Surface Mining Technology
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Lecture 19
Technology for Surface Blasting – V

Let me welcome you to the 19th lecture of Surface Mining Technology. This is the fifth lecture on Technology for Surface Blasting and we will discuss in this lecture on blasting results say after blasting what are the results for which we are interested. There are two lectures on this. This is the fifth and sixth lectures related to the blasting results.

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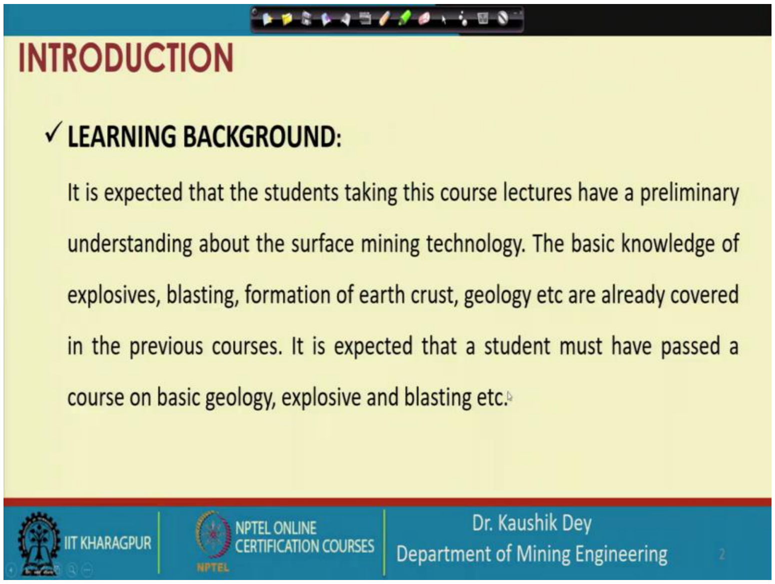

So, as we discussed in every class, this is the learning background for the surface mining technology course.

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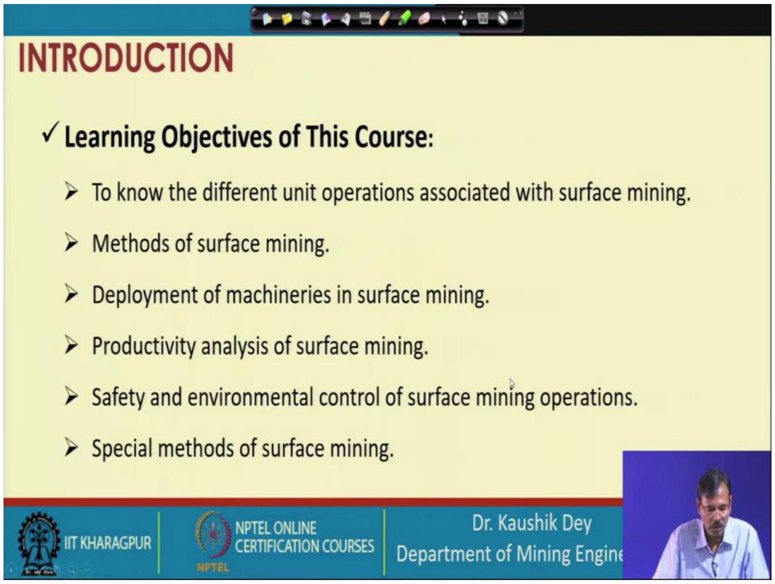

This is the learning objective of the surface mining technology course.

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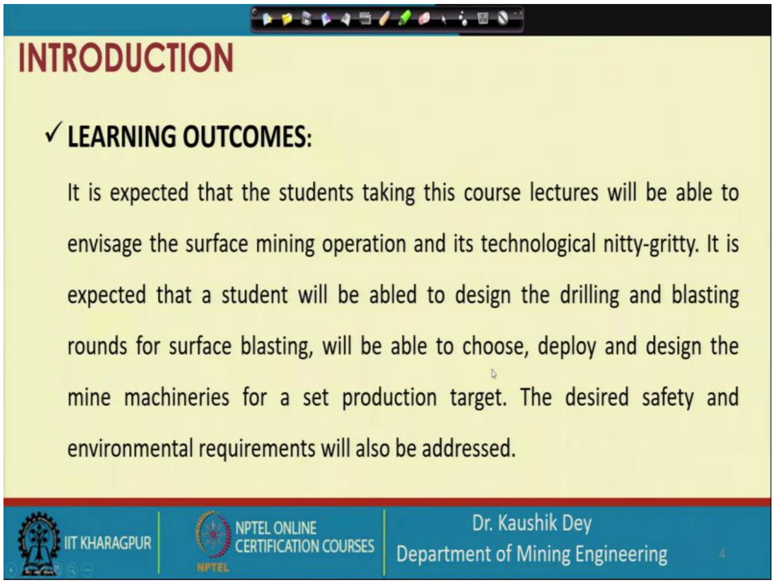

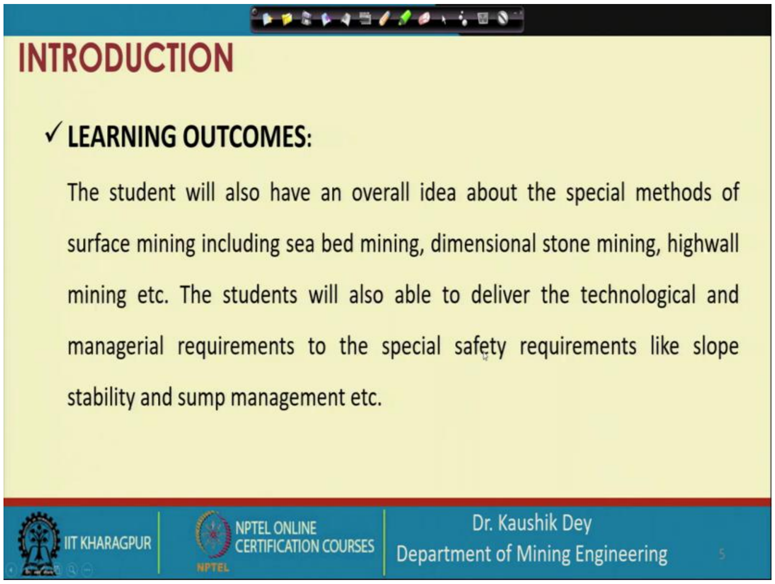

And these are the learning outcomes expected from the surface mining technology course participants.

