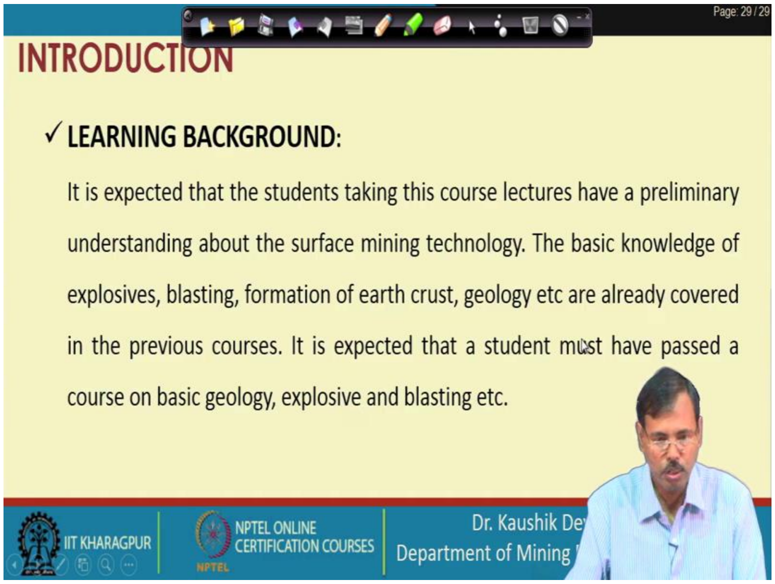
Surface Mining Technology
Professor. Kaushik Dey
Department of Mining Engineering
Indian Institute of Technology Kharagpur
Lecture 16
Technology for Surface Blasting - II

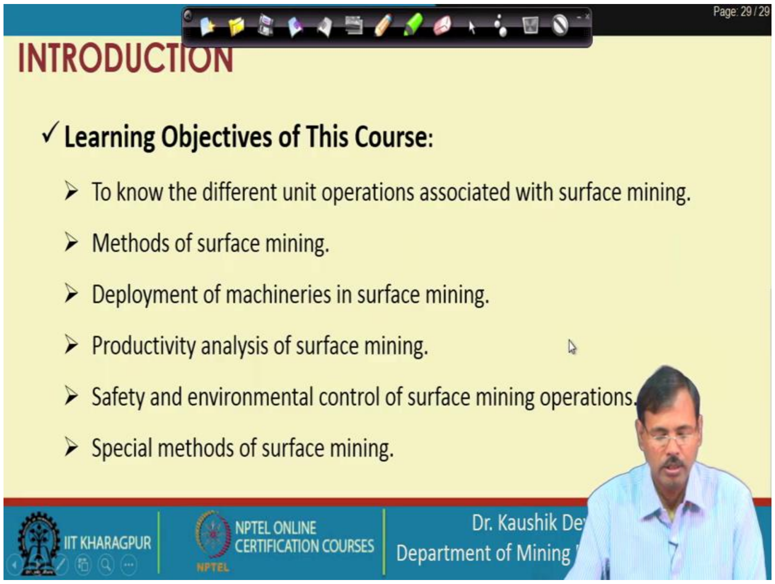
Let us welcome you to the 16th lecture on Surface Mining Technology. This is the second lecture on Technology for Surface Blasting. There will be six lectures in the technology for surface blasting series, the second lecture there.

(Refer Slide Time: 00:31)



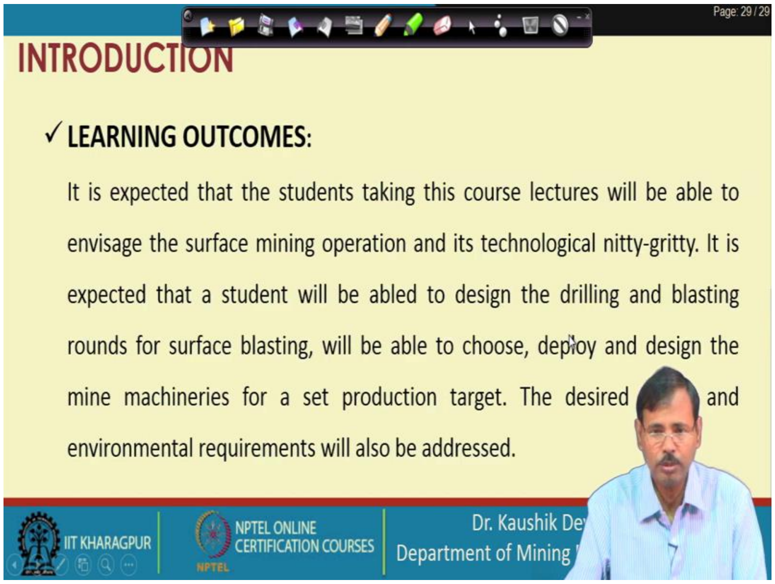
As usual, let us look once what is the learning background for the surface mining technology course that is required.

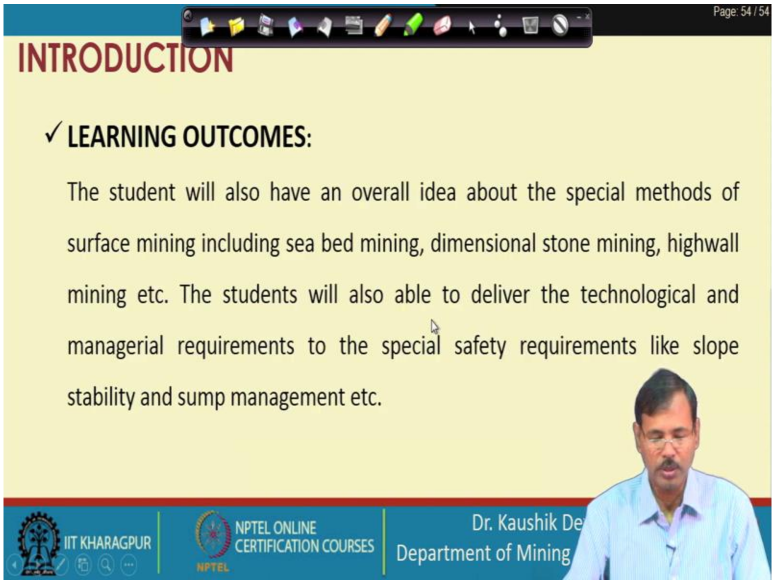
(Refer Slide Time: 00:43)



And surface mining technology course is designed with these objectives.

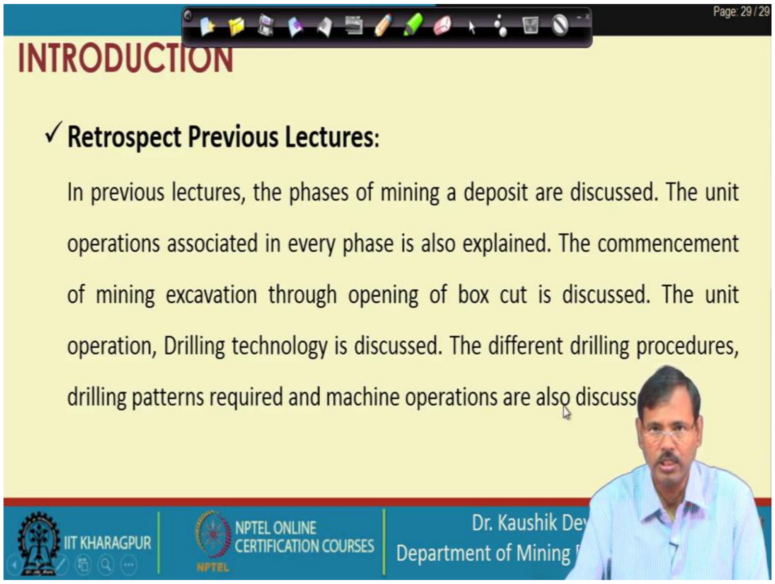
(Refer Slide Time: 00:48)





And it is expected this is this will be the learning outcome for a participant in the surface mining technological course.

