MINERAL ECONOMICS AND BUSINESS

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Week 4

Lecture 19 : Underground mine cost models

Hello everybody, welcome to this class of Mineral Economics and Business, where we will discuss underground mine cost models. Previously, we talked about the surface mine cost model, and now we will discuss underground mine cost models. As you can see on the slide, we will discuss certain basic cost estimating starting points, beginning with preliminary mine design considerations and moving further to stope design parameters. Connected with this are transport and continuous flow calculations as examples. Then, we will take up room and pillar mining as an example of an underground mining cost model.

The estimators who engage in such cost models—or cost estimates—must undertake an iterative process of design and evaluation to assess the potential economic success of developing a mineral deposit. This determination depends on several rounds of iterations:

you assume certain things, aim to achieve certain targets, and then apply the available parameters and cost data. Accordingly, if you want to change certain outcomes, you can modify the inputs or adjust certain inputs to see their effects on the final outcomes. So, it is an iterative process of design and evaluation, redesign, re-evaluation, and after several rounds, you can finalize the model. Now, we can start with an initial target production rate, which is the most common procedure, and then break the process down into the following four steps.

First, we can design the underground workings necessary for the cost estimation process. Then, we can calculate equipment, labor, and supply cost parameters associated with both pre-production and development, as well as daily operations. As you might have seen, the first point is to the extent necessary for cost estimating. This means you have to break it down: for example, we start with the design, then move to development—such as vertical shafts, inclines, adits, or declines. We can separately make them cost centers and then determine the costs involved in those operations.

Then you go on to further development underground, like the drives, crosscuts, and then the transportation arrangements, ventilation, pumping—all these things are further broken down. Then we go for the equipment required for all those smaller segments. Then labor, supply cost parameters—all these things are associated with those development and production stages. Then we go for the cost estimate. How?

Since we now know the requirements of the equipment, labor, and supply cost parameters, we can apply the cost of equipment, wages, and salaries to be paid, or the supply prices—that is, the cost parameters that we are taking into the model. We also find out the capital part and the operating cost separately, and at the end, we can find out the total cost per tonne. Now we can compare the estimated cost to the anticipated revenues under economic conditions pertinent to the project, using the discounted cash flow techniques to determine the project viability. This means that when you have the estimated cost, So now we have—we also have

Further planning—year-wise planning or life-wise—determining which year we are going to produce, how much we are going to invest as capital. So, using the discounted cash flow techniques, ultimately we can find out the project viability. Depending on the estimated cost of this capital—this capital cost—and, of course, the operating expenditures, as we could see in the example of the Rumen Pillar underground mine, underground stoking method for preliminary mine design, for example, we target an optimized economic return. We have inputs, and we have outputs. If we can increase or deploy highly mechanized methods, in that case, we may get more production, but maybe you will be spending more or you may require huge capital.

So, you need to optimize the economic returns on the investment. Accordingly, we determine the equipment, labor, and the supply needs for both pre-production and then the daily operational needs of a mine. For production planning and infrastructure, The pre-production ensures sufficient ore to start operations at the design production rate. When we start developing, that does not mean that after some time you immediately declare that now we are ready to produce.

We have to develop the mine in such a way that when you start production, you can reach the design production rate quickly and then make it a steady process. That means this production development maintains output throughout the mine's life. That means, what I mean to say is that when you are producing, at the same time, you are also developing the mine. You are developing the mine in such a way that you are always ahead of the rate of production. And the developed area has more capacity than whatever you are producing.

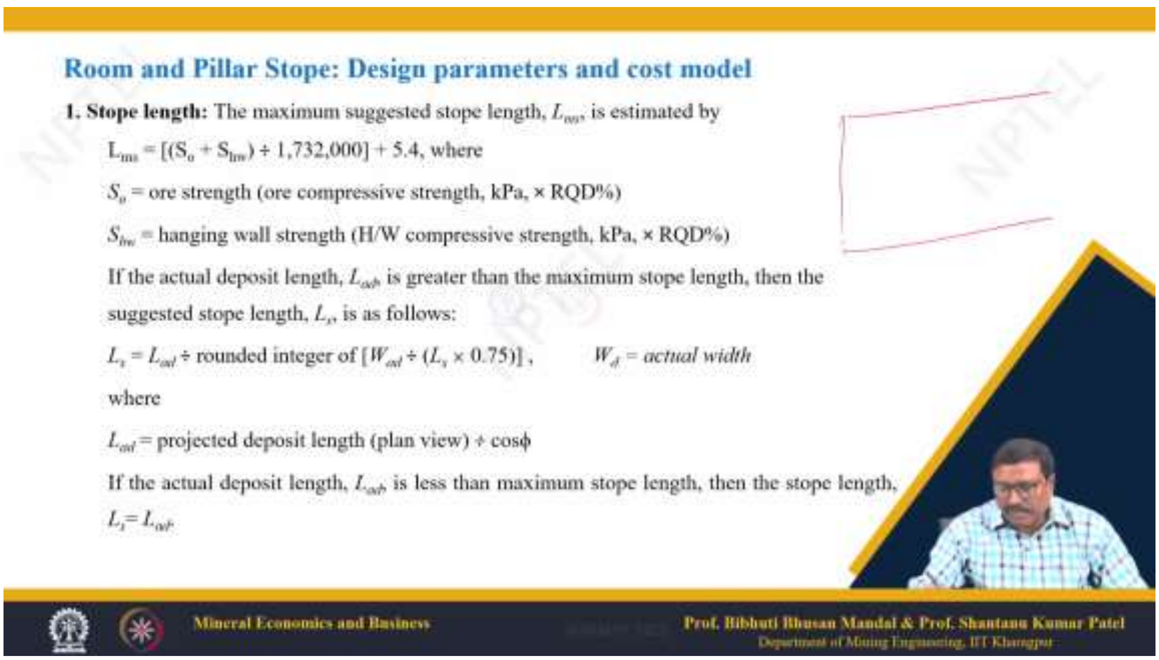
For example, if you are producing 1000 tons per day, then one of the cost models I have seen recommends that you develop the mine in such a way that the capacity of the production from the developed area is 2000 tons per day. So, if in one month you are producing, say, 50,000 tons, for example, in one month, then you develop the mine in such a way that at least the developed part is ready to give you 1 lakh ton of production. The advantage of this kind of assumption is that for any reason, for any capital crunch or anything, If you are reducing the—because these are, I am talking about the capital development. So when you are stopping the capital development for certain purposes, for any reason whatsoever—for market or any reason—then you can continue with the production and stop the development for the time being and go ahead.

So that will not stop your mine production at all. Now the third part is the surface construction that includes workshop, office, warehouse, or workers' change house, the mining plants—all these things. Now then we have the estimated production and development rates. So, more availability in stopes helps determine daily advance rates when the reserve is properly assessed and when you have a particular design, then you can find out the daily advance rates. So, detailed scheduling will definitely affect the project economics, overall cost per ton, and it remains stable when you make a detailed schedule.

Then you can expect that whatever you are saying will be more realistic, but gross estimates will sometimes vary widely from what you see in reality. So, the timing of cost matters, but excessive detailing leads to diminishing returns. Too much detail will not help also because, in certain cases, you have to assume many things. Now, preliminary mine design—the other things are the importance of distances, which is very critical here in the mining process. The importance of what distances? Like the shaft—where it is, what is the length of the Where is the decline mouth, and then from there, what is the distance you are covering?

What is the length of the total development? That will define the pre-production cost because you are developing the mine. These excavation lengths will determine the material requirement. Like, if you are making, say, 1 kilometer or 2 kilometers of drives, then you can assume that so much pipeline, wires, cables, rail, and ventilation ducts if wherever it is required, that will be needed for the purpose of the construction of the mine.