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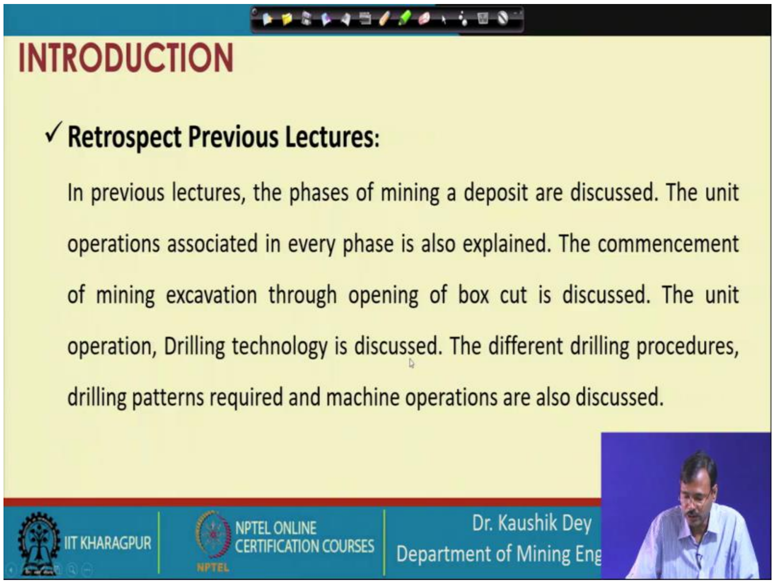

And so far, we have covered the different phases of mining deposits and unit operations associated with these phases. We have also covered the commencement of mining excavation through opening a box cut, unit operations of drilling technology, and different drilling procedures. We have also covered the blasting technology part in the previous four lectures. We have solved the tutorials for the performance analysis of the blast and for the cost analysis of the blasting that is already covered.

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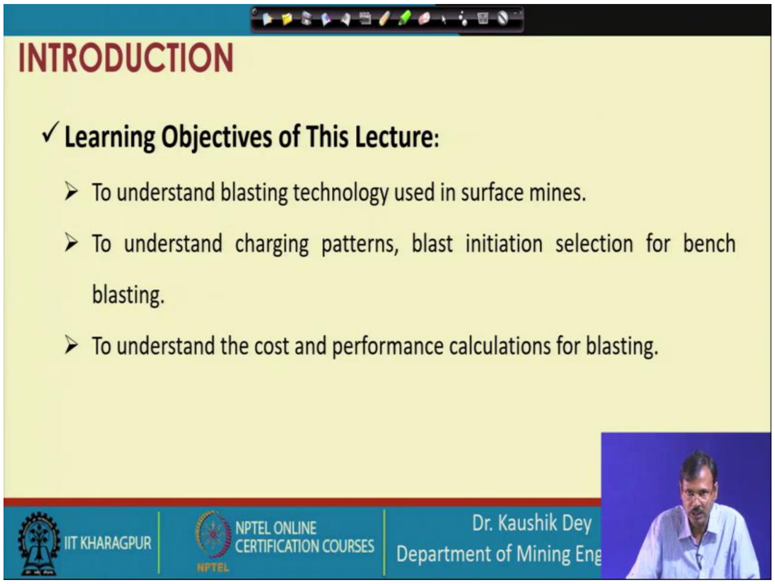

The objective of this lecture is to understand; this is the common objective for the blasting technology, a blasting for surface, technology for surface blasting, and in this particular lecture, we will emphasize the different blasting results and how that can be evaluated and how that can be assessed that will be covered in this lecture.

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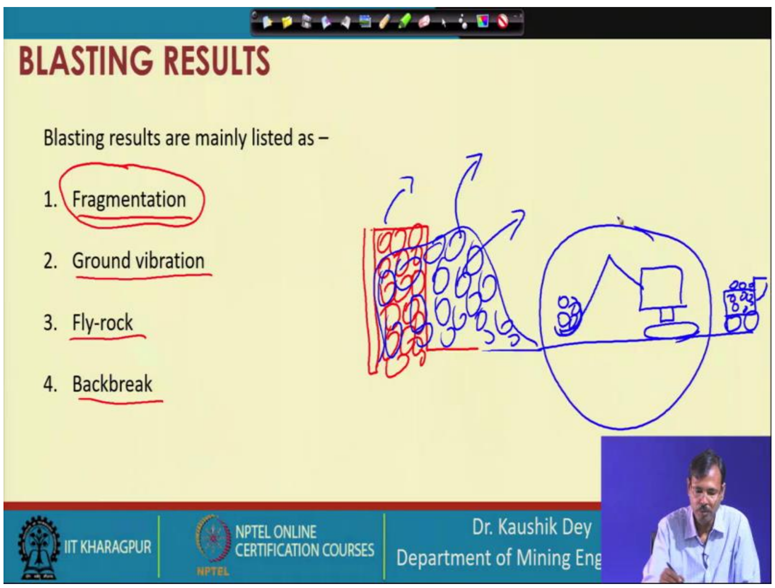

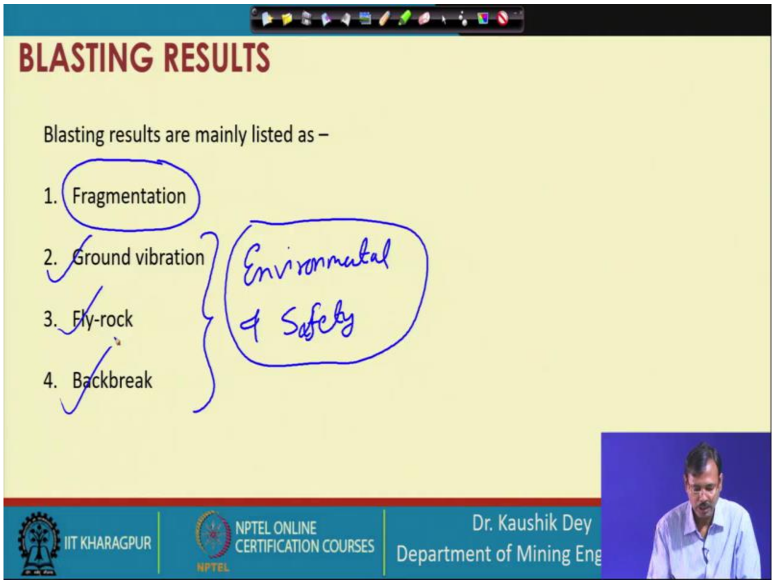

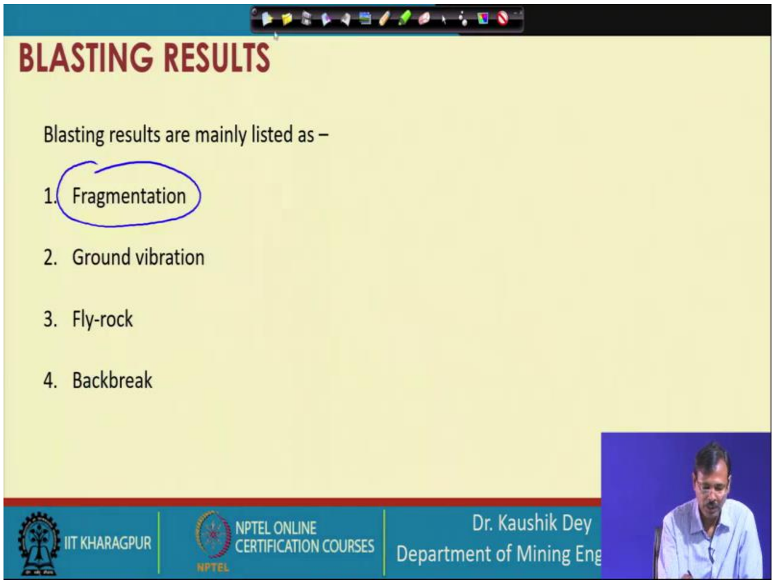

Blasting results are broadly divided into four-part. Fragmentation, ground vibration, fly-rock, and backbreak. This fragmentation is basically the main objective of blasting because to excavate the rock mass, we carry on blasting to fragment this rock mass into a number of small pieces so that these small piece of boulders will create a heap like this, and these boulders will be distributed in a heap like this so that our excavator can take this material easily and can dump that on to a truck.

