Surface Mining Technology
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Lecture 31
Excavation with Surface Miner - I

Let me welcome you to the 31st lecture on Surface Mining Technology. From this lecture we will start excavation with surface miner, so there will be 5 lectures on this. So how the surface miner is working and what is the present status, we will discuss all this in these 5 lectures.

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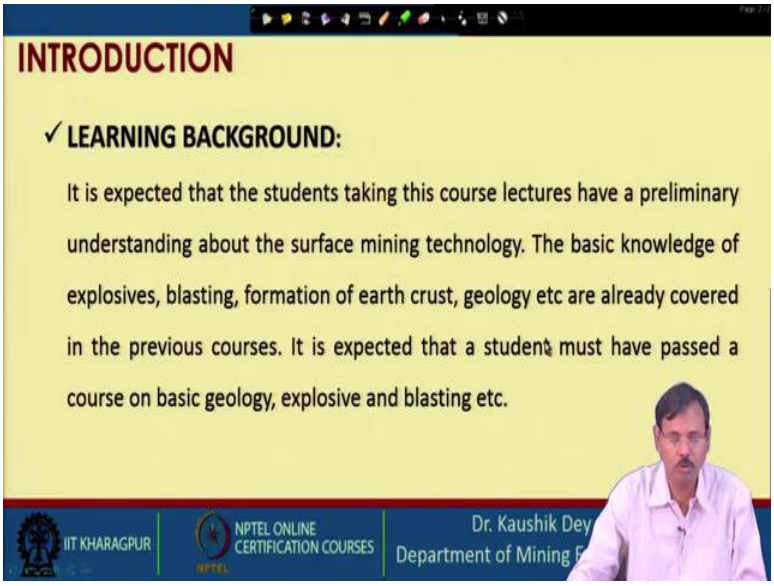

So, as we do in every class let us once look into the learning background required for surface mining technology course.

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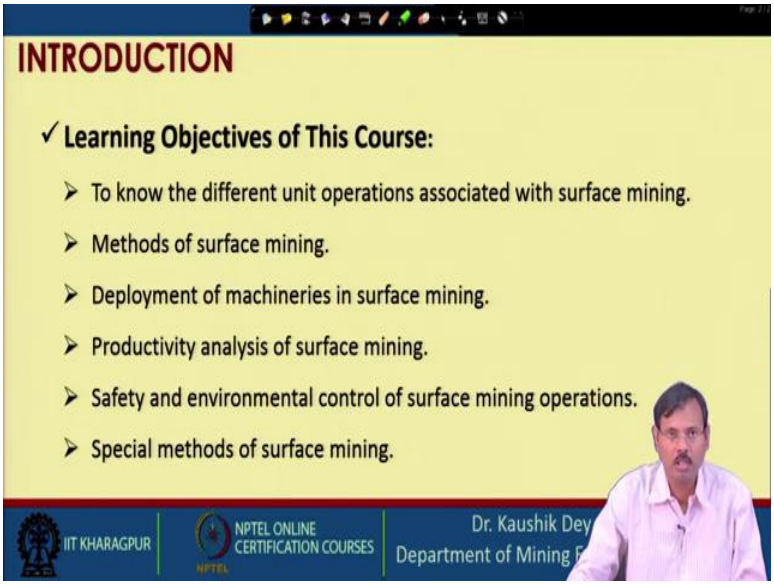

And these are the learning objectives for surface mining technology course.

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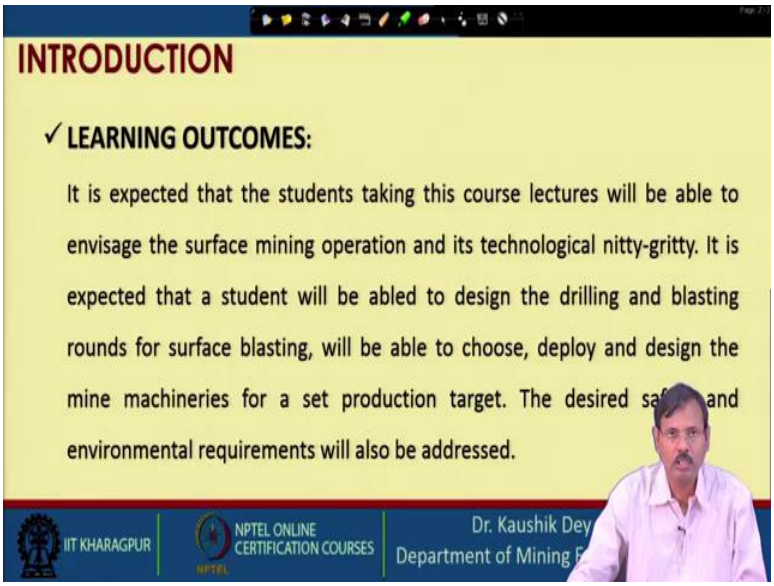