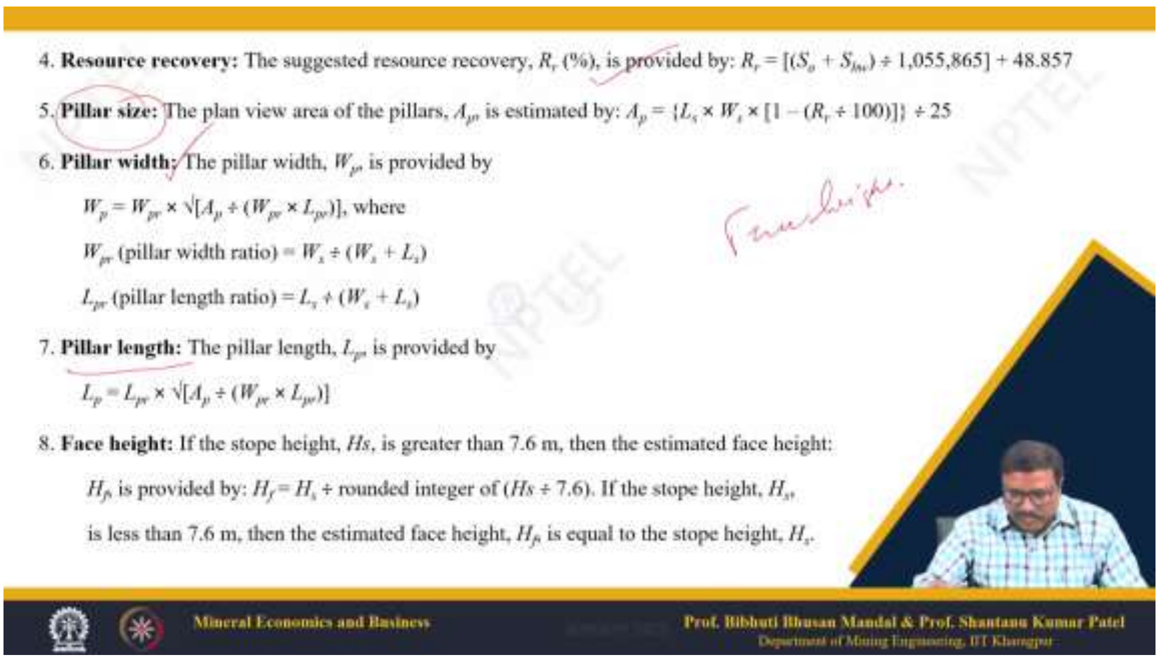
So, for example, we have ah like just an example and then we have the shaft here and if you are thinking that these these will be the different levels. So, from there you can estimate the distances of these the ah connecting ah from the shaft to the ah to the ore body the drifts or cross cuts whatever you are making. So, these lengths are very vital in the in the beginning that mine model is very very important for the purpose of finding out the distances from the shaft and ah from the decline. If you are having a decline then from the decline what will be the distances that you are ah you will be covering in the development stage. Those are very very capital intensive.



So, we need to be very careful in optimizing those ah those excavations. Now, with this basic ideas So, how do I know that how long I will be mining because we will be investing. So, the capital cost need to be distributed and then and accordingly the final cost pattern will also vary. For example, in the beginning we have said in the surface mine modelling also that we use certain empirical formula for finding out the life of the mine.

So the basic and very well known is the Taylor's rule which you must have known by this time. And there are revised Hoskins rules and further revision has been is there. From there we can estimate the project life now the the modern rules are so ah the the revisions or amendment in these things rather the changes in the tell us rules is is towards more production per day so the if the if the life of the mine will will then be less and production rate per in tons per day is more so the resource total resource divided by mine life into operating days per year will give us the production rate Then we have the selection of mining method.

We have said we have the mine life, and then we have selected the mining method. So, based on the deposit configuration and ore body structure. There are different methods also, like some computer programs that are already available. So, that will also indicate what method you will adopt for the purpose of stoping or caving, whatever you want to do if you are not doing open-cast mining. So, from there, we can go for the selection of mining methods.

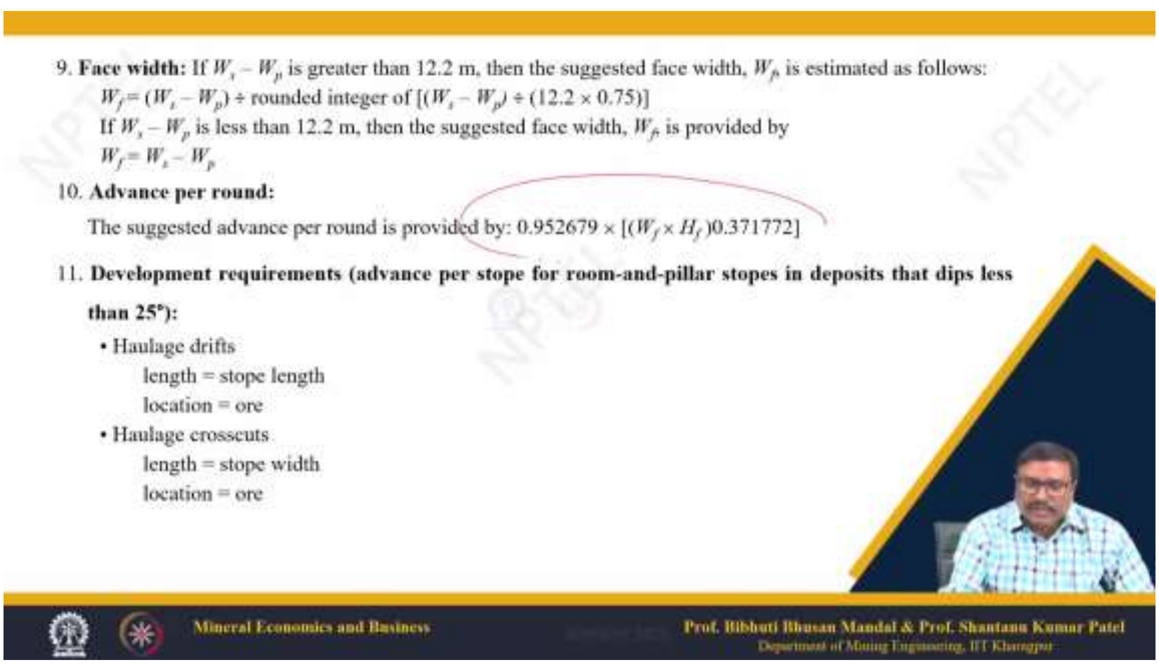


So, that means a detailed and a gross idea rather about the stoping method that you are going to adopt. For example, if you have chosen a room-and-pillar stoping method for almost flat or low-dipping ore bodies, then we may like to know the length of the stope and the width of the stope. So, there are empirical relationships established, or you can use the existing examples that are available. You can test your models with some available data of the length and width of the stope. So, that is also possible, but say if you want to start somewhere, you can use the existing empirical models that are available to determine the length and width of the stope, like what we have seen here.

So, stope length is known, for example, and then we know the stope width, and then also we have the stope height, for example, the stope height is also now known. By calculating these things. This is not exactly the final. So, even for testing the stability of the entire stope based on the dimensions that we are finding out with the empirical or numerical equations. We can find out the changes that we require in the design.

If we know that, for example, 60% or 70% will be recovered from the slope, we can determine it by using those very well-known methods like the tributary area method or similar. So the basic concept was how much will be the pillar area and how much will be the excavation area. So the pillar size can be determined, pillar width can be determined, and pillar length can be determined. From there, we can have a design of the stope of the rumen pillar. Now the purpose is to know how many development ends and how many slabbing phases—we call it slabbing in rumen pillar phases—will be available to us for production purposes.

