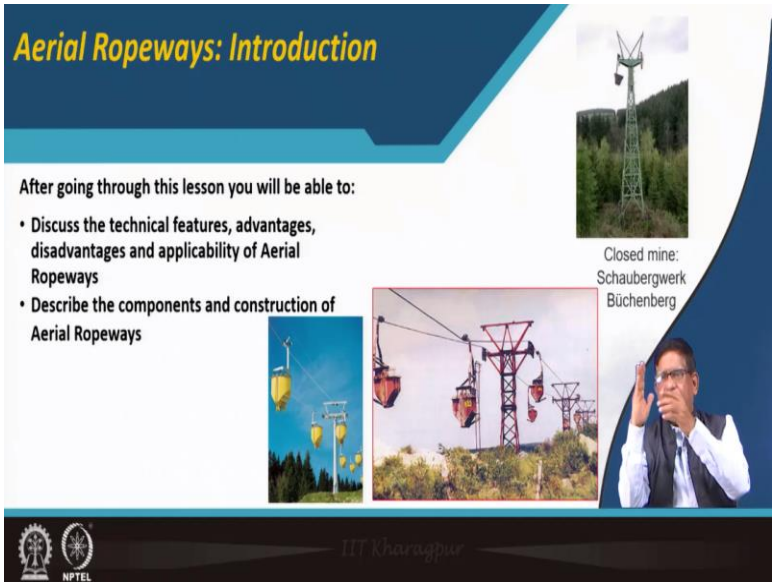
Bulk Material Transport and Handling Systems
Prof. Khanindra Pathak
Department of Mining Engineering
Indian Institute of Technology – Kharagpur

Lecture – 43
Aerial Ropeways: Introduction

So welcome back to this discussion. In the last class we were talking about RopeCon and in the RopeCon we were telling you about how on my rope a conveyor belt is moving then there I was telling that this not just a development of one day that before that there were various way of using ropes and one of the old technology which is there in the bulk material handling as well as for some other transportation is aerial ropeways. Today, we will be discussing about this aerial ropeways.

(Refer Slide Time: 01:00)



Now after this lecture I hope you will be able to discuss the technical features, the advantages and disadvantages and applicability of aerial ropeways. Now, here we will be telling about some of the components of this construction of aerial ropeways maybe the calculation part will club together in some later lectures we will be doing some of the basic design calculations which were there in the first that when these type of systems were first coming into.

In the early 1940s, 1950s, 1960s this was one of the very popular mode of transportation. Today, in many places this maybe not suitable because of the carrying capacity that as such in the aerial ropeway forms that the original form it is not there, but the ropeways concepts

they are going to be more used as we have said in the RopeCon in 2020, 2021 new installations are coming up.

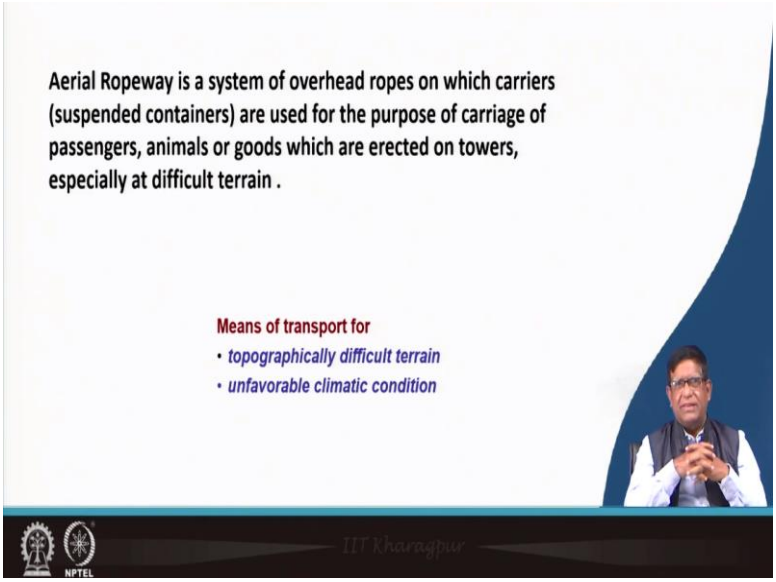
But in some of the places because these are a very simple technology, nothing to be imported and all it can be locally fabricated and can be done in some of the material handling issues, for example, in some of sand mining cases, in some of hilly terrain sand mining applications there this particular system still could be relevant if we properly observe it and study its technique economic feasibility.

Now coming to this now as this picture show here that one of the in the 1970s this mines were almost getting closed there were one German mines they were using this aerial ropeways. Such type of systems were that is your on mono cable one uncable this packet is hang over here and the bulk material is fed into this and also that container can be of different type depending on the design.

Depending on the convenient this figure show that what exactly aerial ropeway is the material is hang from the rope in the air and through air it is getting transported. Basic thing is you are having this trestles on the trestles are the ships on the ships this rope moves, rope are exactly at the end we have got a horizontal shift on this rope when it will go into the end that is a (()) (03:55) on a horizontal it is parallel to the land and there the rope takes a turn and it is there.

So, at the end how your empty will be placed and then how the material will be recharged and how the material will be loaded those are the technologies which we will be looking into.

