Drilling and Blasting Technology
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Lecture – 29
Surface blasting-2

Let me welcome you to the lecture number 29 in the Drilling and Blasting Technology course. In this lecture, we will continue Techniques of Surface Blasting from our previous lecture, where we are discussing the how the different parameters are influencing the blastings. The role of different parameters are already discussed there.

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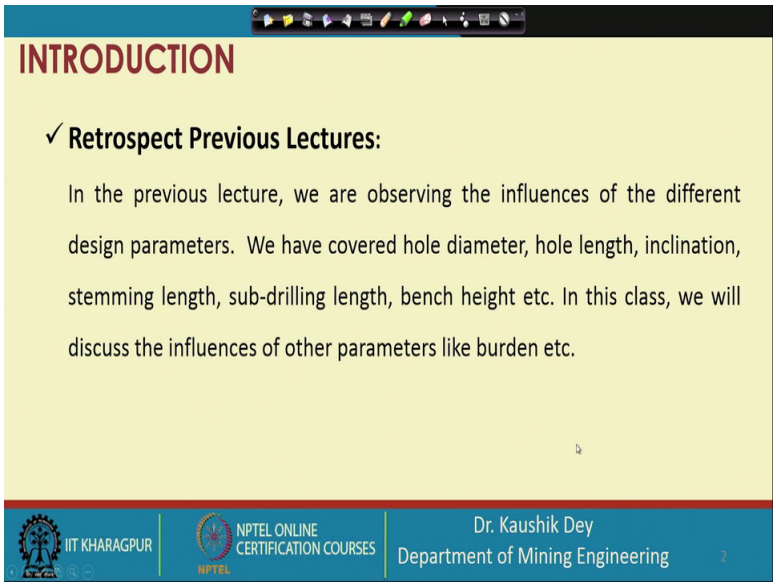

Let us see what we have covered in the previous lecture. Previous lecture, we are observing the influences of different design parameters. We have covered up to hole diameter, hole length, hole inclination, stemming length, sub-drilling length, bench height etcetera. In this class, we will discuss the influence of other parameters like burden etcetera.

And last class also we have discussed what are the objectives of blasting and it must be recalled that while a person is carrying out a blast design for the surface cases, he must keep in the mind that, what is his objectives and how your he is going to address that objective or achieve that objective. So, that is essentially required objective is essentially required before designing the surface blasting.

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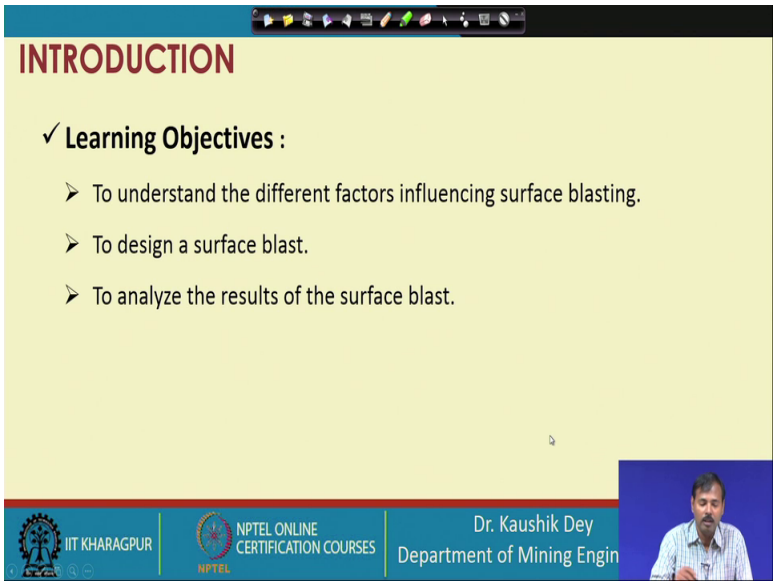

So, our learning objective remains same. We will try to understand the different factors which are influencing the surface blasting. We will try to design a surface blast and we will try to analyze the result of the surface blast which are coming out from the blasting.

So, these are the essential objectives.

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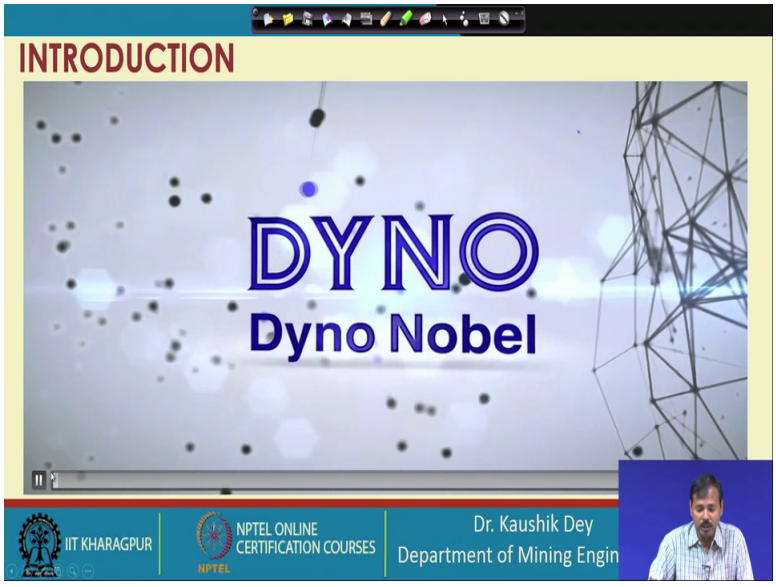

So, as we carry out in every lecture, observing a video from YouTube.

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So, this video is of Nitro Noble available in the YouTube also, where you can see how the blasting is being carried out; say large surface blastings are shown in a very slow time space.

So, this is basically rewinding; after the blasting the video is being rewinded here. So, you can see this is the bench phase; these are the holes and now the initiation is given, you have seen how the shock waves website are travelled in all the part. There are fragmentation is carried out and it is shown; you can see the after the fragmentation, the gas pressure is throwing the material.

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So, this is absolutely considered to be a very good blast because there is no stemming ejection. Stemming is completely successfully carried out; only the throw of the material is carried out in the front direction; only the throw of the material is carried out in the front direction.