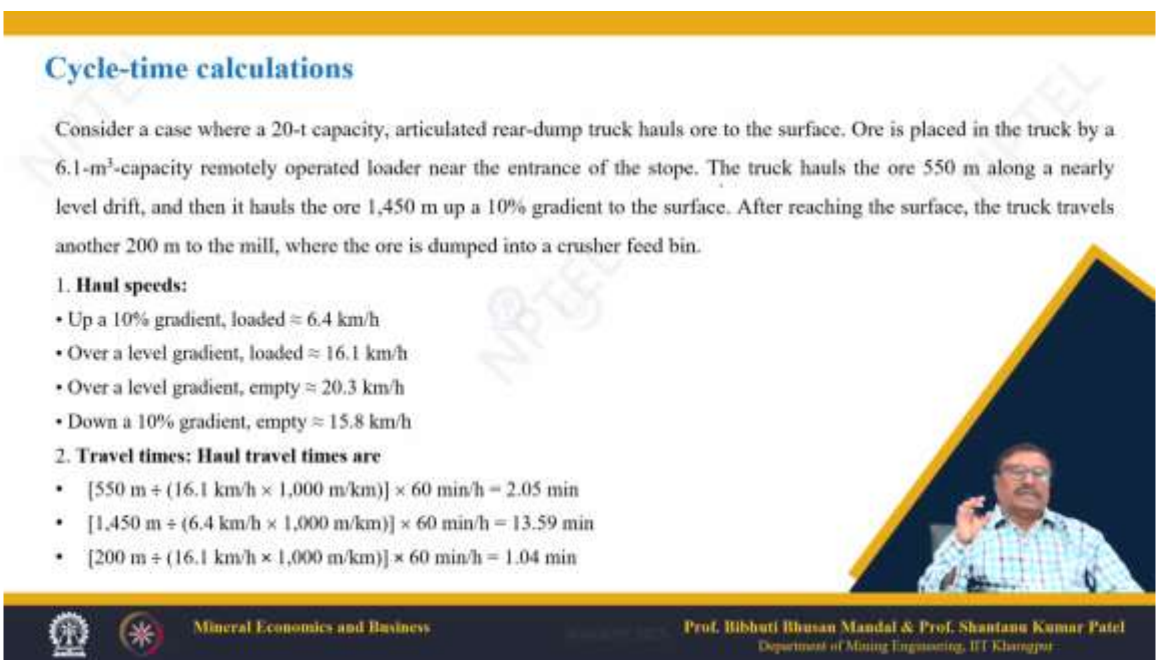
So, from the design, we can find out the face height, as we know. So, if the length of a face dimension and then the advance, the face height, face length, width, and height, and the advance per round, from here we can find out in one round how much will be blasted. Depending on all those parameters like the powder factors, the drill requirement, all these things can be determined. The basic thing is how big the stope is, how many pillars will be there, and how many development ends are to be started at the same time. So, depending on that,



we can find out whether we are achieving the target production or not. We can increase the number of phases at a time. Rumen pillar gives a lot of advantages in terms of mechanization and the number of phases that are worked at a time. Now, for example, the Hollis drifts, so the requirement is that the entire length will be required as the Hollis drift, which is equal to the length of the stope. And cross cuts will be equal to the width of the stope here.

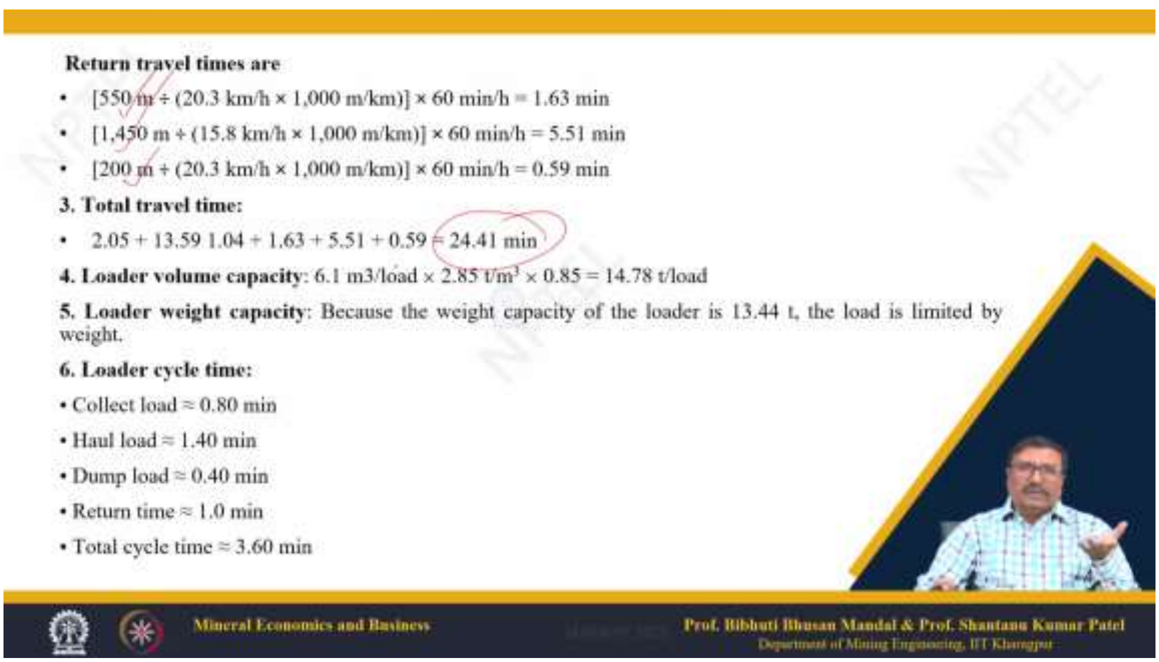
So, from the calculations that we have seen the the pillar size the face size. So, we know that number of machines that will be deployed for the purpose of drilling, charging, rock bolting, transporting all those things we can calculate. So, from there we can have the cost figures when the price of those items. And, of course, the number of people that have to be deployed to run those machines and operate the mine from there. We will take one more example here for, say, the cycle time calculations.

For example, we have, , we have where a 20 ton capacity articulated rear dump truck that hauls road through the surface. That means from the underground it is taking through the decline, it is going underground. Now the ore is placed in the truck by a 6 meter cube capacity remotely operated loader near the entrance of the stove and the truck hauls the ore 550 long along a nearly level drift. nearly level drift and like like like this it it first goes about 500 meter nearly level drift and then a 10 percent a gradient a 10 percent gradient it it it goes up. So, in the beginning we have a horizontal a path and then we have a 10 percent gradient road it goes up and up.



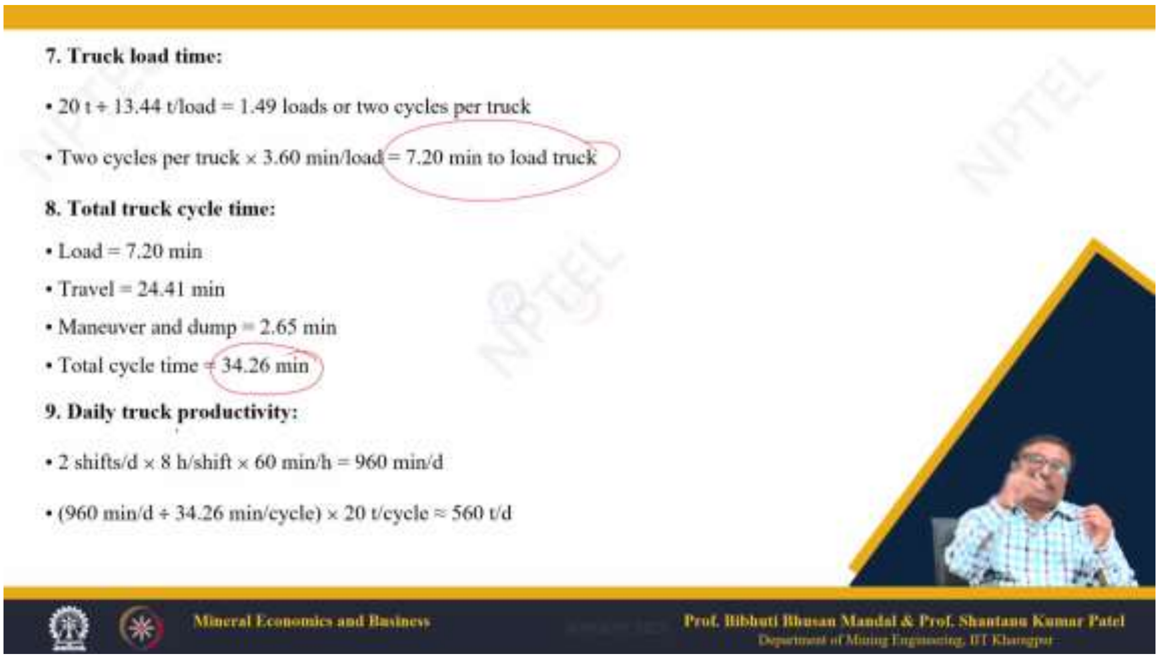
After reaching the surface, the truck travels another 200 meter to the mill where the ore is dumped into the crusher feed. So, this is what is   for one cycle of the truck movement. We are trying remember that we are trying to find out the cost figures. So, you cannot just transform whatever I have said into the cost figures. We must know that up to a for example, we have we have these data available with us that up to a 10 percent gradient the loaded it should not exceed 6.4 kilometer per hour.

