Drilling and Blasting Technology
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Lecture - 32
Underground blast design – 2

Let me welcome to the 32 lecture of Drilling and Blasting Technology course. We are continuing our techniques of Underground blasting, from the last class and you have seen in the last class we have discussed ah about the underground blast design.

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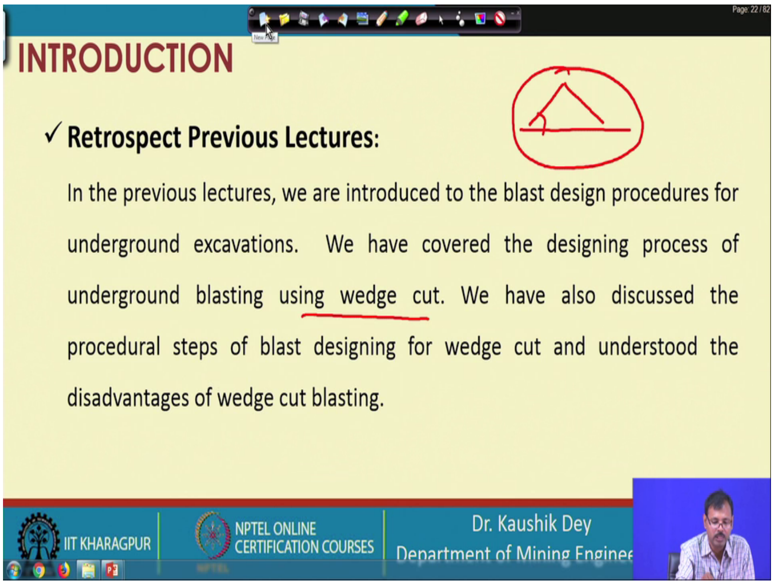

And, you are you have been introduced with the different terminology of the underground blasting. You have seen the in the underground blasting, there are single free face and it is essentially required to create another free face in that blasting and the process, where the another free face is created that is called cut area.

And basically the underground blast design is mainly guided by designing the cut area. We have also discussed in the last class, this designing of the blast for the cut area is basically divided into two parts; one is the wedge cut part and another is the burn cut part. So, in wedge cut two holes are drilled angling to each other, of different degree and this degree of angling depending on the rock mass condition. It may be lower for the hard rock condition and it may be increased for the soft rock condition. And, other modifications of the wedge cut are also there, which are called fan cut, drag cut, which are half wedge cut and pyramid cut is there, which is basically double wedge cut.

So, basically wedge cut is having that angling drilling process and it has been found, this angling drilling is very very difficult while, the drilling is being carried out by a little bit not so much efficient driller. So it is always wiser to go for the a parallel hole and which can be very easily drilled by the driller.

Another drawback is found in the wedge cut that, the length of the drilling is basically, dictated by the width of the opening. So, that is the main drawback of the wedge cut, so it cannot go for, a very very longer drill, which essentially required to achieve a large production. So, to avoid this two cut, there are this two problem in wedge cut, there are other methods of designing this cut area, which is also discussed in the last class, that is called burn cut. So, this is up to designing of wedge cut, we have covered in the last class and we have understood the advantages and disadvantages of the wedge cut in the last class.

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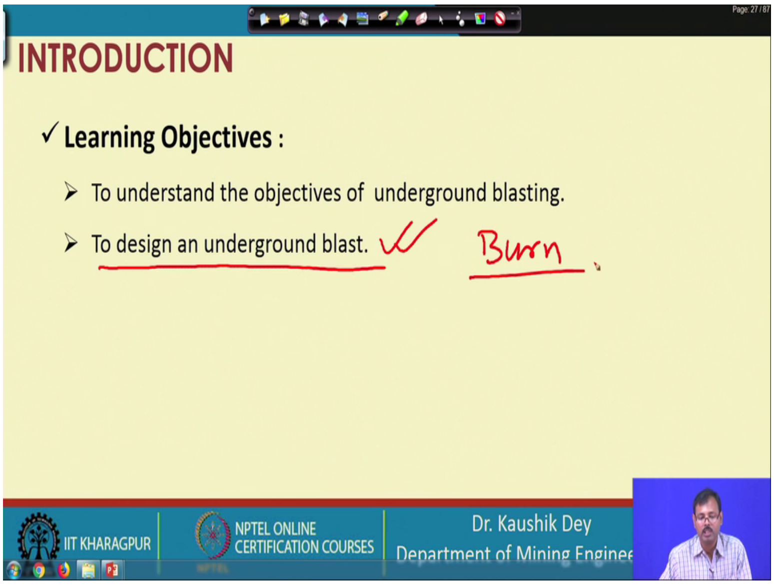

And our objective of learning objective of this class is remain same, with the last class that is to, understand the objective of underground blasting, to design an underground blasting. And in designing process in this case, we are at this position and in this class we will cover the designing of underground blasting using the burn cut.

So, basically every class we start with the videography. Let us start this video which is available in the YouTube also that, how the underground blasting is in general carried out.

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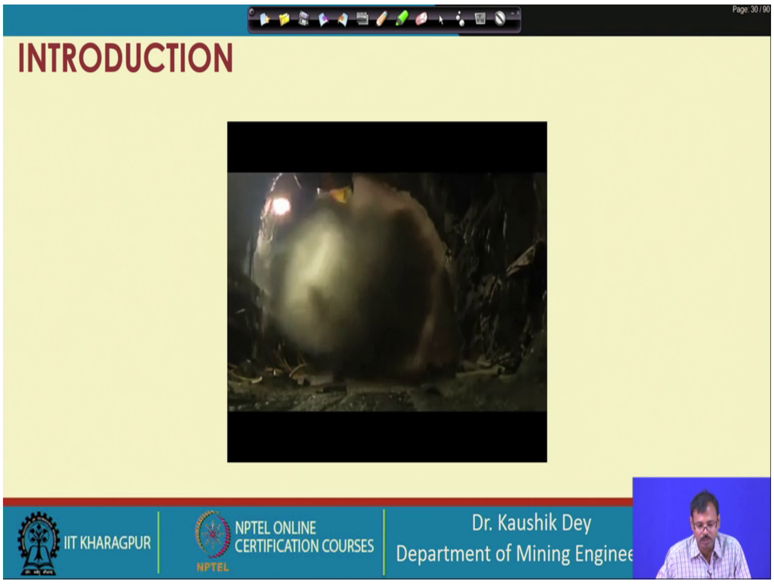

Obviously visibility is little bit less, you can see this is the cut, this is the tunnel area and the surface connections you can see the noels, it is available in the surface. So, surface noels are blasted, which are available on the free area, you will find out the blasting will be carried out little bit late because, the down the hole delay is there. So now you can see the down the hole delay are blasted. So, basically the blasting is over now.

