

**Surface Mining Technology**  
**Professor. Kaushik Dey**  
**Department of Mining Engineering**  
**Indian Institute of Technology, Kharagpur**  
**Lecture No. 45**  
**Some Auxiliary Operations**

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Let me welcome you to the forty fifth lecture of NPTEL Online Certification Course, Surface Mining Technology. This is the lecture on some Auxiliary Operations which are often essential, but often may not be immediate or regular basis requirement, but cannot be avoided in some situation also, these are the auxiliary operations required.


So, these operations in a nutshell, as we have already covered most of the unit operations required in Surface Mining, these are some Auxiliary Operations discussed in this lecture in a very concise manner. These are some important one, all the participants should pay attention on these Operations, while they are working as a practicing mining engineer that time they must adopt or give their whole-hearted concern related to this Auxiliary Operations also.

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## INTRODUCTION

✓ **LEARNING BACKGROUND:**

It is expected that the students taking this course lectures have a preliminary understanding about the surface mining technology. The basic knowledge of explosives, blasting, formation of earth crust, geology etc are already covered in the previous courses. It is expected that a student must have passed a course on basic geology, explosive and blasting etc.




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## INTRODUCTION

✓ **Learning Objectives of This Course:**

- To know the different unit operations associated with surface mining.
- Methods of surface mining.
- Deployment of machineries in surface mining.
- Productivity analysis of surface mining.
- Safety and environmental control of surface mining operations.
- Special methods of surface mining.



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So, as we do before starting let us look once again into the learning background required for Surface Mining Technology Course. These are the learning objectives of Surface Mining Technology Course.

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## 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 able 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 and environmental requirements will also be addressed.



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## INTRODUCTION

### ✓ SOME TEXT BOOKS AND REFERENCES

1. Mishra G. B., 1978, Surface Mining, Dhanbad Publishers
2. Das S. K., 1998, Surface Mining Technology, Lovely Prakashan
3. Deshmukh R. T., 1996, Opencast Mining, M. Publications, Nagpur,.
4. De Amithosh, 1995, Latest Development of Heavy Earth Moving Machinery, Annapurna Publishers
5. Hartman H. L., 2002, Introductory Mining Engineering, Published by John Willey and sons



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## INTRODUCTION

### ✓ SOME TEXT BOOKS AND REFERENCES

6. Peter Darling, 2011, SME Hand book, SME Publication
7. Rzhovsky, V. V., (1983), Opencast Mining Unit. Operation, Mir publications
8. Rzhovsky, V. V., (1985), Opencast Mining Technology and Integrated Mechanisations, Mir publications



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And these are the expected Learning Outcomes, and these are some of the Text and References participant of this course may follow those references.

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**INTRODUCTION**

✓ **Retrospect Previous Lectures:**

In previous lectures, the phases of mining a deposit are discussed. The unit operations associated in every phase is also explained. The commencement of mining excavation through opening of box cut is discussed. The unit operation, Drilling technology is discussed. The different drilling procedures, drilling patterns required and machine operations are also discussed. Blasting technology and sum of the machine operations, e.g. and excavation by ripper are also discussed. Shovel and dumper deployment for loading and transportation is also discussed.

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These are the retrospect of so far we have covered. As we are all almost covered most of the unit operation part, so let us once again retrospect that one. In our previous lecture we have covered the phases of mining a deposit, we have covered the different unit operations associated with each phase, we have covered the commencement of surface mining through by excavation through opening a box cut.

We have covered the drilling technology which is essentially required for drilling the hole, in which the explosive charges has to be placed, we have covered the blasting technology, designing the blast, assessment of the blasting results, we have covered the excavation by ripper which is a blast free technology adopted for the soft material. And we have covered the excavation using shovel or loading by shovel to the transporting system. In transporting system in surface mines, we have covered discrete and continuous transportation system. We have given special emphasis on to the shovel dumper combinations.