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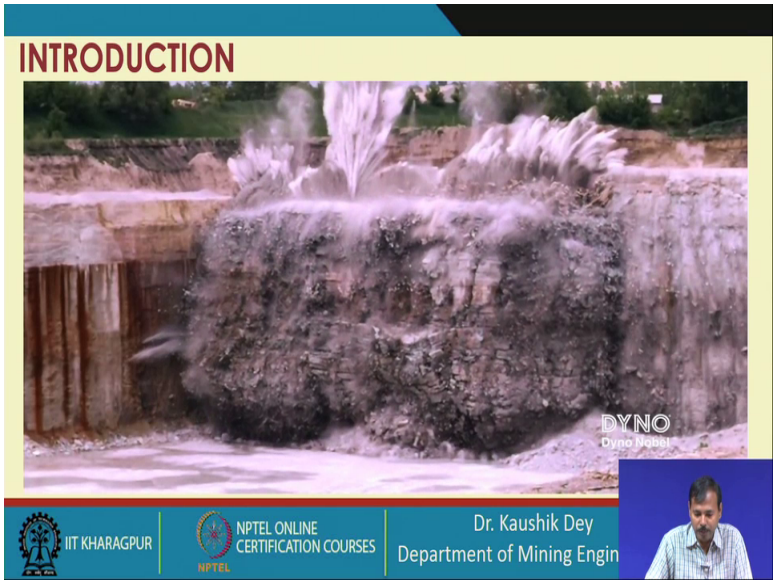

Here, also you can see little bit in few holes, stemmings are ejected; but mostly, we can see how the explosive a fragmentation is carried out. Then the fragmented rock is being thrown using the explosive gas pressure.

So, you can see the rocks are moved in the forward direction because of the this is also very very perfect blasting, we can consider; where there is no stemming ejection at all. The complete rock mass is fragmented using the shock wave, then the gas pressure is showing the material in the front direction.

So, absolutely beautiful blast was this one. So, in this case, you can find out this is basically simultaneously 2 2 benches which are being blasted in that one.

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This is you can see this is a say bench; wrong bench is carried out is blasted out using the explosives.

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And you can see the delay of those different holes on which those are blasted, those are also easily observed. Because this is this video is taken in a high speed camera and it is now showing you at a lower speed. So, that is why the movement of the shocks etcetera can easily be visible through our naked eye.

So, observing this video will clear your doubts very easily. So, that is why it is my strong desireness that you must observe this video. In the earlier video, we have seen the flames can be observed. So, that is the indication that the stemming ejection is carried out and that is why the flame is coming out from the hole. So, that is basically a result of poor blasting- this white smoke is coming out from the detonating fuse.

So, all if you are observing this video, the you can understand how the blast is being progressed and that can be easily accessed by the observer. This is also a poor blasting carried out where the front row was not moved properly.

So, that is why I always ask my student to see the videos which are available in the YouTube for your better knowledge for clearing your doubts. So, this is the very beautiful different blasting video compilation given by nitro noble observed in the YouTube.

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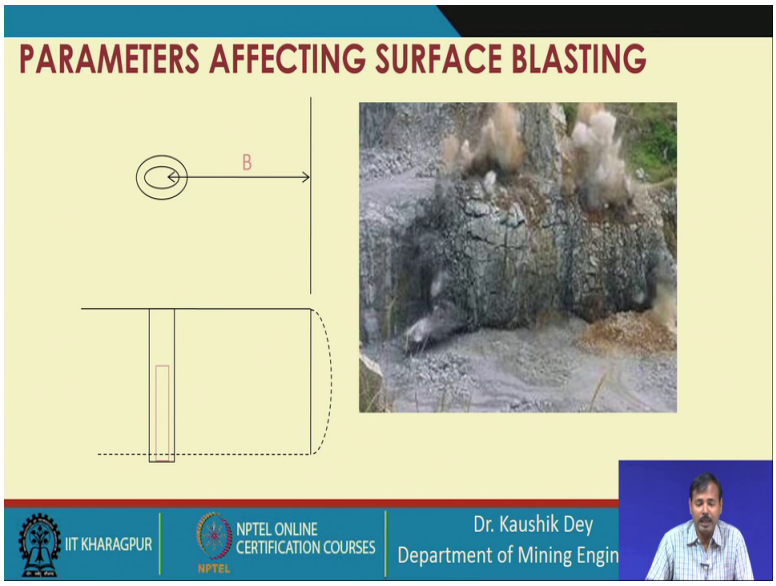

So, we are discussing about the parameters affecting surface blasting and we have we are now in a position, where you can we are now in a position where we can discuss.

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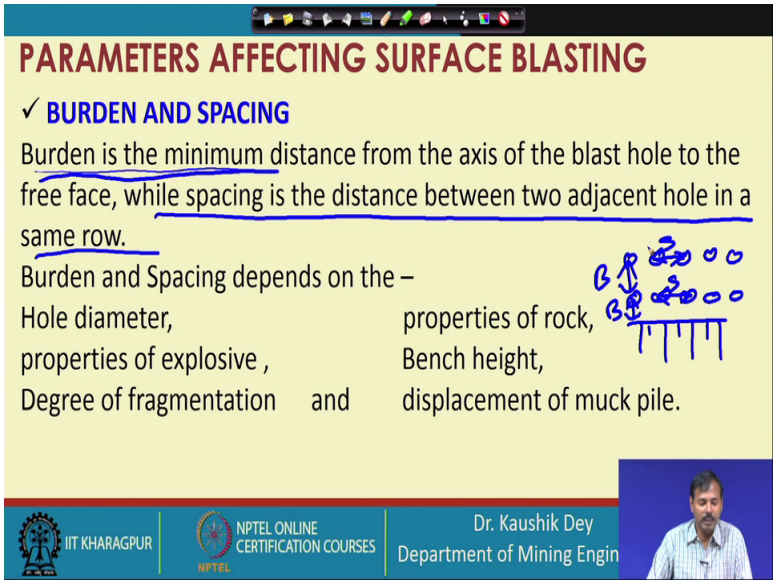

So, we are now discussing the Affect of Burden and Spacing on the surface blasting. So, burden is the minimum distance from the axis of the blast hole to the free face as shown in the previous picture. While, spacing is the distance between two adjacent holes in the same row.

So, suppose this is the free face. This is the free face. There is a first row of holes. This is the second row of holes. Then, this is the distance which is considered as the burden. This is the distance which is considered as the burden and these are the distances which are considered as the spacing. So, burden and spacing are 2 very very important parameters in the blast design and this burden and spacing basically depends on the Hole diameter, properties of explosive, Degree of fragmentation, properties of rock, Bench height and displacement requirement of the muck pile.

When we are discussing about the explosive rock interaction, we have already discussed how the rock property and the explosive property are influencing the determining the burden, the moment someone is arriving at a decision; the moment someone is arriving at a decision that the burden distance is excessive.

