Bulk Material Transport and Handling Systems
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Lecture – 48
Main & Tail and Endless Rope Haulage

So, in our last class we discussed about the underground rope haulage system in which how your direct rope haulage work, we discussed about there and there I told you that we may discuss about the main and tail and endless rope haulage and also some basic calculations. And here today we will be telling about this about how the main and tail rope haulage is against in an underground mine.

And how this endless rope haulage is arranged in an underground mine. And we will see that if some of the very basic calculations you can do, so that to understand that how these systems exactly were introduced in the mines.

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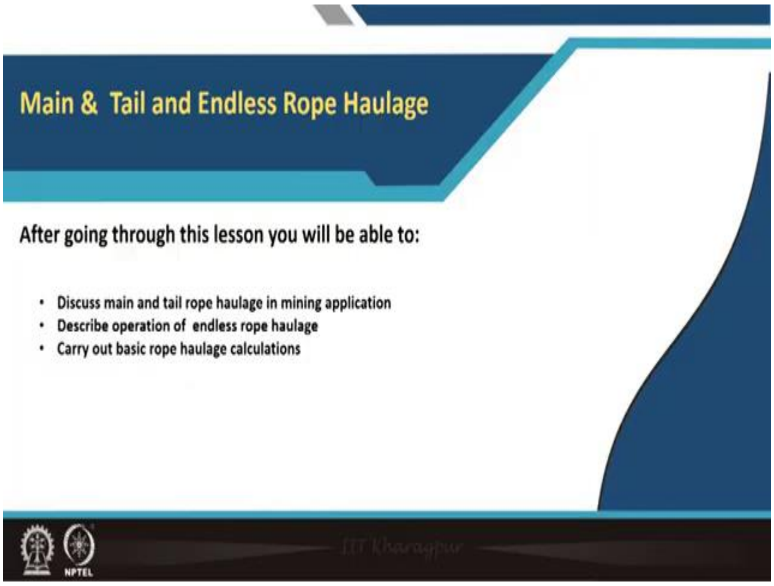

For you should remember or you should note it down, the underground space creating an underground space is a problem and there to operate a system by using taking the power itself is a big problem. Because in a coal mine, when you are telling that you are okay, you give it electric motor and connect it over here. Just like in your surface. It may be very simple thing. But there to take the electric power down into the underground mine itself is a challenge in the shaft vertically.

How you will be taking that cable? How the cable will be connected over there? And then in underground how you will be exactly having your transformer from there? How from a panel you will be taking out the power to the motor? And in a environment where there will be explosive gas mixture, gassy mines. That is, your methane is using out from the coal beds and then the ventilated air is going with that air.

And gas mixtures at any time it can be if your simple spark comes out, there will be explosion. So that is why how that flame proof enclosure that you may be knowing that they are in any underground, gassy coal mine you cannot use any motor or any electrical appliances where the enclosure must be flame proof. And that flame proofness will have to be tested and certified by our director general of mine safety.

And then with the testing facilities at Dhanbad, you know you might be hearing about Shyam Farai they will be doing. So that arrangements and from there, when you are going to do the operations at that time also you will have to see that no spark you will have to operate somewhere. You will have to put the switch that when the switch on and off, if any spark comes, it will be a problem.

So that circuit, by which you will be controlling that switch on off it does not that is why that will have to be intrinsically safe circuit. Now, using those things and then making the mechanical arrangement in a very space constraint and there to make the things happen is a challenge. And the thanks to those mining engineers and the coolier engineers who manage these things to come up and then introduce this technology hundred years ago and still that technology is only improving and getting used.

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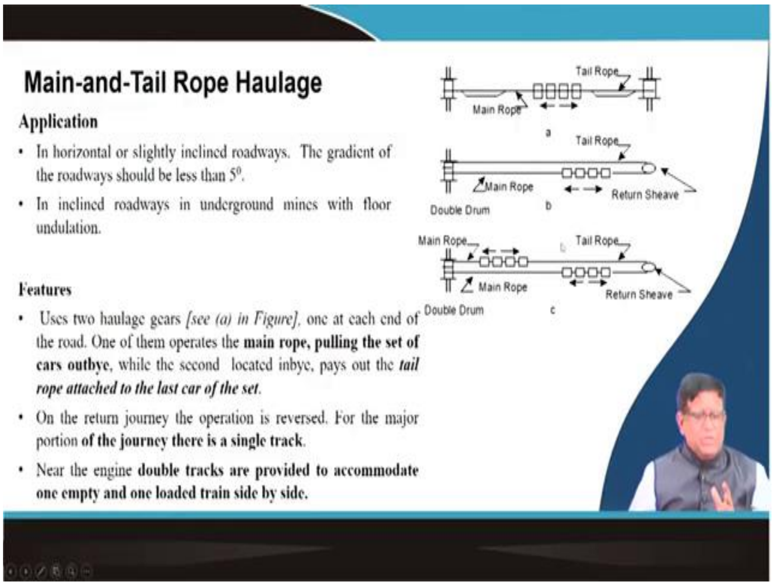

So, what is the main and tail rope haulage? In our direct rope haulage, you have seen that there is one drum and that are being brought. Now, here you can see that is, there is a main rope with a main your drum and there is a tail and drum with a tail rope. That means your that mine cars are forming a train, the end side and front side both side a rope is connected. So that is your exactly main and tail rope system.

Its application, is in a horizontal or slightly inclined roadways because in the direct rope haulage, when your this empties can be taken down by gravity but thing is that, if your things you will have to carry all the times, you will not get in an underground mind that only from there you will have to take the things also horizontally. If you are taking in when you are driving the gallery, you are going in a cold stream or in a in even in your rock with rock you are driving horizontal there.

How the material cut material will be taken and taken up to the top. So, for that you will have to make this systems that is horizontal or slightly inclined roadways, only up to less than 5 degree gradient you cannot use direct rope haulage. And in inclined roadways in underground mine should floor undulations. When the floor is also undulated, at that time, the smooth moving by or its own weight may not take place.

And that is why your there will have to be a system to pull downwards or in the other directions. So, you can have the two drum systems. So, this features uses two haulage gears one at each end of the road. One of them operates the main rope pulling the set of cars outbye that is when it is going in this outward directions. That means it is going towards the cage where the towards the shaft for getting lifted up.

That is called your outbye. Sometimes even that whole outbye could be an incline up to the surface. They can be pull like this because you know that those of you are knowing about the mining engineering that excess can be given by a shaft vertically down. Where you will be using cage or it could be giving only an incline where by this rope haulage, you can bring the whole material up to the surface also.