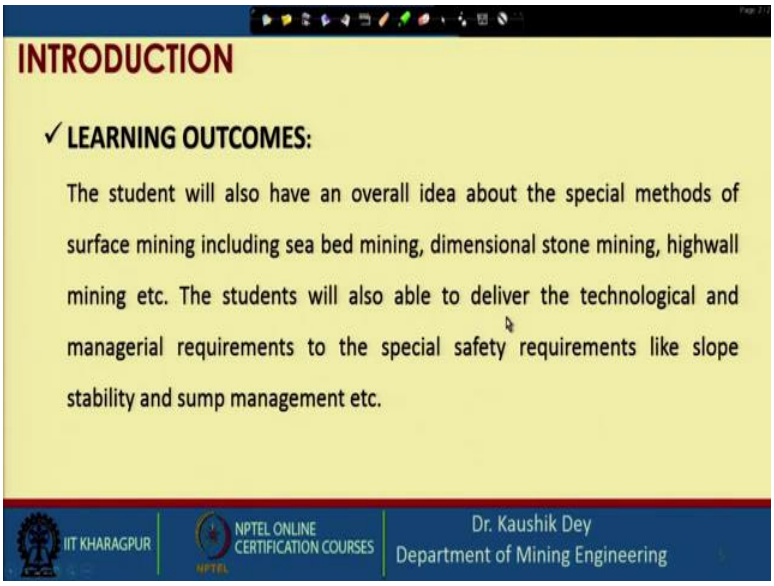

And these are the expected learning outcomes from a participant of surface mining technology course.

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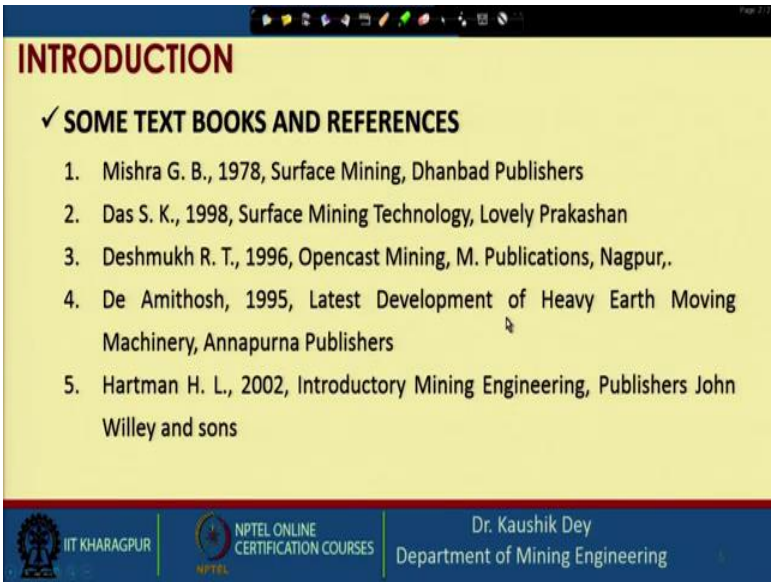

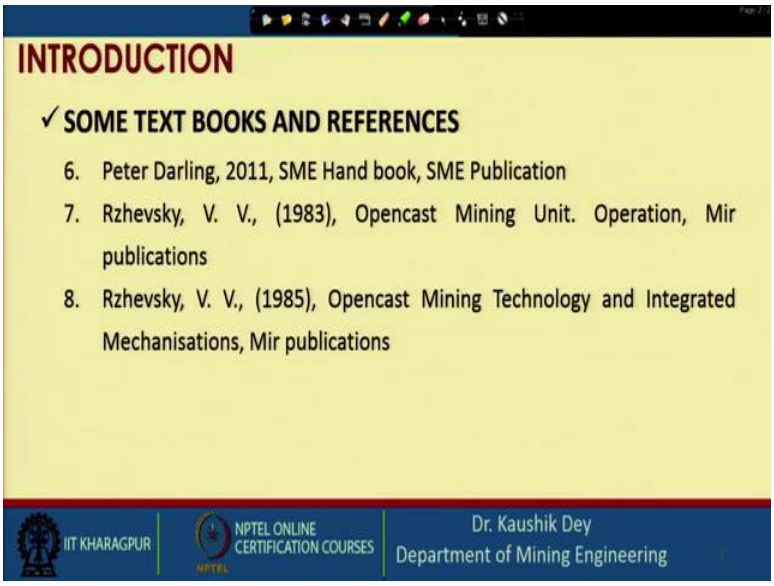

And these are some of the text books and references which participants may follow.

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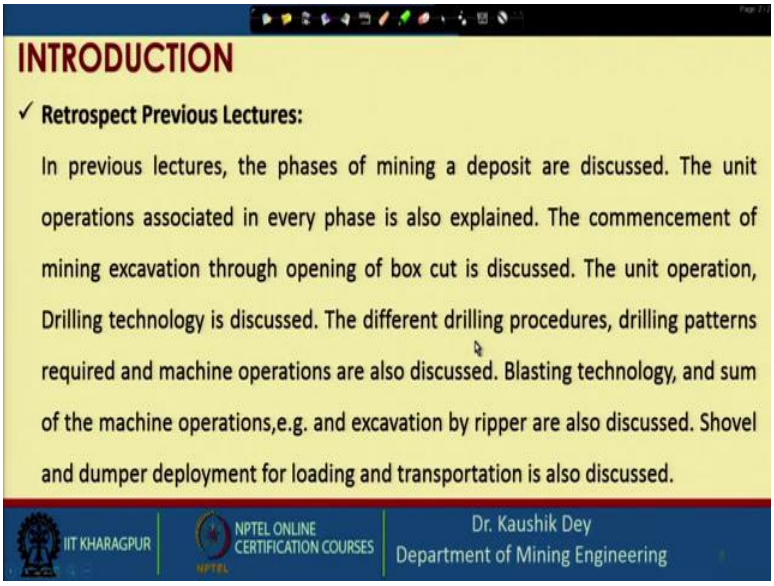

And so far, we have covered in surface mining technology course the phases of mining and deposit and what are the unit operations associated with every phase. We have covered the commencement of surface mining through opening a box cut. Then we had completed the drilling technology, blasting technology for fragmenting the rock into the handable sizes. Then we have covered the Shovel excavation by Shovel.