Then level gradient it can go 16 kilometer per hour speed. For over a level gradient empty empty when it is empty then you can increase the speed and take   20.3 that means when you are coming down and then and when so when you are coming back that 200 meter you can increase the speed also. And when you are going down 10 percent gradient empty, then also you can increase slightly the 15.8 kilometers per hour speed. This is say known to us. Then we from there, if   the distance like the 550 meter, then 1.4 kilometer and the 200 meters, these distances are known and thus the speeds are known.



From there, how much you know? The time will be required for each segment of the travel that can be easily find out from here. So, from here we can project what will be the cycle time. So, one way it has gone now it is coming down again. So, for that 550 meter level and right it will start from this side rather 200 meter then it goes down 101.4 kilometer down and then straight 550 meter again coming back to the place where it was getting loaded.

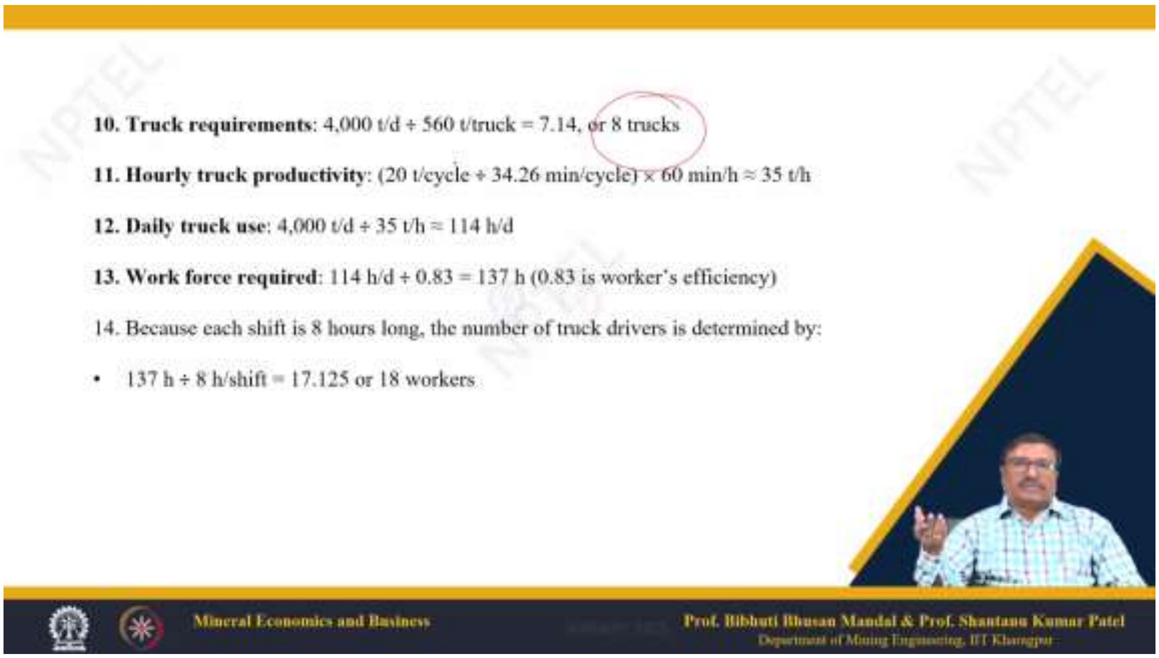
So, the total time for example, we got 24.41 minutes here. Now, the loader volume capacity is 6 meter cube per load that we have seen earlier. So, total it is 14.78 tons per load. Now, the loader weight capacity is because the weight capacity of the loader is 13.44 ton, the load is limited by by the by the by the weight. So, the loader cycle time again it becomes the collect load, the haul load, the dump load, return time.



So, total cycle time is 3.60 minutes for the for the for the loader. So, the track load time is known for 2 cycles per track we now come to we can calculate that it is 7.20 minutes to load the track. The total cycle time is loading, travelling, manoeuvre and dumping. So, total cycle time comes to at 34.26 minute because the truck goes and then comes back and then dumps there and then comes back and then it takes the load in it is not one bucket that will be filling the truck at a time. And not only that is the truck the loader is also not standing at one place.

It is going to the phase from there it is coming and then it is loading and again it is going. So, if the truck has to wait there the full truck capacity cannot be loaded at at at once. So, the total cycle time see is 34.26 time. Even though total travel time is less, but the loading and unloading and all these things that will take time. So, the daily track productivity in 2 shifts per day and 8 hours per shift it will be 960 minutes per day this is the ah ah time utilized.

Now, from there   we can find out that per cycle it can take 20 tons. So, from there we calculate that it will it will give us 560 tons per day. Now, if you have the target production then and different   cycle times based on the based on the location from where it is being loaded and how far it is being   hauled for the purpose of   coming to the surface and dumping. We can find out the number of tracks That is required for the purpose of achieving the target production.

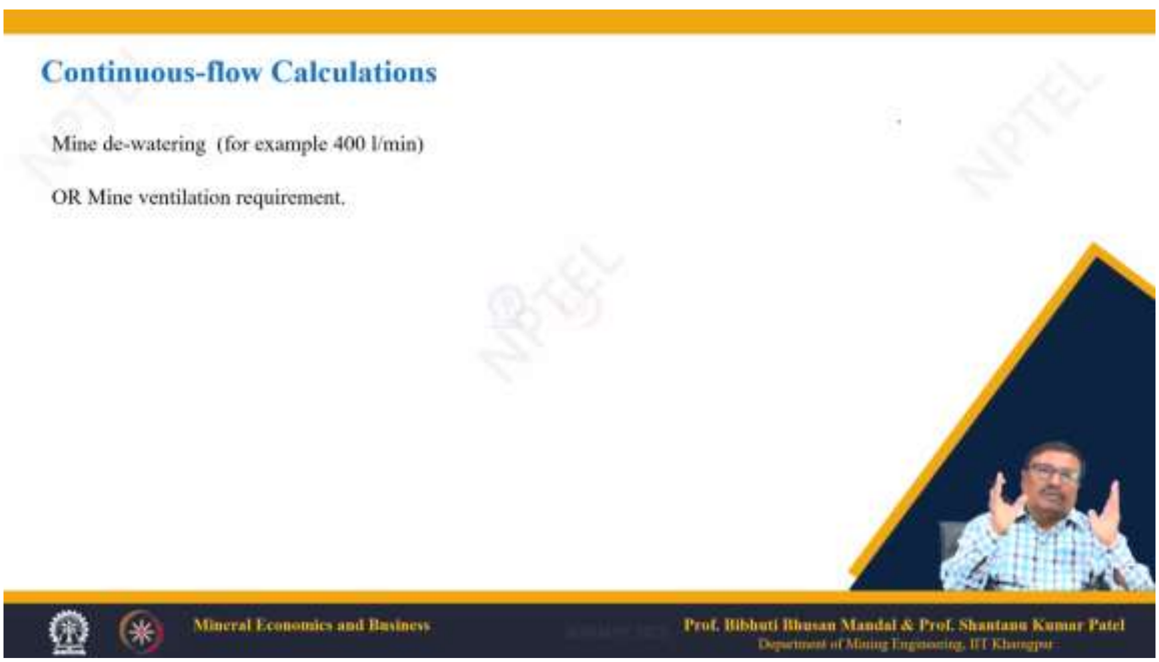


From here, say we have targeted 4000 tons per day divided by 560 tons per track. From there, we can find that we need 8 tracks, ok. A company, if they do not own it, then they will not keep only 8 tracks; they will keep additional ones because of breakdowns and other things. So, that is how many tracks should be required for the purpose of achieving 4000 tons per day. From that Roman pillar stroke. Now, from there, we can also calculate the capital cost in the beginning—how much is required for the purpose of the trucks and the loaders that are required.

