Surface Mining Technology
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Lecture – 15
Technology for Surface Blasting - I

Let me welcome you to the 15th lecture of surface mining technology. From this lecture, we will start the technology for surface blasting; we have six lectures on this technology for surface blasting. Initially, we will understand the different parameters, then the designing aspects, and finally, the tutorials for calculating the designing parameters and calculation of the cost of blasting. So, this is the general schedule for this technology for surface blasting.

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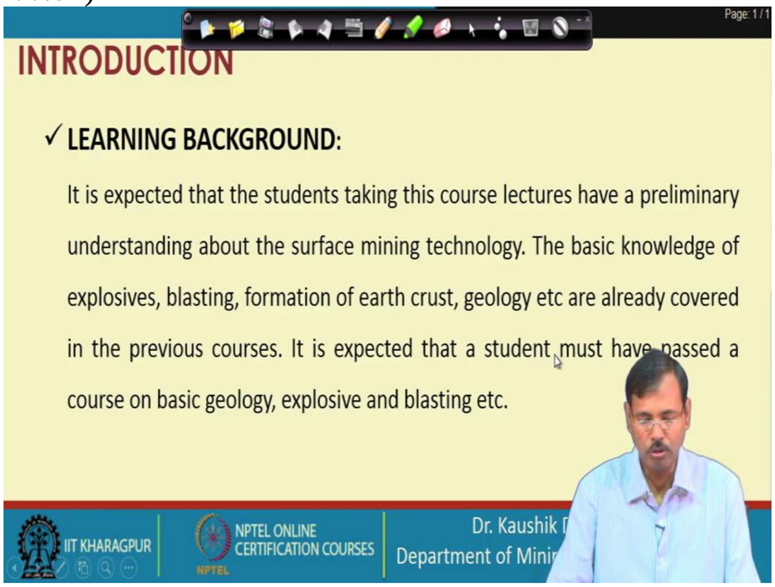

So, as we go for every class, let us look into the learning background for the surface mining technology course.

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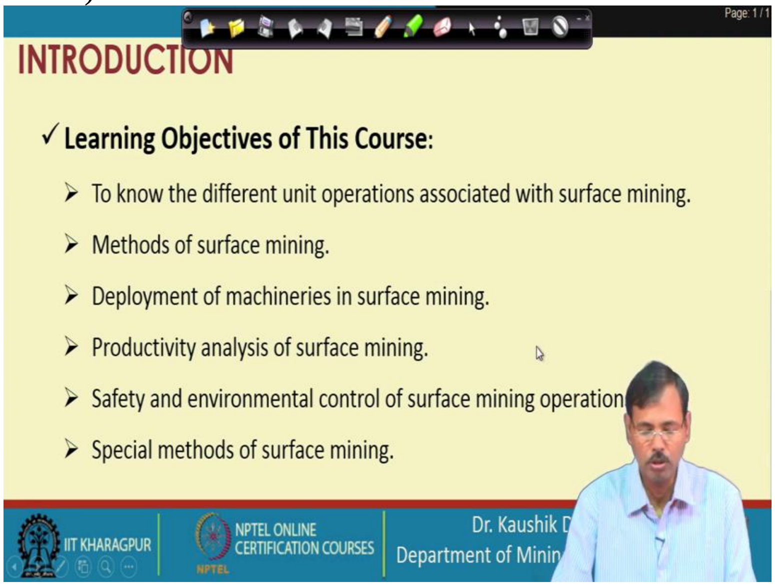

This is the learning objective for the surface mining technology course.

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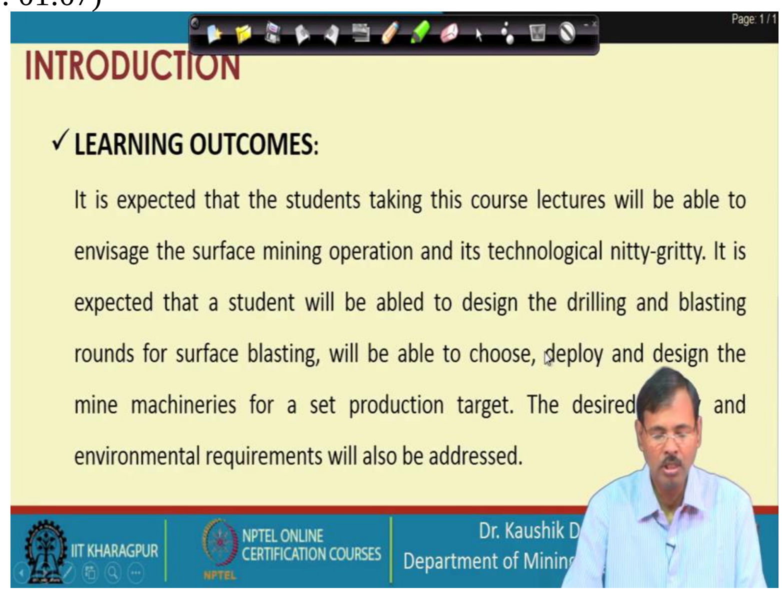

And it is the expectation from the participants after going through this surface mining technology course.

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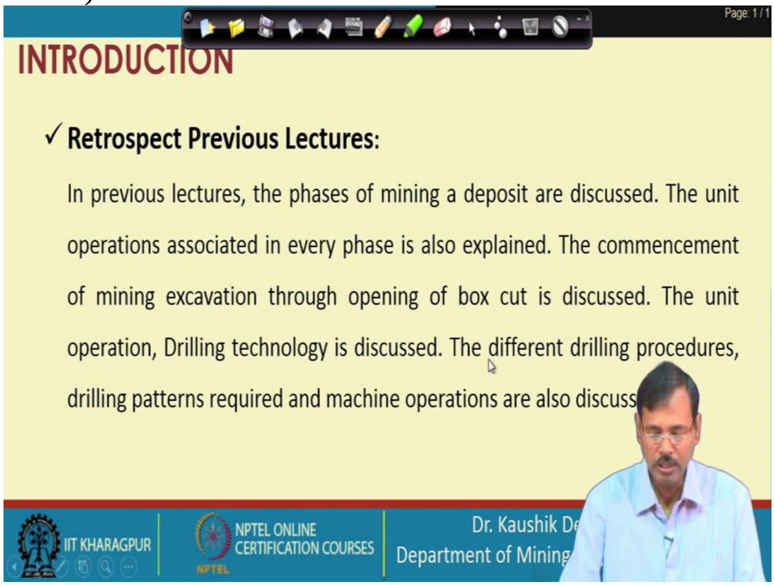

And so far, we have covered the different phases of mining operations discussed earlier. We have also discussed the problems associated with every phase and how the decisions will be based on achievements. We have discussed open, opening surface mining through box cut. We have discussed the drilling technology required for the carrying out of blasting. So, that is already discussed.