So, this coming towards the surface that is called your outbye and when the cars are going inside that is called your inbye. Now, one of them operates the main rope pulling the set of the cars outbye, the while the second located inbye pays out the tail rope attached to the last car of the set it will be going over here. So, we are having this main and tail rope. On the return journey the operation is reversed for the major portion of the journey there is a single track.

That is only near to the where you will be connecting the empties and loaded separately will be changing. You may have this portion and at this loading portion there we are having two track. But the main journey it is by single track. And the near the engine double tracks are provided to accommodate one empty and one loaded train side by side. So, this is your main rope and tail rope. That is why it is called main and tail rope haulage.

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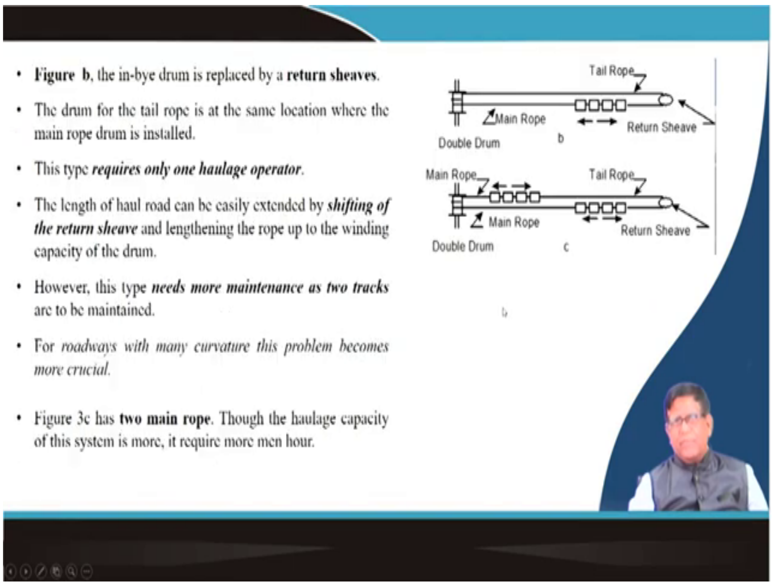

And here we are having this is also a main and tail rope but a little differently. What is there? You can see here at the end, there is no drum. But what it is there? We are having a big sheave. This is a horizontal sheave that just like your one wheel on that wheel that rope is coming and it is there. So, rope is exactly anchored at one end in the drum and the other end it is going from that sheave it is coming and then it is exactly wound on the drum.

So, this type of system is also a main and tail rope. Here that, whatever is that end rope that is where, where they variable that is your this, where it is wound up, this portion is the main rope. And then the where from the anchoring point to the sheave this side which is this, is called your tail rope. So, the drum for the tail rope is at the same location, where the main rope drum is installed that is same drum.

And this type of this type requires only one haulage operator. There earlier one you have seen one haulage drum at inbye and one at outbye. So, they were having two but here only one engine one persons can operate that system. The length of the whole road can be easily extended by shifting of the return shift. As your mining progress, your gallery is increasing going. What you need to do is? Only your this sheave you just its locations can become from here.

If your location is coming and moving in this direction then it will be giving your this you will get that. If you are moving it into this directions and then you that rope whatever is the length is wound over there in the drum that will help you to extend the part. So, this step needs more maintenance of the two tracks because you can see here. There is a two tracks are there.

When that it will be coming from the main road from here that your loaded truck will loaded cars will go and then from the empty cars will be coming and it is connected over here and it is traveling like this. So that all the time there are two tracks will have to be maintained. And the many curvature this problem because this is a to negotiate curves and turns that and particularly in a gallery your when you are making number of pillars.

Then to going to the one district way connecting to the other district when you have to negotiate the curve part. There are certain issues and problems over here. Now, there you can see here this is the main rope and then this is the tail rope and then from this sides the main rope and this sides here from the return sheave, how the arrangements is faint, for you can do it.

So, there are two main rope here in this one figure b, you can see only one main rope but here your two main rope. That means simultaneously the both the rope will be working over here.

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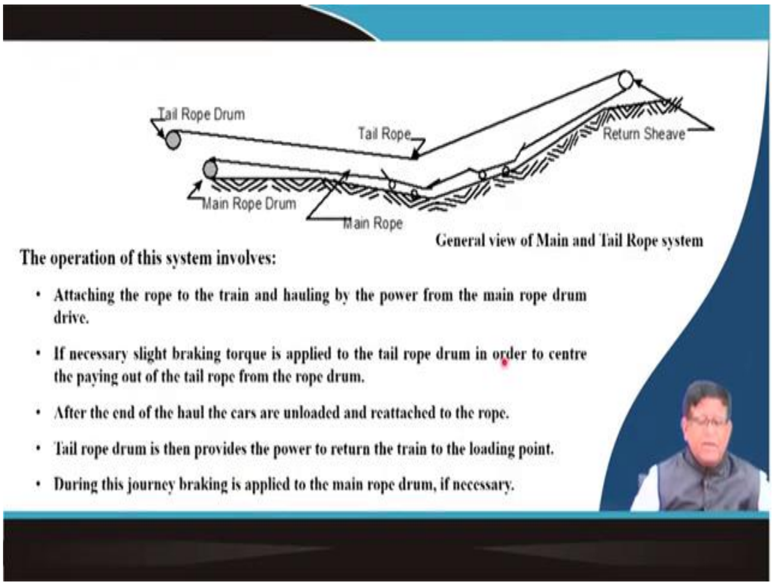

So, there will be more load will be coming over here this is a bigger system. So that means you can arrange the main and tail rope in a different way. In the underground mine you can think that this is there inside the mine. How you are doing there is a your tail and drum is connected over here, main rope drum is connected over here then your this will be the tail rope will be going.

And then here this cars you can see that these are connected over here and this is the way how things will happen. Now, the operation involves what? If you are to operate with this, attaching the rope to the train and hauling by the power from the main rope to the drum and then it necessary, slight breaking torque is applied to the tail rope drum in order to centre the paying out of the tail rope from the rope drum.

Your this much by exactly the operator, will have to control these things. Then, after the end of the hall, the cars are unloaded and re-attached to the rope. That is why, as I said, the manpower required is more because you will have to attach and it has this operations will have to be controlled over there. So that in underground the there will be hauling at the siding sides. A main sardar will be there under whom the miners will be there.

The sarder will be arranging this manpower that because after one train comes then they will be taking some rests over there that when the next one will be coming. And their operation control a lot of industrial engineering and operation research started at these things in the 80’s in the 70’s. Many of the mining engineers were doing debt operation research that how exactly the manpower can be managed over there.

