Drilling and Blasting Technology
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Lecture - 31
Underground blast design – 1

Let me welcome you to the 31st lecture of Drilling and Blasting Technology course. In this lecture we will discuss the Techniques of Underground Blasting; this will be the first lecture, we will discuss few underground blast design cut here. And, we will continue the same lecture in the next class also, but like every class what we do we let us retrospect our previous lectures.

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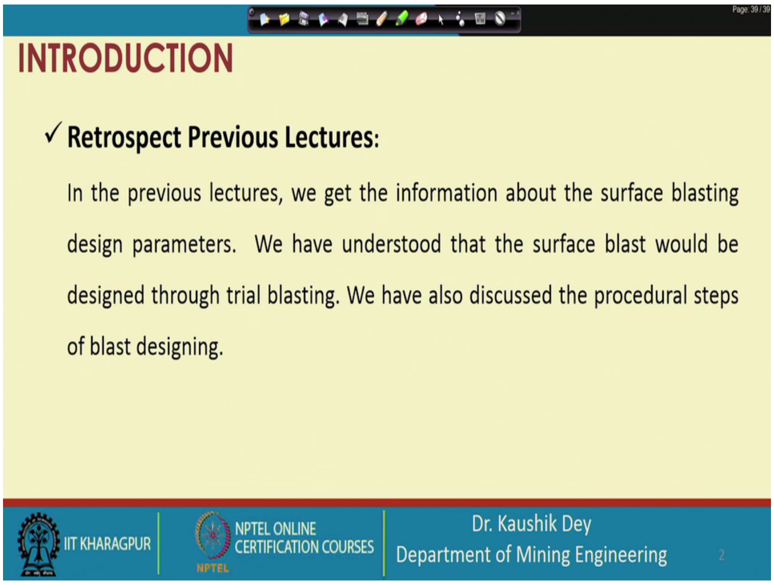

So, far we have covered the information about the surface blasting and surface blast design parameters. And, I believe that you can feel yourself confident that you can carry out a surface blast design. We have understood that the surface blast would be designed through trial blasting; that means, we know exact blast pattern for that unknown rock mass is not possible.

We have to carry out a number of trial blast prior to arrive at the decision, what should be the suitable design for carrying out blasting, in that particular surface blasting condition. And, we have also discussed the different procedural steps to be covered in the surface blast designing. In fact, the procedure is more or less similar for the underground blasting also, but we will discuss how will start in this in this 2 2 consecutive, 2 classes.

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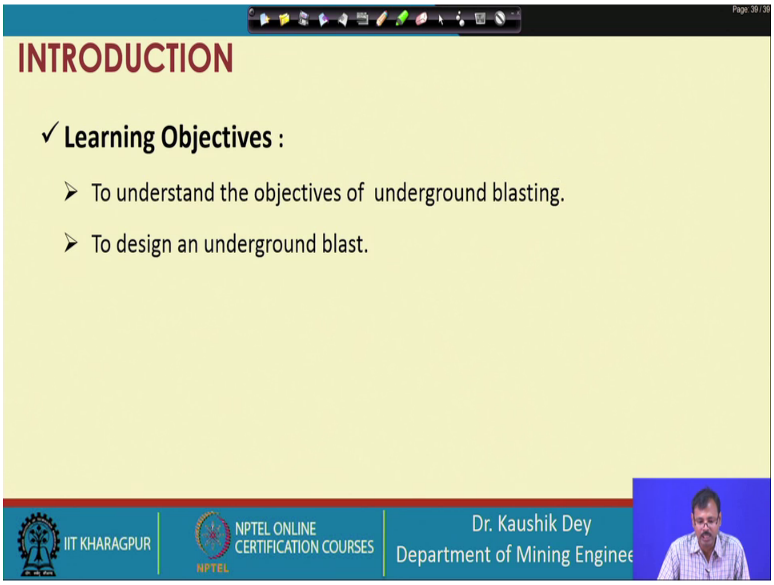

And so, our learning objective for this class and next class is that to understand the objective of underground blasting, and to design an underground blast. So, for this coming to lecture, our objective is to design the underground blast and for that we should understand, what is underground blasting.

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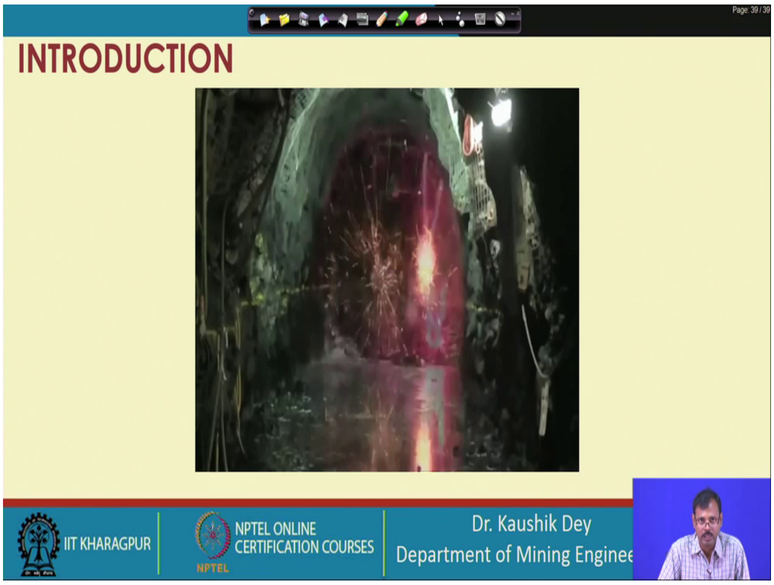

So, let us start with this video for we will get some knowledge about the underground blasting, if we see this video. So, this is one underground you can say opening a tunnel or drift whatever that. Now, you can see this surface connection of the holes are now carried out, then the delay provided in the inside the hole is blasted, you can see the flumes of the explosive now coming out from the tunnel.

And, you can see the first the surface or the outside hole, the connection is carried out and after the blasting of that connections inside the delay which is provided inside the hole that is blasted in little bit time laid. So, that is the objective of this blast and you can understand that this is this blasting is almost very difficult to video graph, because of the generation of the flumes in that blind heading.

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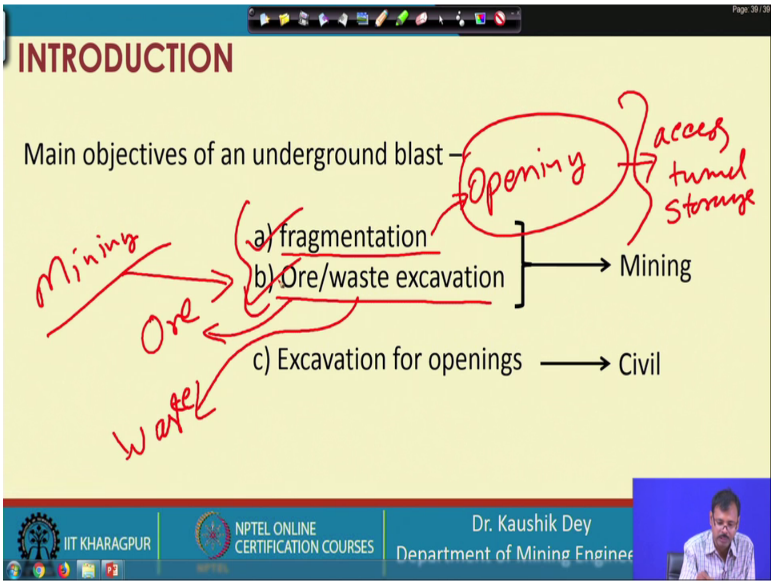

Let us now understand why we carry out the blasting in underground developmental deeps or underground openings. Our first objective is to fragment. Why this fragmentation required? Because, we want to excavate that area that area is filled with the rock mass. So, we want to fragment that rock mass in to a number of small pieces.

