Chapter 6

Rigging

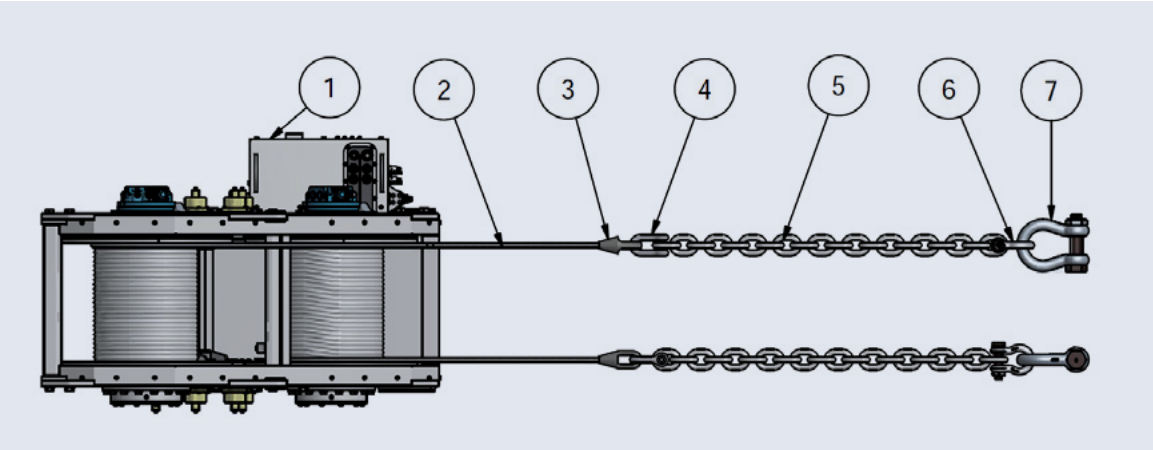
In this chapter you will find out:

- ✓ About wire rope and the different connectors' strength.
- ✓ Why bending a rope can severely damage it.
- ✓ What rigging guidance needs to be followed.

Rigging connects the anchor to the steep slope harvesting machine. This chapter describes the different parts of the system.

Parts of a rigging system

A rigging system has several main parts. These are the winch, wire rope, chain, connectors, and shackles. There are many different options, and some of these are shown. Rigging is only as strong as its weakest link, so all components need matching with their strength characteristics.



1= winch, 2= rope, 3= rollover shackle, 4= hammerlock, 5= chain, 6= chain shackle, 7= steep slope harvesting machine shackle.

Rigging is only as strong as its weakest component.

Wire Rope

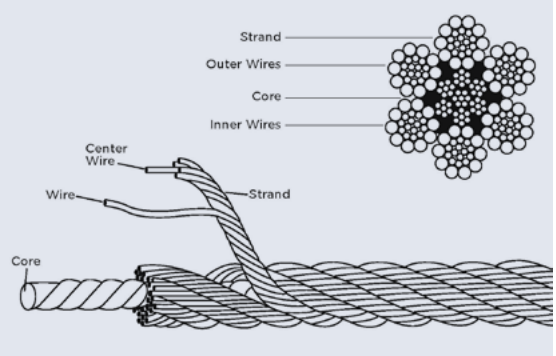
This section describes the basics around wire rope and guidance around its use. Chapter 11 covers wire rope inspections and maintenance.

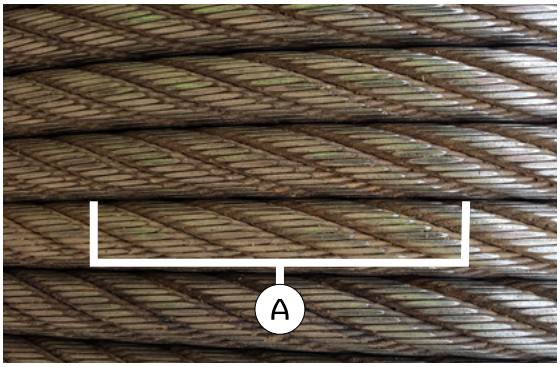
Nearly all 'wire rope failure' incidents are caused by failed end connectors, failure due to poor practice like overbending the rope, or equipment design problems.

