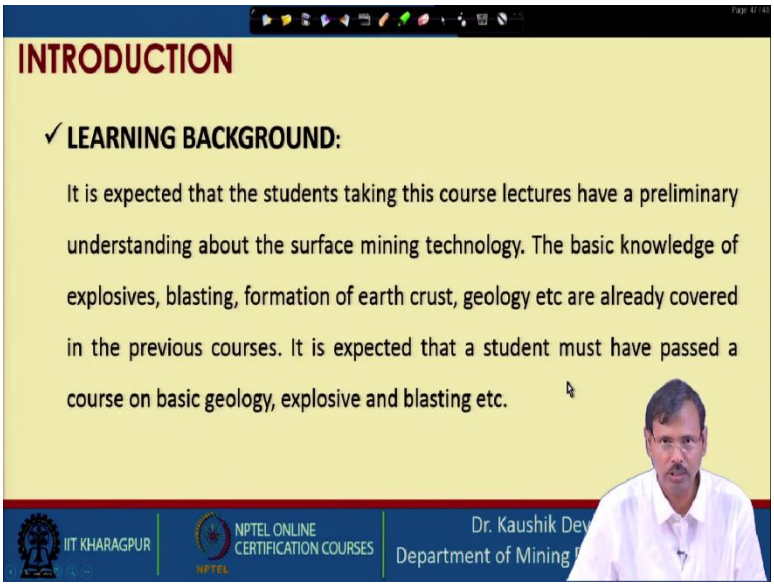
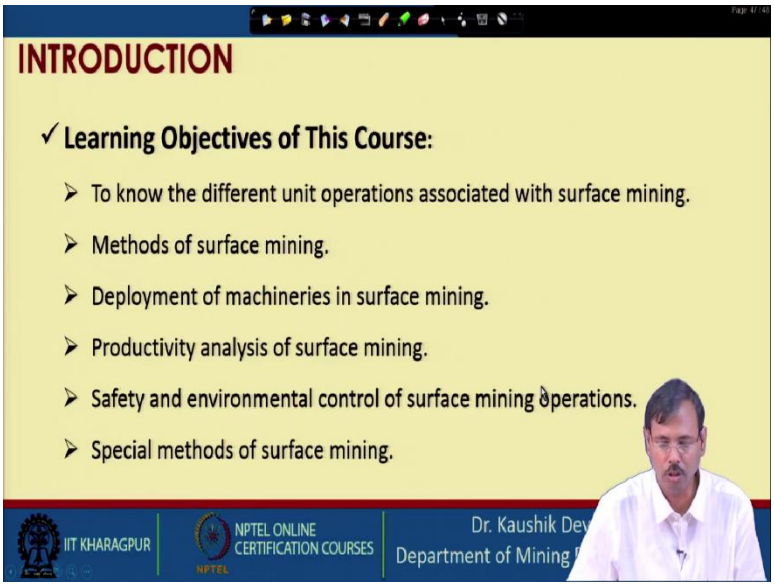
Surface Mining Technology
Professor. Kaushik Dey
Department of Mining Engineering
Indian Institute of Technology, Kharagpur
Lecture No. 04
Stripping Ratios and Pit Layouts - II

Let me welcome you to the fourth lecture of Surface Mining Technology. This is also the introduction to Surface Mining part. Today's lecture is the second lecture on the stripping ratios and pit layouts.

(Refer Slide Time: 0:29)





INTRODUCTION

✓ **LEARNING OUTCOMES:**

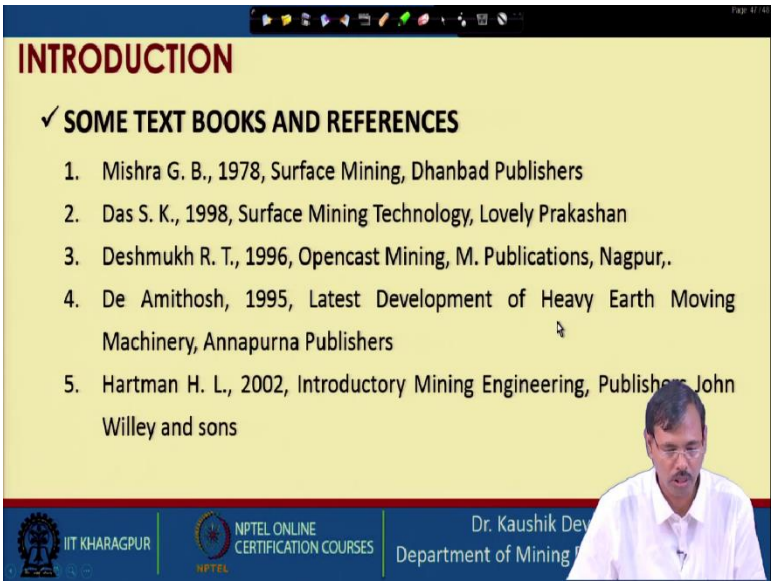
It is expected that the students taking this course lectures will be able to envisage the surface mining operation and its technological nitty-gritty. It is expected that a student will be abled to design the drilling and blasting rounds for surface blasting, will be able to choose, deploy and design the mine machineries for a set production target. The desired s[illegible] and environmental requirements will also be addressed.