So that the maximum number of cars can be taken out per hour. And then because on the basis of that, you will be calculating what is the output per man shift, how many persons you have engaged in that shift. And totally how many cars exactly you have taken up to the surface that was the type of the role of the mind management in those days.

The tail rope drum is then, provides the power return to the train and the loading point you are using the tail drop there. During the journey braking is applied to the main rope drum if necessary because to speed control. Now, you can see here that you are negotiating slow, low gradient and also a different undulating road you are managing with this type of system.

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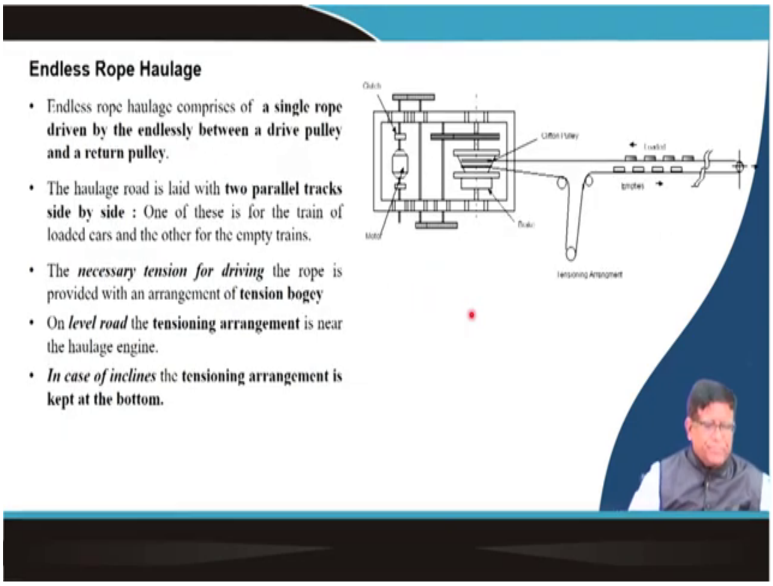

The other one is a endless rope haulage, in the endless rope haulage the system is your one rope. This exactly you can see the rope here it is going over here and it is connecting over there. This is a clifton pulley, a conical drum type of a pulley in which this rope is taking a turn and it is going over here. There is this rope will have to be kept under tension. That is, if the tension is not there, the power will not be going to this or that rope will not be driven.

That is why this clifton pulley, you are having a number of your this gear arrangements. You can see here, the electric motor is there. And this electric motor with the help of this clutch, is connected to the gear system and then this gear after this gear, this pinion this is the gear and it is connected to the clifton. Now, when it is rotating then your this clifton pulley will be all the time continuously, making this endless rope to keep on moving.

But it will be moving at a very slow speed. So, the loaded cars will be connected to the slowly moving rope. And then when it will be coming over here then it will be disconnected manually from the rope and then loaded curves will be going out and then what it will be there. This is going to the your empties will be connected to this and then the empties will be going over here.

In between near to the drive here where your this sheaf changing over is taking place. You are having a you, dig a hole over here and then keep some weight. So that this will be under tension. Because when there is no load at that time, this it may come out because tension is less but all the time to get the drive you will have to have this tensions ready. And this one again in your that build drive or in any rope drive you have learned over there.

That this your any type of this system the tension of this one is under this one. Their ratio of the taut side and the slack side tension will have to be maintained. Their ratio as the is depending on that what is the friction between these two that you might be hearing that very famous eulers equation of T 1 by T 2 = E to the power mu theta. On that basis, to increase that tension, you will have to see that your this type of system is called your take up.

You have seen in conveyor belt also, this gravity take up is there. This arrangement is there in an endless rope haulage. So, here also you will have to have two parallel tracks. And then that is your you will have to maintain the tensioning arrangement and that exactly is the endless rope haulage, the main requirement to maintain the two tracks and maintain the tension.

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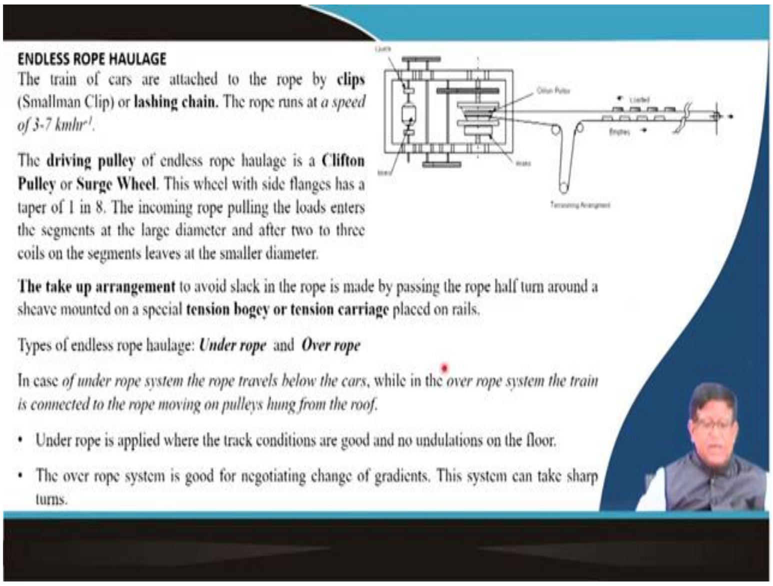

Then the main cars are attached to the rope bike clips. That is a your rope which will be moving over here you will have to clip it. So that it can go on moving over there. And when you are to take it out from there you remove that clip and then your rope will be free you can bring the empty and you can connect it over there. So, this there were the lashing chain and this small man clip there was a in that old days.

These two were the patented product which are used over there. The driving pulley of the endless rope haulage is the clifton pulley, as I said or sometimes it is called also surge wheel. This wheel with side flanges has a taper in 1 in 8. That is 1 in 8 taper. The incoming rope pulling the loads enters the segments at the large diameter and after two or three coil on the segments leave at a smaller diameter.

That clifton pulley is of this type of that it is coming and then making it turn and then it is leaving. The take up arrangement to avoid slack in the rope is made by passing the rope half turn around the sheave mounted on the special tension boge or tension carries placed at the wheel. Now, what is there at this place? Also, you can have a tension boge. That means this wheel it is mounted on a track over here.

And then there could be another depth and then giving a weight over here the tension boge arrangements can be made. Now, as I said, this also can be under rope or over rope system. In case of the under rope system, the rope travels below the cars and in over rope the rope is above the sinks on the roof. Now, under rope is applied where the track conditions are good and no undulations and the over rope system will be applicable where the your roof condition is very good, very strong roof. So that you can anchor over there.

