Surface Mining Technology
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Lecture No. 07
Phases of Surface Mining – II

Let me welcome you to the seventh lecture of surface mining technology. We are continuing with the phases of surface mining. In the last class, we have covered the phases of surface mining part 1. This is the phases of surface mining part 2 will cover in this lecture.

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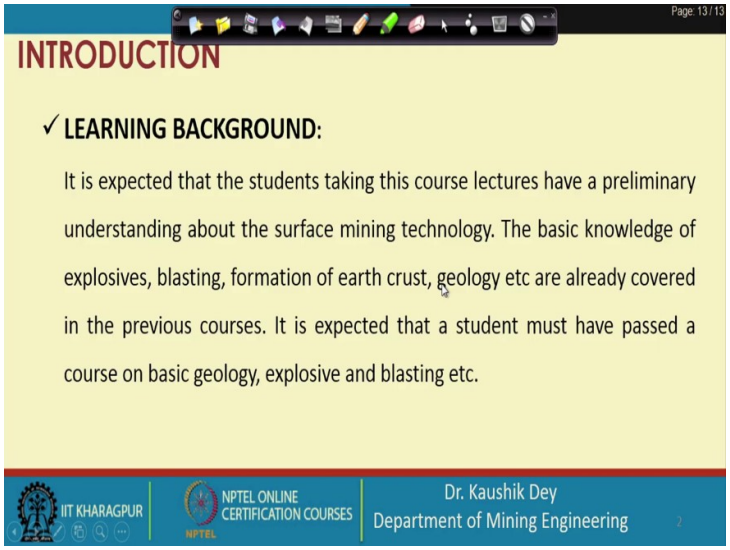

You know that as customary, we saw that the learning background has to be shown of the Surface Mining technology course.

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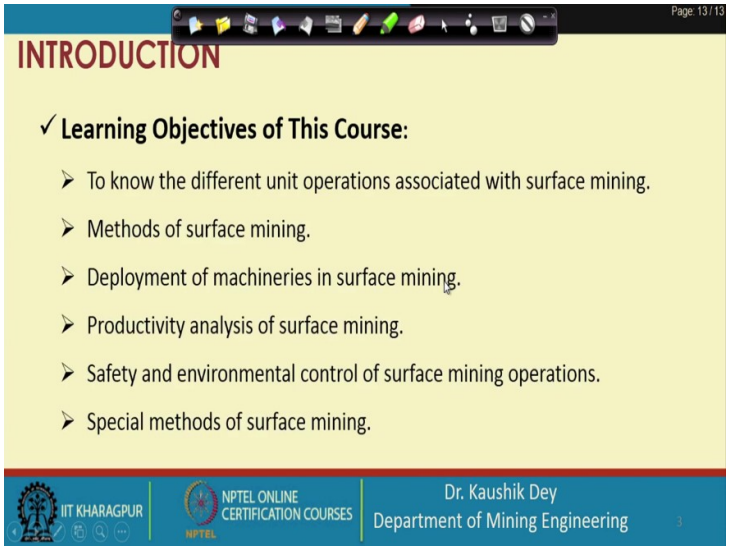

This is the learning objective of the Surface Mining Technology course.

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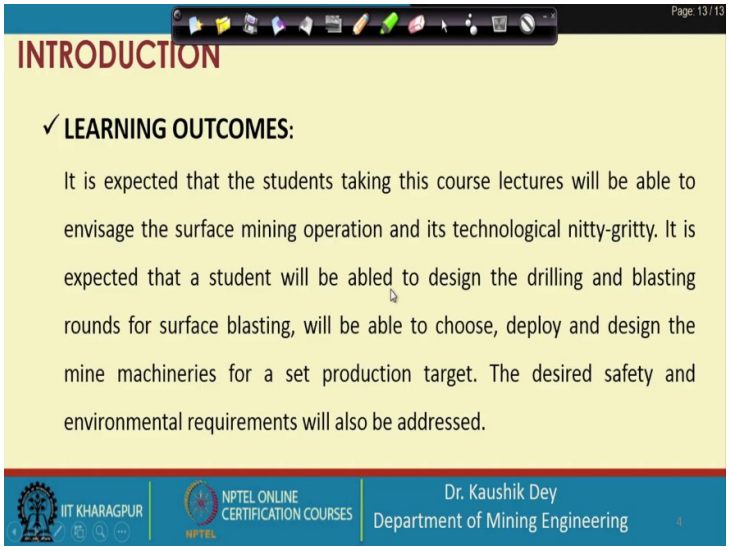

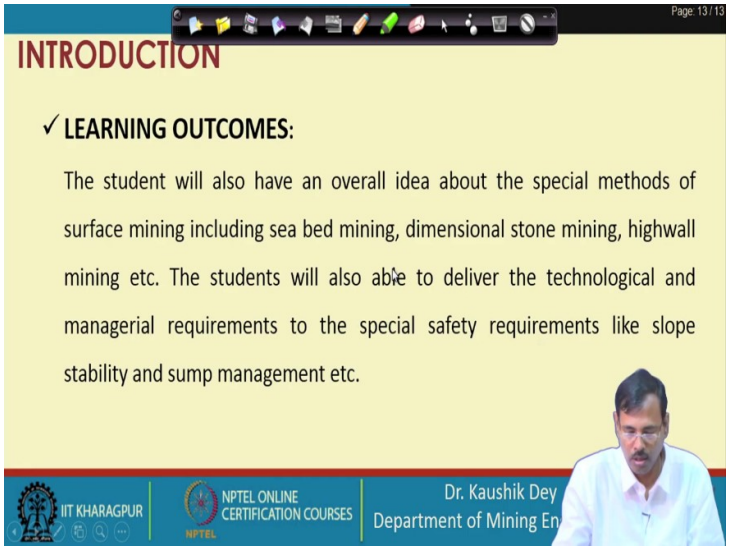

This is the learning outcome that is expected from a participant of surface mining technology.

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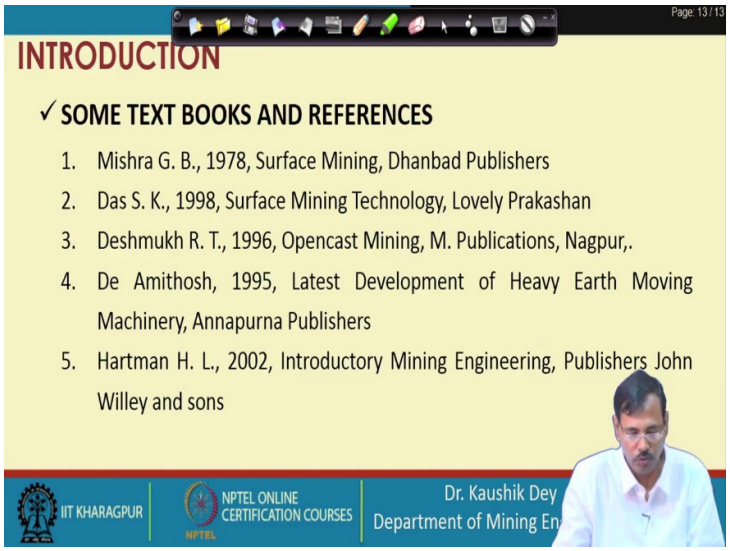