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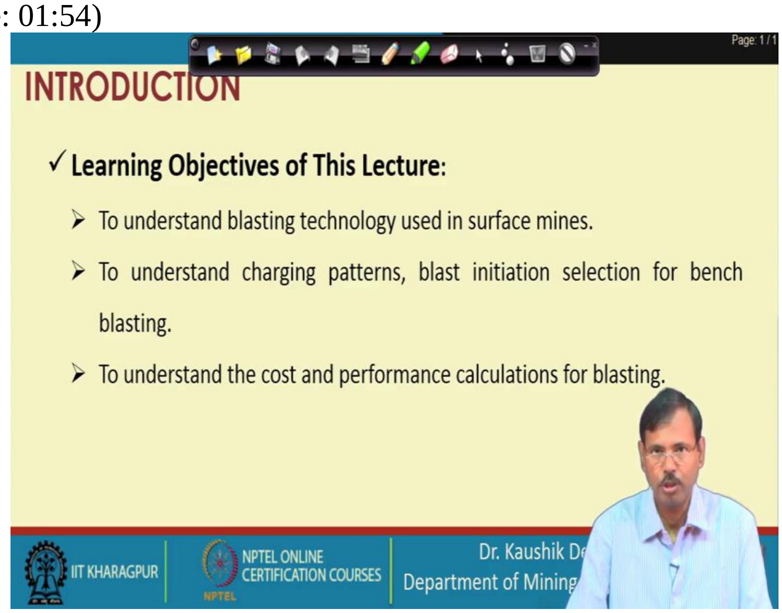

So, we will start now with the technology for surface blasting. The learning objective for all this surface technology for surface blasting lectures is six lectures on this. This lecture’s learning objective is to understand blasting technology used in surface mines. To understand charging pattern, blast initiation selection for bench blasting. And to understand the cost and performance calculations for blasting. So, this is the broad objective for the lectures related to technology for surface blasting. And in this particular lecture, we will try to concentrate on the different parameters of the intrinsic parameters of the surface blasting or bench blasting technology.

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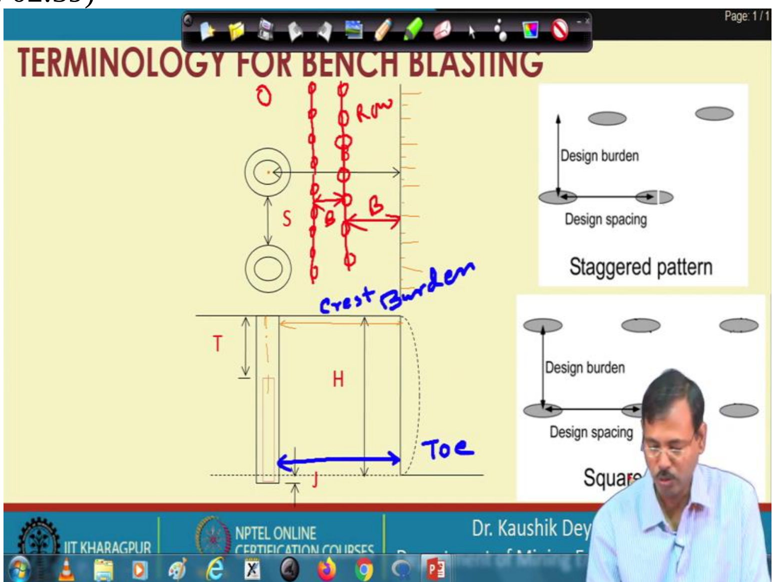

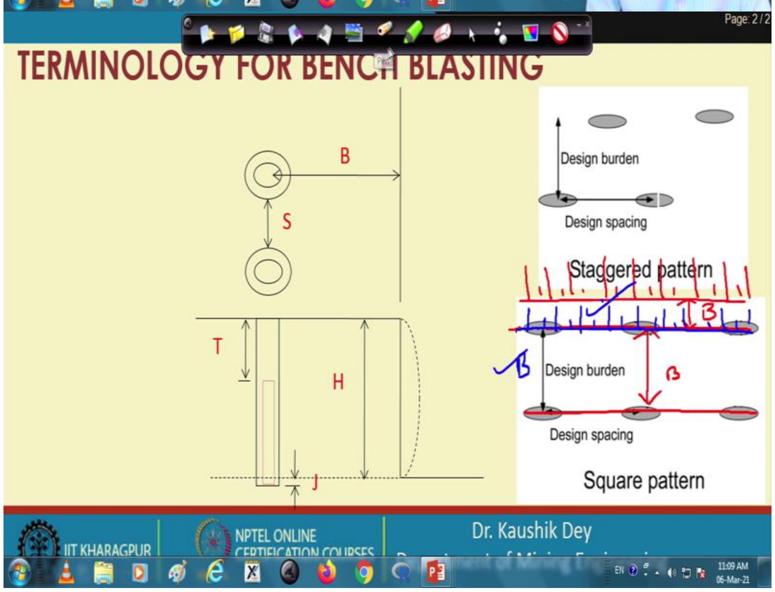

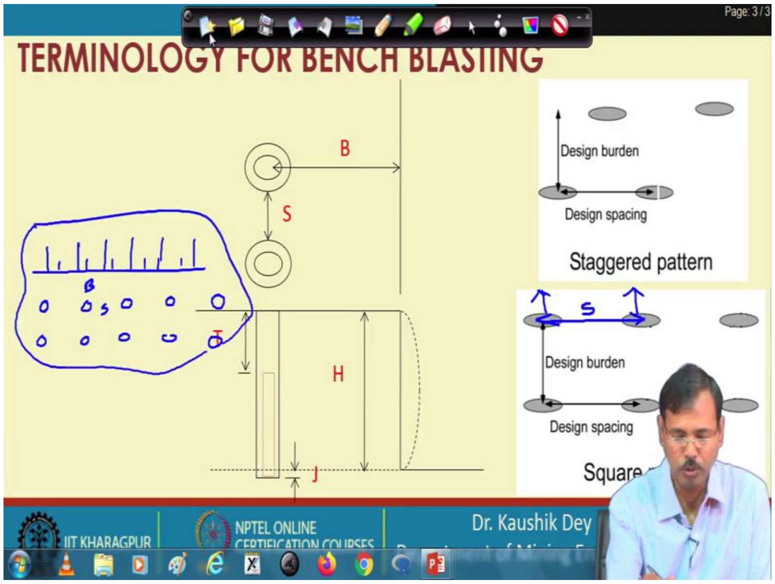

So, see the terminology, see the terminology first. Then, you can see if you are drilling a hole if the hole is drilled at this position. This is the center point; if this is the centerline, then from this point to the free face line, this is the crest of the free face. So, from the hole, the distance from the center point of the hole to the free face is called burden. So, if you are measuring this at this point, it is called crest burden, crest burden. This is called toe burden. If you have more holes in one row, these are the rows we are considering. If this is the free face, then a number of holes that are almost equal are considered the row.

And the holes in the other line constitute the next row. So, if this is the burden distance, this is also the burden distance. The concept is that it is expected that this one will be blasted ahead. So, if you are, if you are looking at this picture, say this is our free face. And these holes are drilled at a burden distance. Then the following rows of holes are drilled. So, this burden distance and this burden distance will be the same or similar.

The reason is that it is expected that after blasting up this hole, this after blasting up this hole a new free face will be created at this position. It may be for a few milliseconds duration, but the new free face will be created here, then this will also be blasted. So, this is acting this also is acting just when this hole should be blasted, just when the new free face is at this position. So, the burden distance for these holes will be this one.

And this will be the same as this. So, burden distance is the distance from the hole to its free face. And spacing is the distance between two holes, the distance between two holes that have the same burden or are being, which are considered in the same row. So, this is called spacing, spacing between two-hole holes. So, these are basically burdens and spacing.

You have to select this when you are carrying out drilling in the mine bench itself. So, you have to select your burden and spacing. And in that case, previously, if this is your free face, the supervisor has to mark the positions where the driller has to drill the holes. So, the supervisor will mark this position. And he has to maintain this burden distance and this spacing distance. So, this will be marked then the holes will be drilled almost in this, almost in the close vicinity of the mark position.