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**INTRODUCTION**

✓ **Retrospect Previous Lectures:**

Apart from these, the excavation with surface miner and bucket wheel excavator are also discussed. The removal of overburden rock for direct casting using a dragline is also discussed. The highwall excavation techniques namely mining etc are also discussed.

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Apart from that, we have also covered excavation by surface miner which is also another blast free technology and we have also covered the operation of drug line which is basically excavation and direct casting of the material where the back filling is practiced. We have also covered the special method of excavation, that is the high wall mining that is also covered previously before this lecture.

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**INTRODUCTION**

**Learning Objectives of This Lecture:**

- To learn some auxiliary operations may be carried out in surface mines
- To learn the procedure of these operations

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Now, we will look into some of the auxiliary operations and for this, we have set the objectives to learn some auxiliary operations, which may be carried out in surface mines, and we like to learn the procedure of these operations.

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**AUXILIARY OPERATIONS**

Some unit operations are occasionally carried out in a mine. These operations are often unavoidable. It is desired to have an exposure to the same.

1. Construction of ramp
2. Fracturing of large boulders
3. Construction of sump pit
4. Water sprinkling on haul road

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So, some of the operations listed in this are the construction of ramp, because from one bench to another bench ramp construction is essentially required. Second one is the fracturing of the large size boulder, suppose in blasting some of the large size boulders has come out, how to fracture that one that as that cannot be handled by the excavator, and we have also covered the covering the construction of sump pit, because sump pit is the place where all the waters are allowed to accumulate and from where the mine pumps are placed to pump out the water from that place.

And water sprinkling on haul road is another important one, because haul road is the main source of the dust generation because of the movement of the vehicles on the road, as the fine particles are generating on the wind those particles are becoming airborne, so that controlling of those fine particles are required for that the water has to be sprinkled.

So, we are basically covering these 4 features here and that is why these are some auxiliary operations mentioned, but these are not the end of the list, there are many more auxiliary operations are there which are not covered in this course because of the time constraint.

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**AUXILIARY OPERATIONS**

**CONSTRUCTION OF RAMP**

- ✓ Ramps are constructed between two benches for connecting them
- ✓ Ramp can be constructed using
  - Drilling and blasting ✓
  - Dozer ✓ #
  - Surface miner ✓
  - Excavator ✓
  - BWE ✓
- ✓ Ramp inclination is important (should not exceed 1 in 12 for tyre mounted equipment).
- ✓ Ramp can be constructed by filling also

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Now, let us start with the construction of ramp. Construction of ramp is made between the two benches to connect them so that the man, material, machines can access from one bench to another bench. Ramp can be constructed using the drilling and blasting method, it can be constructed by the Dozer, which is most of the time we use the dozer to construct the ramp. Ramp can be constructed by the surface miner, surface miner is the machine which by itself it can construct its own ramp.

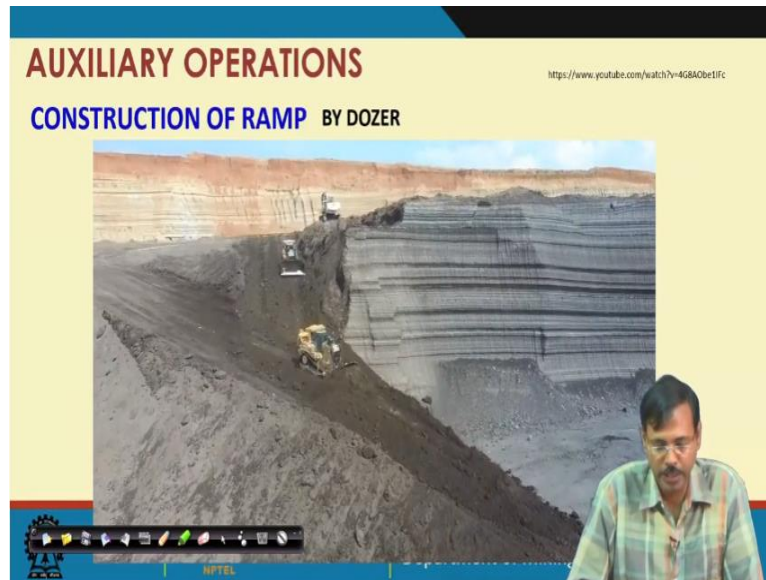
Similarly, bucket wheel excavator is also able to construct his own ramp, it is cut down to construct the ramp and gradually the machine can go into the lower level. Similarly, excavator specially back hole excavator is very effective to construct the ramp, it can cut the material and fill and by this way it can construct the ramp.