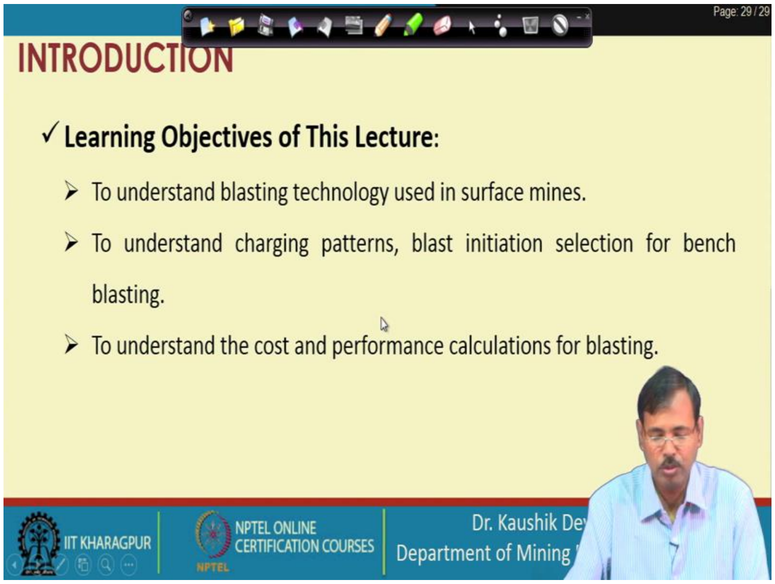
(Refer Slide Time: 00:56)



And let us retrospect the previous lectures. In general, you have seen that we have already covered the introduction to mining, surface mining. We have already covered the phases of surface mining operations. We have already covered the opening of surface mining using box cut. We have covered the drilling technology, possible for surface mining. So, these parts are covered as well as we have covered the stripping ratio all these things.

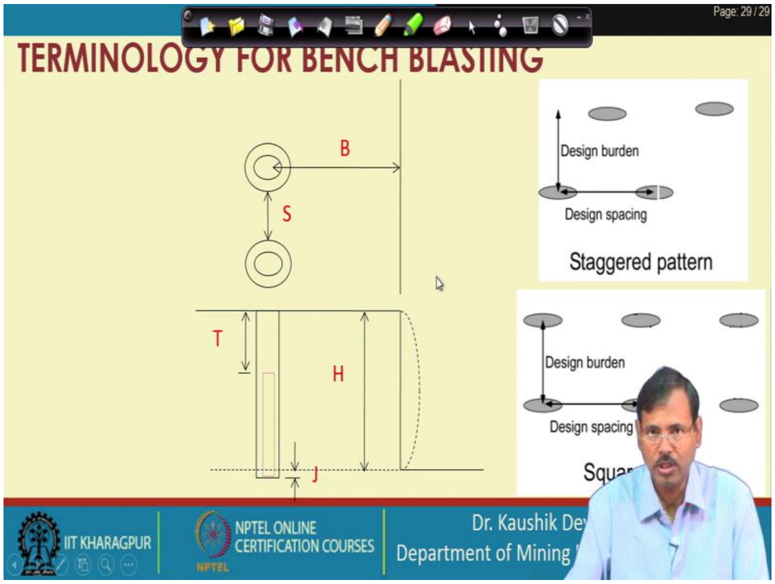
We have started our technology for surface blasting. In the last class, we have completed one course on that. As I also advise you, you once again look back on the drilling and blasting technology course already given in the NPTEL related to the blasting, drilling, and blasting technology. A part of the surface blasting is also covered there. We will cover a little bit in this place also.

(Refer Slide Time: 01:55)



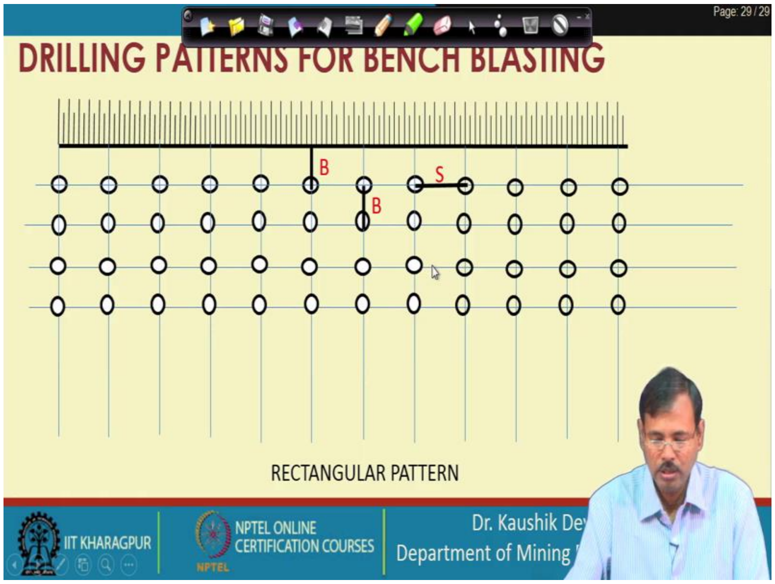
So, in the last class, we covered some of the influencing parameters. These are the learning objectives of this lecture of technology for surface blasting. This is to understand the blasting technology, understand the charging pattern, initiation selection, bench blasting, and understand the cost and performance calculations. So, this is the objective of these lectures.

(Refer Slide Time: 02:20)



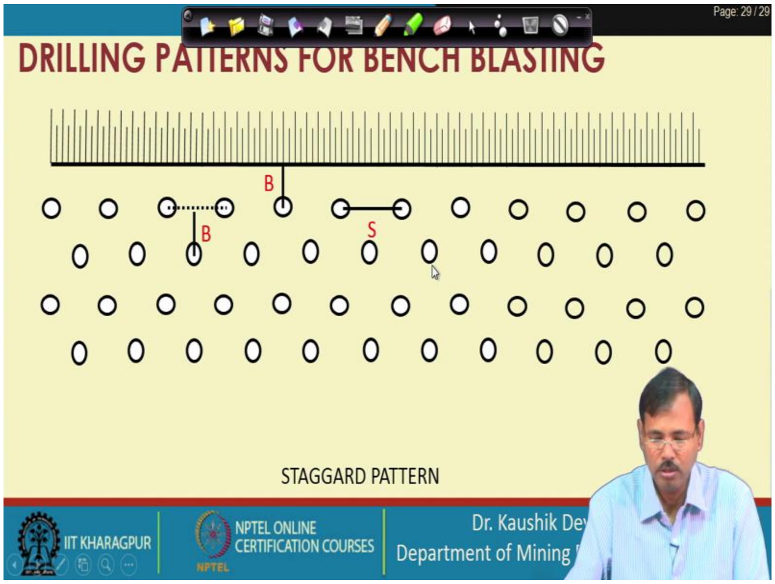
This is the terminology we have covered already in the last class. We have seen how the burden spacing, bench height, stemming, and sub-drilling are affecting the performance of a blast. If the excessive burden is chosen, then what will be the consequences? These are discussed in the previous lecture.

(Refer Slide Time: 02:42)



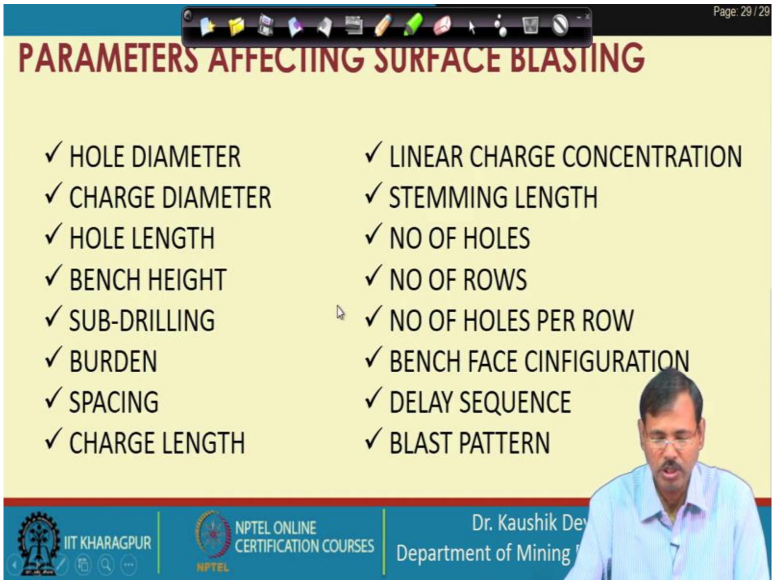
And this is the rectangular pattern we have discussed.