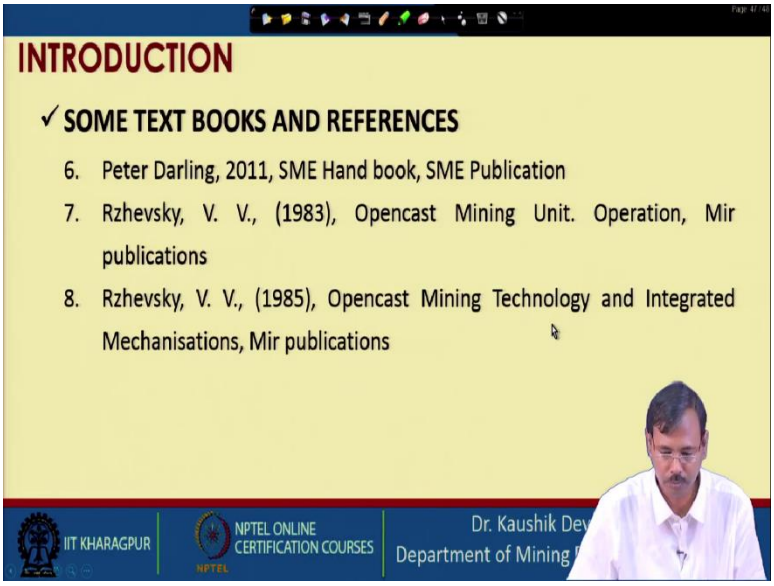
INTRODUCTION

✓ **LEARNING OUTCOMES:**

The student will also have an overall idea about the special methods of surface mining including sea bed mining, dimensional stone mining, highwall mining etc. The students will also able to deliver the technological and managerial requirements to the special safety requirements like slope stability and sump management etc.

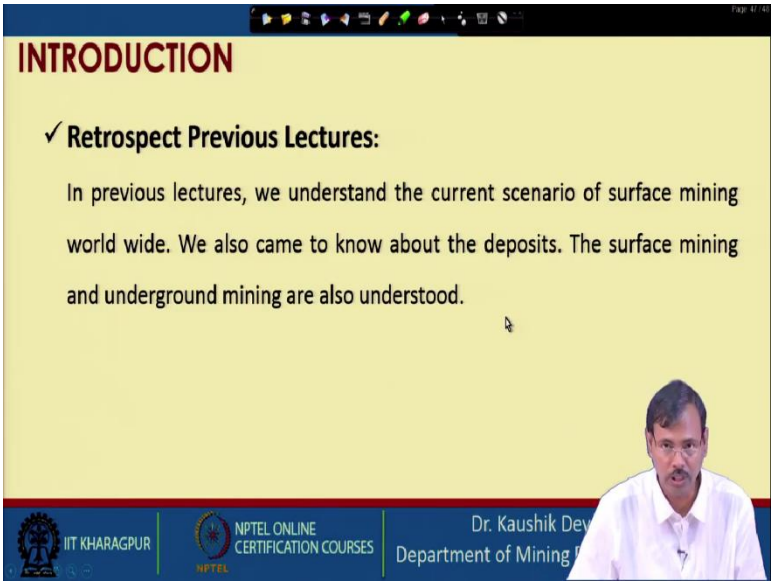
IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | Dr. Kaushik Dev | Department of Mining





We have already discussed as per our requirement, the learning background for the course, Surface Mining technology. This is the learning objective of the Surface Mining Technology course. And this is the learning outcomes of the Surface Mining Technology course. This is a continuation of the same and these are the different textbooks and reference books.

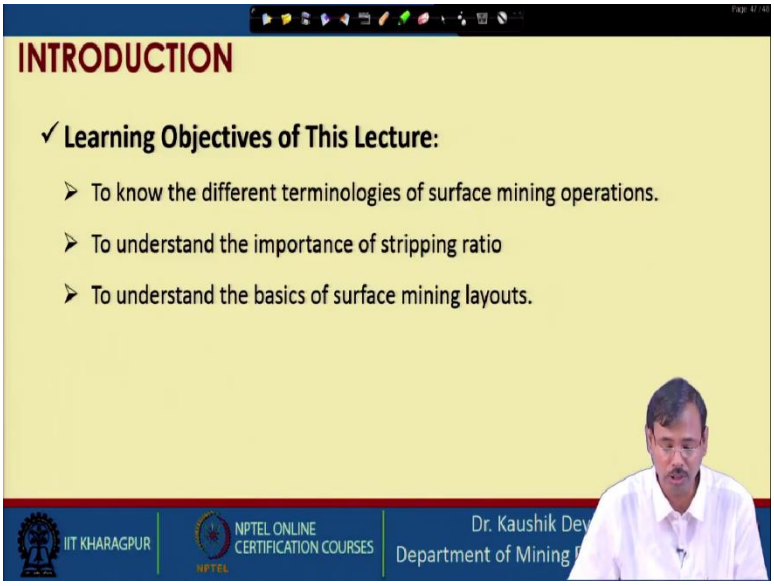
(Refer Slide Time: 1:09)



Now, let us see retrospect what we have discussed in the previous lecture. In the previous lecture, you know we have discussed already in the previous class also, we understand the current scenario of surface mining worldwide. We understood in surface mining, the main problem is the land acquisition and that is very, very, very important.

