

Mining Machinery
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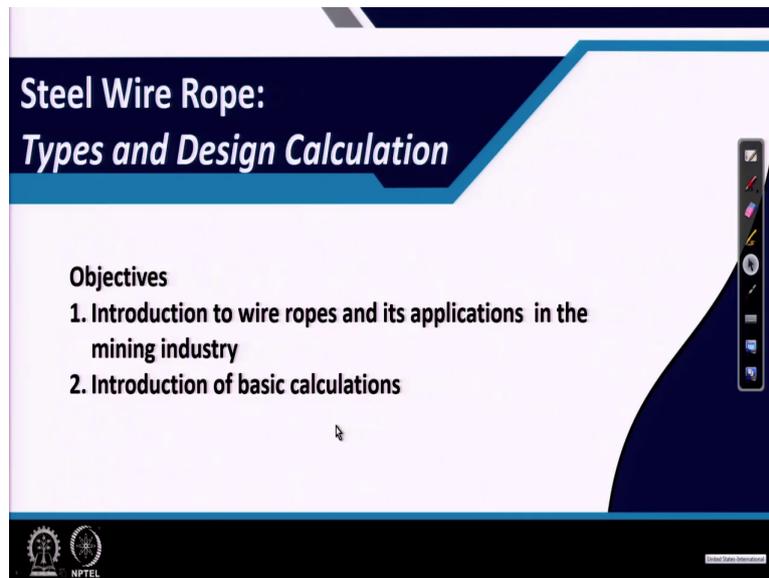
Module - 03
Lecture - 01
Steel Wire Rope: Types and Basic Calculation

Welcome to this class on Mining Machinery. Today we will be introducing one very important type of machinery that is Steel Wire Ropes. So, as such when we talk about this wire rope that is the rope a machine, but if we see that the basic principles on which the way the rope is used, it is a machine. We will discuss about this wire ropes and how it is there.

You may be reading some history of this wire ropes. Exactly the ropes are one of the very ancient applications, even something about 9000, 10000 BC people the human being used ropes for various purposes and over the years the ropes of different types have been used, but when we talk about the wire ropes, it is a metallic wire rope.

It started getting used from the 19th century and John Lang and Albert, such type of names are associated with this wire ropes who introduced this rope for mining operations for many purposes.

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Steel Wire Rope:
Types and Design Calculation

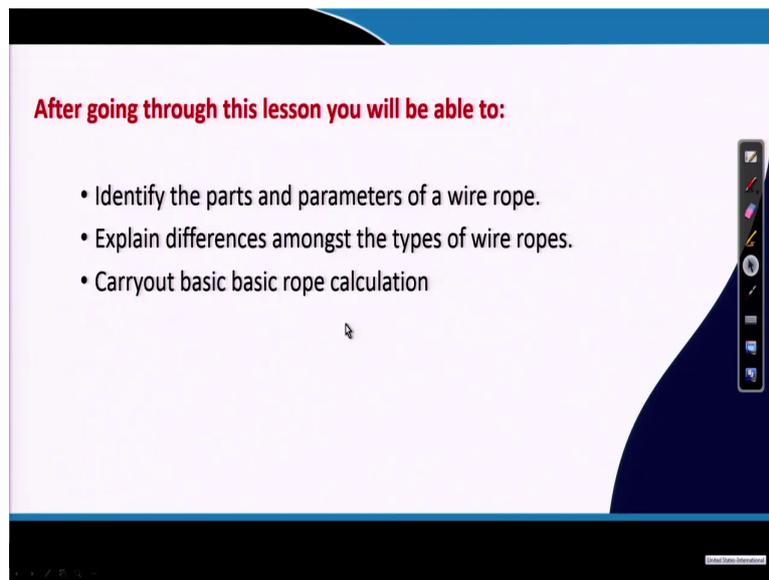
Objectives

1. Introduction to wire ropes and its applications in the mining industry
2. Introduction of basic calculations

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So, we will discuss about this wire rope and what it is. So, our objective of today's lecture is to introduce a wire ropes to you so that you understand that what is this rope is and how it is made of and also, we may if time permits, will be discussing about some of the basic calculations and, then we will be taking one more lecture on this regarding the calculations as well as for how the wire ropes are maintained in the mines.

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After going through this lesson you will be able to:

- Identify the parts and parameters of a wire rope.
- Explain differences amongst the types of wire ropes.
- Carryout basic basic rope calculation

So, this after this lesson you should be able to identify the parts of and parameters of wire ropes; that is what are the main design parameters for constructing a rope and, then also we will be able to explain the differences amongst these different types of rope and they are used for different purposes and some basic calculations we may introduce today.

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The slide features a white background with a blue header and footer. The title 'What is wire rope?' is in a large, bold, black font. Below it is a bullet point defining wire rope as a complex piece of mechanical machinery with various specifications and properties. To the right, a text box lists technical specifications: Diameter (2mm to 100mm), Normal tensile strength (1470 MPA to 2160 MPA), and Steel Wire Rope types (Galvanized, ungalvanized). Below the text is an 'Applications' section with a descriptive paragraph and a list of industries. A central image shows a close-up of a wire rope. A video inset in the bottom right shows a man in a suit speaking. A vertical toolbar with various icons is on the right side of the slide.

What is wire rope?

- **Wire rope is a complex piece of mechanical machinery with a number of different specifications and properties that can affect its performance and service life. It has many moving parts, all working in tandem to help support and move an object or load.**

Applications

Wire ropes are used dynamically for lifting and hoisting in cranes and elevators, and for transmission of mechanical power. Wire rope is also used to transmit force in mechanisms.
Used in : aviation, crane, lift, transportation, fishery, machinery, electricity, mining, oil and gas industry etc.

Diameter : from 2mm to 100mm
Normal tensile strength: from 1470 MPA to 2160 MPA
Steel Wire Rope: Galvanized, ungalvanized
Diameter : from 2mm to 100mm

Now, let us coming to this one, that what is the wire rope. Wire rope is a complex piece of mechanical machinery with a number of different specifications and properties that can affect its performance and service life. It has many moving parts, all working in tandem to help support and move an object or load.

When we say like this, the wire rope which will be used in conjunctions with a drum, maybe a drive for driving it there will be a drive motor, gearbox, their brakes, and also there will be certain way the rope will be terminated to the drum or to the appliance which will have to be there.

So, it can be used for carrying material from one place to another that is why it is used as a it is for traction purposes were or it can be aesthetic to give connecting two points and then, there are different applications of this wire rope, but basically you will be seeing this for lifting and hoisting. You might have seen some greens and those who have been to surface

mines and they have seen the mining rope shovel or drag line you have seen this.

Also, if you have seen drill machines, there also you can see wire rope utilizations, but if you go for a oil well drilling site, you can see a huge applications of wire rope for this say, drill string operations. So, wire rope is also used for transmitting force in mechanisms.

So, in aviation, in crane, in transportations, in fishery, in mining this wire ropes are used. In the figure, you can see that how a wire rope looks like it can be used with diameter 2 millimetre to 100 millimetre diameter 10 centimetre a big thick rope can be there for different purposes.

So, normally the tensile strength of the material which is being mixed for this wire rope we are using up to 470 mega Pascal to 21 2160 mega Pascal and they are basically, the ropes are depending on which material you are using galvanised steel; that is one of the very common type of material used for making wire rope and a rope diameter is selected depending on the type of applications.