So, this is the objective of blasting, to make this portion of rock mass into a heap of fragments like this. That is the main objective of blasting. What is the level of fragmentation we expect so our excavator can easily handle these materials in its bucket and dump them onto the loading system? So, this is the essential requirement, and this is the objective of the blasting to make the rock mass into fragmented small pieces so that they can be easily handled by the excavator deployed in the mine.

So, this is a primary objective of the blasting covered here, but these things are also essentially required. These are the constraint for blasting, so you need to control these for your environmental and safety achievements. You need to control these three also. So, this is the main objective or main results in a blast for which we are interested. Obviously, you understood that fragmentation is the main objective that we are interested in doing to assess during the blasting.

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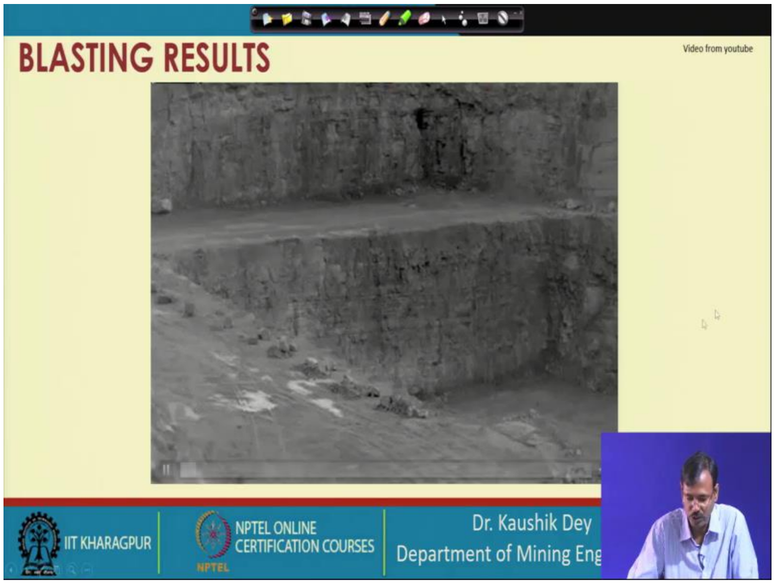

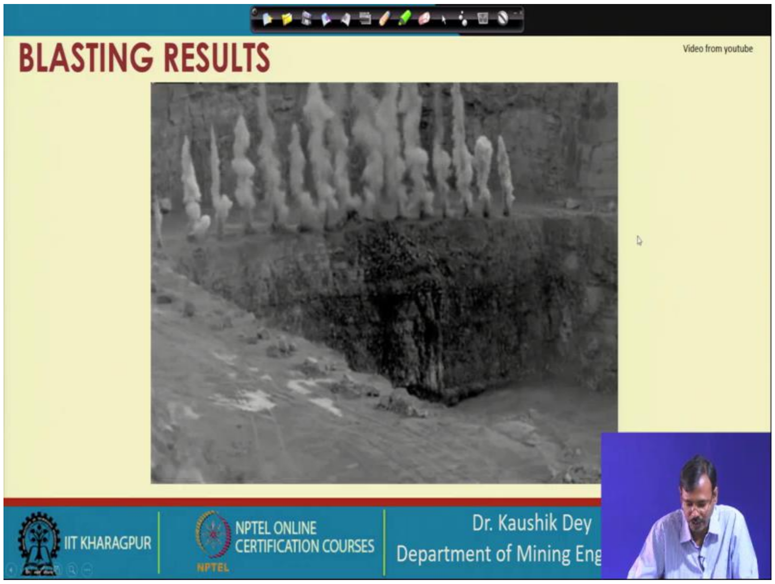

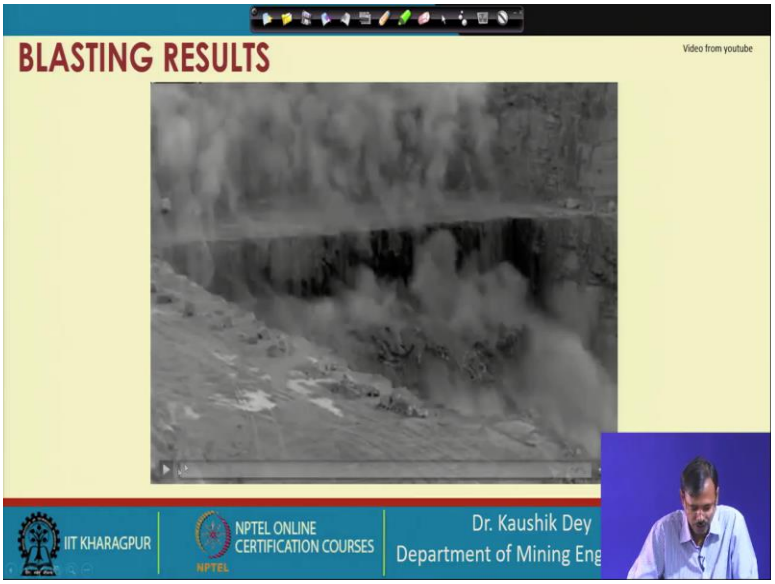

Before going to the details of the fragmentation analysis prediction, let us observe a blast recorded in high-speed videography. Still, we will see it at a very, very slow pace. In fact, this is much, much slower than the normal speed also. So, that is why we can easily see the movement of the bench rocks in the blasting. This is a very small video obtained from YouTube. Please check these videos. You can see how the rock phases are moved, how the blasting is carried out, and how these fragmented rocks have started moving because of the gas pressure, and finally, you can see the blasting is achieved.

Let me show you once again. You see before this one, you can see before the escaping of this gas from this place you can see movement already occurs at this site. So, this basically governs how the blasting is good and how the stemming, proper stemming is provided. So, that is why how the fragmentation is achieved is shown in this video.

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This is another video available in which also the best fragmentation can be observed. You can see in this video, how precisely the blasting is carried out. You can see the face is very, very straight. So that the burden throughout the bench height is kept almost the same and you see very well the rock is fragmented here, and you can see almost uniform fragmentation is achieved in this position.

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So, if you see, look into this, see this is the almost uniform fragmentation achieved in this blast and the excavator can easily handle that. So, this is very, very important.