We have covered the truck transportation system and matching of shovel dumper combinations. we have also covered the excavation of the soft rock material using a ripper. So that is also covered in the previous lectures. So, in this lecture we will start another technology after covering the second technology in which we can go for the blast free mining system. So that is the excavation of rock material or in-situ rock mass using a surface miner often it is referred as the continuous surface miner also.

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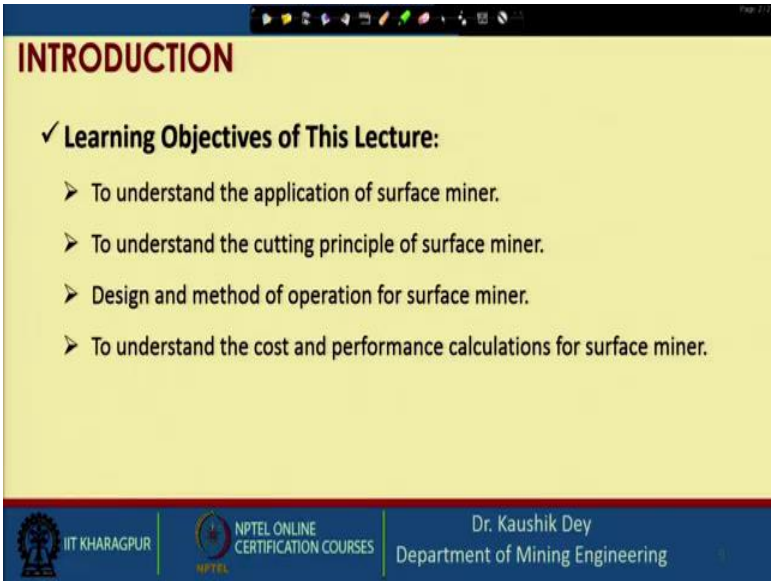

So, the objective of this 5 lectures series will be carried out to understand the application of surface miner; to understand the cutting principle of surface miner; design and method of operation for surface miner and to understand the cost and performance calculation for surface miner. So, these are the broad the objectives we are trying to cover in this 5-lecture series on continuous surface miner.

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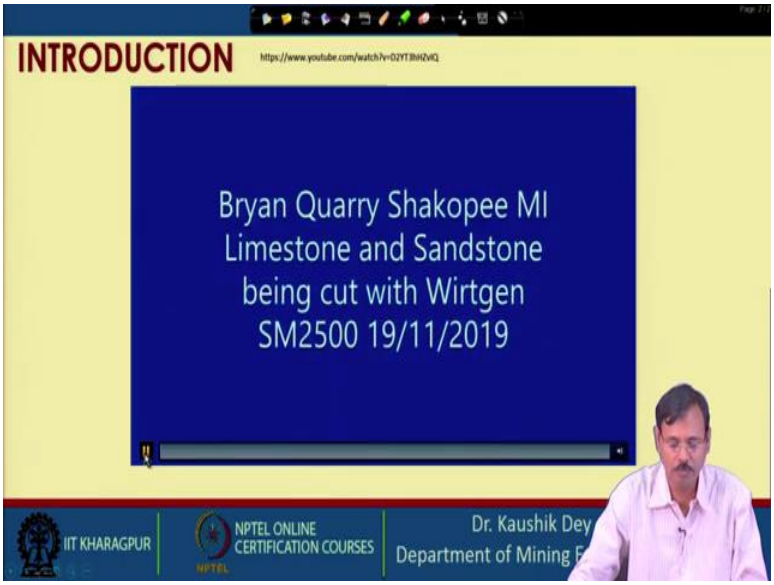

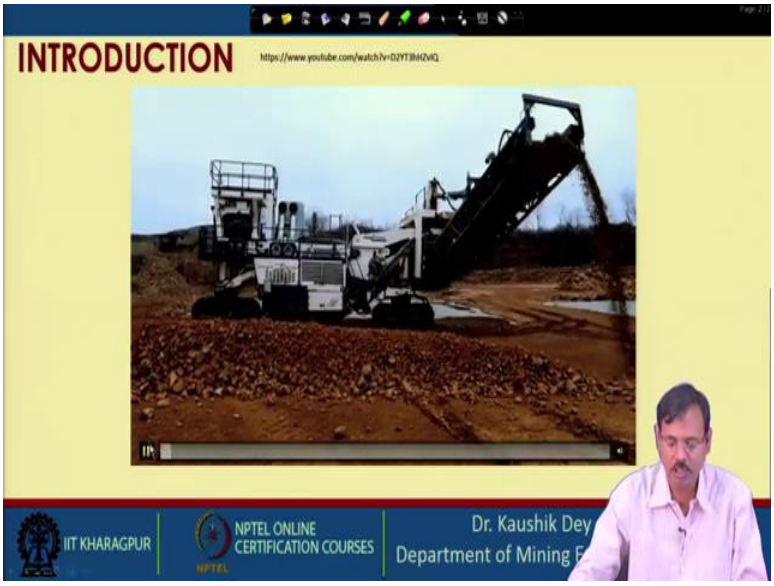

But before going into the details let us just look what is surface miner in this video. This is a video of a query and this machine is called surface miner which you can see as a 4-crawler mounted machine and having a discharge boom, which discharge the cut material and after cutting the material is being discharged. So, there are n number of variations possible with this system and you can see this is a very good-sized material is being excavated and that is being dumped in a row.

