Mining Machinery
Prof. Khanindra Pathak
Department of Mining Engineering
Indian Institute of Technology, Kharagpur

Module - 10
Lecture - 53
Rope Haulage in Underground Mines

Welcome boys, so we have started discussing about the underground mine transports and there I in the last class introduced the various types of transportation system. Now, as you know that is one of the very old system, which is still continuing in many of our coal mines particularly and also in to some extent in some of the non mechanized this say underground mines, but that is very less.

Then this in underground coal mining in the developing countries they use this rope haulage to a large extent.

(Refer Slide Time: 01:08)

Now, today we will be discussing about this rope haulage as it was said in your previous class that in a rope haulage basically this is a tubs which are mine tubs you can see here this type of mine tubs which can be tilted that is here they are locked at this end. Now, this can be unlocked and it can dump the material from the side or there is a some such type of cars which can be one side of the wheels can be raised and then it can be it can be discharged sideways also.

This different type of mine cars they are mounted on this rails and they are just pulled by rope that is a rope haulage you have seen, where this rope is exactly turned on some end and drums or pulleys. So, there are different types of this rope haulage system. So, we will be discussing today what is rope haulage and then what are there.

So, rope haulage is it is a means of moving loaded and empty mine cars by use of wire rope. So, that is exactly it is a very simple primitive way you can say, but it was a very big engineering in those days hundred years ago, that people started using this mine cars by pulling by wire rope and they could do work in a very steep incline wherever they are to go down in the mines.

So, you can have a very steep incline also can be negotiated it with because as we learn that conveyor belt and all they cannot work in normal with a normal conveyor belt they cannot work with an incline which is more than this near to the angle of repose and there were limitations in using locomotive as well. We will be discussing few things about locomotive in a later class.

(Refer Slide Time: 03:06)

But now in this system, what today we will be discussing is basically, how do we will classify this different type of rope haulage system? And also we will try to do some very basic calculations with rope haulage, but before that you please know that this is say as you can see here they can work on a very steep step.

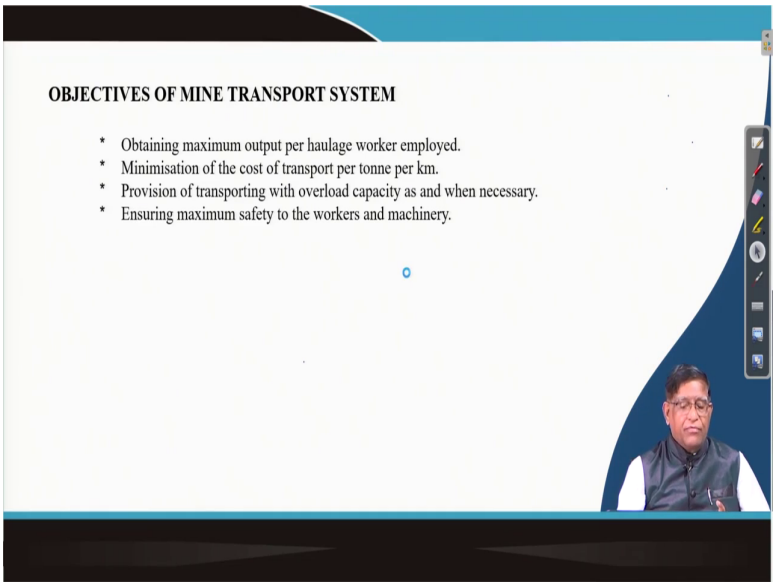
So, basic components of a rope haulage if you see there is a mine car is there. Now and then we are having this your connected with a rope this is the basic component and they are mounted on this rails. You must be knowing you have seen rails where there are slipper these rails are slipper.

Below this slipper there will be some ballast. You may see that sometimes these rocks that are given, in the railway line you have seen there are some all stones are there which is called your ballast and over that there is your exactly the pit floor is there. That is a gallery floor and then this is a mounted that rail can be of different.

This is the rail cross sections you can see depending on the type of load which will be coming we can select different type of rails and that rails they are connected by this clips you can see here that is rail is a on this wooden slipper, they are just anchored with the help of nuts and sometimes nut and bolt, there is a different type of clipping systems different type of anchoring systems are there, which you can study.

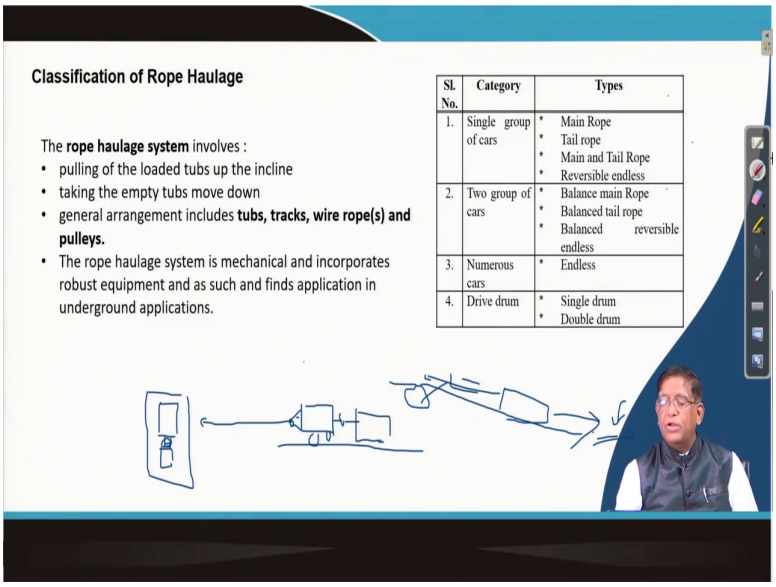
But the old book old mining handbook or that coal mining practice by Statham that was a at one time the bible of mining in the these 60s and 70s people used to study that book that is Statham school mining. So, there you will find such type of figures which are still valid and the system is still continuing.

(Refer Slide Time: 05:11)



So, coming to this our objective of mine transport system, we have already discussed that is the maximum output per haulage worker will have to find out and for that we have.

(Refer Slide Time: 05:22)



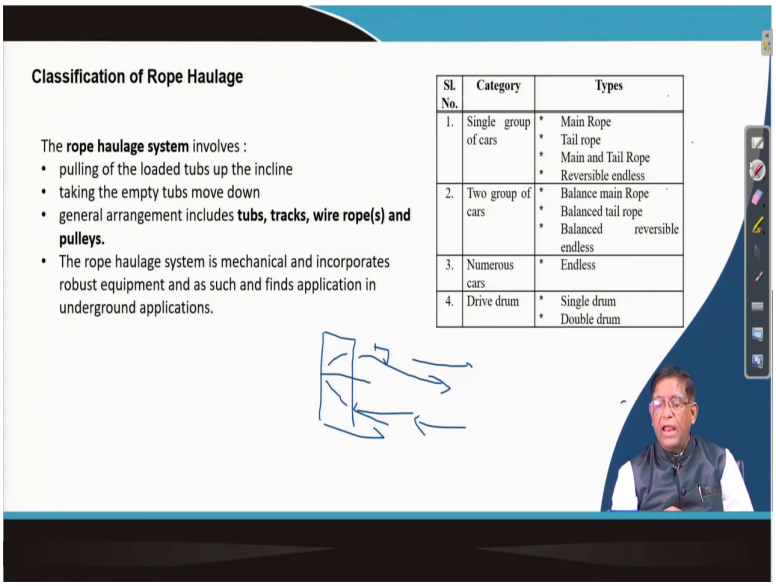
This a rope haulage system that can be classified into a single group of cars that is it will be main rope or tail rope, main and tail rope and reversible endless rope. And sometimes because this rope haulage system that cut that your rope all the mine cars they are exactly connected by these cars which are having on a wheel they will be travelling on this trail. Here you are having a coupling by which the next one will be connected.