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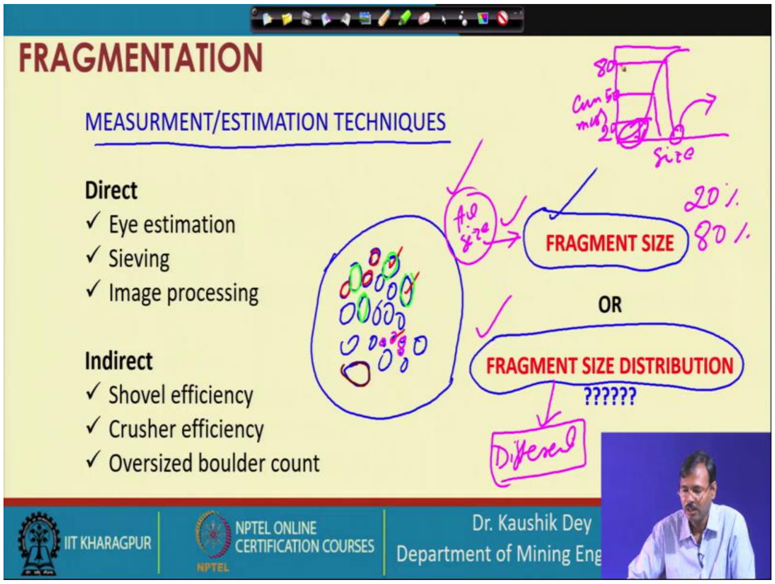

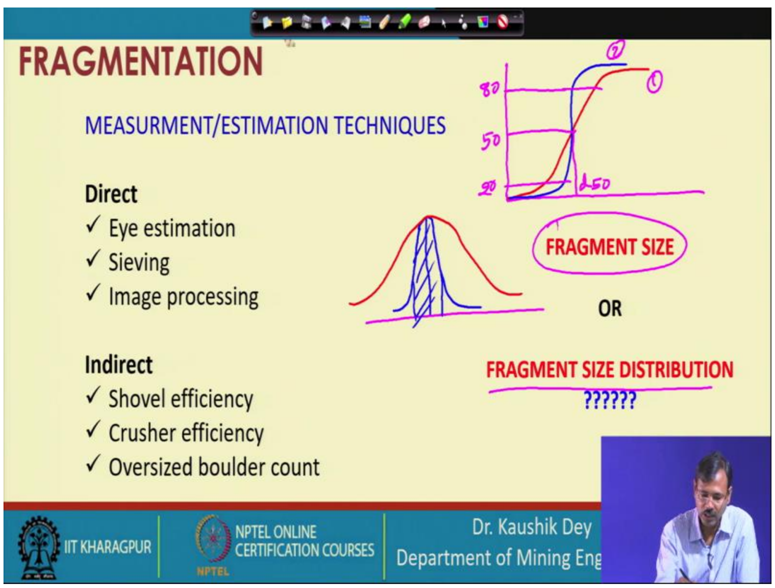

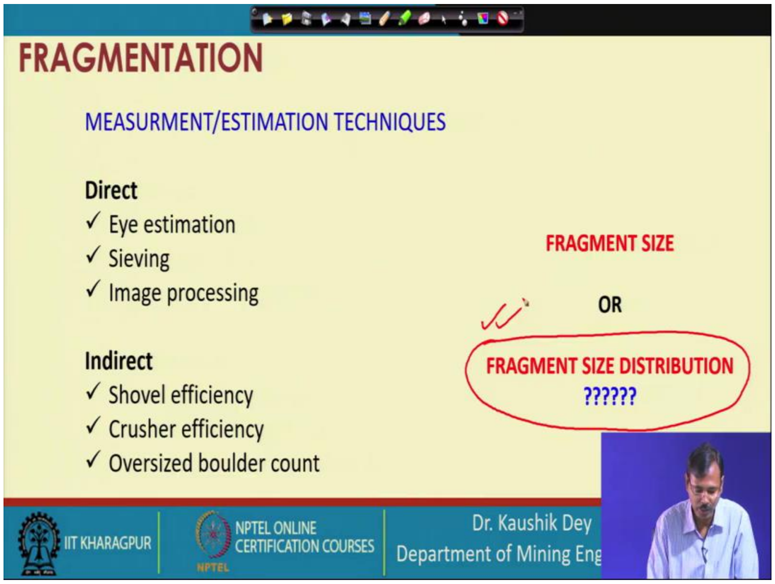

And while we are discussing these, the aspect we are looking at is the measurement and estimation techniques. But before that, we have to think about these two words, fragment size, and fragment size distribution. What is the meaning of this? Suppose, after a blast, we have generated a number of boulders like this. Now, there are so many boulders here and now, if asked, what is the fragment size, then everyone will be confused about whether the fragment size will be for this one, will be for this one, this one, or this one.

So, this discussion is very problematic, and basically it is a distribution. There may be some boulders of this size, there may be some boulders of this size, and there may be some boulders of the size. So, there are different size boulders available or generated in a blast. We have to present them properly so that this fragment size and fragment size distribution can be easily understood. So, what is the way we do it? It is expected that it is impossible to meet, measure, or predict each and every boulder size.

So, in general, it is expected that fragment size is basically the average size being represented, and size distribution is the distribution of the different sizes. Now, the moment it is expected, it is a normal distribution. We expect more boulders related to average size will be achieved, and it may be possible that the other sizes are also available and proportionately less than the average size.

So, in general, there is a distribution that can be presented like this: the cumulative mass is presented and this is the size is presented. The average size is expected at this position which is

50 percent. Obviously, this is 100 percent, and whatever the percentage mass is considered, that is being expected at this position.

So, this is the 20 percent size that means the below the boulder, below this size, whatever boulders are there, if we are comprising the total volume of that that is representing 20 percent volume of that total mark and if we are considering this is the size, then this size what is the below mentioned, below lower than this size fragments are considered at this position and the total volume comprising those boulders are 80 percent of the total mark.

So, this is the representation of the fragment size distribution. We are always interested in the fragment size distribution over this fragment size because this is a very useful material that is considered how well or how much uniform blasting is carried out here.

So, let us draw two separate curves here. This is one distribution. This is another distribution, and say the average size marked as d50 is the same for the distribution, which is 50 percent. But if it is considered, then you will find out the other values that are maybe d80 values or perhaps d20 values; these are significantly different for both the size distribution. So, this is saying that the average size for distribution one and distribution two are the same, but both the size distributions are different.

That means, if it is represented in a normal scale, the size distribution is probably very steep for the second one. That means most of the materials are coming within this range. However, if it is observed for the red one, probably the distribution is something like this. So, that is the difference between these two distribution curves. The dispersion is much, much lesser in the case of the second curve, the blue line, and much more in the case of the first curve represented in the red line.

So, this is the importance of the fragment size and fragment size distribution. As a blasting engineer, the person should be more concerned about the fragment size distribution while he is interested in observing the blasting result. So, this is a very, very important aspect. It is expected that all the participants who are participating in this course must keep in mind that we are interested in fragment size distribution.

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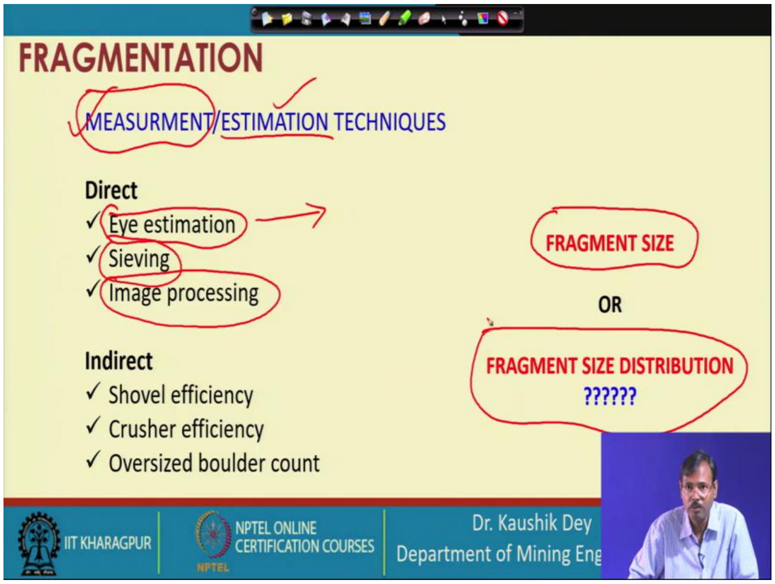