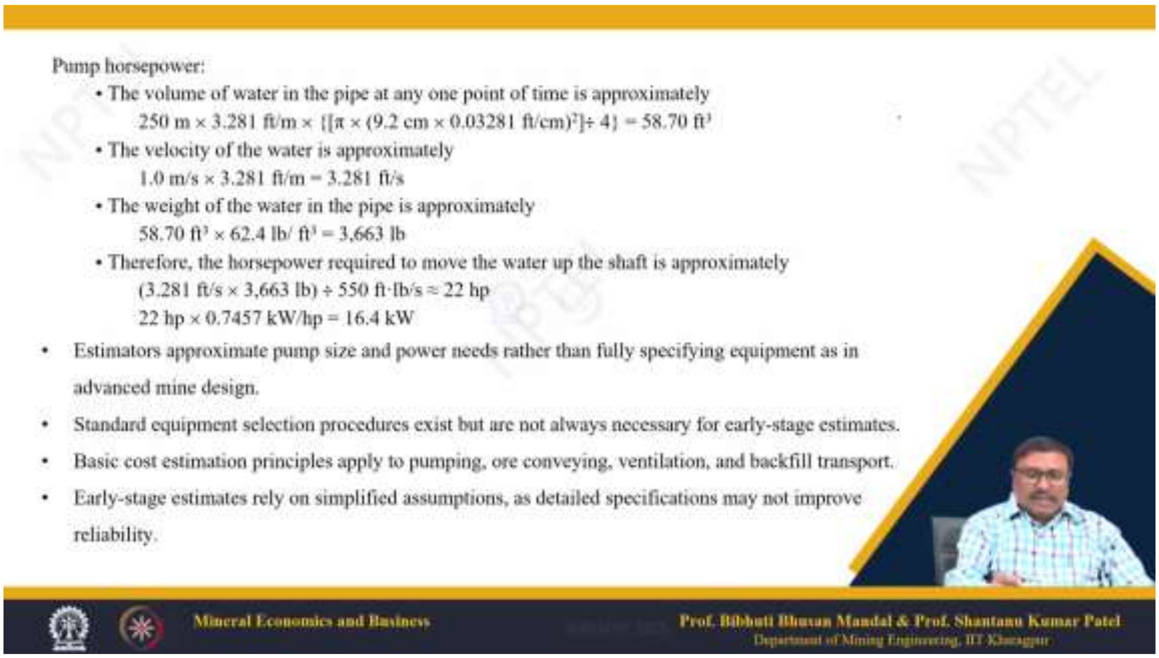
So, hourly truck productivity—you see the whole thing now—it can be further broken down into 35 tons per hour, and daily truck use is 114 hours per day. 140 because we are trying this 4000 tons per day, which is being divided by 35 tons per hour. So, we are getting 114 hours per day. That means these are truck hours—how much time the truck is engaged in producing 4000 tons per day, bringing it from underground to the surface dumping point. Now, this 114 hours per day. Now, if we assume also in the previous cost model, we took 83 percent efficiency.

So, we need 137 hours of operation. So, from here, we can find out. Depending on the information that each shift is 8 hours long, the number of truck drivers is now determined as 137 hours divided by 8 hours per shift. So, we need 17 people or 18 workers. See where we started.

We started with the production target and, of course, a method—room and pillar—that we decided. What is the pillar size, and then what is the distance traveled? And what are the parameters related to the loader, which is dumping and loading onto the truck? And then the truck is coming first out by half a kilometer on straight, level ground. Then it is at a 10 percent gradient, going up and up. And then, after about 1.5 kilometers, it is going another 200 meters on the surface and dumping. From there, we have calculated the number of trucks required and the number of workers required. If the number of trucks required, you also know the spares.



And the consumables that are required for those trucks. Now, we can go for calculating the cost involved or cost associated with all these things. Ah, for the other very important activity. Like now, we have talked about cycle time operations. We have not talked about drilling; we have not talked about blasting. The similar method can be deployed to find out how many holes will be required, what kind of jumbo drill is required, and what will be their cost. All these things can be associated with that.



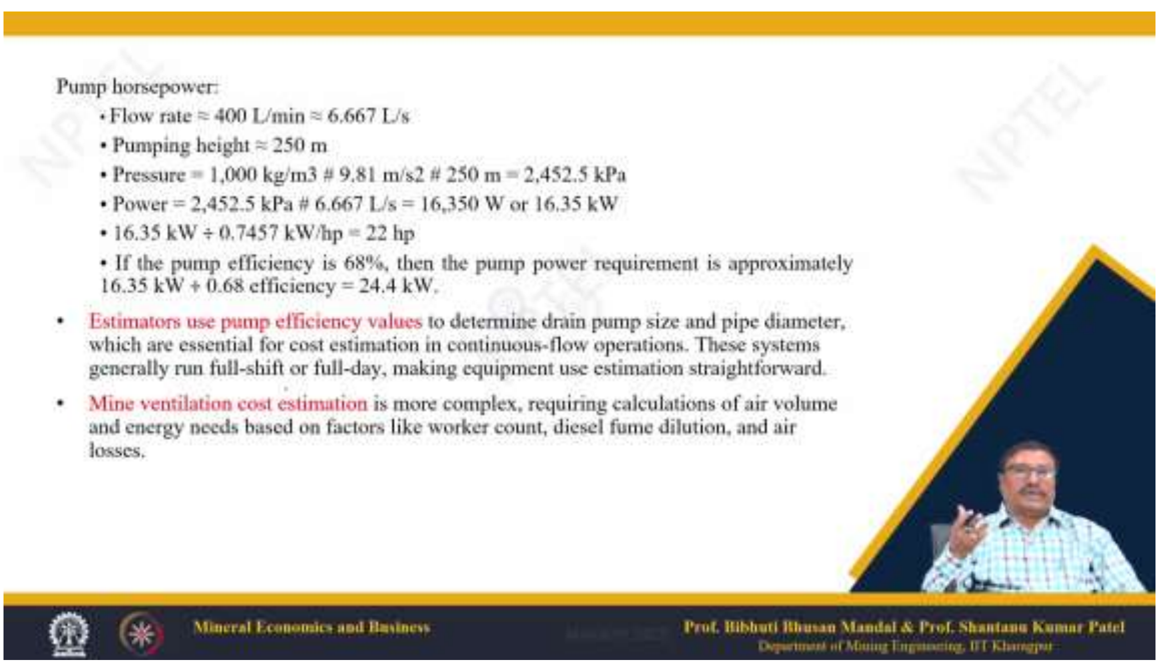
How many detonators will be required? What explosive are you using? That can be calculated by starting with the powder factor and then going down, down, down like that. For development zones, what is the expected advance? For slabbing, what is the expected tonnage? The powder factors are different, so those things will be added. For example, other ancillary things, like pumping, which is essential in underground mines—without that, it would not be possible. For example, we need 400 liters per minute of dewatering from a mine. Say we also need a certain amount of cubic meters or cubic feet of air per minute that will be passing through the working places. We know the ventilation requirement.