Obviously the visibility of the underground blasting is very very poor, you cannot see the proper blasting carried out, but this is also giving you some good idea about the blasting.

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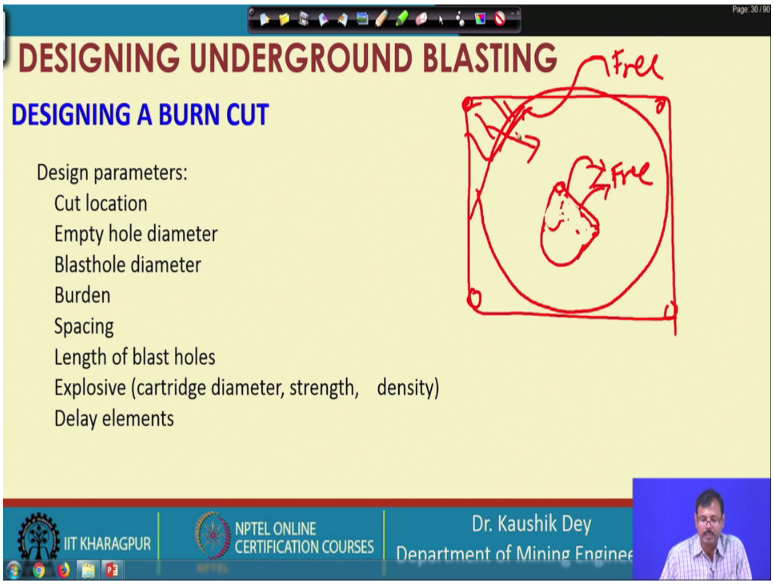

Last class we have also discussed that, burn cut is basically, a cut where cut area, the parallel holes are drilled, keeping an empty large dia holes, very close to the first hole to be blasted. So, basically the idea is that, that empty large dia hole which are placed very close to the first blast hole, act as the free face to that blast hole, so that that three face is considered; say this is the total cut area, this is the cut area and this is the first blast hole loaded blast hole, this is the empty hole. So, this loaded blast hole which is placed, very close to the empty hole and this empty hole act as the free face to the loaded blast hole.

So, basically this is the idea, so that after blasting of this one, you can consider this portion is excavated. So, our free face is now like this and then the next hole which is blasted at this position, will be blasted considering this is the free face and this portion of the rock will be thrown towards this direction, as this is the free face for this hole.

So, this is the basic idea of this blasting. So, before next blasting, this is the total free area available. So, like that way basically, gradually we are increasing the free area or opening area, so that that can act as the free face to the next hole. And, by this way we reached, the desire advance or desired pole after reaching this one probably by this time our free area is like this. And if, we are carrying out blasting then only, this much of rock is being thrown towards this direction as, this is the free area. And this will give us the desired advance and by this way, we can achieve the total cut area blasting.

So, this is the main principle of the burn cut blasting and while we are designing the burn cut blasting, our first objective of this designing parameters are like this; we have to locate the cut area first, then we have to decide the empty hole diameter, blast hole diameter, then we have to compute the burden and spacing, length of the hole, explosive, delay element ok. So, this is basically our consideration and for this consideration, we have to first design the cut location. The decision of cut location will remain same as have discussed in the last class.

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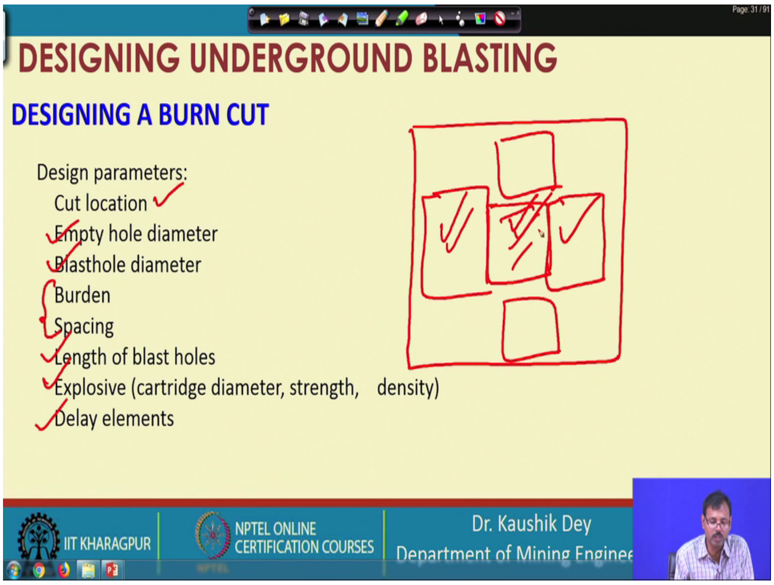

Basically, the cut area ideally is located in the central part. Unlike wedge cut, as in wedge cut we are having a wider cut area because, the length of the hole depends on the width of the opening. So, that is why we are having very very wide cut area, but here the length of the hole does not depend on the width of the opening. So, that is why cut area may be small, the length of the hole depends on the empty hole dia, so cut area may be small.

And that is why we are having option to place the cut area, may be at centrally or may be in a little bit side part or may be in side part, may be in a upper part, may be in a lower part. So, our option, n numbers of options are available in this case. And as, cut area is having the largest concentration of the explosive, it is wiser to move the cut area in the repeated round.

So, if in first round we are having cut area at this place, in next round we should have a cut area at this place, then we may have a cut area at this place, in the next round like that way, we can change our cut area at different places. So, our next design consideration is the empty hole diameter.

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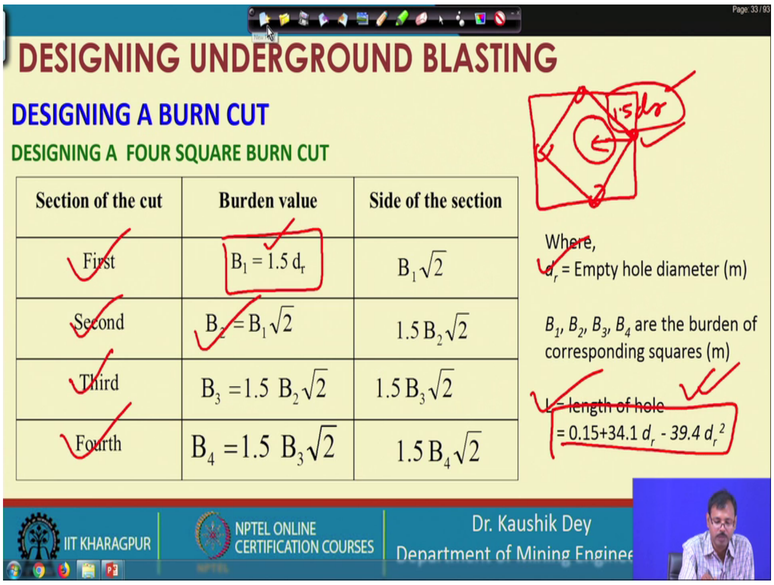

So, we have to first assume, we have to first assume some empty hole diameter. And based on that empty hole diameter, we can have our first burden formula for the first hole. Say suppose, this is our empty hole diameter, we have chosen d r is the empty hole diameter, then the first burden for the first hole is considered as this, this is as per Langefors Kihlstroms criteria.