And then that there in the front of it they can have the chain with the chain they will be connected with a rope terminations and then rope will be going. And this rope will be pulled on a drum. This drum or and there we will be having the arrangements with the motor, that is your electric motor will be there directly you get couple in with a gear box in between here you can connect this things and here this could be located at a different place.

So, this is here. Now, sometimes what may happen that exactly you are just taking it is coming from a steep incline is there. Your system is coming from the bottom and that it is travelling like this and then after bringing it over here, they will be taking this emptying it and then again it will be connecting to these ones and this time because of its load it will be travelling down. Again here it will be taken out from the rope and on this the people will be loading over these things and then the system will continue.

So, this is the very simple rope haulage system, but there what happens? You are telling that the same rope you are getting it connected and disconnected and getting. In other places there can be two group of cars; one will be taking the loaded one, the other one will be bringing the empty one. So, that is your and then it could be a balancing.

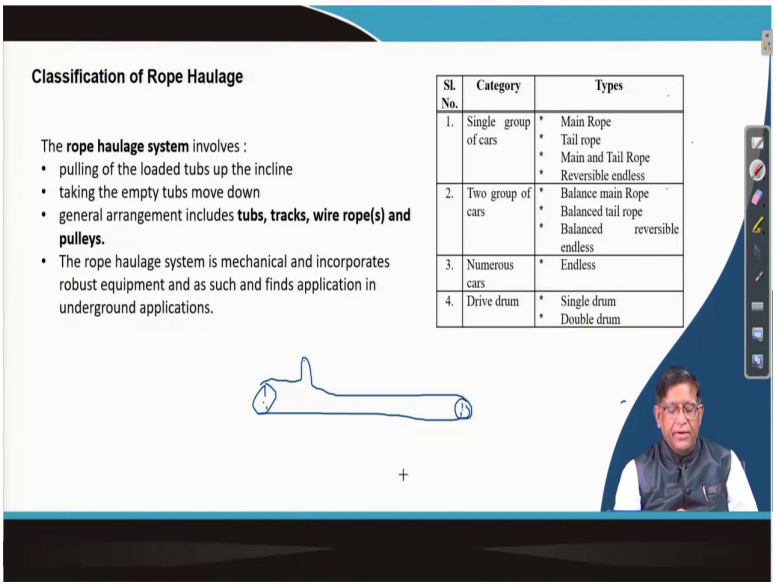
(Refer Slide Time: 07:38)



The same drum on a one particular drum we can have a two system can be maintained over there in between this will be there. Here this part will be having a rope in one directions, it will be releasing down here and this will be raising down here. So, that is you can go like that when your cars will be brought this will be emptied.

After emptying it will be connected over here and it will be going down here while this is the loaded car will be coming in these directions and we can have it. So, these are the different system which is available that is two group of cars and there could be another system where endless.

(Refer Slide Time: 08:24)

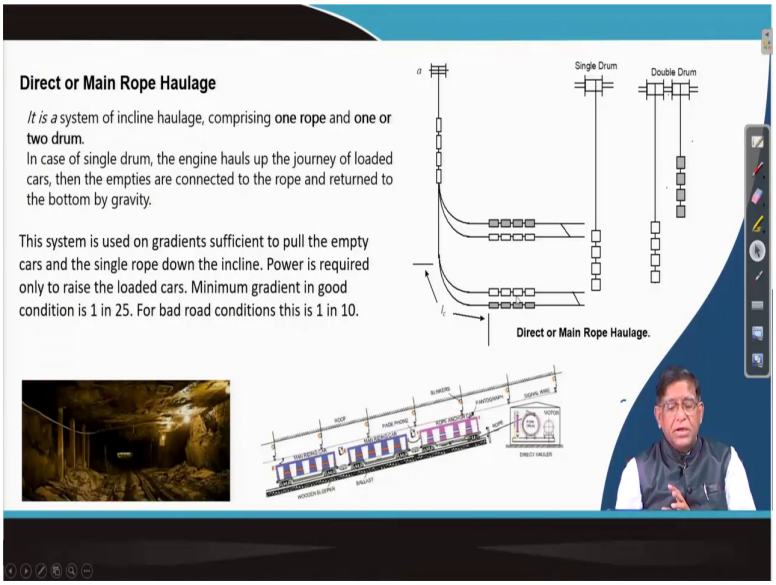


That means that a one rope it will be moving about this there will be two wheels on these two wheels these are on exactly we can put it this is the spokes of the wheels and then this is on a

we are showing the plan view of it and then this rope will be moving like this and then there we can have a some tensioning arrangements over here.

And then this will be giving you as a endless rope, that is that same rope is rotating and your group of cars can be connected over there and they will be carried. So, that is a endless rope haulage. So, and then sometimes this rope can be by one drum or two drum depending on that we are having this different type of system.

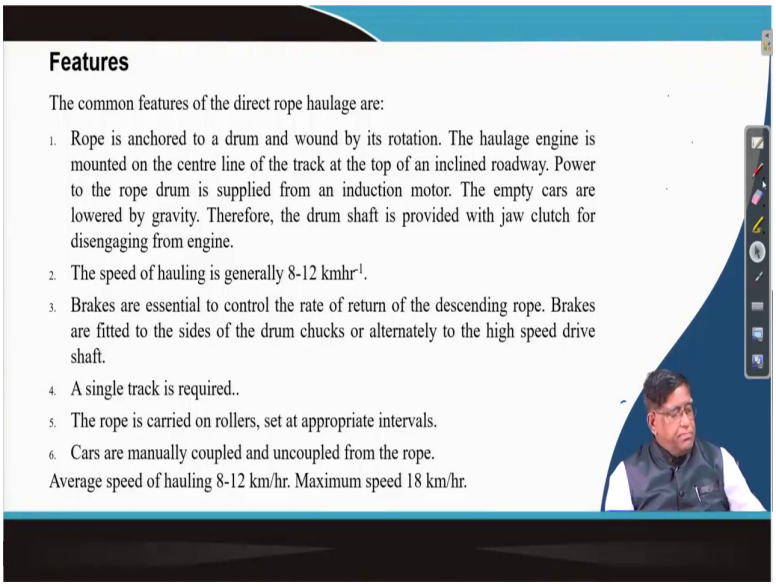
(Refer Slide Time: 09:03)



So, in the direct rope haulage is in which one drum and your things are being pulled, this is a single drum rope haulage this is a double drum rope haulage. And you can see here that is this is the roof of the gallery, you can see this is on the gallery you have got this the slipper and below that this ballast rocks are there, on that wooden slipper, on which this your, in a this here we are having the man riding cars.

That is your same rope haulage can be used for the people will be travelling down and up by this. And there at the end there will be having this your, the drive that haulage drive is here where a motor and the drum and a break system is there that is the way how rope haulage is used for transporting of man in a man riding car like this. So, we are having this direct or main rope haulage and this you can see a, this is a very simple system.

(Refer Slide Time: 10:06)



In your main features of a direct rope haulage is rope is anchored to the drum. Now, how the rope is anchored to the drum in a wire rope is that is called a coupling that is (Refer Time: 10:17) couple. That means, the rope one and is brought within the drum it gives a turning and there is a that is a group in which that your white metal is put over there to anchor it like that.