In ramp construction, the important part is the inclination of the ramp, in India, in general, we follow that at least 1 in 12 inclinations should be kept for the tire mounted vehicles for the smooth movement, for the railway tracks it is 1 in 15 or something like that different criteria are their fixed. So, the inclination is very important and ramp is as mildly, gently inclined as possible is always welcome.

And often ramp can be constructed through the filling material also instead of cutting, ramp can be constructed through the filling material, material can be filled and by this way ramp can also be constructed, as it is carried out in the normal civil construction roadways, etcetera, where the ramp is basically constructed by the filling material. But as in mining we are excavating, unnecessarily after excavating keeping the material in the place for acting as the ramp is not well accepted.

So generally, instead of filling, we generally in mining we go for the cutting to construct the ramp that is the general tendency of the construction of the ramp in surface mines.

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This is one video, in which the two dozers are simultaneously allowed to construct a ramp. Now it can be seen very easily one dozer is basically constructing one ramp another dozer is constructing another ramp, there are actually two ramps. And these two ramps are basically made for serving the shovel which can be seen above. So, here it can be seen that the bench is basically cut and the cut material is basically thrown in the front or dodged in the front to have the ramp.

So, dozer is basically a very good equipment which can cut the material in its front maintaining the hole inclination, hole control on the inclination it can also cut, go for the side cutting of the bench so that the excess material can be taken out from that and it can also guide the cut material in a particular direction for filling that area. So, generally, dozer blade controlling the dozer blade can have control on the inclination of the roadways not only towards the longitudinally but also laterally also the inclination can be made, so that the rain water can be guided in one direction.

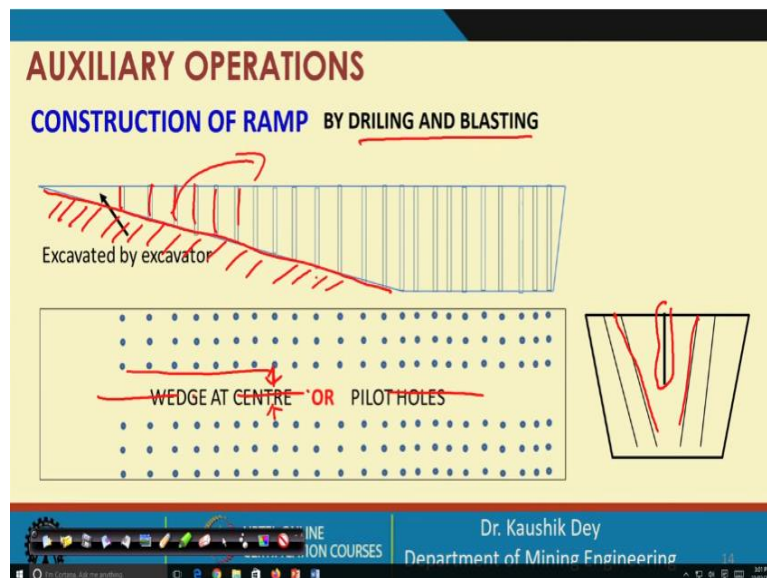
And the benefit of the dozer is it can negotiate a very high inclined roadways, so in a hilly train also dozer can climb up to that and from upper to the lower direction it can construct the ramp for the rest of the vehicles, vehicles movement in that area.

