Bulk Material Transport and Handling Systems
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Lecture – 44
Aerial Ropeways Calculation

Welcome back to our discussions on the transportation machinery. In the last class we were telling you about the aerial ropeways there I introduced you that how this old system which was there before the technological advancement, but today also this particular system is quite relevant and there is a scope of using this aerial ropeway in some of our aerials in bulk material transport because it is a technology implementations and then for its operation and maintenance we require very limited skill is required.

So, it is a very sophisticated skill is not required and considering that our country has got a lot of still not forward area many of our hilly terrains they are in Uttarakhand in Northeast, there are also in our Southern India in our Western Ghat and Eastern Ghat in those areas also, lot of villages are there where the so called modern development progress is slow, but if we see that present stress on the production system.

And present stress on our rural infrastructure development there for the transportations of the products from some of the interior areas where terrain is not very comfortable for different mode of transportation which is very highly cost intensive in those places for bringing the benefit of their marketing of the products to some larger distribution system it is important that aerial ropeways should be looked into with a different perspective in India and some more R and D is necessary.

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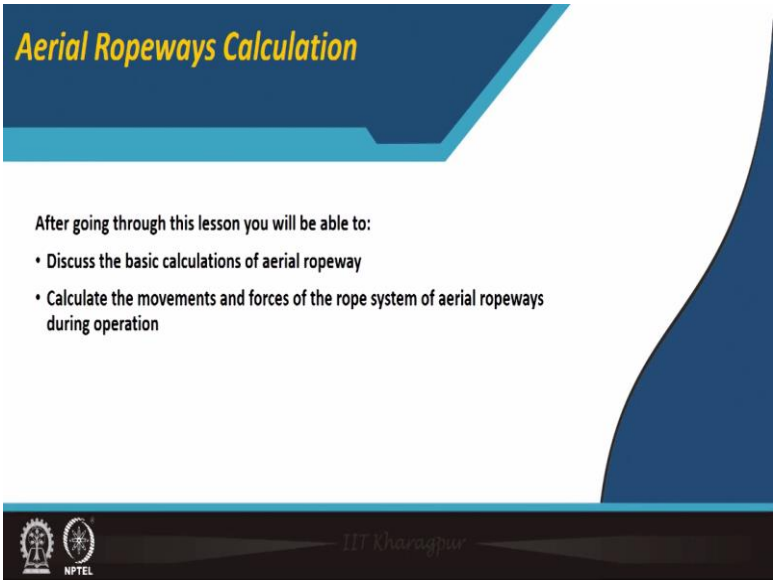

With this introduction I would like to bring today some points that if we want to do an aerial ropeway calculation that is just to do a preliminary assessment whether such type of system if you want to do what would be the requirements and all some basic introductions will be given in this class so that you can understand and calculate some of the forces required.

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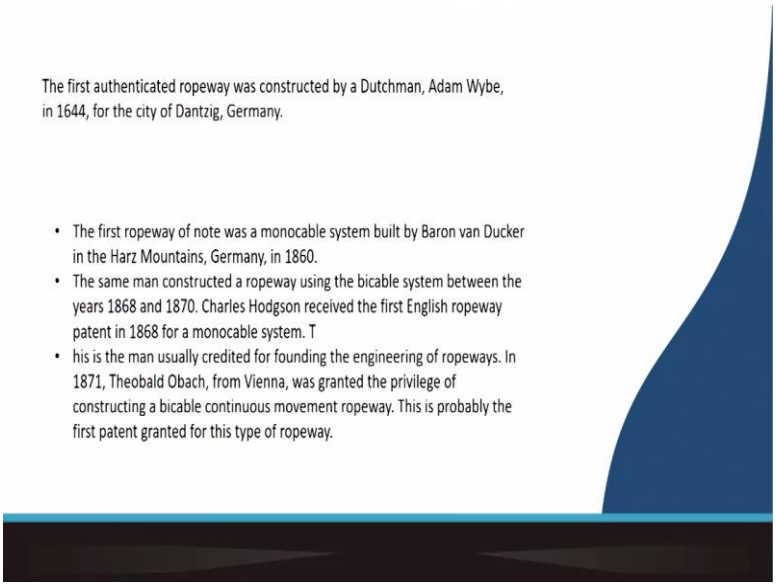

But one thing I just tell you that this system which was first introduced long back in Germany in 17th Century and today there are also lot of develop systems are there.

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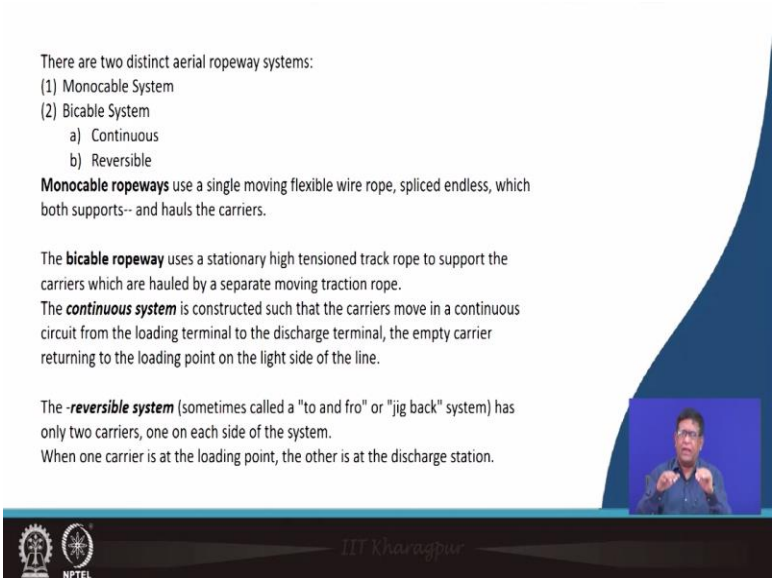

But in this how there are the basic systems which we are having is a mono cable system and bicable system. Now to design this system for the design calculation we need to know how this ropes are handled in a monocable system there are you use a single moving flexible wire rope which is this wire rope is brought both the ends are splice together to make it endless and then that is supported on the trestle.