That is a the how the rope is terminated on that end. And then the other end is going and it is exactly that is at the end it has got the connecting system by which the tubs are connected. So,

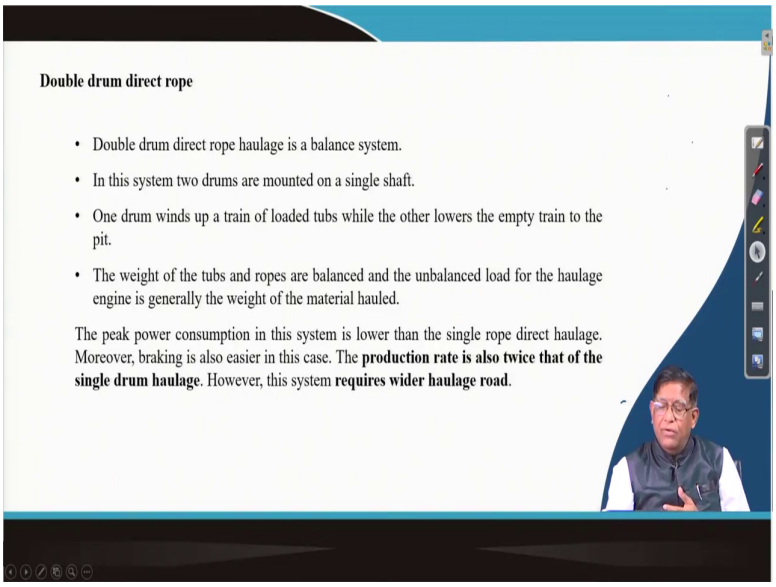
by this system the loading will be done at the pit at the face and then it will be brought up to the near to the shaft, where this will be there will be a layout.

That is just like you have seen your railway shunting that is the two tracks will be there the loaded truck will be coming over there and then this will be disconnected from the rope and from there it will be pulled to the cage and then from there it will go back. So, that is a system in their in the coal mining methods you have studied about that.

And now this system can bring at up to 8 to 12 kilometer per hour speed this will be coming over here. So, this as because the empty cars also will be going by the same route, so, there is only single plan. So, the gallery width need not be very big because in case we are using simultaneously your the loaded's are coming and then your empty are going down at that time on that gallery you will have to have two tracks.

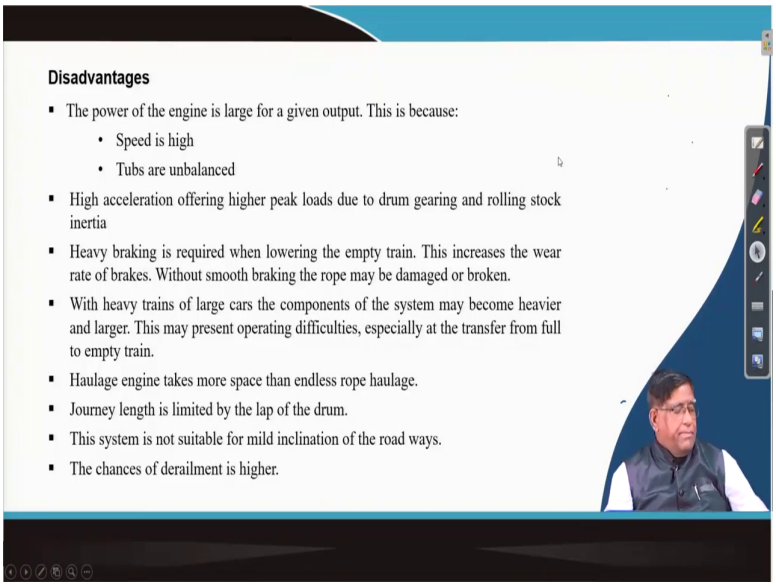
So, that means, the gallery size will have to be wider if the gallery size have to be wider then you support and that your rock or that coal should be competent enough so that the collapse does not take place. So, those are the things, which is taught in your mine mining methods class.

(Refer Slide Time: 12:08)



Now, in a double drum direct rope haulage there are two drums and they are mounted on the same shaft. So, one drum winds up that and then the other and other drum exactly takes the empty to down. Now, while this lower it is getting lowered that will be giving also some advantage. That means the motor will be requiring at least some amount of work is being done by the empty cars when they will be going down. So, that is why it is called a balance type of system because it is working withstand.

(Refer Slide Time: 12:44)

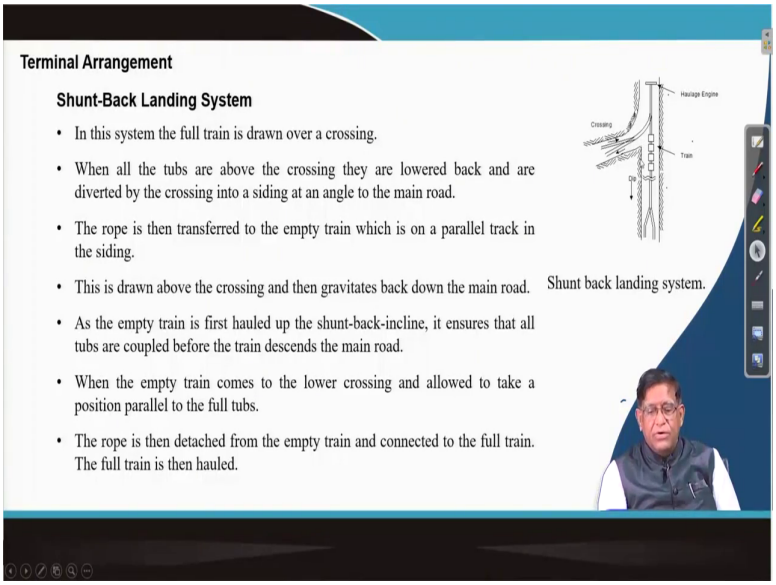


So, this is your; now there are different advantages and disadvantages of this drums. So, this main disadvantage that is, the power of the engine is large for a given output. You will have to get a lot of power is consumed over here then high acceleration offering higher peak loads that is your in a electricity supply in the underground, there the peak load goes higher. Then there is a heavy breaking is required because when it will be going down on a steep incline, otherwise it will take a speed up.

If it speeds up then it may go and hit or there could be accidents because the rope which may exactly give a swinging in that while going and that swap can hit a person's moving nearby if that speed is up because the rope will be guided over some wheels. Now, if it is on that speed it may just come out of it and then it may hit the people.

So, there is a accident proneness increase that is why the operator haulage operator will be applying this break. So, that the speed does not get too much of accelerated. So, then there your haulage engines, that will have to be accommodated underground. So, there is a always a space constraint and then to keep the roof to be competent over there you will have to create a chamber inside the mining and that is what exactly you need to make the arrangement in case of this.

(Refer Slide Time: 14:09)



So, as you say as a terminal arrangement or the shunting back how they do. Suppose here you are having the haulage engines. These ropes which will be coming over here and the train will be brought up to here and then the empties will be brought on a shunting here, from here it will be that near the crossing they will be loaded to that. And then when that empty will be

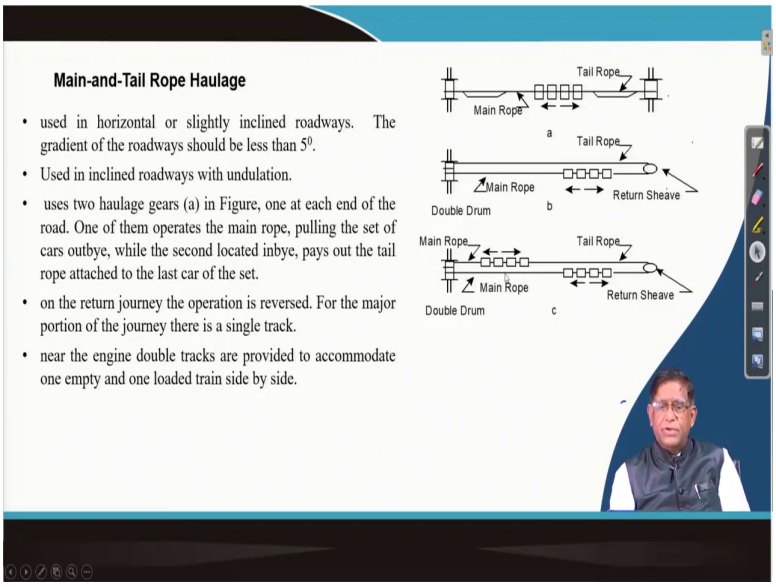
there this will be brought down and again it will go by the if it is a double track single track depending on that.