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Mining Applications

- Rope Haulage
- Winch
- Winding: winding rope, guide rope, balance rope
- Machines: dragline, crane, rope shovel
- Aerial ropeways
- Cable belt conveyor
- Cable Bolting
- Drill rigs
- RopeCon

Jhanjra-MIC, ECL, Burdwan, West Bengal.

So, in this diagram you can see the various applications in the mining industry where your wire ropes are there. As we say here in the lists. So, the Rope Haulage in underground mines for carrying your load from the mine place to the shaft bottom; that is to lift up to that, that exactly this is a mineshaft. You can see here these wire ropes are hanging and from this head gear they will be going down this shaft that cage will be lifted and lowered with the help of this wire rope.

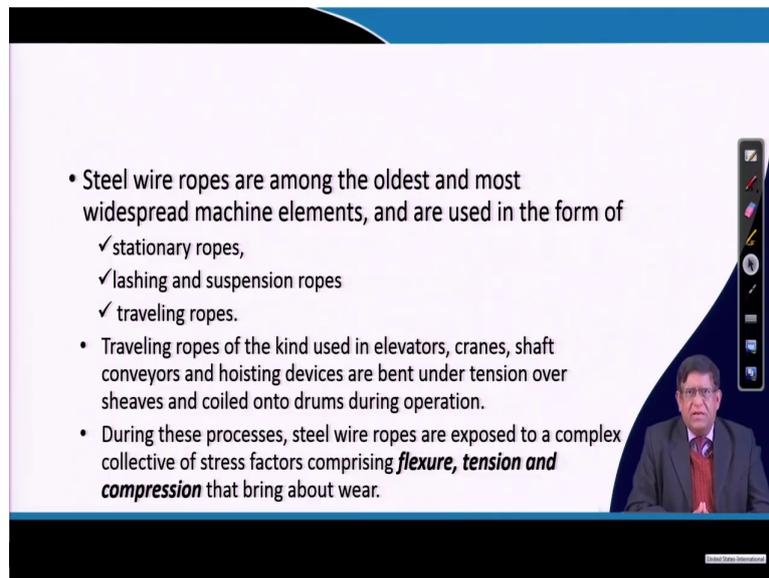
Then there could be Winch. You might have seen many winches in small applications. The Winding and winding rope. They are in the shafts there are different types of rope called guide rope or balance rope. While discussing about the winding systems, we will be knowing about these ropes and then in a machine like this is a Drill rig for a oil well drill rig you can see. Here we are having so many wire ropes for straightening it over there as well as to lowering down the drill bit down this is used.

You can see here a electric rope shovel where this wire ropes are used for raising and lifting this bucket. Similarly, in a drag line you have got a number of wire ropes. This is a RopeCon; that is a new type of conveyor belt where kilometres of the kilometre it can run up to India also there is a 5 to 6 kilometre this type of that conveyor belt can be used in mining industry in Sinbad island, where there is a 638 to 64 kilometre long a single conveyor belt can be made, this system is called RopeCon.

A very new recent last 10 years only this type of conveying systems have been introduced in the mining industry. There are aerial ropeways you might have seen if not seen in the mining industry, if you had been to (Refer Time: 07:37) or in some places there, you might have seen this how aerial ropeways are there for travelling from one peak to another peak on a hilly region.

Then there are also used in underground mine for Cable Bolting. When you do the underground mining that the when you make the roadway or the gallery in the mines to strip the rope above there is a or cable bolting is there so that the rock is lift so that the roof do not fall. So, those type of applications are also there.

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- Steel wire ropes are among the oldest and most widespread machine elements, and are used in the form of
 - ✓ stationary ropes,
 - ✓ lashing and suspension ropes
 - ✓ traveling ropes.
- Traveling ropes of the kind used in elevators, cranes, shaft conveyors and hoisting devices are bent under tension over sheaves and coiled onto drums during operation.
- During these processes, steel wire ropes are exposed to a complex collective of stress factors comprising **flexure, tension and compression** that bring about wear.

Now this steel wire ropes are among the oldest and the most widespread machine elements. There are stationary rope, there are suspension ropes, there are travelling ropes.

Now, the travelling ropes can be used in your elevators, cranes, everywhere in the big multi storey building. You have seen the elevators, those are also just moving with the help of the mostly with wire ropes. Now, steel wire ropes are exposed to a very complex stress that is that the while operating it has to get a its flexure, tension and compression; these three different types of stresses it must withstand.

As you can see that when you are lift is being raised by wire rope. If the wire rope breaks, then the whole lift will be falling down from a top so; that means, it is a very critical component wire rope is a critical component. In mining if the cage is being lowered and raised which people down below, it goes say if we remember though the mine is closed now see more than 1.2 kilometre 2 2.3 kilometre down the art it cages are going in the mines and

this whole thing is being just suspended by wire rope.

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Components of wire ropes

- Wires that form the strand,
- Core :
 - ✓ Fibre core (FC): sisal, manila or jute
 - ✓ Independent Wire Rope Core (IWRC): a smaller wire rope within the strands of the outer wire rope.
- multi-wire strands that are helically wrapped around the core

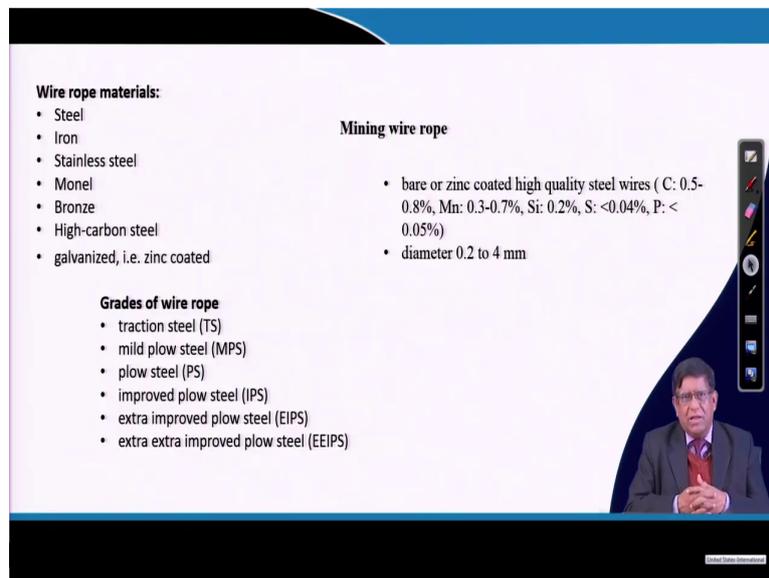
So, you need to design such wire ropes so that it properly can do the job without failure and without any accident and for that purpose, the how the wire rope is constructed. It is same. If you see some of the nowadays, everywhere you can see some this your plastic ropes. If you take up and cut a plastic rope you can find there the construction is same and in case of your wire rope only the material forming this wire is different.

The wires are wound to make a strand and the strands are laid around the core to make the rope. So, that is what is a basic constructions; that means, in any wire rope there will be a core and then there will be this strands and then there will be this wires. Now, the wire can be laid around a core which can be also a wire or sometimes it can be a fibre. So, depending on this there are different types of rope.

