ROPE AND ROPE WORKS, KNOTS, TIES, AND SPLICES

OBJECTIVES

After reading this chapter, you should be able to:

- identify the different types of ropes;
- state the uses of each ropes;
- discuss preservation and maintenance of ropes;
- explain the procedure in making knots and splices; and
- calculate the breaking strength and safe working load of the different types of ropes.

5.1 Construction of Ropes

A rope can be made from almost every pliable material but is generally composed of vegetables fibers, synthetic fibers, steel, iron or copper wire.

Types of Rope Construction

1. **Three-Strand of Hawser-Laid Rope** – The construction of this type of rope, sometimes called **Plain Lay**, is the general standard type of rope for all ordinary purposes.

2. **Four-Strand** or **Shroud-Laid Lay** – Provides the rope with greater bearing surface than three-strand rope, but its weight is greater and its strength less than the three-strand rope of the same size.

3. **Cable-Laid Rope** – This is made by laying there three-strand ropes together. It is normally made **left hand**, but when required, can be made **right hand**. When used in

conjunction with wire rope as a towing spring, it is essential that the lay of the rope is the same as that of the wire rope.

4. **Unkinkable Lay** – In the construction of this lay, the twist of the yarn and the strands is the same, usually left hand, while the rope is right hand lay. This provides resistance to kinking when running through sheaves and is recommended for life boat falls in certain cases.

5. **Eight-Strand Plaited Rope** – It is made by plaiting two pairs of right-hand strands with two pairs of left-hand strands. This construction gives the same strength as the three-strand rope of the same size and it is extremely flexible and resistant to kinking. It grips well on winches and capstans, make it very suitable for mooring ropes.

6. **Braided Rope** – Consists of braided sheath over a braided core. It gives greater strength than three-strand or eight-strand rope and is very flexible, does not kink and gives more grip on capstan and warping drums because the area of contact is greater. This construction is used only for nylon ropes.

The fibers are combed out and form into continuous ribbon, spun into yarn and wound on bobbins. The yarns are made into strands which are layed into finished rope. The lay or angle at which the strands are twisted together, is an important factor governing the performance of the rope. The higher the angle of the lay, the harder the rope.

5.2 TYPES OF ROPES

1. The natural fiber ropes are as follows:

   a. **Manila Rope** – Made from Abaca plant in the Philippines. It is smooth and glossy.

   b. **Sisal Rope** – From East Africa is relatively very cheap but is not a strong as the Manila rope. It is almost white and has a hairy surface.

   c. **Hemp Rope** – Form Europe, India and New Zealand, is used mainly for small cordage.

   d. **Cotton** – A very soft rope, used for ornamental purposes.

   e. **Coir (often called Grass Line)** – Made from the coconut husk it is used before for towing and harbor springs because it will float in water but it has low strength and has been superseded by polypropylene.

2. Synthetic fiber ropes are as follows:

a. **Polyamide (Nylon)** – The strongest of synthetic fiber ropes. It has exceptional resistance to substantial loading. It is resistant to alkalis, oils, and organic solvents except acids.

b. **Polyester (Terylene)** – Almost as strong as nylon and does not stretch as much as other man-made fibers. It resists acids, oil, and organic solvent, except alkalis.

c. **Polypropylene and Polythene** – Ropes made from these fibers will float on water. They have a relatively low melting point. Both fibers are highly resistant to acids, alkalis, and oil, but may be affected by bleaching agents and some industrial solvents. Polypropylene is widely used as it has several advantages over natural fiber ropes and it is less expensive than nylon and terylene and also stronger than polythene.

Note: Ropes made from synthetic fibers is unaffected by rot and mild dew and has greater strength than natural fiber ropes. The following materials used for synthetic fiber ropes are shown in Table 5.1.