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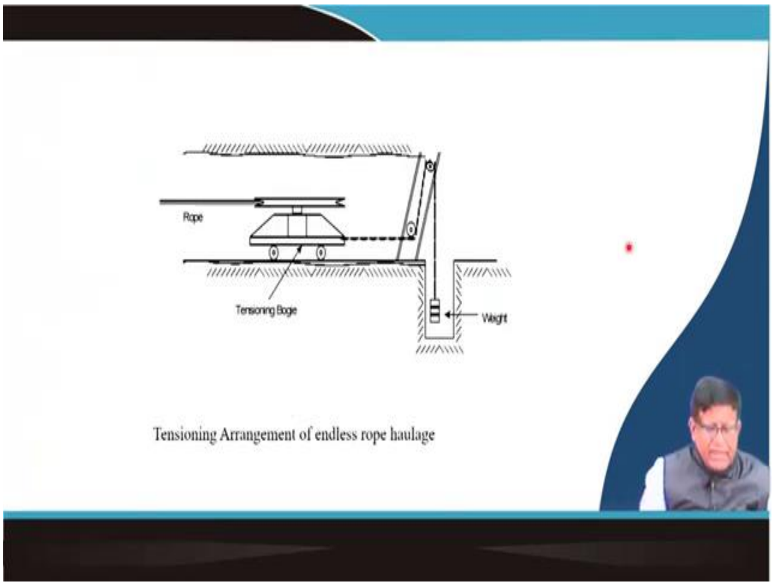

So, this arrangements are there the tension boge which is there that your this is the sheave this sheave which is there at the end. This is a your sectional view. If you see a plan view here that you section you can see, this is your the horizontal sheave. This is placed on a boge. This is called your tension boge**,** you are having a track. On the track you are connecting it and then you have made an excavation in such a way then and then you made a pit over here.

So, this is if your this tension is less then what will happen the slack side to accommodate this weight will be pulling it down. So, this type of tensioning arrangements with the endless rope haulage systems are there.

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And the lashing chain you can see that this chain is the lashing chain and that chain will be coming with a clip is there on the rope it will be connected. And then you can usually this will be moving that where rope is moving and that this at you and you can lash it with that car mine car will be having this type of lashing chain.

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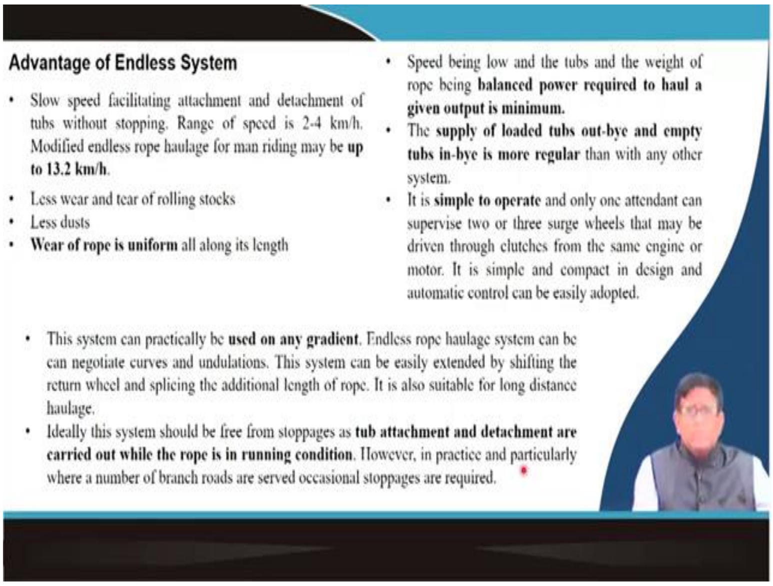

So, the advantage of this system is its slow speed, facilitating attachment and the detachment. That means it will be moving at a speed from 2.4 kilometer per hour at if your man riding system can be used because there you will once it is connected, you will not be disconnected only up to the end you will be going and you can make it up to a speed of 13.2 kilometer per hour. And there the rolling stokes they get less, wear and tear.

There will not be much dust because it is a on track moving and wear of the rope is uniform. The speed being low that is a tubs and the weights of the rope being balanced power required to haul a given output is minimum. The supply of the loaded tubs outbye an empty tubs inbye is more regular. And its operation is very simple and it can be used in any gradient unless rope haulage. That is why this system is being used in most of the modern mines also.

That, unless rope haulage systems can negotiate curves and undulations this is also an advantage of this system. And this is free from stoppages because it is slowly keeping endless rope will be keeping on moving. Only your attachment and detachments will have to be carried out when the rope is moving. So, it was when it is introduced it is found that its productivity is more than both the other type of rope haulage system.

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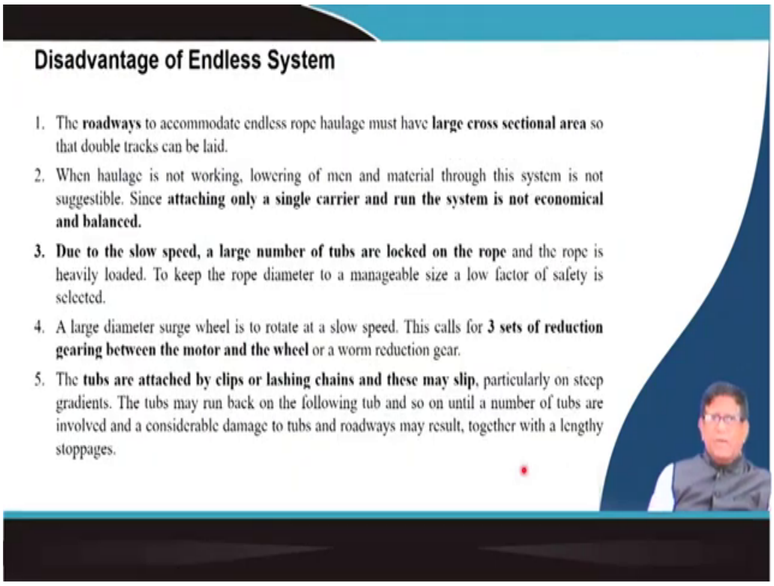

Now, the disadvantage is of course, the roadways to accommodate endless rope haulage have the large cross sections because true tracks will have to be made then it is when the system is not working at that time. Lowering of man and material through this system is not suggested. You cannot use this system because attaching only a single carrier to run the system is not economical and balanced.

So, it is to be used only for this your that number of cars can be attached and detached when the production is going on. So, this will have to be very careful with that due to the slow speed, large number of tubs are locked on the rope. That is and the rope is heavily loaded to keep the rope diameter to a manageable size a low factor of safety is selected. Normally that what is happening your the rope how much tub it will be pulling is depending on that strength of the rope.