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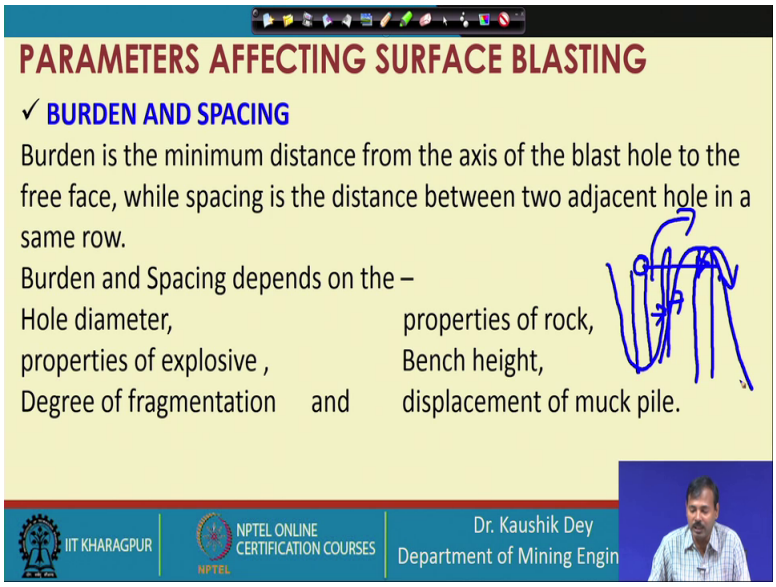

Then, what will happen? The tensile slabbing will not be completed prior to gas pressure is venturing into the cracked zone and trying to throw the tensile slab zone.

So, what will happen? This portion of rock will going towards upward direction and tensile slabbing will not be completed before hand. So, this portion of rock will not be thrown in the front direction. So, there will be remaining rock portion at this position which is unfragmented or poorly fragmented. So, excessive burden is unwanted. Similarly, smaller burden is also unwanted because that will result into the larger throw of the material.

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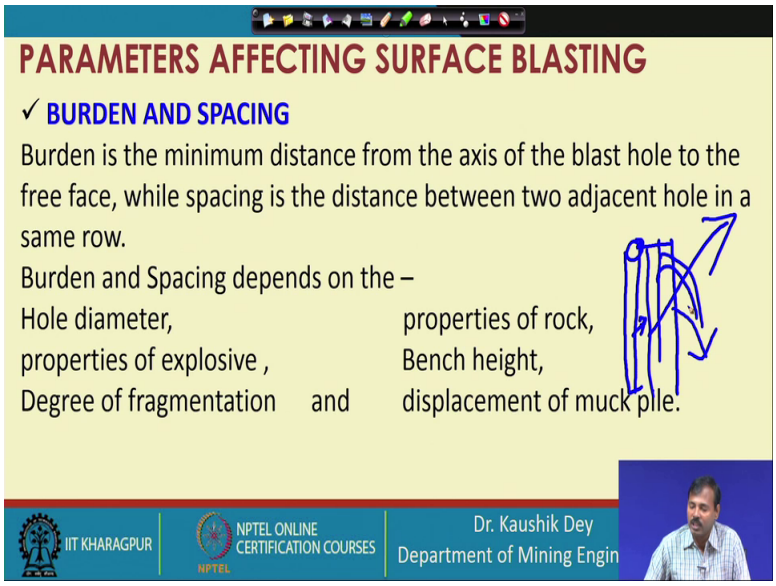

So, what will happen in the smaller burden? If the burden is small, then the tensile slabbing will be completed ahead of the gas pressure coming up to this and trying to throw the rock. As the tensile slabbing is complete though, then the toppling of the fragmented material will start before the gas pressure is trying to throw the rock in the front direction.

So, when the gas pressure is at this position, it will find the rock cover in front of the gas pressure is very limited. So, the gas pressure will throw that rock into the longer distance towards the as a fly rock. So, that is why the fly rock potential the potential potentiality of the fly rock will be more in case of the smaller burden and that is why the optimum burden is essentially required.

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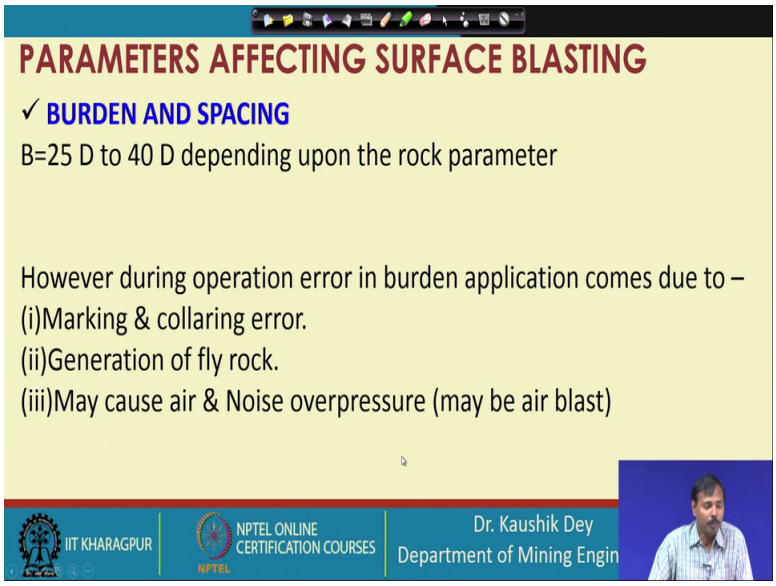

Now, burden can be accessed like this. It should be varying between 25 D to 40 D. This is are also thumb rule based on the practical experience, experience carried out in the field. People have come out with a decision that burden should vary between 25 D to 40 D, but what will be the exact value that can be decided based on the trail blasting only.

So, depending upon the rock parameter, if thumb rule is saying burden is varying between this two. However, during operation error, burden maybe little bit different from the designed burden; where, the marking or collaring error may be carried out, while the supervisor is given the error to the drill machine operator for carrying out the drilling that may be different one. Generation of fly rock that will be resulted from that and poor burden may cause air and noise overpressure also.

So, these are basically the consequences of different poor burden on the blasting results.