So, this first burden center to center, so this first burden distance is 1.5 d r for this hole, so this is the first burden distance which is considered. And by this way we can have a square like this, where all the holes are placed at 1.5 d r distance. So, this is the first square, so this is first square and then our considerations are like this, we have to increase this square in this form and you can have this formula, for this consideration of the square cut.

So, this is basically four square cut where it is considered, if we are having four square like, we can achieve the desired advancement. And the length of the hole, if you are considering this one, depends on the empty hole diameter with this formula as per the

Langefors Kihlstroms guideline. So, this is important in the blast hole design for the cut area, where four square cut is being practiced.

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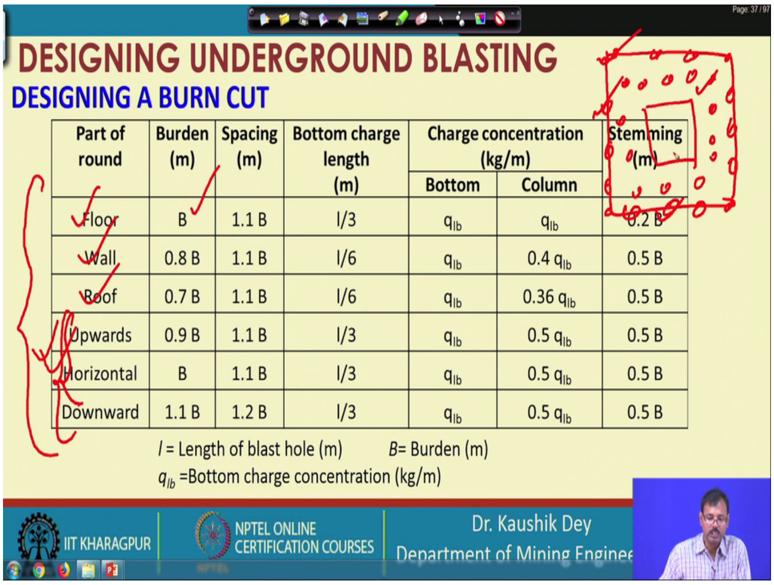

So, as per this, the design criteria is very very simple, for a four square cut using burn cut.

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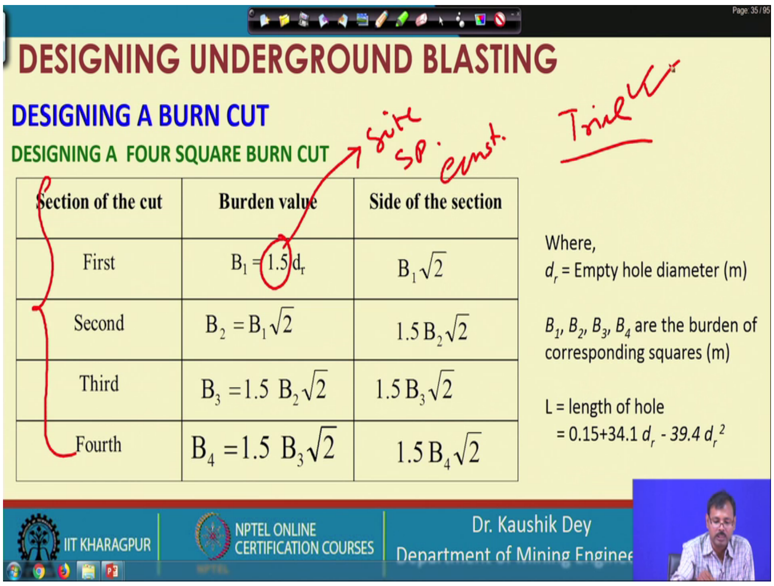

And that makes the burn cut very very popular. However, one must remember that, this design criteria is basically for the trial blast design. And you must consider this is a site specific constant, this is a site specific constant, which may be changed depending on the rock mass condition. So, one must be very very, one must be very very considerable for this using this 1.5, as a constant for the first burden value and from the result absorbed in the trial blasting, this consideration may be changed.

Basically, this 1.5 acts good, for hard rock condition. In soft rock condition if, anyone is practicing burn cut in general, most of the cases soft cut soft rock formation you go for the wedge cut. But if, we are trying to practice the burn cut in those cases, we must consider this 1.5 little bit higher than the, this constant more than the 1.5, for the soft rock condition. So, this in general, the guide line for designing a burn cut for the cut area only. For next of next others hole, floor holes, floor holes, wall holes, roof holes and this are the stoping holes, this three are the stoping holes. For these cases, the formula may be like this and these considerations will remain same for the wedge cut also.

So, the formula for floor hole, wall hole, roof hole and the stoping holes, upward, horizontal, downward, in this three condition remain same for the wedge cut and burn cut because, if this is the opening, this is the cut area, whether we are achieving the cut area either by burn cut or by wedge cut, it does not matter. The designing constraint for the holes remaining stoping holes and roof holes, wall holes, wall holes and floor holes or lifter holes, remains same.

So, basically the designing of this roof holes, floor holes, wall holes and stoping holes, does not depend on the whether, we are designing our the cut area either by burn cut or by wedge cut. So, design considerations for floor hole, wall hole, roof hole and stoping holes, remain same for the wedge cut and burn cut. And these design considerations are like this, the burden considerations are like this. You can see these are the different considerations, the bottom charge lengths are given, the column charge lengths are given and stemming considerations are also given, for all this conditions. Again let me remind you that, these are all for the trail blast design, depending on the rock mass condition in your case, you must change this constants for your particular condition; observing the trial blast design, result of the trail blast design.