So, we will have to know that what should be the diameter of that rope, what should be the type of the rope, what should be the tensioning arrangements in the rope that will be coming. Similarly in the bicable ropeways what is done there exactly the carrier it will be that is the carrier will be supported by a track cable on which on wheel this carrier will be moving, but to move that another cable will be there which will be gripping that carrier and it will be pulled.

And this system can be also reversible say, for example, going from one direction to another the same will be returning back as a to and fro motion. So, this different type of cable will have to be brought and then will have to be arranged in a different way.

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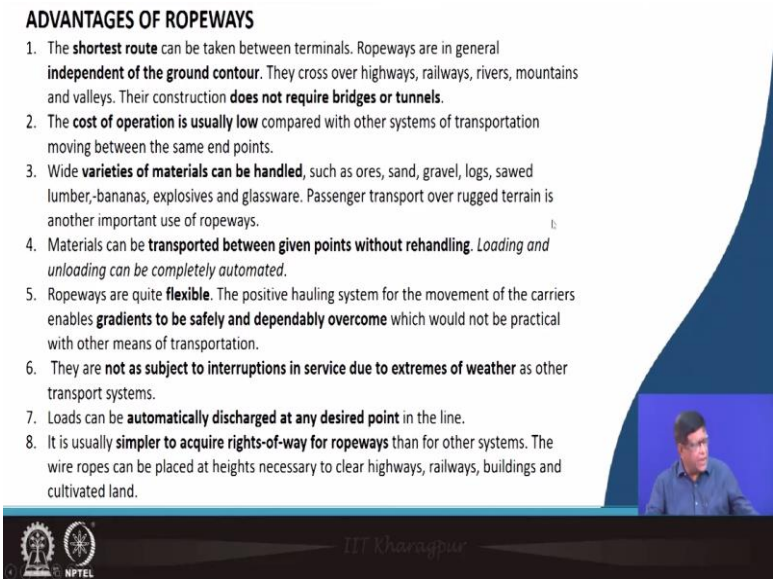

If we see that why we go for designing such systems will have to take care of that what are the advantages we will have to ensure. We know that these system will be giving you the shortest routes that can be taken between the terminals and ropeways are in general independent that is your ground contour we told it already that is your how you will be keeping it above a rough terrain.

And we will be eliminating the requirements of tunnel or requirements of your bridges. So, that is why one calculation which is done in ropeway calculation is the overall cost of transportation development that means why we are bringing an aerial ropeway its different components what will be the cost and if it is done by other mode of transportation with railways or roads or if possible if there is a river connectivity by waterways what will be there.

So, that cost calculation is another type of calculations can be done, but in such type of studies it was found that this cost of operation of aerial ropeway is usually low and then another advantage is that these can be organized to credit different materials so that is a bulk material even the unit load materials sometimes even the logs and woods also a different type of material or carrying human being.

So, this can be handled and that is one of the advantage then it could be transported from one end to the other end in between there is no need of re-handling that you will find that let us say there is it will be have to be always within a fixed path and in that path you have got the

specific locations where you want to your end point and start point can be very fixed, but at the same time in some cases there are certain flexibility.

That means the route you can negotiate that is your it is only that how you rate the supporting system and then what type of gradient you want to maintain on that there is a flexibility of designing and it is exactly they can be designed to not to be getting interrupted by that climatic conditions. It can go on say for example in the wind and all normally it is tariff it is at a high elevations that whether the particular wind velocity will be disturbing.

And then the whole material maybe spilling and all, but thing is that it can be designed that is your height with respect to the wind velocity and there could be designed at the same time if it is to be arrested or it can be stopped that whole control system also can be provided so that all weather operations can be managed then your output that how much is the capacity that capacity can also be you handle that is of course this is not a continuous type of transportation like conveyor belt and all.

Though rope is moving continuously how many number of carriers at how much capacity will be done that too a limited extent can be controlled and the best advantage is that your land below that you need not acquire only some simple permission system can provide you. As a result this can be your other logistic arrangement may take less time.

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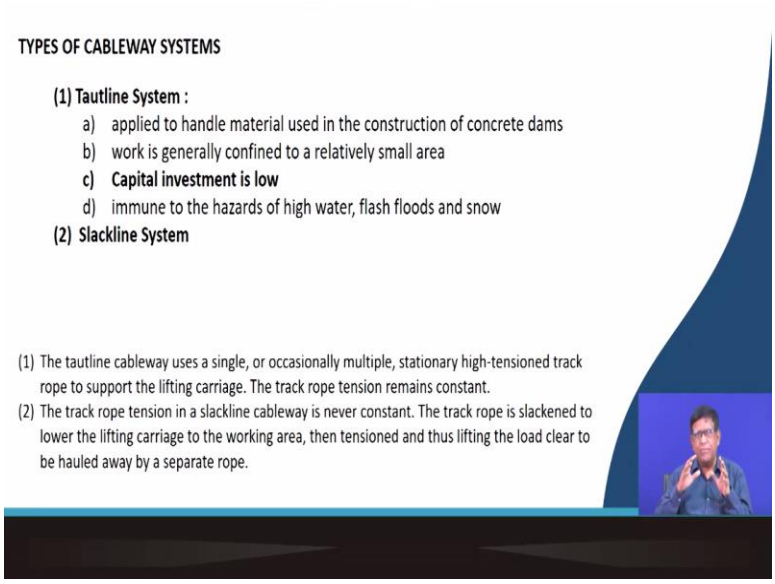

So, when you are going to design the rope system you can have a two type of system. One is the tautline system that is the cable it does not slack and then here exactly it is called your

application to handle material using the construction of concrete dams etcetera where the material transportation to be done there we are using tautline system and then the other one is your slack line system.