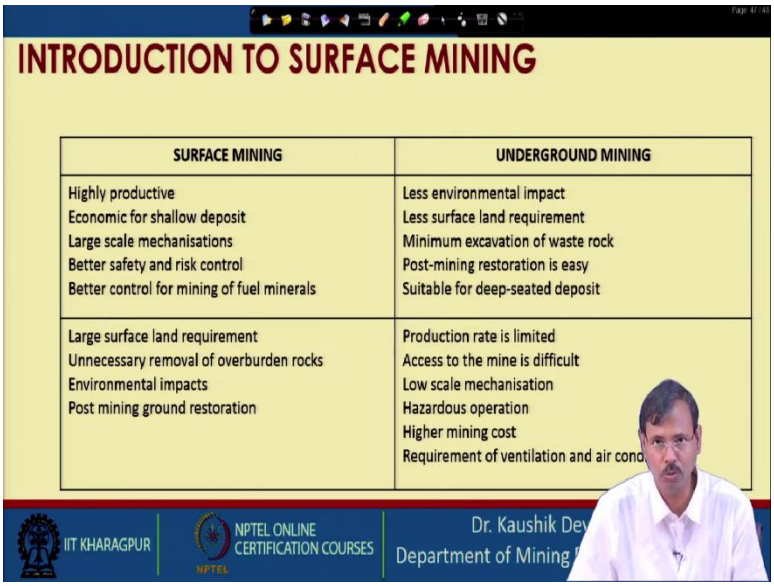
Surface Mining is the main mining system; more than 90 percent of the minerals are being produced from the surface mining. And in last class also we are discussing with our relatively, trying to understand that whether surface mining is possible for, up to how much depth or it can be economic for the deep-seated deposit or not. So, those are, we are in a little bit dilemma, and we will try to know whether the Surface Mining Technology can be applied for the deep-seated deposits or not.

(Refer Slide Time: 2:10)



So, in this lecture our objectives are same as we mentioned in the last lecture also, to know the different terminologies related to surface mining; understand the importance of the stripping ratio. So, far we have not discussed what is stripping ratio, in this lecture, we will discuss it, what is stripping ratio and to understand the basics of surface mining layouts, which we will discuss in the next lecture.

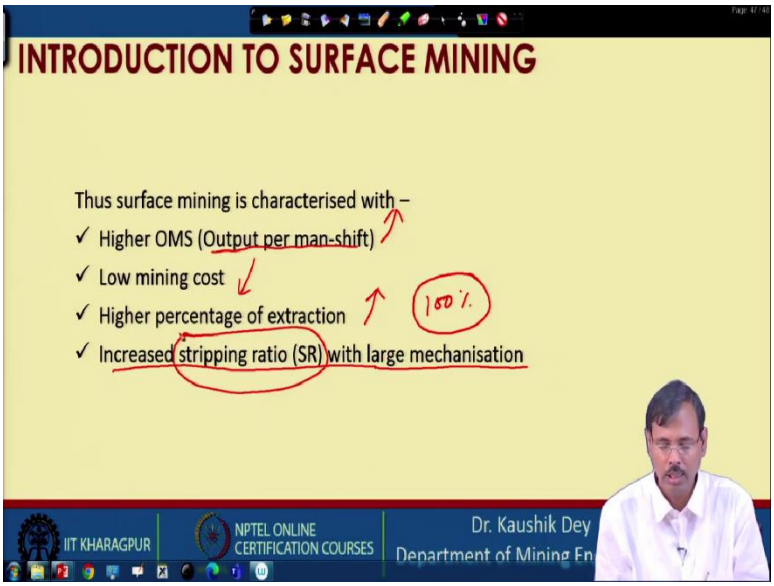
(Refer Slide Time: 2:39)



So, this slides we have already discussed in the last class. In this slide, we are discussing about the perspective of surface mining and underground mining. And we have found that there is no clear

demarcation that up to this step surface mining is possible, up to, beyond this step underground mining has to be carried out. So, this is basically a strategic decision, and this strategic decision should be taken with some economic considerations.

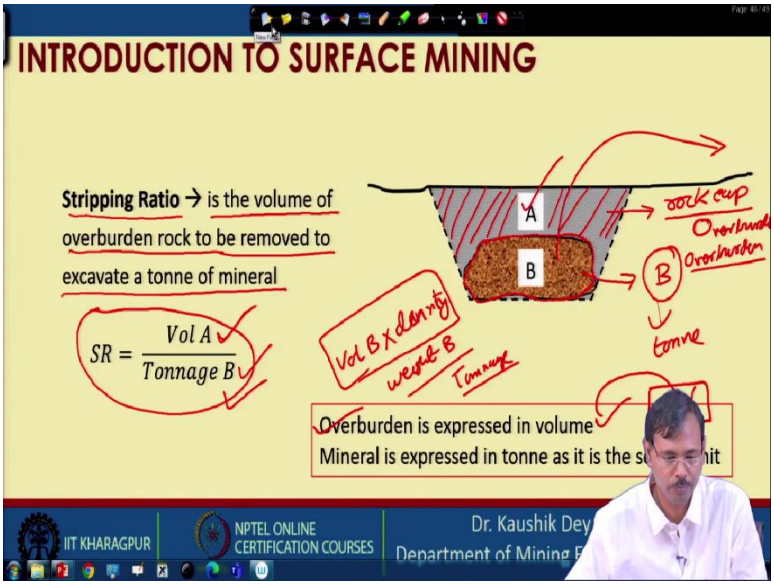
(Refer Slide Time: 3:14)



So, surface mining is basically characterized as we have seen as per our previous lectures with high productivity that means, production per man-shift is very, very high. Mining cost is very, very low. The percentage extraction is very high, because we do not keep any pillars for the supporting. So, whatever available ores are there, complete 100 percent escalation of the ores are possible in surface mines.