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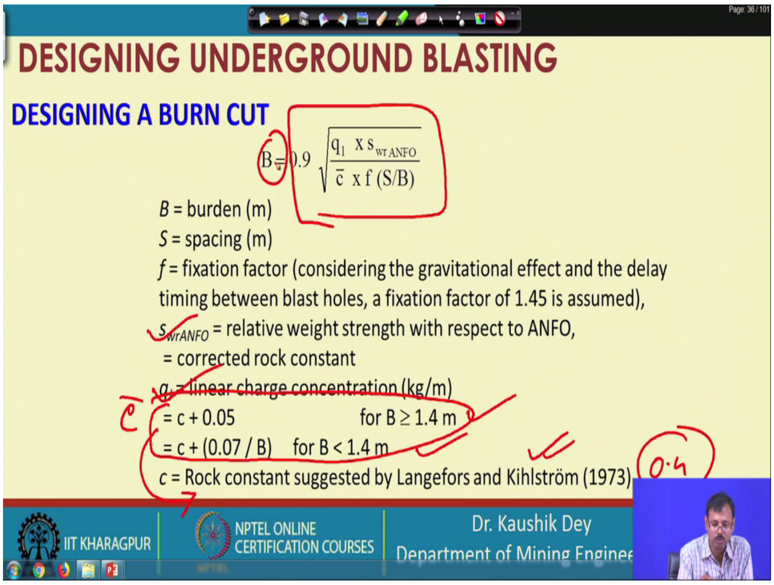

The first burden how you can achieve this formula is given. That B in the previous slide, you can see, you can see in the previous slide, in the previous slide this B is given. The value of this B, how we can achieve is given by this formula and this is, Langefors Kihlstorm formula. B is burden, S is spacing, f is the fixation factor, considering the gravitational effect. This is the relative weight strength of the explosive with respect to ANFO, considering what explosive you are using. This is the linear charge concentration and I think this c actually, this portion will come in the bottom.

This portion will come in the bottom, this is basically c bar, this c bar is equal to c plus 0. 05 for this burden and c by this one and this one using this, where c is the rock constant suggested by Langefors Kihlstrom. In general if it is not known to you, can consider it is 0.4. So, this is the value you can consider and using this, you can get B. You can use this B value in the previous slides, to achieve your different value, achieve the different values for the different components or different parameters.

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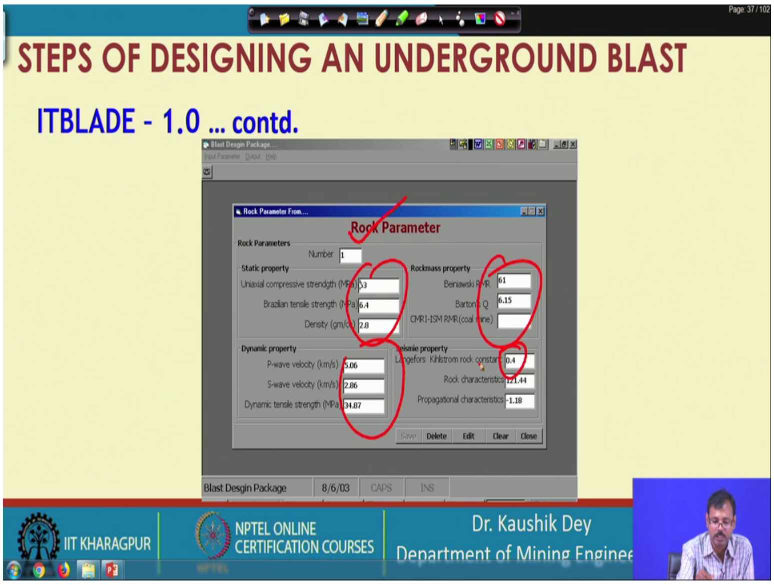

So, now, let us see how, what will be the exact procedure of carrying out the blast design, for an underground mining case or underground opening ok. So, in this case, we should give some input parameter. Let us see what is the input parameter, we will discuss this for the burn cut. However, the procedure will remain same for the wedge cut accept, for the cut area where, the area will be designed in different way other then, the burn cut.

So, this is the first, we need to have the different input parameters. Our first input parameter is the rock parameter, where the different rock parameter strength value etcetera will be required. Say as it is Langefors Kihlstorm, this values rock characteristics values should be given here.

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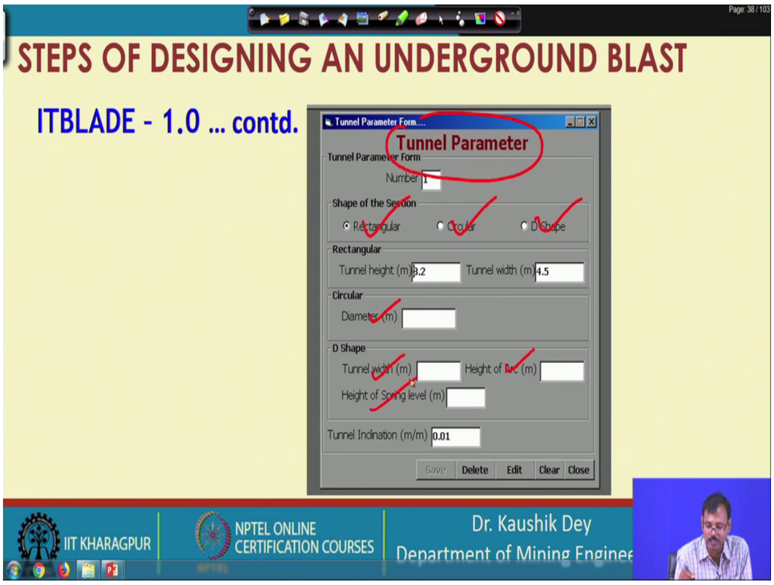

Apart from that, we should have the opening parameters, say it may be tunnel, it may be underground opening. So, it may be rectangular, it may be circular, it may be d shaped, it may be orso shape and with the different considerations, you need to have the different parameters. For the rectangular it is height width, circular it is diameter d shape, then the width height of arc height of spring level all this requirements are there; inclination is also there. These parameters must be there otherwise in wedge cut, how we will consider our drilling length.

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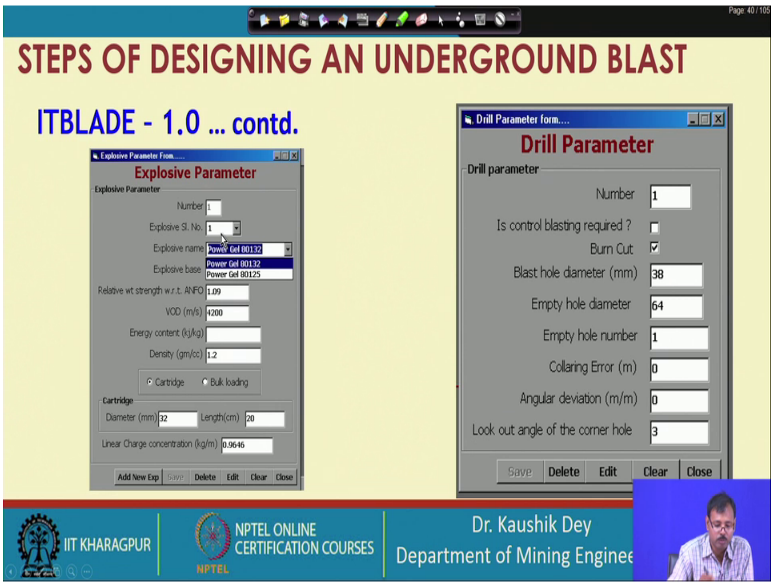

Then the explosive parameters is required because, explosive strength is very very important and drilling parameter is also required because, the diameters are very very important, our all design criteria depends on the diameter of drilling. So, these are basically the four input parameters, mainly rock parameter, opening parameter, explosive parameter, drilling parameter. All this are to be considered while we are designing an underground blasting.