(Refer Slide Time: 02:49)



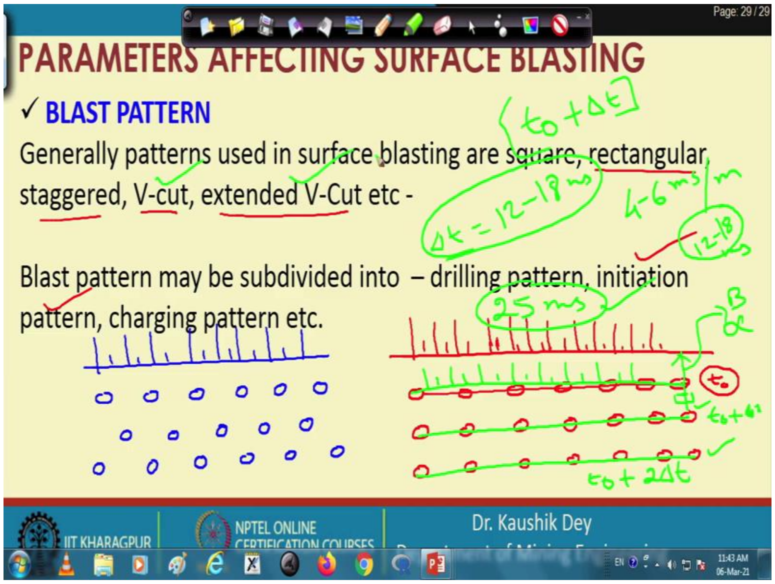
This is the staggered pattern we have also discussed in the last class.

(Refer Slide Time: 02:51)



And these are the parameters we are discussing in the last class. We will continue with the next parameters at this position.

(Refer Slide Time: 02:58)



So, next is the important parameter is the blasting pattern. We have seen the drilling pattern, which is a rectangular pattern. Similarly, we can have some blasting patterns with the same drilling pattern as possible.

Say, suppose this is our free face, and this is the plan view we are drawing; this is the first row of holes. And we can, if we are going for the rectangular pattern, we can have the second row of the holes behind this and if it is a staggered pattern. Now we can have different types of blasting patterns in this case, either this rectangular square, these are drilling pattern and v-cut, extended v-cut these are the blasting pattern. This is occurred because of the changes in the initiation pattern.

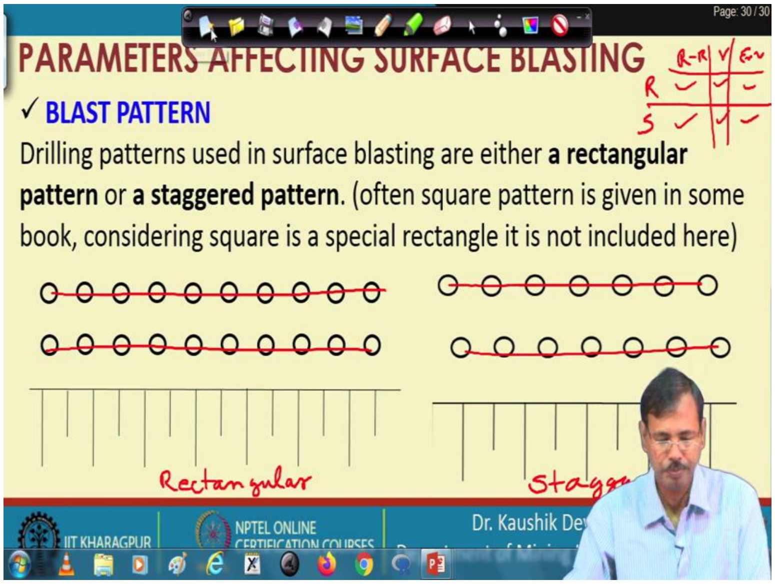
So, if what we are doing, we are say suppose carrying out blasting all these holes at one time, then we have to blast it, say at time t, we are t 0 we are blasting it. So, all the holes of a row are blasted at a time t is equal to 0. But you must carry out blasting of this one ahead of this one. Otherwise, what will happen? If you are trying to blast this one ahead of this one, it will act with the burden of this much distance. So, this will generate an excessive burden, and you can see in this case, this burden distance is almost close to infinity because that is too high.

So, the proper blasting will not occur in this case. So, it is essentially required that this, up to this portion, blasting must be carried out prior to blasting this one so that a new free face is expected at this position. So, it must be blasted at a time t is equal to 0 plus delta t. Let me write it once again t0 plus delta t. So, this is the time expected for blasting of this one, and in that case, this has to be blasted at t0 plus 2 delta t. So, the time of blasting or initiating this explosive must be after the completion of this one.

So, what time will be given depends on the speed of the burden movement. So, in general, we found that the burden movement speed is 4 to 6 milliseconds per meter. So, if you have the burden value of 3 meters, then at least a 12 to 18 millisecond time gap must be given between these two. So, delta t in that case, so delta t should be between 12 to 18 milliseconds. So, if you consider this, generally, we have commercial delay schedules available with a multiplication of 25 milliseconds. So, those are actually used for providing a delay between this one and this one.

So, basically, by using this delay system called detonating relay or the Nonel, all these are available to provide these delays. We go for a different initiation system called a row to row initiation system. There may be another initiation system we will discuss in this class: v-cut, extended v-cut, and they will also discuss their merits and demerits.

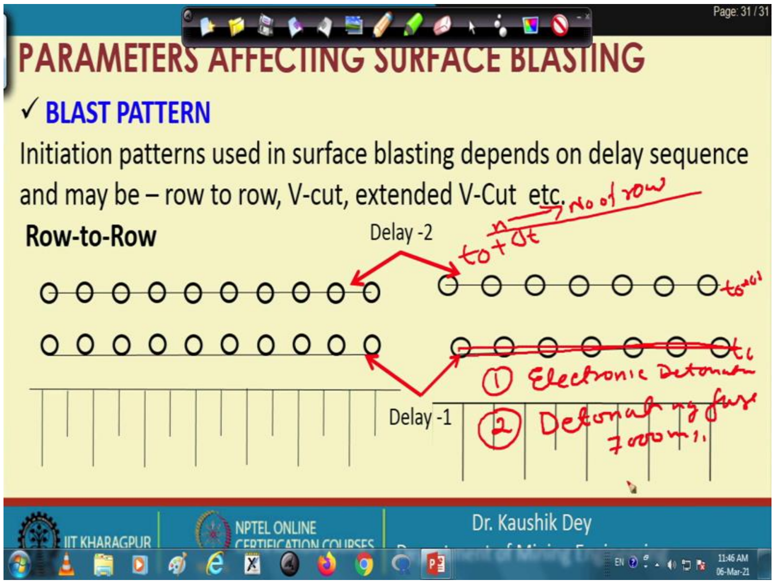
(Refer Slide Time: 08:43)