So, this is one beautiful video where two dozers are operating to construct the ramp. And this two-side part which are the cutting, side cutting teeth of the dozer are very useful to precisely cut the edge side, edge part of the slope and from that in tilting that part the drain can also be constructed.

So, dozer is basically a very, very useful and that machine can operate by standing alone. You can see it has negotiated that much big boulder also while reversing back. So, it can negotiate that much big undulation also. That is the benefit of the dozer and now it is taking that material, moving it, it say it is started side cutting and now along with the shut cutting it is also dodging the material and it will guide the material to dump in this direction.

See, how the blade, controlling the blade, it is also allowing the inclination of the roadways. See this is cut and placed well. See only few minutes are taken by this two dozer to construct one ramp in this way another ramp in this way so they have constructed two ramp for operation of this shovel, using this two dozer and the inclination is kept very, very well controlled and uniform throughout the length of the patch.

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So, this is one. Now, the construction of ramp using the dozer we have seen, construction of ramp can be carried out using the drilling and blasting technology also, and if it is a very hard rock, dozer cannot cut it we can go for having the drilling and blasting with a increasing hole lengths and we can adapt the wedge cut, that is the wedge can be formed centrally, if it is the centre line, in this direction wedge can be formed and if very hard rock condition, we can have a pilot hole also, then if we are carried out blasting then this portion the rock will be blasted.

Now blasting restricted to this line, we are allowing intact rock, hard rock surface at this position and we excavate this path only so this is allowing the well constructed ramp on which the machineries can move very easily, because this is a hard rock surface, so machines can work on this and there will be no, minimum failure on the ramp surface at this position.

So, it will become a strong ramp at this position, so drilling and blasting can be one very useful technology in ramp construction.

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So, this is one another video available for construction of ramp using this, so this is the one back excavator is allowed to construct this ramp, so this is very, very useful, this machine and this can remove the unwanted boulders at the side of the ramp it can having the facility for the sorting of the boulders also and by this way the ramp is made. Now this is gradually cutting this one for maintaining the slope and it is able to construct the ramp very easily. So, this is another operations of the excavator for constructing the ramp.

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The slide has a yellow background with a blue header and footer. The header contains the text 'AUXILIARY OPERATIONS' in red and 'FRACTURING LARGE BOULDERS' in blue. The main content is a bulleted list of methods for fracturing large boulders. The footer includes the text 'Department of Mining Engineering' and the name 'Dr. Kaushik Dey'. The number '16' is also visible in the footer.

- ✓ Large boulder are formed – either due to poor fragmentations or these are naturally exists in a soil cover.
- ✓ Excavators can not load them on the dump trucks, often it is difficult to sort. In such cases dozers are deployed to sort them.
- ✓ Large boulder can be fragmented using
  - Drilling and blasting
  - Dozed at the side
  - Fractured by rock breaker
  - .....
- ✓ Large boulder is completely unwanted as it hinders the production schedules.

Now, our next topic is the Fracturing of the Large size Boulders, this is called Secondary Blasting, so in primary blasting, say if the large size boulders are formed, because of the poor fragmentation and sometimes naturally large size boulders are existing which are impregnated in the soil cover of the over burden, in those cases also sometimes we may need to blast those because those sizes are not within the range of size which the excavator can handle.

So, in those cases the excavators cannot load them onto the truck so it has to be reduced sized then only that can be excavated, so the secondary blasting has to be carried out there. Sometimes the dozers are deployed to sort them, and keep one side and that can be tilted blast at a later stage.

So, large boulders can be fragmented using the drilling and blasting or that can be dosed at a site along with the other waste rock or maybe dump towards the backfield area or it can be fractured by using the rock breaker. Large boulders are completely unwanted because it hinders the production scheduling and the machine deployment for handling, these are totally unwanted and wastage and that is why it is truly unwanted, that is why it is expected the designing of the blast must be proper so that it minimise the generation of the large size boulders.