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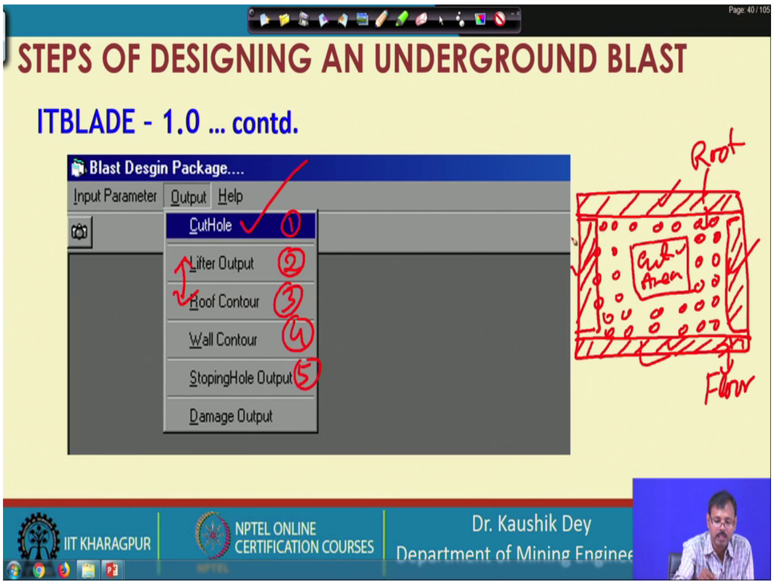

Then considering the input parameters, we have to design the output. And our first requirement, which is the main requirement is that, we have to design our cut hole first So, in this case, you just see the sequences. Here you can see the sequence is cut hole first, so this is one, next we are designing lifter, next we are designing roof, next we are designing wall and finally, we are designing stoping. So, the basic criteria is that, we have to see, how much area is required to generate the cut.

So, the cut area dimension is essentially required, this dimension is essentially required, to achieve the desired pole and desired fragmentation. So, while the cut area requirement is fixed, now we know this is the cut area. We can place cut area at any place but, the amongst the total area how much is area is required for the cut, that is now known to us. Our next part is that lifter one; that means, for blasting the floor holes, how much area is required, but that means, how what will be the maximum burden we can consider for the last periphery holes, that has to be decided here.

So, we can have the desired area, to be blasted in the lifter hole. The next is the roof holes, so we are fixing this part also, how much area is required for the roof holes, how much area is required for the roof holes, So, after fixing this area, this area and this area, we have to fix the wall contour area also. So, this is the wall contour area, remaining available for the wall So, this is the wall contour area. So, our next process is to fix the wall contour area. After fixing this wall contour area whatever remaining area is there, that has to be blasted with the stoping holes.

So, out next idea is to create the opening on the stoping holes and we have to find out what is the burden of the stoping holes. And knowing the burden of the stoping holes, we have to place the stoping holes, it may be like this and in both the site So, first we generate the holes for create the opening in the stoping area, then we basically place the other stoping holes, to blast the remaining area.

So, the stoping holes, the requirement of the stoping holes are decided at the last, after fixing the cut area, then lifter and roof wall and wall. The sequences may be change for lifter and roof. You can decide the lifter first, roof first lifter second also or lifter first, roof second also. But, after fixing roof and lifter, then only you can fix the wall contour holes. So, this are the requirements, one must remember while, they are designing the blasting for underground openings.

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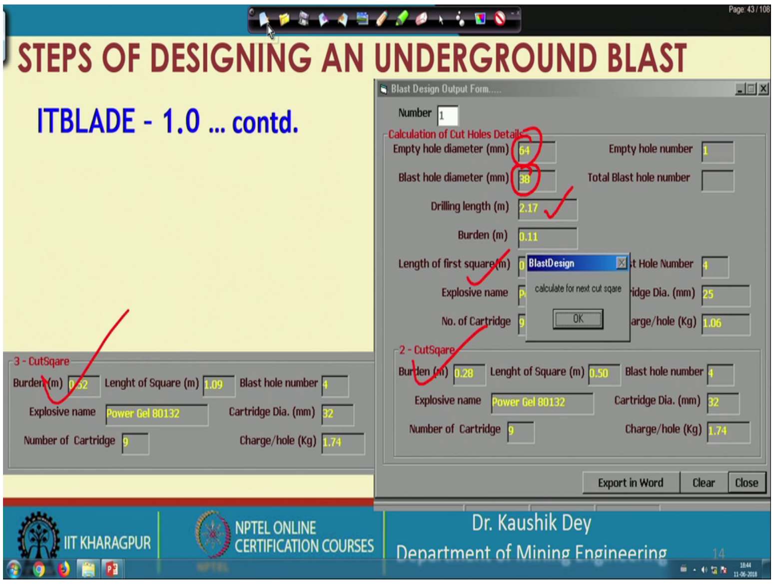

So, let us a see how you can carry out. So, our as we have already discussed, we decide the empty hole diameter. We have assume some blast hole diameter to fix our concentrations, then using different formula, we have received different cut lengths. So, these are the first square cut. this are the second square cut, this are the third square cut, so this are different squat cut, are considered in the four square cut system. However, in this blasting I thought that, three square cut were sufficient for this particular consideration.

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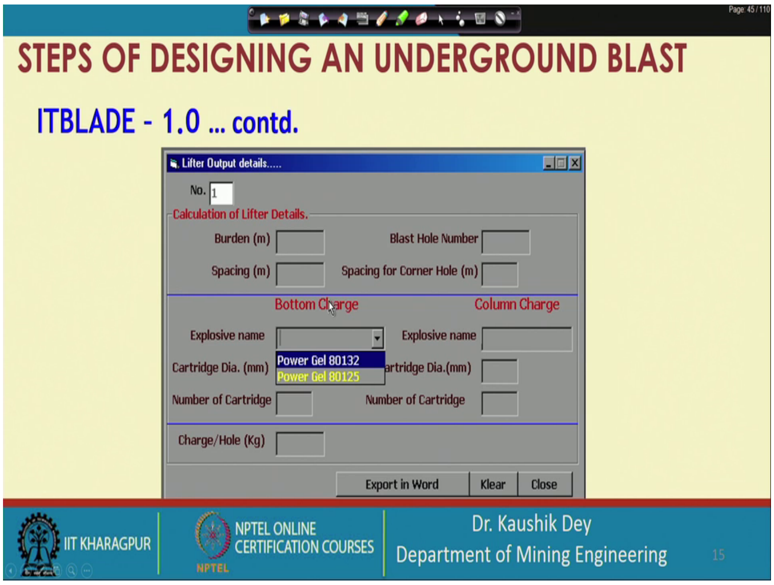

So, after fixing this one, the next lifter holes are decided. In lifter holes, if you see it already, the cut area is fixed.