Normally in the tautline system it is a capital investment is low, but it is not affected by some of the climatic conditions, but in a tautline cable way uses a single and occasionally multiple stationary high tension track rope to support the lifting carries and the track rope tension that will have to be maintained constantly. Now between two trestles the track rope it can slack that means it can have a sag and that is managed.

So, the track rope tension in a slack line cable way is never constant because of the load and all that sometimes this will be sagging sometimes it will be sagging more some sag less so that arrangements we need to find out that how it will be there.

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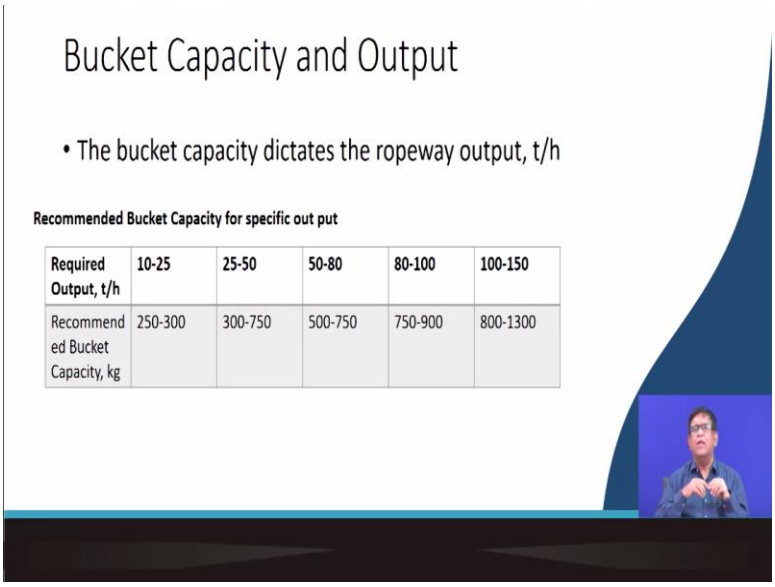

Normally whenever you are developing or designing a system we need to know what is the bucket capacity and output. As you have seen that our basic principle of aerial ropeway is to have the bulk material in a container called carrier or the bucket and then it will be number of them will be connected together and will be pulled through the rope. Now the throughput capacity is the total how much material it can deliver from the point where the source and where you are giving delivery.

So, in that throughput depends on your this bucket capacity that means your bucket capacity can vary from 250 kg to 1,300 kg 1.3 ton large buckets you can use and accordingly your

output that per hour it will depend on total how many number of that bucket can be accommodated under the strength of that wire rope under that particular sag it can be given in that wire rope.

Under that what will be the supporting distance between two trestles and it is found that from the various applications the throughput capacity is 10 to 25 ton per hour to 100 to 150 ton per hour. Now, if you compare here the conveyor belt we are having 10,000, 20,000 ton per hour and here it is you are telling about 150 ton per hour that is why these has got a only specific area specific and location specific applications.

It is not going to be the main evacuation system of an open mine where we will be having our throughput capacity in that 20 to 30 million ton per year even more there this type of system will not work, but it can have some indoor applications in material transportation inside a plant that is your material transportations for in a rice mil it could be in from the village to get the product to a market in a hilly terrain.

In those type of systems where the throughput capacity is limited area, limited distance transportations there it could be ideal.

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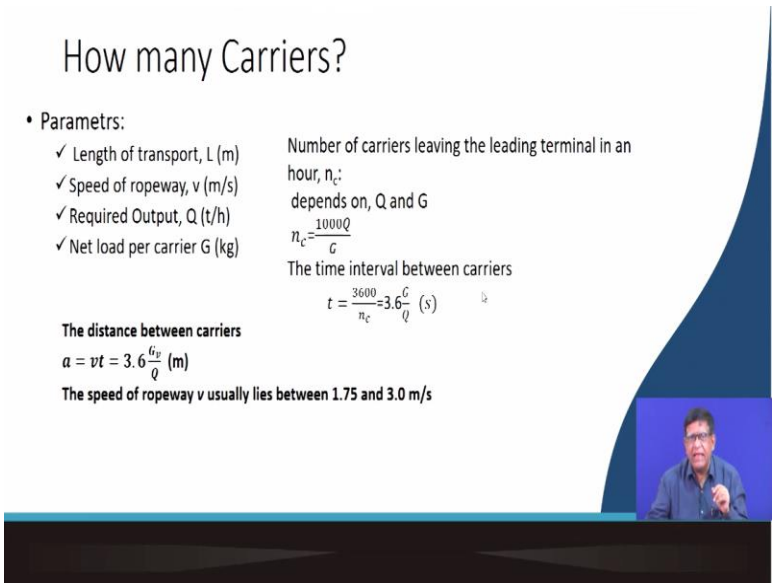

Now when you need to calculate that how many carriers this is exactly will be depending on the parameters mainly the length of transport that is your how much distance it is to be transported and then what is that rope is moving at what speed that is your rope speed of the ropeway and what is exactly you want to you want to take 80 ton per hour or you want a 200

ton per hour that is very important and in one particular container one carrier how much kg of material you will be taking.