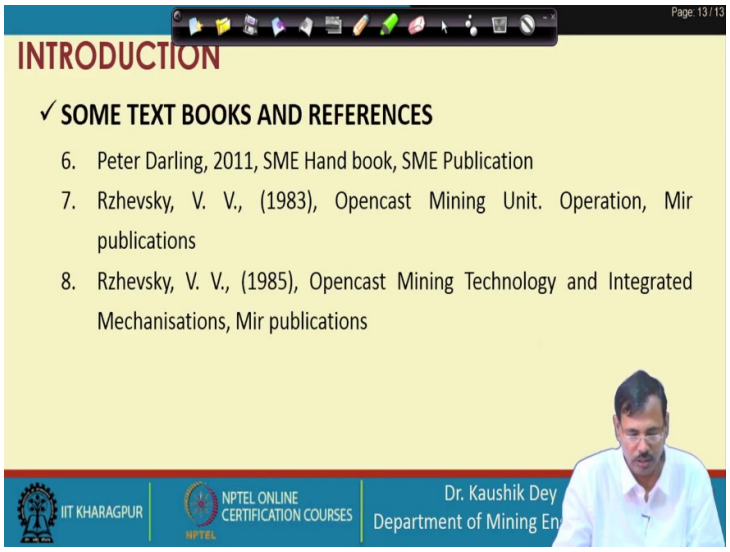

These are the text and reference books for the Surface Mining Technology course. Apart from that, it was requested to go through the different web sources different reference papers or journals.

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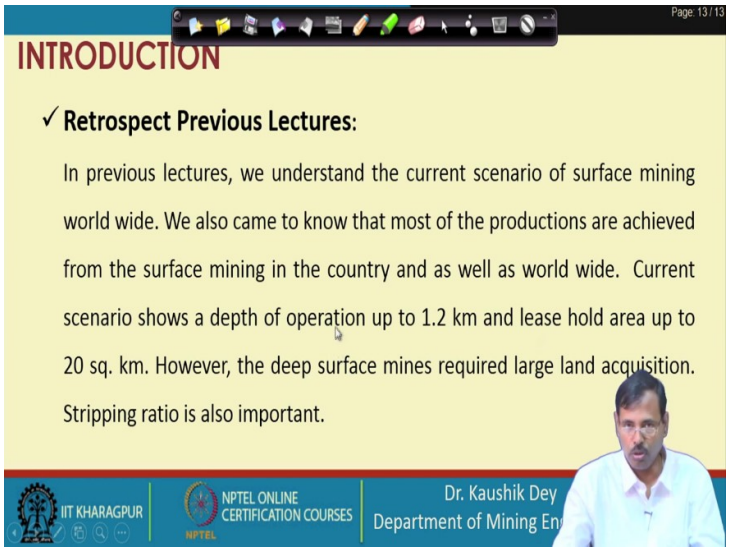

In the previous lecture, we covered all surface mining phases up to geological exploration. And we have seen that in geological exploration, first, we have carried out geophysical exploration. In this geophysical prospecting, we carry out different geophysical tools used in different geophysical tools to get the indication of occurrences of the deposit inside the earth's crust.

And then, when we found that the results were encouraging, we go for geological prospecting and geological prospecting. We found some indications, positive indications of the

occurrences of the deposits. In that case, we invest a significant amount for carrying out exploratory drilling. In exploratory drilling, we have carried out drilling to take out the core samples from the inside the rock mass into the rock mass, and those core samples are placed to find out the possible layers of rock, rocks in the earth's crust.

And then, we find out the core for which we are interested core of that mineral, and we have gone for the chemical analysis of that core to find out the grade of the mineral. Grade means the proportion of that important metal or important parameter for ingredients we are interested in the total mineral matter.

So, suppose if we are interested in, say in iron ore, we are interested and say hematite ore is there in the hematite ore, which is the oxide of iron. In hematite ore, how much iron is present and obviously, as it is coming out from the earth's crust in a mineral matter. So, it is not only the in hematite, not only the iron oxide is there along with that may be aluminium oxide, silicon oxide, calcium oxide, magnesium oxide, these are also occurring.

So, inside the earth crust when all this oxide minerals are occurring simultaneously, in that case, what is the percentage of iron is there that is called the grade of the deposit. So, suppose in that particular case, the iron percentage is 60 percent. So, that means we can understand the grade of that mineral is 60 percent iron.

So, we can get that knowledge from the chemical analysis or go for the XRD, XRF analysis from which you can find out the different mineral proportions available in that mineral. So, up to that, we have covered in the previous lecture.

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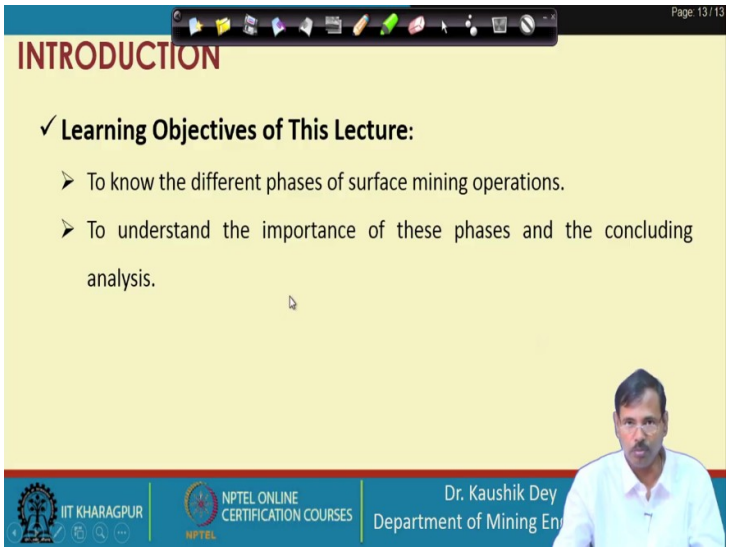

The objective of this lecture is also the same we would like to know the different phases of the surface mining operations and the importance of these phases.