Parts of a wire rope

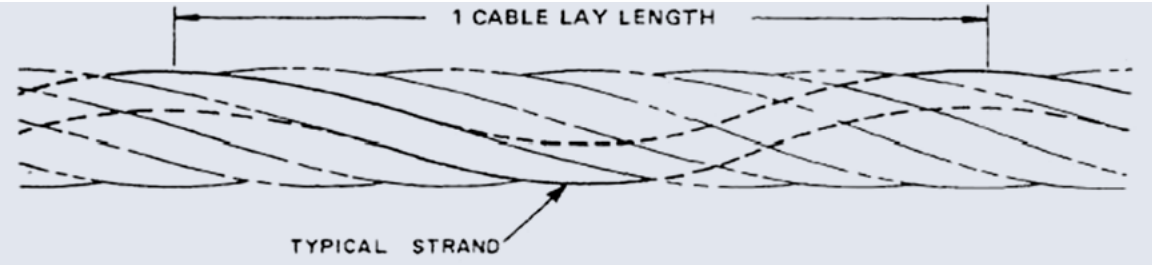
A rope consists of individual wires twisted into strands. These preformed strands are then twisted around the core to complete the rope.

The core supports and maintains the shape of the rope. The rope's cable 'lay length' is one full twist of the rope which is about 15cm for a 1 inch or 1 1/8th inch rope.





A One cable lay length



Different ropes, different properties

Ropes behave differently depending on construction. The combination of the above factors creates ropes with varying properties. There are four fundamental properties to differentiate rope: strength, abrasion resistance, crushing resistance and fatigue resistance.

- Strength increases through larger diameter ropes or swaging.
- Abrasion resistance, or the outer wires' ability to resist wearing away and deformation, increases by fewer or larger outer wires, Lang lay construction and higher carbon content in the metal.

- Crushing resistance, or the ability of the rope to resist deformation, is improved with a strand or IWRC core, swaging, and higher carbon content in metal.
- Fatigue resistance, or the rope's ability to resist bending and twisting, is increased by more wires, smaller wires, fibre cores, and Lang lay construction.

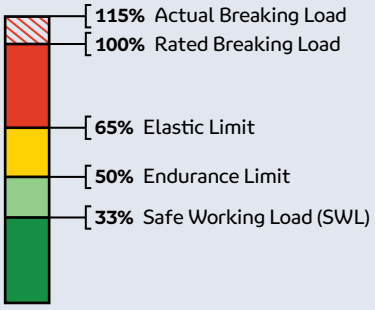
Use the manufacturer's specified rope.

Wire rope strength and the safe working limit

A rope's strength will depend on its properties and type. All ropes have a breaking strength rating.

The ACOP provides the following guidance:

- The SWL to have a factor of safety of three – so the SWL is one third of the rope's breaking strength.
- Operations not to exceed the SWL.



SWL = Breaking load / 3

Definitions

Safe Working Load: Refers to the maximum weight a wire rope can handle without the rope incurring damage. It is currently 33% of the rated breaking load.

Endurance Limit: Occurs at 50% of the wire rope's minimum breaking strength. When a rope is strained repeatedly past this limit, it reduces lifespan, and failure may occur even if the tension does not reach the elastic limit or breaking strength.

Elastic Limit: The load limit at which the wire rope will, when the load is removed, return to its original length without incurring damage. It is defined as 60 to 65% of the minimum breaking strength. If a strain is applied beyond this limit, the wire rope is damaged immediately, e.g. if the SSH moves without the WAM engaged. For a larger shock load that exceeds the elastic limit, cease operations and replace the rope.

Wire rope and bending fatigue

Bending occurs when it goes around something including block sheaves, redirect stumps and logs. Bending can significantly increase the stress on the rope because the many wires that make up the rope are forced to stretch at different rates when going around the bend.

This happens because of the difference in diameter between the inside and the outside of a rope. Bending wear on blocks increases exponentially as the ratio of the sheave diameter to rope diameter decreases.

Follow manufacturers' directions, or if unavailable, a minimum sheave to rope ratio of 16 :1 is recommended.

Bending also increases the tension in the rope due to the rope tension plus the force created by the bending.

For cable logging applications, a block diameter of 20 times the diameter of the rope is often recommended to keep the additional stress to about 10%. Such a stress loading needs to be included in the factor of safety.

Shock loading, redirects, and bending can all increase rope tension beyond the SWL.

Sheave/Rope Diameter Ratio	Tension in outer wires of rope
10 times	+27%
12 times	+21%
14 times	+17%
16 times	+14%
18 times	+12%
20 times	+10%
24 times	+8%
30 times	+5%

Small diameter ratios create an unacceptable increase in stress

Acceptable diameter (account for in the SWL)

Bending creates an uneven stretching of the rope. The tighter the bend, the more rope damage.

Wire rope and ground contact

Ideally, wire rope should not have ground contact. However, initial rope testing research showed that external wear from ground contact does not significantly affect winch-assist rope due to winch-assist ropes moving at relatively low speed. The rope is also on top of the ground with no sharp angles.

However, depending on anchor placement and system type, the winch-assist rope is dragged often through the edge of landings and roads. This is because the anchor machine needs to sit back far enough so the steep slope harvesting machine can be lowered off the slope, and the road and landing edges often lack anchoring strength because they are in fill.