So, these are the main parameter and then you can have these calculations, but what is the number of carriers leaving the leading terminal in an hour. In one hour how many number will be going? If you know that number then if you know the capacity you can each of the bucket of each carrier then you can find out. So, now that simple you can correlate with this by converting the ton to kg you can easily find that n c = 1,000 Q / G obviously it is a very simple one.

Then you know that your rate this means the time interval between two carriers if that many numbers n c number of carriers have taken the material in one hour then between two your carrier how much will be the time required. If you know that time you can find out that when you will be that is your clipping the bucket on to that rope what will be depending on the speed of the rope you know now that means a distance between two carrier will be this much.

So, this means that distance should be such a way that when you are connecting and disconnecting them that with that personal will be working or the mechanical when we will be fitting that time will be there. So, this gave if you are to carry say 100 ton per hour at a speed of say your 2 or 3 meter per seconds speed if it is moving then you can find out for a distance of say for about your 500 meter how many number of your carriers will be required.

Once you find that then you can find out if the cost of one carrier is this much then total how much money you will have to do as a capital investment. So, basically from the simple relationship you can do some of the planning operation. So, distance between two carrier is depending on that velocity and this time you have find out so you know that during this time how much it will go and you can find out that what will be the distance between this.

Now here certain things will have to be known that normally if it is more than 3 meter per second at the time of your receiving station and also at the time of when you are unloading there could be a problem. So, that we will have to be seen that what mechanism has been put to open a lace and then taking the material out or at the time of filling the bucket that is what type of arrangements you are making at the loading stations.

So, that during in the loading station these bucket so its capacity is that your Q kg capacity of the bucket that means if you are loading you have open the chute that bucket is getting loaded. Now by that time the rope is continuously moving so your chute from which the material is falling into the bucket of your aerial ropeway that time how the rope is moving over there within that speed the bucket will have to be filled.

If you make it more than 3 meter per second speed then when the bucket will have to be filled that time which is the time during which the bucket will be under the feeding chute your bucket may not get fully filled that is why you will have to match these things so that is why we need to do this calculation.

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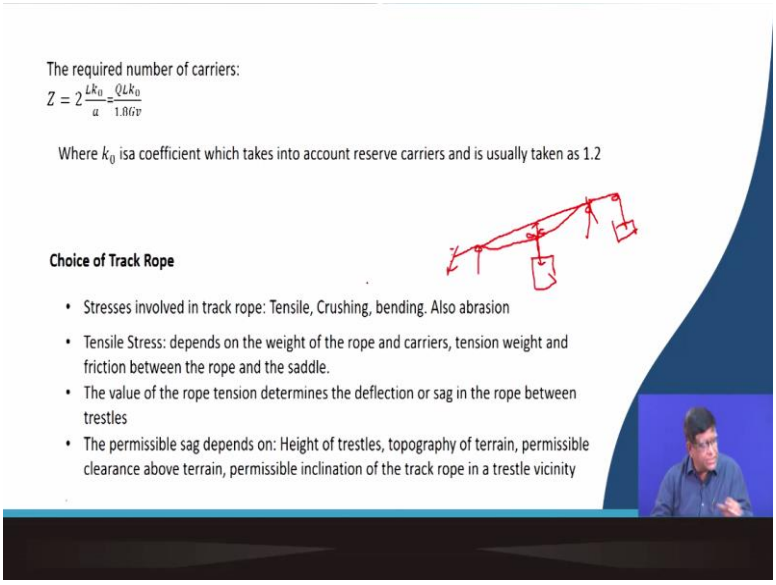

Now the required number of carriers for a given capacity it can be (()) (18:29) so that is these are the main parameters that is your how many number of carriers what will be the speed, what will be their capacity and what will be the throughput capacity very simple you can do number of permutations and combinations of problem you can define yourself and you can do it.

Now when you say in a bicable system there is the track rope that means on the trestle if you remember that we were discussing earlier that if you are in a aerial ropeway system we are having there will be your trestle on the trestle we are having this say maybe this trestle maybe of any time it can be any structures and here you are having this structures are there and then this rope is going over here maybe your this rope on which exactly you are having a wheel or this wheel could be on a two wheel are there.

It will be moving over here because there will be a carrier is hanged over here on which this material is placed and another cable here which is getting locked that is your clipped over here and these rope is exactly will be this is a moving in this direction carrying this whole material which has been placed over here this material will be carried in this way, but here this is your track rope.

Now this track rope which is normally a lock coil rope there you will be having this you will have to have this rope systems the track rope at what point it will have to be supported so that the track rope do not get slacked. Sometimes in some of the terrain your two track ropes maybe quite at a distance when you keep the load if there are three, four buckets of carrying load is there then they may come down below there.

And if something is moving it may heat and if that rope becomes weaker and sometimes it has elongated then it started getting elongated means that sag will be more than the bucket will be coming down near to the ground. So, that type of problem maybe there and that is why how the track rope will be mounted at what gap it will be kept those things need to be taken care.

So, now there this track rope on which this your carrier is moving it will be subjected to tensile, crushing and bending stresses and also that when this your wheel will be moving over there, there will be always a abrasion. So, your material from which this wire ropes will be made also is a very important thing how exactly it is lubricated is an important thing so that the abrasion and wear can be minimized.

Now this tensile stress that will depend on the weight of the rope and the carrier that is how much the total rope by its own weight also will be having it and (()) (22:14) then if your one end is anchored and the other one you may give a tension so if the tensioning load is more than only the track rope will be in a that is a tough condition then the value of the rope tension determines the deflection or sag on the rope.

And the permissible sag that will depend on the height of the trestle, your topography, terrain and permissible clearance for the track and that you need to look into. So, that means what is happening if you are having this is your track rope you are mounting say for here you are

mounting it then in somewhere you will be giving it is an anchored over here and the other side where it is mounted over here there it can be given a tensioning arrangement some load is there.