And surface mine can be carried out with increased stripping ratio, if we are having large mechanism. Now, this new term is there, stripping ratio. So, what is the stripping ratio, let us try to understand.

(Refer Slide Time: 4:25)



Stripping ratio is the term used for the volume of overburden to be removed to excavate a ton of minute. So, that means, whenever we have carried out underground mining, we need not to remove overburden. But in surface mining, we have to remove overburden. Now when, while we are comparing this two, we have to understand for taking out 1 ton of ore how much waste rock or overburden rock is required to be excavated and taken out for getting that 1 ton of ore. So, this ratio is called stripping ratio.

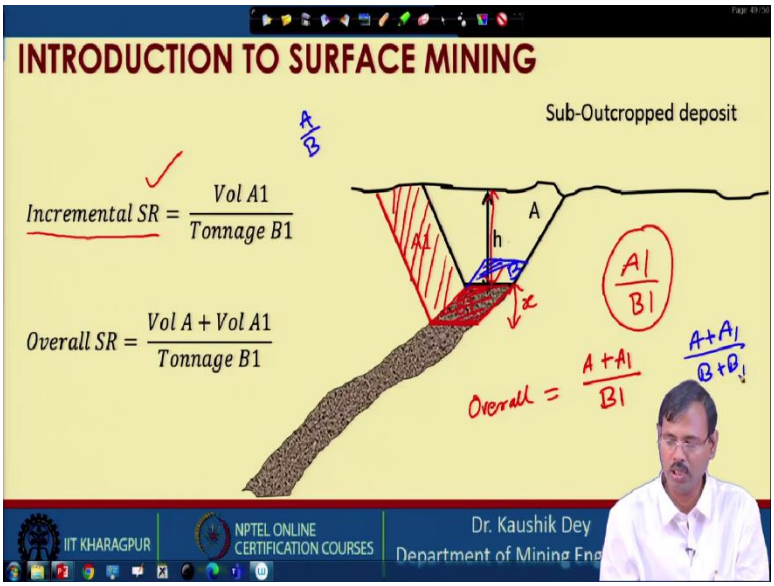
Now, if you look into this figure, you can see this is the ore, which we need to excavate and the total ore tonnage is B, but to take out this ore from here to outside, we have to excavate this portion of waste rock, which is basically the rock cap, rock cap lying above this mineral, lying above this mineral. So, this rock cap is called overburden.

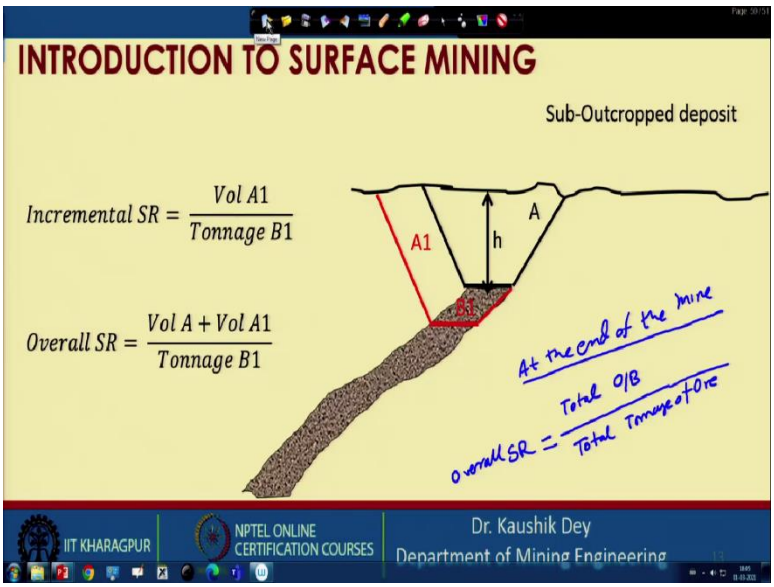
So, this stripping ratio is the ratio of volume A that is the volume of overburden and the B, tonnage B because the ore is in general expressed in ton. So, this is tonnage B means the volume B, multiplied with the density is basically giving us the weight B that is called tonnage. So, this stripping ratio is the volume of overburden divided by the tonnage of ore that is called stripping ratio.

So, in other word, to get 1 ton of material, how much volume of overburden has to be removed that is called stripping ratio. So, this line is important overburden is expressed in volume because it does not have any commercial value, but you have to find out a volume area where you need to

accommodate that one. So, that is why overburden is expressed in volume because you need to address that for removing and placing that in a particular place, that is why it is called volume here and mineral is expressed in ton because it is sold in ton.

(Refer Slide Time: 8:22)





Stripping ratio can be of different types. Let us discuss the different types of stripping ratio which is available. First is that increment, first is that Incremental Stripping Ratio. Incremental stripping ratio means, suppose, today you are having a mine position up to this. Now, your mine management has decided that to increase further depth of a portion up to x, then what is the situation?

So, if you are extending your operating depth from h to h plus x in that case, by doing this you will generate an additional B1 tonnage of ore. But to get that one additionally you have to take out your A1 volume of waste rock or overburden rock. So, this A1 by tonnage B1 is called incremental stripping ratio.