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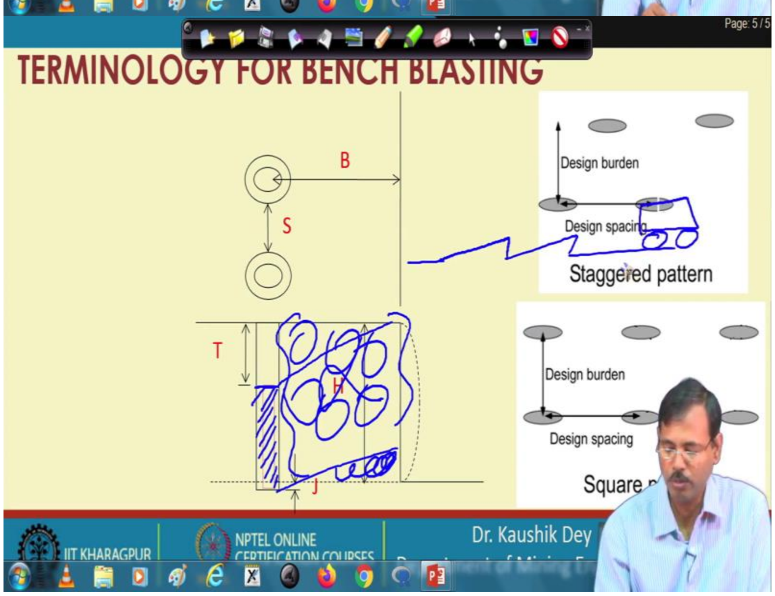

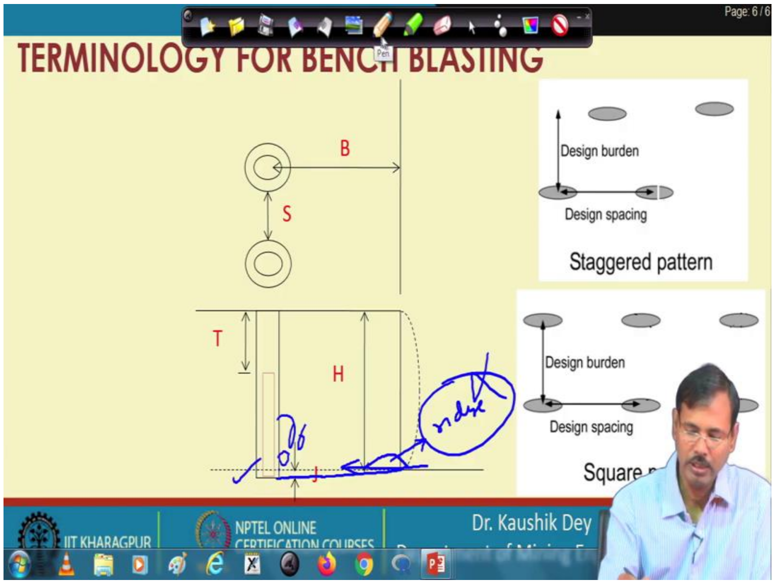

If you are looking at the hole sections, you will find out the drilled hole is, in general, a little bit longer than the bench height. If your bench height is H, then you will find out your drilled hole length is L. And this L is a little bit larger than H. So, you are basically carrying out some additional drilling, which is called J. So, this J is termed as sub drilling, sub drilling or subgrade drilling.

So, this additional drilling, this sub drilling is required to avoid any ridge formation at this place. So, how is this happening? Suppose you blast this position and place your explosive in the hole up to this height. Now, this one, and as this is your free face, this one is acting like this. And that is why this portion of rock will be fragmented. If it is acting like this, a ridge is formed at this position.

So, if you will find out in a mine your bench floor is like this, then it is creating a problem. If your floor is like this, it creates a problem for the machines' movement. So, to avoid this one, you go for additional drilling so that the excavation will be carried out like this. And this portion, the rock will be fragmented, and finally, you will receive a smooth floor. And there will not be any ridge formation at this position.

So, there is no ridge formation at this position. So, that is avoided by carrying out some extra drilling. But if you are having two layers of rock, say suppose this is one bench, and this is another bench. And these are the two different types of rock, and these rocks are, and these rocks are readily separable. And these rocks are readily separable. So, it is very easy to separate this rock; in that case, you need not go for subgrade drilling for the particular mine.

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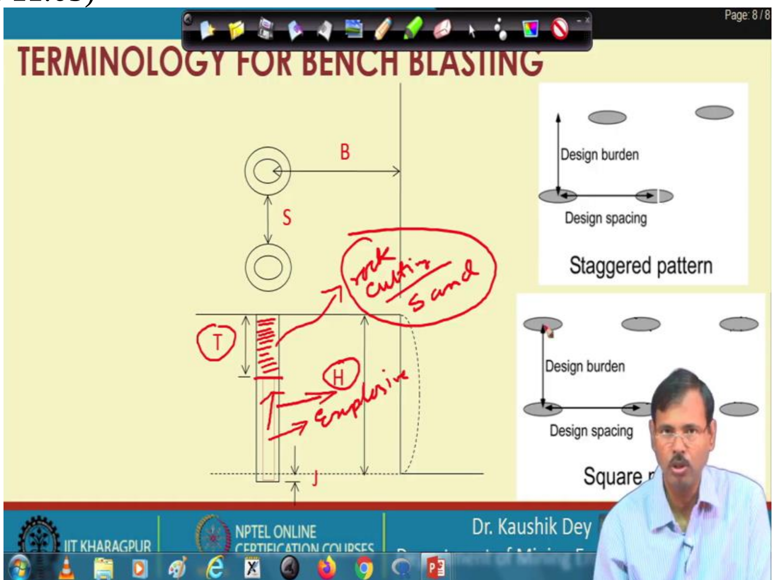

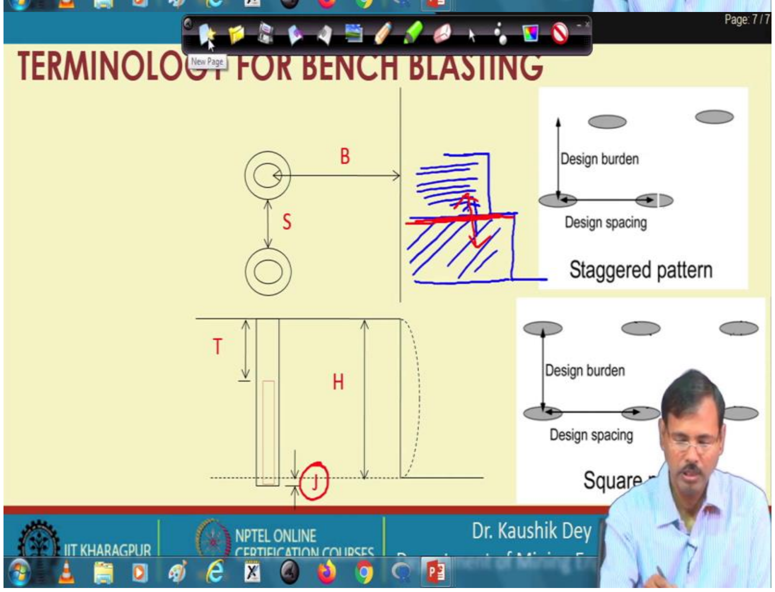

So, let us understand the terminology here first; this is bench height. This is stemming length, which means the portion of the hole, after placing the explosive at this position, the portion of the hole you filled with the rock cuttings, rock cuttings, or sand. This is carried out to avoid the escape of the gaseous products coming out from the explosive of the blasting. So, that gaseous product coming out from the explosive of the shot they are escaping is restricted by this filling of this area.