So, now you can see it is taught. Now in case your some it could be there then when you are hanging some load on it then this truck maybe coming in this form because of the load it has come down and this amount which has come down here that is called your sag. So, now here because of the load then there will be your tensile strength that is the rope will be getting elongated at the same time because of the pressure on it on the rope also a compressive stress also will be coming.

Now as because this load which will be travelling over here on a wheel because this load is supported on this whole load box is coming on this wheel so that wheel will be moving on this track rope so that is why your abrasions also will be coming in. So, that is why what is important here is to see that this system properly works.

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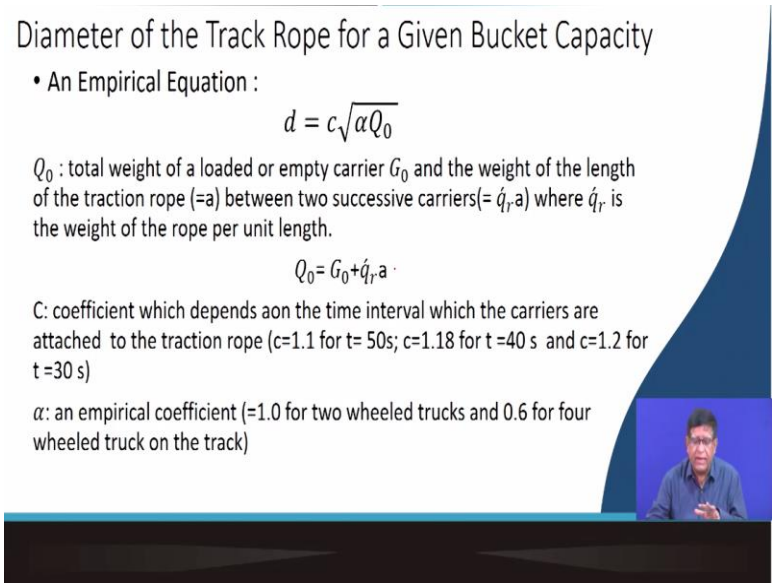

We will have to find out that what should be the diameter of the track rope for a given bucket capacity and for that this empirical equation you should note down that is the total weight of the loaded empty carrier if it is known and then if that your total weight of this length of the traction rope is known and then you can find out that what is the weight of the rope, total weight of the rope is that your Q R and if you find that is exactly total weight = length multiplied by the rope the total per unit length what is the rope?

Normally, whenever you go for procuring any wire rope you will find that the wire rope specification is kg per meter that means depending on the type of material which is selected that is a galvanized iron ore it is your core is also a steel or core is metal made of fabric depending on that rope we will be having a different specifications and this coefficient it depends on the time interval on which this carriers are attached to this because depending on the time interval as I have said earlier the distance between two carrier will be coming.

And depending on the distance between these two that how the rope will be loaded will be coming and then how the sag will be coming that will be depending on this. So, this time interval and that is said that this coefficient if the time interval is within 50 second it is 1.1 and then when this time interval is more like 30 second your increase up to 1.2 and that is your alpha that coefficient is given for your whether this whole carrier is supported on two wheels or it can be on one wheel there could be various design on that this depends.

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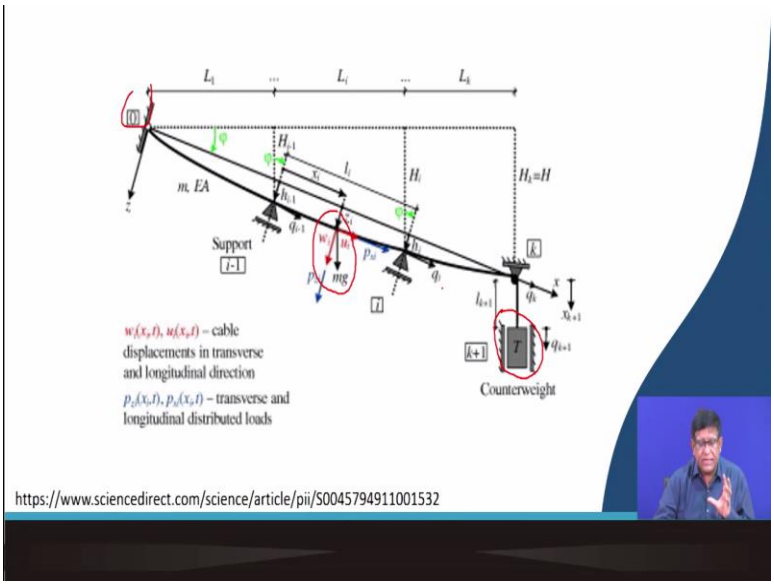

Now, you can see here in this you can practice that when you are having this you are supporting this wire rope between two trestles then this you are having these trestles are coming and at this portion you are having this load. When this load is coming at the time you can see here this total length the distance which is there it can be into number of components and there whatever the counter weight we will be giving this is for your giving the tension over here and you have kept it here anchored.

So, that in a rope system this is a basic concept and you can develop a mechanical model you can find out how this load will be working.