Also, this creates an erosion and sedimentation problem if the site is not remediated.

Pulling a rope through the ground runs the risk of it bending sharply around a hidden rock (or similar), or that grit/clay works its way into the rope, decreasing its useable life.

A Ropes are carving through bund and landing fill

B Rub logs help keep the rope above dirt

Guidance for wire rope

- Visually check all connections daily.
- If a sheave is used, make sure they have a minimum of 16:1D/d ratio.
- Joining splices should not be used to repair broken or damaged winch ropes.
- Use blocks where possible. Avoid running wire over sharp bends or redirect stumps or trees.
- Avoid cable drag over abrasive surfaces like rock and through the soil.
- Minimise shock loading. Shock loading rope and rigging reduce its life.
- Wire ropes used for winch-assist should not be used for log extraction or hauling.
- Review tension log data daily and whenever shock loading is known or suspected. Stop operations and inspect the wire rope for damage.

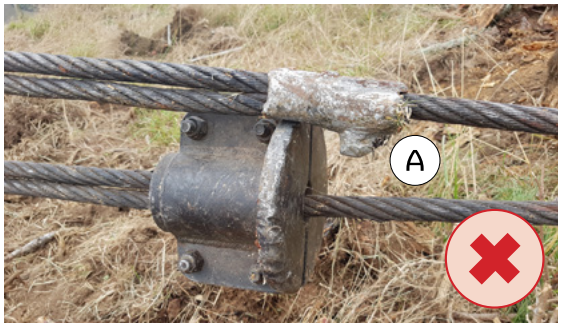
Beware of shock loading or dragging a cable over rock.

Connectors

Connectors are used to join the wire rope to the anchor and the steep slope harvesting machine.

There are various types and most have advantages and disadvantages. There is no 'best' connector.

Common end connection options



Left: The stopper should be to the right of the second or slave ferrule to stop it from being forced into the block. A challenge with pressed ferrules is that the soft ferrule metal wears easily if dragged along the ground.

A Ensure that cable connections do not contact sheaves

Always grommet or bolt shackle ends.

Logger's eye splice

The logger's eye splice is the most common end connector in winch-assisted harvesting operations due to quick splicing time and its popularity in cable harvesting operations. It also pulls easily through the block and is easy to inspect.

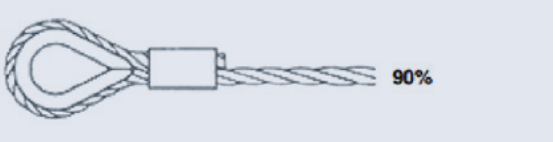
However, the spliced eye is not the strongest connector (~80% efficiency). Using a thimble adds strength and prevents eye deformation (up to 90% efficiency). Balancing strands is not as critical as thought. Eye splices failed at the last tuck at similar tensions, whether balanced or not.

Logger's eye with rollover shackle and hammerlock link.

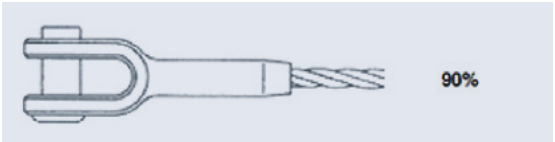
Tuck loggers eye splice three times on one side and two on the other (ACOP).

Ensure no eye-to-eye splices.

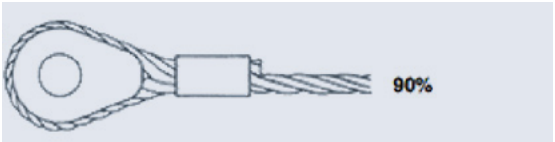
Different connector's strength compared to the wire rope



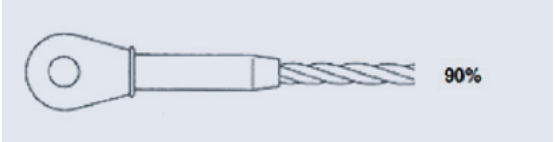
DIN 3093 Aluminum Splice with HD Thimble