So, this is giving the confinement of this gas. So, it forces the gas to move out or pressurize this rock to move in the front direction. So, that is the purpose of stemming. So, in a nutshell, we understand what the different terminology is. In general, we use it for getting out in the blasting.

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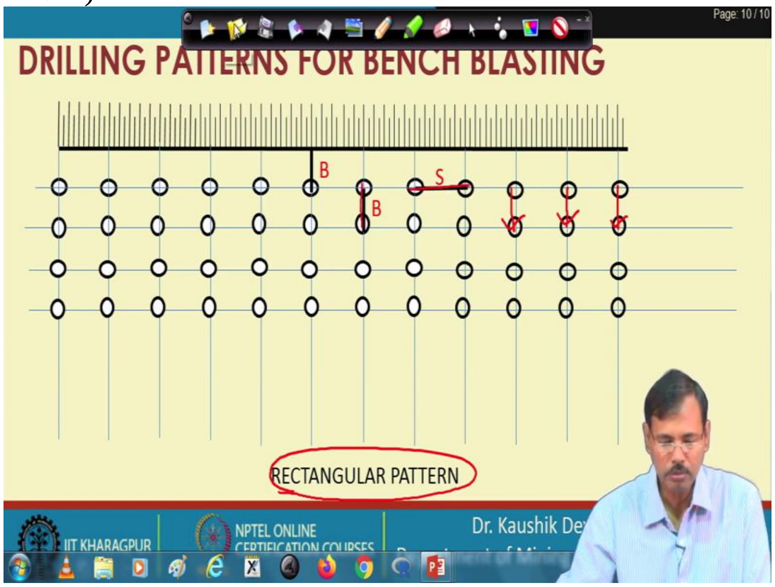

This part we have already discussed in the drilling part. This is a; this is called a rectangular drilling pattern. The next row holes are placed directly behind the front row holes. And you can see this is the spacing; this is the burden.

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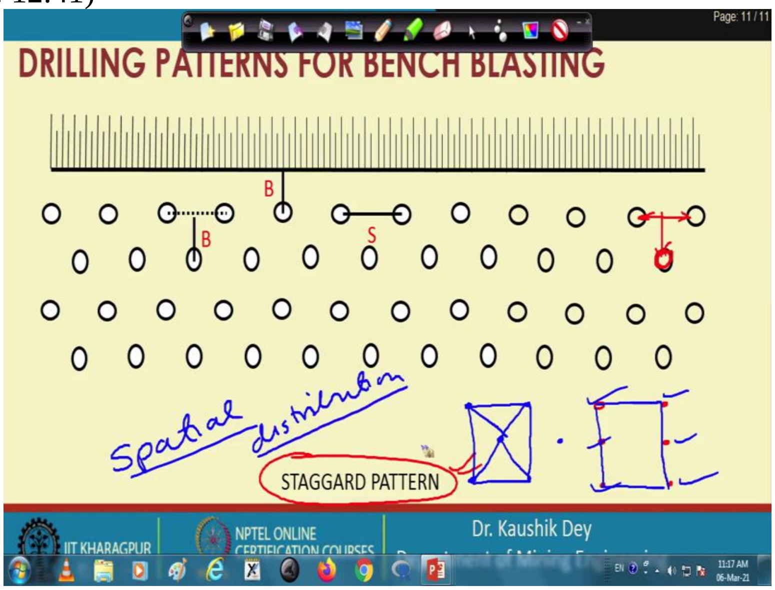

And this is called a staggard pattern, where the next row holes are placed between two front-row holes. So, in between two front-row holes, the next row holes are placed then. It is called the staggered pattern. If you are looking at the rectangular pattern, this is a rectangular pattern. And if we are looking at the staggard pattern here. Then you can see, if you are looking at this particular formation, see here the charges are placed in a better way than this portion of the distribution. So, the staggard pattern gives a better spatial distribution, spatial distribution of explosives, and spatial distribution of explosives over the rectangular pattern.

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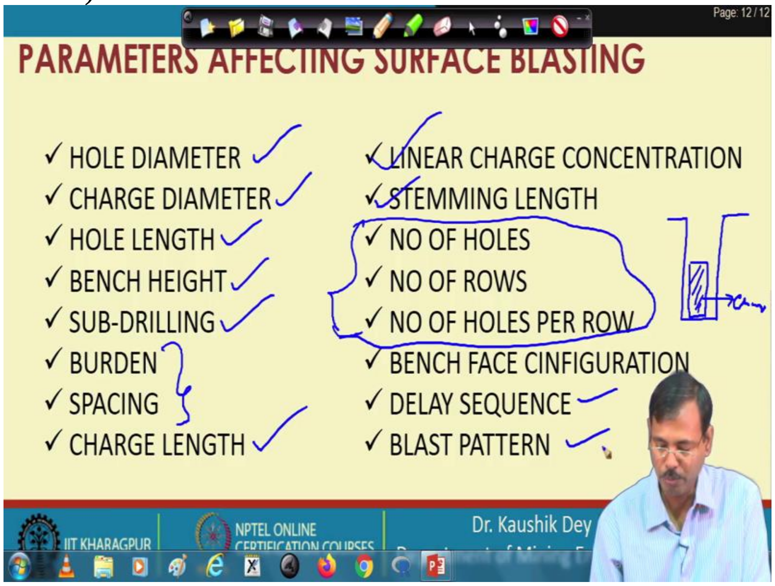

Now, let us see the least of the influencing parameters; there are a host of parameters affecting the results of the surface blasting, simultaneously the designing of the surface blast. So, these parameters are hole diameter and charge diameter. So, in our, this is the diameter of the hole, and this is the explosive charge, which is placed inside the hole in a cartridge form. So, that is the charge diameter, hole length bench height sub drilling.

So, we have already discussed these interdependent parameters, burden, and spacing. And how to identify the burden in the lecture on drilling and blasting. Technology in that course, we have already discussed the selection of burden and spacing—charge length in the hole, linear charge concentration, which is very important—then stemming length, number of holes, number of rows, number of holes per row.

These are the design requirement; this is the design requirement for planning a surface blast. And if you say, doing it for a number of 100 holes 400 holes, you have to provide the delay sequence and blasting pattern for that judicially, and that is very, very important. So, let us look into the influence of these parameters in this lecture.