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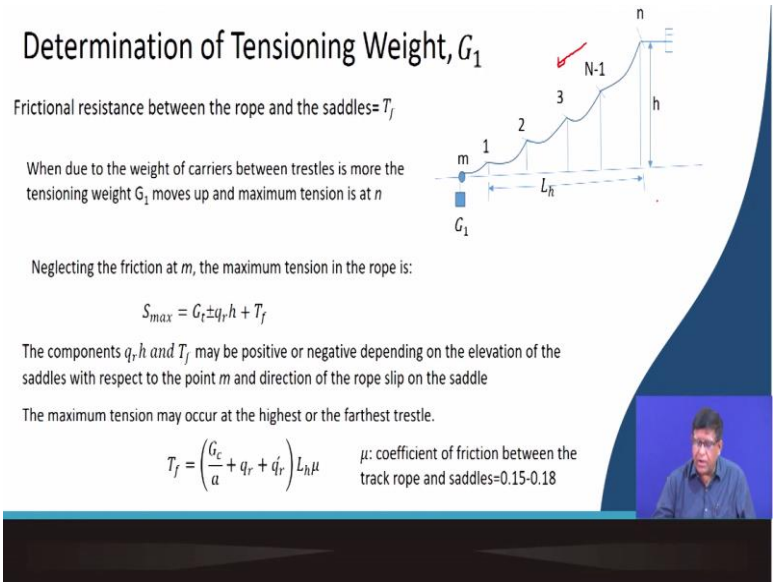

So, for example, we need to determine what will be that is your tensioning and then what will be the weight over here. You can see number of trestles could be there that it is giving a tensioning arrangements here so what tensioning weight will be necessary will be depending on how much weight are being carried over this while you are lifting that or you transport that whole part it can be at a distance of L h and it is going a height over here.

So, the maximum tension in the rope will be coming because of the there will be a frictional resistance with the rope and the saddle that saddle on the wheel where it will be moving that frictional resistance will have to be overcome then due to the weight of the carriers there will be your tensioning weight will be coming over here and that is your maximum tension of this one will be at this end this rope will be having your maximum tensions.

Now, if you neglect the friction at n this point of friction is neglected the total tension maximum tension at this point will be your total tension that is your total rope has got a weight that is your qr h and that frictional resistance. This total together give here the maximum tension which will be coming over here. Now, you can do a little bit of calculations over here.

This qr h and the T f they may be if your directions in which you are moving you are travelling in this directions or you are taking the material up there so this tension force will be different. Now the maximum tension will be occurring at the farthest trestles here and you

can calculate by this where this coefficient of friction between the rope and saddles for your calculations you can keep it as a 0.15 to 0.18.

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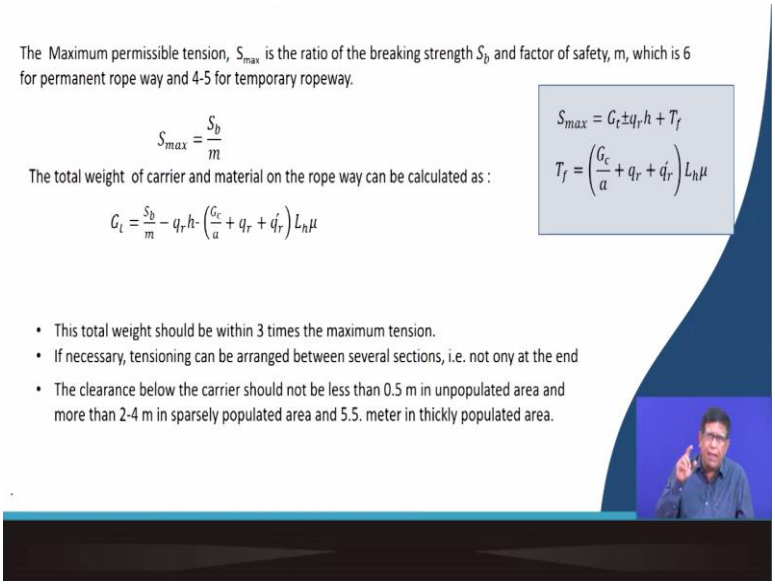

So, the maximum permissible tension that is the ratio of the breaking strength and the factor of safety. Once you find out that is what should be the breaking strength where rope is very important because if your load is putting more and then your rope you have selected less than that of rope will get snapped or it will break. The total weight of carrier that material on the rope that can be calculated from this because you know the factor of safety is kept as m.

Then your distension will be just subtract that other load what it is coming you are getting calculating this thing. So, you know that your maximum tension is this value and your frictional that is your tension which is coming friction force you are getting so from there you can find out the total weight that the carrier can be there on your aerial ropeway will be. So, this total weight normally it should be within 3 times the maximum tension that is a thumb rule you should follow.

And if necessary tensioning can be arranged between several sections not at the end and in between also you can give some tensioning arrangement so that you are using a band pulley with your things engineering can be carried out that how you will be giving a tension between two trestles and clearance below the carrier should not be less than 0.5 meter in a unpopulated area that is exactly that below here this if you are having a material you are being carried out in this wire rope.

Then while carrying this between 1 and 2 or between your say 3 and n – 1 number of trestle they if the area on the ground level it could be highly populated, thickly populated, thinly populated depending on that your clearance is defined by statutory regulations.

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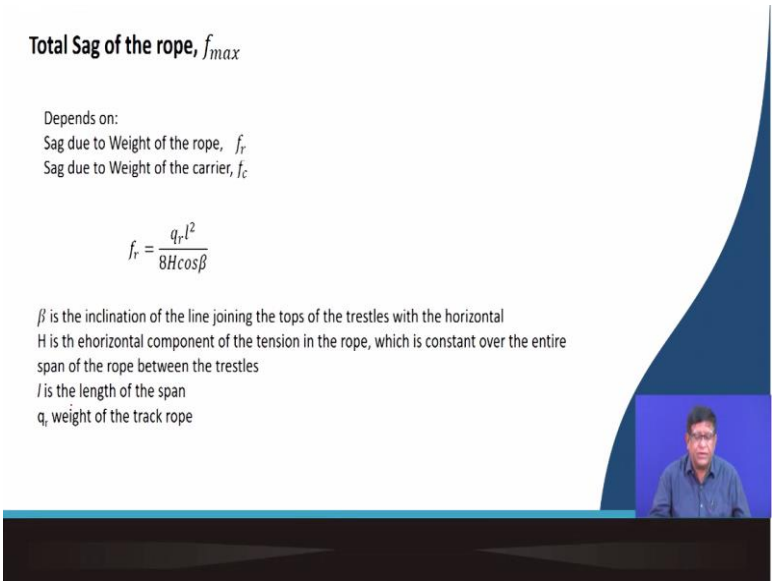

And then another important thing is to total sag on the rope that need to be calculated and this sag will be depending on what is the weight of the rope itself and then due to the weight of the carrier that is how much material is there in the bucket or the carrier and this weight due to the rope it will be depending on that what is the total length and what angle it is carrying that is your rope is making what type of angle that determines the things over here.