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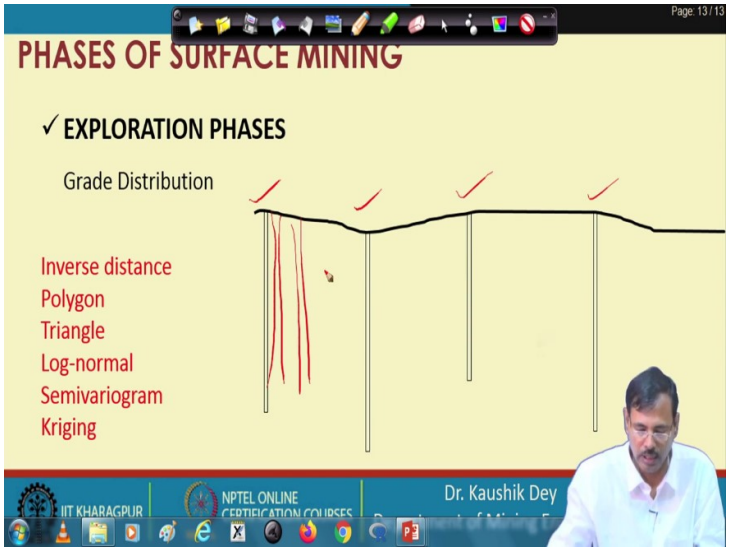

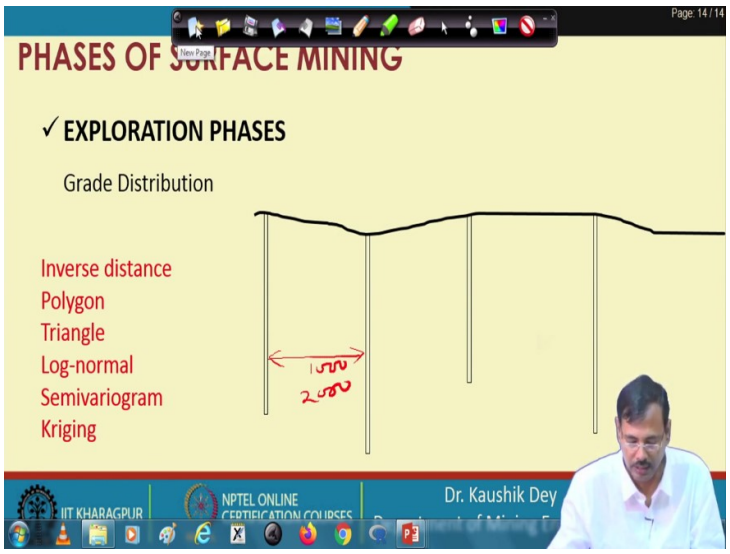

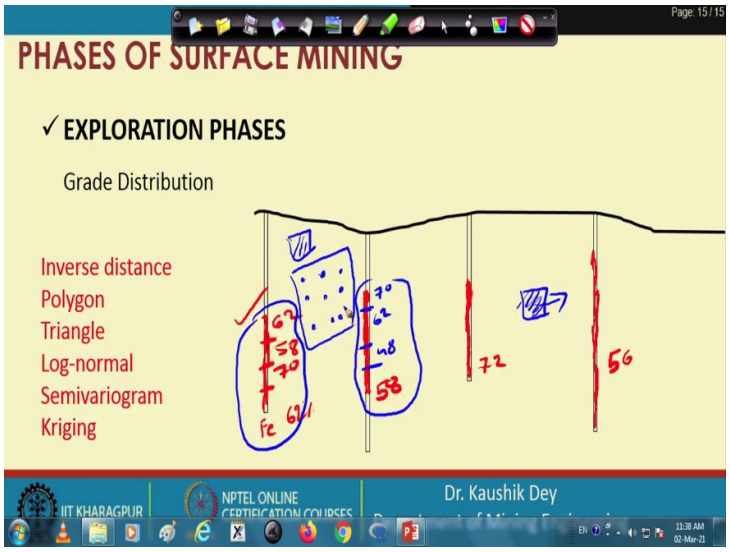

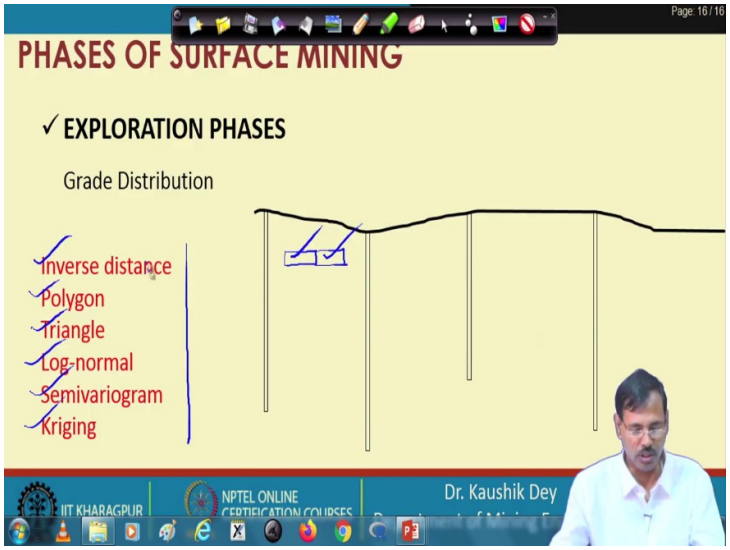

Now, what is happening? We understand we have carried out drilling in the earth crust at this position, at this position, at this position, at this position, at this position, at this position, at this position and at this position. You understand to save money we cannot carry out drilling in each and every position like this. That is not possible. So, that is why we carry out dealing at a distance. Initially, these distances are maybe 1000 meters or 2000 meters, and whenever we find that the results are encouraging, we may decrease these distances to smaller distances.

So, if the results are encouraging, then we go for investing more money on this and find out the occurrences of different minerals. So, we have found this is the mineralized zone here. This is the mineralized zone at this depth it is found. If it is found that Fe percentage of say 62 percent here Fe percentage say a 58 percent, here say we are found this is the occurrence

of the mineral zone say this is 72 percent. This maybe a large we have found a occurrence of source of mineralized zone here.

And from saying this is 56 percent or we may have been differences of this say this part is 62 percent, this part is 58 percent, this part is 70 percent. So, like that, there may be distributed in one hole also and this is the distribution of the grade we found in the different portion of the hole. So, now, we have found this is the grade distribution inside the hole. Similarly, we can get some grade distribution in this place also maybe this is 70 percent. This is 62 percent. This is 48 percent.

So, something like that the distributions are there and this is great distribution inside the hole This is in this hole so, like this a grade distribution are available, but we do not know the grade distribution as this place. So, what is the grade of the ore body at this place? What is the weather is there any water at this place or not because that is not covered in the drilling.

So, whenever we have carried out drilling, and we have some knowledge related to the grade of the important mineral at this place, we have to estimate what could be the grade at each and every part of the in-situ rock mass. So, whether it is interesting, it is within our useful grade level useful percentage level or not. So, that has to be determined, but we should have some estimation system so, that we can have the idea about the grade distribution inside the rock mass thoroughly.

So, this so, to do this we are having different techniques called inverse distance technique, polygon technique, triangle technique, log normal techniques, semivariogram models, and creaking models. So, all these models are available to carry out this grade distribution inside the rock mass. These details of these models are not part of the syllabus of this course.

So, we are not going into the same, but you can have some additional reading on this, this these are all discussed in the book of Hustrulid and Kuchta in which mine planning is given. So, that is available. The details of these are available in that book. So, we are not discussing here, but these techniques are available. Using this technique, we can assess the grade of each and every position of the mine.

So, we know the possible grade at this position of the mine and the possible rate at this position of the rock mass. So, these are possible, and these are the grade estimation technique that can be utilized here.