TABLE 5.1 – Properties of 40-mm Rope Made from Different Fibers

Types of Ropes	Breaking Strain (kg)	Specific Gravity	Melting Point (^{o}C)	Extension at Breaking Load
Sisal	10.4	1.50	-	10 – 20%
Manila	11.7	1.50	-	10 – 20%
Polypropylene	19.4	0.91	165	25 – 40%
Polythene	15.4	0.95	135	27 – 37%
Terylene	23.9	1.38	260	23 – 33%
Nylone	30.0	1.14	250	33 – 46%

5.3 PREPARATION OF FIBER ROPES

Natural fiber rope should be stowed away in a well-ventilated space and either hung from wooden pegs or stowed down on gratings. Do not stow oit in the vicinity of boilers as excessive heat will cause dryness which makes the fiber brittle. Manila and Sisal ropes are shortened by the action of saltwater, so after immersion in the sea, the ropes should be cleaned and dried.

Synthetic fiber rope need not special stowage like natural since both are man-made fiber ropes but they should not be stowed near boilers. They should be covered by tarpaulins when on desk as they can be harmed by exposure to sunlight. Synthetic fibers,

particularly polypropylene and polythene, have a relatively low melting point and tend to become sticky. Frictional heat is likely to develop at the warping drum which will tend to fuse the fibers so that the rope should be walk back and not surged. Few turns as possible should be taken on the drum end with polypropylene rope but on whelped drums, extra turns may be made to get a good grip.

5.4 PRECAUTIONS WHEN USING A FIBER ROPE

When a rope is under strain, as few persons as necessary should remain in the vicinity. No one should be allowed to stand in a bight of rope across a rope under strain. Synthetic fiber rope, unlike natural fiber ropes, gives no audible or visual warning when approaching the breaking point and as the stretch of the rope will be recovered almost instantaneously, there may be considerable recoil.

5.5 KINDS OF WHIPPING

Common Whipping

The end of the rope is whipped so as to prevent it from looking like a dish mop when it unravels. To avoid wastage, especially when you have a number of ropes or lines, such as reef points or lacing lines, to be whipped one after the other, apply the whipping twine direct from the container or spool and cut it off close by the rope when you have finished.

You can take the turns round towards you or away from you when you apply the whipping. If the loop starts to kink when you are heaving it out, you can guide the twine by inserting the point of your spike in the bight. If a smooth whipping is required, first smooth the twine itself by smearing it with a line of a little beeswax or a spot of tallow. The length of the whipping should be about 1½ times the diameter of the rope.

Sewn Whipping and Sailmaker's Whipping

With sewn whipping, the turns are held when you pass the twine over them along the contline and you sew it across the strands with the needle. With sailmaker's whipping, no neddle is used, the rope is just unlaid and a bight is left at the start of the whipping before the turns are taken. The bight encircles a strand and when the turns are complete it is passed over the same strand and then hauled tight. The ends are knotted beyond the whipping with a reef knot.

The sewn whipping cannot slip off the end of a smooth rope. When applied to braided or double braided ropes instead of spiraling up between the strands, it should be spaced out crosswise round the circumference. Core and sheath must be stitched together.