So, basically by carrying out this blasting, we are basically fragmenting the rock into a number of smaller pieces. So, that our equipment or the loading machine can handle those smaller pieces and that can be removed to create an opening. So, our objective is that will drill the hole insert the explosive inside the hole and then we blast that explosive to fragment the rock. So, the first objective is basically the fragmentation. The next objective is the ore or waste excavation. So, fragmentation may be carried out in a rock, where we need to create the opening, we need to create the opening.

Or, we need to go for excavation for escorting or removing the ore which can be processed or to create an opening so, that in future time we can extract the ore or remove the ore for that the excavation is carried out in the waste. So, basically we carry out this ore or waste excavation in search of in search of mining. So, this is carried out opening for any other purposes, may be the excess or tunnels or may be storage, whichever the condition it is, but this are for other purposes and this are for the mining purposes. So, that is why this are the 2 main excavations carried out.

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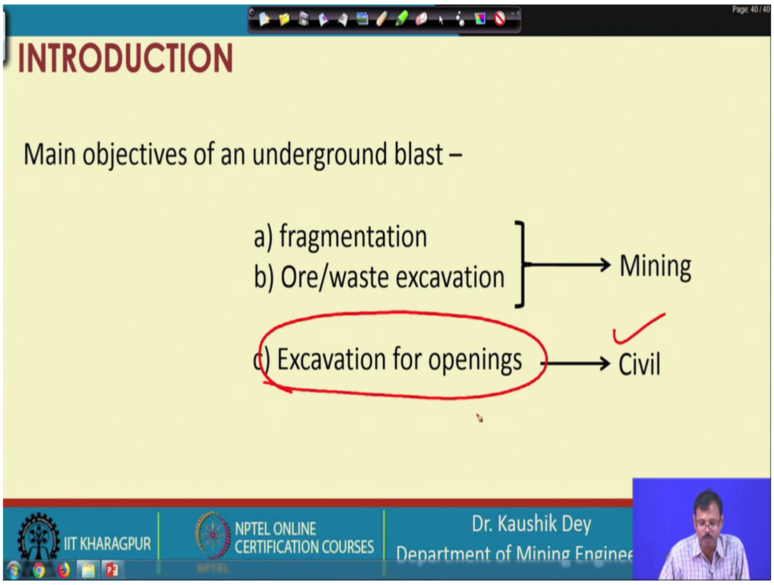

And, this is for the civil structures where the excavation is carried out large underground openings are carried out like theaters underground high stocky stadium all those large openings are created for the different civil purposes. So, these are the different objectives of creating the underground openings and for that the underground blasting are required, because those are carried out in the strong or very strong rocks

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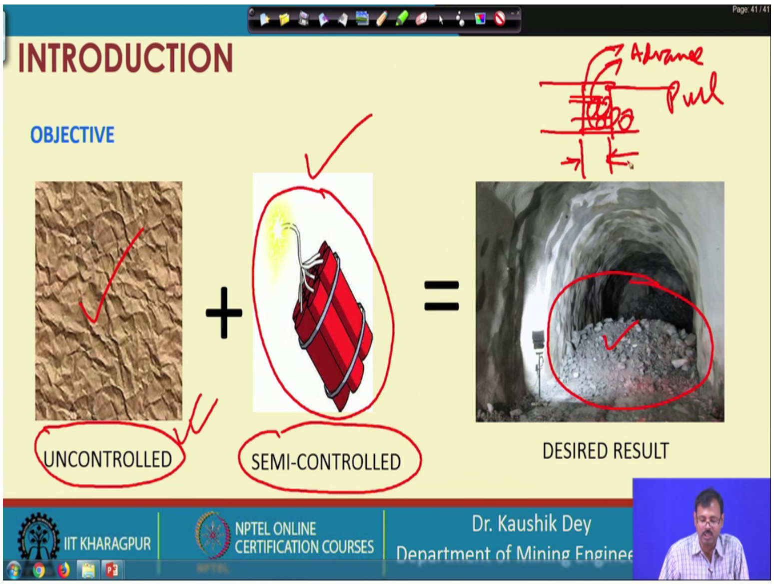

So, like the surface blasting, the present scenario is that we are having a rock, and we are having explosive, and as we have discussed already this rock is uncontrolled we cannot alter this rock, because the rock is there inside that area we cannot change it. This is the explosive sometimes here having the option to change it, but often we do not have the option to change it, because there are it is it may be already procure the decision may be taken by the higher management or often that other types of explosive are not available like in India, we are only having that ammonium nitrate based explosive.

So, like that way we are having some partially contour on the explosive. We do not have any contour on the rock, but we have to achieve our desired result; that means, we have to fragment the rock and with the desired length of advancement; that means, if this is the underground opening and we would like to excavate this part by drilling, this are the drill holes. Then, we expect that at least up to this length to be excavated or to be fragmented into the smaller rock masses, tock pieces.

And, this fragmentation is essentially requires and up to this length, the advancement or pull is also required. So, this is another objective that has to be fulfilled. So, one is the fragmentation that is the size of smaller rock pieces. And, second one is the advancement that is the up to what depth up to what depth, the opening is advanced by one round of blasting this 2 objectives are must be fulfilled in this condition.

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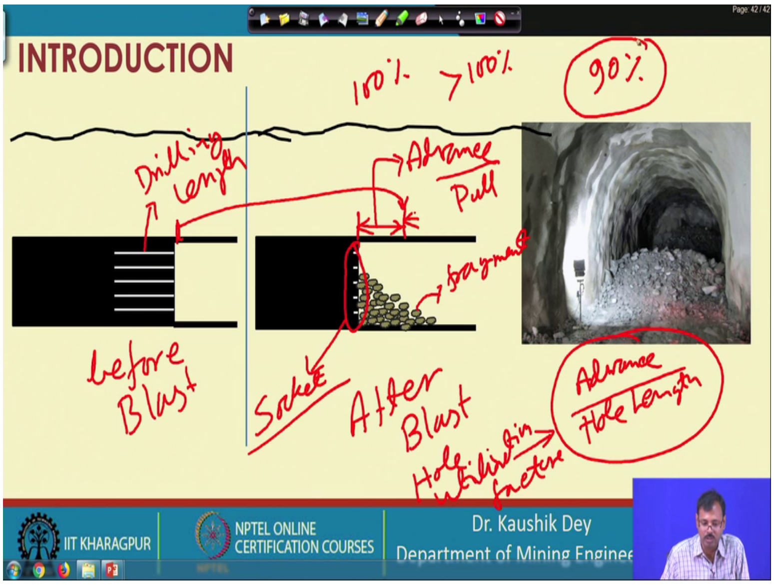

So, in an elaborated way you can see this is the opening prior to blasting before blast. So, this is before blast and this is after blast. And, before blast you can say this is the drilling length you are carried out this much of drilling. And, after blasting you can see you have achieved if this is the previously a previously this part, this is the position. And; that means, we have achieved and advancement this is the advancement or in other terms you can call it pull, if it is a pull mining case upto which the rock is fragmented into the smaller pieces.

So, in this case we are achieving an advance of this much and this portion of hole remain they are as a hole mark which is called socket. So, a very often the hole total hole length is not utilized in this case and a part of hole length is utilized; that means, the advance achieved and the drilled hole length, drilled hole length is having a ratio which is called hole utilization factor, hole utilization factor.

So, in this hole utilization factor we achieve upto a percentage of hole length, that much advance is achieved. it may be considered very good if we are achieving 90 percent, but depending on rock mass condition for very quick rock or if the joint sets are like in very favorable condition, in the those cases we can achieve 100 percent 100 percent hole utilization often, it may be greater than 100 percent also.

But, in more or less we consider ninety percent is very good performance of a of an underground blast, less than that may be often accepted for the difficult blasting condition also.