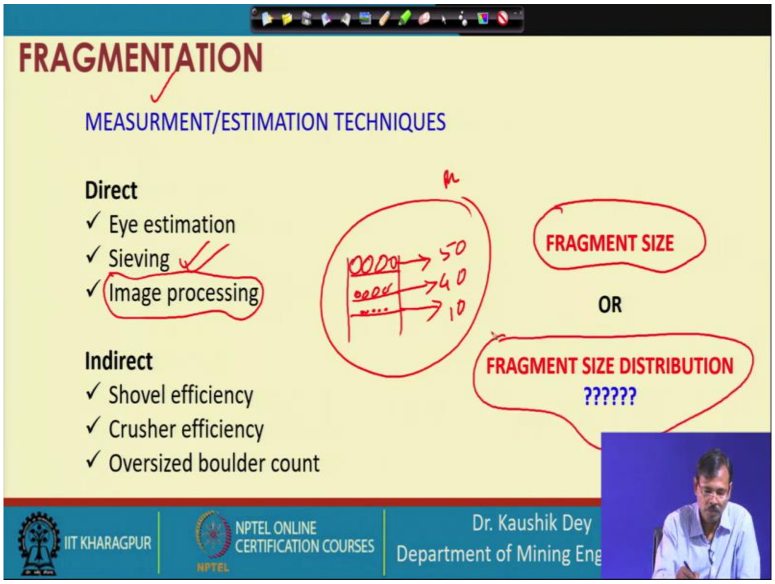

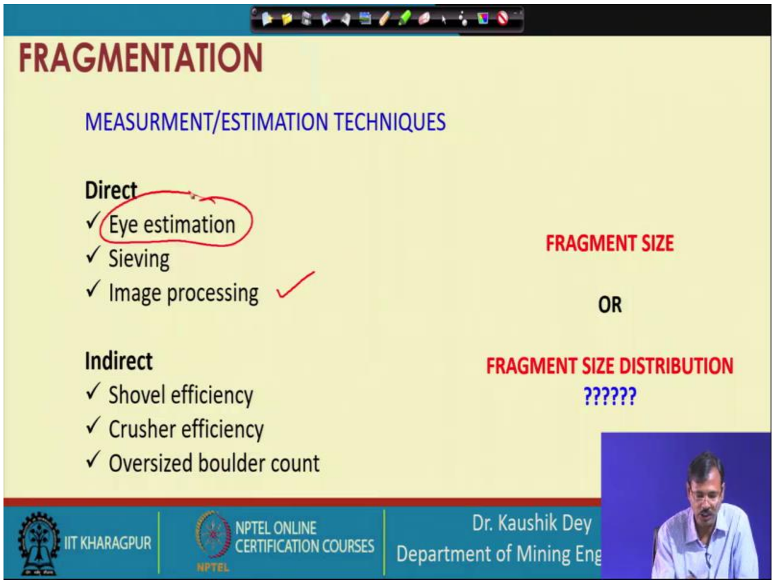

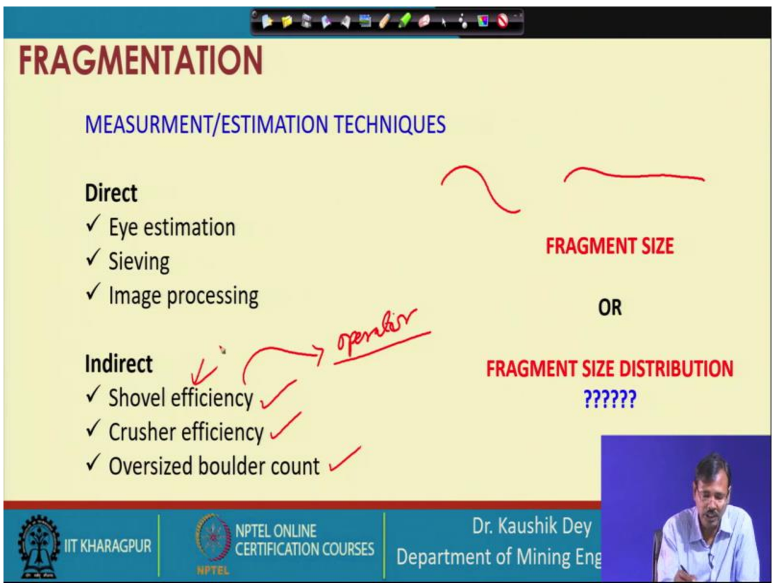

Now, let us look into the measurement or estimation technique. Obviously, this measurement and estimations that is characteristically different. But measurement of this high volume of rock is very difficult. So, in general, we go for estimation. Measurement is possible for a small quantity of material, maybe for the seed grain or maybe for the granular material, which is readily available for the screening that can be carried out. But we will look into the generalized techniques available for the measurement and estimation.

So, direct techniques available are eye estimation, sieving, and image processing. So, these are the direct measurement or estimation systems for the fragment size or fragment size distribution.

Eye estimation is basically depending on the experience of the person who is doing that one. So, it is something like that way in the video. Also, I told us that okay, it seemed that the fragment size distribution is very good, that is why we are observing this video. So, a similar way is the eye estimation. We have not actually measured, but from the eye estimation, we can say that this fragmentation distribution seems to be good, but in that case, we cannot say the value for this fragment size or fragment size distribution. It is only that we are talking about the uniformity of the fragmented boulders. So, we are saying that it seemed to be very good.

Sieving is very important in that sieving is nothing but screening. We provide the different sized screens, different sized screens are provided, and in this other sized screen we go for allowing the sieving of the material and segregated different size boulders. We find out the volume or weight at this position. By that, we are finding this is the 50 percent material, this is 40 percent material, this is 10 percent material this way, we are basically differentiating. So, this is a direct measurement technique that is available.

And the third one is the image processing technique, where the edge detection technique is utilized in the image processing, and the edge of the boulders is found. From there, we estimate the volume of the boulders. In this way, we can find out the equivalent diameter of the boulder to arrive at the fragment size of the boulders, and by the way, when we find out the fragment size of each boulder, we can establish the fragment size distribution.

So, these are the direct method, and obviously, it is understood sieving the huge volume of mining rock is almost impossible. So, the most preferred estimation process is that image processing. But image processing is also sometimes time-consuming. So, often mining people will go for eye estimation only.

Apart from that, there are some indirect methods: the shovel's efficiency, crusher's efficiency, and oversized boulder count. These are the indirect methods from which you can have some idea about how the fragmentation size distribution is good. So, if the uniform boulder size is available, the shovel efficiency increases. In that case, one goes for the decision that the fragment size distribution is okay.

But you have to remember this also depends on the efficiency of the operator, then the position of the muck profile. If the muck profile is like this, it is easy to load or muck by the shovel. But if the distribution is like this, it will take a long time for the shovel to take it up, but that does not guarantee the fragment size distribution is poor. So, other parameters are affecting these things. So, that can be considered while we utilize this indirect method for estimating the fragment size distribution.