Now, this it can have an independent wire as a core, then it is called IWRC wire rope. Now,

this type of wire rope where there are number of strands, then we say it also call it as a multi strand wire rope.

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Wire rope materials:

- Steel
- Iron
- Stainless steel
- Monel
- Bronze
- High-carbon steel
- galvanized, i.e. zinc coated

Mining wire rope

- bare or zinc coated high quality steel wires (C: 0.5-0.8%, Mn: 0.3-0.7%, Si: 0.2%, S: <0.04%, P: <0.05%)
- diameter 0.2 to 4 mm

Grades of wire rope

- traction steel (TS)
- mild plow steel (MPS)
- plow steel (PS)
- improved plow steel (IPS)
- extra improved plow steel (EIPS)
- extra extra improved plow steel (EEIPS)

Now, the wire rope can be made of Steel, Iron, Stainless steel, Monel, Bronze, High-carbon steel, galvanised zinc coated, there are different types of iron and that steel of which this wire ropes are made, they are also of different grade of steel. In the metallurgy, they talk about that which type of steel will have to be there only thing this names and all we need to tell about what will be the total load coming on it and the braking strand of the rope is more important.

Now, thing is that the material when it is in a particular wire it may have a different type of (Refer Time: 11:43) strand, breaking strand when will be winding it, then how it is going to change those things are there and there are a wide range of tastes that by which you can taste that is there rope will be which tending the load you are taking carrying or not.

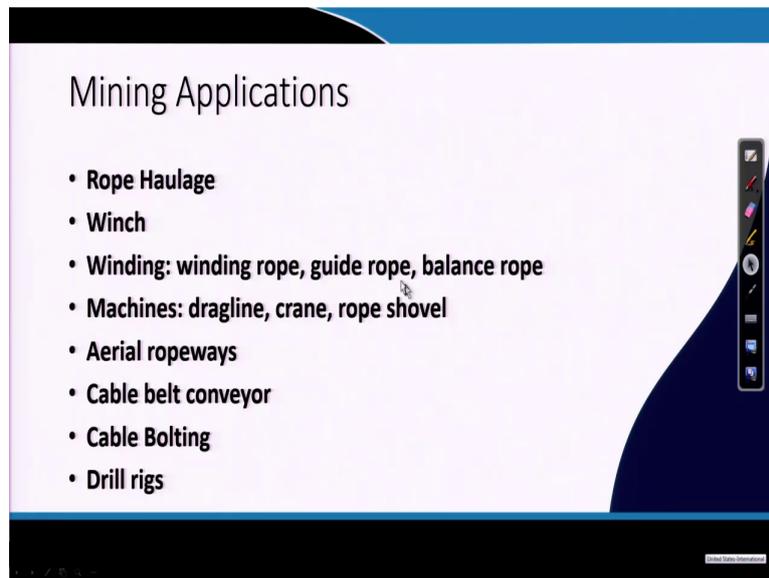
Now, when this wires are made in the forming this strands, then the diameter of this rope and

diameter of this strand and this diameter of the rope, their ratios are very very important. If this is very tightly wrapped, then the diameter of the rope the ratio of this the diameter of the wire that will be telling exactly how much whitespace is there inside or how compact the rope is and that the strengthen everything will be depending on that.

Now, in case of our mining wire ropes mining operations are always in a humid and in a very different type of conditions. So, it will have to be protected so that no corrosion takes place, because under the corrosion the rope will become weak and weak rope if it rupture, there could be accident.

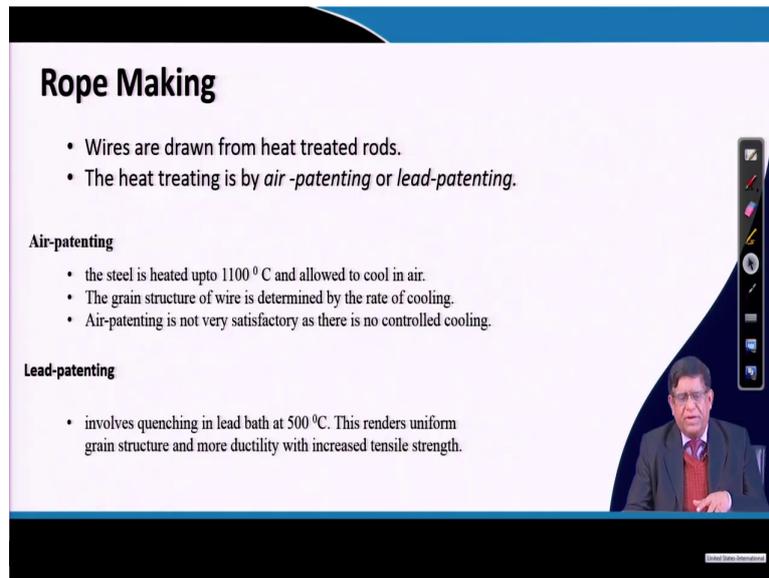
So, that is why they are always galvanised and steel is used that steel composition as you can see here maybe with 0.5 to 0.8 percent of carbon with 0.3 to 0.7 percent of manganese, then silicone of 0.2 to per 2 percent sulphur this can be 0.04, phosphorus can be 0.05 percent; that is a particular type of idle material which could be used for mining wire ropes which are normally within 0.2 to 0.4 millimetre wires are used.

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Now, if you see that this in the mining applications already I have said that these are the basic operations or basic machines where it is used. But to make this wire how the wires are manufactured. It is exactly drawn from heat treated rods.

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Rope Making

- Wires are drawn from heat treated rods.
- The heat treating is by *air -patenting* or *lead-patenting*.

Air-patenting

- the steel is heated upto 1100 °C and allowed to cool in air.
- The grain structure of wire is determined by the rate of cooling.
- Air-patenting is not very satisfactory as there is no controlled cooling.

Lead-patenting

- involves quenching in lead bath at 500 °C. This renders uniform grain structure and more ductility with increased tensile strength.

The slide also features a video feed of a man in a suit and glasses in the bottom right corner, and a vertical toolbar on the right side of the slide area.

You may be knowing that in Ranchi, there is the Usha Martin, a company which is the main manufacturer of wire ropes in India and they do this by heat treated rods from there they draw the wire and this is under they undergo the heat treatment which could be by air patenting or lead patenting.

Now, the how we are manufacturing depending on that the quality of the wire ropes are determined. In the air patenting, the wire rope is heated up to 1100 degree centigrade and then it is allowed to cool in air and in that the rate of cooling how it is getting cooled by that exactly these what type of grain structures take place in the wire that depends on that exactly determines the quality.

So, that is exactly it is said that when you are doing lead patenting in which that is exactly the molten lead at 500 degree centigrade, there this wires are cooled down slowly, then it gives a very uniform grain structures and because of that the wire becomes more ductile. The ductility and the strength these two are the main property which are required in case of you are making a wire rope and that is why the lead patented wires are good for manufacturing

wire ropes for critical operations.

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Core types

- fiber core (FC),
- independent wire rope core (IWRC),
- wire strand core (WSC)

Function of Core

- The core acts as the foundations of a wire rope;
- It provides proper support for the strands under normal bending and loading conditions
- If the core cannot support the compressive load imposed, the rope will lose its clearance between strands and its service life will be shortened

Cross section of wires.