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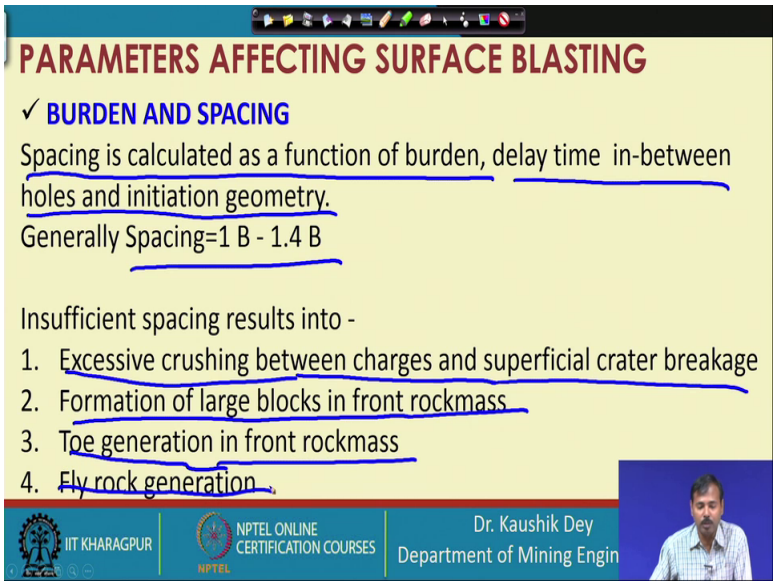

Similarly, the Spacing is also calculated as a function of burden and it is affected by the delay time in between the holes and the initiation geometry. So, as a again rule of thumb, we can consider the spacing may vary between 1 burden to 1.4 burden and insufficient spacing, may result into the - Excessive crushing between the charges and superficial crater breakage. Formation of large blocks in front of the rock mass; Toe generation in front of rock mass and generation of Fly rocks because of the improper movement of the rock between the 2 holes. So, these are the different consequences of insufficient spacing if that is designed in the practical field.

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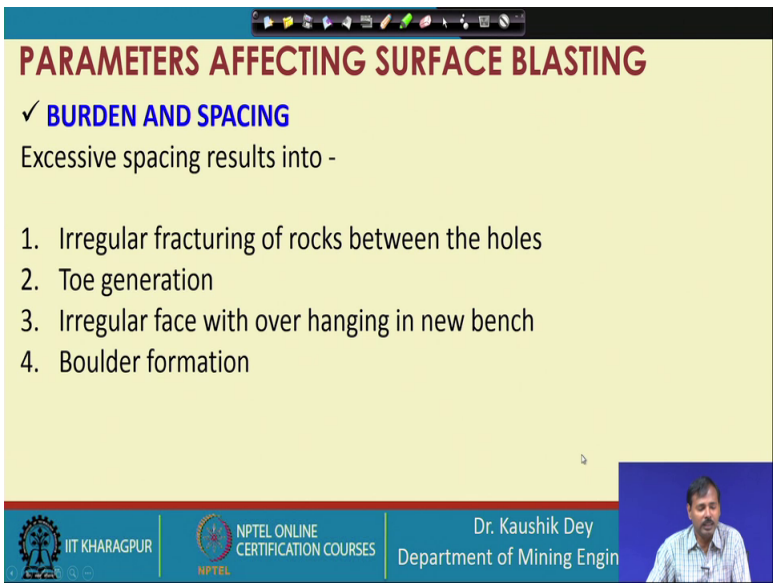

So, excessive spacing result into Irregular fracturing, Toe generation, Irregular face with over hanging in new bench and Boulder formation. So, these are the results of excessive spacing if we are poorly design it.

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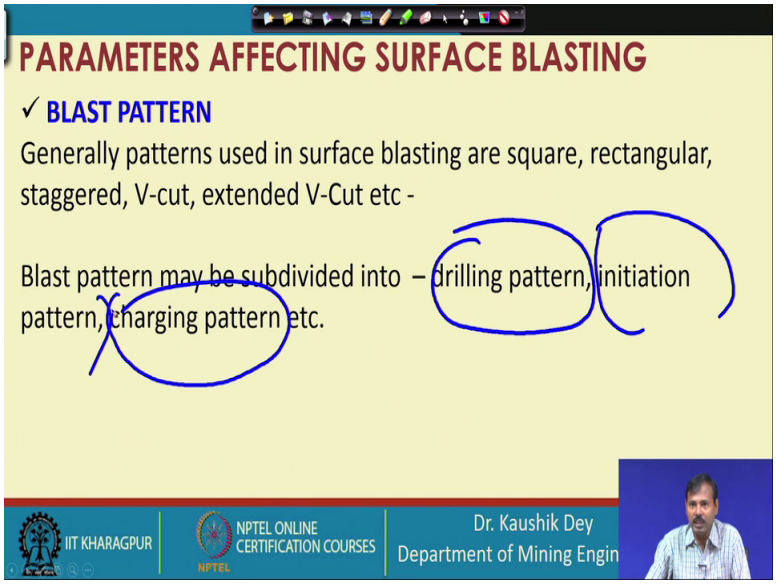

Now, blast pattern is very very important after the decision of the burden and spacing which is carried out. Blast pattern, it normally when you will see you will find out people are telling it like that it is square; it is rectangular; it is staggered; it is V-cut; it is extended V-cut; it is echelon. But basically I believe that it can be carried out in 3 part; one is the drilling, drilling pattern. Second one is the initiation pattern and third one is the charging pattern.

Now, drilling pattern basically gives us the option of special distributing explosive inside the rock mass by providing that drilling places differently. So, let us see how these are different to each other.

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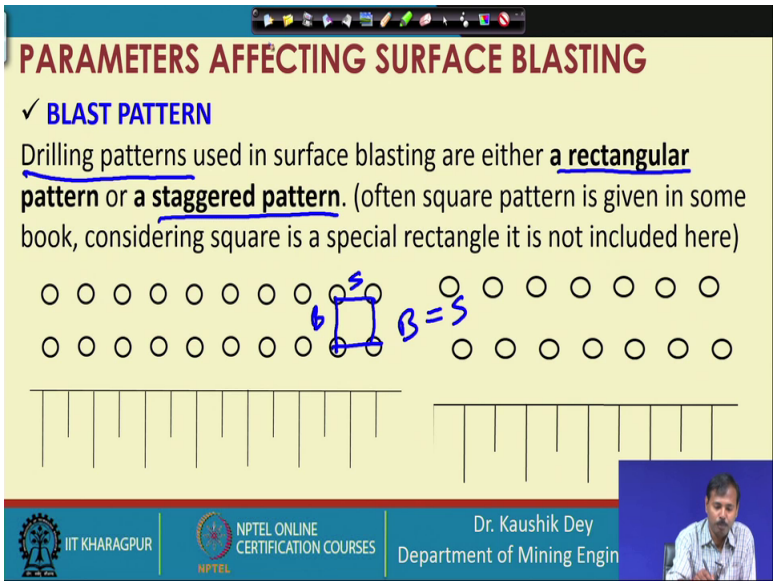

So, this is the drilling pattern, variations in the drilling pattern used in surface mine. I classify it in 2 part; one is rectangular and other is staggered. In some book, you will find out another pattern is described they are square pattern. Square pattern means where burden is equal to spacing. So, as the burden is equal to spacing, this is the burden and this is the spacing; as the burden is equal to spacing as B is equal to S. So, it is forming a square.