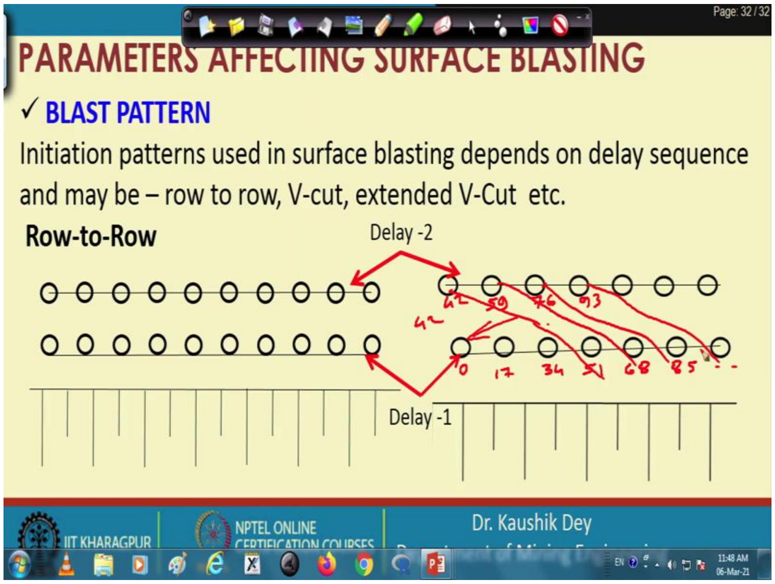


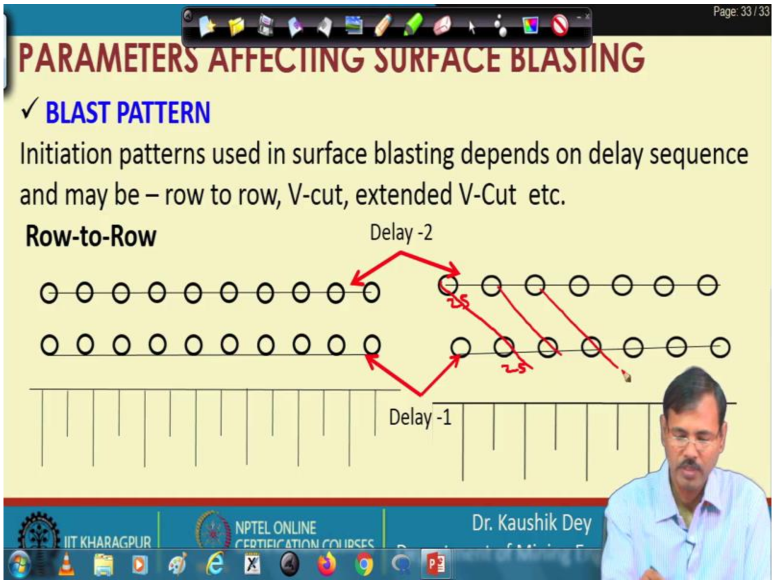
So, we have already seen two options: a rectangular pattern and a staggered pattern. These are the drilling properties, and these drilling patterns are available as all the blasting patterns, which means the initiation sequence is also possible with this. We have seen that this is the rectangular pattern, which is staggered. So, this rectangular and staggered, you can see you have a row to row blasting here; you have a row to row blasting here. So, this is possible.

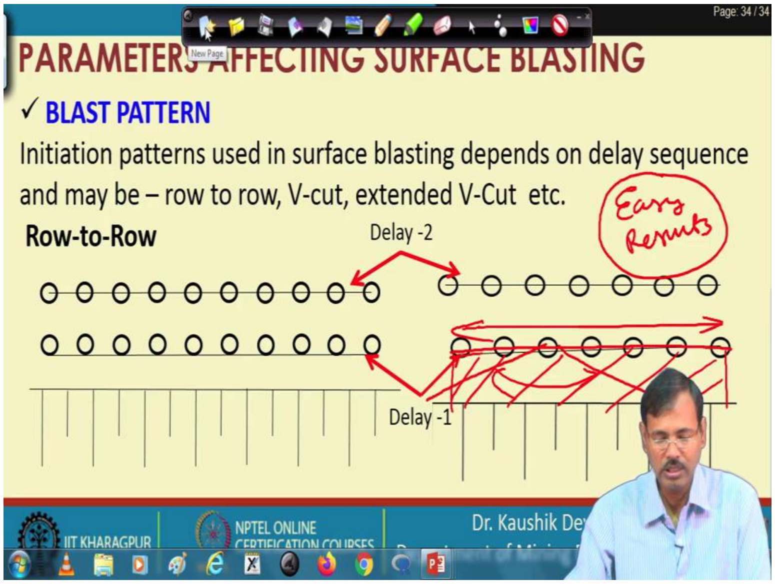
So, the drilling pattern does not have any relationship with the initiation pattern or blasting pattern. All the drilling patterns means rectangular and staggered, and the blasting patterns row to row, v-cut, extended v-cut, so all these are possible with both the rectangular and staggered pattern system.

(Refer Slide Time: 10:07)









So, the first one is the row to row blasting. Row to row blasting, you can see that all the holes are blasted at t0 plus delta t, t0 plus delta t. So, this is n delta t, and the number of n is the number of rows. But the problem is how you can initiate all the holes at one time. There are two options for this. The first option is that either you need to go for an electronic detonator, in which we will program all the holes at one time, or you can connect all the holes with detonating fuse; detonating fuse is a very high VOD, and that means you can consider all the holes are almost blasted simultaneously. So, that is the consideration.

So, if you are connecting the holes with the detonating fuse, you can expect to have a row to row delay in this, simultaneous blasting of all the holes at a time. In another case also, you can achieve a row to row blasting using a Nonel you can have, but it will not precisely at the same way you can see, but this is in a different way you have to carry out. Suppose you are using a No and say you are using the Nonel of 17-millisecond row to row, hole to hole, and 42 milliseconds, say row to row.

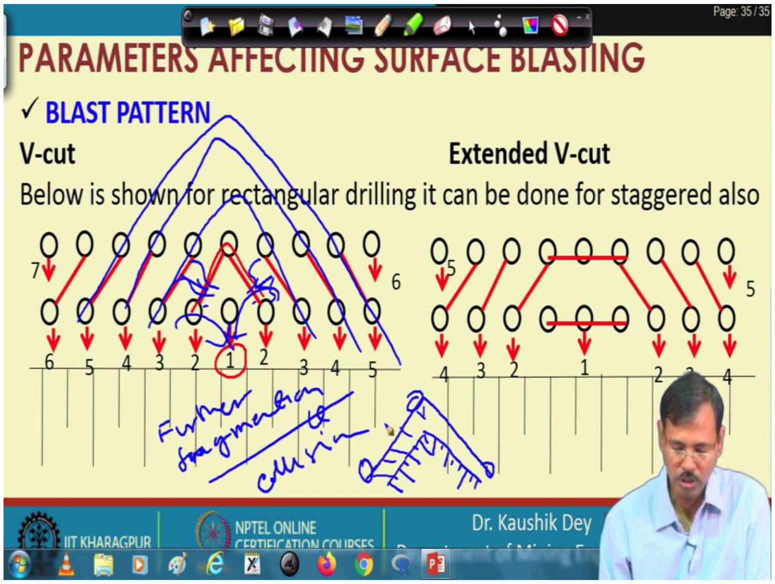
So, what is happening in this case? This is 0; this is 17; this is 34; this is 51; this is 68, then 85, and so on. And if you are considering this is 42, then it is 59, then it is 76, then it is 93, and so on. So, you can consider the; this hole that is blasted almost like this, this hole is blasted like this, this hole is blasted like this. So, this is creating a row like this, and that is why you are also achieving a row to row blasting this way.

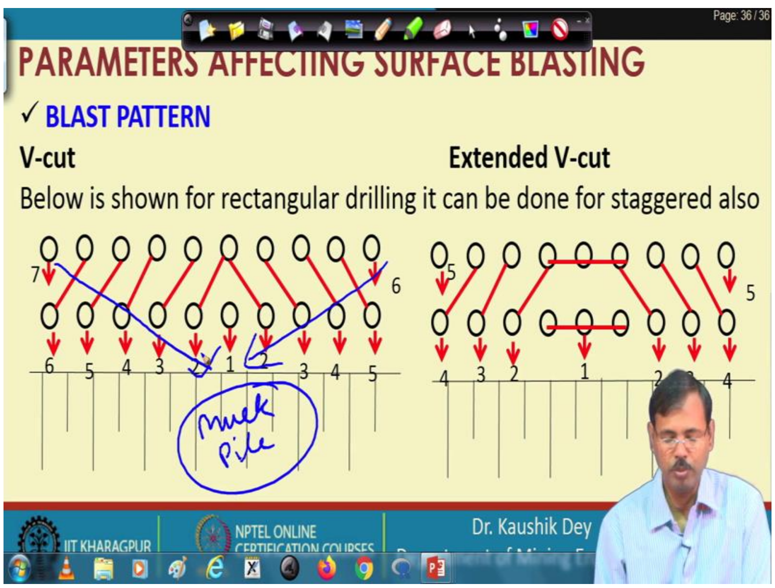
So, this is another aspect of row two-row blasting, but this is not the exact row to row blasting we are achieving in the, we are achieving in case of our detonating fuse and electronic detector systems. So, this will create a little bit different in this case. So, or in other words, if you are considering this is 25, this is 25, then probably this will make sense like this.