Circular, Triangular, Full Locked Z-Shaped, Half Locked

Wire Rope Strands

Round, Oval, Triangular, Flax-Fiber

FIBER (FC), INDEPENDENT WIRE ROPE CORE (IWRC), WIRE STRAND CORE (WSC)

Now, you can see that this from these core around which the ropes is own owned that core can be a fibre core which can be a jute this material and there could be only a core that is one wire it can be a core or number of wire making a strand and that strand is made a core.

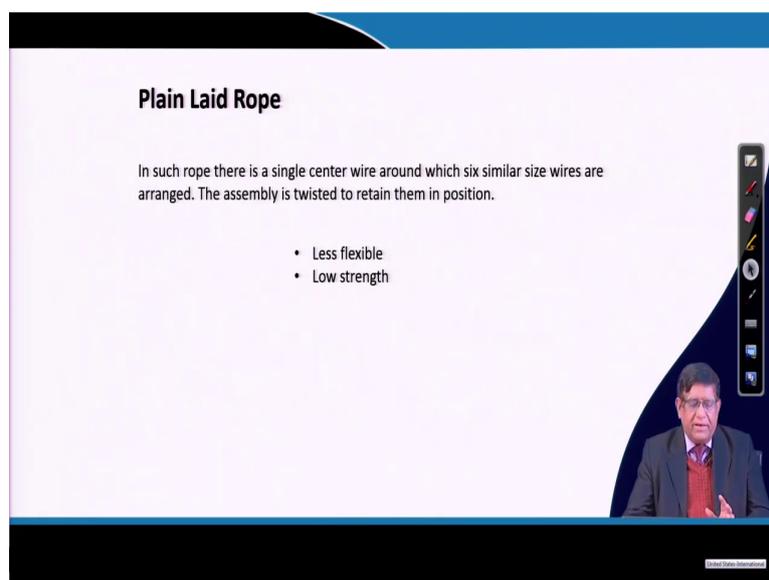
So, depending on that different types of ropes are there. Exactly in the wire rope manufacturing companies, they give sometimes this a plain wire sometimes they called a wire called sealed wire that is a wellington wire rope. There are different types of wire rope depending on what are the sizes of these wires and the ropes and the strands and how they are exactly put it over there.

Now, the core around which this wires are ropes are lead, it will be giving as a foundation for the rope and then it provides a support for the wire and when this rope will be moving over there, then exactly how the load inside will be distributed the internal wear and tear of the

wires also is depending on what type of core it is being used.

Now, these wires out of which this rope is made it can be of different cross sections like Circular cross sections, Triangular cross sections or a full locked or 'Z'-Shaped cross sections or Half Locked cross sections. Depending on that we can make the strands as a round strand, we can make oval strand or triangular strand or a flat or this. So, wire ropes can be made depending on the type of use you make it.

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Plain Laid Rope

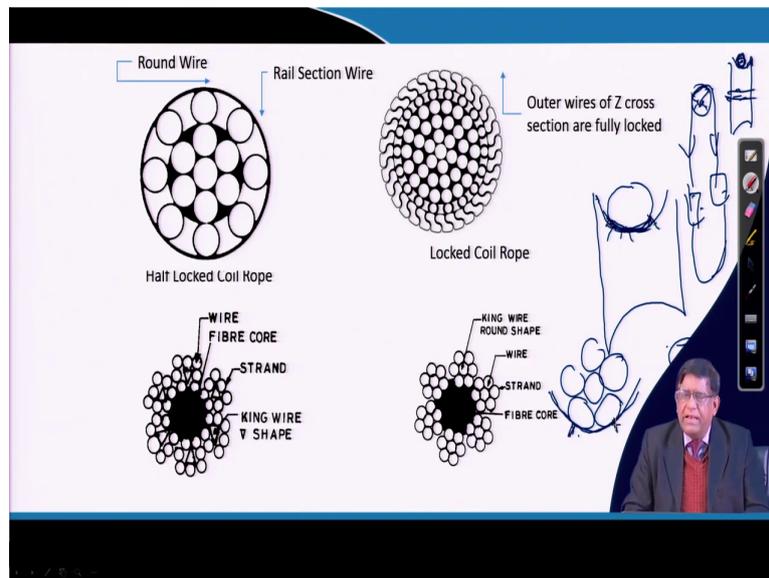
In such rope there is a single center wire around which six similar size wires are arranged. The assembly is twisted to retain them in position.

- Less flexible
- Low strength

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So, normally a if we are having a single wire at the centre and then six similar sized wires are made to make a strand and then they are laid that is call your the plane wire laid rope and which is very less flexible and very low in strength.

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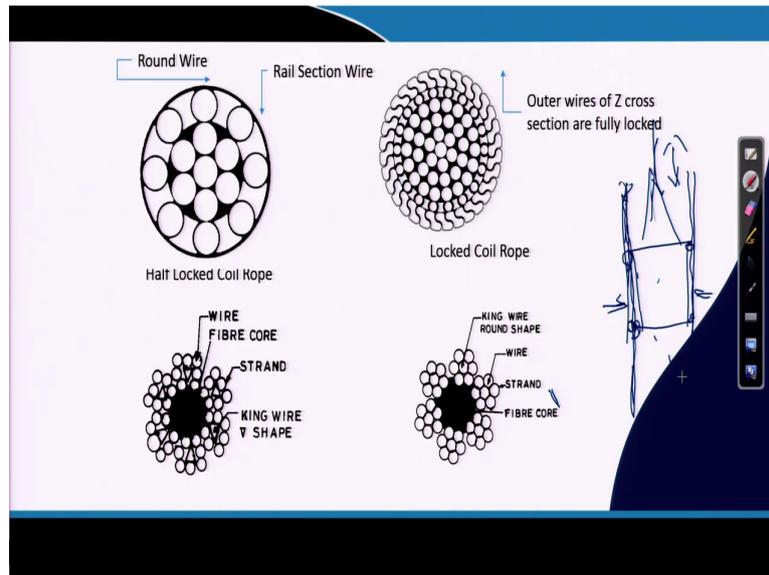
So, that is why there are different types of advanced rope manufacturing is there. One in mining industry you will find a Locked Coil Rope, because this you can see the outer surface is made a smoother. If you are making the outer surface smooth; what is the best use of it is here, you can see that if your rope is moving on a sheave. Suppose you are having a sheave on which this rope will be moving.

Now, this exactly if there is a that smooth surface or if you are having a core and then we are having a strands like this. Now, when it is resting on a sheave where it is passing through this load. Suppose, this is exactly the sheave and then you are having this load over here suspended loads are there and then what happens your this rope is supported over here and this is their sheave then sheave is exactly if you see the cross sections it is like that this is the axis now; that means, the wire rope is stranding over here.

Now, when this is supported a more area is a getting supported means the load is uniformly

distributed. If here it is there the whole load is coming over only at two points. As a result, there will be you will be having the more wear and tear of the outer surface of the rope will be taking place. So, that is why this locked coil rope are used wherever if you see a cage is going down.