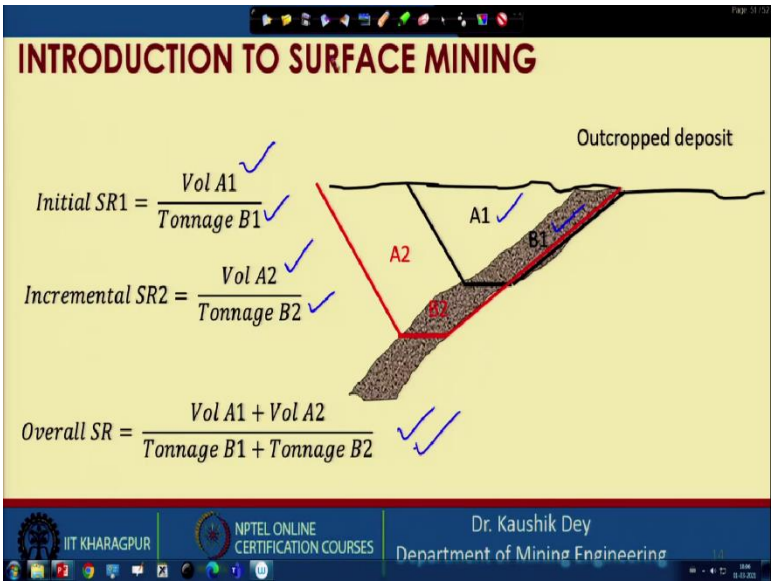
$$Increamental\ SR = \frac{Vol\ A1}{Tonnage\ B1}$$

$$Overall\ SR = \frac{Vol\ A + Vol\ A1}{Tonnage\ B1}$$

And if you have carried out this and an incremental volume of A1 is removed an incremental tonnage of B1 is achieved then your overall stripping ratio, overall stripping ratio will become volume A plus volume A1 divided by B1. If you had some, suppose you had some previously owned ore B here in that case, before this your stripping ratio was A by B and then after an incremental excavation of depth x, your overall stripping ratio in that case will become A plus A1 by B plus B1.

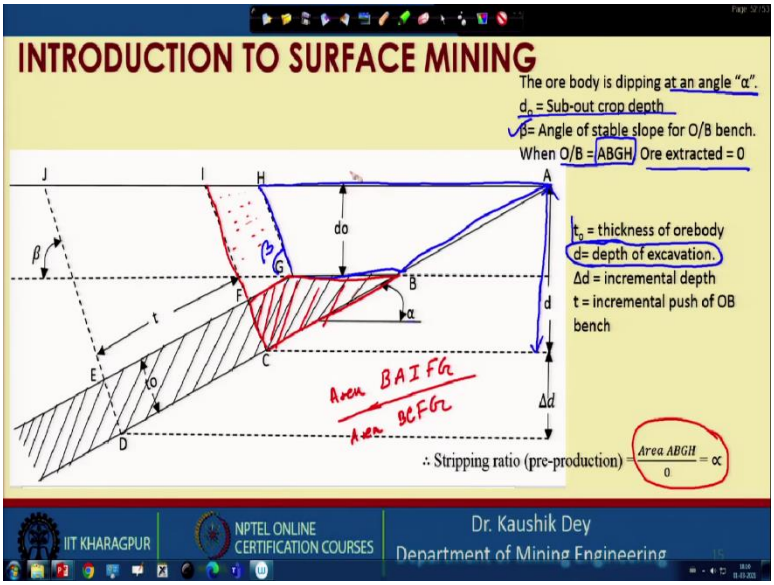
So overall stripping ratio means at the end of the mine, at the end of the mine, the total overburden removed divided by total tonnage of ore excavated is called the overall stripping ratio. I think now, it is clear to you. We are just discussing about the different types of different types of stripping ratios.

(Refer Slide Time: 12:04)



So, you can understand the Initial Stripping Ratio as we have discussed earlier. The initial stripping ratio is A1 by B1. So, this is A1 by B1 and implementers stripping ratio A2 by B2 and overall stripping ratio become A1 plus A2 by B1 plus B2, as we have discussed earlier.

(Refer Slide Time: 12:49)

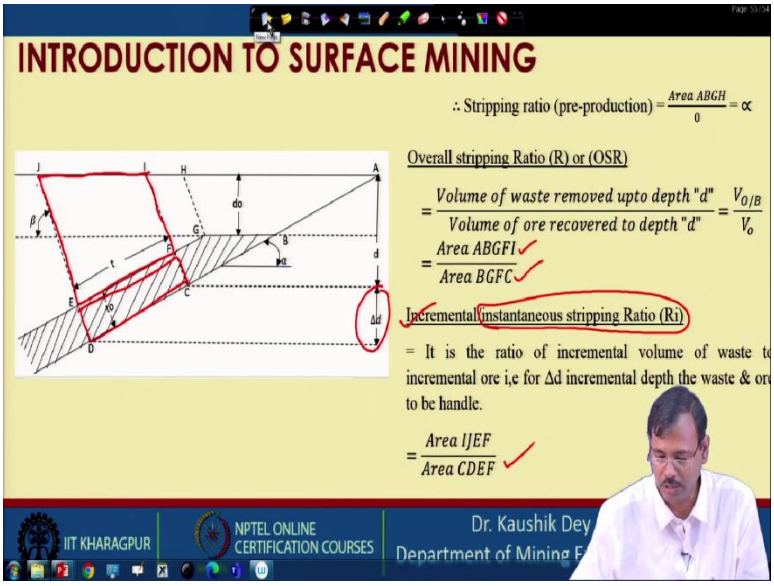


Now, let us see it in a different way. So, suppose our ore body is dipping at an angle alpha d0 is the sub-out crop depth means orebody is not exposed to the surface. If the orebody is exposed to the surface, then it is called outcrop. If it is not expressed to the surface, it is not, it is called in-situ, in that case, ore depth up to which the overburden starting its occurrence that is called sub-out crop depth.