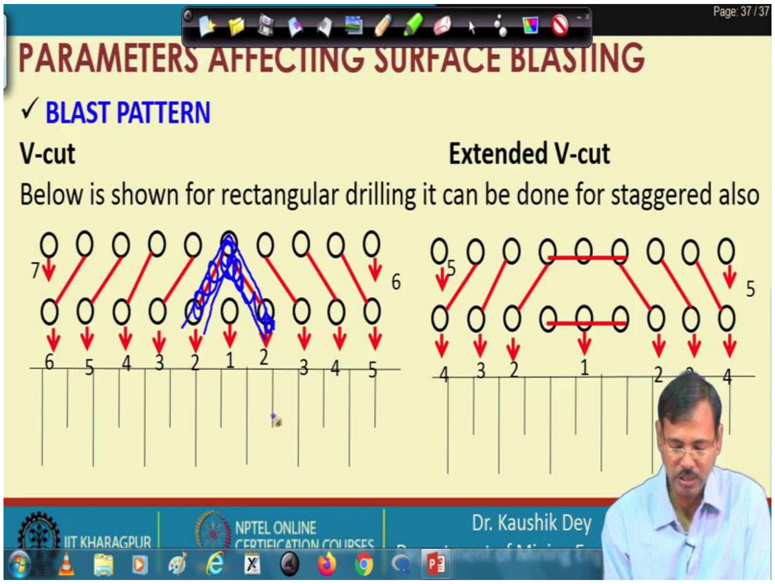
Now, this is row to row blasting. The row-to-row blasting is very easy. All the holes always achieve an almost free face; see if you are considering this one, this is having an available free face of this angle. So, that is why you can see the holes are very free, and as you are cutting out simultaneous blasting of this one, the resistance to the explosives is less, and you will achieve a better blasting in this case.

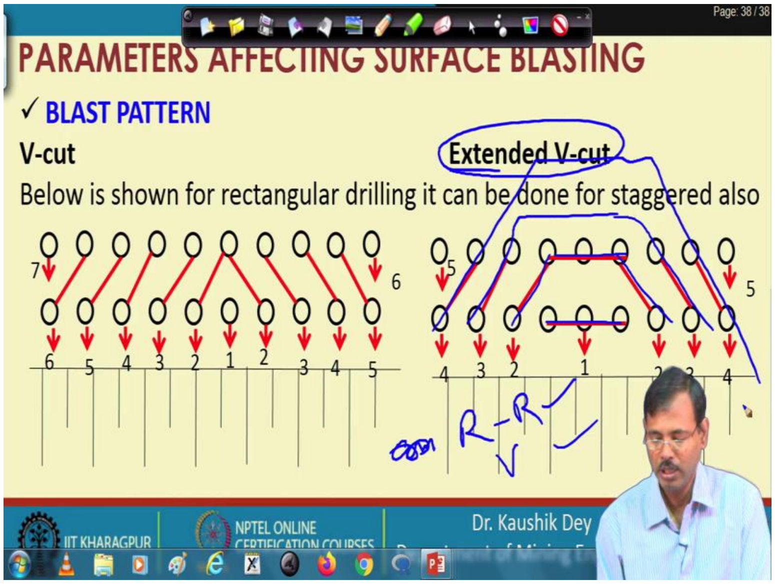
So, row-to-row blasting is very easy. The results are also obvious and satisfactory, but the only problem is that it allows the simultaneous blasting off a huge quantity of explosives. Apart from that, and if you are connecting with a detonating fuse, the detonating fuse is basically generating the noise or the situation of air blast. So, that is air over-pressure is increasing with the use of the detonating fuse. So, that is the main drawback of the row to row blasting and often that is why it is avoided.

(Refer Slide Time: 14:50)









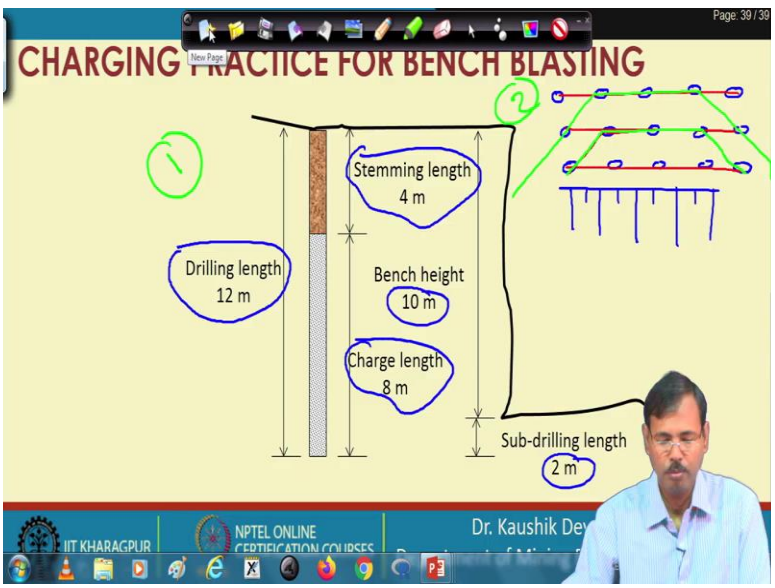
This is an example of the v-cut pattern. When, this one is blasted at the first delay, this one in the second delay, this one in the third delay, and this one in the fourth delay, it always creates a v shape. Except for the first hole, this is creating a v shape. So, the explosives are allowed to blast like this, and your free faces are; this is the free face acting in this case. So, this much rock is being blasted using the explosive at these positions. So, this is the technology; this is the technology for blasting in v-cut.

Here we are basically guiding our movement of the rock on this side. So, in this case, the benefit we are achieving is that his fragmented rocks are colliding with this one. So, the rocks are basically colliding, and further fragmentation due to collision occurs. So, that is why you can expect better fragmentation in this v-cut blasting. Not only that, but you are. Also, all the holes are guiding centrally. So, a central heap is generated, and a central muck pile, a centrally mock pile, is created in this position. So, that is also a benefit of the use of v-cut.

But the main drawback of the v-cut is that the confinement of charges is very high. So, charges are confined at this position. So, the constraint to the charge, to throw the charge as these are very angular way this is confined like this way. So, the charge has great resistance to throwing this rock in the front direction. So, that is why this is, charged confinement is considered very high in this v-cut blasting, and that is why this sometimes creates a little bit of problem by the increased vibration, etc., because the charge confinement is high.

So, extended v-cut has come out, which compromises row to row and v-cut blasting. So, this is a compromise between this. We are providing some row parts here. Also, we are providing some v part here, similarly there, and similarly there. So, in this way, we are promising between row to row and v-cut, and by this, we are satisfying our result as per our requirement. All these are also possible. These are shown in a rectangular way. You can draw a different staggered pattern also. So, all these blasting are possible for a staggered pattern.

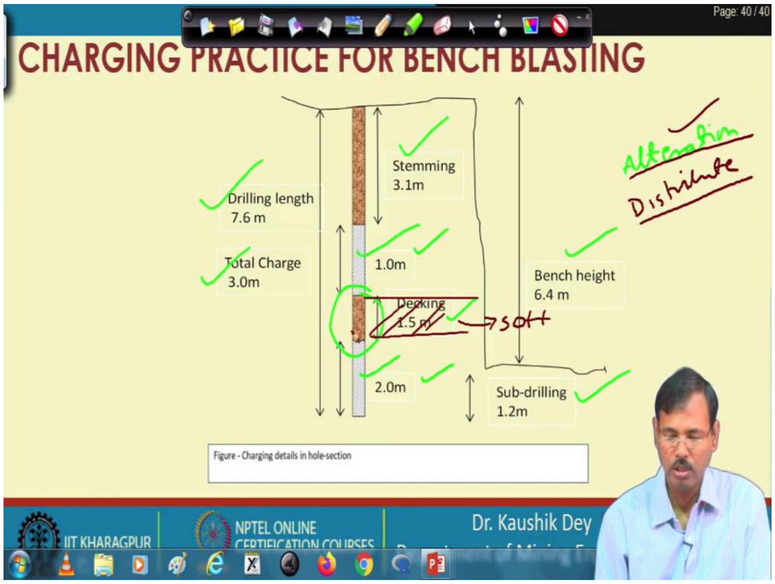
(Refer Slide Time: 18:28)



This is a simple example of how we will carry out blasting in a section. So, if this is the blast, you can say you can have a 10-meter bench height with a 2-meter sub-drilling. So, your total drilling length is 12 meters and you have found the charge. The length required is 8 meters, and the stemming height is 4 meters.

So, this is the charge configuration inside the hole. So, blast design means you have to provide a section like this, and you have to provide a plan view of the blast mentioning this is showing the drilling pattern, and you have to say the initiation pattern, whether it is row to row or extended v-cut whichever it is you are opting for, you have to saw this. So, this is one picture. This is another picture. You have to calculate show as your designed blasting pattern.