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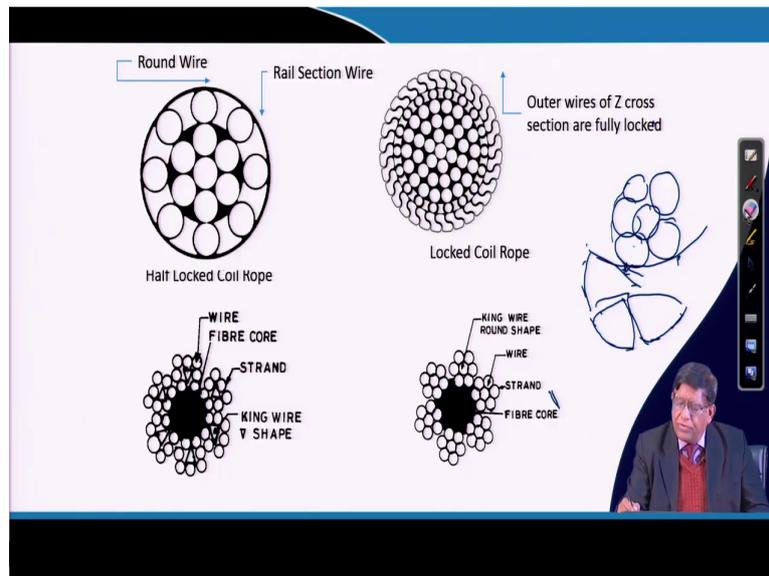


If this is your going to your underground mine. Now, you are having a cage is suspended by this rope now if it is moving up and down there will be an oscillations of the cage. So, the people will be having uncomfortable; that is why inside that shaft there will be the guide ropes and there will be a groups by which it will be holding over here and then; that means, when the cage goes up and down about this rope, it is exactly holding it like that and then moving.

So; that means, this rope will be subjected to your frictions with the this sheave with which it will be gripping. So, that is why the locked coiled rope will be used as a guide rope in the in

your winding installations. Similarly, half locked coil rope here you can use, because of the cross section of the half locked type here also you can get a just like a rail sections or these are the cross sections of the wire rope; they will be also making a smoother surface.

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So, there is sometimes what we do that if we are having a strand like this all are round strand, then the total supporting this (Refer Time: 20:37) it will be less. What we can make. We can make the strands looking like this a triangular strand. So, if you make a triangular strand like this, the outer surface will become smoother. So, that is what exactly is shown in the this figure over here. So, that is way how the wire ropes are being manufactured.

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Rope Classification

- Number of strands and wires
- Lay:
 - ✓ Right Hand lay strands are laid around the rope core in a clockwise direction
 - ✓ In a Left Hand lay, the strands are laid anti-clockwise
 - ✓ Steel Wire Ropes are conventionally produced Right Hand lay unless special circumstances require Left Hand lay.
 - ✓ Ordinary lay means the **wires in a strand are laid in a direction opposite to the direction in which the strands are laid** in the final rope.
 - ✓ Lang's lay means both have same direction of laying

Lang's lay ropes have superior properties in resistance to wear, abrasion, fatigue and scuffing.
In Lang's lay wear on an outer wire is distributed over a far greater area than in Ordinary lay



The diagram shows five cross-sections of rope with different lay patterns. 1. Right Hand Ordinary Lay: Strands are laid clockwise around the core, and wires within each strand are laid counter-clockwise. 2. Left Hand Ordinary Lay: Strands are laid counter-clockwise around the core, and wires within each strand are laid clockwise. 3. Right Hand Lang's Lay: Both strands and wires are laid clockwise. 4. Left Hand Lang's Lay: Both strands and wires are laid counter-clockwise. 5. One Rope Lay: A single rope with a single wire, showing both directions of lay.

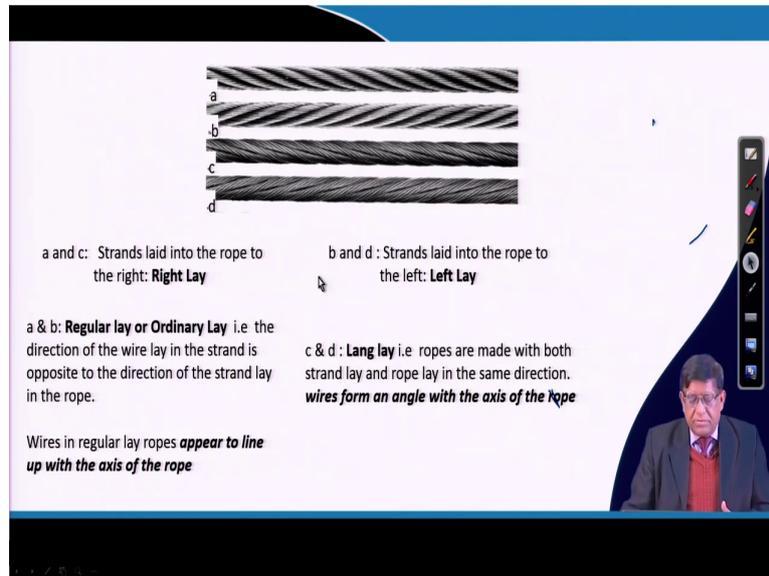
So, you can see that these ropes can be classified depending on how their wires are laid. This there are ordinary lay and there is a Lang's lay. Lang's lay it was a John Lang he exactly thought that the if we wind that is a wires in the strand and the strands in the rope if they are made in the same direction, he thought that this will be give a better rope, but exactly he was wrong, but this Lang's lay is one where both are in the same direction.

So, this ordinary lay is where they are having in the opposite directions. So, some resistance to wear abrasion and fatigue and scuffing they say that this is because of the total area on which the load is getting supported is increased in case of your this Lang's lay.

So, this when the that whether you are winding in the Right Hand directions or you are winding in the Left Hand directions depending on that the wire rope can be said as a Right lay or Left lay. Lay means how exactly the winding is done, how the wires have been laid down, because of that they say Regular lay or that say Ordinary lay or Right Hand lay or a Left

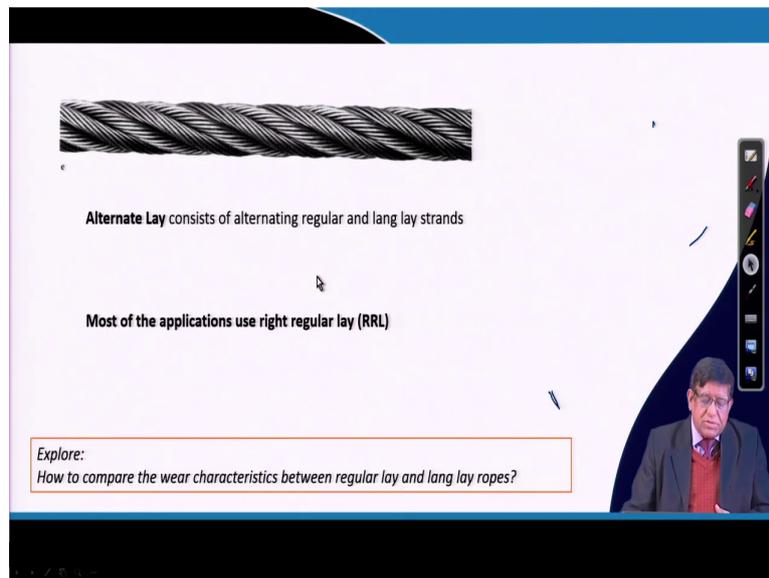
Handed lay.