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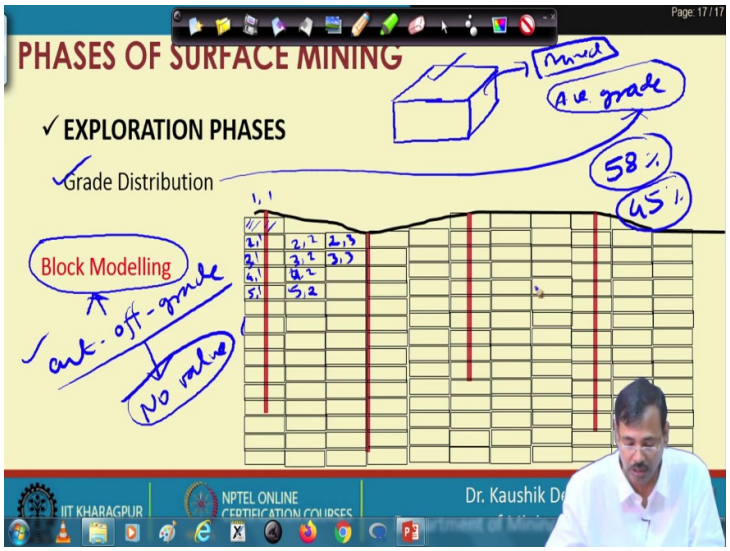

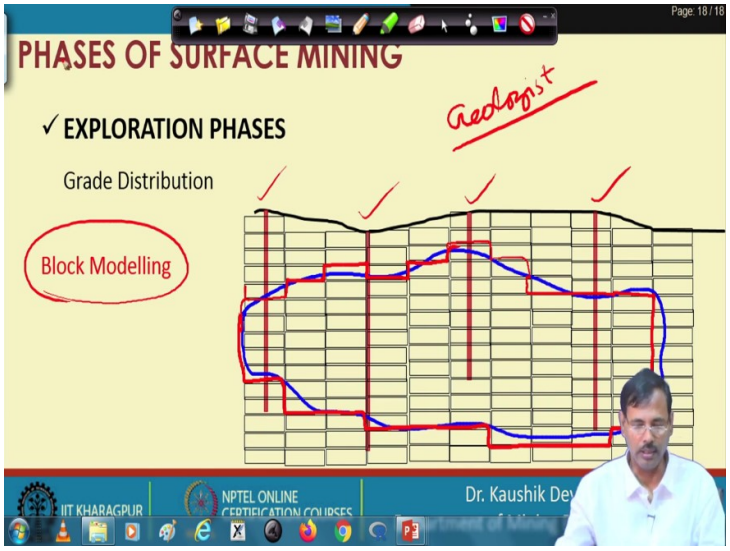

Now, our next phase is that we have to go for understanding the distributed grade inside the rock mass so, that we can assess whether the mining to be carried out here or not. So, what is the requirement? We distribute the total area in a number of blocks. So, these blocks are divided So, this is 1, 1 block, this is 2, 1 block, this is 3, 1 block, this is 4, 1 block, this is 5, 1 block, this is 2, 2 block, this is 3, 2 block this is 4, 2 block, this is 5, 2 block, this is 2, 3 block, this is 3, 3 block.

So, like that way, we divide the total area in a number of blocks, and we use beforehand what we have discussed in the grade distribution model, we find out the details of grade distribution for each block. So, suppose in that case that total area is divided in a block. This is when we are considering a two-dimensional analysis. If it is a three-dimensional analysis,

then it is the blocks like this, and we find out the average grade of the block using this grand distribution technique, which we have already discussed in our previous slide.

So, we know this is the block average grade of this block, and by this way, n number of blocks are available, which are placed that way we place the brick inside the brick for our wall. So, in a similar way, these blocks are available, and for each and each block is assigned with the average grade as mathematically calculated using the grade distribution models.

Now, what should be the dimension of these blocks? Generally, the dimension is considered as a block that can be mined as this single unit mining. So, the single mine even mine unit is considered the dimension of the block. This way, the complete in the complete area is divided with a number of blocks, and grades of these blocks are estimated using the grade distribution models.

So, this concept of modelling is called block modelling, and this block modelling is carried out so that the complete area can be estimated with the location of the deposit. So, that complete area now has the deposit is located, and we must consider one part here. I must give you the term that is called cut-off grade. Cut-off grade is the grade of the mineral above which it can be mined profitably, and that is accepted for the farther useful that is having the market where it can be sold and below which it has no commercial value. Above which it is sellable. Below which it has no value. So, it is considered a waste.

And this depends on the technology available, and this depends on the market situation and from time to time, it may change. Maybe in the 1990s, the cut-off grade of iron ore was 58 percent because our blast furnace technology accepted that one. Now it is reduced to 45 percent because our blast furnace technology has changed. Blast furnaces accepting iron ore of 45 percent also and that can be we can get the economic analysis of the cut-off rate we will discuss that later on.

So, what will happen is we can go for block modelling and with block modelling, we can find out the distribution of the ore body maybe like this. Based on our block model analysis, we can find out this is the possible distribution of the ore body and in that case, we should carry out our mining like this. So, the total deposit which is available here can be taken out using the mining system. So, this is the concept of block modelling that is very popularly utilized in mining and this is up to this is carried out by the geologist.

So, first the geophysicist came this geophysicist they give the indication that this is the location in this location possible, possible minerals those are available here these are the possible minerals and the results observed by the geophysicist found it is encouraging there is a potentiality that this area may be developed as a profitable mine in future.

So, this is the geophysicist in a nutshell, those who have taken few money and are telling this is the result. As the result is found encouraging, then the authority will engage the geologist, the geologist will come, they will find see the geophysicist report, they will search first initially find out whether there is indications of the deposit they are in the not or no. So, if it is found indications are there they go for the spending money they go for the exploratory drilling.

So, they take out the core from the earth's crust and different positions, if the results say first they have carried out this, if they found the results are encouraging, they go for additional drilling at this position. So, this drilling is carried out. They take out the core go for the chemical analysis of the core to find out the grade and grade distribution in the hole. Based on those grade and grade distribution in the hole, they estimate the distribution over the area in that particular zone.

So, what is the area they have found and using the different grade distribution model they have found and using that they have demarcated this blue line as the deposit area? Then they establish the block model to show the distribution of the grade at this position.