So, this is called windrowing, we have also covered that shovel is often also allowed to go for windrowing. You can see this is very sized material and that is why it is conveyable also. The

material is cut by the machine, then the material is lifted by the machine, and material is discharged by the machine. So, this in a nutshell is the operation of a surface miner. A surface miner basically works on the principle of cutting, it cuts the in-situ material and the interesting part is that it cuts the floor. The material is basically cutting the floor on which the material is standing. It is basically cutting in between the first front crawlers and the rear crawlers, so material is cut in such a way that the rear crawler is standing on a lower platform, upper crawler is standing on an upper platform.

The other variables and variations also available with the machine, where the cutting drum is placed in the front of the machine, material cut in front. It is also cutting the floor, but in front of the machine or in the rear of the machine; generally, the cutting drum is placed. So, these are the variations and necessarily all the surface miners are having the cutting system based on the peak mounted system where the cutting peaks are placed on a cutting drum and as the drum is rotating the cutting peaks are cutting the material.

So, you can see the size of the surface miner is a big system and this is the operator cabin, this is cutting drum is placed at this position. The front crawlers; these are the rear crawlers and the material is being transported in the back side of the machine, this is the primary conveyor which is taking the material and this is the discharge conveyor which is gradually discharging the material.

In this case the material is being discharged in windrowing system or you can say material is discharged as a site casting system. So, it can be observed that the machine is also having a good speed of cut, so the discharge quantity is also significant. This video is available in this YouTube link and this type of machine can be applied for surface mining.

It can be applied for the cutting of the roads, it can be applied for the trench construction, it can be applied for the excavation of the surface profile. So, there are n number of applications of surface miner. If you look and retrospect into the history of the surface miner excavation system, surface miner was basically evolved 1970s onward and this was basically developed from the concept of road milling machine.

So, that is why its actual origination was for the civil work but later on in mining sector it is found that it has significant applicability, so that is why it is adopted. The main reason for the

popularity of this system is that this is very-very economical and adopted in most of the mining cases. So, now let us look into the details of this machine.

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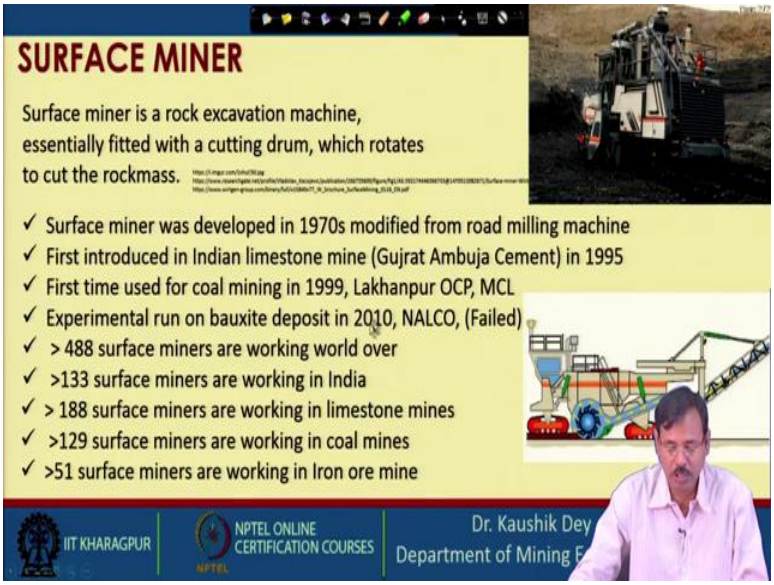

So, surface miner was developed, in a nutshell you can say surface miner is a rock excavation machine essentially fitted with a cutting drum which rotates to cut the rock mass. This is the generalized definition of the surface miner and if you look into the history surface miner was developed in 1970s and originally modified from a road milling machine.

The first introduction of the surface miners was carried out in a bauxite deposit of South Africa and later on it has become popular. First it was introduced in Indian limestone mines in Gujarat Ambuja Cement Limited in 1995, a second-hand machine of WIRTGEN GmbH was deployed there on a contract basis. So, that was basically an experimentation or a field trial you can say and later on it has been found that machine was found to be very well acceptable and that is why it is widely accepted in the surface mining technology.

Especially the limestone and coal deposits which are basically bedded deposits have opted for this machine and it was developed initially for the limestone mines. Later on, around 10-15 surface miners were deployed in the limestone mines mostly for the cement sectors like India Cement Limited, Madras Cement Limited, Gujarat Ambuja Cement Limited. They had opted for mining with these lime stones, where the strength of the lime stones are lying between 50 to 80 Mega Pascal.

Later on in 1999, it was deployed in coal mines, first it was deployed in Lakhanpur opencast project of Mahanadi coal field, where again it was deployed on experimental basis because in that particular mine the blasting was prohibited because of the close proximity of the inhabitances. So, that is why on experimental basis surface miner was deployed there and the initially it was deployed in a very high price; 60 rupees per meter cube.

But later on, it has been found that there was a significant reduction in the price also and in 20 rupees, 30 rupees per meter cube also was found profitable for the mining with surface miner. So, experimental run-on bauxite was carried out in 2010 in NALCO but that experimental run was failed. Currently around 500 surface miners are working in over the world, among that 133, so almost close to one third surface miners are working in India.