If we break down all those things the way we have shown earlier, then we can come and then conclude to the cost figures. Say we if the the volume of water in the pipeline that at any point of the time is passing, then from there we can find out the and the head ah the ah the the power required can be calculated in terms of HP or say in terms of kilowatt also. So, estimators what will they will try to approximate the pump size and power needed rather than fully specifying the equipment as in advanced mine design. So, later on when we go we are going for detailed installation requirement engineering designs then we will give   if you require 16.4 kilometer 4 kilowatt should you go for 20 or 25 those engineering considerations will be much later. What will be the installation requirement?

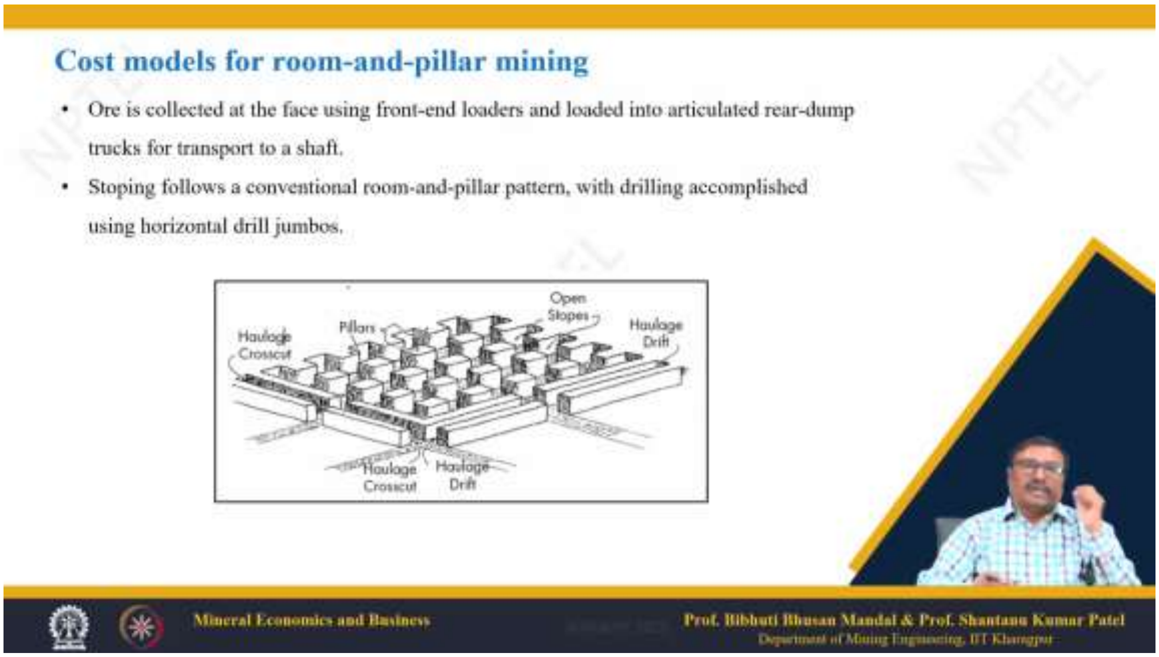
Size of the bed and the cost involved in the installation of the pumps, electrical cables, everything. Those are advanced design tests. And that will be for the final project appraisal. But in the beginning, you can find out, okay, this many pump with this much of the horsepower, we should keep a provision in cost modeling for the purpose of dewatering from the mine. So, in the beginning standard procedure will exist, not necessarily the detailed or advanced one.

That gives you a gross idea. So, the basic cost estimation principles apply to here say pumping, ore conveyance, ventilation, backfill transport. So, the earliest estimates rely on simplified assumptions. We are not going to details. The detailed specification may not improve reliability in the beginning.

First, we will just see whether it is feasible or not. So, for example, we have now found out the 24.4 kilowatt flow rate for 400 liters per minute. From there, we could find out the pump efficiency is around 68 percent. We found out the needed power. Now, the estimators use pump efficiency values to determine the drain pump size, pump diameter, these things, and then later on we go for the detailed planning. The mine ventilation cost estimation is more complex because it requires calculation of the air volume and energy needs. Based on factors like worker count, diesel, fume dilution, and the temperature,



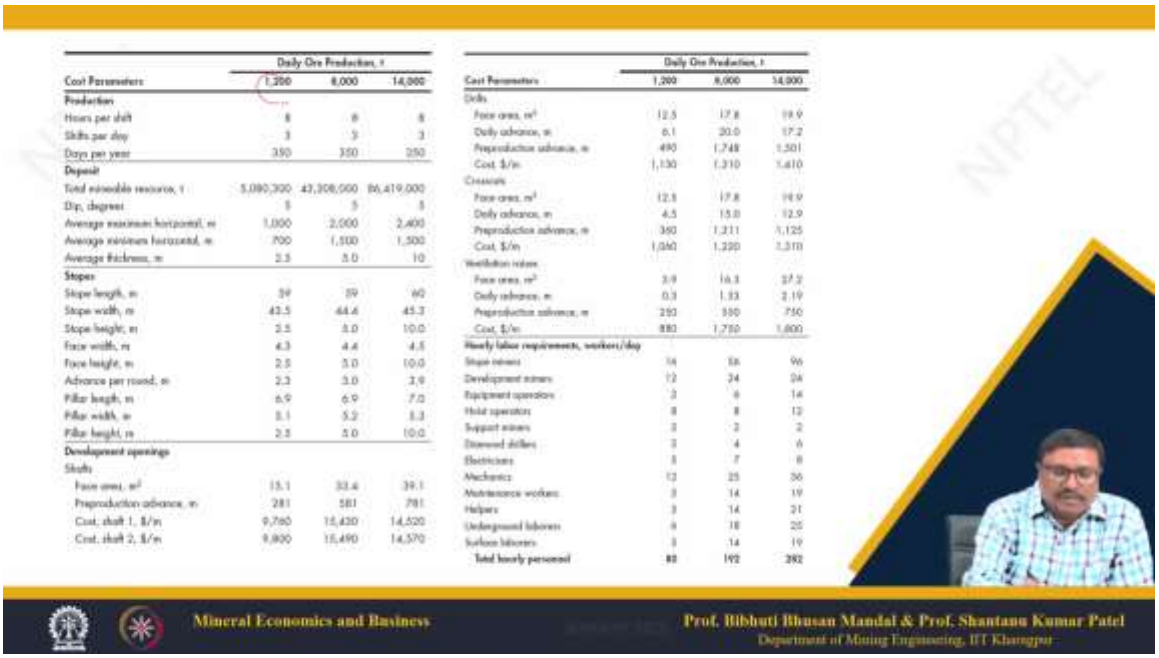
humidity, all those things.



So, from there we can find out what the main ventilation requirement will be, the main ventilation fan capacity, the cost of installation, cost of operating, all those things can be found out from there. Now, we will just give an example. Having said that, we will now provide a chart of the cost associated with all these things that we have mentioned earlier, just to see how it looks. The costs are not realistic because this is taken from the US InfoMine book and SME handbook. So, it will just show how it looks and what are the items that are essential for preparing a cost model. Now, the ore is collected at the face using front-end loaders and loaded into articulated rear dumps.

These are the assumptions that we have for transporting to a shaft. The stopping follows a conventional and the remnant pillar pattern that we are talking about. Drilling is accomplished by horizontal drill jumbos, then the loaders or blasting, followed by loading and dumping onto the dump trucks, and that is how it goes. Now, this method will always have certain development parts and certain parts where we are getting more production. It goes side by side. Now, look at the data that we are presenting here. We have three options shown here. I will just go on with only one, say 1200. The rest of the things are calculated.

We have assumed 8 hours per shift and 3 shifts working 350 days per year. So total mineable resources as for example is this one in this case and we have taken a modest 1200 tons per day. Now the dip is here only 5 degree almost flat core body maximum horizontal is 1000 meter and then your 700 is the minimum is actually the width part rather it is the horizontal part it means that it is not an uniform at a maximum the width is 1000 and the minimum is 700 it is a variation. So, it is a irregular body. Average thickness is 2.5 meter at any place.