(Refer Slide Time: 04:20)



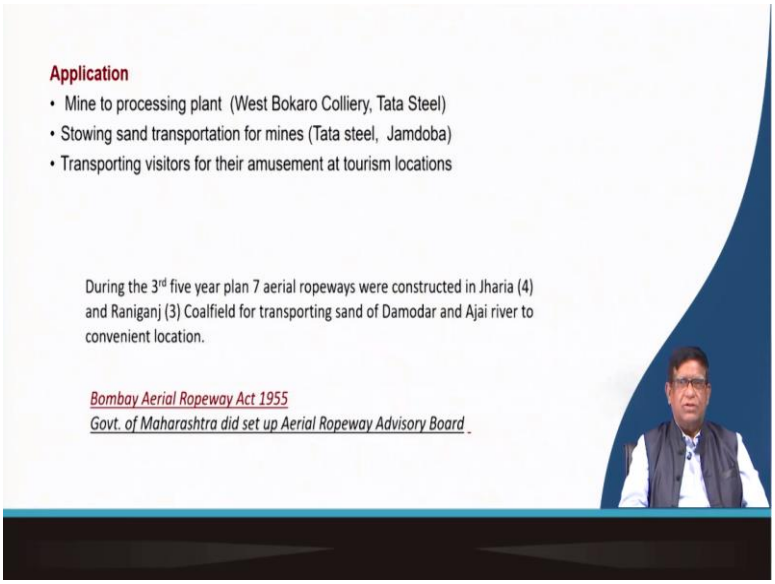
What is a aerial ropeway system we can say it is a overhead ropes on which carriers are that is carrier is a suspended containers and they can be used for different purposes. In some places they were used also for transporting animals say for crossing rivers and all there were the horses and ships they were also transported by aerial ropeways in the past. The history of aerial ropeways is about more than 2,000 year.

It has been used in different civilization in different form because it is there and then (()) (04:59) horse power in true sense that is hold the driving power or given by horse they were rotating the ship and things were there. So, aerial ropeways are also used for bringing water collecting water in some of the regions in different way in the past in the history it was used, but still it is relevant in topographically difficult terrain.

You can use it and then where there is a unfavorable climatic condition for your movement of your trucks and then conveyor belts and all in that case also this is a good only the disadvantage you will find here the capacity is limited container and also there is a chance of if you are going over carrying over there on a hanging if there (()) (05:48) and then people are going on the roads are there.

You will have to protect with some means so that it does not hit and does not lie on the people.

(Refer Slide Time: 05:58)



So, where it can be used and in India as I said there are example of your mine to the processing plant and that is exactly in the West Bokaro Colliery from the mine the things were carried over there to the coal washery as also that for taking the sand from the river sand were carried to the underground mines for stowing purposes this is there a practice which were done in India.

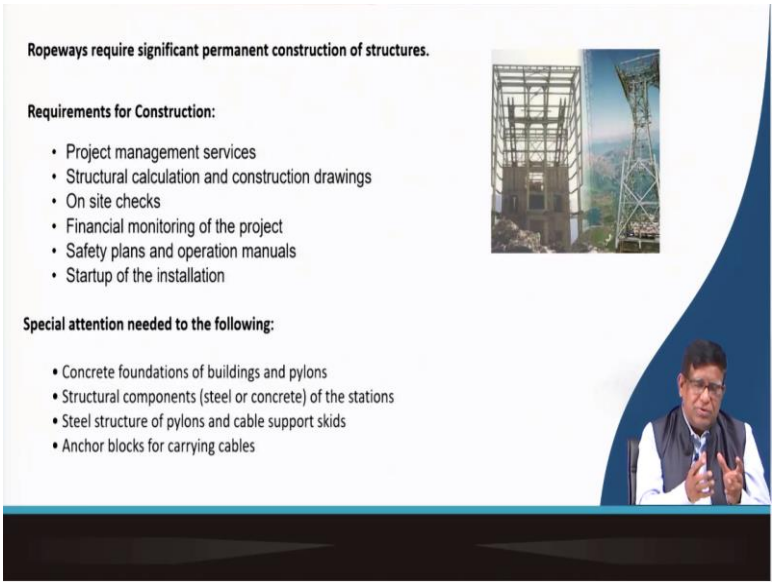
Then the sand stowing in many of that exactly Tata Steel they were (()) (06:39) using these things in the early 40s, 50s, 60s if these were working in our mines then there also can be used in sometimes for the aerial ropeways or for that your human transport I told you in Rajgir, our many of the museums and all they have got this system so they apply in a different way.

Now in India even our third five year plan in the 1955, 1960 during that time it was exactly a technology in those days it was considered that bringing this was the introduction of technology it came and that is why there were regulations were also moved there in DGMS Mines Act once regulations also you find that what are the things to be done and then Bombay Aerial Ropeway Act of 1955 were there where the government of Maharashtra they created even Aerial Ropeway Advisory Board.

So, historically also there is things and now it maybe there many of those have got closed, but thing is that they were whether in some places this can still be used where definitely sometimes some of the trestles and all that things can be developed very easily, locally so

without investing much on the truck and the fuel that is on the diesel it could be possible to have this type of system.

(Refer Slide Time: 08:25)



Now one thing is there, there will have to be when we go for designing such systems as they said that it is one of the major advantages. It can be made your installation commission constructions can be done at a very low cost, but the disadvantage is it cannot carry a huge quantity, but the advantage is it can work on any terrain over any terrain it can go where there is a river then hills it can be taken.