But my argument is little bit different. I consider square is a special type of rectangle, where the 2 sides are same. So, that is why I consider square is also a rectangular type of pattern.

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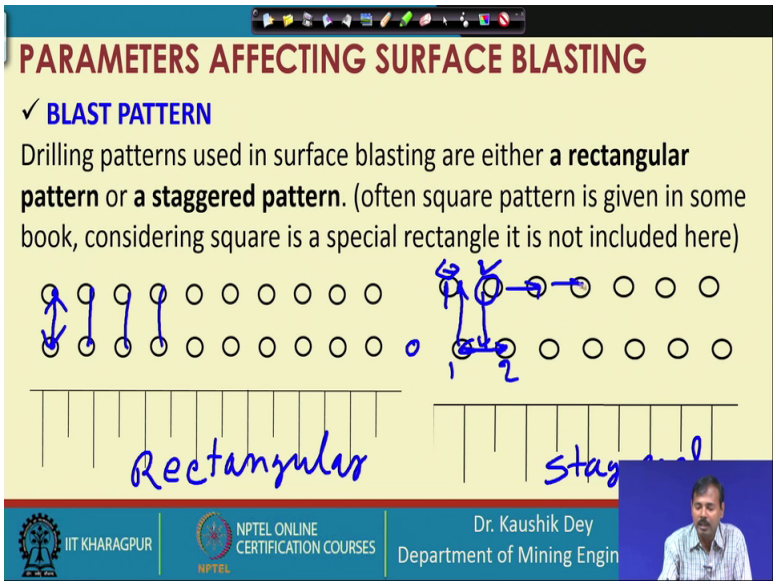

And that is why I classified it in 2 way; one is the rectangular pattern, one is the rectangular pattern and another one is the staggered pattern.

Now, in rectangular pattern, we provide the second rows of hole directly behind the first rows of hole. So, this is the position of the first hole in the first row, the second first hole in the second row is just placed behind the first hole of the first row; similarly for the second hole; similarly for the third hole; similarly for the fourth hole. So, like that ways the consecutive rows holes are placed directly behind the previous rows of previous rows of holes. So, that is why it is form a rectangular type. This type of drilling is called drilling pattern is called rectangular drilling pattern.

Unlikely in staggered pattern, the next rows of holes are placed in between to first row; in between to first row holes. So, this is basically staggering of the holes in the second row is carried out. So, if this is the first row of the first hole if this is the second row of the first hole or it may be the zeroth hole or there is no existing like that, in those cases the next first hole of the next row is placed not directly behind the hole; but at a little bit distances from that.

So, it is basically staggering up to this distance by this hole. So, the second hole of the second row is placed just below the between the first and second hole. So, like that way, staggering of the holes are carried out in this cases in this case. So, this is called staggered drilling pattern.

You will observe that in staggered drilling pattern, the explosives are placed in a different manner; that means, if you are considering the third rows of hole, you will find out the third row may be placed like this.

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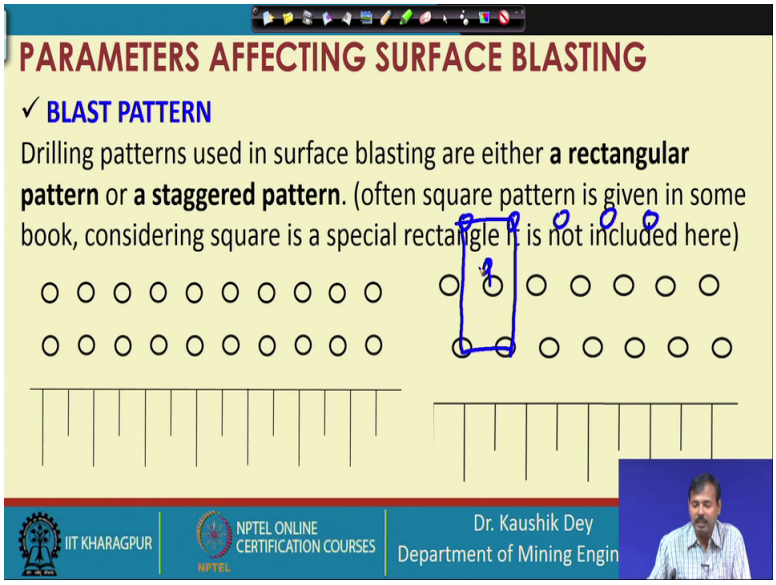

So, basically if you are considering this much of area, you are you will find there is a central location of hole which is basically giving the charge concentration centrally. So, the charge distribution may be better in case of staggered drilling pattern than the rectangular drilling pattern.

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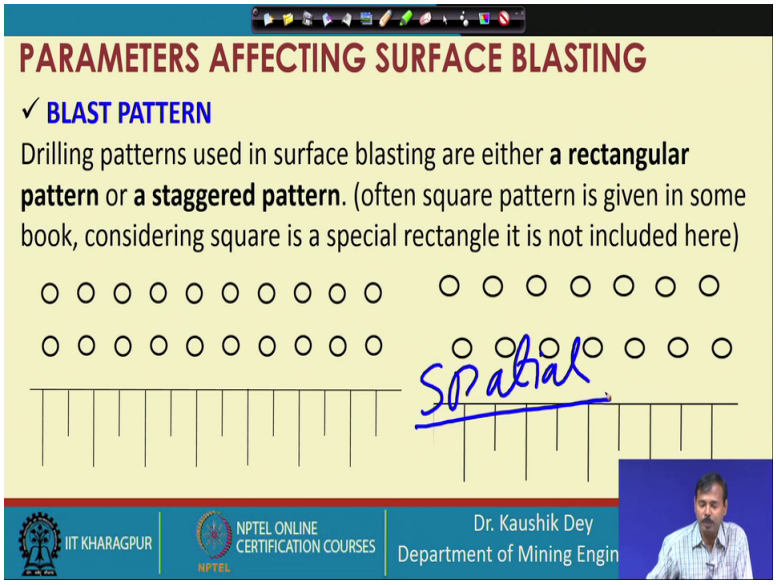

So, in other words, you can say the spatial distribution the spatial distribution, the spatial distribution the of explosive is better in case of staggered drilling pattern than the rectangular drilling pattern.