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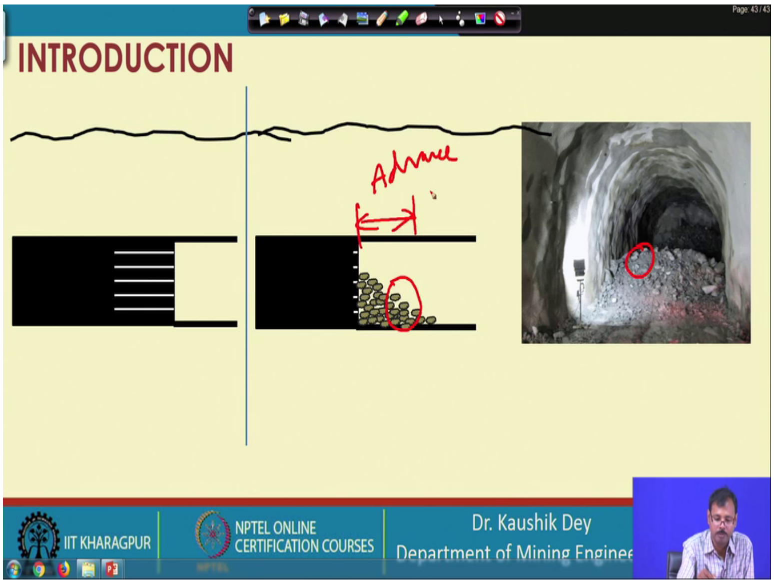

So, our objective of fragmentation objective of fragmentation and objective of hole utilization factor or advance is very important.

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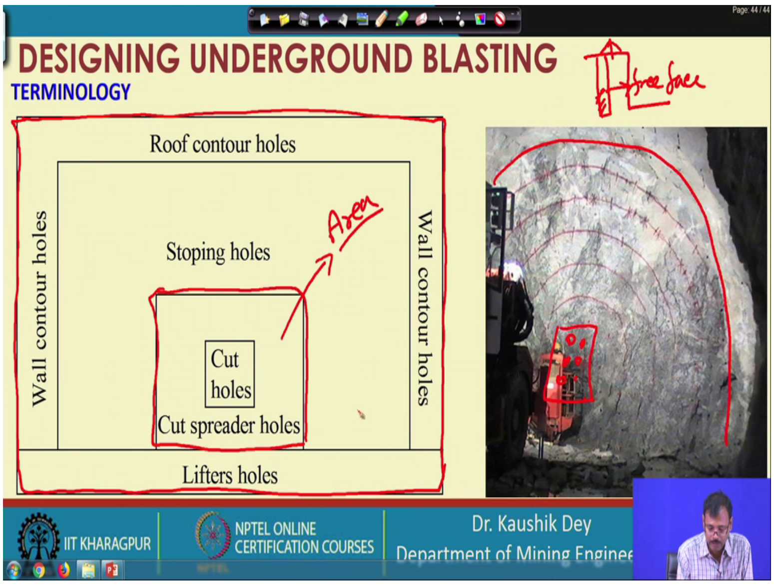

Or now, let us understand the terminology for a particular case if you are looking into the photograph, you can see this is the opening you can see this is the opening this is the opening this side it is not visible. So, this side you can see this is the opening and if you are considering this is the total periphery area, this is the total periphery area which is supposed to be excavated suppose to be blasted.

Then, our procedural is that we create another free face. Now, again let me discuss with you because it is already discussed that in surface blasting we are having 2 free faces, we carry out drilling like this. So, the explosive placed here is having one free font in this direction and another free font in this direction. So, much basically there are 2 free faces available for a surface blasting, but in underground blasting you can see this is the only, this is the only free face available in the underground rock, which is not available in case of second free face is not available in case of underground blasting.

So, our first objective is our first objective is basically to generate another free face and for that we carry out blasting in a part which is called cut area. So, the first area is called cut area, which in general centrally located. In this case this is the cut area in the placed in the central part of the opening. What is the objective of this cut area? The objective of the objective of this cut area is that we drill the hole in this position this are the different holes. So, that we can create an opening in this place first so, if you look into the into this from the session or from the plan view it may it may look like this.

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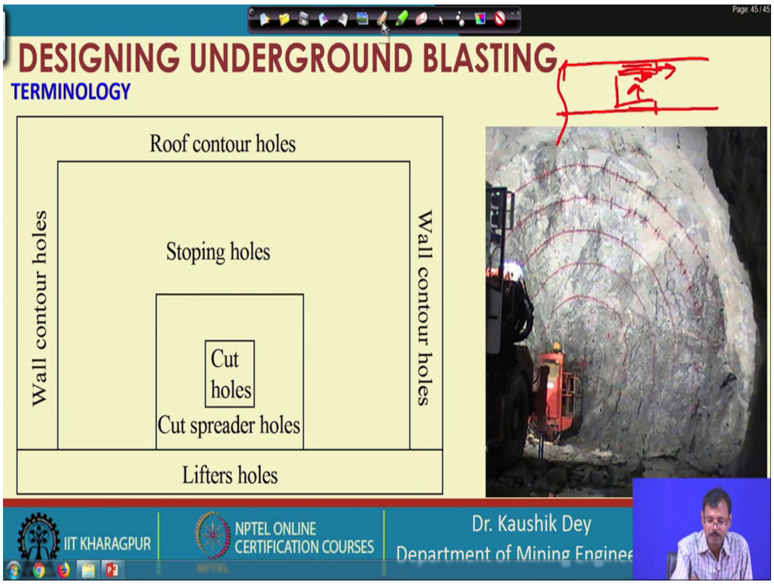

If, these are the holes drilled initially, then we try to we try to create an opening here. So, that so, that the other holes drilled at this position, may use this place as the second free face this face as the second free face other than this one as the free face.

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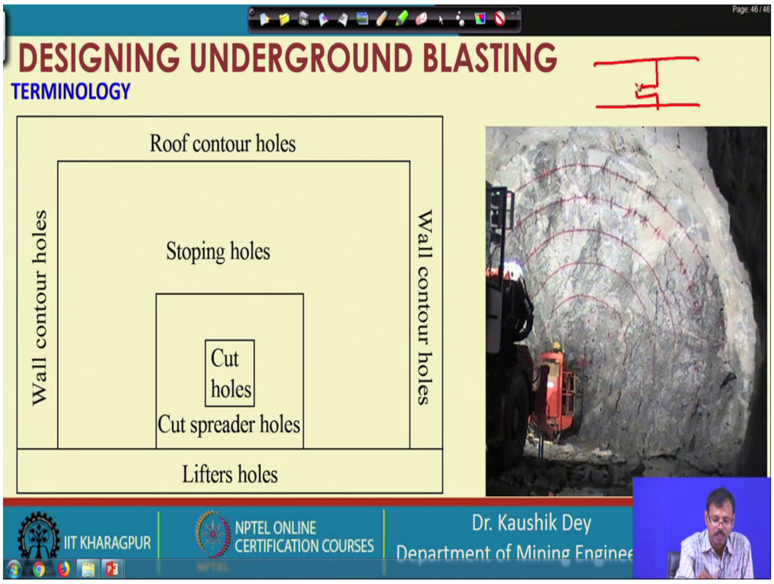

So, our objective is to first create another faces and for that centrally an opening centrally an opening is basically created, in this part which can act as the free phase for the other holes.