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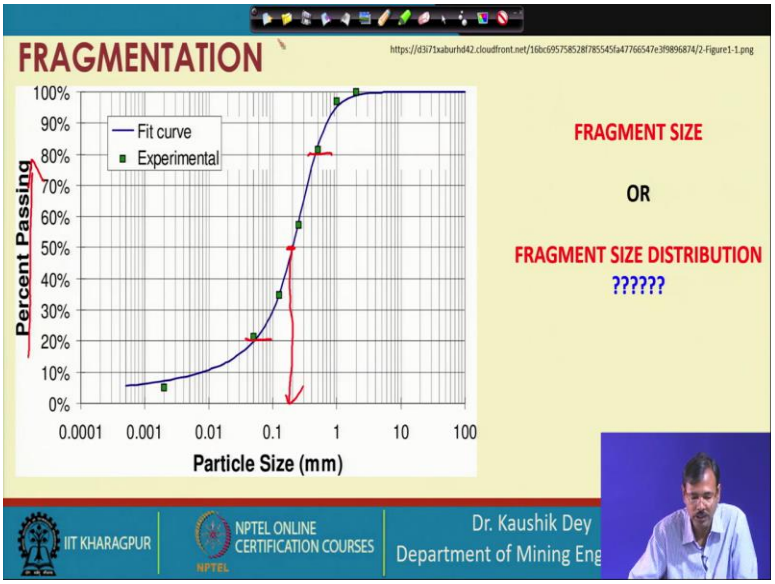

So, let us move into one by one these activities. This is the discussion over the fragment size distribution. You can see this is 20 percent, this is 80 percent, and this is the 50 percent, and by providing this point, we can find out this is the particle size, and here we are representing cumulative particles passing the screen. That size is presented here.

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So, this is the sieving technique in detail discussed here. Eye estimation is not discussed. See this is the multi-deck screens provided. In the multi-deck screen, this larger size boulder, then finer, finer, finer, and finer are allowed to move, and different points are collected. So, that is called sieving. So, this is a very common technique for size separation in the crushing plant or any other industrial plant industry.

But in mining, as the boulder sizes are very large, say boulders of the 1-meter cube, 2-meter cube, or 5-meter cube size boulders are used, so for that heavy screens are required, and that is why these types of screens are becoming very costly, and that is why it is not used for sieving purpose. So, in general, sieving is not a very popular idea for the fragment size distribution of the blasting.

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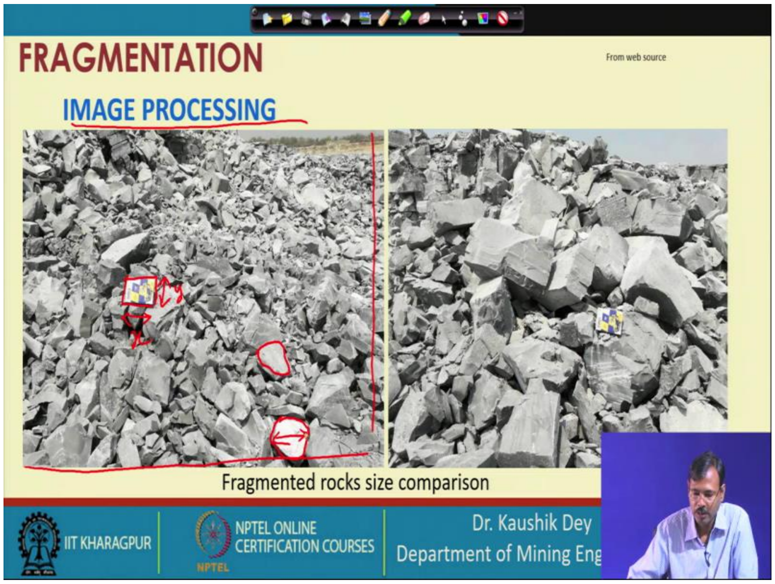

So, alternately, we go for the image processing technique, where the photographs of these photos are also taken from the web sources, pictures of the fragmented marks are accepted, and you can see a scale is provided, where x and y values are known. So, in the software, these x and y values are given as representative factors to easily understand the scale of x and y.

Then the edge, using the image processing edge detection technique, the edge of the boulders are outlined, and from there, their equivalent diameter size is computed. So, this is the technique used, and from this equivalent, the fragment size and their distribution are determined.

Nowadays, image processing techniques have become more advanced. Different companies have come out with the camera fitted with the shovel boom. From there, millions of images can be taken, which are automatically detected because the cameras are placed with a fixed zoom. In this way, millions of photographs are taken, those are analyzed, and finally, the distribution curve is made.

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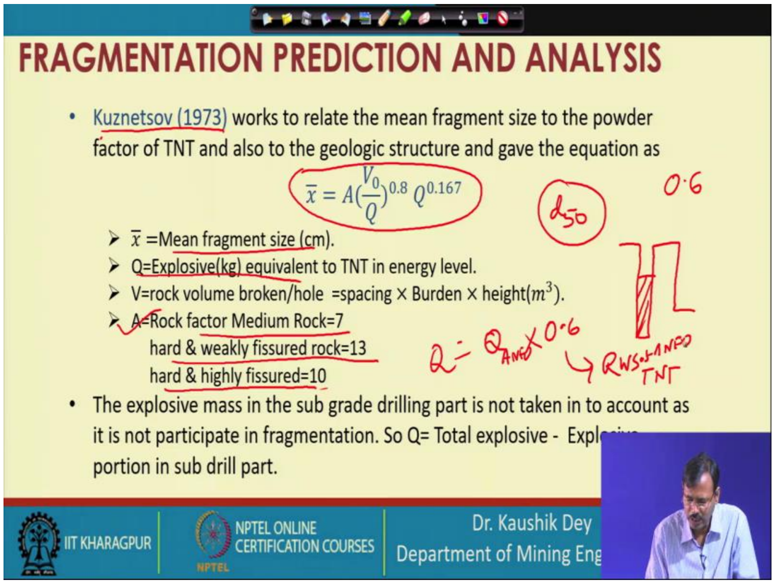

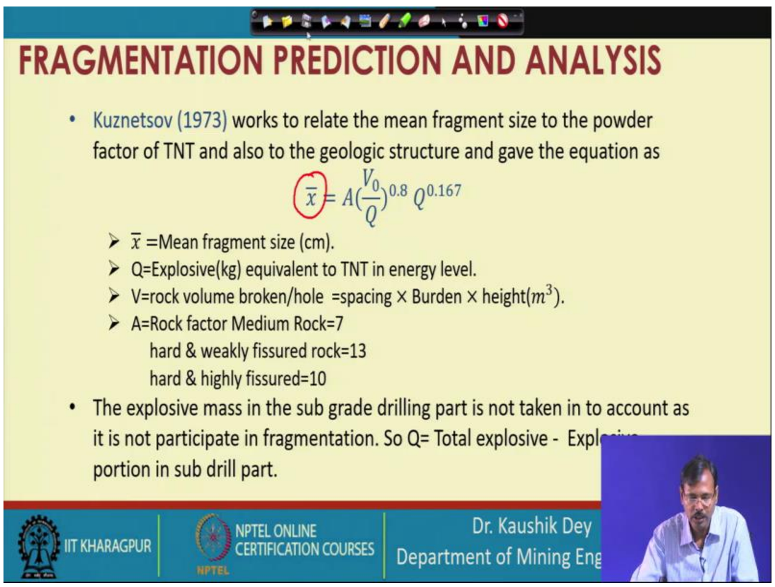

So, let us now start with the fragmentation prediction models which are available, and using these models, you can predict the fragmentation for a designed blast. So this first model was given by Kuznetsov in the year 1973, and he came out with the equation this one where x bar is the primary fragment size which means it is the d50 size.