And also sometimes when you are taking from a higher elevation to a lower elevations you do not require any energy also by which itself it will flow only the empty low energy input will be required to raising them, but when you are going to construct then you will have to systematically determine what are the basic requirements that will be coming in constructing or designing this.

So, basically what will be there the project management services that where you want to carry out that project you will take as a project concept that how you will be investing, how your work organization will be there, how exactly the people will be keeping track of the progress means how you will be monitoring that whole project management things come over there. There also you can see that say if in a local market if your rivers and these obstacles and then there is a big agriculture field beyond that river that side the people and village roads are still not developed and that is a car and all they do not come.

And then within a short period you need to collect the whole things over there and in that cases if the quantity of that material is much could be just developing aerial ropeway people can bring it over there options are there. So, that what you need to do the structural calculation and constructions that drawing will have to be made. This is a civil engineering job again that is when you are giving such type of structures on which it will be coming, what type of building and all enclosure it will be there.

There exactly the safety is the important aspects if your design is not withstanding over the whole lifecycle then there could be that whole purpose may get deferred. So, that is why whenever you want to do or think that whether it is their feasible or not need to be seen by onsite (()) (11:06). You will have to see the site, such type of thing if you want to do whether aerial ropeway will be suitable for transporting some material from a particular mines or not.

Maybe where there will be some queries they are having they are producing stones say 50,000, 60,000 tons per month if they are taking it out. Now with their heavy weights and things like that to get trucks into those terrain conditions and all if it is the tire puncture and tire problems may be prohibitive getting this that diesel may be prohibitive there are so many things.

So, in that case if you can think of having that your this ropeways it could be suitable, but for that what we will have to do first you will have to study the terrain. So, there exactly in the mining engineering you learned called digital terrain model by using all the satellite imagery remote sensing will be developing the digital terrain models see the elevations and then what type of route can be there for this aerial ropeway.

Once this route is finalized then you will be finding that what type of this structures will be there because depending on the load, carrying capacity and others you will be determining the strength and the sizes of the tower and also you will be determining that your how much exactly you will have to give the gap between two towers depending on the load all those things come under your design calculations which we will be seeing.

But that another important thing you are taking up is a project for this transportation project how you will do the financial monitoring that means that your whole when you are running this whole system with a power and then you have given that how many cars or how many

exactly container can be added to it, how much its capacity to take over load and then how much it is exactly when by sending some amount of things will become it is going running under loaded at what conditions it will be very your energy efficiency will go down.

So, those study those monitoring of the technical monitoring for financial analysis is also an important then you will have to operate it safely. So what are the things that need to be monitored that some of the structural integrities, some of your drive motor power and then whether this ship their wear and tear whether they can create a damage a wire rope where in the rope get damaged and at a certain time you will have to replace it.

Otherwise if it just snaps then there could be jeopardizing the whole system. So, that safety plans and their operation manuals will have to be done and then after you have done the whole thing you commission how exactly will install that, how your first run will be given so all this things it is exactly a project that this project to divide it into the groups then what are the mechanical engineering part, what is the electrical engineering part, what is the financial part and how overall management will be done.

And while doing this erecting the whole system how much time it will require those things are done when you are thinking of a transportation project to take up it a particular system. As because this is a very simple system there it is very good for taking your academic exercise. You can think of say, for example, you want to have your aerial ropeway in any construction site for taking out you might have seen in many places. ‘

There are in a very high storey buildings are being made and for cement, slurry and all that thing in many places only the human labour are taking them and putting over there in some of the cases how it can be done faster and by putting there are many places where materials are to be transported in a very small by putting a small distance some certain degree of elevation level aerial ropeways can be easily constructed.

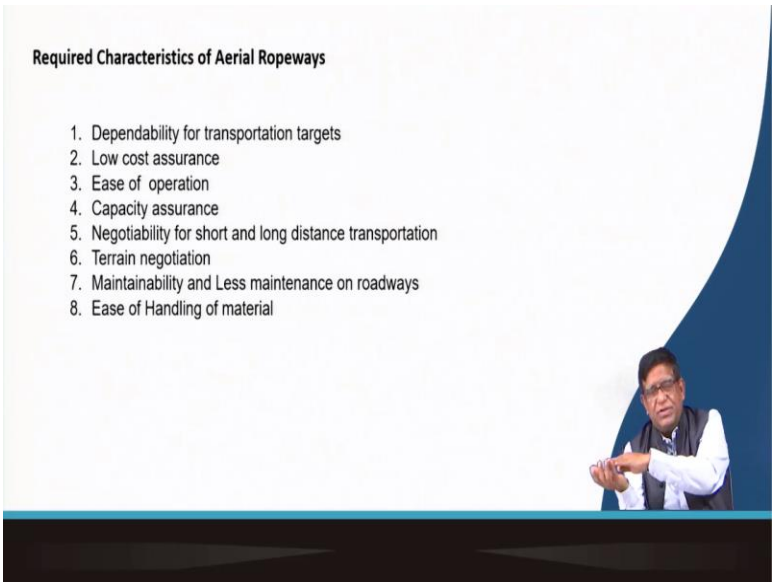
And then dismantle and that could be a good way of transporting because during the construction project few 1,000 tons of materials you will be transporting how it can be made. So, in that project also you can take it up, but their this requirements and then you will have to give some special attention that what are those exactly that is your when you are making your building for this aerial ropeway or you are making the trestles on which it will be there.