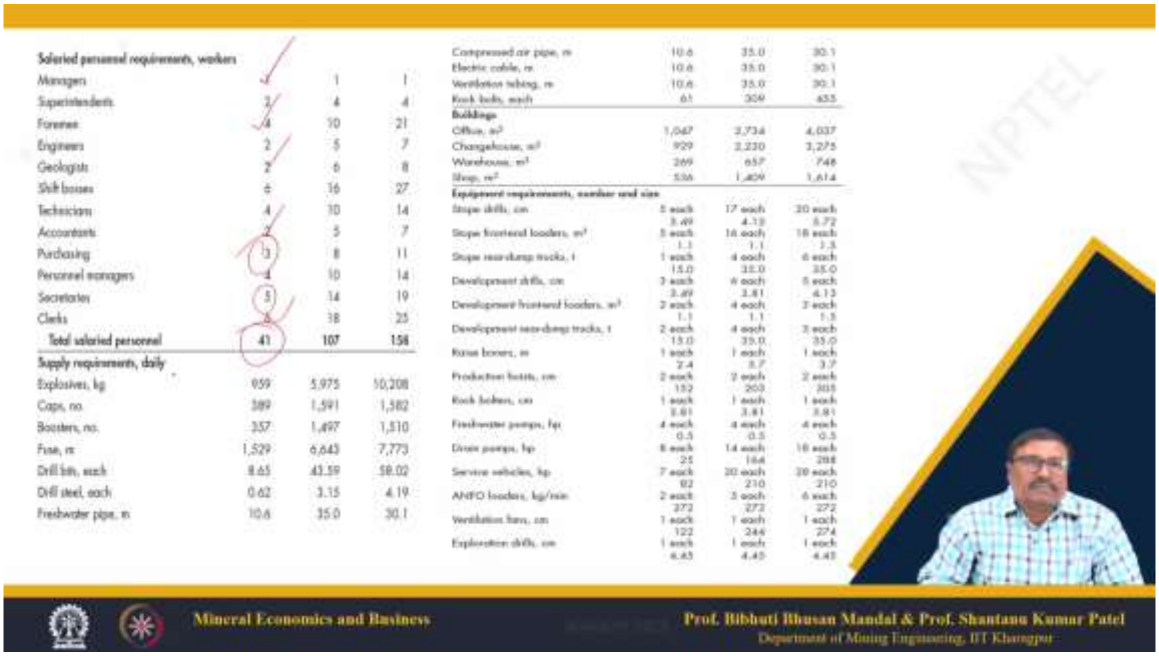


Cost Parameters	Daily Ore Production, t		
	1,200	8,000	14,000
Production			
Hours per shift	8	8	8
Shifts per day	3	3	3
Days per year	350	350	350
Deposit			
Total mineable resource, t	5,080,300	43,308,000	86,419,000
Dip, degrees	5	5	5
Average maximum horizontal, m	1,000	2,000	2,400
Average minimum horizontal, m	700	1,500	1,500
Average thickness, m	2.5	5.0	10
Stopes			
Stope length, m	59	59	60
Stope width, m	43.5	44.6	45.3
Stope height, m	2.5	5.0	10.0
Face width, m	4.3	4.4	4.5
Face height, m	2.5	5.0	10.0
Advance per round, m	2.3	3.0	3.9
Pillar length, m	6.9	6.9	7.0
Pillar width, m	5.1	5.2	5.3
Pillar height, m	2.5	5.0	10.0
Development openings			
Shafts			
Face area, m^2	15.1	33.4	39.1
Preproduction advance, m	281	581	781
Cost, shaft 1, \$/m	9,760	15,420	14,520
Cost, shaft 2, \$/m	9,800	15,490	14,570

Cost Parameters	Daily Ore Production, t		
	1,200	8,000	14,000
Drifts			
Face area, m^2	12.5	17.8	19.9
Daily advance, m	6.1	20.0	17.2
Preproduction advance, m	490	1,748	1,501
Cost, \$/m	1,130	1,310	1,410
Crosscuts			
Face area, m^2	12.5	17.8	19.9
Daily advance, m	4.5	15.0	12.9
Preproduction advance, m	360	1,211	1,125
Cost, \$/m	1,060	1,220	1,310
Ventilation raises			
Face area, m^2	3.9	16.3	27.2
Daily advance, m	0.3	1.33	2.19
Preproduction advance, m	250	550	750
Cost, \$/m	880	1,750	1,800
Hourly labor requirements, workers/day			
Stope miners	16	56	96
Development miners	12	24	24
Equipment operators	3	6	14
Hoist operators	8	8	12
Support miners	3	2	2
Diamond drillers	3	4	6
Electricians	5	7	8
Mechanics	12	25	36
Maintenance workers	3	14	19
Helpers	3	14	21
Underground laborers	6	18	25
Surface laborers	3	14	19
Total hourly personnel	82	192	282

So, we have shown how to calculate the slope length requirement and all those things depending on that the slope length is 59 meter, slope width is 43, slope height is 2.5 is equal to the average thickness and this almost flat. So, we have kept 2.5 meter, face width, face height all are calculated, pillar length, pillar width the calculations are shown before, but not in detail this is just to give you an idea these are the design requirements here. So, the in development ah openings the face area is 15.1 here by face height and face width if you multiply you get it. P production advance ah in meters then cost shaft in ah shaft 1 and shaft 2 there are 2 shafts in this design. So, where we have the 9760 dollars per meter here this is 2009 figure of course, this is just a model nothing else and the ah shaft 2 is also again 9800 ah dollars per meter here.

For drifts we have the ah face area. Daily advance, reproduction advance and the cost involved in this operation. Then cross cut the size and the cost. Ventilation raises for the purpose of maintaining ventilation. We have cost dollar per meter is 880.

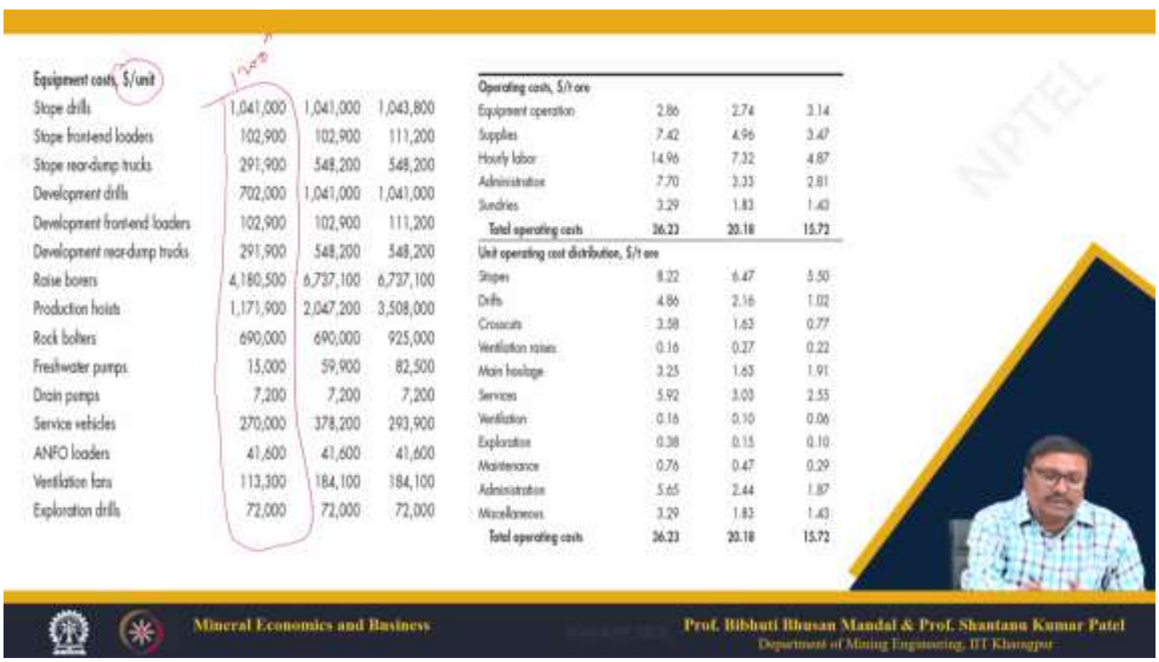


Now from this now we calculate the as we have I have shown earlier the how many people will be required 16 for the stope mining in the stope. For the development ends, we have 12 people, equipment operators 2, hoist 8, support miners 2 for general activities. And your ah this thing ah your ah the diamond drillers for detailed exploration in underground, you have another 2 like that electrician, mechanics, maintenance workers, sales pairs. From there you calculate that you need 80 people. be required for for the purpose of mining workers per day we have calculated.

the for the purpose of managing safety and the managing the overall operations, we need these man powers. We need managers, we need foreman, engineers, geologist, ship boss, technician, accountant, personal manager, HR, secretary, clerk. So, there we need another 41 here you see. So, these are the ah other ah manpower required. Then we about the supply requirements daily consumables like this explosives, ah detonators, booster, fuse this this is that time they have taken the fuse also in.