And rest are given as the A is the rock factor. For medium rock, it is 7; for hard but weakly fissured rock, it is 13; and for hard and highly fissured rock, it is 10, and Q is the quantity of charge which is placed inside the hole, quantity of charge which is placed inside the hole, but that is made equivalent to TNT energy level that means it is multiplied with the relative weight strength of the, of that explosive with respect to TNT.

So, if Q is the charge provided, say Q is ANFO, and this ANFO has a relative weight strength with respect to TNT is 0.6. We have to consider this Q is equal to; this Q ANFO is equal to, this Q is equal to Q ANFO into 0.6, which is the relative weight strength of ANFO with respect to TNT. So, this is the relative weight strength of ANFO with respect to TNT that is considered in this case. But this model has a great disadvantage in that it gives us the idea only about the x bar the fragment size distribution for that this model remains silent.

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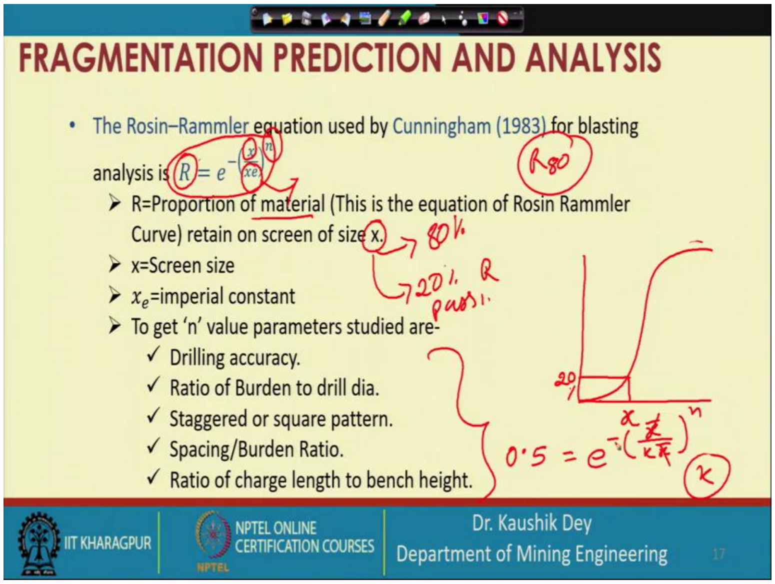

So, to avoid this, Rosin-Rammler has come out with the equation. The modified Rosin-Rammler equation given by the Cunningham using this, where R is the percentage of mass retained or proportion of material retained over the screen size x. So, this is the screen size, and this is the percentage or proportion of material or fraction of material you can say retaining on that screen.

So, suppose you are interested in the screen size on which 80 percent of the material will retain. In that case, you are basically interested in the screen size on which 20 percent of the material is passing. So, the value R20 and R80 represents this point where 20 percent of material passes through, and 80 percent of the material is retained. So, this is called screen size x.

So, xe and n are two constants, n is called uniformity index, and x is another constant, which if it is known to you, previously known to you, then you can easily compute this fragment size distribution. The value of this n depends on this parameters, and xe is a very common parameter. You can calculate xe for the 50 percent size. For the 50 percent size, R will become 0.5, and if you are considering this is e to power something, say, and this is x by K into x bar.

If you consider this, then x for this size, this is also x bar, so x bar x bar will cancel, and whatever value is coming from the K value, you can compute the K value from this equation. So, you can have this one and replace this equation by x by x bar into K, and in this way, you can utilize this as your part of this. So, you can easily compute that part and let us see how you can get the n value.

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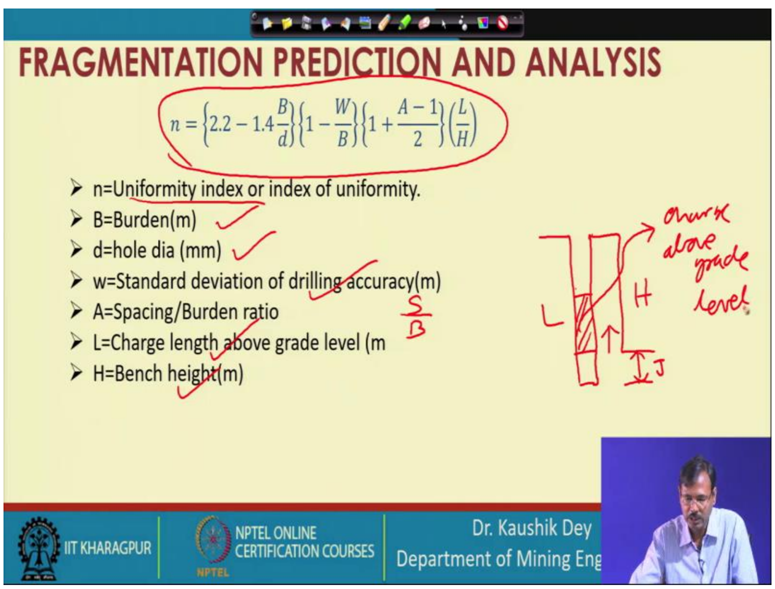

For achieving the n value, a formula is proposed for blast fragmentation only, where n is the uniformity index, B is the burden, d is the diameter of the hole, w is the standard deviation of the drilling accuracy, A is the spacing by burden ratio, L is the charge length above the grade level, and H is the bench height.

So, charge length above the grade level is, if this is your blasting, this is your bench height H and hole length L, and this is the sub-grade drilling or sub-drilling you can say J. The explosive charge you are placing above this height is considered the charge above grade level, is considered charge above grade levels. So, these are the considerations one must make during identifying n.

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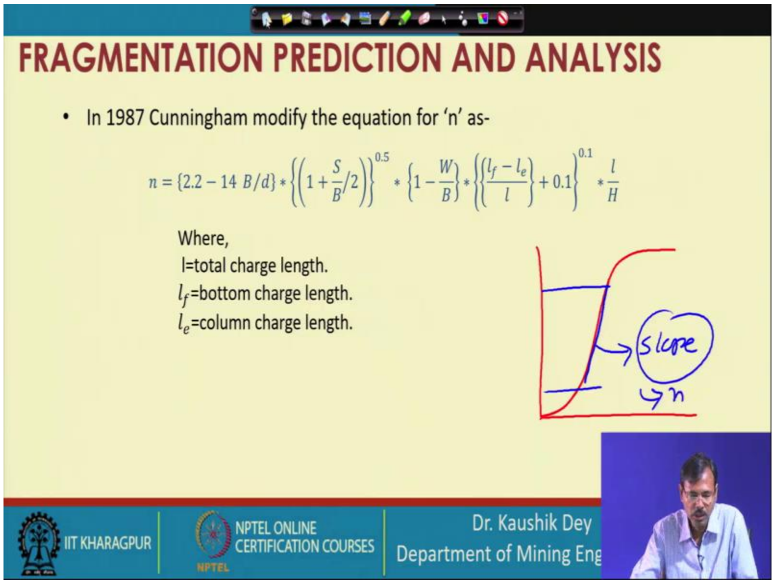

This is another Cunningham modifying his equation of n in 1987. But there is another way to determine this n. If the fragmentation size distribution is plotted, then this straight line portion, then this straight line portion the slope of this portion, the slope of this one can be considered the n value. So, this slope is the n value and can be considered to achieve the n value.