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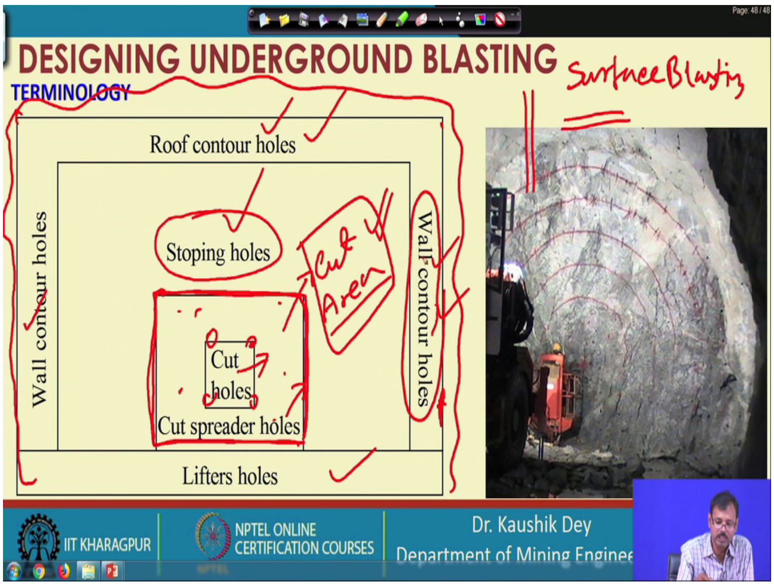

So, for that the area is considered that is called cut area. So, in cut area we drill the holes, the first holes which are drilled and blasted are called cut holes, then the other holes which are drilled and gradually blasted. Till it is achieving a desired length of excavation is called cut spreader hole, and it is respected in cut area the desired length of advance is achieved and then the other holes are placed. So, that that much advance can be kept consistence advance for the remaining of the face area.

So, that is why if this is the cut area and it is very important. And all the designed factors, what will discuss in this class and the next class are basically for designing the cut area only. The designing principle of the stoping holes, which are basically for the holes which are basically used for inclosing the opening area, inclosing the opening area surrounding this cut area. So, that it can be reach to the periphery. So, that those are called stoping holes.

The periphery holes, which are places in the roof side is called roof contour holes periphery holes, which are placed under the wall side is called wall contour holes and which are placed in the floor side it is called lifter holes. So, or floor holes.

So, basically this last row of holes which are placed in the periphery are designed. So, that additional excavations; that means, additional excavations should not be there we want to rest it the excavation upto this desired periphery only, upto this desired periphery only. So, for that the controlling measure is carried out in this designing. So, basically this design part contour holes part and stoping hole part, this design hole part is more or less same to the surface blasting to the surface blasting only the changes are there in surface blasting our holes are vertical here holes are horizontal.

So, only this much changes are there from the surface blasting. So, the design consideration is more or less similar apart from that damage contour techniques in the contour holes, apart from that the design contour holes is more or less similar for the stoping holes and the contour holes, which are more or less similar for the surface blasting holes also. So, the design considerations are made only for the cut holes. So, that is the special characteristics in this designing of the underground blasting.

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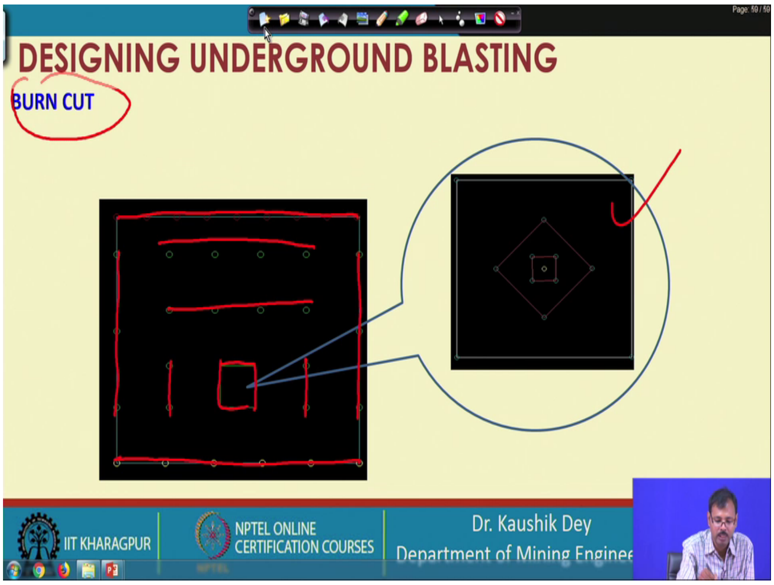

So, now let us consider about the different designing theorem. We are having one burn cut designing theorem, in which the holes are drilled parallelly and all the holes are horizontal there is no angled holes. And, we have already discussed this case in case of our drilling consideration. So, I while we have carried out our drilling patterns for the underground miles and that term we have already discussed how the burn cuts are there?

So, the burn cut patterns are discussed there will design will understand that designing of this. If, you look into this burn cut you can see this is the cut area and the details of this cut design is this one, which we will discuss how it will be there? Then, this are the stoping holes, this are the stoping holes this is the lifter hole or floor contour hole, this is the wall contour hole, and this is the roof contour hole which is basically controlling the damage to the periphery rock mass.

So, our burn cut is specially for the horizontal drilling.

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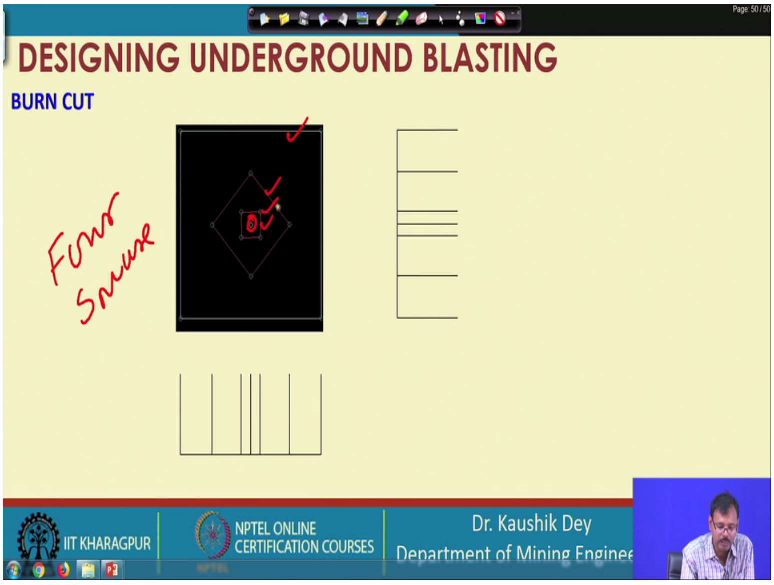

If, you look into the details of the burn cut you can see the burn cut this is basically 4 square burn cut, where you can see basically here it is 3 square, but 4 square burn cut you can see 1 square, 2 square, 3 square if it is required you can go for 4 square also. So, in this square in general you place an empty hole in the center, which is surrounded by the explosive loaded holes.

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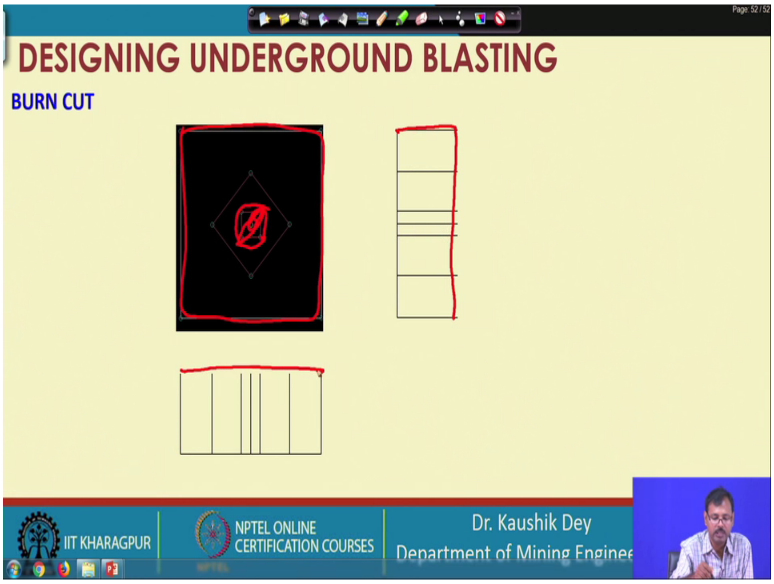

Empty holes, then the explosive loaded holes and this empty hole is basically act as the free face for this loaded holes. So, if we are asking this one first, if we are blasting this one first, then this act as the free face and ultimately an free face area is developed like this.