So, d0 is the sub-out crop depth. Overburden is dipping at an angle alpha and beta is the angle of stable slope bench. So, if you are having a stable slope bench angle of beta, then only your slope will remain stable, otherwise it may fall. So, that is why beta is the stable slope angle. Now, at the very beginning when your overburden is having an area of ABGH that means, if you are overburdened is having an area of ABGH, your ore excavated is 0, okay, you do not have any excavation.

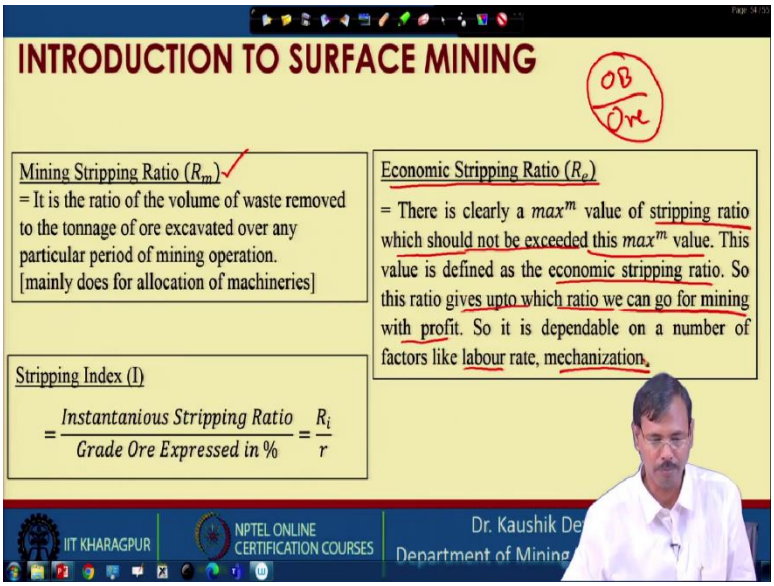
But after that, if you excavate, t0 is the thickness of the ore body and if you go for a depth of excavation of d. Now this is the depth of excavation of d to have this depth of excavation d, you need to achieve, let me change the color of the pen, then you will excavate this much of ore body. And for this, you have to excavate this much of overburden. So, your pre-production stripping ratio was area ABGH by 0 so its stripping ratio become infinity here. But at excavation depth of d your stripping ratio will become area, this is the waste rock excavation area and ore excavation area are BCFG.

(Refer Slide Time: 16:22)



So, your pre-production stripping ratio was infinity and overall stripping ratio will become this one, we have already informed that, and the ore production is this much. And if you are going for an incremental depth of excavation of this one then your incremental or instantaneous stripping ratio will become IJEF that means, and ore excavation is this much EFCD. So, EFCD. So, this is the incremental or instantaneous stripping ratio.

(Refer Slide Time: 17:38)



The next stripping ratio is Mining Stripping Ratio. Mining stripping ratio is basically used for deploying the machineries, which means the mine management has decided that in this month or

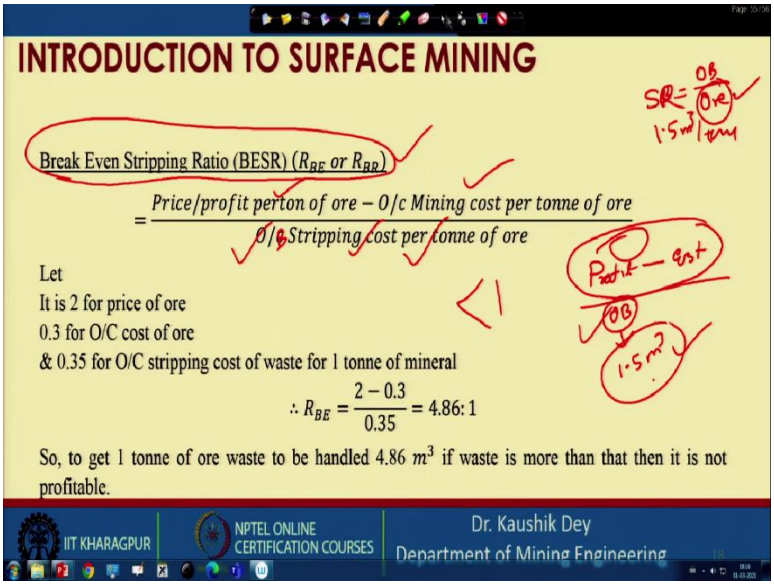
maybe in this week or maybe in this shift also, this match of overburden has to be removed and this much of or has to be removed. So, it is a particular planning which is carried out.