So, this is a depending on what arrangements is there you have different pit bottom layout and pit top layouts are made in wherever rope haulage or this being carried out by the cars. Then at the bottom that is near at the bottom of the shaft, how you will have to make a layout? Because there this loaded cars will have to come and the empties will have to go.

So, for doing that arrangements we will have to do. Then the empty train is first hauled up and the shunt back incline and it ensures that all tubs are coupled before the this train is descending. So, that if you do not couple it properly then something will be remaining about their accident proneness will be there.

So, a strict supervision and monitoring for the safety is essential in any operations in underground mine and then this while the empty train comes to the lower crossing and allowed to take positions parallel to the full tubs. So, that is how the work arrangement is made down. And is the rope will be from that when that loaded is coming you will have to detach the whole train and then again empty will be attested and then there will be let going down.

(Refer Slide Time: 15:54)



So, there is a other things other type of rope haulage, here you can see that there is a two drums. One that is your same rope exactly it can be while this drum will be pulling it up and this drum will be pulling it down. So, that is your that is your main and tail rope that is your tail side also a we are having a drive.

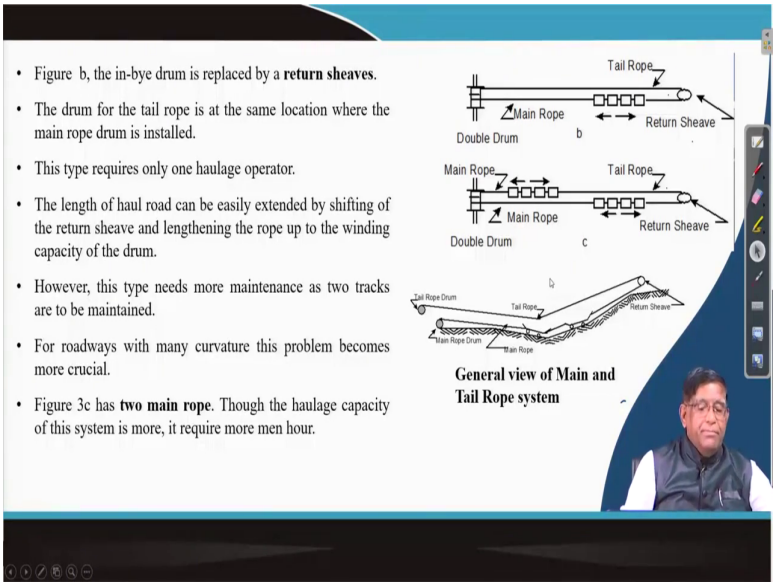
Now, sometimes what happens, there is a in this tail rope that exactly from the end side a rope is connected there is a return sheave and it is connected over here. There is only a double drum on the same shaft two drums are there and then it is this your loaded will be coming like this and then empty will be going along like this.

So, that is the way and here we will be having the arrangements near the phase where the coal will be loaded onto these cars and then there is another this is exactly sometimes you do not connect this ones. This is when you are connecting with this here the tail rope it may not

connect that these ones will be rotating in both the directions and then this is will be just shunting like this.

So, that is way, now depending on how you are arranging the operations. It may so happen that exactly you can both the things it will be also loaded, it will be also loaded. It will go like a loaded one and return with a empty one or you can just do the loaded in one that empty in the other that another way, but one thing is there if you are using this system then your gallery will have to be wider because two track systems will be used.

(Refer Slide Time: 17:36)

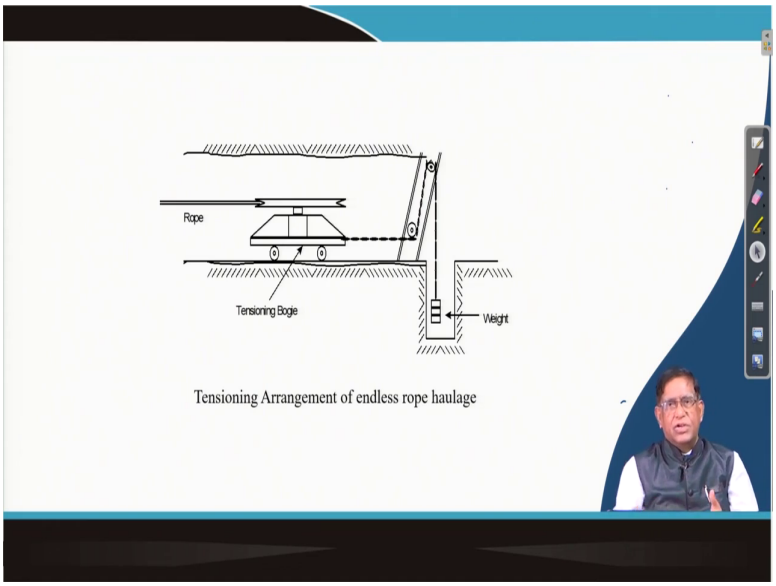


So, this here you can see here this is how these systems are working on the. The drum for the tail rope is at the same locations where the main rope drum is installed, by seeing the figure you can easily explain it. So, what it requires? Only one haulage operator because here this is only sheave.

So, here you do not require another just like in this system you will have to have one more operator here, but in this system no needed that only one operator will be working over here. So, the length of the haul road can be easily extended by shifting of the return sheave, you can just take more rope over here which change this locations and your that you get served to another one.

So, this is it is easy because at the roof also you can have that sheave you can go and you can make a cross by you can take up call from another area you can take a turn over here. So, that type of flexibility of arrangement is there in a main and tail rope system.

(Refer Slide Time: 18:41)

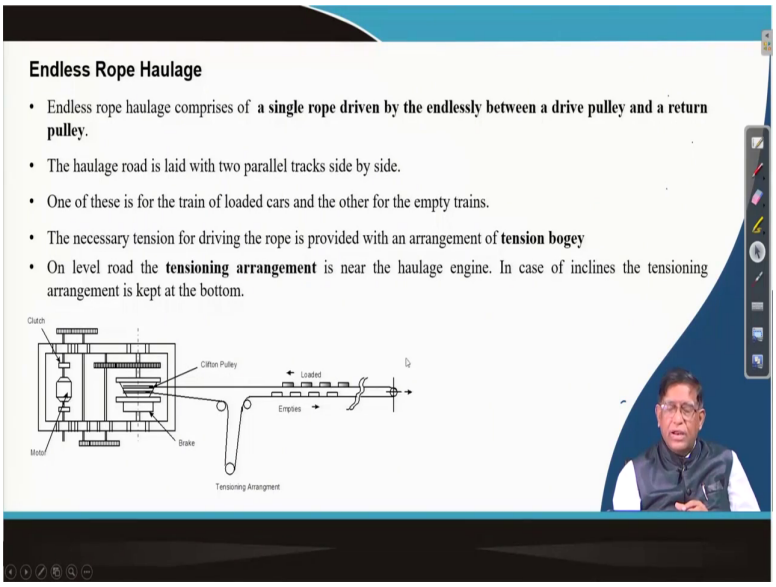


Now, one thing is there that rope whenever you are using say this is a sheave and then this is the rope it is connected. That rope will have to be always under tension for doing that tension in underground what is done, a tensioning buggy is used. There is a rail, on that rail these

buggy is there and here your with a rope you are connecting this rope and pulley system you dig a portions and then you suspend the weight so, that this will keep all the time that haul road, hauling that rope is always under tension.

So, this is an arrangement which is made over there.