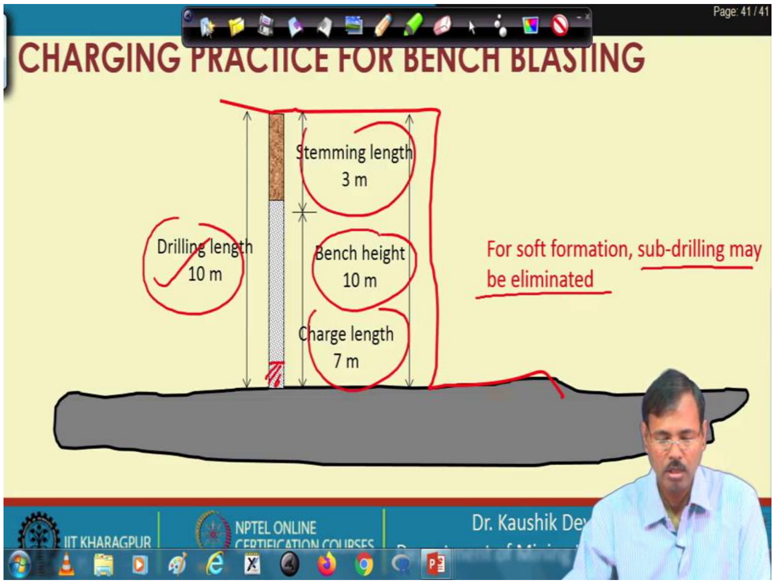
(Refer Slide Time: 20:07)



Now, this is another option where you are using a deck charging. In that case, you are providing an inner decking at this position and distributing your charging two charge columns. So, one is 2 meters here and is 1-meter charge column, so you are placing 3 meters of charge altogether. You are providing a 1.5-meter decking here, and this is a 6.4-meter bench height, 1.2-meter sub-drilling. Your total drilling length is this one. This is your full charge length, and this is the stemming column you are providing at the top.

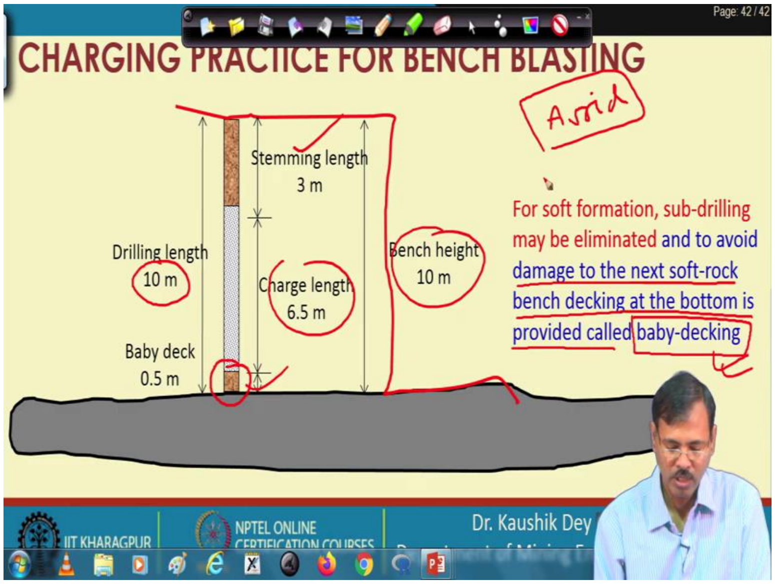
So, this is another type of blasting pattern you can have, where you are distributing the charge using decking in between the charge. So, decking is, in general provided either there is an alteration in the rock strength, alteration in the rock strength, or you need to distribute the charge. So, alteration, either in the alteration of the rock properties, say this portion there is soft rock. So, you are avoiding providing the charge at this position. So, this is another aspect of practice.

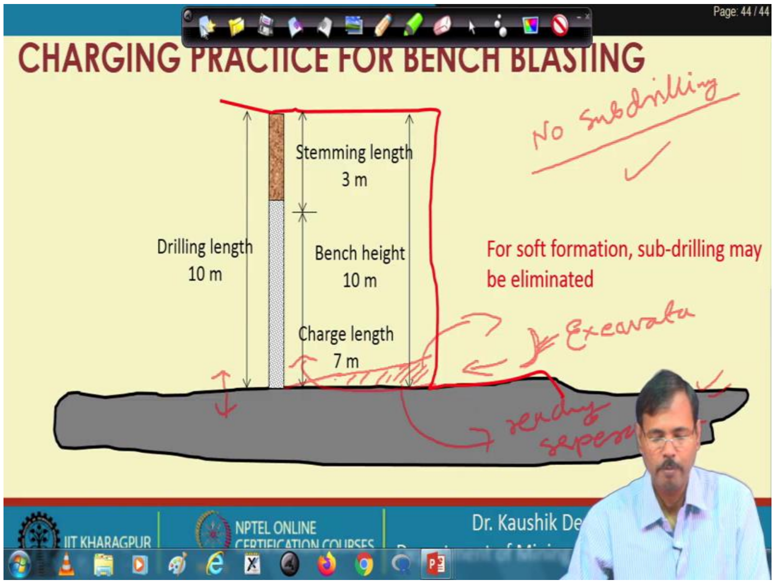
(Refer Slide Time: 21:50)



And this is for the case of soft rock; this is for the case of soft rock. You can see in soft rock we have eliminated sub-drilling. So, sub-drilling is eliminated, and say if it is a very soft rock, often we go for stemming this one, and so now you can see drilling length is equal to bench height and you are providing the charge length here and stemming length here.

(Refer Slide Time: 22:28)



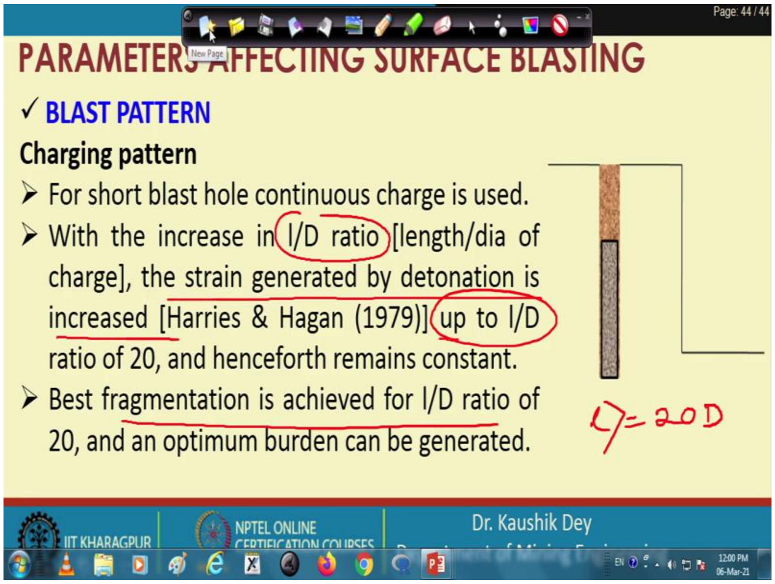


And you can see in this case you are providing a decking, bottom decking at this position to avoid the damage to the next soft rock, which is called baby-decking. So, these are basically local terms. So, this baby-decking is a local term. So, you can provide this. Now, you can see your charge length is; drilling length is the case with the bench height, and you have reduced the charge length to 6.5 meters so that this bottom part is avoided, and this is the decking provided here, and this is the stemming height.

You may ask, sir, we have discussed the sub-drilling required to avoid toe formation and how these are avoided here. Say if, let us go to the previous slide, I think that is better. So, if it is seen at this position, we are expecting a tow because there is no sub-drilling. So, a toe is formed at this position. So, what will happen when your excavator is trying to dig this one. Then as these two are readily separable, this portion will be taken out by this excavator; the power of this excavator is utilized as these are readily separable.