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So, here you can see in a Right Lay you can see the first figure and that this figure that is a Right Hand and then this is your Left Lay. So, these are the different type of lay. Then you can see that in a Lang's lay in that is your c and d; these are Lang's lay where ropes are made on both strands lay and rope lay in the same directions. This is how ropes are classified.

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Alternate Lay consists of alternating regular and lang lay strands

Most of the applications use **right regular lay (RRL)**

Explore:
How to compare the wear characteristics between regular lay and lang lay ropes?

And there the applications will be depending on the how they will be requiring flexibility. You can have this Alternate Lay. You see here for getting more flexibility, there one rope is regular lay another is Lang's lay and then they have made over there. So, mostly you will find the right regular lay RRL ropes are mostly used.

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Lang lay construction characteristics result in greater fatigue resistance than is found in regular lay rope

The lines a-b, on drawings and photographs, indicate the rope axis

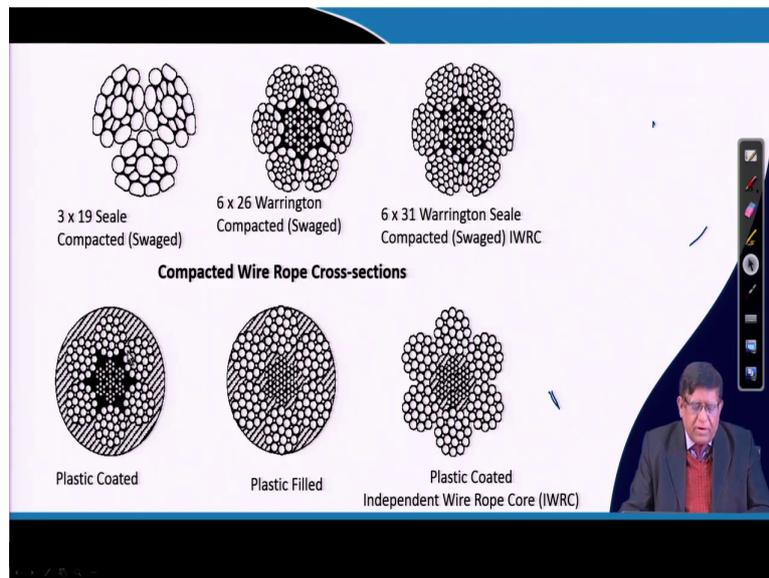
Lang' lay rope is has longer exposed length of its outer.
When bent over sheaves, Lang's Lay rope span is longer providing greater fatigue resistance.

The worn crown of the regular lay wire has a shorter exposed length

When the regular lay rope is bent, the same degree of bend is imparted to the crowns of the outer wires. Lang lay rope displays 15 to 20% superiority over regular lay when bending is the principal factor affecting service life.

So, you can see that which is better; that is how the wire rope behaves when it moves. You can say the Lang's lay rope has a longer expose length. Now, if on the sheave it is coming, because this if your if you say this is a regular lay and this is a Lang's lay, you can see here a longer length is being exposed. So, because of that it is having that that is the load is distributed over a bigger area. So, the wire will be getting minimum wire; that is what is observed over there.

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I have already told about the triangular strand. These are the triangular strand to make it a smoother rope, then we can have this ah. Sometimes, on the wire rope you can give a plastic coat depending on the type of uses. Sometimes, in the wire rope you may have a plastic fill. So, this is a something plastic coated. These are different type of. So, give a smoother and then to protect the wire ropes, increase the life; that is how the different type of wire ropes are made of.

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Rope Description

- Lay Length
- Rope Diameter (size)
- Preformed (pref) or non-preformed (non-pref)
- Direction and type of lay
- Finish
- Grade of rope
- Type of core
- Fatigue resistance
- Wear resistance
- Corrosion resistance

True or False?

1. More the flexible a wire rope higher is the fatigue resistance of the wire rope.
2. Lang's lay ropes are more fatigue resistance.
3. Ropes that have larger wires forming the outside of their strands are more resistant to wear than ropes having smaller wires

So, when you go for designing a wire a wire rope for a particular purpose, you need to calculate what will be the lay length. Lay Length means when you are having a suppose your one wires will be that that will be making like this. So, from one to the other; say that is exactly when a rope will be making like this you can see here that that same one will be going and then it is coming over here. So, this distance just like your wavelength that is called your Lay length.

So, wire rope diameter it will be depending on the that will depending on the load you will have to design that what should be the diameter of the rope. Now, if the for very heavy load if the diameter of the rope is very big, then to turn over the sheave, the sheave diameter also we will have to be bigger, because that is what exactly needs to be calculated.

Now, the if the what could be the maximum length of suspension a wire rope will be giving; that also need to be calculated. Sometimes, because if you are going to have a say 2 kilometre

deep mining. If you are going down a 2 kilometre to the 2000 metre, then if you are having say 50 say your 50 millimetre diameter wire rope; if you are hanging it over there, you can find out depending on the steel used the total how much that steel material will be suspended from the top.

Now, its own self weight it can get extended, because and then, because then it may rupture over there. So, that is why for the safety purposes, you will have to find out that to what lengths the rope will have to work, depending on that that much load that strand should be there even if it elongates it will not be able to it should extend.

So, those load calculations is a very important calculations in wire rope designed. Then you will have to design that what will be the your type of directions in which way whether you will be using a Lay Lang that is Right lay or Lang's lay or Regular lay or Lang's lay will be depending on where you are using.

If you are using a small sheave having a more flexibility required then you cannot use some of the very thick wires rope, because that the flexibility is less so, depending on those application criteria you will have to select.

So, that what type of core then mainly the fatigue resistance, because when you are using a wire rope on a repeatedly moving applications, then what exactly the service life is required. Depending on the service life required, then how much fatigue it will be undergoing, then you will have to select the material and you shell will have to design the wire rope.

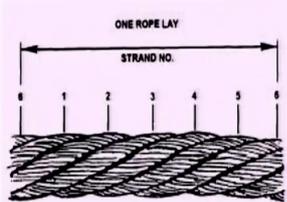
So, you may sometimes think of that more the flexible wire rope, higher is the fatigue resistance of the wire rope. If you are going to make more flexible; that is you will have to have more fatigue resistance otherwise, the rope will fail. Then Lang's lay ropes are more fatigue resistance, because there they have got the wire and the and the wire in the strands and the strands in the wire being in the same directions they have got more flexibility and fatigue resistance.

So, now ropes that have larger wire forming the outside of their strands are most resistant to wear than the wire rope having smaller wires. So, these are the things.

(Refer Slide Time: 28:49)

Length of a rope lay

The Lay Length or length of a rope lay is the **distance measured parallel to the center line of a wire rope** in which a strand makes one complete spiral or turn around the rope. The length of a strand lay is the distance measured parallel to the center line of the strand in which one wire makes one complete spiral or turnaround the strand.



The diagram, titled "ONE ROPE LAY", shows a cross-section of a rope with six strands. The strands are numbered 1 through 6 from left to right. A horizontal double-headed arrow above the strands indicates the length of one rope lay, which is the distance from the center of strand 1 to the center of strand 6. The strands are shown in a helical pattern, with each strand making one complete spiral around the rope's center line.