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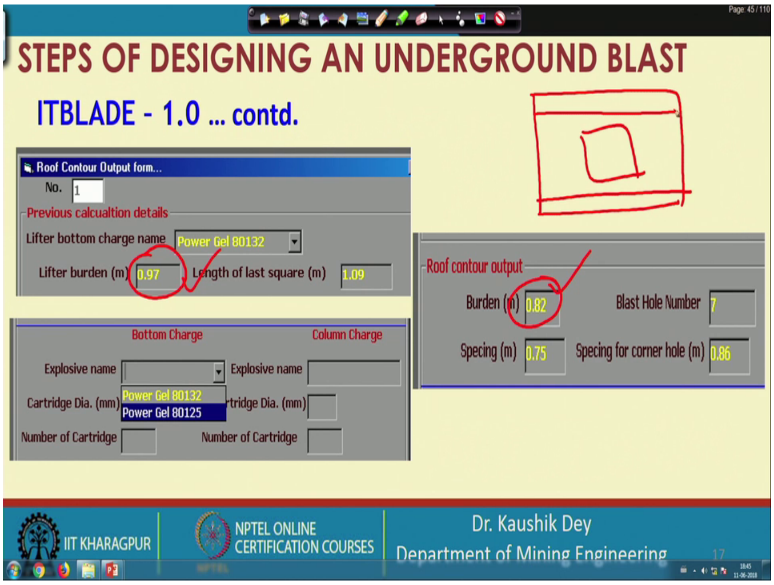

So the lifter holes are calculated first and you can see the burdens of the lifter holes is fixed, then the roof holes are calculated, then the burden of the roof hole is fixed now. So, burden for lifter hole and roof holes are fixed. These are not dependent, so independently it can be fixed and at this position our cut area, you can consider our cut area is now fixed, our lifter area is now fixed, our roof area is now fixed.

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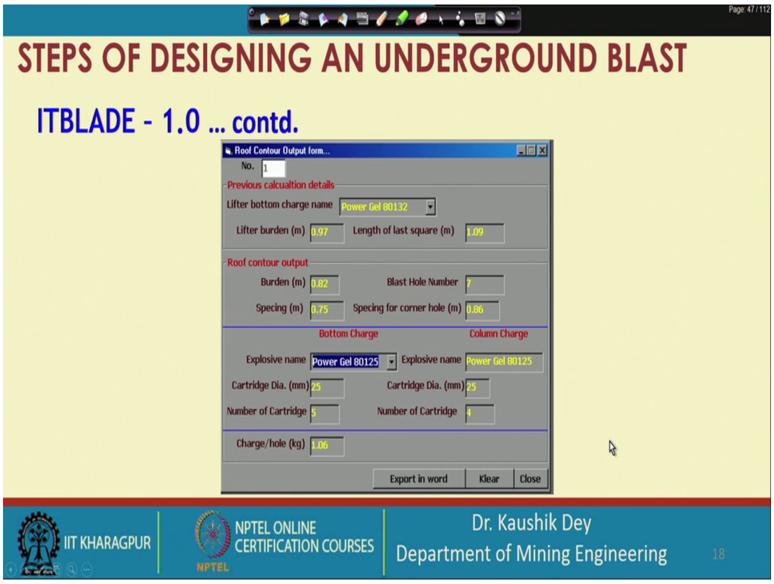

So, these are the fixed conditions. Our next designing is for the wall contour.

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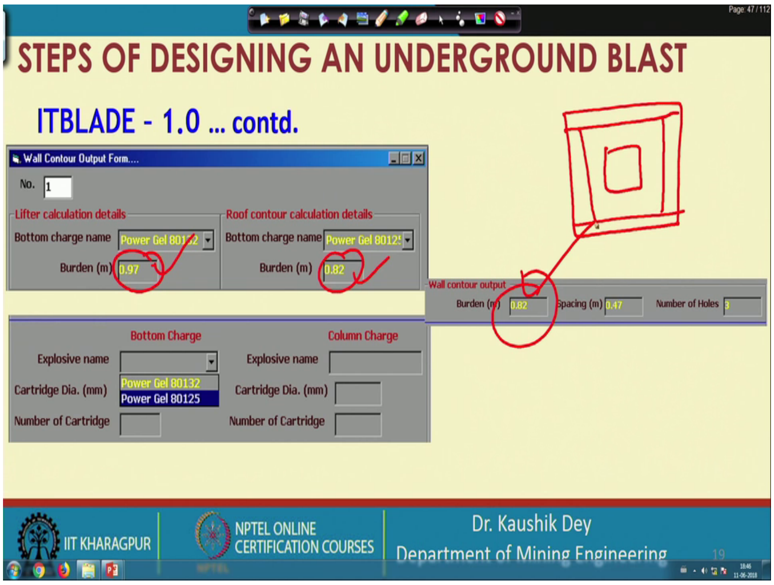

So you can see in wall contour, we have fixed this one. And considering this, we have achieved we can achieve, the burden value of this, for the wall contour holes sorry, this is for lifter holes, this is for roof holes and we have achieved the burden of this one for the wall contour holes. So, this wall contour hole is now fixed So, at this position, we are in a process where, this is the cut area, this is the roof area, this is the floor area, this is the wall area, which are already fixed.

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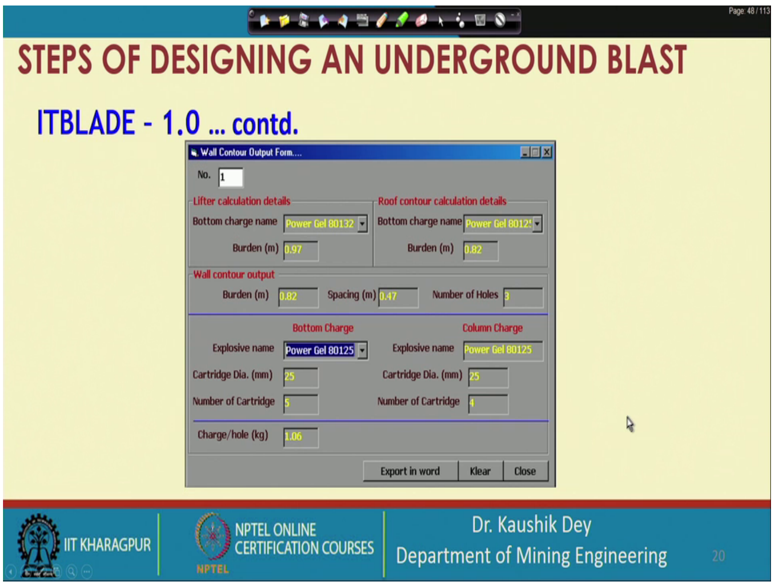

So, now we need to decide the stoping hole.