Whether their foundations are properly there or not if tilt, if it breaks then there will be a jeopardizing excellence is there then there is your when what type of you will have to select all the structural components their slight distress and columns that latest structures which are coming in that, that will have to be resided that steel structures on which the whole cable will be supported that she will be there.

What should be exactly the type of bearing which will have to be there so it is a very important thing because if the ship do not rotate then there will be lot of rubbing on to the wire rope and then wires that strength may come out and that will be giving a problem to the wire rope maybe failing. So, that is why whether you everywhere everything is okay working perfectly or not that you can do by installing sensors for monitoring it.

And then right from the noise to your vibrations and that your conditions of each and every item and that how it will be exactly health of the system will be considered that also will be done when you will be studying this transportation by aerial ropeway you want to develop as a project for a particular site.

(Refer Slide Time: 17:44)



So, then for that what exactly we will be looking for from the aerial ropeway if you want to use aerial ropeway our first thing is whether we can depend on it for the transportation target means transportation throughput means that how much per hour it will be able to carry. So, now when you install a particular rope and particular drive and particular things that how

many number of that container can be connected if you can connect more container that will be there.

So, that will be continuously moving the containers are moving, but each container is taking a batch of material when it will go to the dumping site receiving site it will receive and then it will carry and then it will be done then the next one will be coming. Now one particular container giving it over there then it is released and then next container will come and put it over there. This distance between these two they will be exactly affecting the capacity.

Maybe in our next class we will be calculating some of this how the capacity will be, how the hourly output can vary depending on the speed and depending on their spacing these things you will have to be calculated then you will have to because you have selected this because we told that it could be your cost benefit that it could be economic operation so you will have to ensure the low cost, low cost will be ensured only when your operational cost will be minimum.

That means you must not have many number of people to run it and operate it, you must not have a lot of energy required for that energy, wastage should not be there, it should not create lot of environmental relation that while mitigating your cost will be going up. So, this low cost to be assured by properly managing and maintaining the site then it should be having ease of operations.

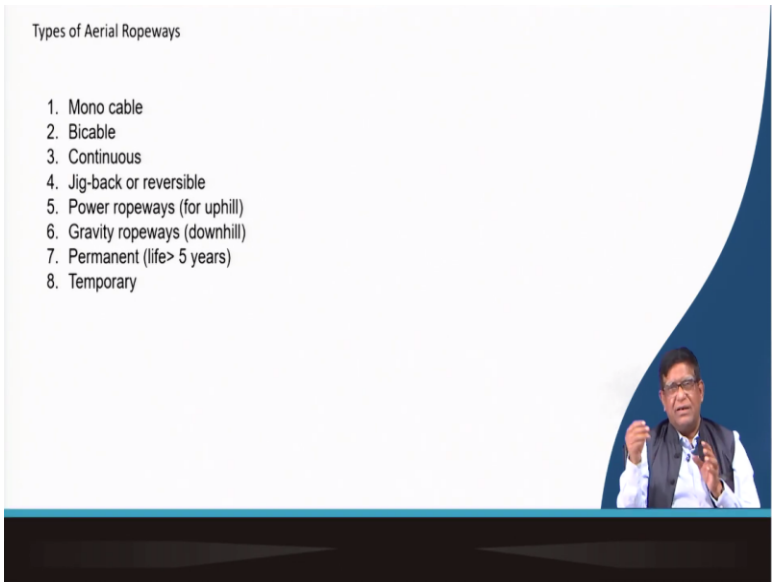
Any transportation system when you will select in this case for aerial ropeway because we have said it is a very simple technology so the operation is very easy in Nepal in rural area they are exactly from going from one hill to the next hill or villages and all they are using it over there because it is a very simple the village persons he is just only managing it then doing it, but that it is not that efficient, not that time efficient, but it does.

So, that ease of operation is one advantage over here and that the capacity assurance that when we say that capacity with reliability. There were many cases when the transportation of goods and man and all the things while crossing the river many accidents have taken place in the past people get suffer, but thing is that when we will have to give that assurance it will be when you have said here person can sit or two persons can go or two ton of material can go it must take that load then that is there.

Then negotiability is for short and long distance transportation. So, in the same system if it is to go for a longer distance means you will have to do the extensions that how it will be done, how you will negotiate that part is also important then it can negotiate the terrain conditions we already said then maintainability and less maintenance on the roadways. It should be maintainable well that for the maintenance you must not have a lot of critical services.

Lot of expertise should not be there and of course the material which we will be transporting over there you will have to handle that then at the receiving stations when the material is received to the container or when it is delivering from the container to the next user there you will have to do the handle. These handling how we will be receiving, how we will be discharging those points are also very important.

(Refer Slide Time: 21:45)



Now coming to this type of aerial ropeways there are many types. So, that is we say that first thing is a mono cable or bicable that is only one cable is there and on that you are hanging it is okay. In a bicable means your two cables are there and that your trolley or that material on which you are taking it may be having two axles and then just like on the rope this container will be sitting.

Just you think of a just a box with two axles and four wheels and it is standing on that rope as a grip and the rope is sticking and the whole material is going. So, that means two cables are being used then it will call the bicable then of course the continuous means whether it is

whole thing it is going continuously our characteristics all the time it will be continuing I am not stopping it.