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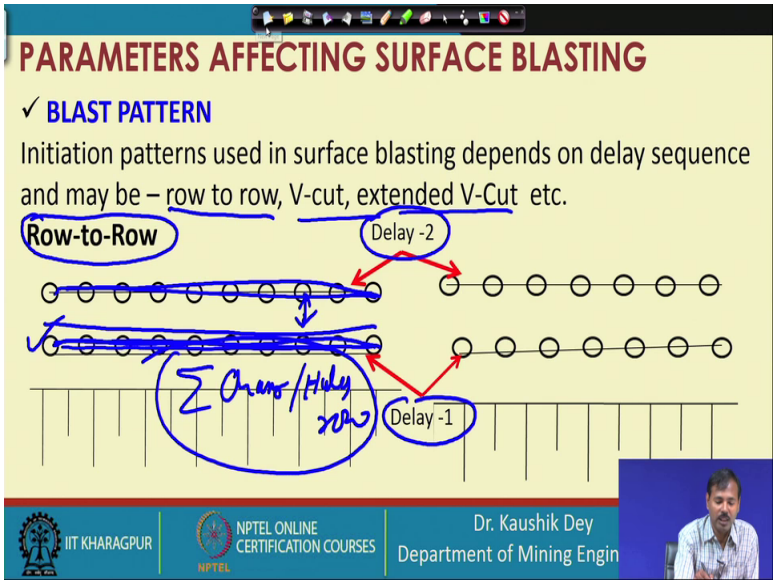

Now, next is that Initiation pattern. Initiation pattern basically gives the idea about how the delay sequences are provided into the holes. So, as different holes are given in different delays, the blasting times of the delays are different. The moment if you join those holes which are supposed to be blasted at same time or the simultaneous blasting is carried out on those holes. If you join those holes in a similar in a by an imaginary line imaginary line, you will find out that is forming some special shape. So, that shapes are described in this initiation pattern. So, initiation pattern is basically give some us idea about the initiation sequence of this holes.

So, this initiation pattern maybe the row to row, V-cut, extended V-cut. So, these are possible initiation pattern. So, let us first discussed about the row to row initiation pattern, where each rows of holes are blasted simultaneously. So, say at Delay number 1, this row 1 is being blasted. This is for rectangular; this is first staggered. So, in both the cases, the row 1, all the holes of row 1 is being blasted at 1 delay.

So, you can connect those holes with an imaginary line and showing those lines and that is called row to row. So, this is holes in a row this is holes in row. So, it is row to row blasting. So, this holes are blasted at Delay number 1; this holes are blasted at Delay

number 2 and as it is blasted Delay number 1, after this delay the new free face is generated here. So, that will act as the burden for the next delay.

So, row to row blasting is one kind of initiation pattern and row to row blasting is very very easy to monitor. It does not have any biasness; all the holes are unbiased; all the holes are being blasted independently. There is no dependency of the blasting of the holes to the other holes. The supervision of this is very easy and only the problem of this is that fragmentation is also easy; only the problem of this row to row initiation pattern is that the charge quantity blasted at one instant is very high because it is the summation of charge of all the holes in one row.

So, the total charge is being blasted at one instance is very very high which may create more vibration to the surrounding field. So, that is why row to row blasting though it is giving very good result, then also it is often not used if the blasting is carried out in a place where nearby inhabitancies are there.

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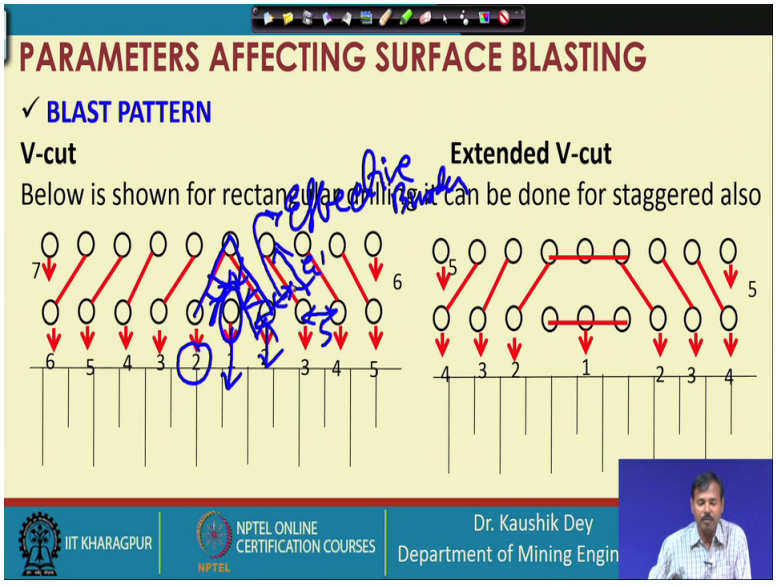

V-cut blast pattern is also another type of blast pattern, where you can see this is the Delay number 1; first hole is being blasted here as this hole is blasted.

The new free face generated here like this. So, the next row holes which are blasted at one instant at Delay number 2 is now acting in front of this free face; considering this is

as the free face and that is why the effective burden this will become the this distance will become the effective burden.

So, that this is the drill spacing. This is the effective spacing. This is spacing; this is effective spacing. This is the drilled burden this is the effective burden.

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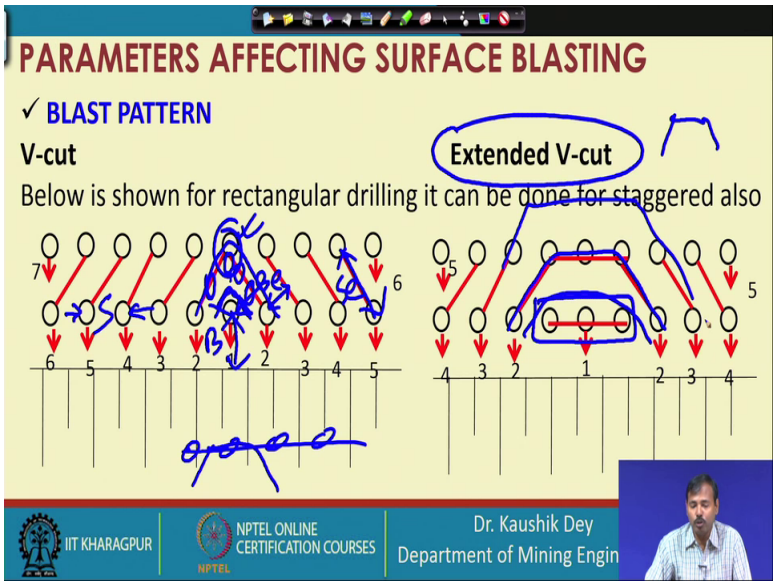

So, let us observe once more this is the effective burden; this is the drilled burden. B, this is B e. This is the drilled stemming and this is the effective stemming ok. So, the effective burden and effective stemmings are different for this blasting. Moreover, the moment it is blasted; this rows of this row of hole is blasted which is basically drilled in different row, but blasted in one at a time.