Nowadays you may not use that, but you can use detonator or no nail blasting also or whatever is available ah and ah drill bits, drill steel, fresh water pipe for the purpose of connecting the face uneven for water supply and washing the face also. Compressed air pipe requirement and then your electric cable, ventilation tubing all this and the rock bolts for supporting. Now these are supply requirements daily. This much is required.

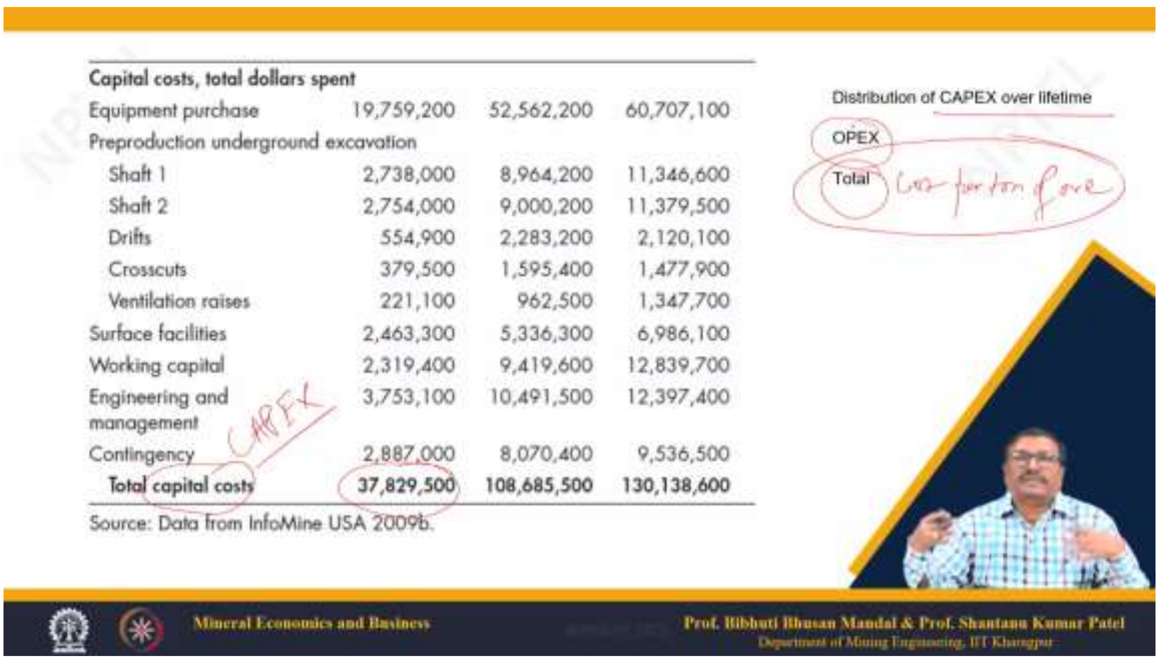
Now, for this entire thing, we need buildings, offices, change houses, warehouses, and shops. So, now these figures are for the purpose of installations; permanent installations are there. For the whole thing now, one thing we have not discussed so far is the capital expenditure here. So, we need to buy stove drills, stove front-end loaders, stove rear-dump trucks, development drills, development front-end loaders, and development rear-dump trucks. Raise borers, production hoists, rock-bolting machines, fresh water pumps, drain pumps, service vehicles, and full loaders for loading into the blast holes.



Ventilation fans, then exploration drills, meaning diamond drilling machines. So, all these things—this equipment has to be purchased. So, these are the capital costs involved. So, if you have the price from the course or the available data from even the internet. So, you can now find out the cost.

So, the equipment cost is dollars per unit. So, for now, we are charging the cost figures. So, for one stove drill, this much. One stove front-end loader, this much. Like that, for 1200, this is 1200 tons per day.

These are for other capacity. Now the operating cost depending on all the consumers and other things whatever we have the labour requirement, the administration part, these things the operating cost now we have calculated that it is coming to 36.23 dollars per ton of ore produced. The beauty of this just see that when it is increasing the operating cost is also decreasing here. That means it is not very linearly related, but more volumes does not mean more operating cost that there are cases where with more mechanization more volumes can be excavated operating cost can go down. Now, if I distribute this operating cost per ton of per ton of ore, that means dollars per ton here, then for example, for stooping operation, drift, cross cutting, ventilation, main hollies, all this ventilation, exploration, maintenance, administration all broken down to per ton of ore.



Capital costs, total dollars spent			
Equipment purchase	19,759,200	52,562,200	60,707,100
Preproduction underground excavation			
Shaft 1	2,738,000	8,964,200	11,346,600
Shaft 2	2,754,000	9,000,200	11,379,500
Drifts	554,900	2,283,200	2,120,100
Crosscuts	379,500	1,595,400	1,477,900
Ventilation raises	221,100	962,500	1,347,700
Surface facilities	2,463,300	5,336,300	6,986,100
Working capital	2,319,400	9,419,600	12,839,700
Engineering and management	3,753,100	10,491,500	12,397,400
Contingency	2,887,000	8,070,400	9,536,500
Total capital costs	37,829,500	108,685,500	130,138,600

Source: Data from InfoMine USA 2009b.

It is coming to say 36.23 here, total operating cost here is 36.23. So, here part turnover is coming 36.23 unit operating cost distribution, but now we will add the capital cost part whole thing. Whatever we have purchased whatever we have shown in the previous slide this is the total cost involved in purchase of the equipment. So, from there we can find out the capital cost that means, the CapEx capital expenditure Now we have to distribute this capital expenditure over a certain period where you want to capitalize or assetize the entire thing.

Not that in the first year we load everything. So in costing we will be distributing these things. In this particular exercise we have not shown the depreciation part and certain other things we have not like the tax is also not shown here. But the other things are shown. If the period over which this the capital expenditure will be distributed, the capex over the lifetime or even you can capitalize before that also.

And the operating expenditure, as we have shown in the last slide, then you can find out the total cost per ton of coal. From a mine which is using the room-and-pillar method, which is mining through the room-and-pillar method. Now, this part turns up ore once, and if the market price or if you are not selling ore, then you can compare it with the other mines where it is producing where you are. And if you are selling it directly, then it does not matter, and you can easily find out whether it is profitable or not. Of course, these things will be now. This is the basis of the cost estimation faster and for project viability. All these figures will be distributed over the time period of the entire life, and depending on the discount rate. The cash flow will find out the net present value and the project valuation, project viability.

That will be learned in the next series, next week, the classes in the next week. I hope I have tried to introduce the basic cost model, and you must have enjoyed this class. So, with this, we have come to the end of the cost estimate. Or rather, cost models for surface and underground mines. This gives you an idea as to what are the parameters that you must take into consideration for the preparation of the cost model. This is not a complete cost model, but it just gives an idea how to do it. Thank you very much.