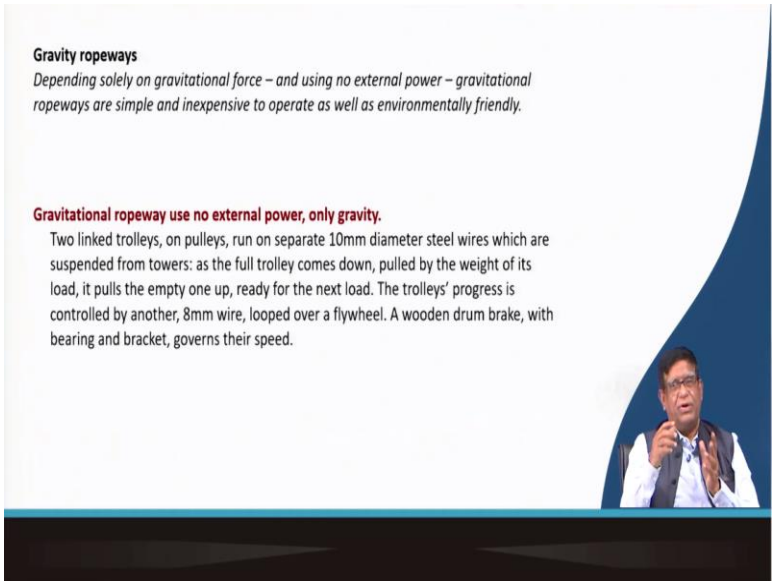
Only thing is that the container when it is coming and joining it is something like that all the time train is running you will just jump in and when you have to get down will jump out, but the rope will be going on continuously moving. So, there you will get the arrangements of that how your material loading will be done when it is moving and then or if it is a discontinuous means you will be loading and then again stop the belt and again we do and that is an intermittent type of operation.

Now jig back and reversible means jigging means while you are going down at that time your other end is coming up so that means when you are jigging means while going down that power itself you are bringing up without giving any other additional energy that type of jigging and then also in some times it is not there that your only rope is there it is just your material is going down.

Now the same rope the other container will be carrying up. So, this is exactly a reversible the same rope will be going up and down. Now there are power ropeways that is your rope will have to be given additional power and sometimes gravity ropeways means the rope will be having it will get each momentum because that load is there and it is by acceleration due to gravity it will be rotate and the material will be going down.

Only the empty will have to be now the power and take it up then if the life is more than five years you will say them as a permanent, but there could be many temporary one that means you have done a small job for say one month or two months you have done then dismantle we will go to the next location you do it over there.

(Refer Slide Time: 24:29)



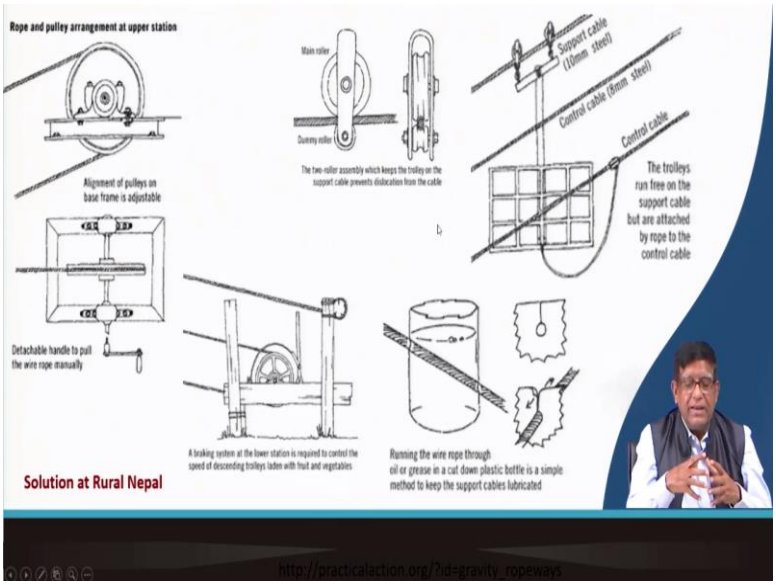
So, these are the different type of ropeways are there, but the gravity ropeways is one of the very common type that is you are depending solely on the gravitational force and using no external power gravitational ropeways are simple and inexpensive to operate as well as it is environmentally friendly because you are not burning any diesel so there is no diesel exist no problem.

But a gravitational ropeway use no external power only gravity. So, this is the thing you need to remember. Now there are many things let us say example how people have used the two linked trolleys on pulleys run on separate 10 millimeter diameter steel wires which are suspended from towers as a full trolley comes down pulled up by the weight on the load it pulls empty one up and ready for the next load that is how what I have said that is going down and other one is going up.

Now how much will be the sizes of it how it will be there that you need to calculate out depending on when you are giving how much force will be required to stop it over there that need to be whether it is manually it is possible or whether it will have to be done with electric motor or by some labour arrangements you will be applying the brake to stop it. Now there were wooden drum brake in the past.

Now there is lot of your that for governing the speed and then doing this and in the modern electrical system if it is going down then it will be generate that electricity will be generating and that will be giving the braking power those systems are also there.