(Refer Slide Time: 19:17)

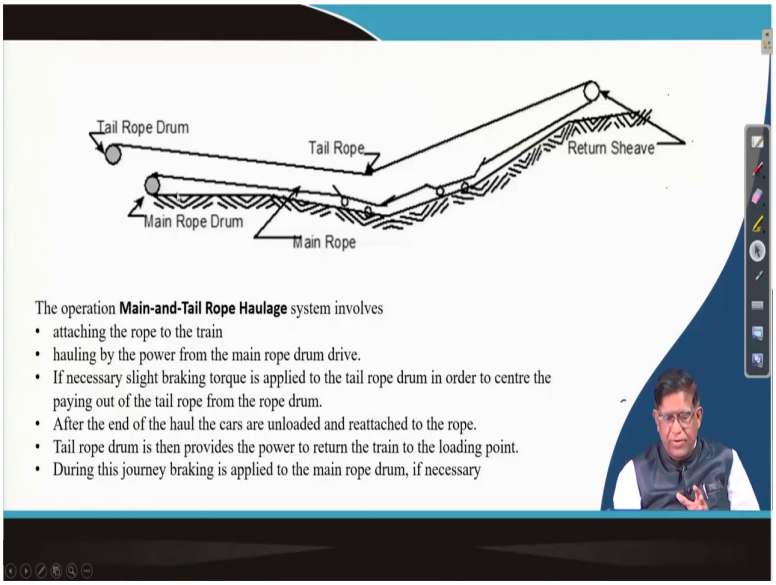


Now, the other thing in a next class I will be talking more about this endless rope haulage. In the endless rope haulage you are having the drive stations where a Clifton pulley or surge pulley is there. And this pulley with gear system is driven by a motor and then the rope is endless it is going over here and again it is turning at this.

So, that means, the same rope is taking a turn and then going back and there is also a tensioning arrangement. The loaded cars are added over here and the empties are returned

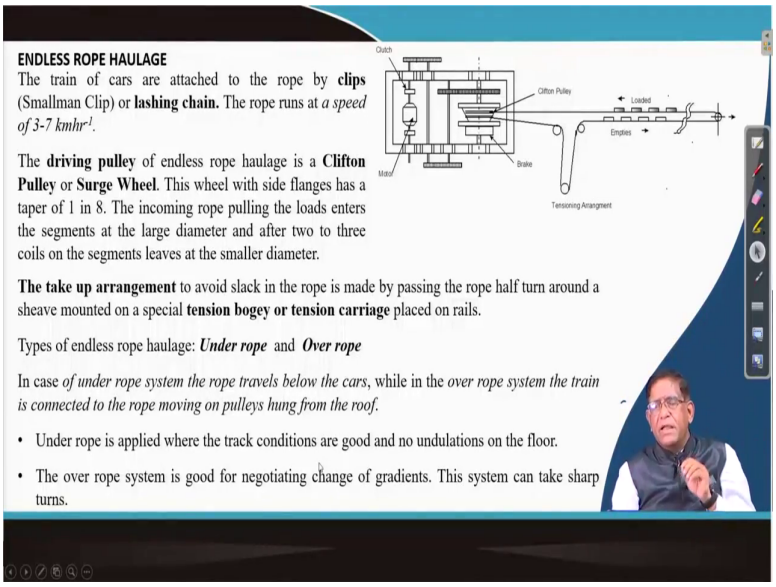
over here. So, it is just brought along this things. So, this is a endless rope haulage which is available.

(Refer Slide Time: 19:53)



Your main and tail rope haulage I have already told that is your how it will be travelling over here.

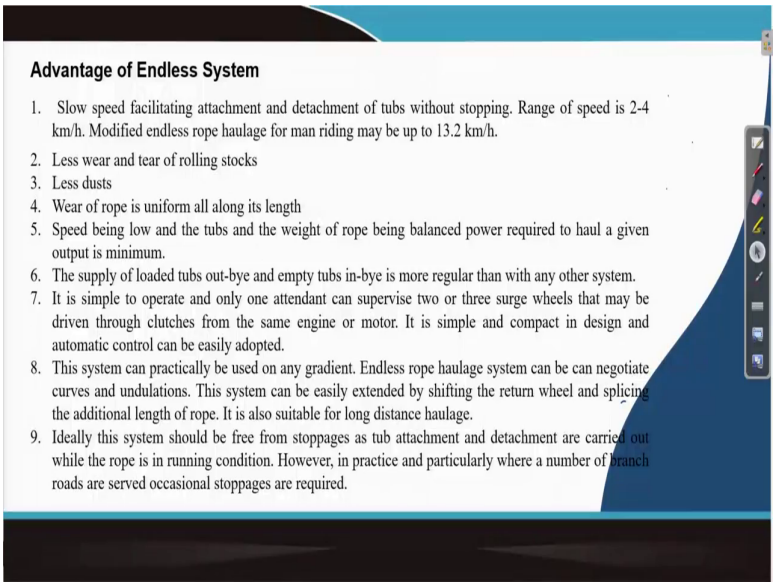
(Refer Slide Time: 19:59)



Then in this endless rope haulage a as you have seen this is basically a driving pulley which is called a Clifton pulley they do the operations and this can be done by two ways, it is under rope or over rope. In case of over rope in a gallery your rope is going at the top of the on the it is suspended from the roof and then the in a under rope it is laid on the floor.

Now, when it is under roof the advantage is the floor there will be always the (Refer Time: 20:31) is water and all will be there. So, that is why the rope will not be effected by this, but there are all advantage and disadvantages because your the place walking places and all need to be properly given and your roof must be very competent then only you can do it over there.

(Refer Slide Time: 20:50)



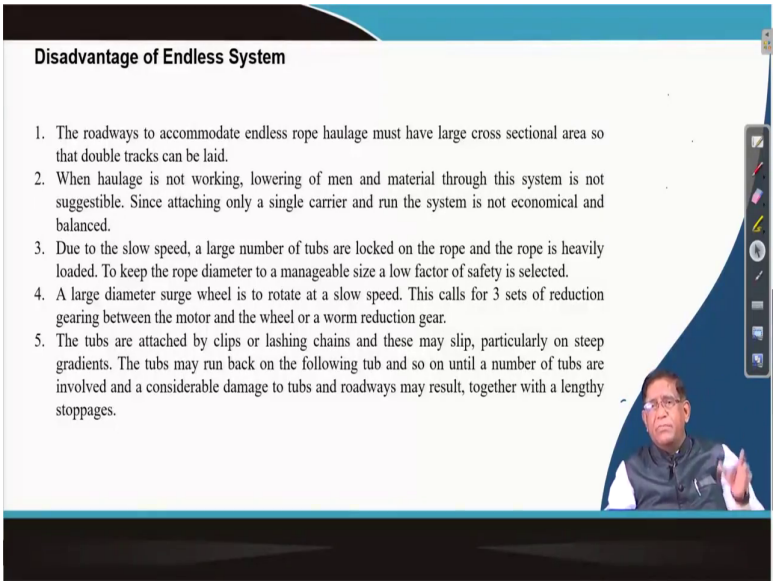
So, that endless rope haulage got advantages that it has slow speed facility. So, you can attach the tubs whenever it is there and the speed is normally 2 to 4 kilometer per hour. Whereas your in this can be with a change that is your by changing the gears and all you can run it up to 13.2 kilometer per hour also.

When you are carrying it is for using for man riding purposes. So, there is a in endless rope haulage there is a less wear and tear of the rolling stock, that is the rope it will be going over some pulleys those pulleys will be that is a the wear and tear is less because of the speed is less. And then this system do not create much dust in the underground and that wear of the rope is always uniform.

So, this type of advantages are there in case of your this rope haulage system. So, the supply of loaded tubs out by an empty tubs in the in by is more regular than with your other system

because this is exactly continuously running and then you can just only connect and disconnect at the loading and unloading stations, it is whether the operation is smoother.