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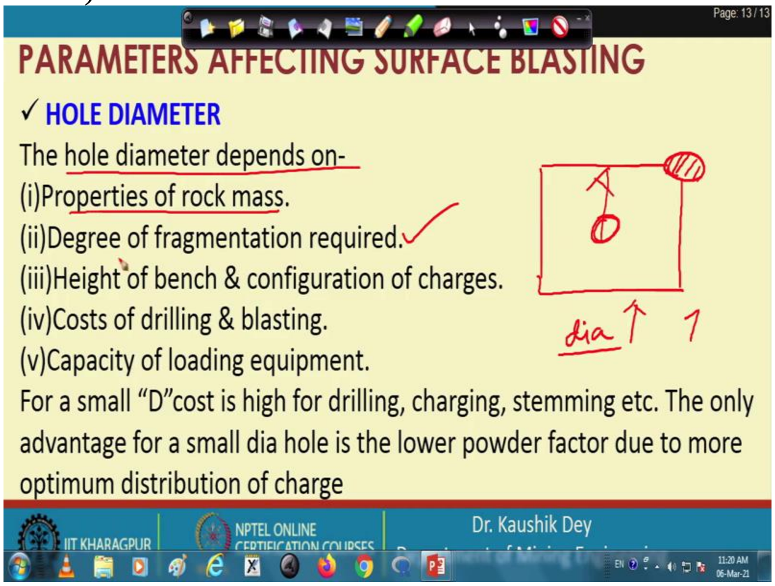

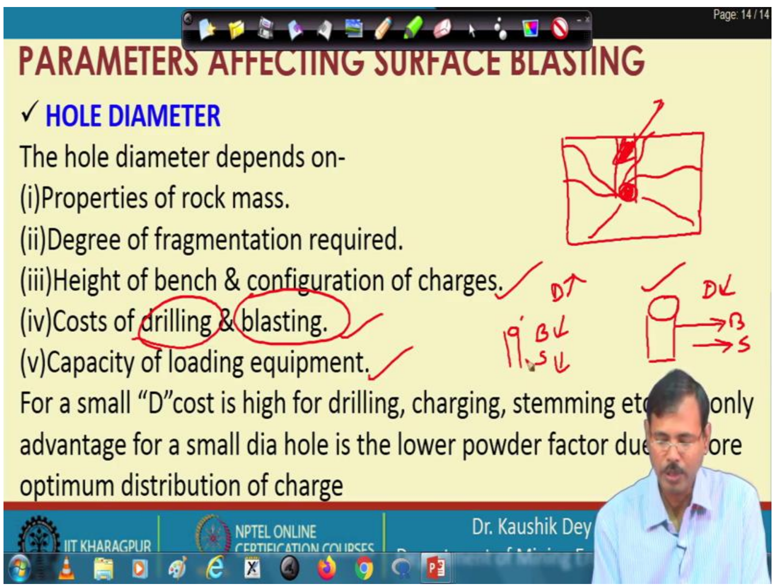

The first hole diameter is the main parameter. And most of the designing guidelines, you will find the based-on hole diameter only. So, if you see, the hole diameter depends on rock mass properties. If you have a strong rock mass, then you need to place, you need to place the explosive, more explosive for a particular cubic meter of rock. So, in that case you need to increase the diameter of the hole.

So, this is basically with the diameter of the hole, with the diameter of the hole, you are basically increasing the charge concentration. So, if you increase the diameter of the hole, you increase the charge concentration. Because in unit area, you are giving more explosives. So, that is why you are increasing the charge concentration with the hole diameter. So, the degree of fragmentation is also very, very important.

If your hole diameter is more, you are placing the more explosive, more quantity of explosive obviously, you have to increase your burden and spacing. You have to increase your burden on spacing, which is the influencing area. So, this burden and spacing, etc., will be increased. So, that is why your degree of fragmentation will be affected. So, if you improve the charge diameter, you increase the burden and spacing.

This will lead to the larger size of a fragmented boulder. So, if the size of the loading machines is higher in that case, we can go for a large dia of holes—then bench height and configuration of the charges. We can go for large diameter holes if the bench height is more. If it is less, we have to reduce the diameter. Cost of drilling and blasting. And this is very, very important. The capacity of the lording equipment, we have already discussed.

With the cost of drilling and blasting, you have to remember one thing: what is the drilling? Drilling is nothing, but we provide space; we provide a space inside the rock mass to place the explosive in that position. Ideally, we have to place at the central part of a cubic meter rock mass. We have to provide some quantity of charge so that it will fracture the whole rock mass.

But we cannot access the central point unless and until we create a hole from the surface to reach this position. So basically, we are carrying out drilling to reach this position. That is why after placing this explosive again, we seal this portion using a stemming material. So, that is the technique basically carried out in the blasting. And that is why you have to compromise between the combination of the drilling cost and the blasting cost.

So, if we use a large-diameter hole, we are increasing the burden; we are increasing the spacing. So, our drilling requirement is going to be reduced. But if we use a small diameter hole, then our burden and spacing both decrease. So, we are basically increasing the drilling cost. So, in this case, our drilling cost is increased, and in this case, your drilling cost is decreased.

But the effect is that if you are carrying out a small burden, with small spacing with a small diameter hole, your fragmentation will be smaller; in this case, you will get the larger fragment size bolder. So, you have to compromise between these things while designing the blast.

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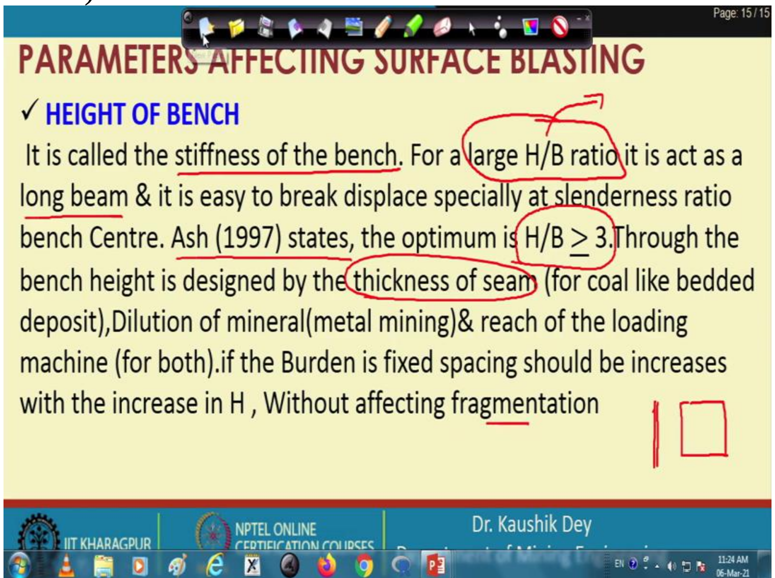

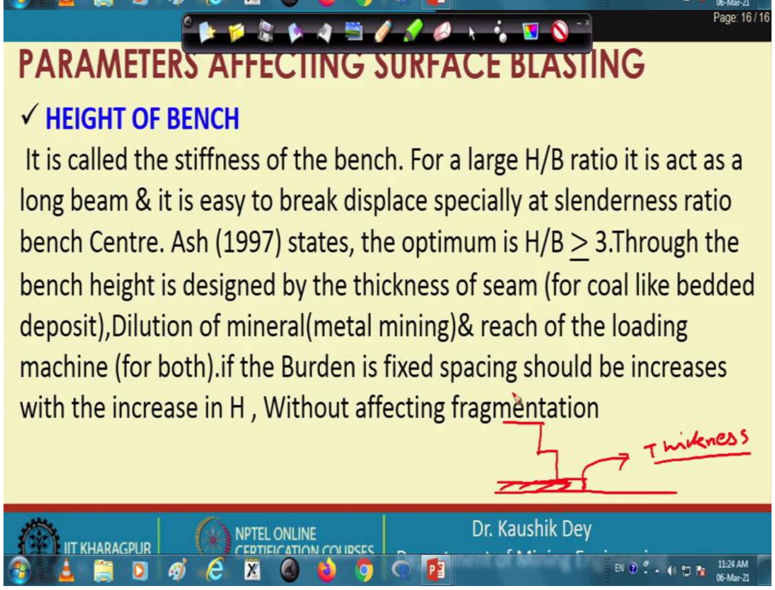

Next is the bench height; bench height dictates the stiffness of the bench. So, the H by burden ratio is considered the long beam. So, if it is creating a long beam, you can understand the long beam is very easy to break. But, if it becomes a slab like this, it is not that easy to break. So, this H by B ratio is very, very important. Ash 1997 has argued this H by B ratios should be greater than 3 for the blasting purpose.