4 / 8

Then you can see here the length of a rope as I said that exactly that how where it has started the trend and then it is coming over there; that it that is the way how you measure the length.

(Refer Slide Time: 29:00)

Basis	Types	Comment
Calculated ultimate tensile strength of wire	110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210 kg.mm ²	
Wire ductility		
Wire surface	Bright wire ropes Galvanized wire rope For light duty For Medium duty For heavy duty	
Wire cross section	Round Flat and round (Locked coil construction)	Locked coil construction has the greatest efficiency in filling the cross section with metal (0.865 as against 0.45-0.60) in open construction. The locked coil construction ensures a minimum of abrasion wear of rope surface, since the rope is fully in contact with the drum chute while other ropes are in contact only at separate points.
Wire diameter	All wires in the strand of same diameter Different diameter wires in the strands (Compound rope)	Compound ropes have better flexibility due to fine filler wires. The thicker outer wires of each strand make the rope more wear proof. In the compound rope the adjacent wires of each strand are in contact with each other over the entire length, which provides a more uniform wear of wires and a greater durability of rope life.

Now the different ropes have got different tensile strength. Their ductility, wiring surface whether that will be having a light duty or medium duty, wire cross sections how will be determining the cross sections with the material and load. So, different type of rope will be giving you different.

Now, that exactly if a wire rope wire rope is made up of say 6 strands and each strand is having say 19 wire; that is a 6 by 19 wire rope. Now, that depending on the wire ropes diameter, you can find out the what is the total cross section of the material.

And then if you find out the diameter of the wire rope, there exactly you will find that the depending on the total cross section of the material and the total cross section of the wire rope, there is a difference. Depending on that we can say that there is a how much wire space is there. So, that will be exactly affecting the strength of the rope.

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Core material	<p>Metal Core (all metal) With an ordinary metal core With a special duty wire core</p> <p>Soft core Of organic fibres Of mineral fibres</p>	<p>A considerable amount of ropes is made with organic cores, which are designed not only for safe-guarding strands from getting displaced or from falling in, but also for the lubrication of the inner layers of rope wires and for the prevention of inner corrosion.</p> <p>The core material should have high compressive resistance and ability to doubly retain the lubricating staff.</p>
Number of cores	<p>One core Multi-core</p>	Ropes with many cores are more flexible.
Number of strands	<p>Single strand (spiral)</p> <p>3-strands 5-strands 6-strands 7-strands 8-strands 18-strands</p>	Multi-strand ropes, built up of 18 strands arranged in 2 layers around the central organic core are utilised for vertical load lifting with machines having small diameter drum. These ropes use larger cross section wires for the same rope diameter giving higher strength and, at the same time, have considerable flexibility and lesser untwisting tendency.
Direction of strand lays	<p>Right lay rope (clockwise) Left lay rope (counter clockwise)</p>	According to the direction of strand twisting

So, these wire diameter and their ratios are important. Similarly, that for what type of core material you will be using. In a metal core with an ordinary metal core can be there or with special duty wire rope core can be there or organic fibre could be a core.

A considerable amount of ropes is made with organic cores which are designed not only for safeguarding strands from the getting displaced from the falling in, but also for lubrications of the inner layer of the rope wire and for prevention of the inner corrosions, because that fibre it can take the lubricant. So, that inside when the wires will be rubbing into each other, they will get lubricated.

Now, there is also a type of rope called pre formed wire rope, because when they will be having a particular helical winding; if the wire itself is be given some groups so that that helical groups they will be fitting together and then if the rope is suspended, it will not get twisted or (Refer Time: 31:20) that is called what pre formed wire rope.

Then the multi strand ropes built up for 18 strands range in two layers around a central organic core are utilised for vertical load lifting with machines having small diameter drum. These ropes use larger cross section wires for the same rope diameter giving higher strength and at the same time have considerable flexibility and lesser untwisting tendency. So, we will have to study the different literature on rope to know how exactly ropes are used.

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Lay method	<p>Ordinary (Twist rope)- after removal of the bindings the strands and wires do not retain their original position</p> <p>Non-twist rope-Ropes donot untwist into separate strands and strands do not untwist into wires</p>	<p>By the direction of twisting of wires into the strands, ropes are manufactured as cross lay (ordinary lay), one way lay (lang's lay) and combined reverse lay ropes.</p> <p>Along its entire lenth the wire roes must have a uniform pitch of twisting both of strands in rope and wires in strands.</p> <p>In the cross lay the direction of wire twisting in the strands is opposite to the direction of the strand twisting in the rope. In the one way lay, both the strands in the rope and the wires in the strands run in the same way. In this case the wires are inclined at a certain angle in relation to the centre line. In the combined reverse lay rope any two adjacent strands have wires twisted in the opposite directions.</p> <p>Cross lay rope does not untwist and one way ropes are more flexible. The combined reverse lay rope exhibits both the qualities.</p>
Mutual wire contact	<p>Point contact</p> <p>Linear contact</p>	<p>The pitch of strand lays in point-contact ropes does not exceed 7.5 diameters and the linear contact by 6.5 diameter.</p>

So, there depending on their Lay Lang and depending on that how they will be putting and that you can find it out from the literature they use.

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Selection of Wire Rope
Wire rope selection is done by considering the following rope characteristics :

- Strength
- Flexibility
- Resistance to wear and corrosion
- Jointing
- Cross section packing efficiency
- Endurance (fatigue strength)
- Elongation
- Weight per linear metre

Efficiency of Rope construction:

$$\epsilon_{\text{rope}} = \frac{B_r}{nB_w} \times 100\%$$

where, B_r is breaking load of rope, n is the number of wires and B_w is breaking load of one wire. Values are:

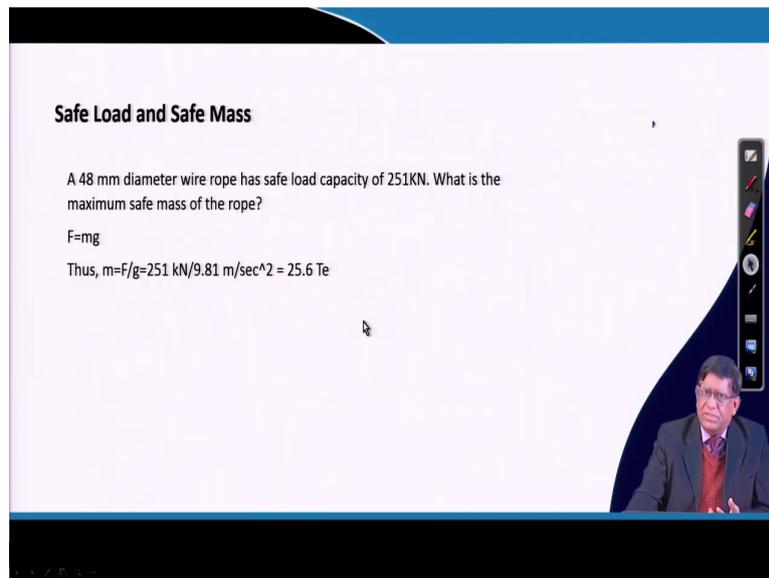
- Simple 6-strand rope: 95%
- Locked coil rope: 87.5%
- Flattened strand: 87.5%
- Multi strand: 80%

And or wire rope in different machines; so, basically the wire rope will be selected based on the strength flexibility, resistance to wear and corrosion, how they will be jointing, cross sections of the picking efficiency; that is how the wire ropes are how compact they are, how there will be endurance to fatigue and then how they will be getting elongated and then weight per meter. These are the parameters considered while selecting the wire.