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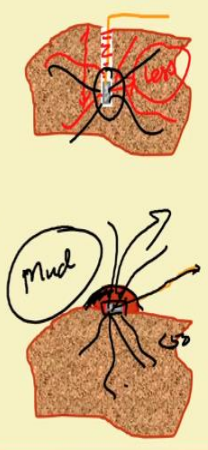
So, now let us look into one video in which the Secondary Blasting is carried out these are the links of this videos. Now this is the secondary blasting being carried out. So, this is the secondary blasting carried out where big boulders are blasted into the smaller size pieces.

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**AUXILIARY OPERATIONS**

**FRACTURING LARGE BOULDERS BY BLASTING**

- ✓ Secondary boulder blasting can be carried out .
  - Pop shooting (Drilling and blasting)
  - Plaster shooting (only blasting)
- ✓ In pop shooting small diameter holes are drilled up to the 2/3 depth of the boulder thickness. The blasting is done with a little charge.
- ✓ In plaster shooting the explosive cartridge is pasted on the surface of the boulder and covered with a plaster. Then the blasting is done.



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Now there are two basic way for fragmenting the large size boulders one is called Pop Shooting, where the drilling and blasting is carried out, second one is called Plaster Shooting where only blasting is carried out no drilling is made. In Pop Shooting, generally we carry out a drilling in the boulder, we place the explosive in the hole, and then stem it and blast it.

This is the general pattern, this drilling is carried out up to two third depth of the size of the boulder and the after that the charges are placed, minimum charges are placed here the charge requirement is very less with a very small charge, only the shock pressure, shock waves are allowed to propagate or shock waves are generated to initiate the fractures in this, that is good enough to fragmenting the rock and that can be that, further that can be handled by the excavator.

So, this is the most common practice but this drilling of boulder is a little bit troublesome process so often it is not opted by the mining authority, that time the Plaster shooting is basically practiced. In plaster shooting we do not go for any drilling in the boulder, top surface of the boulders or bottom surface of the boulder or whatever, a suitable place is found we keep the explosive charge there.

We keep the explosive charge at this, that place and then initiate that using the initiation system and before initiation we go for plastering that with some plaster material either a cement plaster or the plaster of paris or the mud are used. The most commonly mud are used for plastering this one, so that the explosive remain intact with that and on blasting the shock energy propagates through this and that generate the cracks in the boulder.

But energy utilisation is much better in this case because all the shock energy are utilised here, here less than 50 percent shock energy is utilised, rest stock energy is propagating as a sound or air over pressure and generating huge noise frightening the nearby inhabitants, apart from that gas pressure is also not used because it is mud capped, the gas pressure is escaped in the air itself which wherever in this case the gas pressure is also utilised.

So generally, Plaster shooting is not very wanted one but because of the non-availability of the small drill machines or non-availability of the boulders in a proper form, the plaster setting has to be sometimes carried out otherwise Pop shooting is in general preferred mostly in the mines.

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**AUXILIARY OPERATIONS**

**FRACTURING LARGE BOULDERS BY BLASTING**

✓ Pop shooting is more effective.

✓ It associated with additional small dia drilling

✓ Through of boulders are significant

✓ Plaster shooting is not energy efficient.