And that is why the bench height is designated often by the thickness of the seam, like say if the coal bed suppose you are having, think, you are having overburden benches like this. But you have a very thin cold bench. You have to take this thin coal bench separately. So, in this case, you do not have an option. Your bench height is governed by the thickness of the coal bed only.

So, these are the different parameters you also need to consider while selecting the height of the bench. Otherwise, bench height is also governed by your excavator's reach, which governs the bench height.

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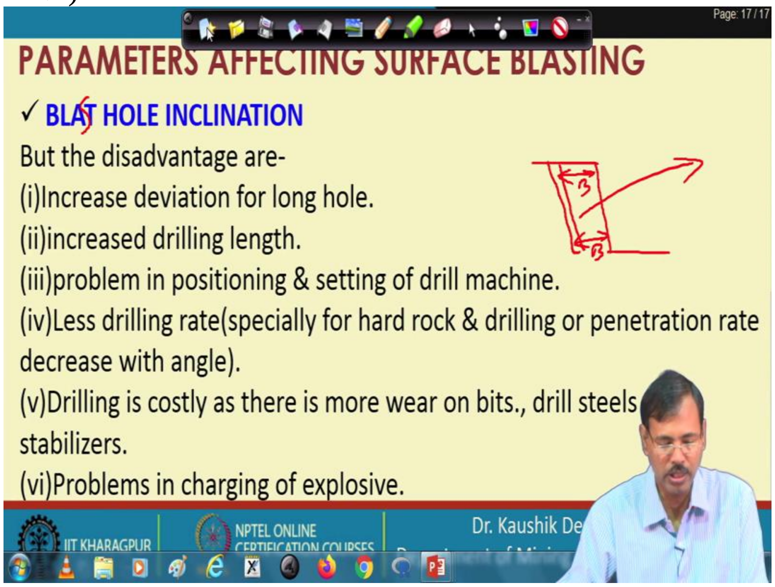

Drill blast hole inclination, this s is missing. Blast hole inclination is another important parameter. And if your bench is, having a slope angle to having an equal burden throughout the bench height, in general, you can go for a, to have the toe burden and crest burden same, you may go for an inclined blast hole. Or, if you need to throw the rock over a longer distance, you can also go for an inclined hole drilling. But, generally, incline hole drilling is not very easy. Drillers always have confusion related to that. So, that is why inclined drilling is often avoided during the actual blasting practice.

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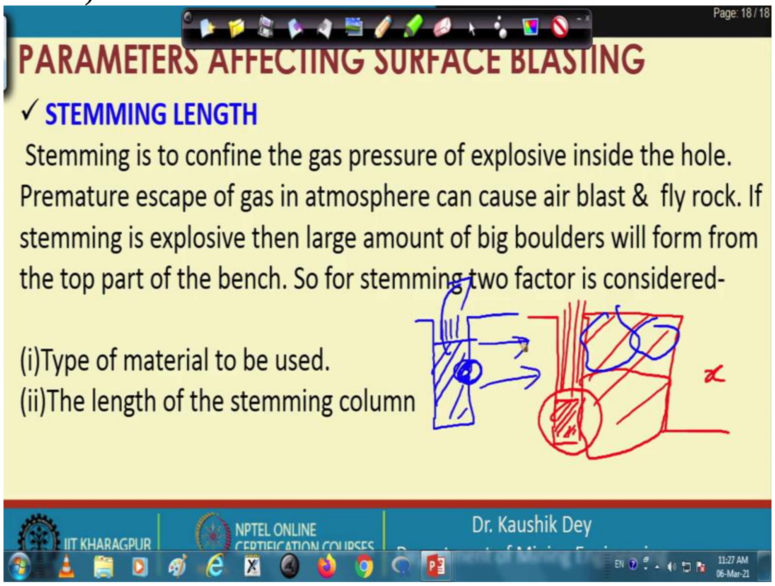

Stemming length is important because this governs the charge distribution. Suppose, to blast this rock, we need x kg, and x kg can be accommodated at this place. But what will happen in this case? This x kg is concentrated in the lower part of the rock only, and this part is completely stemmed. So, this is over stemmed, and the charge distribution is not significant.

And this portion will generate that case; in the top part, it will generate larger-sized boulders at this position. But if you have a reverse condition, when you have placed your explosive like this, this part stemming is insufficient. Then the gas pressure generated by these explosives is escaped, showing this stemming part. And then the throwing of this part may not be significant enough, and you will not get the proper blast fragmentation in that case also. So, proper stemming is also very important.

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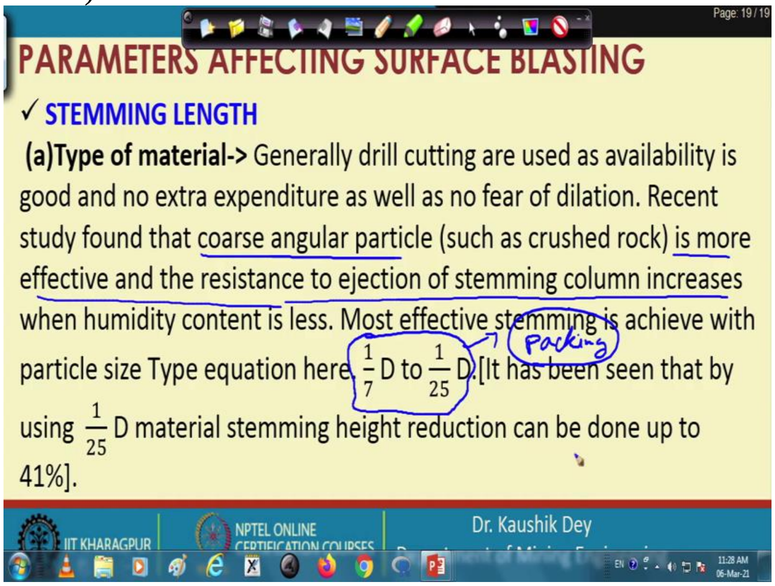

These are the criteria for the selection of the stemming material. Generally, the stemming material fragment size is considered in the range of 1 by 7 D to 1 by 25 D. This is supposed to give the best packing inside the hole. But, one very important part is that coarse angular particle is more effective. And resist the ejection of the stemming column because these have interlocking types.

Simultaneously, another problem may occur, the coarse and angular particle on the time of hammering onto the steaming part, which may damage the nonel or the detecting fuse, in this connection, given to the explosive. So, that part must be taken care of while the stemming operation is actually practiced.