These rocks at this position will collide to each other and give a better fragmentation. So, V-cut blasting is carried out to have a better fragmentation due to the collision of the fragmented material. Because in this blasting the 2 arms of the B, the rock mass closed this to representing these 2 arms of the B are colliding with each other and giving the better fragmentation. However, the confinement of this hole, the confinement of this hole is very very high unlike to the row to row; row to row blasting all the holes are having equal confinement and almost holes are free in all the directions. So, almost holes are free the confinement is very very less.

But here, as it is closely bounded at this position the confinement of the hole is very high particularly to this. So, the charge confinement is high. So, the magnitude of ground vibration may be little bit of higher. However, the charge quantity at one instant is not that much significant. So, V-cut blasting is basically representing a larger confined charge blasting, but it gives better fragmentation. So, row to row blasting the confinement is less, but fragmentation is not that much; but in V-cut blasting confinement is high, but fragmentation is better. So, extended V-cut blasting is basically extended V-cut blasting is basically devised to compromise between in the row to row blasting and the V-cut blasting.

Here, what is done? A group of holes in the first row is blasted together to create a free face like this. Then, we try to go for a slanted free blasting where, instead of V we use this shape. So, this is the shape the row the slanted B is blasted. So, it is not chopped B is blasted.

So, the holes of this are blasted this is called extended V, where the V's arms are extended and joined by a line are blasted, then the similar thing is carried out it may be extended like this also for the next row. So, this extended V-cut is practiced. So, extended V-cut is the most popular cut practiced in the mining as it is giving us the benefit of row to row blasting as well as the benefit of the V-cut blasting also.

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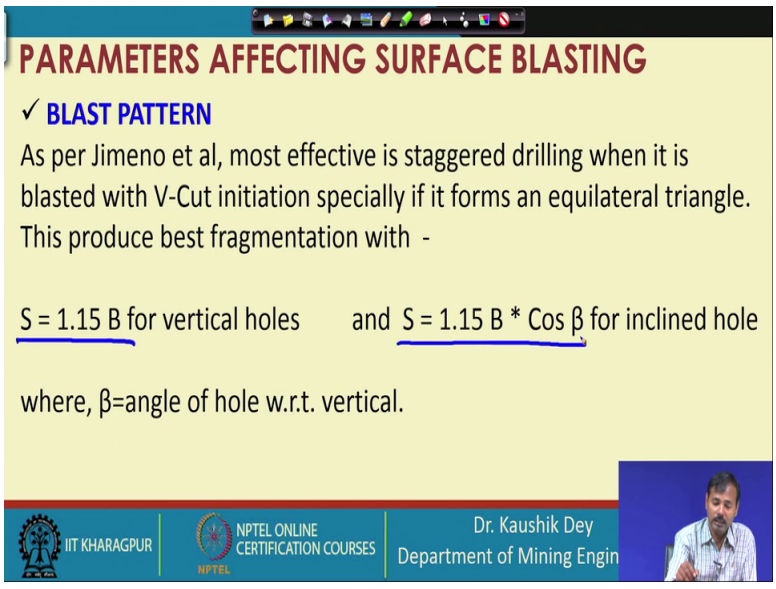

So, as per Jimeno, most effective blasting is the staggered drilling with a V-cut initiation pattern and in those cases if it is formed an equilateral triangle by shape, the spacing can be considered the spacing can be considered as 1.15 burden for vertical holes and 1.15 burden into cos beta; where beta is the inclination with respect to the vertical for the inclined hole. But again these are the thumb rules rule of thumbs. So, if this actual acceptance of this depends on the trial result observed in the trial blasts.

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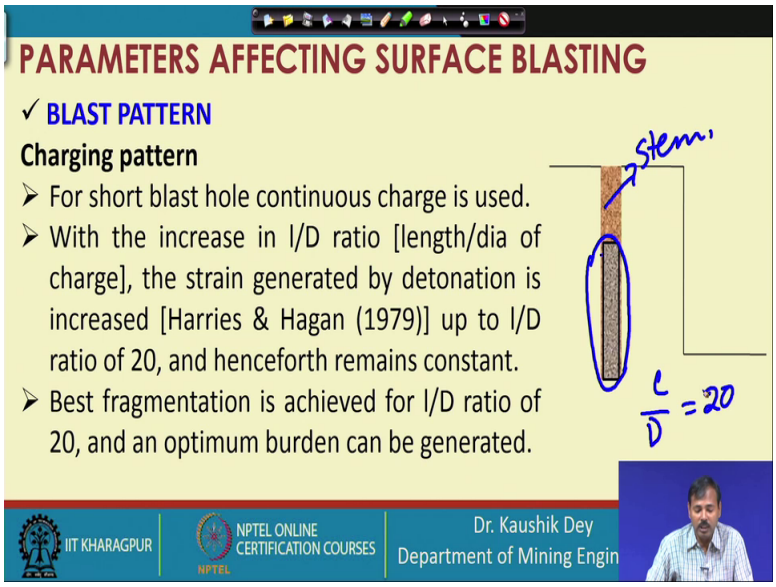

Next is the charging pattern; say it is very easy for us to understand. Generally, mostly we consider of a continuous charge column, where the explosive charges is placed like this. Explosive charge is placed like this, above this is stemming. So, this continuous charge is used with the increased l by D ratio that it has been observed with the increase in the l by D ratio that is the length and diameter ratio of the charge; the strain generation by detonation is increased initially up to the l by D ratio is 20. So, up to the l by D ratio, the strain is generated from the detonation of explosive is increased and after that it remained constant.