(Refer Slide Time: 22:05)



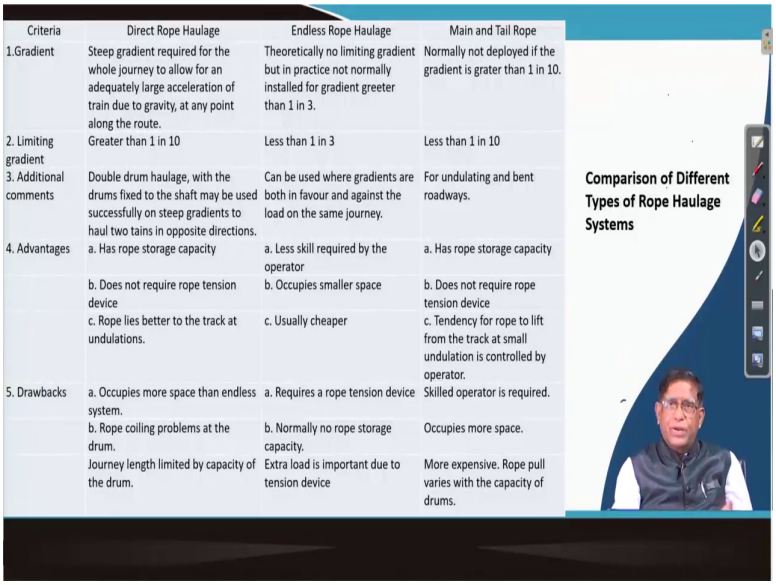
Now, but the disadvantage is the roadways to accommodate the endless rope haulage must be large cross sectional area. So, that double tracks can be laid. So, this is, in an endless rope haulage because the one end is taking another one is going down. So, as you have seen in that figure you need to make a wider gallery and then when haulage is not working lowering of man and material through this system is not suggestible.

Since, attaching only the single carrier and run the system is not economical and balanced that is what as an operational you can study in your method of mining, but because of this slow speed a large number of tubs are locked on the rope and the rope is heavily loaded because speed is less.

But to make the productivity you will have to increase the number of cars number of cars and then that is why when a more number of cars are connected to the rope. The rope is being pulled at the time there is a more stress or more work is to be done by the rope. Now, this the gear box at the at your driving stations that need to be also very strong enough that is powerful.

So, that it can work with that different speed at different load it is coming so, that the design of that will have to be made properly. So, that there is no failure then these are the connecting of the this rope will be discussing in our next class that how exactly we will be connecting by different type of clips.

(Refer Slide Time: 23:37)

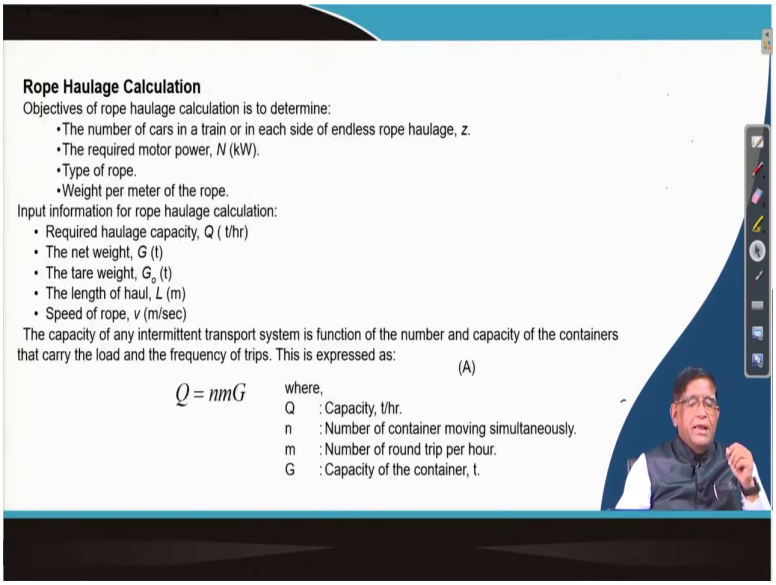


Criteria	Direct Rope Haulage	Endless Rope Haulage	Main and Tail Rope
1.Gradient	Steep gradient required for the whole journey to allow for an adequately large acceleration of train due to gravity, at any point along the route.	Theoretically no limiting gradient but in practice not normally installed for gradient greeter than 1 in 3.	Normally not deployed if the gradient is grater than 1 in 10.
2. Limiting gradient	Greater than 1 in 10	Less than 1 in 3	Less than 1 in 10
3. Additional comments	Double drum haulage, with the drums fixed to the shaft may be used successfully on steep gradients to haul two tains in opposite directions.	Can be used where gradients are both in favour and against the load on the same journey.	For undulating and bent roadways.
4. Advantages	a. Has rope storage capacity	a. Less skill required by the operator	a. Has rope storage capacity
	b. Does not require rope tension device	b. Occupies smaller space	b. Does not require rope tension device
	c. Rope lies better to the track at undulations.	c. Usually cheaper	c. Tendency for rope to lift from the track at small undulation is controlled by operator.
5. Drawbacks	a. Occupies more space than endless system.	a. Requires a rope tension device	Skilled operator is required.
	b. Rope coiling problems at the drum.	b. Normally no rope storage capacity.	Occupies more space.
	Journey length limited by capacity of the drum.	Extra load is important due to tension device	More expensive. Rope pull varies with the capacity of drums.

So, here you can see that in a summary there are three types of system. In that we can have a direct rope haulage, you can have a endless rope haulage and main rope haulage you prepare a

table, what are their advantage? What are their limitations? Where they work? So, such type of comparatives study will help you to know about this system.

(Refer Slide Time: 23:58)

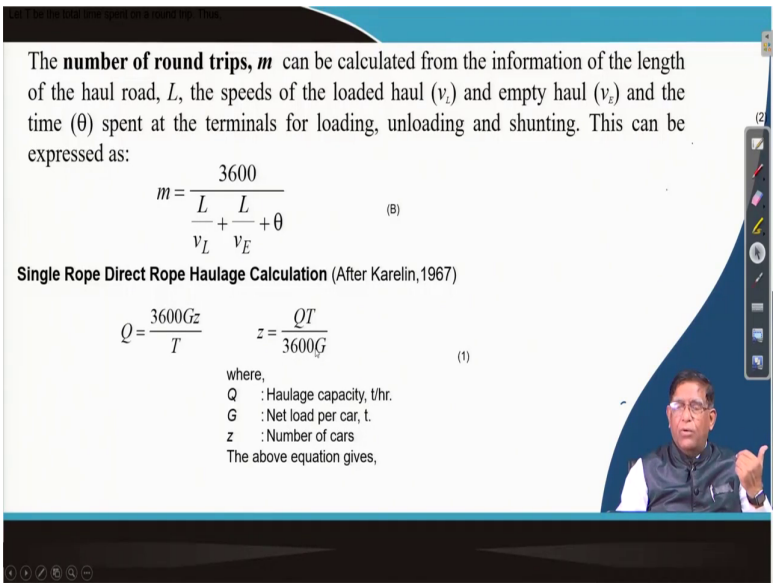


Now, coming to this the calculation is also very simple in these cases. Now what is there? We need to know that is how much is the driving power or how much is the capacity. So, this will be depending on the mainly the parameters which will be effecting, it is the haulage capacity will be effected by the net weight of that mine car. And then what is the tare weight that is exactly that is how much is the on the metals part of it and how much is the load part.

So, that is net weight and the tare weight and then what is the length of the haul and then what is the speed these things only will be giving you basically that capacity in ton per hour can be calculated by how many number of cars are there and how many trips it has made.

And what is that container is taking how much material what is the material net weight is there. So, if you multiply that it will be giving you capacity. So, calculation is very simple in that way.