✓ No need of drilling

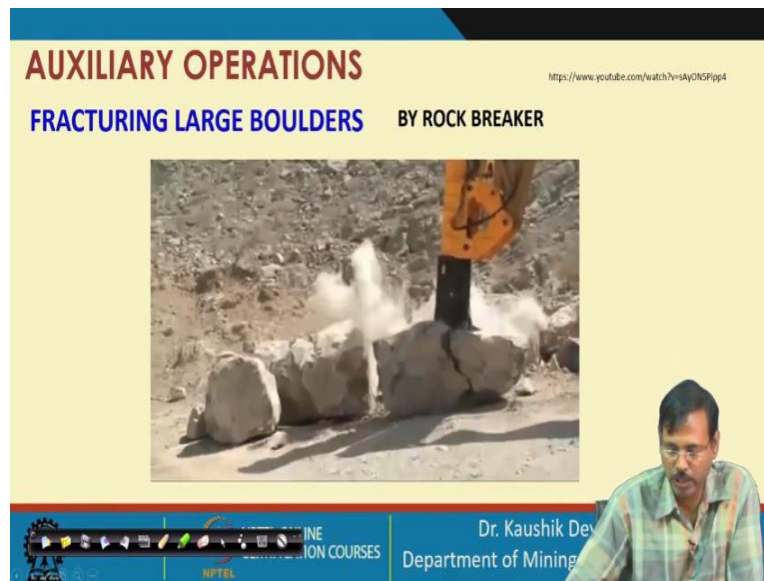
✓ Generates huge noise and air overpressure

✓ Easy to execute

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So, this is the comparison between the Pop shooting and cluster Plaster shooting, Pop Shooting is more effective, associated with additional small drilling, boulders through the boulders are significant. Plaster shooting is not energy efficient, no need of drilling, greater noise but it is easy to execute that is the benefit of the Plaster shooting.

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Second method of fracturing is the Rock Breaker, this is a hydraulic or pneumatic breaker in general used for breaking. Let us look into this video, so this is the breaker where a hydraulic hammer is basically attached to a boom of the excavator utilising the same hydraulic power of the boom and it is allowing the hammering of the boulders. So, this is very efficient and boulders can be significantly broken into the figures.

However, these are depending on the compressive strength of the rock, if the rock is very, very hard say compressive strength of 200 mega pascal, 250 mega pascal in those cases rock breaker may not be that much effective and may be the Pop shooting is the better option for those cases. Otherwise in the most common rocks, breaker is a very good and preferable technology cost effective also these are used the downtime is not significant.

In Plaster shooting, before Pop shooting the manpower has to be withdrawn from the mine, so that is a loss of time schedule that is not wanted so rock breaker is a very very good and approved technology very, very popular technology nowadays used for fracturing of the large size boulders. So, this is big boulder with some small blows, it can be fractured.

So, it can negotiate the face of the boulder also and by that it can blast and it can fragment it, see with a of now it is fracturing this big boulder. So the direction of the boulder can be changed also, the direction of the hammering can also be changed. And depending on this, there are number of big hammers are possible.

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**AUXILIARY OPERATIONS**  
**FRACTURING LARGE BOULDERS BY ROCK BREAKER**

- ✓ Rock breaker is basically a hydraulic or pneumatic attachment fitted with the excavator boom.
- ✓ It gives hammering action on the rock boulder.
- ✓ There are different types of rock breaker
  - Ripper type rock breaker (gives a shearing force also)
  - Chisel type rock breaker (hammered on the chisel)

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<https://indeco-breakers.com/products-breakers-hp25000/#~:text=indeco%20breaks%20all%20records%20with,winning%20and%20extra%20hard%20rocks.>

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So, these are the largest rock breaker. This is the largest rock breaker available, there are different types of rock breaker, Ripper type rock breakers are also available, Chisel type rock breakers are also available so there are varieties of rock breakers available this is the 25,000 HP Rock Breaker.

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**AUXILIARY OPERATIONS**  
**FRACTURING LARGE BOULDERS BY ROCK BREAKER**

**HP 25000 Specifications**

Operating Weight	24370 lbs	11054 kg
Carrier Weight Min	130,000 lbs	58967 kg
Carrier Weight Max	303,000 lbs	158,757 kg
Tool Diameter	10 in	216 mm
Hydraulic Flow	110-137 g/m	416-518 lpm
Pressure to Breaker	2050-2600 psi	179 bar
Impact Frequency	240-460 bpm	
Energy Class	25000	

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This is the HP 25,000 specification which is having 11 tonne operating weight, and this is the chisel diameter, this is the hydraulic flow, this is the 179 bar pressure generated, so this is the largest rock breaker one figure of that one from this wave source are found.