And if you are looking into the worldwide, around 188 surface miners are working in limestone mines, 129 surface miners are working in coal mines and 51 surface miners are working in iron ore mines. So, it has been found that applicability of surface miners is there with the strong deposits like iron ore also and most of these belongs to Australian iron ore mines.

That means the surface miners are applicable for soft rock to hard rock also. Depending on the formation characteristics, it has been found that surface miner was applied for granite rock also in a tunneling project of Japan and there are n number of other applications; it has been utilized for construction of the ground; it has been utilized for the construction of the dam. So, there are different applicability of the surface miner.

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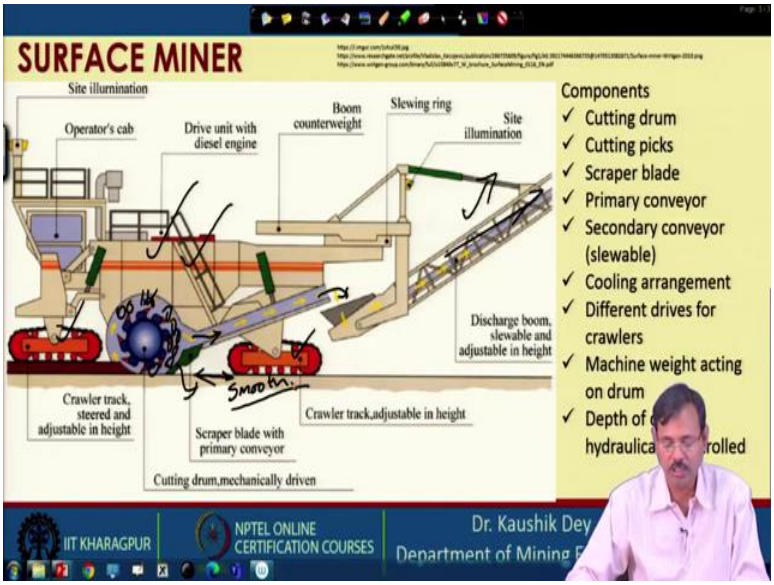

Now, let us look into the detail of the machine. This is details about a particular machine where the cutting drum is placed between the front crawler and the rear crawler or maybe the vice versa also. The cutting drum is operating in up cutting direction, so the drum is rotating. The drum is rotating in this direction, it is cutting in upward direction and material is moving like this. There is a scraper plate. This is a scrapper plate, which is placed behind the cutting drum.

So, whatever cut material is available, the cut material is allowed to remain or encased with this housing system. This is the drum which is rotating. This is the front housing system up to this. It is a closed surface; back side is closed with a scraper plate and this is the primary conveyor which is placed at this position.

So, this is allowing the fragmented material, which is cut by this cutting drum's cutting peaks, then the fragmented rock material is allowed to remain in this encased area which is allowing further crossing of the material into a smaller size. Then as the material is filled with this wide position, then there is a small opening which is opening towards this primary conveyor, so through this small opening, the material is coming into the primary conveyor in a smaller size then that is converted to the secondary conveyor.

And then from secondary conveyor it is discharged whatever is the way either to a truck or to a conveyor system or to the windrowing system or side casting system. This is the front crawler or rear crawler. There are two sets of both and this is the machine. If you are having the water

sprinkling system, you have to provide the water sprinkling systems through this. This is the secondary discharge conveyor which is salvable.

Secondary discharge conveyor can be angled and lowered apart; all these facilities are provided. This may be a diesel operated, this may be electrically operated also and these are the more or less facility provided here and this crapper plate is very-very important. This is allowing post cut, a smooth floor surface. So, this floor surface is kept smooth and this smooth floor surface is allowing the better tire life for the pliable machines also over this floor. So, this is a benefit in this system and that is why it is wholeheartedly accepted.

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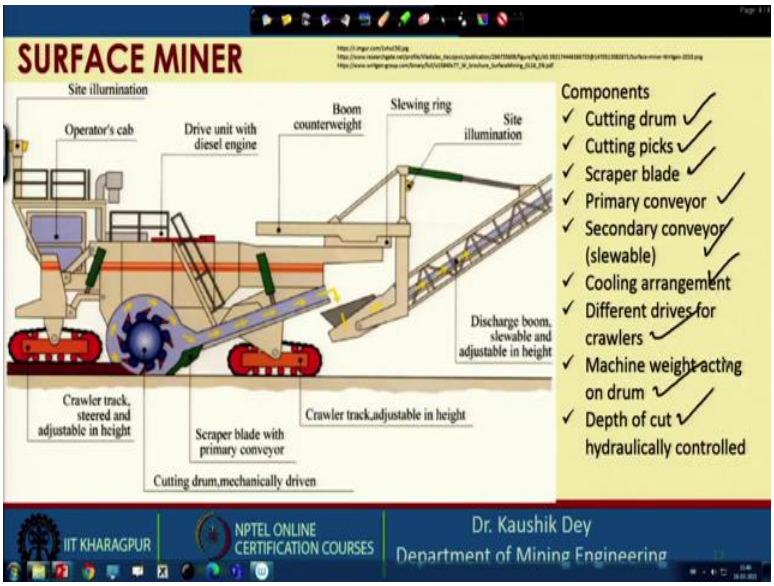

So, components are cutting drum, cutting peaks, scrapper plate, primary conveyor, secondary conveyor, cooling arrangement, different drives, machine weight acting on the drum and depth of cut; these are hydraulically controlled; these are the features for this particular model of the surface miner. There are other models also. There are some models having some advantages; some are having some disadvantages, so all these are mechanical control systems are there.

