these are the first fact.

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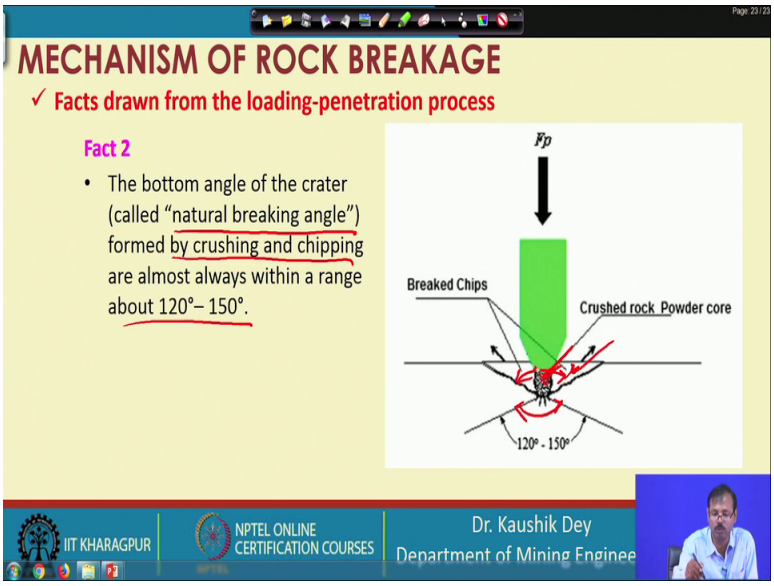

Next let us look into the second fact, in the second fact you can see the bottom angle of the crater, this bottom angle of the crater; which is called natural breaking angle formed by crushing and chipping. So, this part is cracked crust this part is chipped. So, this crushed part these chipped part are almost within a range of about 120 degree to 150 degree.

So, the angle formed this angle formed is having almost a region of 120 degree to 145 150 degree, and if you look into this next slide.

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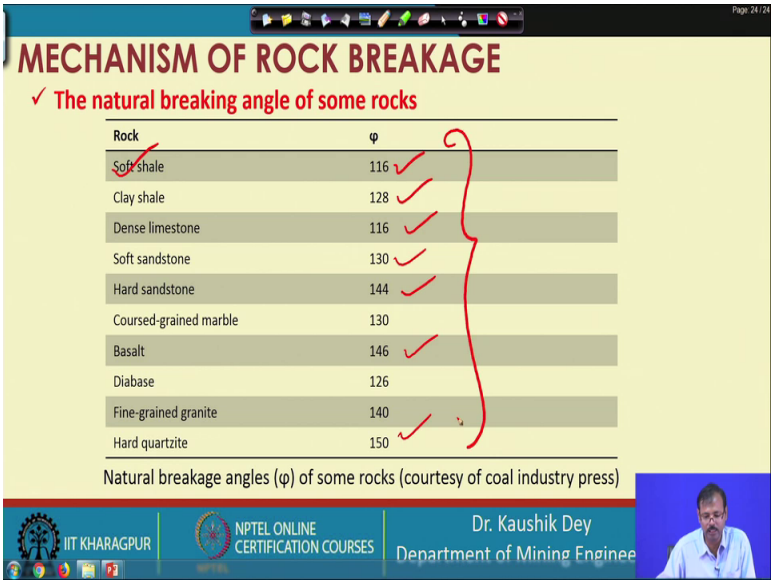

You will find out the this angle measured by the those Chinese coal industry a place for different material you can see this angle is for Soft shale if this is 116 degree, Clay shale 128 degree, Limestone 160 degree, Soft limestone a Soft sandstone 130 degree, Hard 144 degree Basalt 146 degree, Quartzite 150 degree. In this sense we can guess, this has some link maybe with the brittles of the material, but more research is required on this dependency of this angle with the material property.

So, let us stop at this point. In this lecture we will continue drilling in the next class also.

Thank you.