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**AUXILIARY OPERATIONS**

**SUMP PIT**

- ✓ Sump pit is the place where an artificial pit is made to accumulate the mine water.
- ✓ Mine water is pumped out from sump pit.
- ✓ Sump pit is often constructed using
  - Drilling and blasting
  - Excavators
  - Surface miner/BWE/Ripper etc.
- ✓ Pumping can be done -
  - Using large mine pumps for shallow mines
  - In stages for deep mines

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Next is the sump pit, sump pit is the place where an artificial pit is made to accumulate the mine water and after accumulation of this mine water the water is pump out from the sump pit. Sump pit is often constructed by drilling and blasting the way we carry out the box cut or we can use excavator, surface miner, bucket wheel excavator, ripper, and etcetera.

And pumping is carried out using the large mine pumps from the shallow mine and stages of pumps are used for the deep mines, this is in general we go for the sump pit, sump pit allowing the mine to operate dry, this is also allowing the fight against the inundation situation, in rainy season many of the mines prefer to work in the upper benches because of the water logging problems.

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**AUXILIARY OPERATIONS**

**SUMP PIT**

Open Pit Mine Dewatering System

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This is one animated video related to the mine sump, so this is the mine sump considering and in rainy season because of the rain and huge rain because of the installed copper capacity of the mine pump is less and so the water level of the sump is increasing but in the dry season the pumping capacity is more than the input of the waters so the water levels are reduced.

So, the designing of the pumping capacity is important and this pumps are allowed to take out the material. Often, the choice of pump is very, very important, submersible pumps are sometimes used, sometimes pneumatic pumps are used if the muddy conditions are there, so all these considerations should be should be considered. All these considerations should be considered while the sump pit is constructed.

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So, this is one sump pit where mine pumps are installed on the pontoons. These are the pontoons having the mine pumps, this is the high wall of the mine and this is at the end of one mine and this water is being controlled like this. So, this video is available in the YouTube also. So, these are the pipelines laidd for removal of the water, discharge of the water to a particular point.

So generally, there is guideline standards of water, mine water before discharging that to a discharge water source, in that case that quality has to be maintained. The mine water can be discharged into the agricultural field, can be discharged into the live streams like river, etcetera, can be discharged into the marine coast, can be discharged into the municipality sewage or normal sewage. In every cases the standard has to be properly maintained and as per the guidelines of the Ministry of Environment that quality of the water should be maintained.

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**AUXILIARY OPERATIONS**

**WATER SPRINKLING**

- ✓ Water sprinkling is carried out for dust suppression in haul road
- ✓ In general a water sprinkle of 10000 to 100000 litre capacity are used as sprinkler.
- ✓ With the modern sprinkler solenoid controlled valves are used for restricting the excess watering
- ✓ Water sprinklers has multiple inter connected compartments. This arrest the wave formation in the water during undulation of the haul road

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And final one is the Water Sprinkling System for the suppression of the dust in the haul road, water sprinkling needs to be carried out in general ten thousand to one lakh litre capacity water sprinklers are available. Nowadays modern sprinklers are fitted with the solenoid control valves where the loss of the water is restricted and operator is having the full control based on the dryness of the haul road surface, the water quantity can be controlled. Nowadays automatic sensors are also available for this.

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**AUXILIARY OPERATION**

**WATER SPRINKLING**

<https://www.youtube.com/watch?v=xUo6QjH2CKA>

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We can have this one water sprinkling, how the water sprinkling is carried out, so these are the sprinkling of water carried out so that the whole road wetness can be maintained. So, this is more or less end of this 4 Auxiliary Operations we have discussed. There are other

Auxiliary Operations like Operation of road grader is also there for levelling the road etc. But that is not discussed here these are some of the auxiliary operations we have discussed in this lecture. Thank you.