5.6 **KINDS OF KNOTS**

at least 15 knots of knot

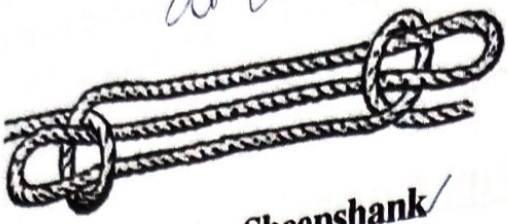

Figure 5.1 – Sheepshank

Figure 5.2 – Figure eight double

Figure 5.3 – Blackwall hitch

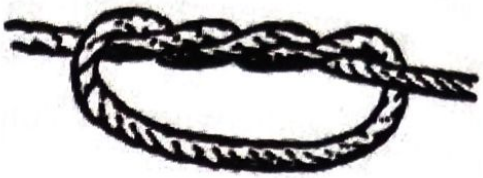

Figure 5.4 – Double overhand

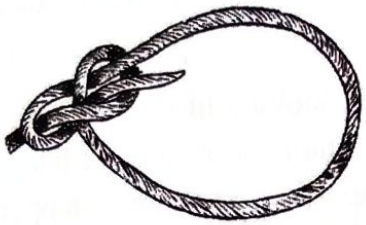

Figure 5.5 – Bowline

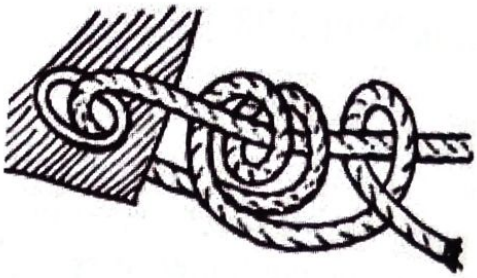

Figure 5.6 – Taut line hitch

Figure 5.7 – Hitching tie

Figure 5.8 – Bowline on bight

Figure 5.9 – Miller's knot

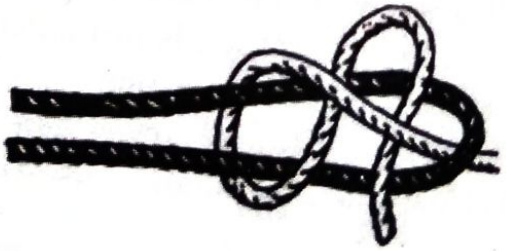

Figure 5.10 – Tiller's hitch

Figure 5.11 – Two Half hitches

Figure 5.12 – Bow knot

Figure 5.13 – Midshipman's hitch

Figure 5.14 – Fisherman's bend

Figure 5.15 – Slippery hitch

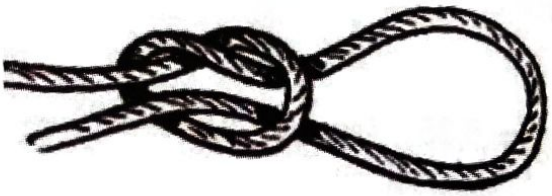

Figure 5.16 – Running knot

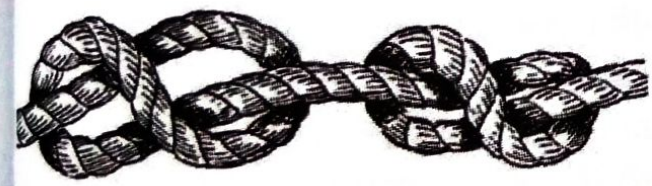

Figure 5.17 – Figure eight knot

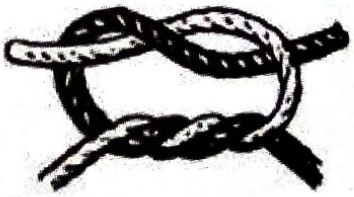

Figure 5.18 – Surgeon's knot

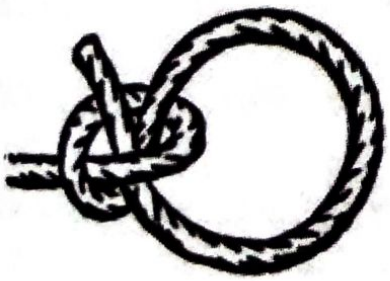

Figure 5.19 – Lariat loop

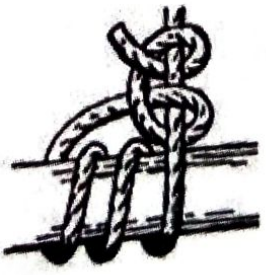

Figure 5.20 – Rolling hitch

Figure 5.21 – Cat's paw

Figure 5.22 – Lark's head

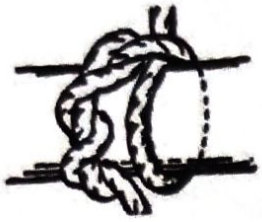

Figure 5.23 – Killick hitch

Figure 5.24 – Timber hitch

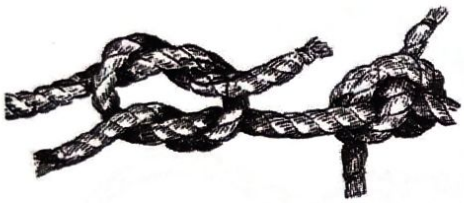

Figure 5.25 – Granny knot

Figure 5.26 – Marlinspike hitch

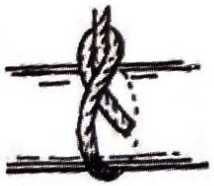

Figure 5.27 – Half hitch

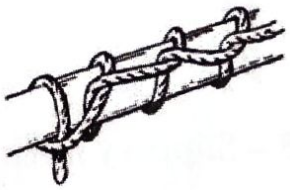

Figure 5.28 – Chain hitch

Figure 5.29 – Fisherman's eye

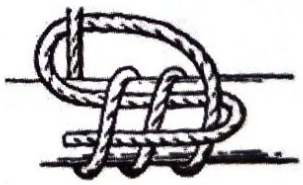

Figure 5.30 – Halyard bend

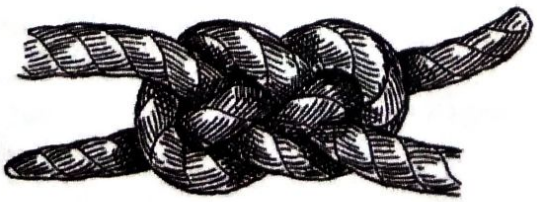

Figure 5.31 – Garrick bend

Overhand Knot or **Thumb Knot** – A stopper knot and is made to prevent a rope from slipping through your hands. It is also being made if a rope is not to slip through a ring, eye, or hole.

Figure of Eight knot – This is thicker and, therefore, more efficient than the overhand knot. It is also preferable because it does not jam as tight and it is always very easy to undone even after being subjected to a great load.