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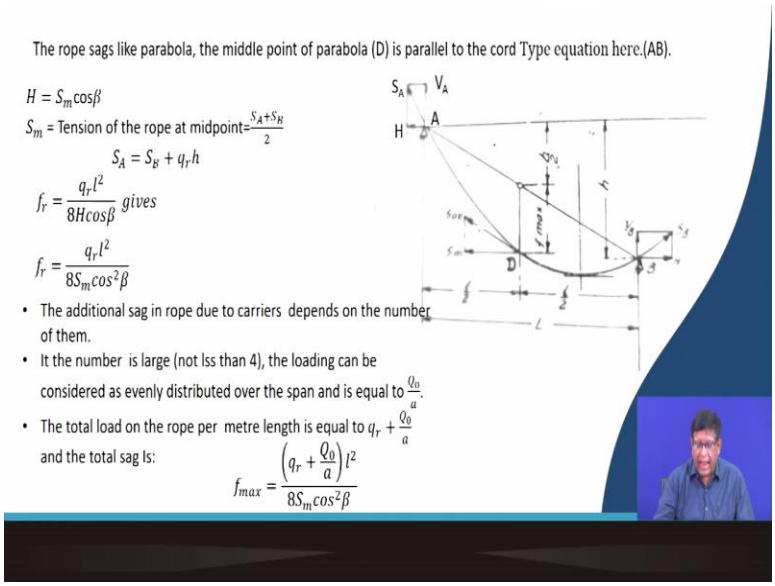

As you can see here that if we this point here if you resolve that is your it has got a horizontal component of the tension, a vertical component of the tensions and this is your tension at that

point similarly at (()) (32:54) if where that your central point that is a middle point this whole it will form a catenary part and this one can be called as a parabolic at the middle point where the maximum sag will be there.

Here this you can find that your tension will be parallel to this cord line and when you resolve this tension into horizontal and vertical component and from there you can find out this calculations as a tension of the wire rope at the middle point will be average of these two tension S A + S B / 2 and you can also say that as because the rope is having that is your weight is q r.

And then as because it is raised up to here that is the total potential energy spend on it that will be coming as a tension that is why your S A will be equal to S B + this total rope tension it is coming and from there you can find out that what is this f r coming equal to depending on the parameters you can easily calculate this for a given situation from this you can find out that what is the total frictional and what is the total tension coming on to this.

So, the total load on the rope that per meter length it can be find out and then the total sag that is your that how that wire rope will be getting sagged that is the maximum sag at the point it is f max can be calculated like this equation. So, in a aerial ropeway this sag is a very, very important things and that can be calculated over there.

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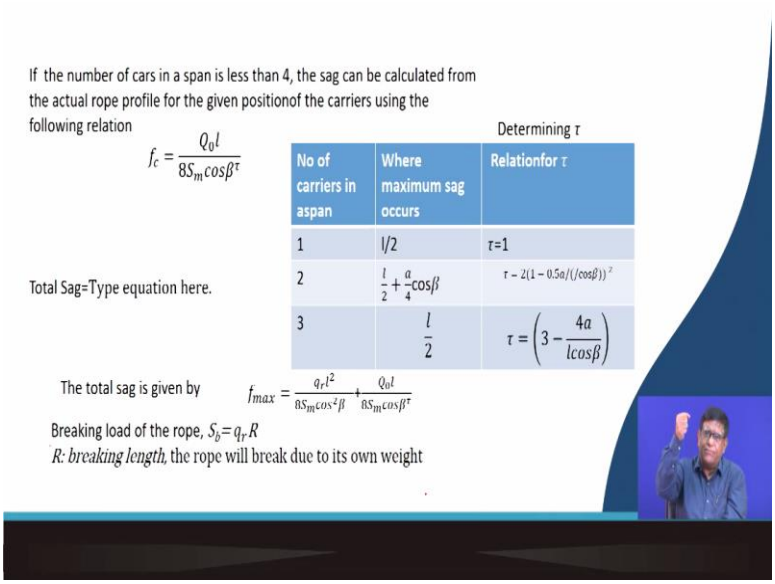

And then normally the number of carriers that is your number of carriers within a span that is your between two trestles if you are having your only one carrier than the maximum sag will

be the in the middle. If there is 3 than also it will be coming in the middle, but if there is a 2 that is depending on that sag will be making what angle that means your rope is from one trestle and then this is another trestle there you are having a slope that slope angle is beta.

And depending on that you can find out where will be your maximum sag coming and then you can total sag can be calculated from the rope parameters by this. Now once you know this sag at that time the rope will have to be competent enough that will be depending on what is the breaking load of this. Now, if every rope has got a breaking length if a rope is there if you hang it and because of its all weight that rope will be breaking that when you suspend from a point if that rope break by itself that length is called R.

That your breaking load it can be calculated is the relations from the total weight of the rope into the length it is equal to the breaking strength.