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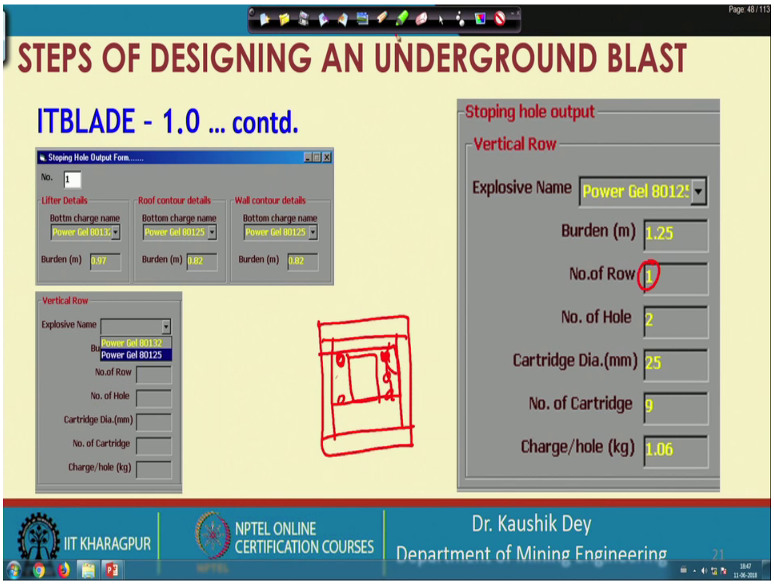

So, let us consider the stoping holes now. So, in stoping hole, first we are considering the vertical rows. Vertical rows means, this is the roof area, this is the floor area, this is the cut area, these are the wall contour holes and vertical rows of holes means, this are the holes which are considered the verticals. So that; this total area is considered as the excavated one, then the horizontal holes will be calculated. So, the vertical holes, the number of holes and number of rows there it is one; that means, this is not required as per this considerations, only one is available and two holes are there. So, you can consider one hole is here, this is this is not there, another hole is at this position may be sufficient.

So, two holes are required, two holes are required and only one row is required as per this consideration. So, using this only, the total area may be, total area may be considered as the total area may be considered as the excavated so that; the horizontal row may be placed. And in this case you can see this is the burden, which is calculated.

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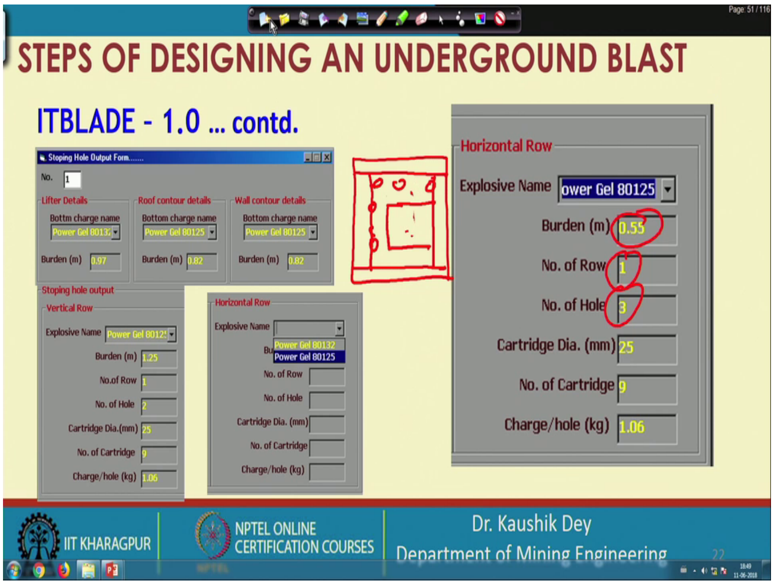

So, after decision if the vertical row, the horizontal row are calculated, where burden is found this one, row is found this one, number of holes are found this one and this may be now designed like this. There may be a cut area, lifter area, roof area and wall area, so basically, as per our consideration our cut area as we are having only one vertical row. We can consider our cut area is like this and this are the, sorry there are two holes, these are the vertical holes, stoping holes and there are only one horizontal rows, of holes available in this condition.

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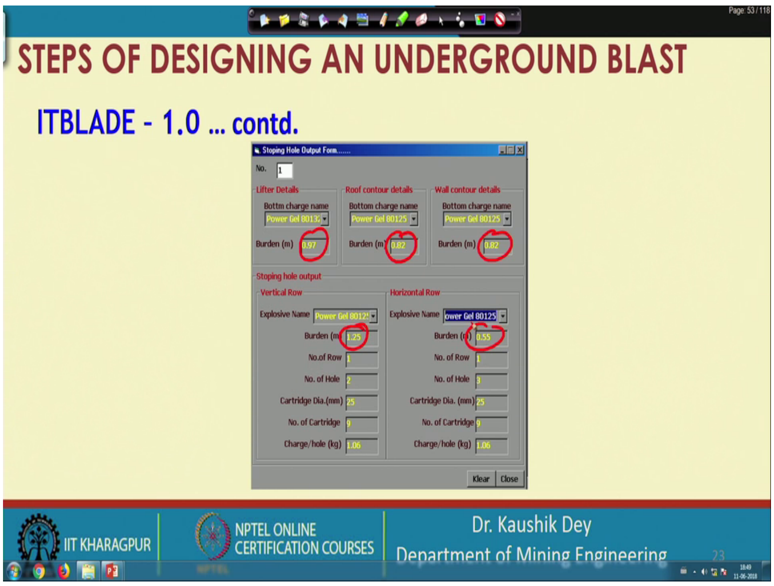

So, this is the design considerations or you can see is the design procedure, one may be can follow, while they are designing the blasting for underground and this is the final consideration, where the burden value you can see. This is the burden for lifter, this is roof, this is wall, this is vertical, this is horizontal stoping holes.