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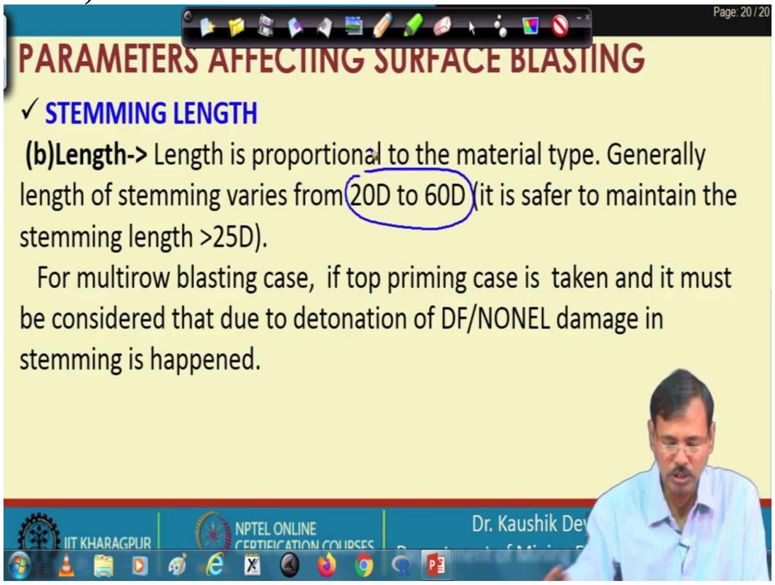

Stemming length, we will come to the design criteria at a later stage. But in general, different researchers have given a range of 20 D to 60 D depending on the type of material depending on their own design guidelines. In general, this is practice, but different researchers have given different criteria for this.

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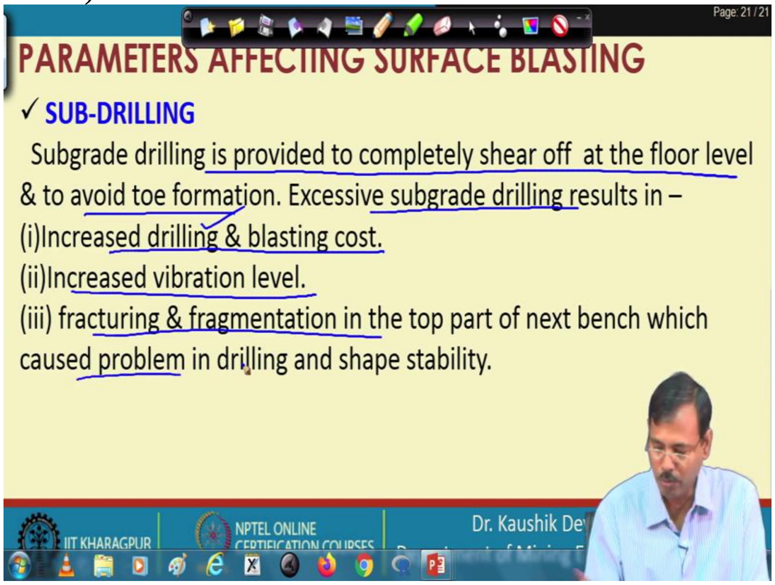

And sub drilling we have already discussed. To avoid toe formation, the sub drilling is provided to complete shear off of the floor level. But, if we go for excessive sub drilling, that may increase drilling and blasting costs because we are additionally drilling is carried out, which is unnecessary. It may increase vibration levels also. And fracturing and fragmentation in the top part of the next bench may create the problem, which we show in the next slide.

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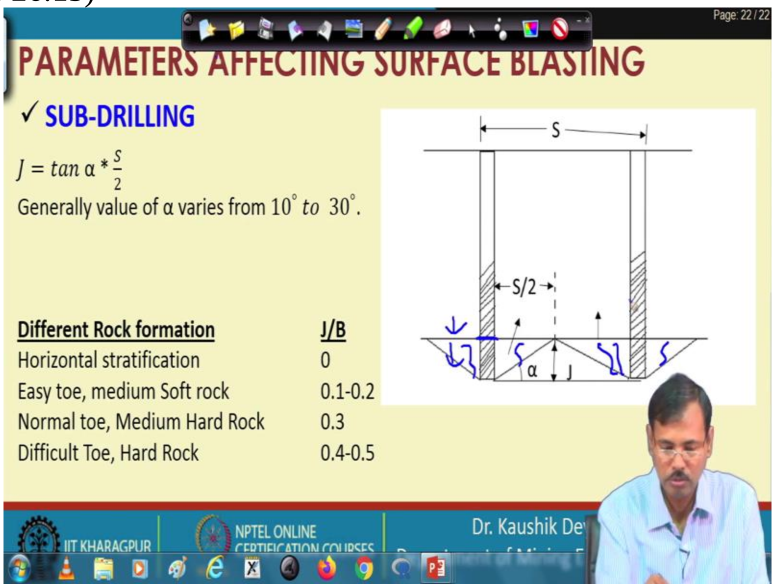

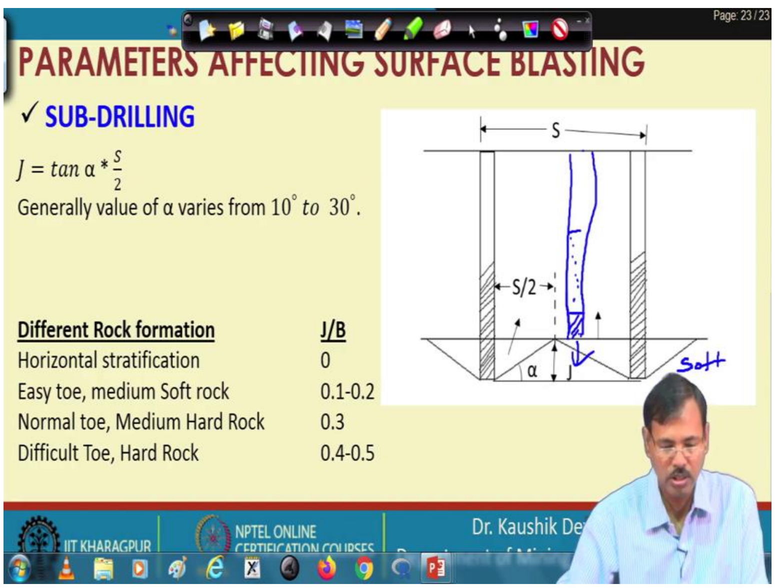

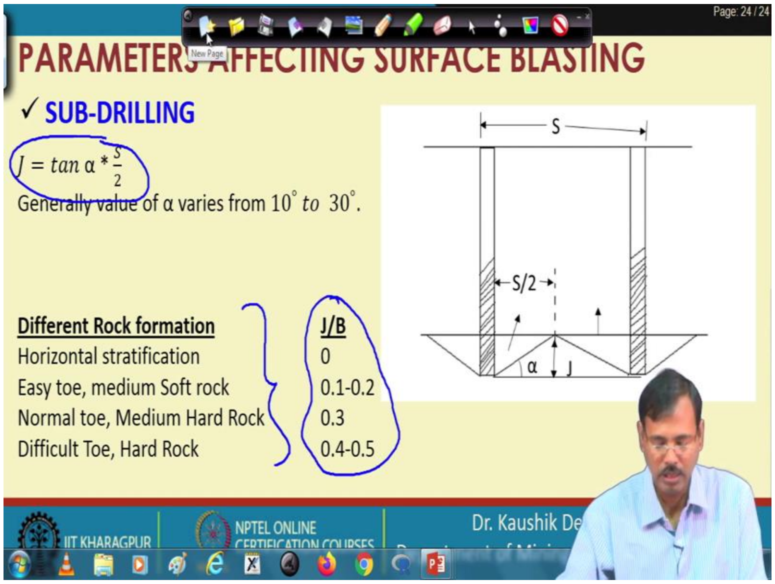

See, the fracturing that occurs at this position may create the problem. So, we sometimes go for restricting up to this only, without sub drilling, if these two are ready and readily separable. And if this part is soft, if this material is soft, we drill up to this instead of going for sub drilling.