The strength of the rope is determined by the diameter of the rope. And that, if you are having a large number of cars and then your weight will be more that is why the diameter will be more. And if you put the diameter small or less that means you are you will be sacrificing with some of the factor of safety. So, this need to be taken care of and then the regulations will have to be followed up to what factor of safety you will be using for this purposes.

Then the clifton wheel or the charge wheel is to rotate at a slow speed and then three sets of reduction gearing. In the diagram you have seen that here when we are showing you this diagram, you might have noted that there is a number of gear that is here block motor. This is the first stage as a second stage then the third stage, the three times the gear ratio that is your the speed, is reduced from the drive motor.

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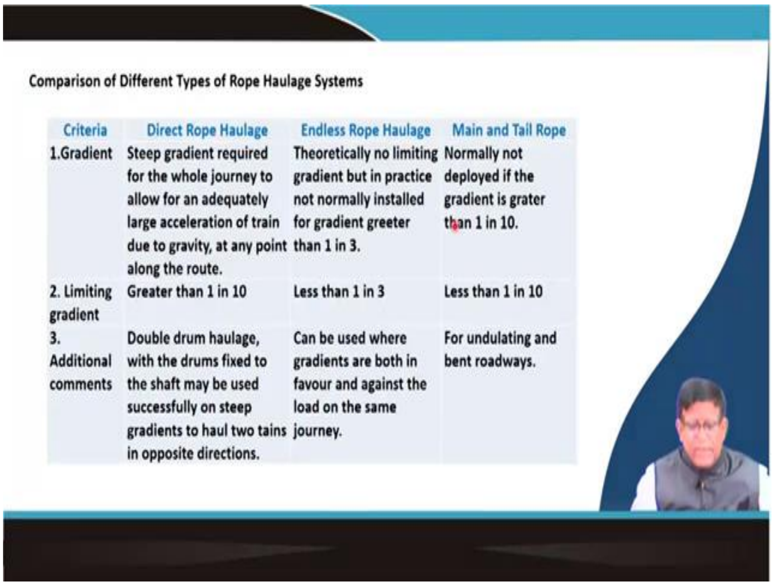

Criteria	Direct Rope Haulage	Endless Rope Haulage	Main and Tail Rope
1.Gradient	Steep gradient required for the whole journey to allow for an adequately large acceleration of train due to gravity, at any point along the route.	Theoretically no limiting gradient but in practice not normally installed 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.

So, now out of all these three systems if you see that the direct rope haulage you have seen, endless rope haulage you have seen, main and tail rope haulage you have seen. So, as a learning activity try to find out that how these three systems can be compared? Where can be used? You do with the basis of whether it is on the gradient which one is at a your main and tail gradient then it can be 1 in 10.

But your direct rope haulage you can use that any steeper gradient, limiting gradient also there where you will be using. Then additional comments are on a comparative comment double drum haulage with the drum fix to the shaft may be used successfully on steep gradients and then your endless low polish can be used where gradients are both in favour and against the load on the same journey. But in main and tail rope for undulating and bent roadways, you can use them.

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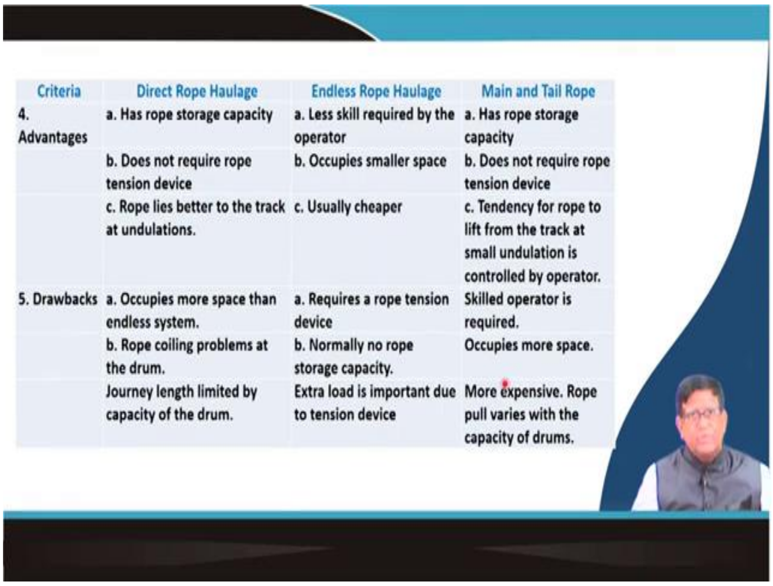

So, there are advantages and disadvantages you can compare there.

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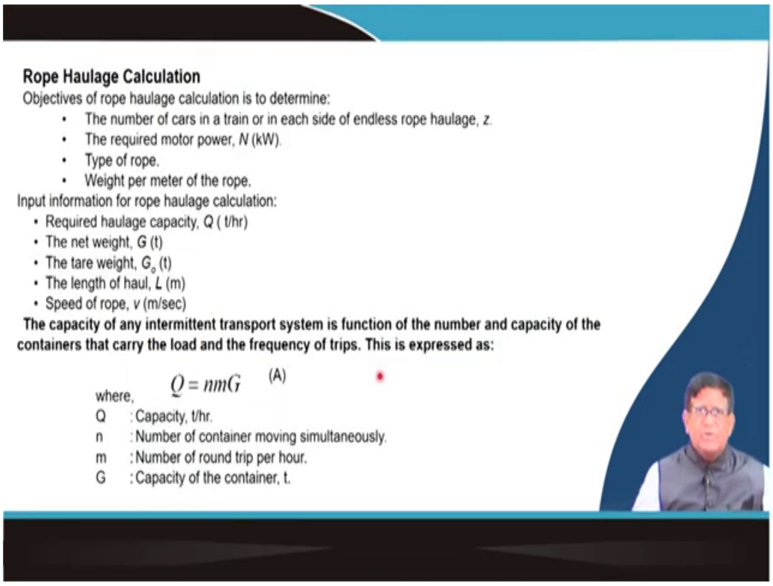

And once you have done these things, try to draw the drawings of them you will be able to know. Now, when you are to do some calculation of this. The objective of the rope haulage calculation is to determine that what is the number of cars in a train or in each side of the endless rope haulage? How many number of cars you will be connecting that z, calculating that is a one issue.

Then you will have to also calculate what is the total power requirement. We are telling as a n in kilowatt. Then what will be the type of rope? That is your what should be the diameter of the rope? And then how many strands of the rope this also to be designed or calculated. Then what will be that rope? What will be each whole weight per meter? Because that weight of the rope will be having direct bearing with your the motor power requirement?