(Refer Slide Time: 24:59)



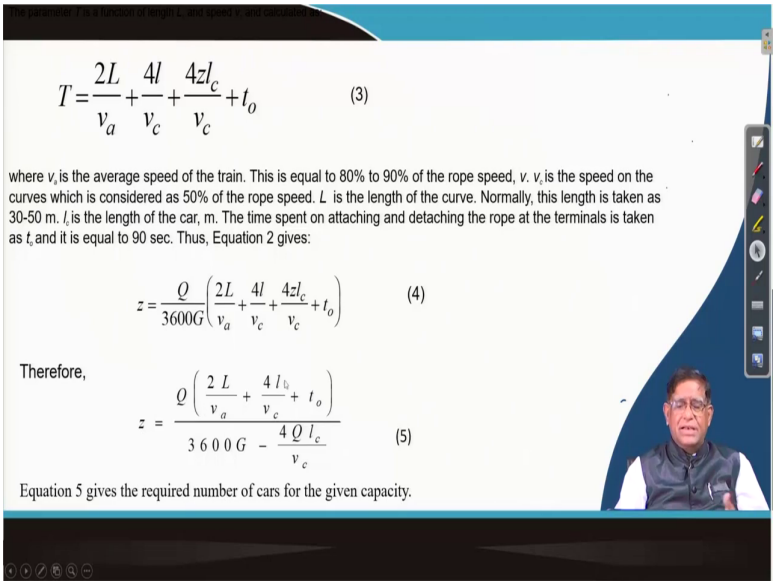
Then you can find out that is your how many number of round trips will be there it will be depending on what is the length and if you know what is that your loaded tub will have to go at that time, what is its speed? And then when that empties are going down, what is its speed? And then at the loading and unloading some time will have to be there.

So, you can find out that is your, the time in if you are finding it how many second it has lost there. So, these times are note we have converted to this and that many number of exactly

trips it will make in an hour. So, a single rope or direct rope haulage their haulage calculations it is just your haulage capacity.

And then your this whatever the cycle time is there that you are multiplying and then you are giving this. So, this will be giving you the total how much ton per hour simple calculations you can do it very easily.

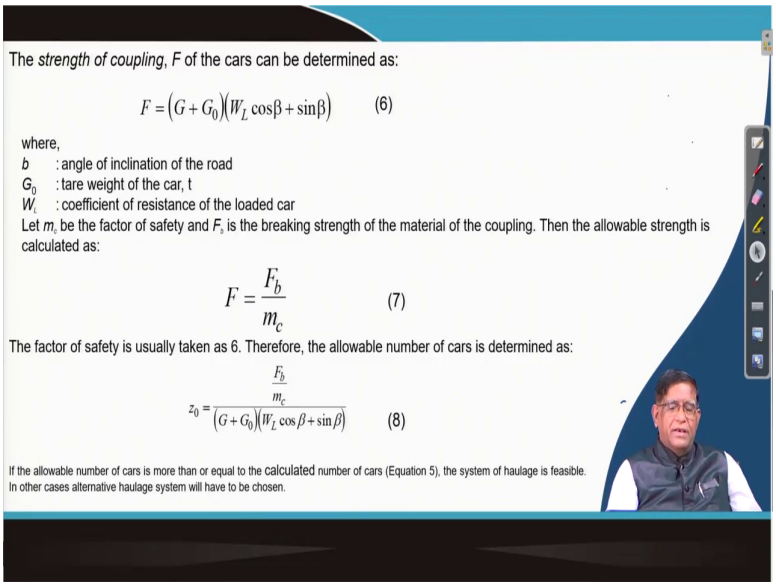
(Refer Slide Time: 25:59)



So, that cycle time that is how much time the trip will make it will mainly on an average speed and then these the speed on that curve because whenever it is to negotiate the curve the speed will be different. So, that curve if you take separately, then you can make these calculations out.

So, this, these equation deriving is very simple just only by the general your whatever you have studied in school that knowledge is only necessary. So, that another thing is there as a mining engineer you will have to know that how many cars exactly you should have for maintaining your this productivity. So, that tub calculations you can easily find out from this simple calculations.

(Refer Slide Time: 26:50)

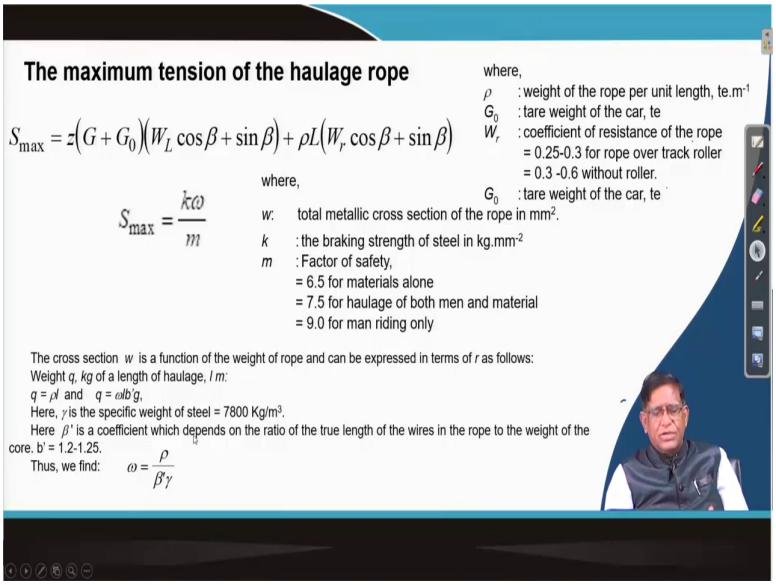


Then another thing is there that how much is the coupling that whatever couple you will be using that car to car and the car to rope that is connecting. And there it should not get broken or it should not snap for that their strength it will be depending on, that what is that your inclination angle and then that total force how much it is coming over here and you can calculate by taking into this the coefficient of resistance to the loaded car is taken over here and then you see that is why beta is your inclinations.

So, the breaking strength which is exactly that it depending on that if your total resistance is coming total force is coming this much and then your the wire ropes that metal or that the couple that material by which it is made its breaking strength is given depending on the type of material being used. Their ratio is the factor of safety that factor of safety is that your what is the breaking strength divided by the this forces which is coming over there this mc is your factor of safety.

So, in while calculating you will have to calculate out that factor of safety that it should not be less than 6 and if it is some in some cases where you are man riding and all it may sometimes even suggested to be more than 7. So, in mining underground mining no other places you take a factor of safety like 6, 7, but in sometimes in winding we have got a mining design with factor of safety 10 also because that we cannot take any risk of any failure.

(Refer Slide Time: 28:33)

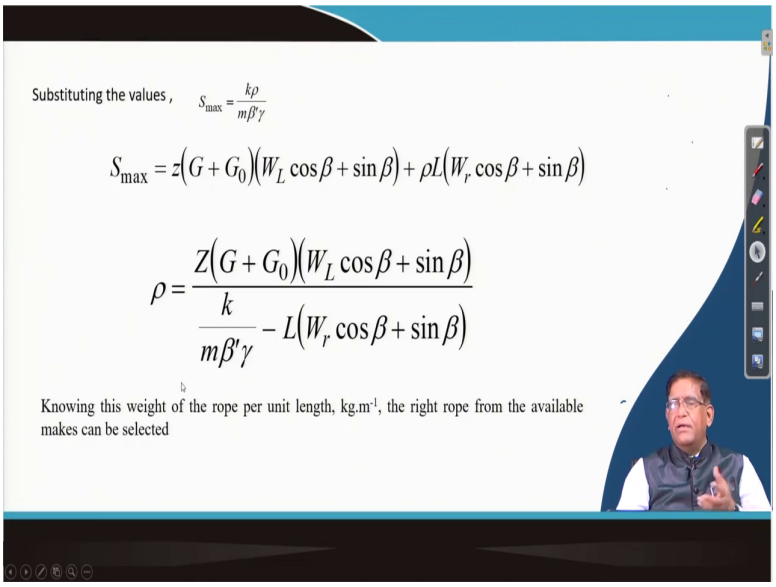


So, the maximum tension in the haulage rope you can find out the total load whatever is coming, that is your from the tear and the gross weight and then from the inclinations how much percentage of weight it is coming. And then what is the weight of the material gravity forces total is coming.