Similarly, when this one is blasted a free face area is developed like this. So, while this one is being blasted that time the total free face length is this one to this one. So, this will be blasted considering this total area is the free face area. And, gradually like this gradually the free face area is becoming extended. And it is finally, reached upto this the total free face area is achieved and it is respected that the desired length of a excavation will be completed at this place, in this place also.

So, this is the basic consideration of the burn cut blast design.

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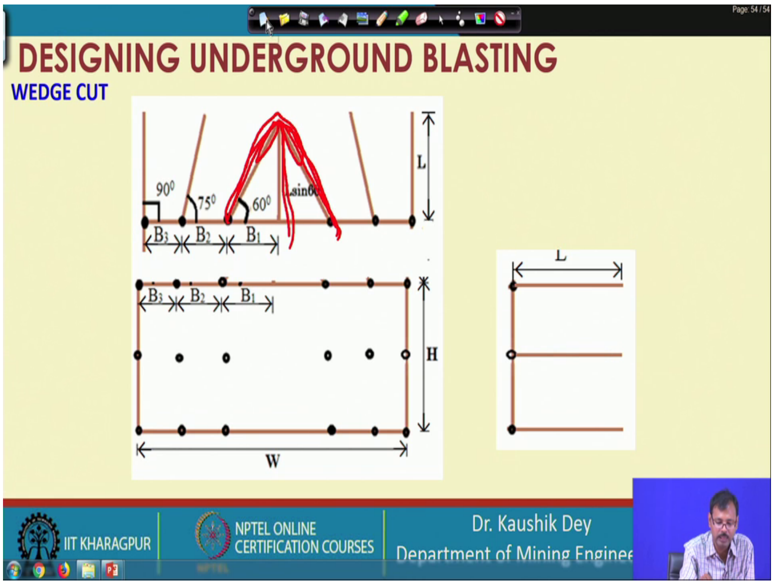

This is the wedge cut blast design, where we consider the initial an angle is provided. So, that will there is no; so, that a particular rock resistance at this place may be reduced. And, basically a cutter blasting type blasting will occur and if the explosive will placed here, this will try to excavate to this portion of rocks and explosive placed at this position will try to excavate this position of rocks.

So, finally, by blasting this one and free face may be created like this. So, by blasting this one a free face may be created like this.

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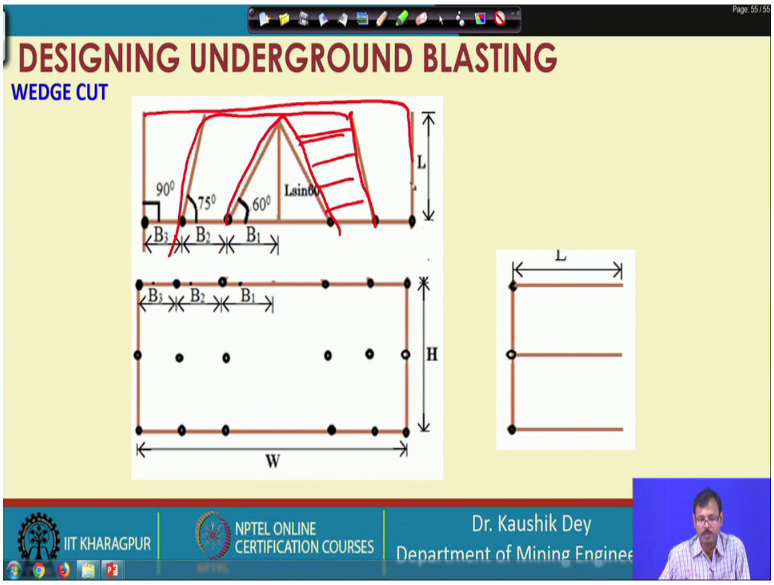

So, for this hole this will act as the burden and a free face like this will be observed after this blasting. And finally, a free face like this one will be observed. Basically in our design consideration we have already discussed, that fan cut and drag cut is basically up wedge cut.

And pyramid cut is basically a double wedge cut. So, our design consideration will discuss a mainly for the wedge cut and for the burn cut only, we will discuss a very little of the fan cut and drag cut.

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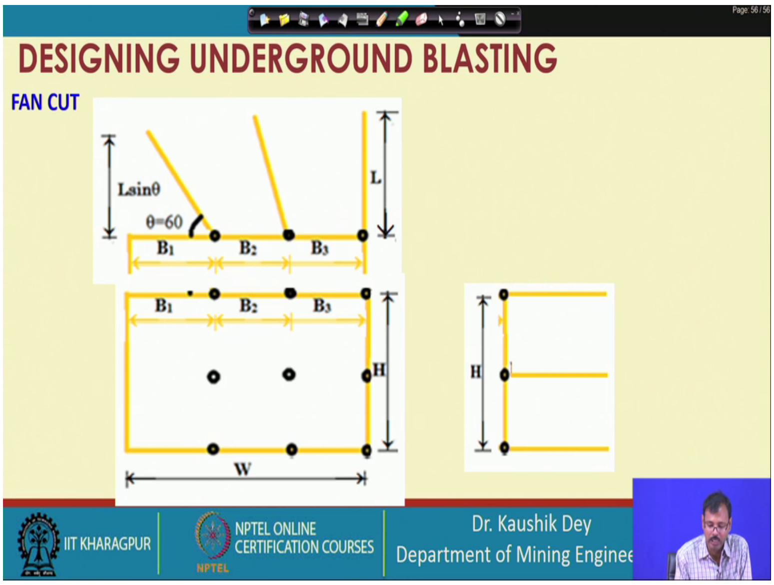

So, let us see how it is how the fan cut is there you can see if the fan cut is basically up wedge cut, where the wedge is wedge is placed horizontally. That means, if you look the previous one again you can see if you are if you are cutting this part.

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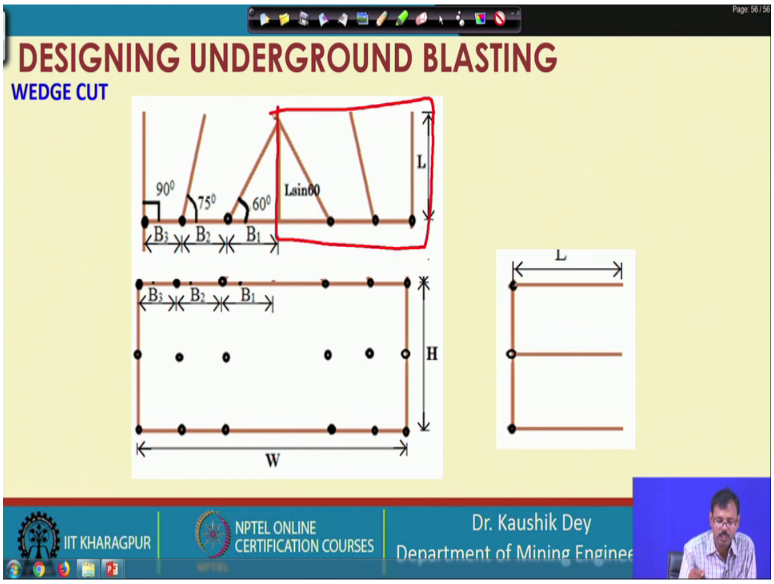

It is more or less it is more or less becoming similar to the fan cut. It is becoming more or less similar to the fan cut.