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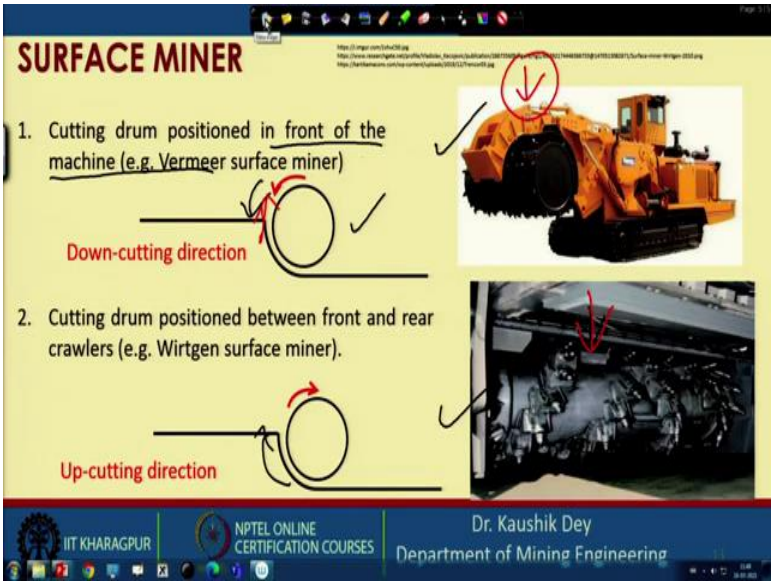

So, surface miner can be broadly classified in two ways; one is that the cutting drum is positioned in front of the machine. So, this is the cutting drum positioned in front of the machine and this is allowing the rotation of the cutting drum like this, this is the allowing rotation and second type is that cutting drum positioned between the front and rear crawler. This is down cutting; this is up cutting and both can be reversed also. Depending on the type of application, this can be made.

So, these are two broad classifications; one is in the front of the machine; one is below the machine. The basic difference is that in this case the machine weight is acting on the drum and give an additional normal force gives. Here the drum has to be made the heavy, so that the sufficient normal force can be given. Otherwise, the moment drum is allowed to cut in a normal force the drum will try to jump from the floor, so you need to provide a sufficient normal force, so that it can cut the material.

So, in this case the machine weight is acting on this, so the significant normal force is given but, in this case, you have to additionally weighted this drum to have this desired normal force. So, let us watch videos of this one.

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So, this is the YouTube link for this video and this is the cutting drum placed in front of the machine or rear of the machine and the material is being excavated like this. So, as the crawlers are moving and the material is being cut in the down cutting direction by this drum. So, machine is moving in front direction, machine is moving in this direction and material is being cut like this.

So, this is the down cutting direction where the cutting drum is placed. In this case, it is behind the machine and this is the depth of cut; you can see up to this the cutting depth is achieved. So, the problem is that in this case crushing is not possible because there is no encasing of this cut material, so cut material is basically thrown back to the cutting direction and that is why a little bit lump size boulders are produced here.

So, this is the depth control system which is allowing controlling of the depth of cut and this is how the cutting is carried out and these peaks are basically fixed with the cutting drum like this. And this is the other one, where the cutting drum is placed between the front and rear crawler and this is the way up cutting; in up cutting direction the drum is rotating. So, here the empty run of the drum is shown in this video where after lowering this drum part, it will start cutting.

So, now gradually the drum is being lowered and that drum is allowed to cut the material. So, this is the rear crawler and this is the front crawler and this is the cutting drum which is moving. So, in this case, the heave of material is left behind the machine and that is why there is no

conveyor system used here for loading the cut material onto the truck. So, separate loader has to be utilized in this case. So, this is cutting in up cutting direction.

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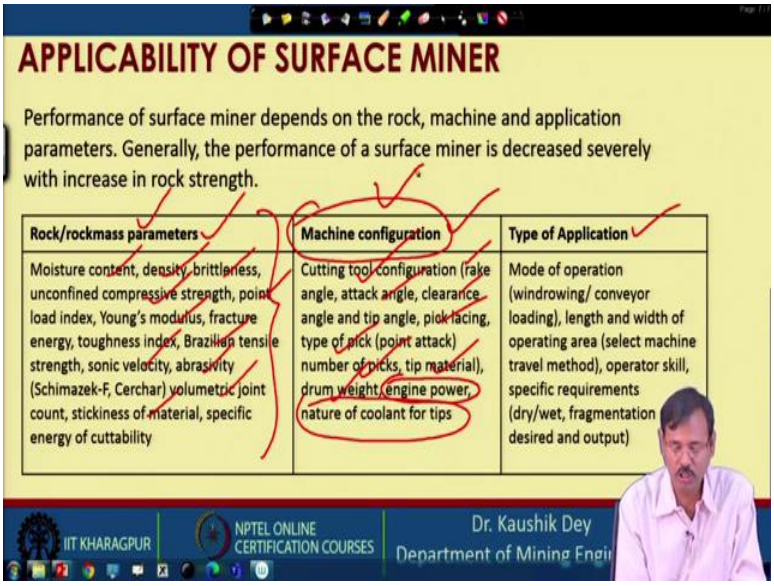

So, surface miner applicability can be dictated by the rock parameter, machine configuration, type of application. Among the rock and rock parameters: moisture content, density, brittleness compressive strength, point load, Young's modulus, Tensile strength, Abrasivity, sonic velocity, volumetric joint counts, stickiness of the material are the main properties or influential properties which are dictating the applicability of the machine. This is rock mass uncontrollable rock mass parameters.