So, these are the things need to be calculated and for that your this designing or planning it your. What are the main input? Exactly your input is for what type of capacity you want to determine. That is a required haulage capacity. That is a very important point we need to. That is a starting point rather and then what will be the net weight? That is how much is that and then that your car which you are using? What is its tear weight that is its own weight?

How much exactly additional material will be coming? So that that your the total load calculations can be made. And, of course that hole thing will be determined by how much is your length of the hole total distance to be travelled and then at what speed it will be going. Now, if you see this parameters, input parameters, you have considered that things are very simple. The capacity will be depending on the number of container and the number of round trip per hour.

Then hourly production will be depending on that if one container is having your say, t tone carrying then your n container, with a m number of trip, will be giving nm and each one is having your net weight is G. It is the G tone of the coal or ore is there. So, you can find out that quad that is, your capacity will be product of these three parameters as given in this equation a you can see that nmG.

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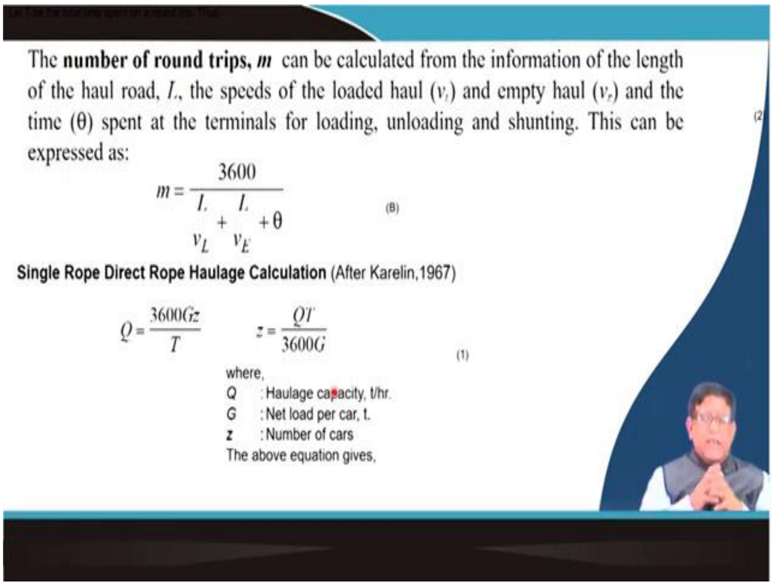

So, what once you know this then you need to find out how that m, your for this, the number of round trip per hour? How many trips it will make in an underground conditions? It can be calculated from what is the length of the hole? What is the speed of the loaded hole and the empty hole? That is your loaded will be going at a different speed say v L and the empties are going with a v E and then if it is total time theta that has been spent at the terminal and for loading.

Because this is a as I said that your the loading and unloading that is your taking out the cars then putting it to the case all are manually. So, it exactly takes a most of the time is spent over there. So, when you are to think of that productivity there you can make many development came there how semi mechanized system could be made so that this could be faster. The theta that that exactly reduction of that was the most important thing, as you can see here in that equation your that it is only out of that in a per hour.

You are finding this total time in the L by v L + L by v E + theta. If you can reduce it, your m can be in increased. Then your single rope or direct rope haulage there what will be that q coming then? Because if you know the net load per car that is your net load is, it may be having the total it is. I am not telling about the weight of the that car that will be weight of the car will be coming while calculating the motor power that this G is the what is the amount of coal it is taking and that number of car is known?

That is why you can find out this. What will be the number of car required for giving a particular production rate, so, you can calculate here, if you want to make 300 ton of coal per hour. And from an underground mine you can think how many trips it will have to be made.

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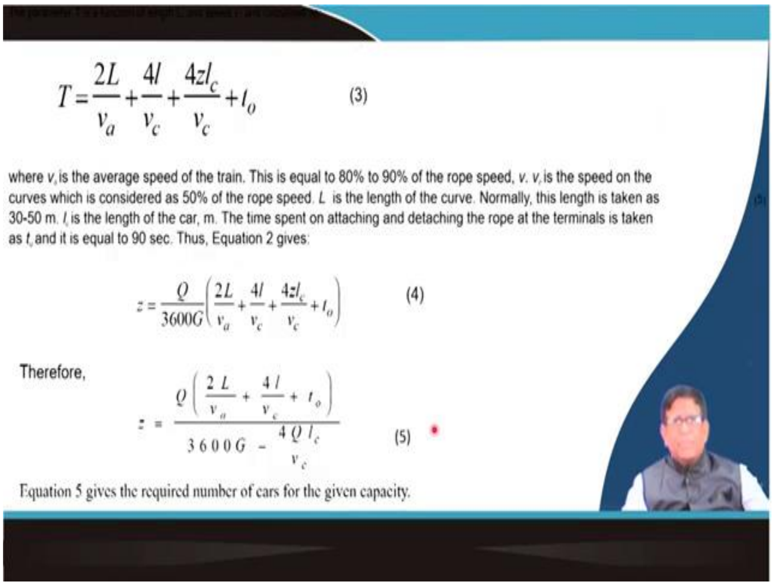

So, this type of calculations can be carried out by this simple equations. That this time which we are taking that is your the if your total time required here as say your this total time will be the main factor that is the for the whole productivity calculation and this is calculated by knowing that that is your the velocities that speed that is, average speed of the train and then when it is carrying out that is your the at the curve.

When you are negotiating the curve, there will be your speed will be different. And then your other parameter is mainly that your the total length of the curve. And then if you take this parameter out that is average speed and which could be your 80 to 90 percent of the rope speed which is your the that, as per the specifications given of the haulage system. Then this at the curve, the speed could be 50 percent of the rope speed and the length of the curve is known.

So, from here you can calculate this time and then you can calculate that how many number of cars it can be carried out. Once you calculate this by using this equation then you can find out what will be the your particular systems capacity.