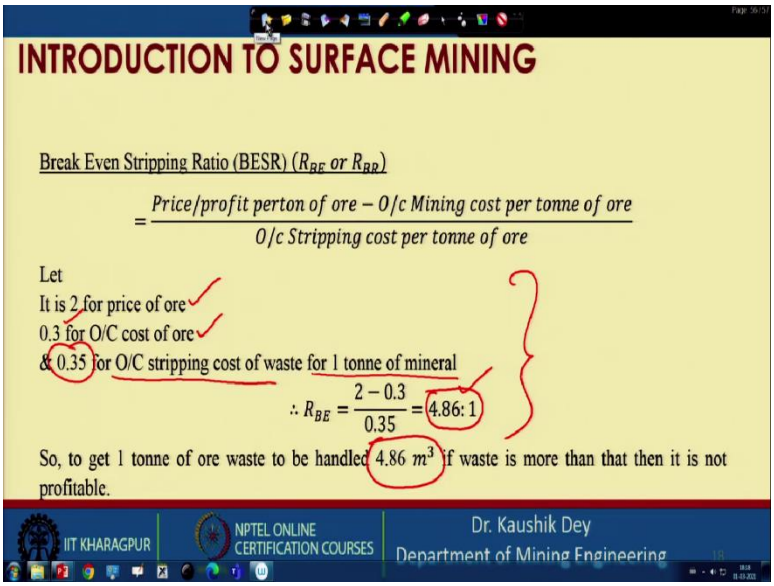
So, it is the ratio of volume of waste removed to the tonnage of ore excavated over any particular period of mining operation that means, it may be for a month, it may be for a week, it may be for a shift also, this is basically carried out for allocating the different machines, the population of the machines that is required for achieving the production.

So, what is happening say, suppose in rainy season etcetera, if your demand is less that time mine management will deploy more machineries to remove the overburden rocks and they reduce the excavation of the ore. So, that time you are stripping ratio will become more. And if you are in other dry time if you are excavating ore mainly and reduce the excavation the ore a lot in that case your stripping ratio will be decreased a lot. So, this is depending on the demand and depending on the machine deployment, it is carried out so, that is called mining stripping ratio.

There is another term which is used is called stripping index. It is the instantaneous stripping ratio divided by the grade of ore expressed in percentage that is called stripping index. And the economic stripping ratio, it is clearly a maximum value of stripping ratio which should not be exceeded by this maximum value. This value is defined as the economic stripping ratio. So, the ratio gives up to which ratio it can go for mining with profit. So, it is dependent on a number of factors like labor rate, mechanization, etcetera.

(Refer Slide Time: 20:19)





$$Break\ Even\ SR = \frac{Selling\ price\ per\ ton\ of\ ore - Mining\ cost\ of\ per\ ton\ ore}{stripping\ cost\ per\ ton\ of\ ore}$$

The most important stripping ratio is named as the Break-Even Stripping Ratio. Break Even Stripping Ratio is defined as the profit per ton of ore minus the opencast mining cost per ton of ore

divided by the stripping cost, open cast stripping cost of overburden for per ton of ore. That means, if you have to the stripping ratio is basically given, gives us the overburden quantity required to be excavated for tonnage of ore.

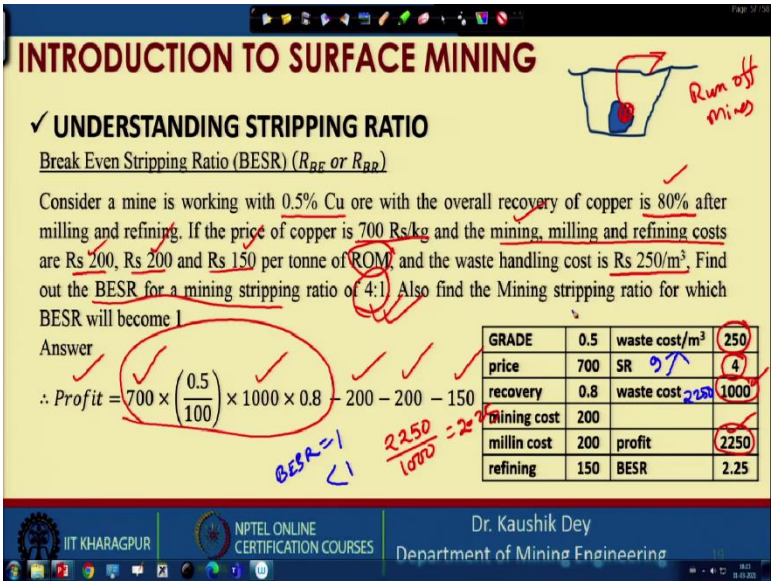
So, break even stripping ratio is basically the economic term, it is giving us the profit we are getting by selling one ton of ore from here we are deducting the cost of excavation of one ton of ore. So, the remaining amount what is lying with us we are checking whether that amount is sufficient for excavating the overburden, this is overburden. So, overburden that quantity of overburden which is required to excavate one ton of ore. So, if the stripping ratio is 1.5-meter cube per ton then this overburden quantity is 1.5-meter cube.

So, the cost, cost of overburden removal for per ton of ore means the cost of removal of 1.5-meter cube overburden. So, this ratio is called break even stripping ratio and in no condition you will allow the breakeven stripping ratio to go beyond or go less than 1, low below 1, so, that if it is 1, less than one that means your overburden removal cost is becoming higher than the amount lying with you after the selling of the ore. So, that is not allowed because it will not fetch you any profit.