And the efficiency of rope construction, it is exactly the breaking load on the rope and then you will have to that is your breaking load of the wire. If there are n number of wire, then their total breaking load and then our total overall rope breaking load. This ratio is called your Efficiency of Rope constructions.

How tightly or what lay length you have made, what type of diameter you have selected, what type of core you have used. Depending on that, this B_r that breaking load of the rope will be depending and that way you can find out that what is the efficiency of rope constructions.

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Safe Load and Safe Mass

A 48 mm diameter wire rope has safe load capacity of 251kN. What is the maximum safe mass of the rope?

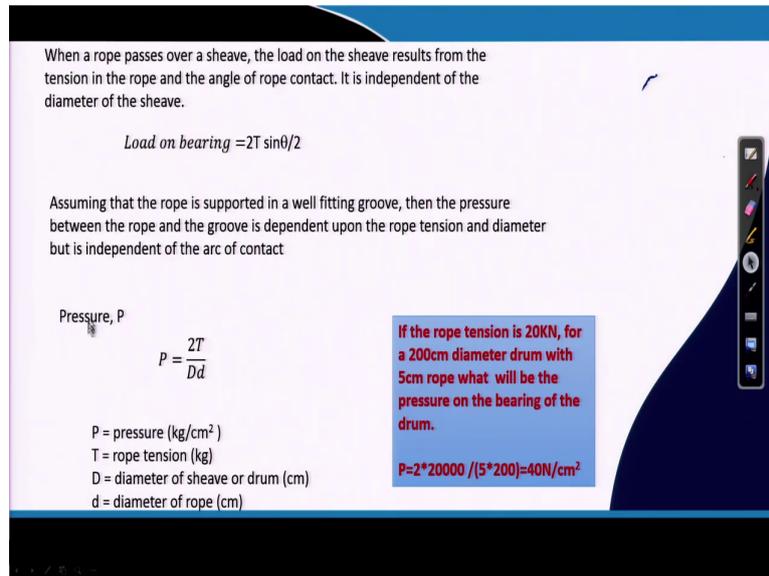
$F=mg$

Thus, $m=F/g=251 \text{ kN}/9.81 \text{ m/sec}^2 = 25.6 \text{ Te}$

And then you can calculate out easily some simple calculations like here is an example. If a particular rope diameter they can carry a particular amount of load, then the maximum safe mass; that is how much exactly the material is used can be calculated from the very simple air force into $m g$ equations and you can find out; that means, in this particular example your 25.6 this ton of material is required for raising this 251 Kilo Newton capacity.

So, that that is why you can if you know this mass, then you can find out exactly what should be the diameter of each wire that type of calculations design calculations are carried out.

(Refer Slide Time: 34:10)



When a rope passes over a sheave, the load on the sheave results from the tension in the rope and the angle of rope contact. It is independent of the diameter of the sheave.

$$\text{Load on bearing} = 2T \sin\theta/2$$

Assuming that the rope is supported in a well fitting groove, then the pressure between the rope and the groove is dependent upon the rope tension and diameter but is independent of the arc of contact

Pressure, P

$$P = \frac{2T}{Dd}$$

P = pressure (kg/cm²)
T = rope tension (kg)
D = diameter of sheave or drum (cm)
d = diameter of rope (cm)

If the rope tension is 20KN, for a 200cm diameter drum with 5cm rope what will be the pressure on the bearing of the drum.

$$P = \frac{2 \times 20000}{(5 \times 200)} = 40 \text{N/cm}^2$$

Now, these regarding the pressure how much it will be giving on the group, it can be calculated by this rope tension if it is there.

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D/d Ratio affects service life of wire rope

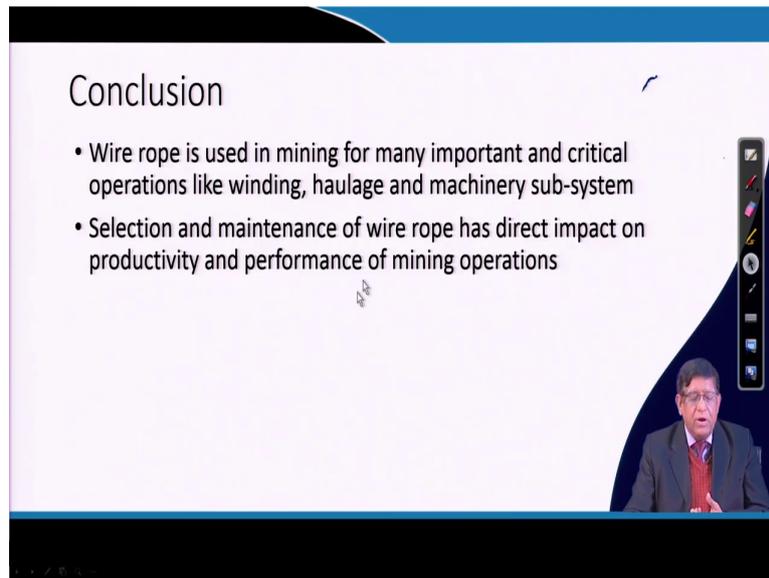
Using the given graph, determine the % increase in service life of a 40 mm diameter rope being used with a drum of diameter 800 mm is made to work with a drum of diameter 2000 mm.

A rope working with a D/d ratio of 26 has a relative service life of 17. If the same rope works over a sheave that increases its D/d ratio to 35, the relative service life increases to 32. In short, this rope used on a larger sheave, increases its service life from 17 to 32 or 88%

If we do not need any sheave if you are having the material over here you are getting this two tension, then on here on the sheave how much load will be coming that is calculated from the by these equations as you have seen here. So, you have you have seen here that this is exactly that that pressures on the that group can be calculated out.

And then the D by d ratio; that is your diameter of the rope and the diameter of the wire, their ratio is a very important parameter to know if you know by that ratio, then you can find out what is the service life of the rope; that is your if the D by d ratio is here, then the service life you can get more. This type of things you can find out from the rope manufacturers catalogue and you need to do it.

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Conclusion

- Wire rope is used in mining for many important and critical operations like winding, haulage and machinery sub-system
- Selection and maintenance of wire rope has direct impact on productivity and performance of mining operations

So, you can use this type of graph for selecting your wire rope. So, wire rope is used in mining for many important and critical operations like winding, haulage, then your machinery sub-systems like your winding systems in a drag line or in electric rope shovel or in a drilling the drilling string or in an diamond drilling for a wire line drilling for digging out the core when you are doing the core drilling.

Then selection of maintenance of wire rope has a direct impact on the productivity and performance of mining operations.

So, with this a I want that you should read some of the references like ah. We have got a number of literatures as well as book handbook for mining engineering there discuss a lot on rope constructions and maintenance. In our next class, we will be discussing the common problems that are faced with wire ropes and then how those type of problems can be resolved and also how to determine the diameter of a wire rope for a particular installations.

Thank you very much.