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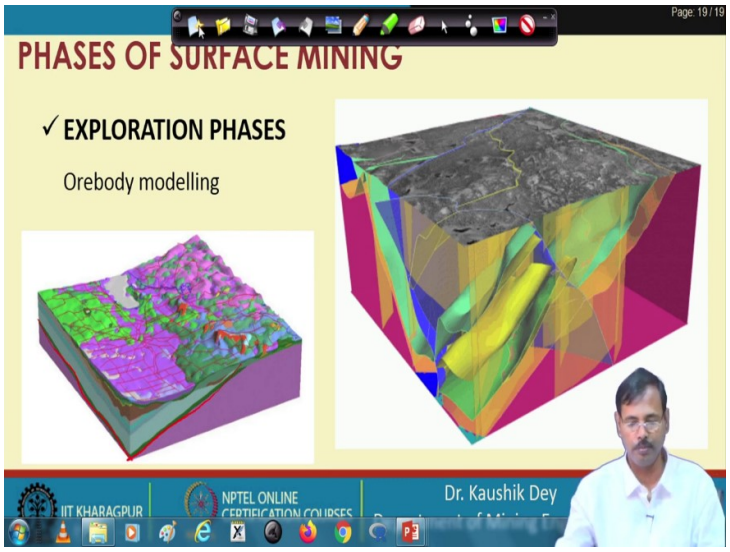

This is a computer-generated figure three-dimensional figure for the distribution of the grades you can see these grades are distributed like this. So, this is called orebody modelling. So, the orebody is now modelled, say, suppose in this case, if you are considering this one you can see this is the orebody which is shown deposited like this is shown in the model.

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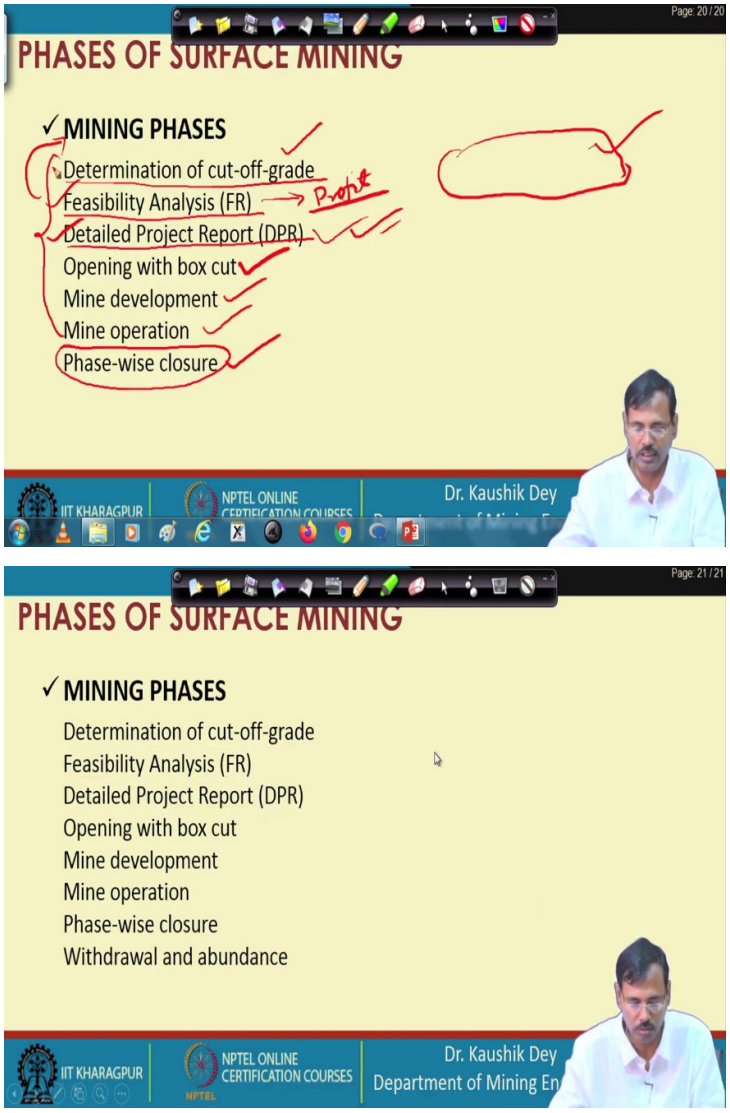

Now, the next part is the mining phase, where one has to understand what the cut-off grade is? And how, what is the cut-off grade? And considering the cut-off grade, what are the available minerals, whether the mining of these minerals are economically feasible, or not that is called feasibility report. That means if the mining considering this is the cut-off grade considering this is the orebody we are getting mining of this is generating this much of money possible mining expenses are this much.

So, the profit out of this is this much. So, if the economic analysis of this is found encouraging, we prepare the detailed project report. So, this is basically the economic report. This is the technical report. When the economic or financial appraisal is telling that mining of this deposit is profitable, then you go for preparing the detailed technical report in which we find out which type of excavators will be deployed?

Which type of machines will be deployed? What are the dimensions? What the possible excavations for each why? What are the phase out of the machines? All these are basically carried out here, then after preparing this total a detailed project report that is the designing of the mine is complete here, then we go for the open commencement of the mining through the opening up box cut.

Then, we go for a service on a box cut, we develop the mine, we operate the mine and finally, we go for closing of the mine. So, this is the closing of the mine. So, we can say post mining activities and up to these are considered as the mining phases. So, let us look into this one by one.

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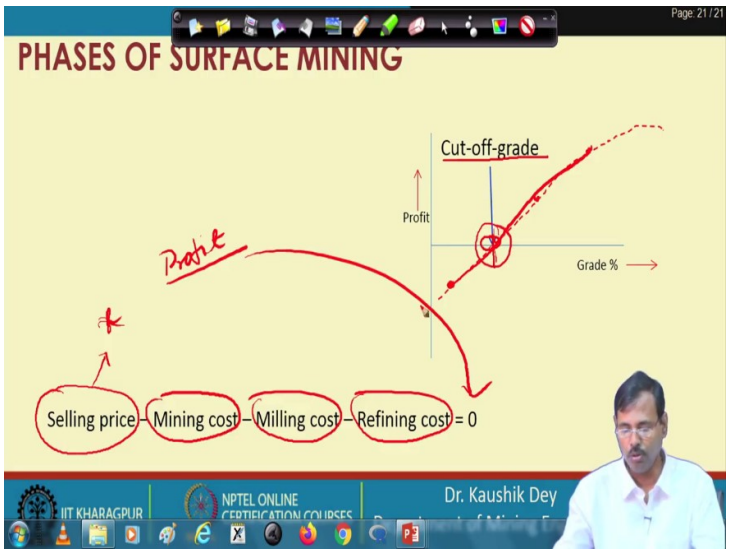

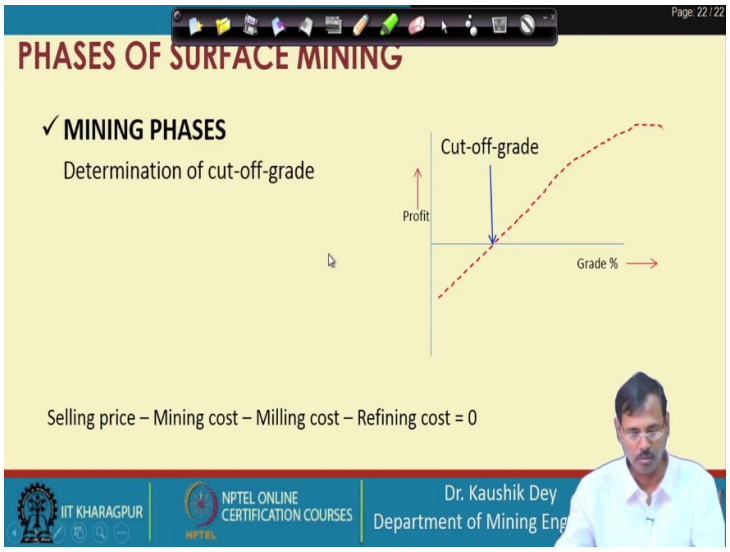

The cut-off grade is basically the grade at which your mining is carried out with no profit no loss condition. So, that means, if you are great, this is the economic perception of the cut-off grade. Another perception is that you are following technology is accepting or not. Suppose, in the case of iron ore, whether your blast furnace is accepting that grade or not is important.