So, mostly it is considered that the l by D ratio should be 20 for the charging the hole. So, that is why the charging for charging this explosive column it is better to have the length of the explosive column is equal to the 20, above that the benefits are not that much significant.

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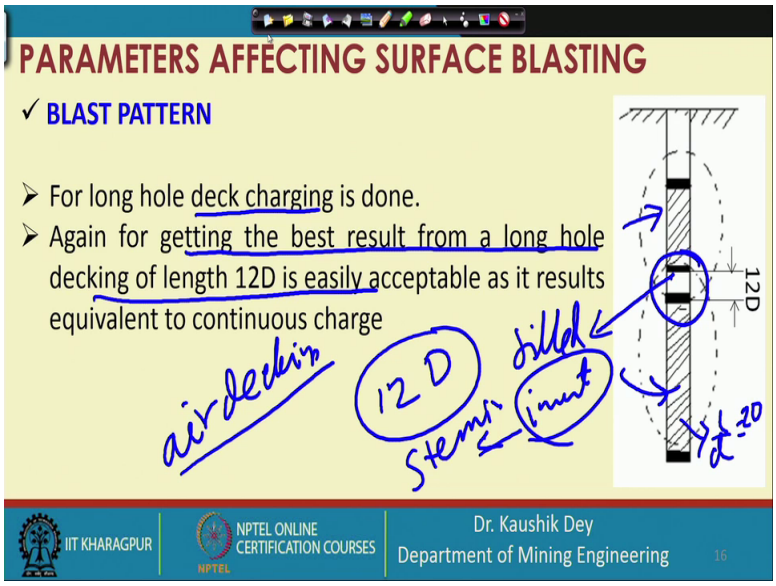

So, in charging pattern we can have our modification on that. For a very long bench height instead of having l by D ratio more than twenty we may reduce some explosive consumption by providing a gap in between.

So, this gap may be provided in between two explosive charge columns which are of l by D ratio of l by D ratio of 20 and we can provide a gap between this without costing this explosive, this has give us the benefit of having the same result. And it has been observed this gap, this gap maybe up to 12D distance maybe up to 12D distance. So, for a long hole, this phenomena is called deck charging.

We can go for deck charging, this phenomena is called deck charging. We can carry out for long hole where l by D ratio by continuous charging l by D ratio may increase more than 0. So, in those cases we can go for deck charging and the best result will be obtained, if the deck charging length is equal to the 12D.

So, this deck charging which is basically filled with the inert material, filled with inert material that is similar to our stemming material that can be carried out. The modern concept it has been found instead of using the inert material here, we can go for air decking. This air decking will give us additional source of oxygen which gives us the better burning of the explosive chemicals. So, that is why air decking is also another phenomena not only that air providing air also gives us the reflection of the shockwave. So, that is also properly utilized in this case.

So, basically decking is carried out for a long blast hole to reduce some explosive consumption.

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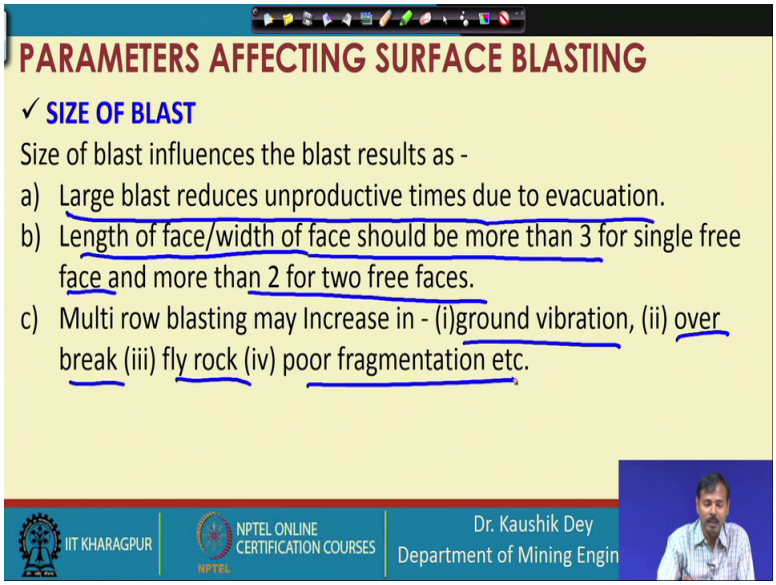

Next is size of the blast. Size of the blast basically dictates with the number of rows, number of holes per row and large blast reduces the unproductive time due to the evacuation which has to be carried out during the blasting. The length of face by width of the face should be more than 3 for a single free face and should be more than 2 for two free faces. Multi row blasting may increase in the ground vibration because of the improper burden movement, over break, fly rock, poor fragmentations.

So, more number of rows say 20 - 30 rows of blasting may not be desired, but few rows maybe give carried out which can gives us a better result and our volume of volume of excavation per blast round may increase.

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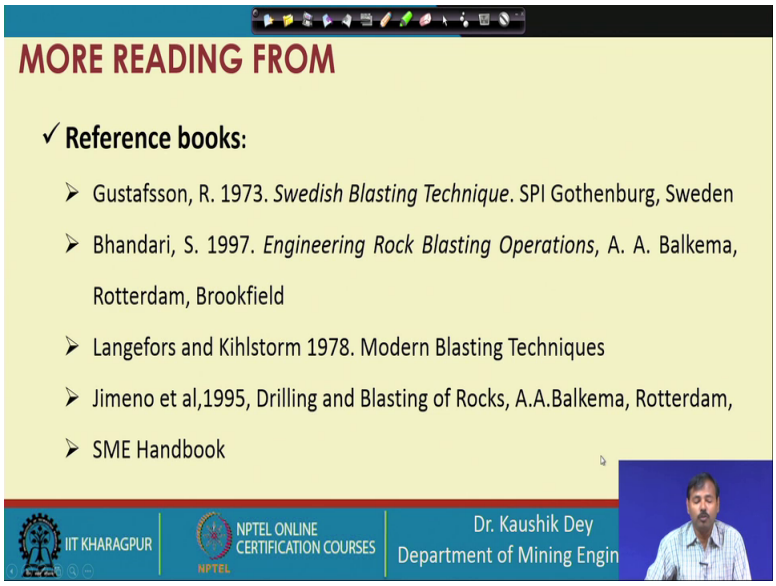

I request you to have a more reading from these reference books. Already discussed to you, the blast design; how it can be carried out will be discussed in the next class. So, the surface blasting techniques of surface blasting, we will continue in the next class also, but before that you must go through the different other parameters which are influencing the blasting surface blasting from these books.

Thank you.