When you find out the total forces you will be getting the total resistances and from there you can find out that, what is that maximum tension? And also from the value of the total metal total metals value there also you can find out what is the maximum tension depending on a for a particular factor of safety, it should be the total tension which is coming can be calculated out.

From there you can find out that total cross sectional area that is your that cross sectional area is a function of the weight of the rope and that can be expressed in terms of this density and you can find out in this way. So, this is the basic calculation principle which you can apply over here.

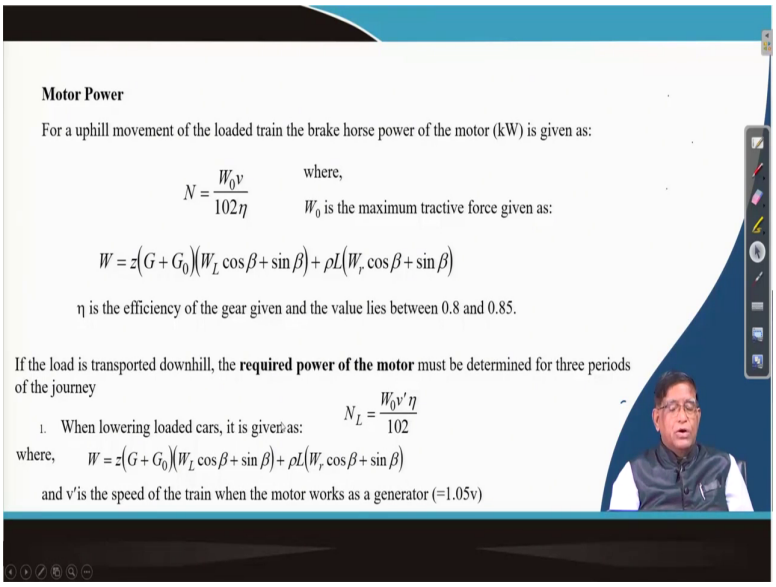
(Refer Slide Time: 29:38)



And by that once you determine these maximum tensions coming then you can find out what should be the density of the material of which that rope is made of. So, when you are going to buy wire rope for a haulage systems you must know that is what type of material that will have to be selected. If you do not do that there will be the problem of wire.

So, that is a very basic principle is, while doing this application of wire rope you will have to determine this the material specifications will have to be made or you need to check that whatever rope you are purchasing that whether the right material has been selected or not, that what exactly the density depending on the breaking strength will have to be found out, that selection that is important.

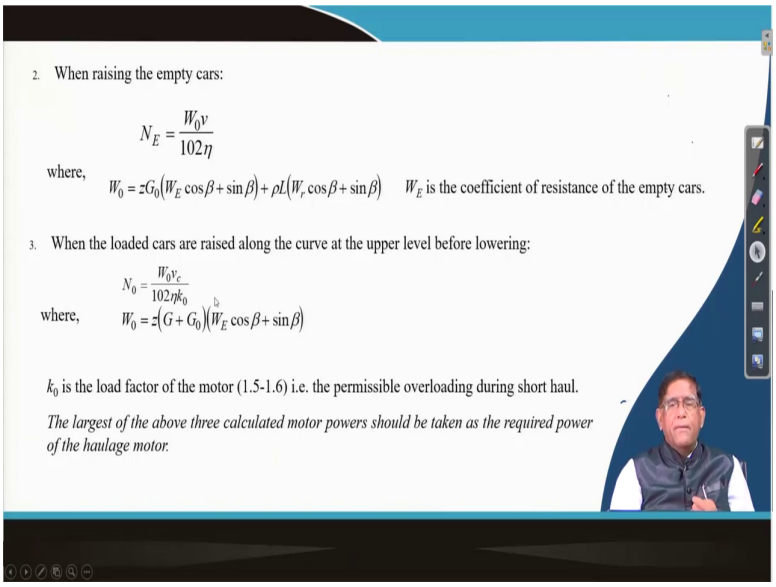
(Refer Slide Time: 30:27)



And now once you know the total tractive force that is total resistances how much to be overcome then which at what speed it will have to be there then you can find out. This is the simple your electric power calculation this is this much of watt of the power should be there of the your electric motor.

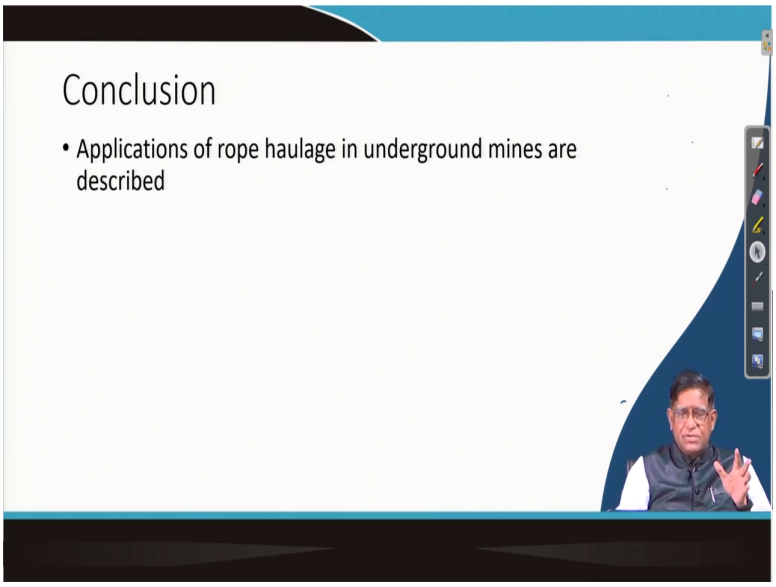
And if you find out that what is the efficiency then you can exactly for the systems, you can select a motor by considering that what is the efficiency of the motor and what is the efficiency of transmissions in the gearing and all taking over there you can calculate out the motor power. So, these equations you will have to it is very simple one you can easily derive it and then you can do some of the small calculations.

(Refer Slide Time: 31:11)



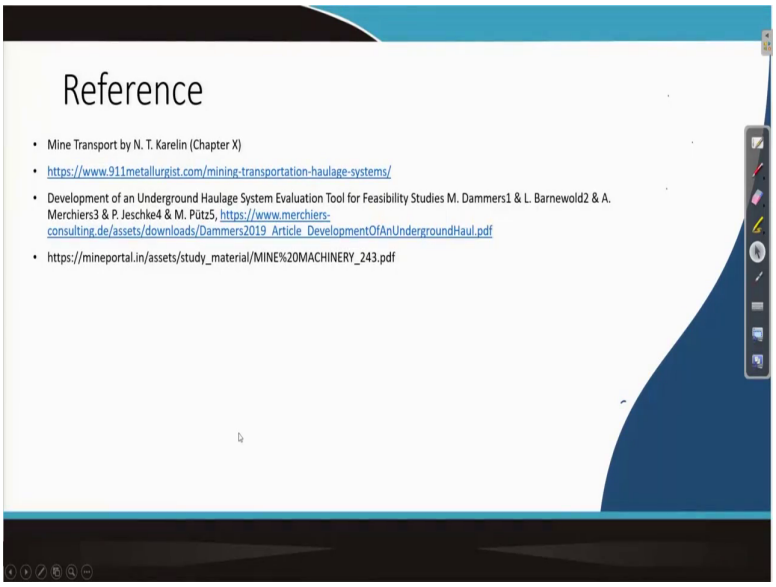
So that means, the motor power required for the empty drum or and that what is the motor power required for raising the loaded drum those things you can separately. And you can find out that what could be peak load during the operations of it.

(Refer Slide Time: 31:27)



So, coming to here that application of rope haulage in underground mines are we have discussed over here, you have given a very basic principles, things are very simple only what we will need to know that what are the total resistance is coming and how much will be the power drive. So, and anything whatever you have studied in your school physics is sufficient for understanding that.

(Refer Slide Time: 31:50)



But still that your how engineering way you apply there are some references at the N. T. Karelin's book you please read that one then.

Thank you very much.