So, similarly, in this case, the cut-off grade is basically an economic analysis here in this case, if it is if your profit and loss for operating of that grade is coming to 0, then that is called cut-off grade. That means, what the selling price of the material say, metal. The selling price of the metal, whatever you are getting, said that is x, and if you are taking out the mining cost, milling cost and refining cost from that, that is basically dictating the profit.

So, if this is the profit and becomes 0, that is considered the cut-off grade. So, what do we do? We find out the profit and loss at different positions, then we project on that and based on that what when that is crossing the line 0, that grade is considered as the cut-off grade. Again, you will find out more little analysis in the mine planning sectors, mine planning courses related to this.

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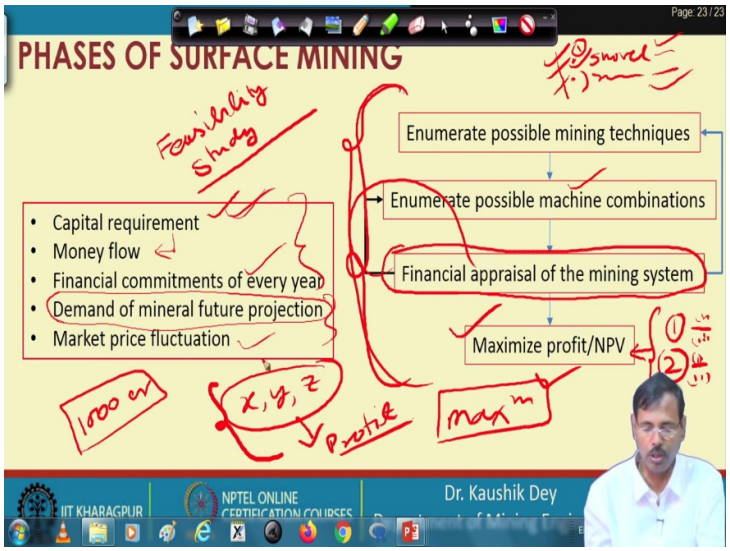

So, now, if you look into the phases of a mining, mining phase particularly the first we have to go for the feasibility study. So, this is feasibility study. In the feasibility study, what we need to do we have to find out a list of possible mining techniques. Say we are deploying shovel, dumper, drilling, blasting, then maybe we can use surface miner, etcetera, etcetera. Some different types of techniques are available, we adopt all these techniques and then we find out what is the financial appraisal for this particular technique.

So, suppose if we are using drilling blasting, then take out the material using a shovel and dumper and then we find out how much profit we can make out of that and find out the least. So, this is if this is one number, so, the profit of one number is listed here also, then we try for the next one. So, next combination is the surface miner, dumper, etcetera, etcetera. So, using that technique, we find out the possible costs of this.

So, that is listed second. We can have it another technique we can have the variations of the machine combinations say like 100 tonner dumper, 5 metre cube shovel. So, we can change that to 10 meter cube shovel to 100 tonner dumpers and we go for the another iteration here. So, here is also there, there are a number of iterations and here is also here having different number of iterations.

And by this way, we can have a list of maximum economic analysis list of economic analysis. We have to choose the maximum of that here. So, the maximum of that is basically giving us the possible mining system with a maximum profit or maximum NPV for what we are opting for. This is also an economic term, or the net present value of the mine will be maximized or

the profit will be maximized, that is the managerial decision to be or economic decision to be taken by the management.

So, whatever is found related to this must be the as per the business rule that must you must have a sufficient profit to carry out these operations and these operations after this study we have come out that okay the mining of this deposit which is given by the geologists as shown before as part of the orebody modelling, and we have to carry out this mining with this x, y, z combinations of the machines.

And by this, we will get the profit of this much or we can have a cash flow like this. So, this is the result and this economic analysis has to be carried out by the mine management first then only they will go for the actual starting of the mine, mining and after this economic analysis for the mine management will do, for carrying out this they have to procure these machineries they have to invest some money so, for that a huge capital is required.

So, if you are observing into this geophysical prospecting may be costing us few lakhs of rupees, an exploration that is having some dealings etcetera that is few crores of rupees. But whenever you are actually carrying out the mining that is costing us 1000 crores of few 1000 crores of investment, few 1000 crores of investment is required for carrying out the mine because we have to procure a number of huge machineries there. So, that is a very big investment. So, the capital requirement is there.

So, you have to prepare this feasibility report. You have to submit that report to the bank or the financer so that you can borrow capital from them, and you have to invest that. So, you have to show the money flow also. So, if you are investing crores of rupees every year that must return you to the profit from that, then that money flow has to be shown, then the financial commitments you have to phase out the machine. So, you have to maintain those machines those are the financial commitments and also you should know the demand of the mineral in the future.

So, suppose currently if your current is absorbing into the current situation, the demand for lithium is increasing because the battery technology is coming and demand of the fossil fields is decreasing because we are phasing out the diesel-based or petroleum-based vehicles. So, this is the future market demand that growth of the market, movement of the market that has to be considered while you were preparing this mining plan, because the moment to start starting your mine as you are starting your mine you have to made in the idea that in for the

next coming 20 years or 30 years then mine has to run so, that you can properly utilize these machineries.

So, market fluctuations and market future demand are very important while preparing the feasibility report and deciding on investing in a mining plan. So, once the feasibility report is made and say feasibility report is means made, you have not actually spent your money on the investment of a few 1000 crores. So, you have made only the feasibility report if it is interesting, then only you prepare the detailed project report.