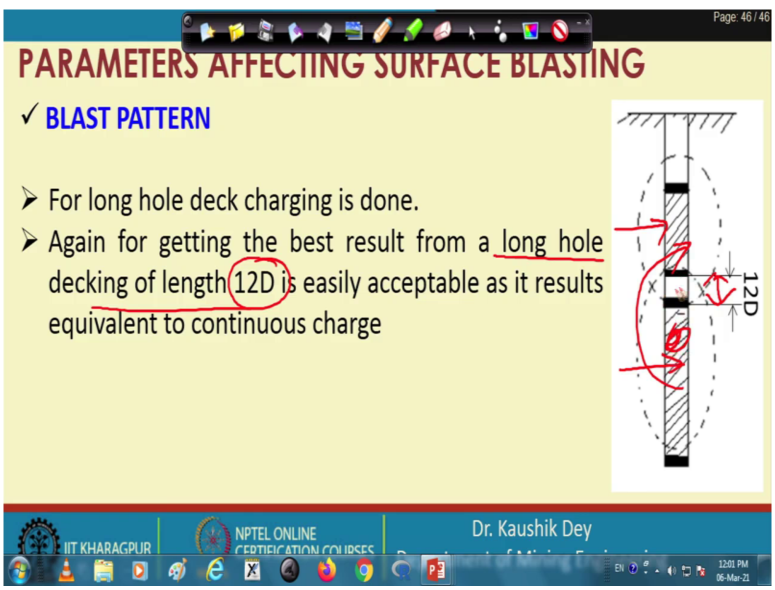
As these are readily separable, the excavator can detach this part. So, that is why the toe formation can be avoided here, despite not having any sub-drilling. So, the same thing occurs; the same thing happens in this case also because this is very soft rock; these are easily excavatable by a good excavator and this position.

(Refer Slide Time: 25:08)



So, these are the different charging patterns. These are different guidelines given by different researchers. Here you can see the l by D ratio is very important, and it is seen that the strain generated by detonation is increased up to an l by D ratio of 20. So, l must be greater than equal to 20 D, and it is, that is why it is told the best fragmentation is achieved at l by D ratio of 20 D. So, that is why it is very, very important.

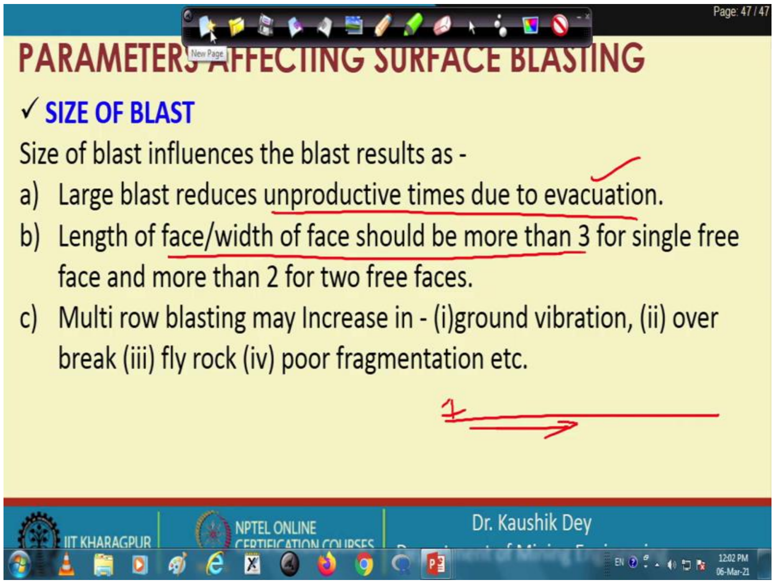
(Refer Slide Time: 25:52)



The second guideline is given related to the decking or every placing of two explosive columns in the hole. It is telling that it should have a decking length more than this. So, 12 D, more than

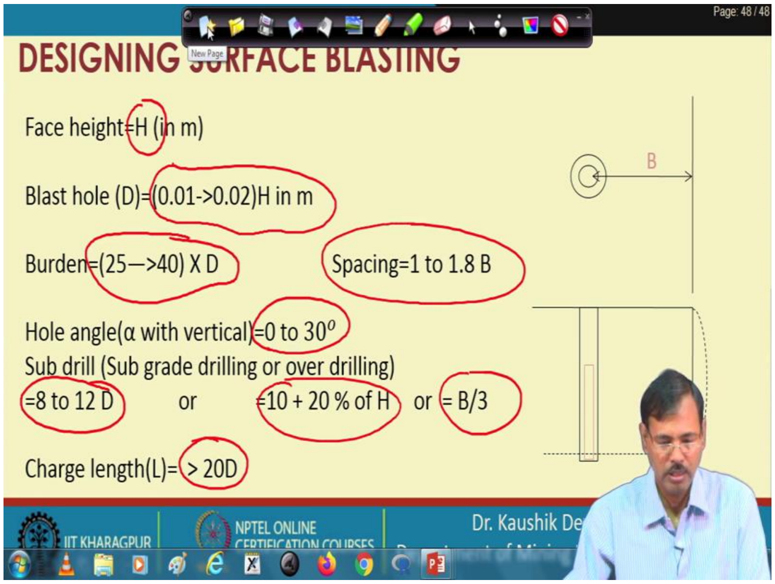
12 D, must be separated between two charge columns. Otherwise, the blasting of this one is sympathetic. It may blast the second one also. So, to avoid sympathetic detonation, we should go for a 12 D, more than 12 D separation between the deck charging, and it is expected that an acceptable result will be achieved in this case.

(Refer Slide Time: 26:50)



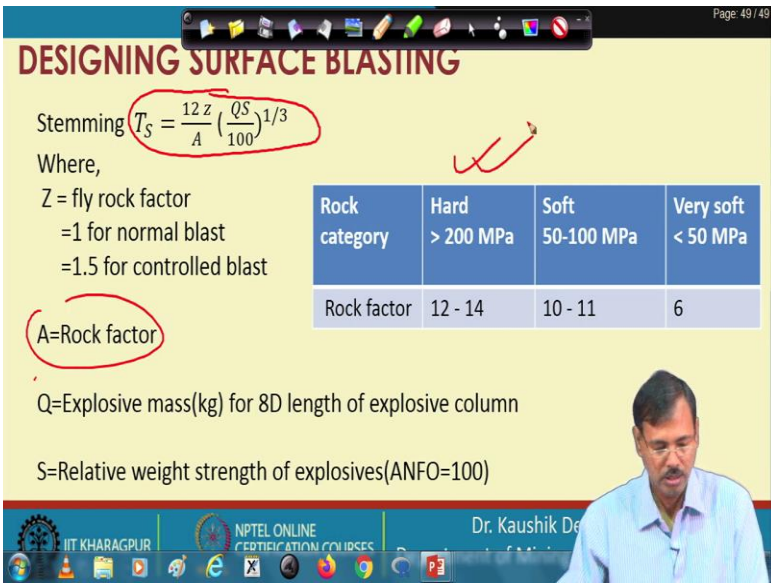
And the size of the blast depends on the production requirement. More blast rounds are avoided because blasting has unproductive times for the evacuation. The long face and width of the face are also other factors. If you have a long face length, but the width is not significant, your excavator has to propel a lot. So, sufficient material must be given to the excavator to avoid this additional propelling. So, multi-row blasting, these are some of the factors one must be taken care of while the blasting is carried out.

(Refer Slide Time: 27:34)



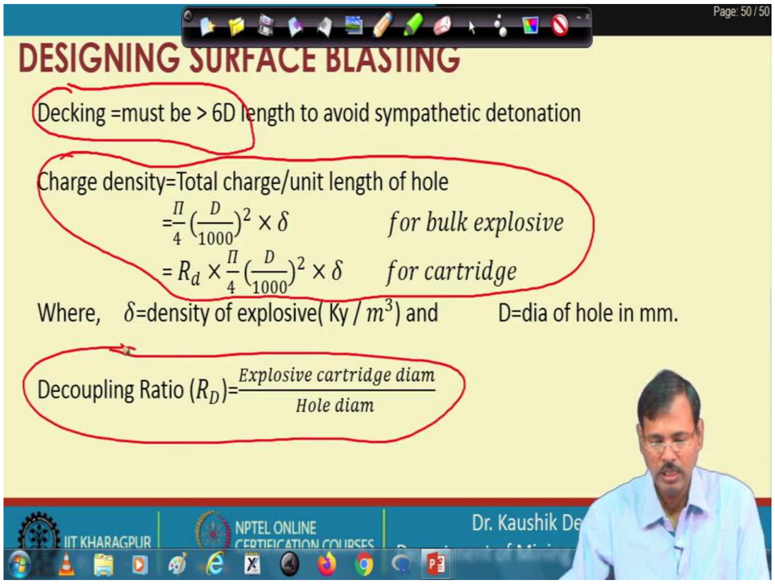
Now, these are some of the design guidelines. We will look into the different researchers have given different approaches. Say if the face height is H then the blat hole diameter, this guideline is given, the burden is given like this, spacing like this, hole angle, sub-drilling, these are the different criteria given by different researchers and from researchers to researchers these criteria are changing.