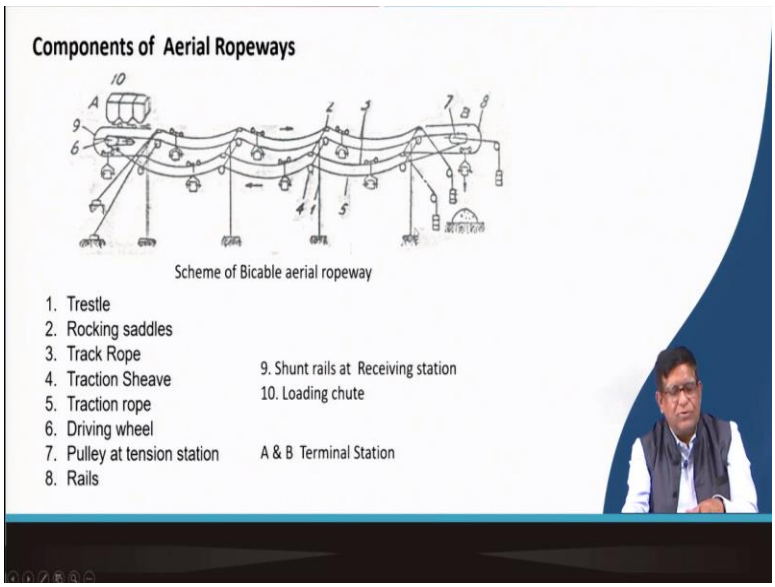
(Refer Slide Time: 26:15)



Now you can see here as a component in some of this one the rural Nepal they are using you are having a block on which this rope is moving over here and then they are giving a control cable by which they connect the container and all could be adding over there, how you keep the rope by having the grip all these things are there in a very simple manner you can do it this rope is being placed between this is the free to rotate, this is also free to rotate.

In between there is a group on the group this rope is going and then of course after sometime this will get wear and tear and all that thing then we will have to replace this your ship by that you are keeping the rope to move over there and this rope is mounted in some of these things only wooden frame is there to mount it over there.

(Refer Slide Time: 27:13)



And then once it started lowering down by the gravity it will go, but as a component of the aerial ropeway system for transportation of goods what is here you can see it carefully. There are number of trestles here on this trestles on this trestles your ships are mounted this round one you can see these are the ships which are mounted and then there is one aimless rope which is moving over here.

And then this rope exactly you can see it is having anchored that is your tension is by giving this (()) (27:58). Now there is a rocking saddles are there so this what is the job of this that means you are exactly the rope when it will be going up it will be just going like that it will be putting at the trestle side and then there is a track rope, track rope is on which it will be moving that means this rope you can see here your carrier it is suspended on these things as a grip it is there that this will be moving on this one.

So, it is supported over there and then there is a traction rope you can see here this is a traction rope which is connected over here. So, that means when this is pulling where these two wheels which are there at the top it is moving on the track rope. So, this is your traction rope this number 5 you can see it is the analyst this is the horizontal shift that your horizontal pulley and similarly there is another you are driving wheel or that pulley here this exactly horizontal shift it is rotating over there.

And in between this number 5 the traction rope is continuously moving and then your this at a 7 this pulley this traction rope also will have to be under tension. So, that is why this pulley is mounted and with some gravity weight you can put this rope under tension and then there is at the end side here you can see some this porton is rail see here where there is a traction rope it is coming and it is anchored giving that your tensioning weight here, but from here where the rope has done there is a rail. This 8 you can see this is a rail part.

Now when this trolley is having suspending this your container this container was loaded from this is your exactly a loading chute that all the material have been stored over here you open a gate and the material is fed. Now here in this end when this container will be loaded over here and then they are connected to the traction rope will pull that rope will pull it over when it comes over here the grip from the traction rope get disconnected.

And with that momentum this that upper the trolley this wheel it will get from the rope to the rail. When it is coming over here then at this point they will just triple that they will heat over here a liver will happen and then the bucket will get opened up and they dumped the material over here and this empty bucket now will get connected to this and this one will go and moving over here and then this empty bucket when it is going over this rule again it will become positions to take the load over here.

Once the load is taken again it is there. So, on a continuous rope the material collections and dumping it is done cyclically. Now depending on let us say here gap between these two and the capacity of each container and this velocity these are the parameters from there you can find out what is the total throughput capacity model. Now that means before going to those calculations you need to know about how exactly it operates.

So, basically now component wise of the system you are clear that there is a container which is your carrier it is just like a small tub which has got a hanger and then the hanger is at the top on that is your trolley and that trolley it is exactly having a shift it is moving over a rope wire rope which is a fixed rope. Now that hanger on which this whole curve suspended at that time there is a grip.

Now there is another rope which is just continuously moving on that rope this will kept a grip because the rope is moving it is also moving like this and at that time at the top it is just having on rule we will be going and ruling over here. So, this is the way as we have seen in this figure that on your this is a fixed track rope on which it is there this two track ropes would get seize they trenched over here and there ends are connected to the rails.