And then there are the machine configurations: cutting tool configurations, rake angle, attack angle, clearance angle that we have already covered details about in the chapter of reaper class excavation by reaper. So, apart from theses, we are having pick lacing, type of picks which are used number of picks, material of the pick.

Drum weight, engine power is very-very important that is we have seen in ripper also and whatever coolant we are using for the cutting tips or not, that is also another machine configuration which are influencing. So, this is uncontrollable, this is one time controllable after choosing this there is a very little chance for the users to change this so this is depending on the machine model.

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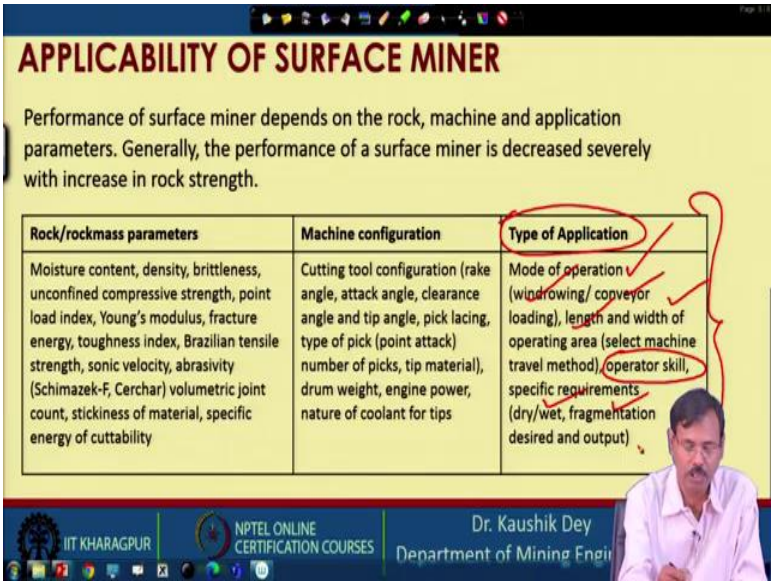

But user can change the type of application. You can opt for different mode of operation modes: windrowing, conveyor loading etc. Length and width of the operating area: if you are providing more length then the performance will be increased, operator skill: a skilled operator can negotiate the depth of cut very well and that is why proper utilization of the machine can be carried out and specific requirements like dry weight, fragmentation required depending on the peak lacing has to be carried out. So, these are the important parameters, that user has to control at his end to achieve the desired performance from a surface miner. So, this is very-very important and should be controlled.

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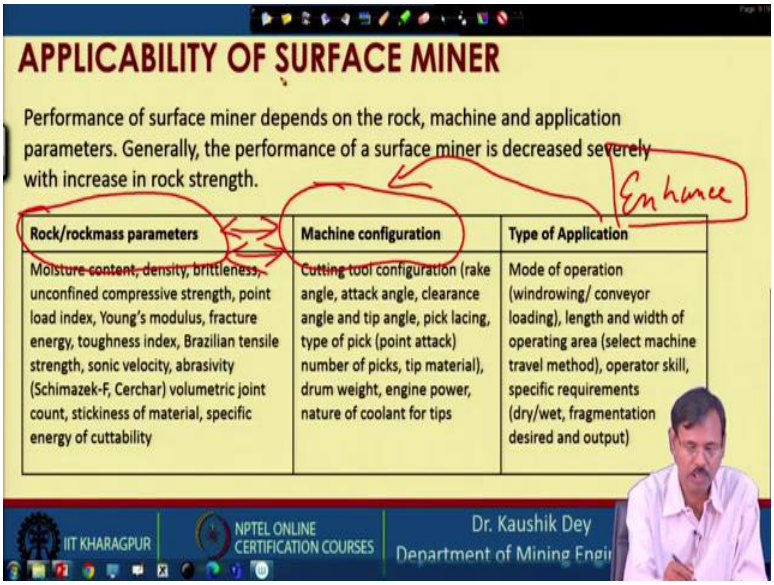

So, there is a rock for which first job is to decide for a suitable machine. After that there is a more or less good match between these two types of application basically to enhance the performance of the machine. So, that is the importance for this and this is very-very important while the applicability is basically decided in the surface miner.

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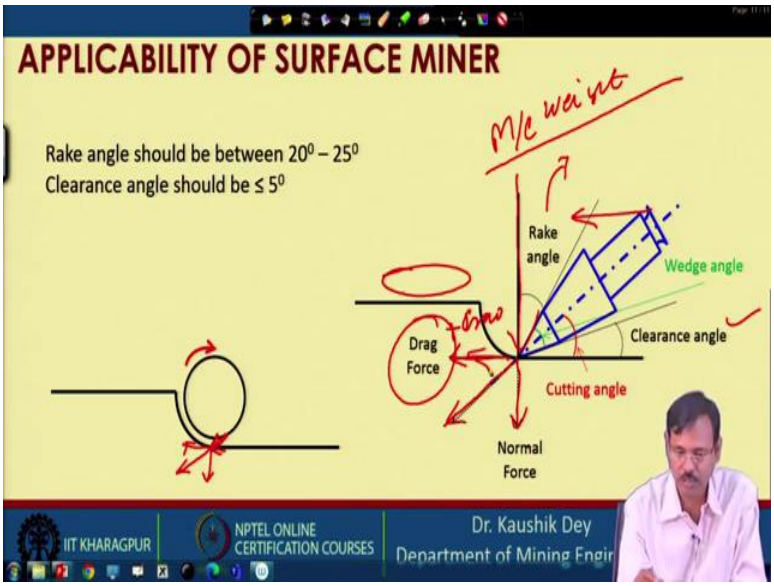

Now, this is the mechanics behind the surface miner. If this is the cutting tip which is basically acting at this place, acting at this place, then if this is the cutting tip, this is the clearance angle,

this we have seen similar to our ripper also. This is called rake angle and this is the wedge angle that is known and this is the cutting angle with the axis of the peak.