(Refer Slide Time: 28:14)



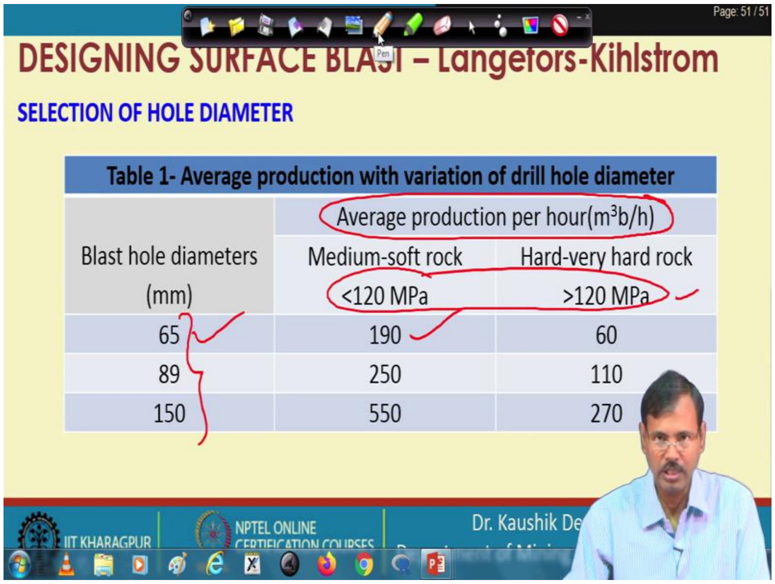
So, let us these are a few more properties stemming. These are the factors, and these are the how you will apply this formula. These are the guideline given for this. Let us once look into the guideline.

(Refer Slide Time: 28:35)



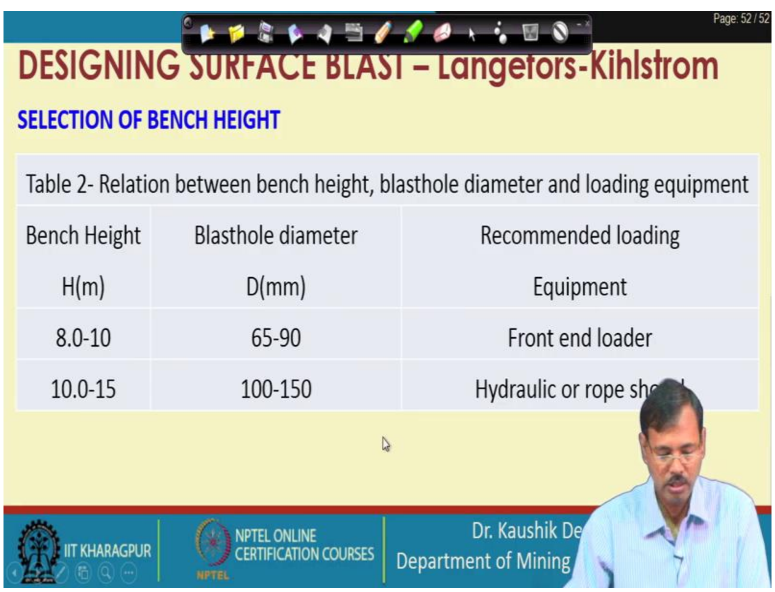
This is given for decking. This is for charge density, and this is the decoupling ratio. Generally, we opt for the bulk explosive so that the decoupling ratio must be 1. But often, to reduce the damage to the wall that is for the controlled blasting, we may go for the decoupled charge for this case.

(Refer Slide Time: 29:08)



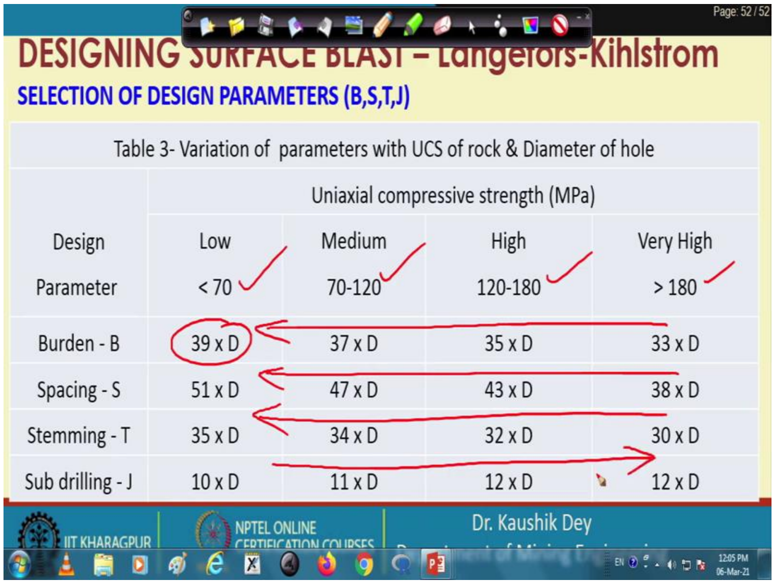
This is the Langefors-Kihlstrom criteria for designing the blast. So, you select the drill diameter of the drill hole, depending on the strength of the rock and the hourly production of the bank meter cube. So, this is the hourly production requirement of the bank meter cube, depending on the strength. You are selecting the diameter of the hole, and after the selection of the diameter of the hole, you have to go for calculating the burden spacing. All this is based on the diameter of the hole.

(Refer Slide Time: 29:50)



This is the bench height relationship given.

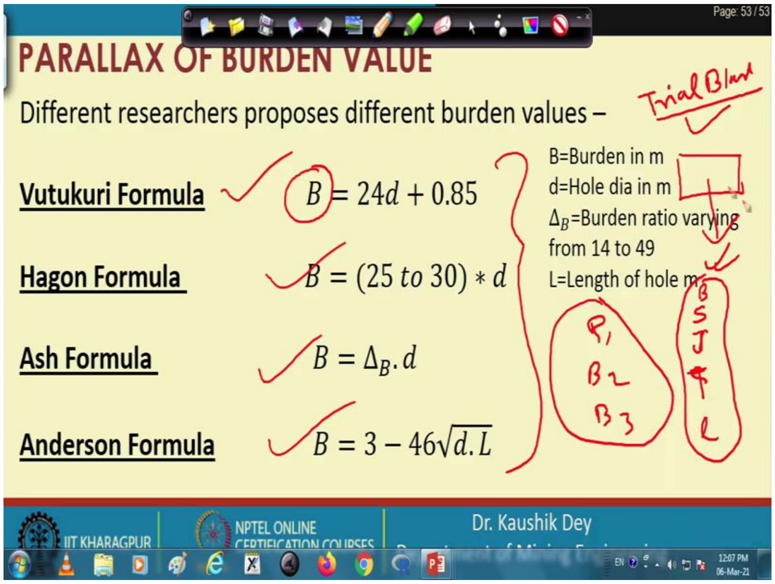
(Refer Slide Time: 29:57)



And this is the criteria for selecting burden and spacing, stemming, and sub-drilling depending on the strength of the rock 70 MPa, 70 to 120 MPa, 120 to 180 MPa, and more than 180 MPa. So, you can see that the burden values are gradually decreasing, spacing value is gradually decreasing, and stemming value is also gradually decreasing.

But sub-drilling gradually increases with the strength of the rock. So this shows the how the variation of the selection of the different properties, and all these are basically based on the diameter of the hole. So, all these are based on the diameter of the hole. This criterion is fixed by Langefors-Kihlstrom. But one essential part that must be considered in this case is.

(Refer Slide Time: 31:07)



Different researchers give all these guidelines. I am presenting here the same burden value given by Vutukuri is this one, Hagon is this one, Ash is this one, and Anderson, this one. So, these are the different values. If you use some values of d etc., delta B all these things, you will get some different B1, B2 by different this formula. So, that is why these are not common, and you do not know which formula applies to you. This is a great problem.

So, it is better to always use any criteria for designing the surface blast and consider those criteria as your trial blast. So, use this blasting criterion for carrying out the trial blasting. From trial blasting, whatever result in you are obtaining based on that you go for iterating the values, the result obtained, accordingly you change the designing values like say burden spacing, sub-drilling, stemming all these values will change and the charge length.

So, you change these values and find out what result you are obtaining when you are satisfied with the result you consider that is your design criteria for that particular bench. So, that is generally mainly carried out in most. This is the basis of the blast designs, and we will continue blasting lectures in the next class. Thank you.