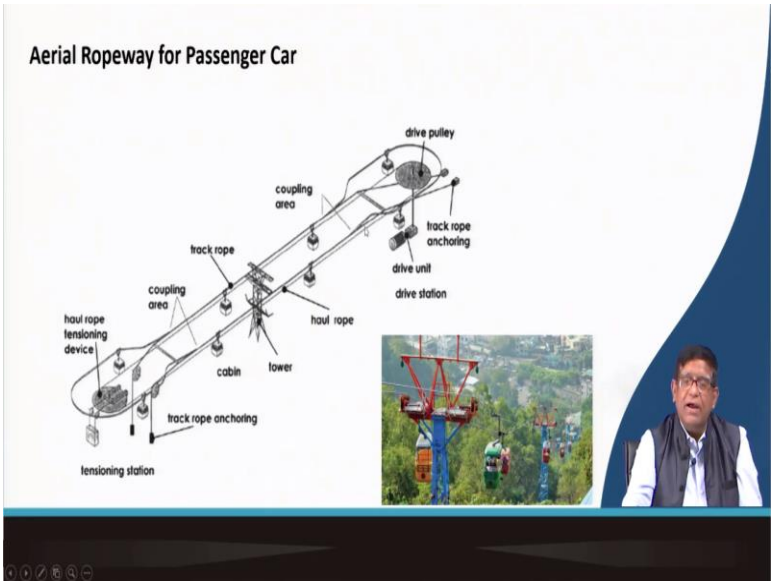
This bucket get loaded over here in the loading station and then the bucket grow up to the unloading stations when it gets it get over there and with the same rope after unloading it get again connected to the traction rope and it is taken. So, I hope now you have understood that what is the components. Now the same system is there when you go to Rajgir or Nalanda or any site.

(Refer Slide Time: 33:40)

That means how the material is loaded you can see over here the very old one it is about 14, 15 century that drawing the material is coming over here and then this bucket it is getting loaded over here and then this loaded bucket will be coming up to here and then this ship is rotated so that this rope will be now taking this material will go out and then as a modern you can see that how this is the trolley I was telling.

And this is your here it does not have a second cable say here it is a bicable two cables are there it is traction cable and the track. Now here what is there from here itself you are taking the grip the rope can pull them out that is the whole rope will be pulley and the whole material will be going up to the end stations. In the end stations they will be giving a hinge will be waiting over here this bucket will get topple and you can do it in a mono cable way it is taken over here.

(Refer Slide Time: 34:47)



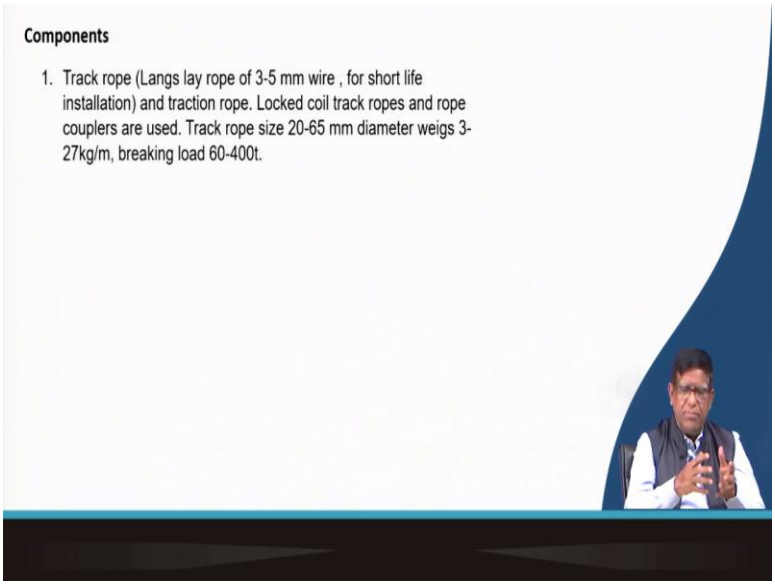
Now in a passenger car now when you go the you might have seen here this type of your places where people are going from the level to that it is going to upper level such type of your man riding aerial ropeway are available in many hill resource skiing area and then tourist places they may have over here. Now here also the same thing the rope it is taking over here at the end station there is a track over here.

Now the people you can see that rope it is getting anchored over here the track rope and the carrying rope it will be going on carrying over here at the bottom that you can see that this is a ship on that ship that smaller you can see that this carrying rope is connecting over here it is going and this is another horizontal pulley. So, that this pulley is driven and there is another this pulley at the end terminals it is kept under tension.

So, that this traction rope it will be always under stations and there that cabin on which the people can come and ride while this is coming over here it will be slowly going on these things and you might have seen when it is just going very slowly you jump in and got it over here and then when it is coming over here than it get caught by the traction rope and then the speed goes up.

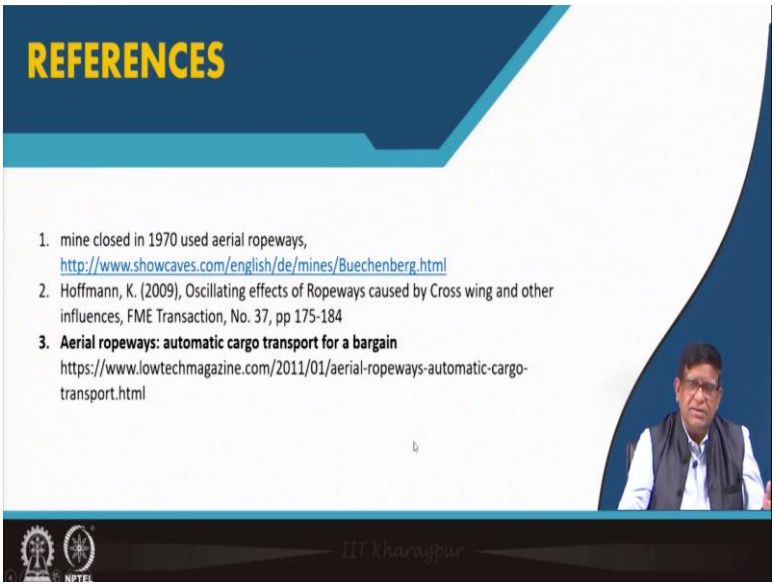
So, this system many of you might have enjoyed such trip, but by now you should be able to draw and then how much power will be required to drive such systems that calculations we will have to do.