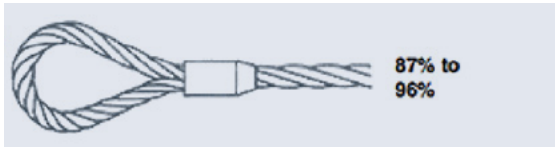
Open Swaged Socket



DIN 3093 Aluminum Splice with Solid Thimble

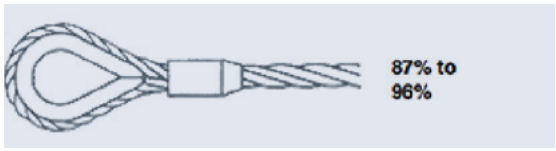


Closed Swaged Socket

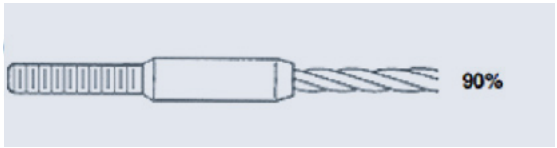


Flemish Eye with steel sleeve

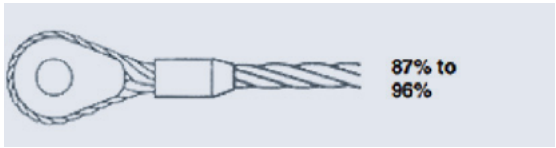
UNI-LOC™ Button



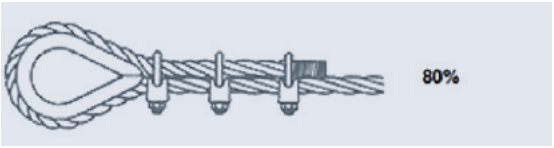
Flemish Eye with steel sleeve and HD Thimble



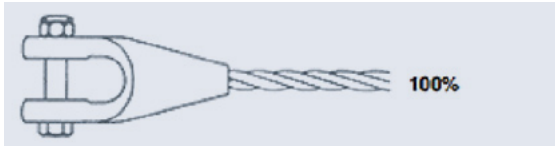
UNI-LOC™ Threaded Stud



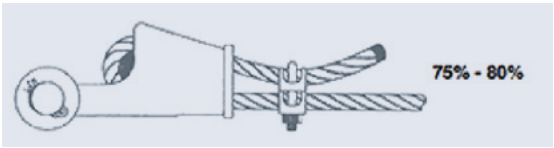
Flemish Eye with steel sleeve and Solid Thimble



Forged Wire Rope Clips



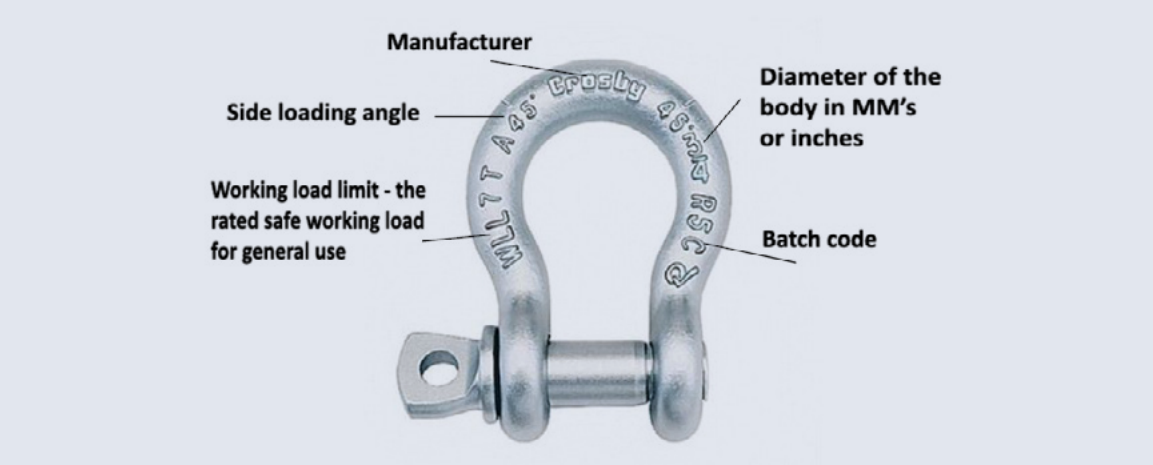
Open Spelter Socket (Closed not shown)



Wedge Socket

Shackles

Shackles need to be rated to match the SWL requirements for the rope. The safe working load, the Working Load Limit (WLL) is marked on the shackle.



Use shackle with visible WLL markings.

Guidance for connectors

- Check end connectors daily.
- Use a rigging register. Maintain a schedule and document inspections, maintenance, replacements and incidents. The register must list each component's rated breaking limit, the SWL and the safety factor.
- Every connector's rating must match or exceed the wire rope safe working load.
- All rope eyes must be married and spliced with a minimum of three tucks per strand.
- An approved wire rope company must form swaged eyes.
- Anchor strop strength must be equal or greater than that of the winch rope.
- Ensure that cable connections do not contact sheaves. Use a second pressed metal ferrule where the ferrule could run into blocks or sheaves.
- Use a heavy-duty chain segment to prevent or reduce wire rope wear close to the steep slope harvesting machine.
- Replace rigging as per the manufacturer's requirements.
- Prevent shock loading to the wire rope and other system components.