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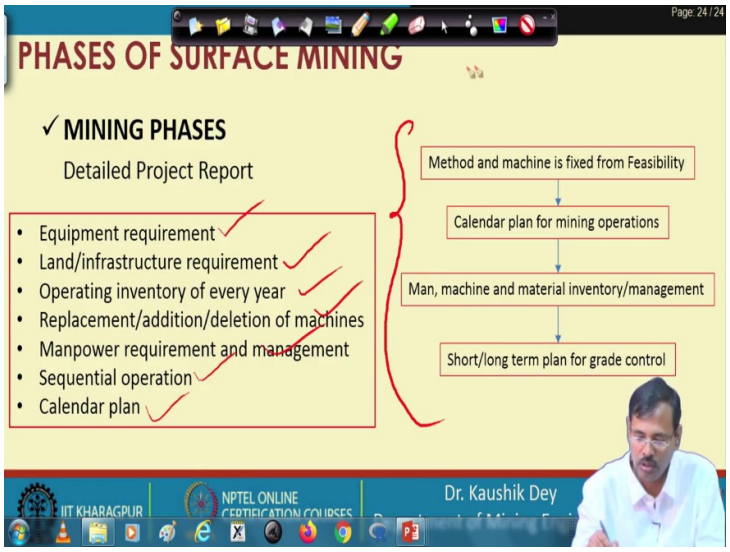

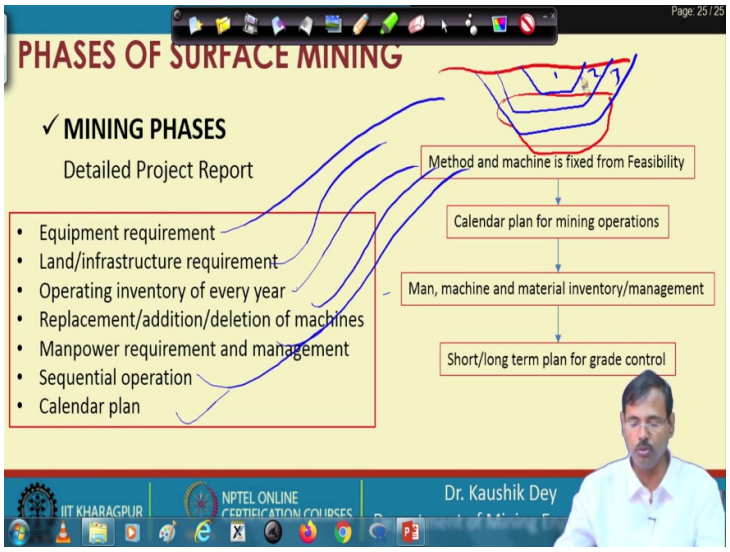

So, what is the detailed project report? It is basically the technical report in which you will find out the method of operations, the movement of the mine, the allocations of the machines, the calendar plan for the mining operations. So, day to day operations will be carried out that

is given in a larger timeframe, which means it may be in 1 year, 2year what will be the position of the mines. This has to be given there.

So, basically, a detailed project report gives us the details of the equipment requirement, land and infrastructure requirement, operating inventory of the inventory in every year replacement, addition, deletion of the machines, manpower requirement and their management, sequential operations and calendar plan.

That means, if, if this is the deposit your calendar plan is telling, in the first year you will mine up to this in the second year you will mine up to this in the third year you will mine up to this and for this what are the equipment requirement? What is the land requirement? What are the operating inventory? What is the replacement addition of the machines? Manpower requirement, sequential operation and calendar plan.

So, this is year 1, year 2, year 3, this is this are basically discussed in this project report so, that the mining workers they need just need to follow this detailed project report so, that they can carry out mining very easily in the future.

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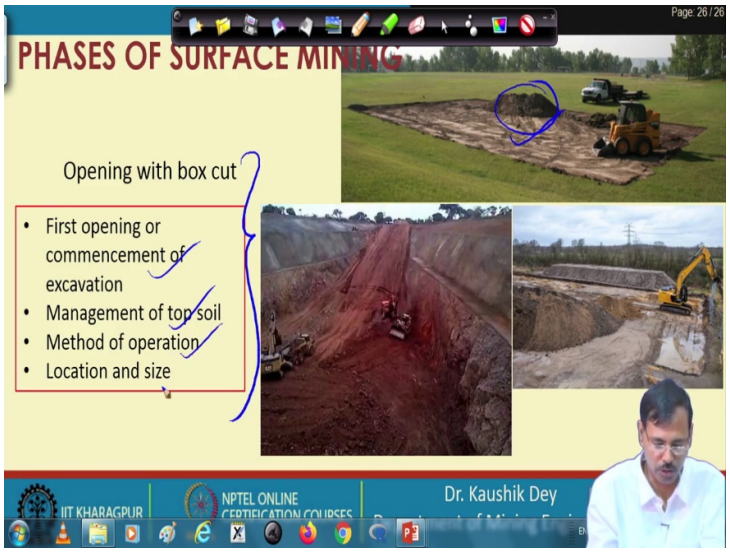

Now, you have to start operating the mine. The mining is carried out with the box cut operation. You can see the first mining is carried out here. You have to take out this topsoil, you have to restore this topsoil, then gradually you have to open up this pit. So, this is called box cut. And all these are basically considered in box cut. Then, management of topsoil, method of operation, location and size you have to; this is box cut is basically the commencement of the actual mining.

So, that means you have made up your mine to invest thousands of crores of rupees by observing the feasibility report is interesting DPR is made, so, you have commenced the mining operation.

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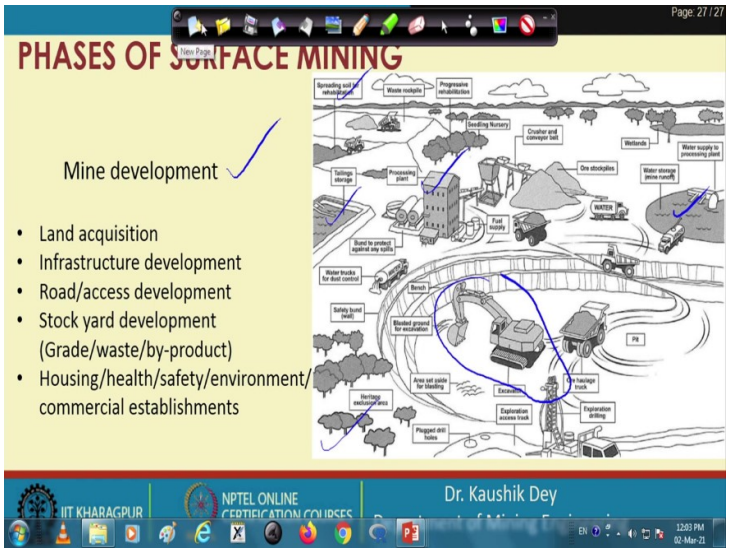

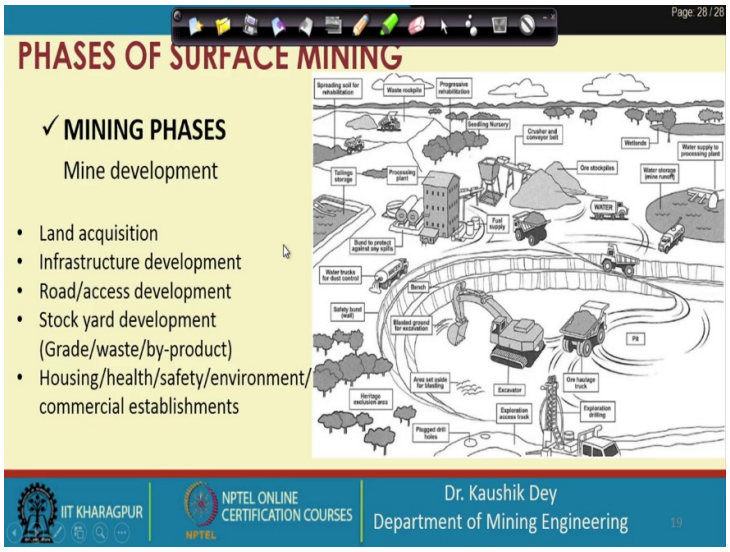

This is the development of the mine you have to find out the locations of the different infrastructures, this is the processing plant, this is the telling this is the topsoil management, this is the water storage system, this is the topsoil rehabilitation, this is the actual mining carried out at this place, this is the afforestation.