(Refer Slide Time: 36:30)



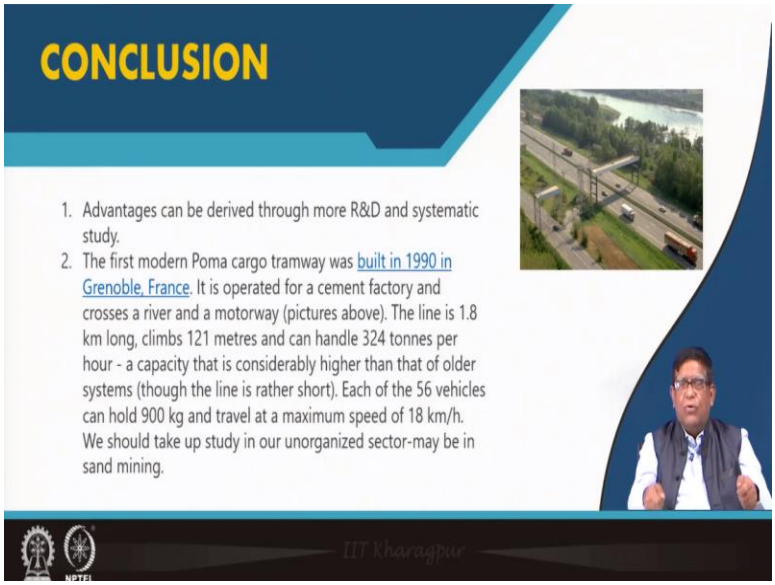
So, there are various type of you can go and finding out what are the existing dimensions of it because if this dimensions go more than the energy requirement and all those will be coming under your general calculations. So, as such this old technology it is still relevant and they may be useful in many places.

(Refer Slide Time: 37:00)



So, there are many references are there, history is there, but by (()) (37:06) mine transport book there is a very good chapter its numerical it is there.

(Refer Slide Time: 37:13)



And to conclude I will just say that these advantages in our system it can be brought, but we need to do a lot of research and then we need to do a analysis. We like to develop an analytical model of where it could be applicable. It can be merged this old technology can be merged with our modern systems and it can be economically useful in many places particularly this is having the most biggest advantage.

It can be environmentally friendly as because it can eliminate lot of dirty trucks running over this in your normal areas and then near the colony and all that thing by releasing lot of greenhouse gases and contributing to the global warming. So, though sometimes you may have to sacrifice the capacity, but there could be engineered way to doing it better, but ultimately of course the business propositions will have to be looked into.

So, already even in 90s these type of systems have come in France that is where you can see here under all the modern things are there these aerial ropeway is running this is crossing the road so that no spillage nothing takes place they may (()) (38:40) over here. The aerial ropeway is just crossing the road like this and it is going over here. So, it can cross the river and the motor way.

And it is done exactly 1.8 kilometer long it is travelling climbing up to 121 meter and it can handle 324 ton per weight that could be made little bit more, but they are doing it but while using this 324 ton per hour by this thing if it is to be done there would have been exactly quite a number that is your 12 tonner road tracks there would have been 56 trucks could have

been travelling over here and they are to bring the 324 because on your road on truck will be taking 12 ton only.

So, you need a more number of truck means more number of people involved, more number of diesel involved, more environmental problem so many things are there. So, ultimately we can do this particular technology depending on our situations wherever you are thinking of buying a truck for a business for your closed path you have got a fixed destination from here to there.

It will be taken if it is a captive mind if it is your captive steel plant that you are having your own iron ore and you are taking up to the plant that could be in many places it could be useful, but you need to study the calculation of the aerial ropeway that will lead you to do the calculations how we will be doing for RopeCon or the cable belt conveyor. Cable belt conveyor is also a part of using this rope.

So, we will be talking in our next class may be that with the calculations or before that we may talk about the whole rope business because now you know that is wire ropes are very, very important for RopeCon, for cable belt conveyor and also for aerial ropeway. So, that rope itself is also a very important factor and a proper manufacturing and properly using this rope as a machines also is a very important for the material handling and transportation.

You will be knowing in other places also that rope which is heart of this aerial ropeway is also for your in grab bucket type of collected that in the port you maybe requiring to keep a grab bucket that means again a crane type of things with the whole operated by road. Even a bucket will reclaimer the whole reclaimer will have to be worrying and hosting their operations also require rope.

So, we will be discussing the wire ropes also as a part of our this material transportations and handling components because in our next class maybe some calculations on our agile ropeway and then we will be going how rope is used as a haulage particularly in the mining industry underground mining this rope itself is used as a basic hauling equipment. So, with that I hope you have understood now what is aerial ropeway and how it can be used in our bulk material handling system. Thank you.