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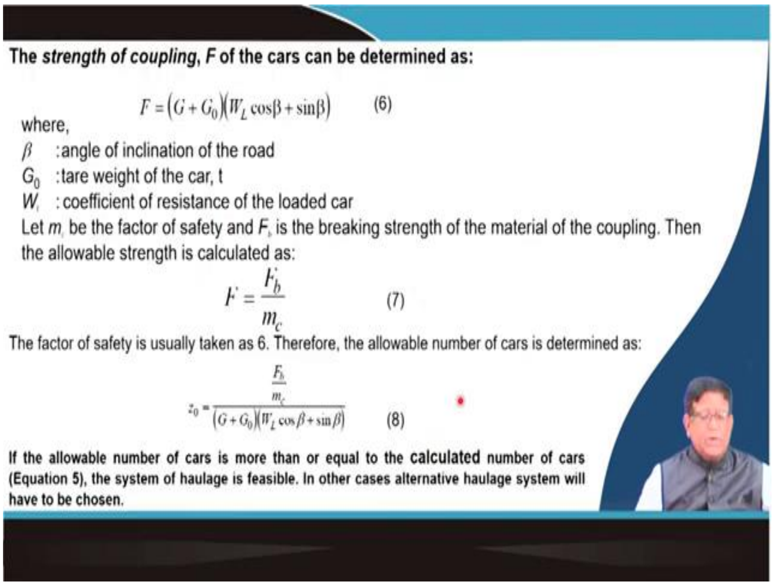

Now, another thing is required that when your two cars are connected together that coupling it is very important that is your if this coupling force you are not taking into account then it may snap it can create and there could be safety problem. So, this that will be depending on total weight of the G + G 0, is the that which load what will be the mine cars total load. And then, if that angle of inclination on that, how much load it is coming.

So that total load which is coming at the end to end to the between two curves that is calculated by this equation which depends on the angle of inclinations and the coefficient of resistance of the loaded car. Now, if you are taking a m C as the factor of safety then if you have known that, what is the breaking strength of the material of the coupling you may have wrought iron, steel or any aluminum alloys, whatever you take their breaking strength, if it is known.

Then, the allowable strength, this factor that means you calculate it out and if this factor of safety is normally should be 6 and from there you can find out. The total load which you have taken on that particular gradient is suitable or not. This type of simple calculations then once you know this this under this strength for the given force of the coupling which is provided in that you can find out now how many cars you can connect to it.

So that means the train you can take with z 0 number of cars, provided you consider that it will be operating sheaves. That means at the coupling strength is very important so that it should not get decoupled or the break at that point. And here, this calculations most important thing is we are maintaining with a factor of safety 6. Now, if the allowable number of cars is more than the equal to the calculated number of cars, the system of haulage is feasible.

Then in order this other cases alternate haulage system will have to be chosen. So, whether in a particular mine, your, why we go on using this we are taking only 10 or 12 cars because exactly that material. Now, you can change the coupling and then you can change this your haulage capacity depending on that you can increase the load. So but that is why a 300 ton per hour mine cannot be made overnight by just adding the cars to a 500 ton per hour capacity.

This will have to be seen that feasibility and when this, if we require now making a underground mines to produce 2 million 3 million ton of coal per year, this type of systems will not work because of this failure. Then we will have to think that why you go for this your conveyor belt or sometimes this your other type of this railways and all which have come now that the other day I was telling you.

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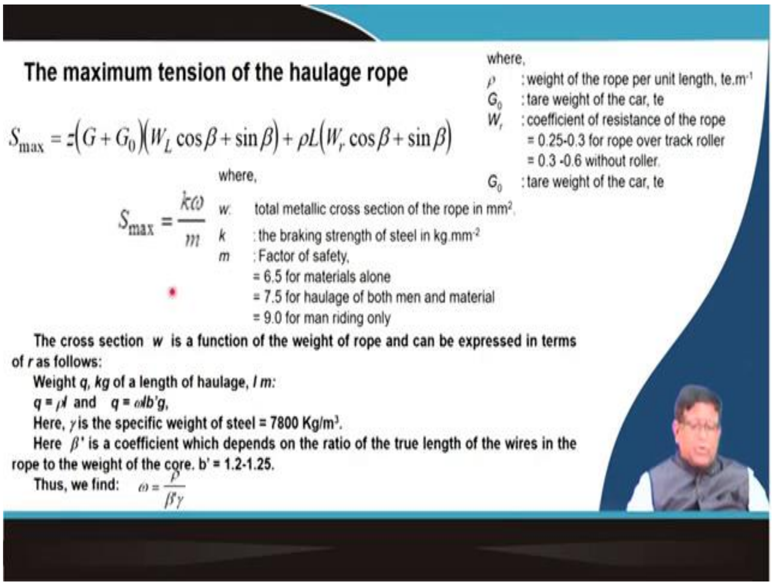

So, this gives you an idea that the maximum tension on the always rope you can calculate out now that will be depending again with the number of cars, with the total weight of it. With that, your total length wise that your. How much is the that your load due to the inclination is coming that gradient force? And while you take all these considerations then you can find out the maximum tensions.

And once you know the maximum tension and then the breaking strength of this and the factor of safety from there also, you can calculate it out. And once you know this, the share what is the cross sectional area that is, it is a function of the weight of the rope and can be expressed in terms of the radius of the rope and that is why to check what is the diameter suppose your weight is a Q kg of a length of always one meter.

Then your Q is equal to rho L and then by this equations, you can calculate out that your what will be the total of this your cross sectional area of the rope. And then you can verify whether this rope will be useful for your systems or not.

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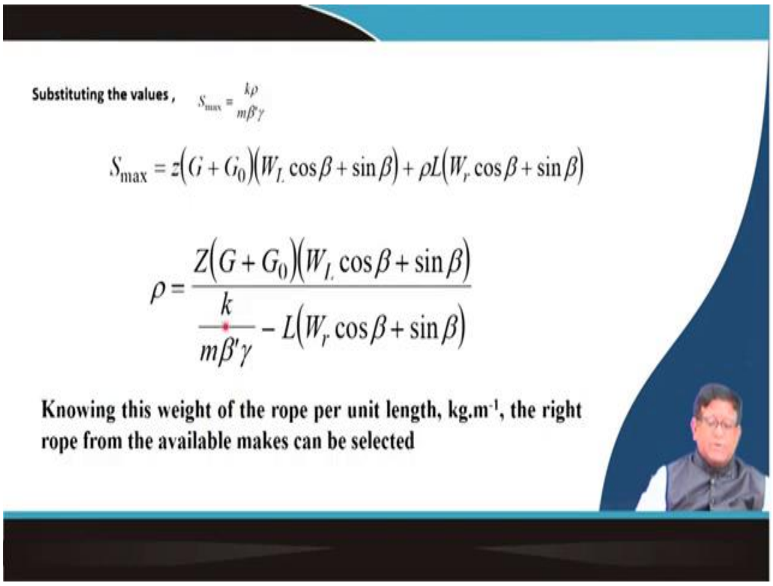

So that means the from the knowing this maximum tensions over here. And then, when you will be knowing what will be the your weight of this that is your the per meter rope weight because this will be ultimately contributing to what is the motor power required. So, knowing this rope the weight of the rope per unit length, the right rope from the available make can be selected.

Because whether it is your 6 strands, rope 8 strands ropes have flock coil rope, your the type different type of rope may be manufactured by different companies will be giving. And then from those catalogues or the that your manufacturer leaflets, you can calculate it out. So, this is how exactly a mine manager works. He does this calculations and from there he from the vendors select that this is your appropriate one.