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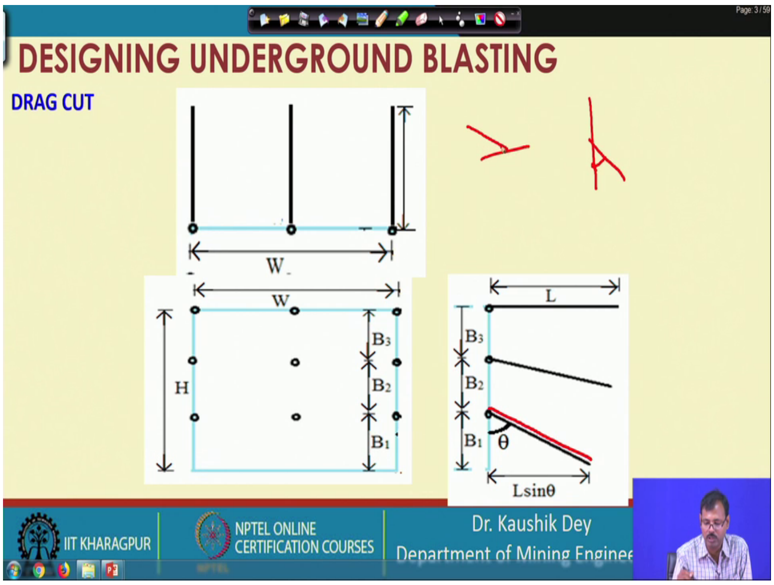

And, if you just tilt it 90 degree. So, that the wedge angle is becoming creating an wedge with the horizontal, creating an wedge with the horizontal then it can be called as drag cut. So, basically this is fan cut and drag cut this are 2 up wedge cut, where the wedge is creating in drag cut with the vertical in fan cut in fan cut we get the horizontal. So, this is the little bit modification in the wedge cut is made considering the different rock mass condition.

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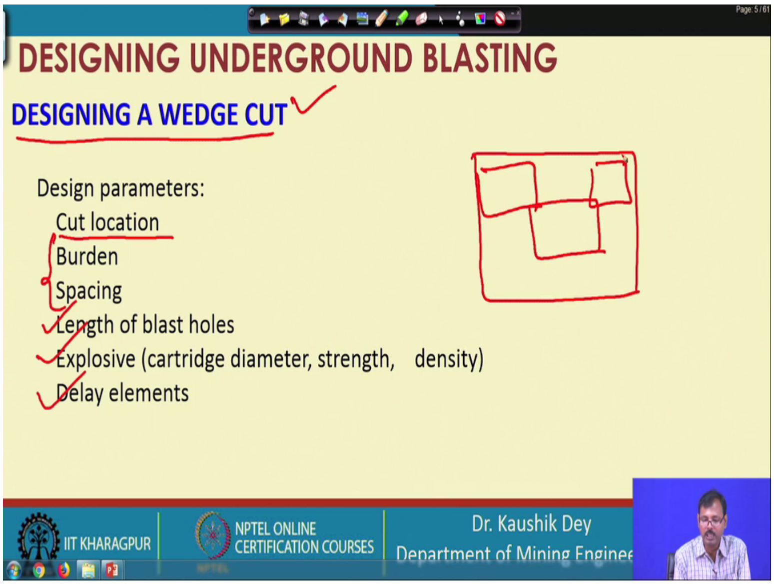

And that is why basically we carry out our designing forth wedge cut and for the burn cut not for any other cut, the procedure is more or less similar for the both the for the other cases.

So, let us start our designing the wedge cut, which is our main objective for this lecture next class we will discuss about the designing the burn cut. So, our design objective for our wedge cut is that, first we have to decide the cut location. Then, we have to compute the burden and spacing, length of the holes, explosive requirement and the delay assigning.

So, first our requirement is assigning the location of the cut area. So, this is the location of the cut area and this may be at any place, cut area may be at any place and where it has to be placed that is the first essential decision.

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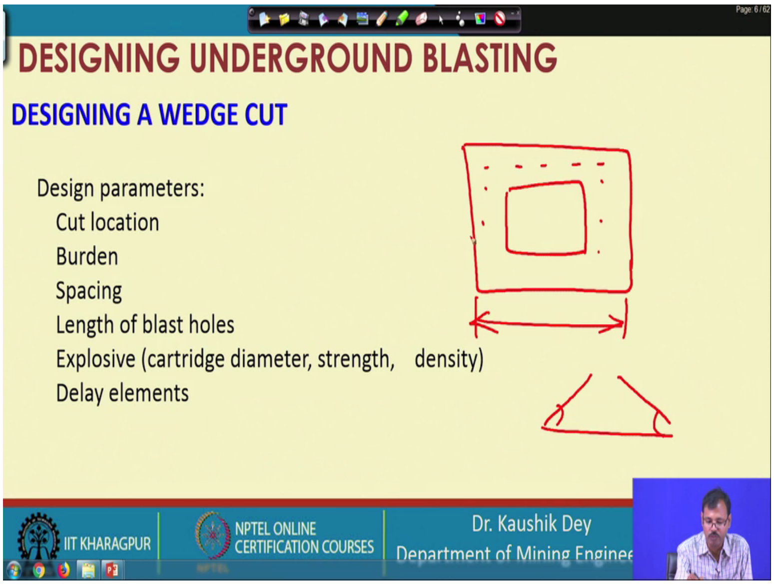

In general the most common believe is that, we have to place the cut centrally. So, that once it is carried out the for the rest of the places it can be used symmetrically for the other stoping holes.

So, in general we place the cut centrally and you understand, while drilling class we have discussed the main drawback of the wedge cut is that, it is length is basically dictated by the area or world width of the opening. So, drilling length is basically dictated by this because the first angle is there which is basically restricting the drilling length.

So, that is why in general we try to have an very wider wedge, we try to have an very wider wedge cut, in an effort in an effort to achieve the maximum length to be drilled.

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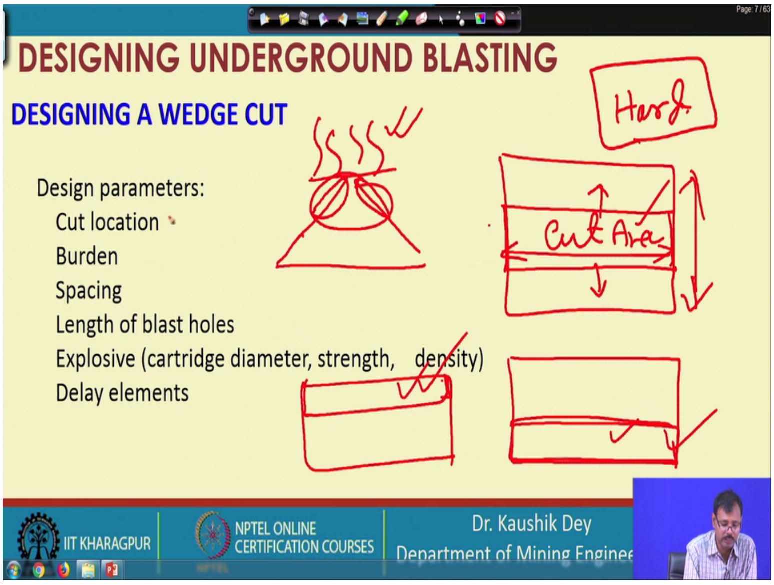

So, this is the cut area in general we try to achieve, but we can have the option we can have the option we can place our cut area may be at this position or may be at this position. So, the cut area may be varied at different position in vertical consideration, ideally it should be in the central part, or it may be in the lower part, or it may be in the upper part.

So, this type of variation is possible though we try to place it centrally and maximum width must be covered maximum width must be covered. So, that we can have the maximum length, but one consideration is very important at this place, in cut area you can understand we are having the charge concentration is very high. So; that means, if you are placing charge at this position charge at this position, charge concentration in this position is very high, which may damage, which may damage the rock part below that level where it is not blasted.

So, to avoid that situation, generally in practical cases we try to little bit shift, our cut area little bit, lower part little bit, upper part. So, that much shifting is carried out very frequently in a hard mass rock blasting condition, where wedge cut is utilized, because the damage rock mass it is very difficult to carry out drilling. So, cut location is decided basically considering all this, but ideally or theoretically, it must be placed centrally now let us see, how we will calculate the burdening spacing?