So, for that let us take one small example here, suppose the price of the ore is 2 rupees, the cost of excavation of ore is means two unit, you do not consider it is 2 rupees, this is 0.3 unit. Then you, if the stripping cost is, your stripping cost of waste for 1 ton of material is 0.35 unit, then your break-even stripping ratio is 4.08, 4.86 into 1. So, 2 minus 0.3 divided by 0.35, so it is coming this value.

Now, what it is showing that means, it is showing, if our stripping ratio is further increased then also our opencast mining will remain in profit unless and until we are having the stripping ratio increasing for more than this value. So, if our stripping ratio is increasing more than 4.86, then only our mining of, with surface mining technology will no longer remain profitable to us. So, that is why break-even stripping ratio is very, very important aspect for decision making about the weather mining to be continue or not.

(Refer Slide Time: 24:40)



So, now, let us consider one problem in this, say consider a mine working with 0.5 percent copper ore with overall recovery of copper of 80 percent after milling and refining. If the price of the copper is 700 rupees per kg and the mining milling and refining costs are 200 rupees, 200 rupees and 150 rupees per turn of ROM. Now, let me explain you ROM. ROM means, run off mines, ROM means run off mines that means, whatever this material is taken out from the mine that is called run off mines, it's the direct output achieved from the mine is called run off mines.

So, the cost of mining is rupees 200 that means to take out one ton of run off mines is rupees 200 that treatment treating of 1 ton of run off mines is rupees 200. The treating cost of 1 ton of run off mines, refining cost of that is rupees 150. That means, suppose run of mine is 1 ton, from here you are getting some portion, say 0.8 ton maybe coming to the mill and then, output of the mill, that 0.8 ton is then subjected to refinery then that cost is basically considered here.

If the waste handling cost is rupees 250 per meter cube, find out the breakeven stripping ratio for a mining stripping ratio of 4 is to 1. So, if 4 is to 1 is the mining stripping ratio, let us find out whether it is it remained profitable or not. So, let us find out, to solve this let us find out what is the profit, profit is that from 1 ton of run off mines 0.5 percent copper we are getting. that copper actually we are selling not 0.5 percent, 0.5 percent is the grade, but 80 percent is the recovery.

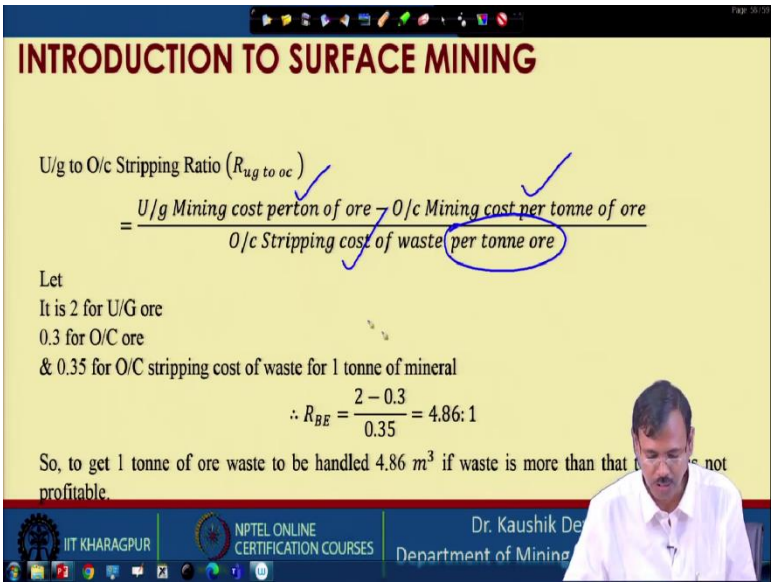
So, 0.5 into 0.8, so that much copper we are getting from the treating and refining, a milling and refining of the copper ore that is prices rupees 700 per kg and as we are considering that ton, so,

we are multiplying it with the 1,000 to make it ton. So, this is the price we are getting, and we are subtracting mining price, milling price, defining price. So, by this one, we have found our profit is coming rupees 2,250 and our waste handling cost is 250 rupees per meter cube.

So, the 4 is to 1 if it is the mining stripping ratio, so, 4-meter cube of overburden has to be handled for to get 1 ton of run of mines that means the copper ore, so to remove 4-meter cube of waste rock, we have to spend1,000 rupees. So that means, profit is 2,250; waste handling cost is 1,000 rupees, so BESR is 2,250 divided by 1,000, so 2.25. So, that means, it is further, it is still profitable we can carry on mining.

But you just think if instead of mining stripping ratio of this one, if mining stripping ratio is become 9 in that case this will become 2,250, then our BESR will become break even stripping Ratio will become 1 and if it is more than 9, then BESR will become less than 1. So, it will, the mining will no more profitable in that case. So, above the stripping, mining stripping ratio of more than 9 the mining will not become profitable. So, mine can, mining cannot be carried out in that case.

(Refer Slide Time: 29:45)



The final one is the underground to open cast stripping ratio. This is the Underground Mining cost per ton of ore, this is the open cast mining cost per ton of ore divided by the open cast stripping cost of waste which is for the per ton of ore that means, here also you have to consider the mining stripping ratio. So, another problem is given here also for this. So, this is more or less about the stripping ratio. This topic we will continue for the next class also. Thank you