So, the moment when the peak is striking on this, this basically has two components; one is the normal force and another is the drag force. So, the crawler is this. After hitting this, is the normal force, this is the drag force, apart from that this peak is also dragged by the crawler system so that drag force is also acting on this. So, this normal hitting force plus drag force given by the crawler is basically the drag force.

And normal force is hitting and along with that the machine weight working at this position. So, these are the force calculation of the force how the machine is applying force for excavating this rock material from this position from this area.

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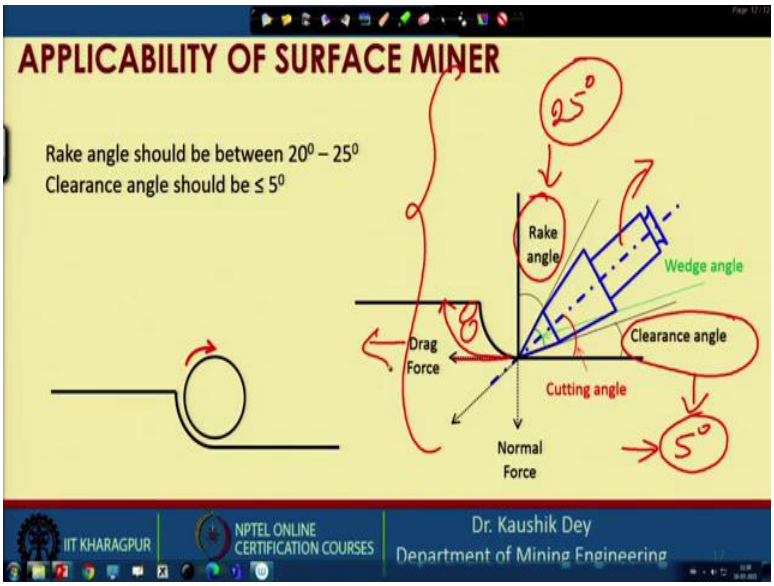

How it is excavating this one, this portion of rock how it is taking a bite. So, this is basically given by this. After good research, it has been found these two are very-very important. So, a clearance angle close to 5 degree is basically advised for surface miner and it has been found that this 5-degree clearance angle gives the optimum result in case of surface miner and a rake angle of 25 degree is considered as the optimum rake angle for a surface miner excavation as per the British experimental research.

So, these are the rule of thumb but this all depends on the type of peak also. There are different types of peaks available. They are having their own different types of applications like for soft rock the peaks are different. For hard rocks the peaks are little bit wider with a more greater wedge angle, so these are the different types of application. For abrasive material also you need to have a larger wedge angle and more drag force for the abrasive material. These are important part that has to be taken care of while the selection of machine and selection of the cutting system is considered in case of surface miner.

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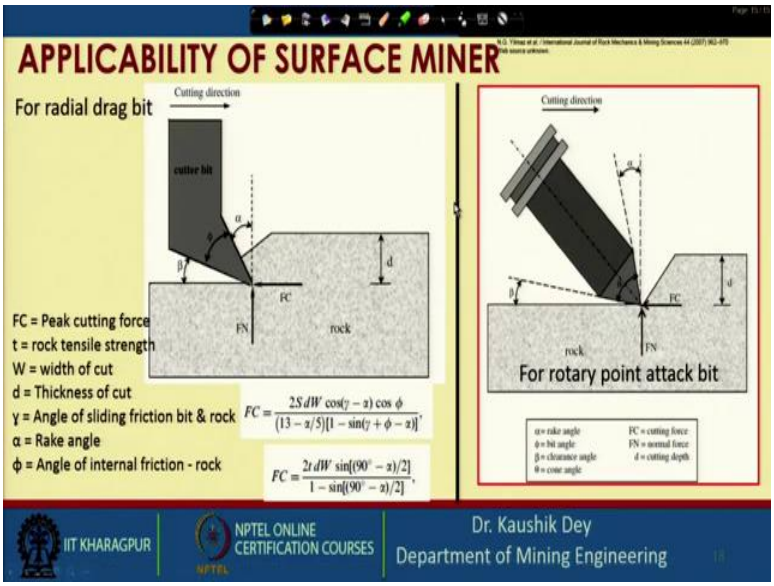

And this is another picture which is giving the details of the surface miner working principle. So, this is more or less about the introduction of the surface miner which is giving the little bit idea about its application. We are not going into the details of the application, but I would like to refer one book in this case. There is a book available, which is basically a book for the Lathe Operation, that is a metal cutting by professor Amitabh Bhattacharya. That book is suitable for this surface mining cutting operations also.

Principles are more or less same but in metal cutting generally we are having rake angles in the negative side also. So, that is depending on the different applications, physics behind those cutting system can be more detailed or can be studied from that book. So, this is more or less introduction about the surface miner applications. We will go continue in the next class about the classification and working method of the surface miner. Thank you.