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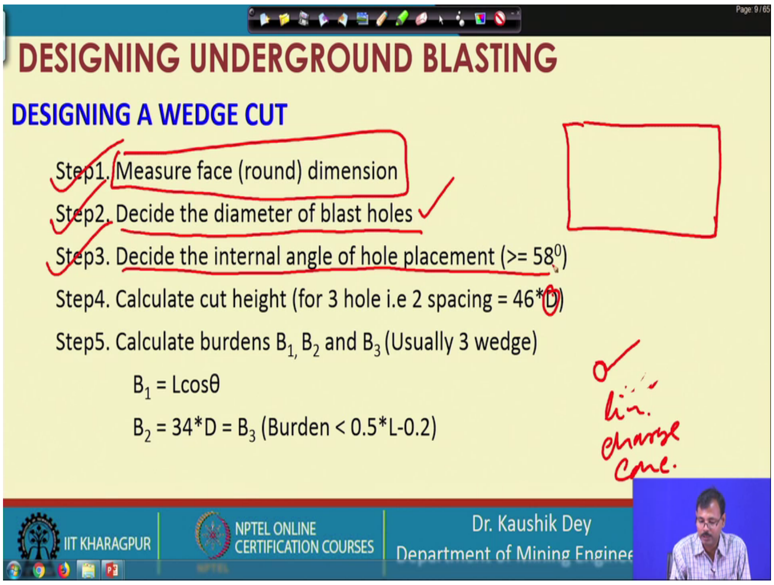

So, our let us consider it in step by step mode our first step is that we have to measure the dimension of the face. So, first consideration is that we have to measure the dimension of this, because this width is basically dictating our wedge cut drilling length. Then step 2 is let us decide the diameter of the blast hole first, basically this are the iteration. So, what this iteration? Initially, we assume some diameter of the hole, because the diameter of hole is basically guiding the linear charge concentration, linear charge concentration.

So, basically this is dictating the linear charge concentration and that is why we decide the blast hole. And, most of the authors those who have give the guideline of the designing the blast, they basically starts their they basically starts their designing with the diameter of the hole. So, we first assume some diameter of the hole first, then our next assumption is the to decide the internal angle of the hole to be placed.

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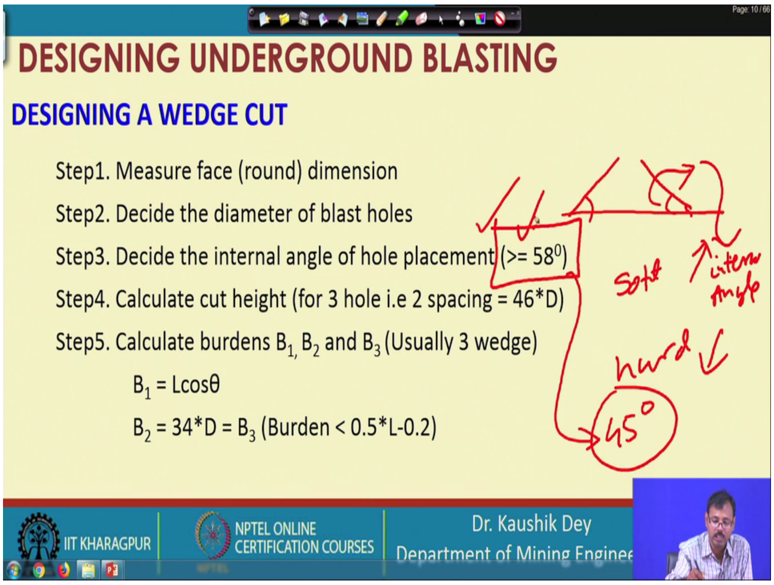

That means, the first angle, the first angle in an wedge cut has to be provided, that is angle needs to be decided. Basically, the guideline is that if the rock is soft will go for the impleast angle internal angle internal angle, impleast internal angle if the rock is hard we have to decrease the internal angle, but in no case we should not go less than 58 degree or you can say it is one radian we should not go less than one radian of this value.

This guide line is given by Langefors Kihlstroms Gustafsson etcetera. Though if you see the Dj deshmukh book you will find out this is given 45 degree as per the Dj deshmukh book. But, in practical cases in general we follow this one, especially, in the hard rock blasting condition, we must follow this 58 degree considerations.

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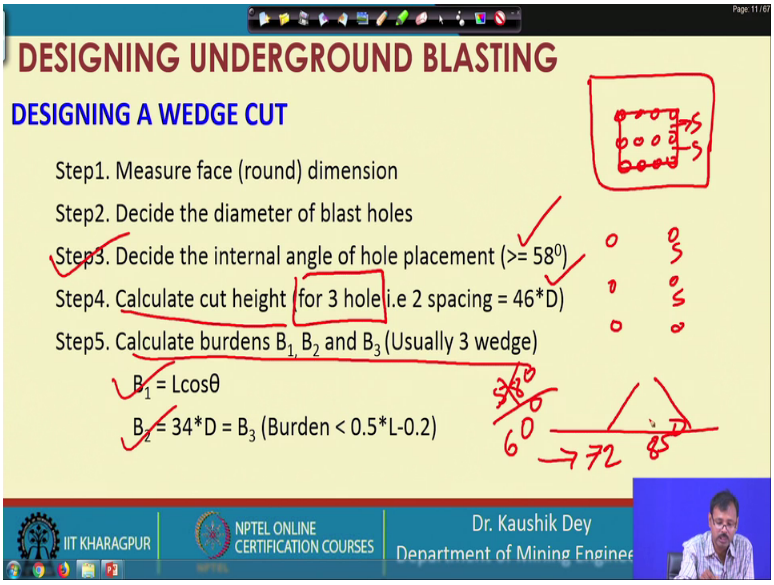

Then, we have to calculate the cut height, in general this cut height is considered for 3 holes; that means, this are the 3 holes for which this blast is designed and this is the cut height.

So, if this is the area of the opening, this is the cut area it is a expected the holes are like this and another holes are like this. So, that the cut area is basically 2 spacing, 2 spacing this are the spacing and that is in general considered 46 into D as per Langford guide line. And, after decision of the first internal angle, in general we calculate the burden as per this B 1 is l cos theta, B 2 is 34 degree, 34 D is equal to B 3, and we accordingly we change the angle from 58 degree basically we go for 60 degree instead of 58 degree, because it is easy to measure, then that to 72 degree, 85 degree like that way depending on the rock strength consideration.

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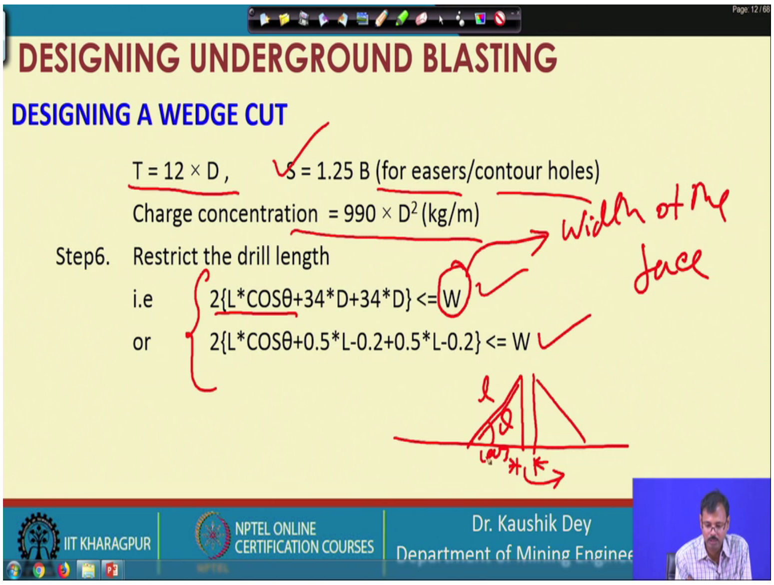

So, basically these are the design guide line as per Langefors Kihlstorm, we go for this is the stemming length T is equal to 12 into D, which is considered. And, this is the spacing for other source stoping holes and contour holes, in general we go for spacing is equal to 1.25 burden, charge concentration is considered this one and drilling length restriction is considered as per this 2 condition, you can see where W is basically giving us the guideline about the width of the width of the face.