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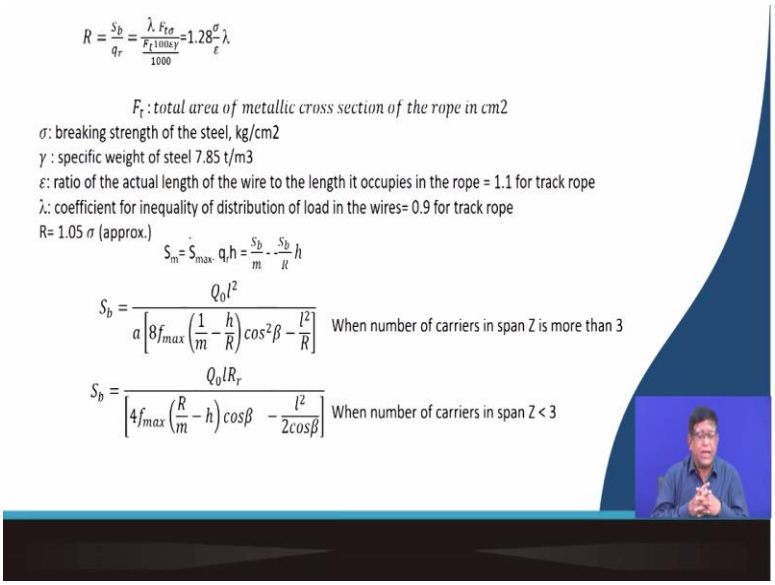

Once you know the breaking strength from there you can exactly calculate the total how the sag will be there this is an equation for finding out the total area of the metallic cross sections of the rope if you find that from there you can find out what will be the diameter of the rope. So, after you calculate this points and then you combine together you will be finding out what is that exactly the maximum sag coming.

And then your that is if the number of carrier is more than between more than 3 then the sag can be given by this equations given over here and if between the span that is between two trestles if you are keeping that less than 3 that means 2 or 1 carrier only between one trestles

than your maximum sag will be coming over here. Now why I have said here is that sag is very, very important for different regions particularly for how much clearance will have to be given.

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So, to conclude here that means aerial ropeway calculations basically you need to find determine what is the wire rope diameter and then what will be the sag coming and then once you know these things then you can calculate out that what is the total resistance coming and once you know the total resistance to overcome that at a particular speed if your total resistance is say t and if it is moving at a speed v that tv that is your effective tension into velocity is the power.

And that power will be required that will be the power of the driving motor and if the motor has got an efficiency say for eta that your total resistance multiplied by velocity divided by the efficiency with the motor will give you what will be the motor power which we have said as a basic equation for calculating the drive power for any material handling system whether it is a conveyor belt whether it is a rope haulage whether it is any other form of transportation system.

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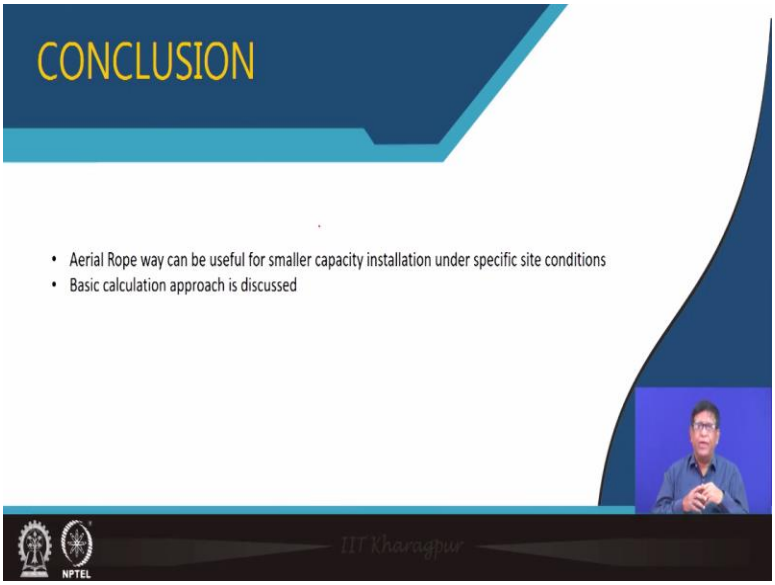

So, we have just very briefly discussed about that what is that installations and what type of calculation it is required and that only a basic calculation form is introduced here. I hope that you will be studying the aerial ropeway and try to find out that how you can create a small problem think of that from your wheel to say five storey building roof top you want to take carry water in a bucket by an aerial ropeway.

Then what should be the type of rope you will have to use and then what is the resistance to be overcome and if you use a particular given rope that it will be sagging this type of calculations while sitting at home you can find out and you can create some you can imagine some of the engineering and once you do that is you can find out how your bulk material handling ropeway can be rate.

So, you think create a very small problem think of that in your neighborhood from the field if all these rice sag and things like that to be taken into your home instead of taking by a bullock cart if one can use aerial ropeway even for driving that aerial ropeway the bulls can be used even in close things they will be just moving and then like it is similar to use your bulls for taking sugarcane juice that is in such type of system you can use for transporting the things.

You can think of how the sugarcane cultivator can take all the sugarcanes collected and cut in the field from there they want to take it to the place where there are exactly taking up the juice so many a times they are taking the tractor, tractor is moving in different places and

over there can you think of that if you can use aerial ropeway for a vast field and then many number of people can exactly load over there.

And how a portable and different types of systems can be thought of which will be giving exactly your cost of diesel, cost of your tires and cost of the driver and then maintenance of the tractor for transporting the sugarcane you can calculate it out even a system can be developed by aerial ropeway for transportation of those sugarcane or the whenever waste is to be there then how it will be taken to different places. Many things can be thought of as a bulk material handling problem and it can be designed. Thank you very much.