And initial part is stemmed fast before providing the explosive. So, that explosive will reach up to this, and this rock will not be damaged because of this explosive. So, often we go for that also. So, this is the calculation part of the sub drilling. And general, for different rock formations, the sub drilling, and burden ratio is basically governed by this thumb rule.

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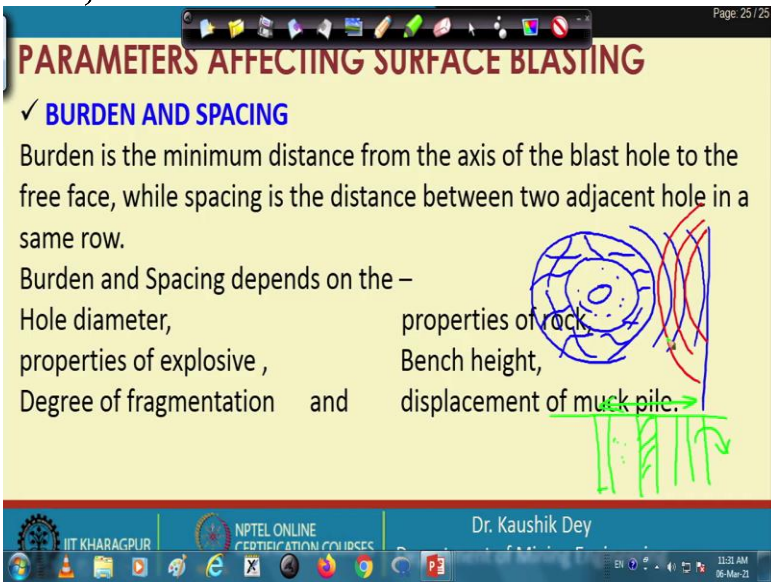

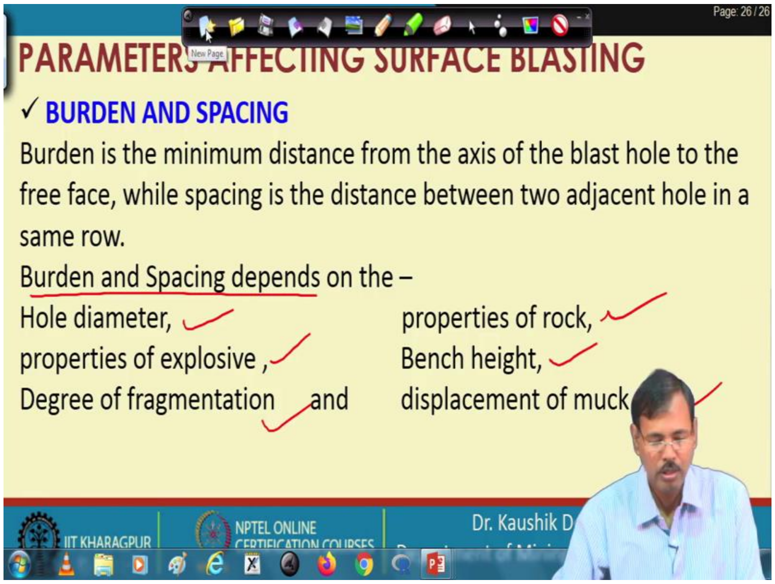

Now, the main part is burden and spacing. We have already seen how the burden is governed in our drilling and blasting technology lecture; there is a crust zone. Then the radial tracking zone, in blasting. And after that, this is the reflected wave, and this is basically, this is basically creating for the if you are looking at the section, this is the hole. Then the initial, this is the crush zone.

This is the cracked zone, becoming the slabbing tension zone, which allows the topple of the material. So, our burden is governed by this theory that we have already discussed in our drilling and blasting technology. So, load and spacing depend on the hole diameter, properties of explosive, degree of fragmentation rock properties, bench height, and displacement required for the muck pile.

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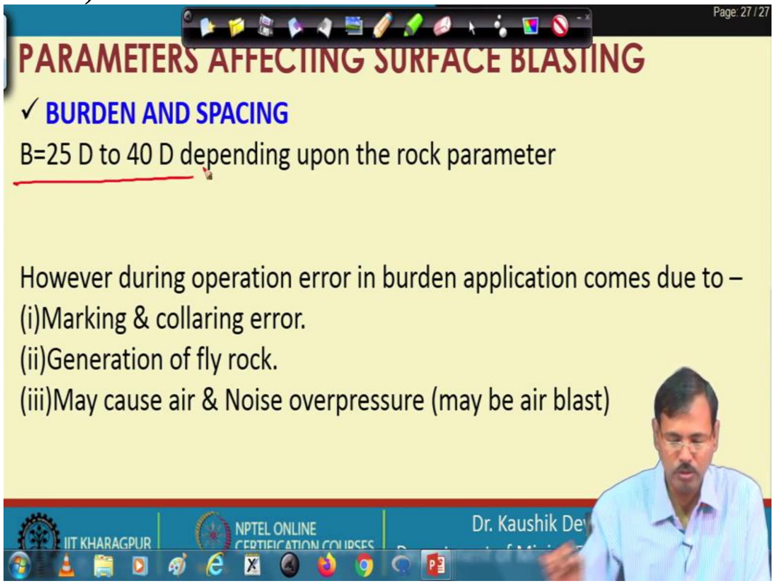

We have already discussed that excessive burden creates the problem of fly rock. And also, the smaller burden creates the problem of fly rock as well. So, proper or the optimum burden must be utilized. Generally, this is the range in general; we go for actual practical mining fields we design our blast related to this.

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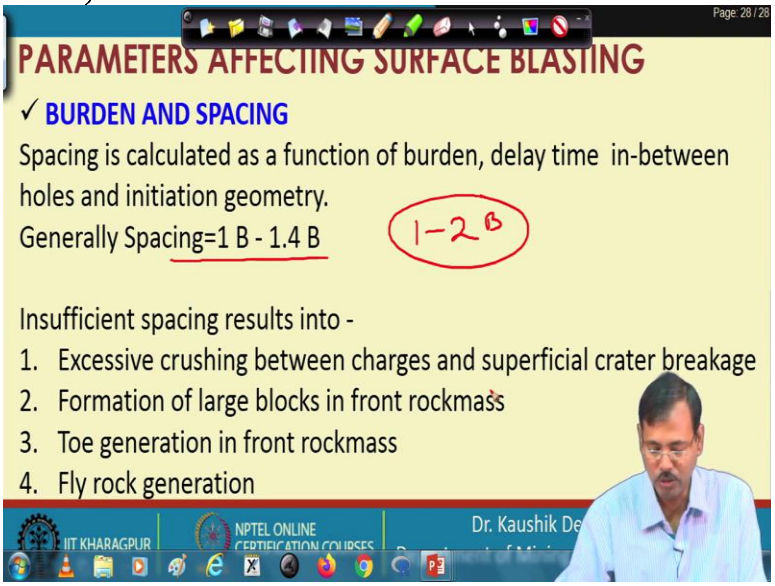

Similarly, this is the criteria for general; we go for spacing; sometimes, we may go for 1 to 2 times the burden. Also, we can go for spacing. Excessive spacing may result in crossing between the charges superficial crater breakage. So, all these other problems may arise if the spacing is not chosen correctly. So, this is the difference we have seen; this is how the different parameters affect the design of a blast. So, let us end this lecture at this position; thank you.