Now, today, why I have put this one is you can do these things by a simple you can develop a excel based calculation system or you can make a mobile app for giving as a rope selection criteria, collect the different information's from different rope vendors. Then you calculate the different type of materials properties. Then you can make a small app that is your in which way you can help the mine manager to select the right type of wear rope for optimizing the power consumptions and maximizing the factor of safety of operation. So, this is what the today's engineer must do.

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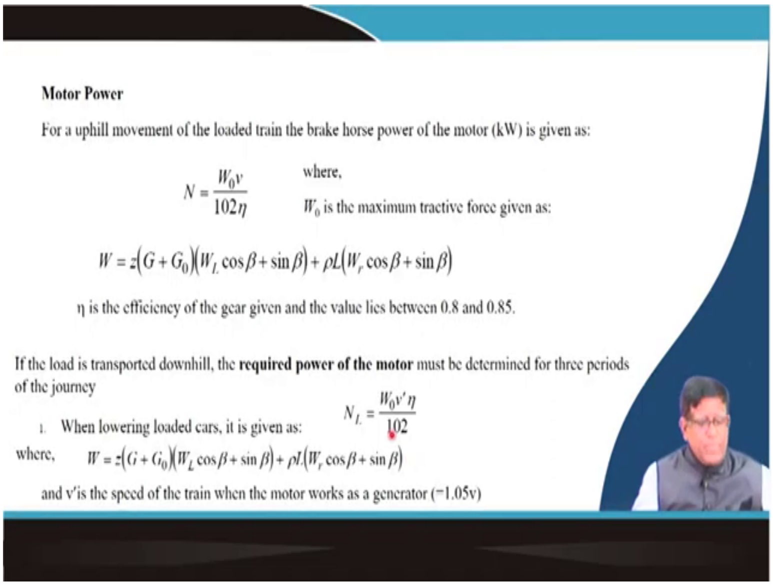

So, the motor power requirement if you know that is your what is the total attractive force which is required, attractive force you know, the velocity you know and then by this equations you can find out what is the total power required motor power required and that this total maximum attractive effort it will be, depending on the number of cars total weight then grade resistance and your total resistance coming over here.

So, in this way your required motor power must be determined for different period of the journey. That means, when the lowering of the loaded cars when carrying up the upper cars and when you are moving at a constant speed.

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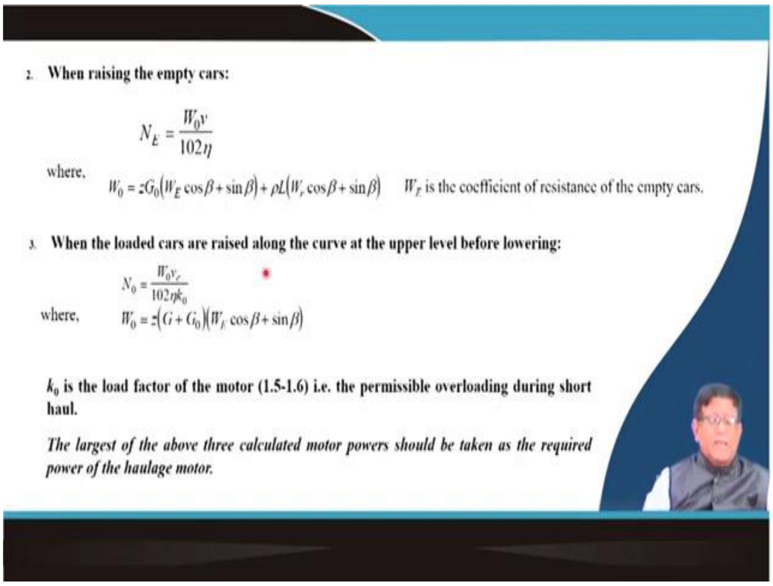

That is when raising the empty cars and when loaded cuts are raising along the curve. So, under these three conditions, you can calculate out the total power required. And your normally, this factor which is you, are keeping as a load factor 1.5 to 1.6 as a for overloading you will have to do it because while calculating in mining operations, you always see that the factor of safety is always taken at a higher.

And the load factors are also we are keeping in a safer side because there, under this working condition and constrain, will have to be very very safety conscious.

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So once you will I request you kindly go through this book of mine transport by N.T. Karelin. This book will be giving you a good idea, particularly the chapter 10. If you read, you will find out that what are the basic calculations for your rope holes system and also, as I told earlier that much of the Kyushu University, he has compiled these things. Other than that lot of study materials are also available. The text books are available but that will not help you.

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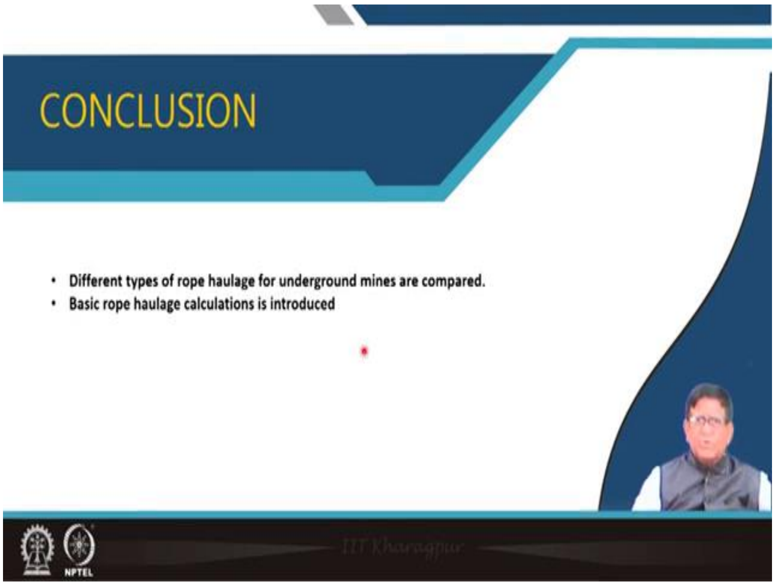

You will have to do your own as a problem. You take up that how a the motor power calculations for driving a rope haulage if you can prepare a simple excel based calculation model with using the equations given in this class. It will be useful for you to construct knowledge. So, we have just different types of rope haulage for underground mines are compared. We have discussed about it.

The basic rope haulage calculation is also introduced to you. Please take up some learning activities on this and then I hope you have understood now. What is the underground rope haulage system. So, maybe in the next class I will tell you about this the layout that is your what is your sub pit bottom and a pit top layout. So that we can go to the next mode of transportation. Thank you very much.