So, all these are basically location wise you have decided, and you have started mining, and all these infrastructures are developed in the mine development. So, you have opened the box cut, you have developed the mine you have started the full-fledged mining system in this case.

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Now, this is a picture of the actual mine site. You can see this is the mine and this is the infrastructures these are the offices and housings, and this is the processing plant, this is the tailing topsoil management, this is the tailing management and this is the mining is carried out here. So, you can see all these infrastructures are developed like this, this is the access roads.

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This is another picture of the same. This is colonies showing here, presidential colonies showing here.

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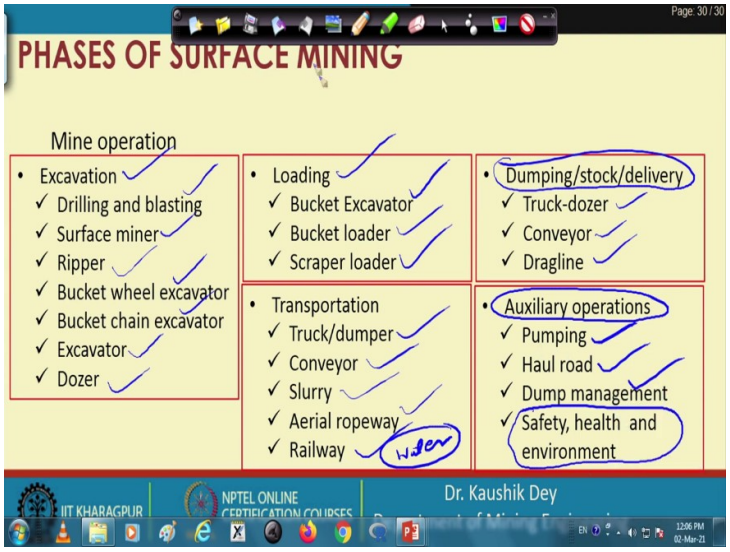

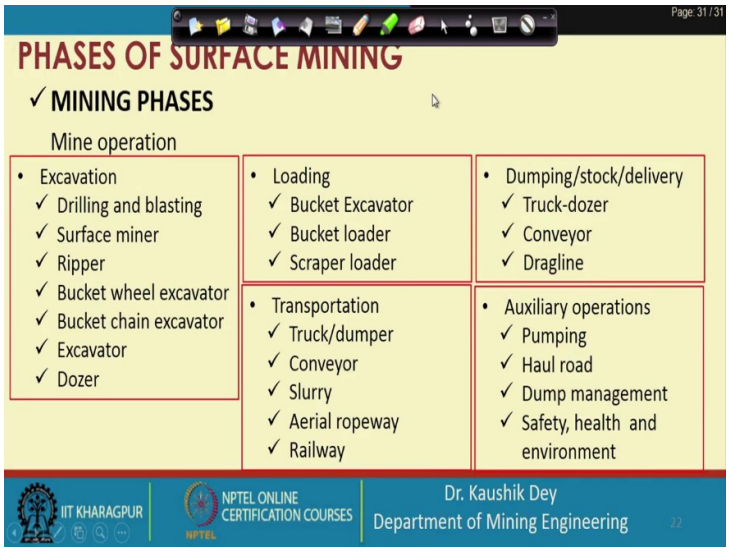

So, mining operations can be shown in a nutshell like this. Excavation may be carried out using drilling and blasting, surface miner, ripper, bucket wheel excavator, bucket chain excavator, shovel excavators and dozer. These are the excavating equipments.

There are loading equipments, bucket excavators, bucket loaders, scrapper loaders, these are the loading equipments or transport system may be the truck transportation system, conveyor transportation systems, slurry transport system, aerial ropeway, railway there is another one which is not actually practiced in the mining except the seabed mining you can have the water transport system also that is possible only in case of the inland transportation system.

The truck-dozers, conveyor, draglines these are also used for the simultaneous dumping and stock or delivery system that can be used simultaneously. And every mining operations are associated with auxiliary operations which are not directly the productive operations, but very very important operations without these operations, you cannot continue the mining operation that is pumping whatever water is coming inside the mine you have to pump it out, if you are not managing that one your mine will be inundated you cannot operate.

You have to maintain the haul road so that the transportation system can run smoothly, and the wear and tear, wearing and tearing to the playing equipment should not be there. You have to manage the dump properly. So, that it will not slide down it will not create any hazard and safety, health and in the environment must be maintained in the mine; otherwise, you may be imposed on the statutory banning.

So, these are very, very important operations and a mine in his life cycle has to follow all these requirements and these are the possible mining operations to be maintained.

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And this is the pictorial representation of the different operations. You can see a dragline here this is a stripping shovel, this is a dipper shovel. This is a back-hoe shovel.

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This is surface miner, this is the wheel loader and this is a bucket wheel excavator.

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We will come to the details of this operation that will look at later. This is a spreader; this is a dumper.

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This is dust suppressant so water sprinkler, so that the dust suppressant can be made. This is the diesel bowser, which will give the mine fuel. This is a ripper-dozer. This is only a dozer.

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This is a bucket chain excavator, this is drill machine, this is a typical surface miner called trencher.

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This is the rock breaker and this is the highwall minor which are the commonly used in a surface mine.

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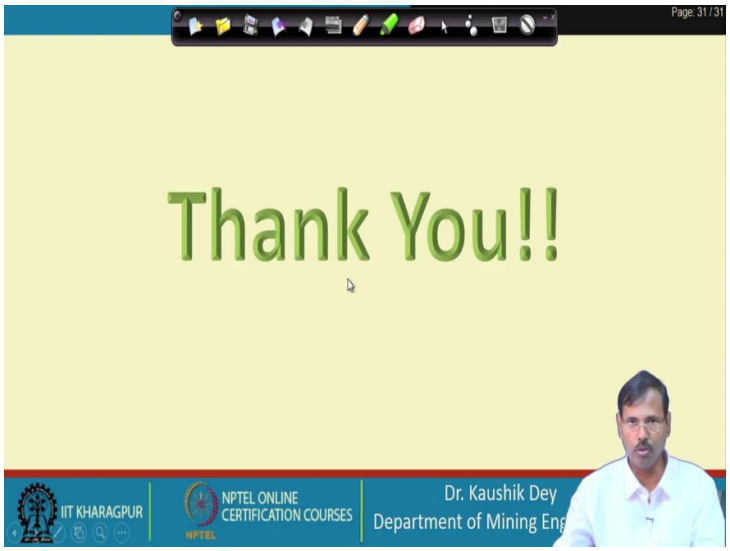

So, let us close that this lecture at this position. We will continue the phases of mining in the next class, where we will discuss the post-mining for post-mining closing of the mine. Thank you.