So, basically 2 into if you go for 2 into l cos theta. So, this is l cos theta. So, this is 2 into l cos theta if there is some gap, then you have to add this one which is not added here.

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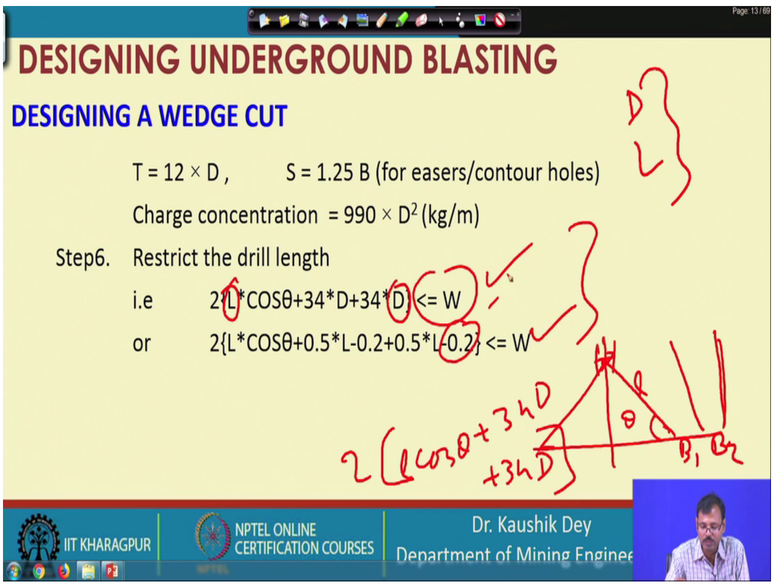

So, this is 2 into l cos theta l cos theta, so l cos theta if you are considering this step, then the next burden then the next burden. So, this is B 1 B 2. So, l cos theta 34 D plus 34 D, this are the 2 burden this multiplied by 2 is basically the total face and this must be less then equal to total face that is the restriction or this is the condition, this is basically consideration of this additional this wedge part, if appearance is considers in this case.

So, if these 2 conditions are not satisfied we have to change the drilling length, we have to change the drilling dia and we have to go for the next iteration. So, basically we have to consider, we have to consider this D, we have to consider this L, then we have to go for the design considerations, and we have to check whether it is satisfied, then we have to accept it go for the trail blasting, otherwise we have to go for the next iteration for this blasting.

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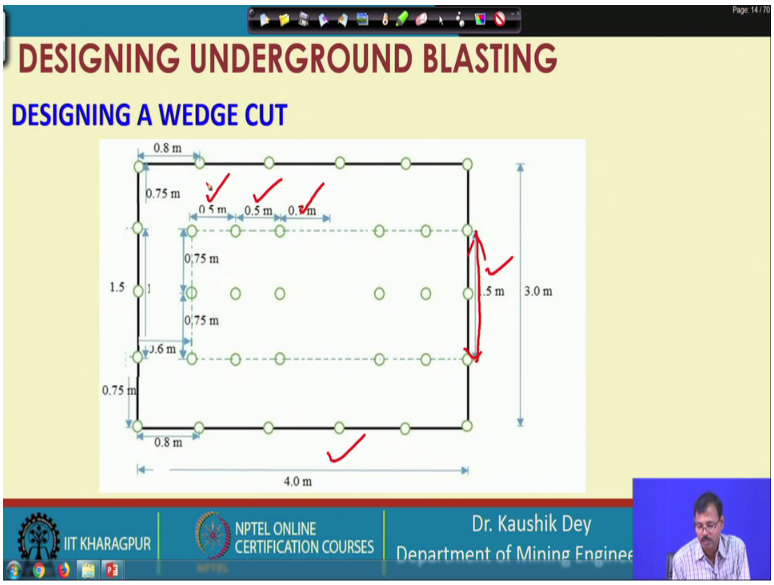

So, let us consider one such design experiment. In this case it is a 4 meter tunnel width for wedge it is considered and you can see this is the first L cos theta is coming 0.7 meter, then the 36 34 D is coming 0.4 meter 0.4 meter. This is the 2 spacing is coming 1.5 meter, that is 46 D and considering this is the total face design.

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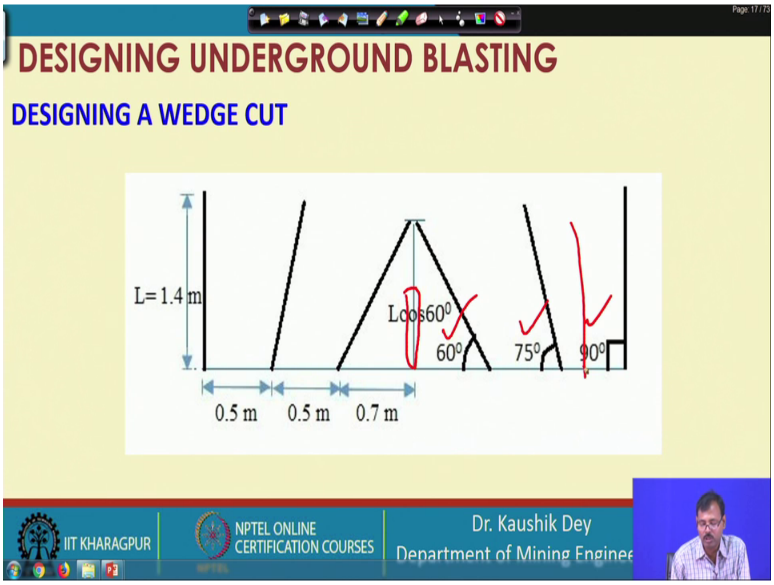

And, you can see this is the first consideration is the 60 degree, 60 degree second consideration 75 degree, next the third one is 90 degrees. So, this is the consideration in very hard rock condition we have n number of modifications are there we go for the stab holes here we can have more angle drilling in between. So, all those are considered while we are carrying out the trial blasting in actually filled and based on that designed modification has to be created.

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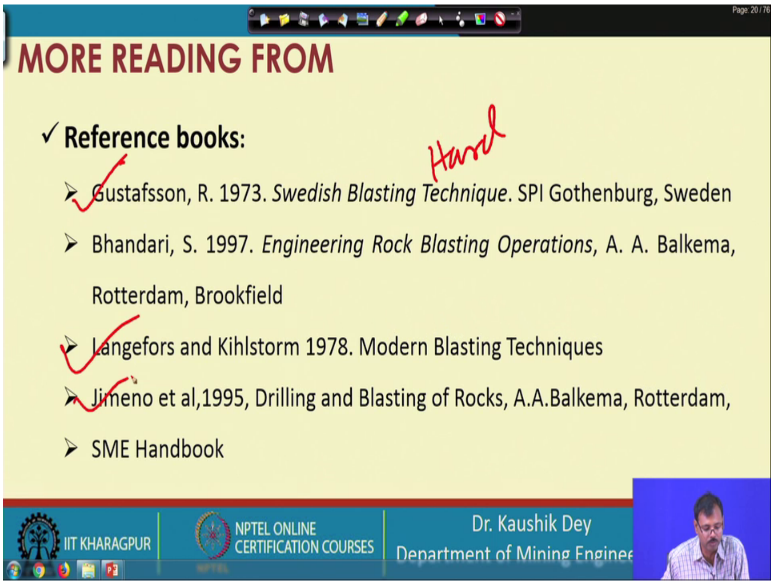

You can go for more reading for wedge cut design blast design pattern. Specifically this 2 book is very important, this 2 book is very important, for the wedge cut blast design in especially for the hard rock condition. In soft rock condition 60 degree is not at all required you can go with the 72 degree or 75 degree like coal etcetera, that gives us little bit easy in Jimeno book also a good representation of this Gustafsson and Langefors Kihlstrom criteria is also available.

Basically wedge cut is very popular because the explosive requirement is less in wedge cut as compared to the burn cut, we will continue with the burn cut in the next class.

Thank you.