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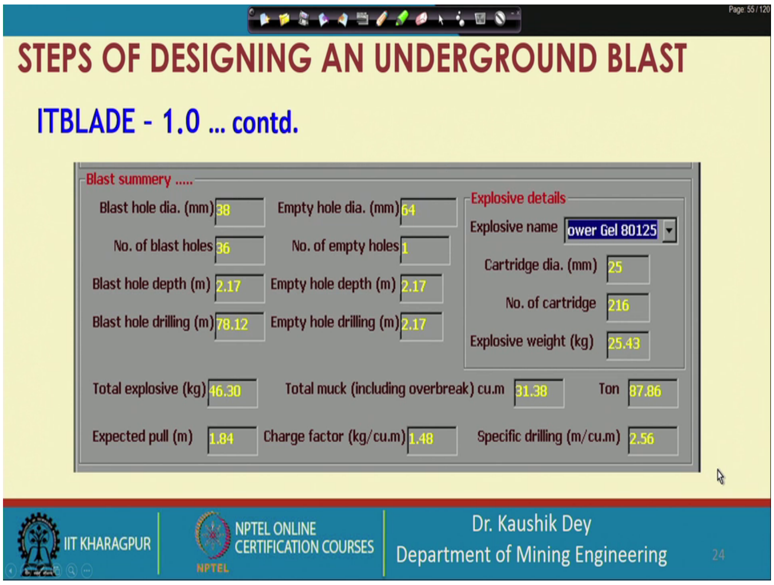

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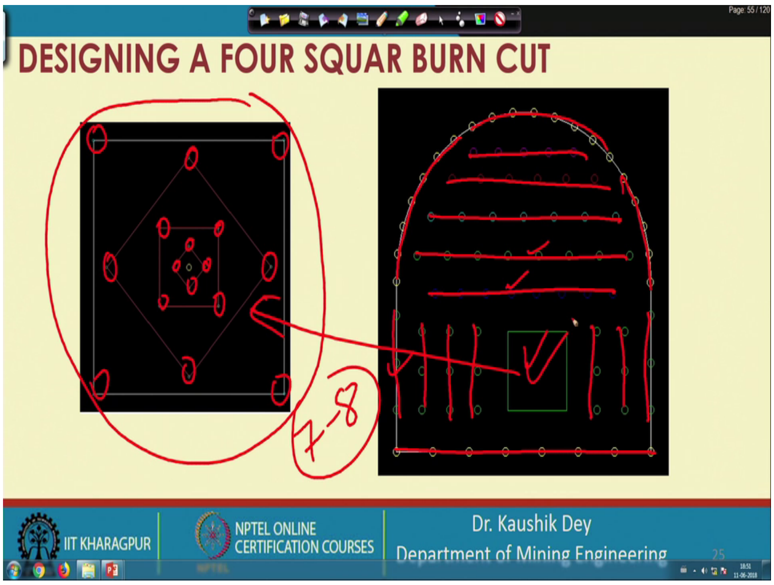

And this is the summary you can calculate and you can consider in this case, this may be the cut area. So, this is the cut area and this is basically, showing the different delay. So, the delay this are the first delay, then this is the second delay, then the third delay, then the forth delay, then fifth delay, sixth delay, seventh delay, eighth delay, then, ninth, tenth, eleventh, twelfth wall contour hole, then thirteenth, fourteenth, fifteenth, sixteenth, seventeenth, eighteenth, nineteenth, twentieth, twenty first ok.

So, this may be the sequences, obviously you can blast this one and this one together or may be, this one this one together, on the same delay. So, n number of delays are required, while you are practicing the underground blasting because, you can consider that significant number of delays almost 7 to 8 delays are essentially required, for only this cut area. But delay sequence must be proper so that, the proper expansion of the opening will be followed. So, that is essentially required in the underground blasting and this is the main requirement of the underground blast designing, delay sequence is very very important.

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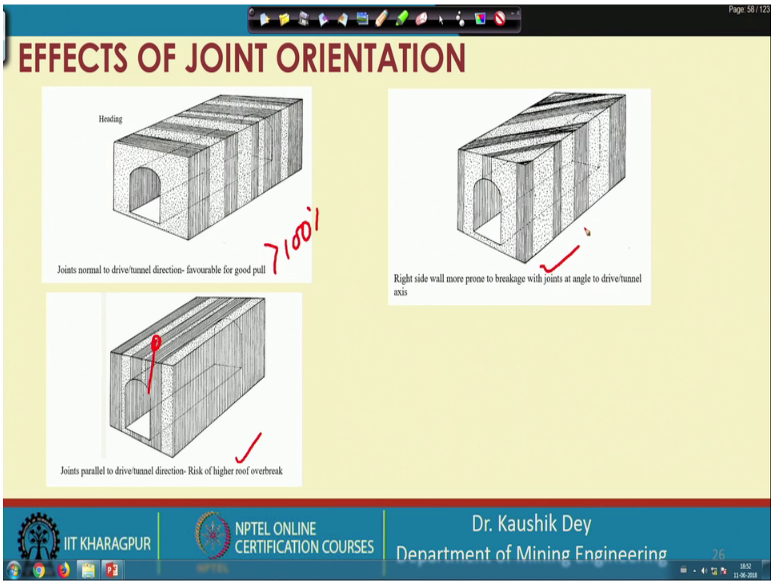

So, you can understand, this is the effect of the joints, if the joint sets are parallel; obviously, last class we have discussing about the pull, almost you will get good pull because, it is the very favorable condition, even if you can have more than 100 percent pull also in this case. In this case, it is very very risky because, as the joint sets as vertical in that case, there may higher roof over break, huge quantity of rock may fall from the roof area. And here joints are at an angle with the drive or tunnel axis and it may be proven that, the breakage will be with the joints and an angle face may be absorbed, which is very difficult in the drilling consideration.

So, these are very very important, for someone is carrying out underground blasting or designing some underground blasting. But for our requirement this is probably sufficient.

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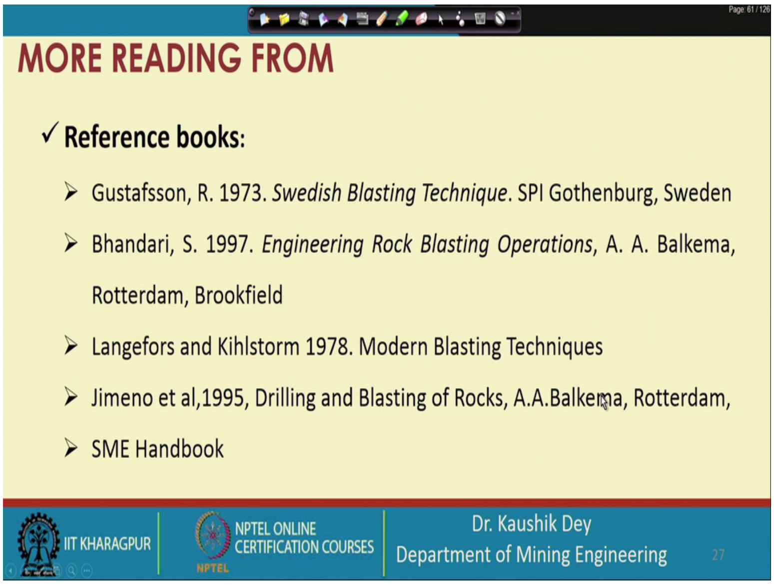

However, you can go for more reading from these books. Again I am particularly referring Gustafson books, Langefors Kihlstorm's books, Jimeno's book, some handbooks. These are very very important. Further readings are essentially can be carried out from this. And, let us stop at this position, next class we will discuss the result of the blasting.

Thank you.