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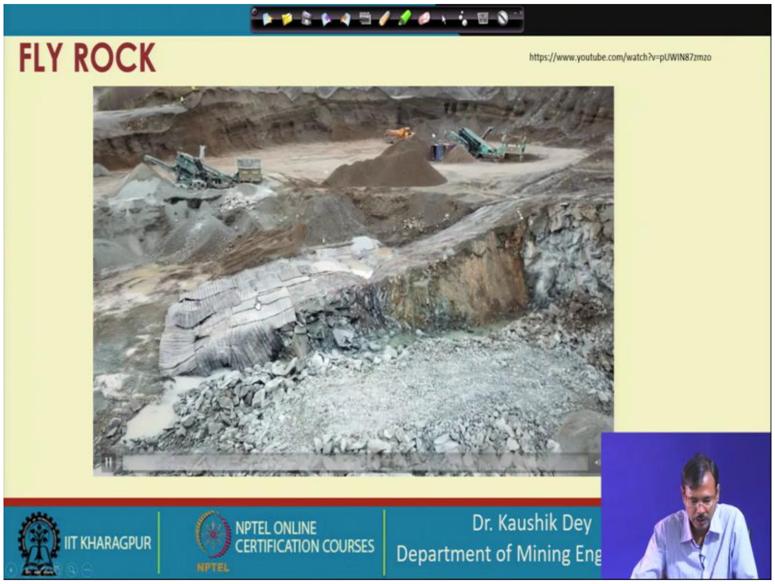

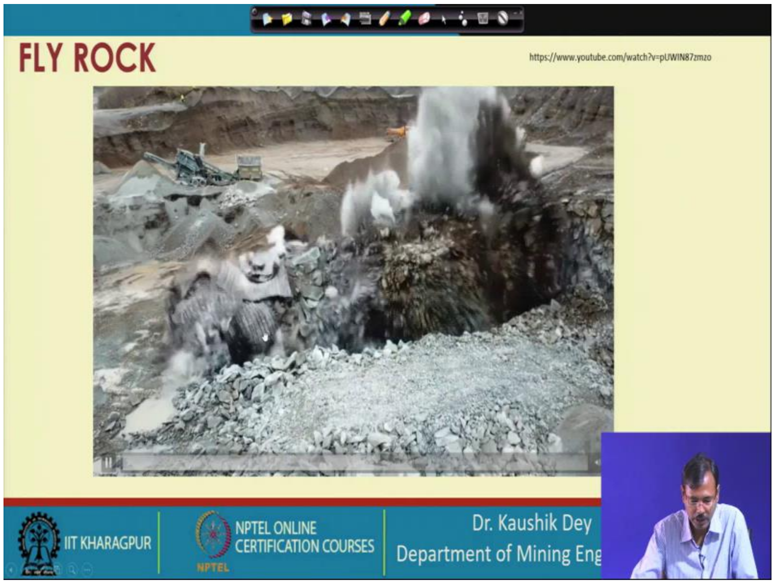

So, next is fly-rock. This is what you can see in the video. This is the matting provided. You can see. See, these are called fly rocks. These rocks are coming and dispersing in all directions; despite providing a matter on the top, the rock is dispersed in all direction. So, this fragmented fugitive particle from blasting is called fly rock, and this is very dangerous and poses a safety threat.

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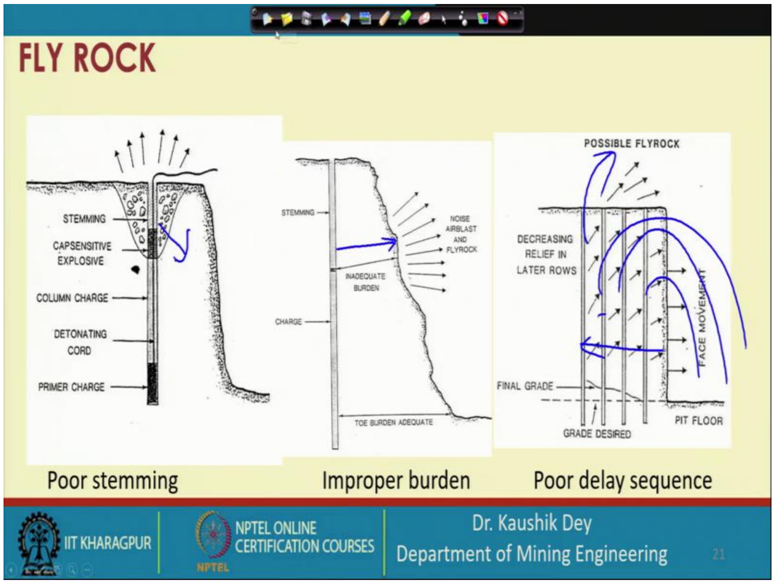

So, to avoid this one, we go for controlling this one. These are the different sources of fly rock, inadequate burden, improper stemming, and over choking the portion. If you are having more number of rows with the blasting of this one, then gradually this one, finally when the blasting is carried out at this one, no free phase is available, in that case, fly rock may generate So, these are the problem associated with the multi-row blasting. So, that can; this may can generate the fly rock.

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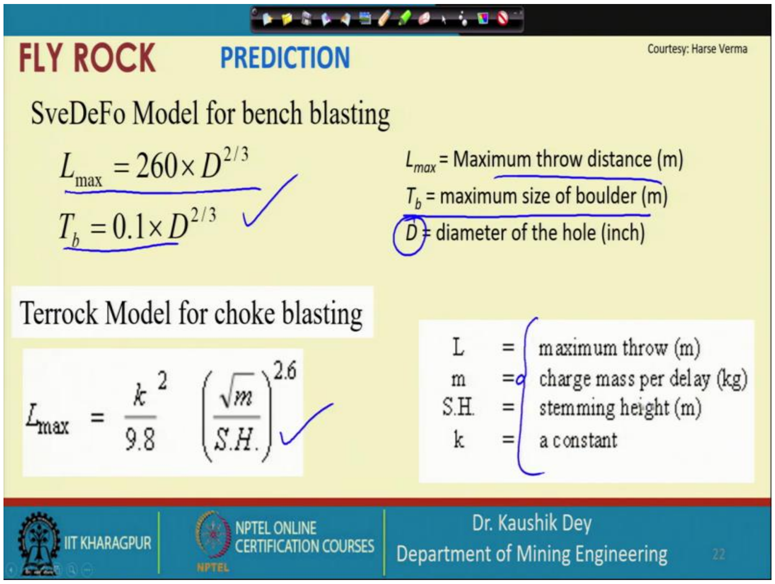

So, these are some of the empirical equations different researchers gave to estimate the fly rock. So, L max is the maximum throw distance, and Tb is the maximum boulder size that is moving up to this depending on the diameter of the hole. It is given here. This is another model where L max is shown like this, and these are the different variables expressed in this equation. So, in this lecture, we have discussed two blasting results. We will discuss another two blasting results in the next class. Thank you.