Two-Half Hitch – The first-half hitch is slipped when you need to be able to free the hitch easily. When the rope is long, the hitch is made with doubled rope to save having to pull all through. The fishermen's bend is most often used when making semi-permanent mooring lines fast or when bending the anchor cable to the anchor ring.

Clove Hitch – Used to attach a rope (say mooring rope) to an object such as mooring post. After passing the line around the post or the rope, be sure to take end beneath standing part before taking the second turn around the post or rope, because otherwise, the hitch will be awkward to complete and more importantly, much more difficult to free.

5. **Rolling Hitch** – Made when a line under load must not slip along a spar or another rope, as for example, to secure a pendant to the following:

   a. A shroud.

   b. A sty or mast.

   c. Halyard to a yard or gaff or a sailing dinghy such as an optimist.

   d. Secure the line beneath the flag that holds it to the flagstaff or individual towropes to a central towrope when a number of boats are towed in parts.

6. **Bowline** – Made when a non-slip loop is required, as for example, in a mooring rope, a warp, or a towrope. You will have no difficulty over making knot. To lengthen a towrope or anchor cable, you make bowline in the ends of both ropes with the loops interlocking like chain links. If the rope is very slippery.

WIRE AND WIRE ROPES

OBJECTIVES

After reading this chapter, you should be able to:

- identify and explain the different types of wire ropes, their uses, and how they are constructed and preserved;
- identify and use properly the different wire rope fittings; and
- measure correctly the diameter of a wire rope and calculate the strength and the safe working load of the different sizes of wire ropes.

6.1 WIRE ROPES

Wire ropes used for marine purposes usually consist of six strands laid up around a central heart of fiber or about a seventh wire strand. Each strand is made up of several wires twisted around a central fiber core or around a single center wire, the number of wires of the rope depends also on the purpose for which it is required. Increasing the number of wires to the strand for the same size of rope gives greater strength and flexibility.

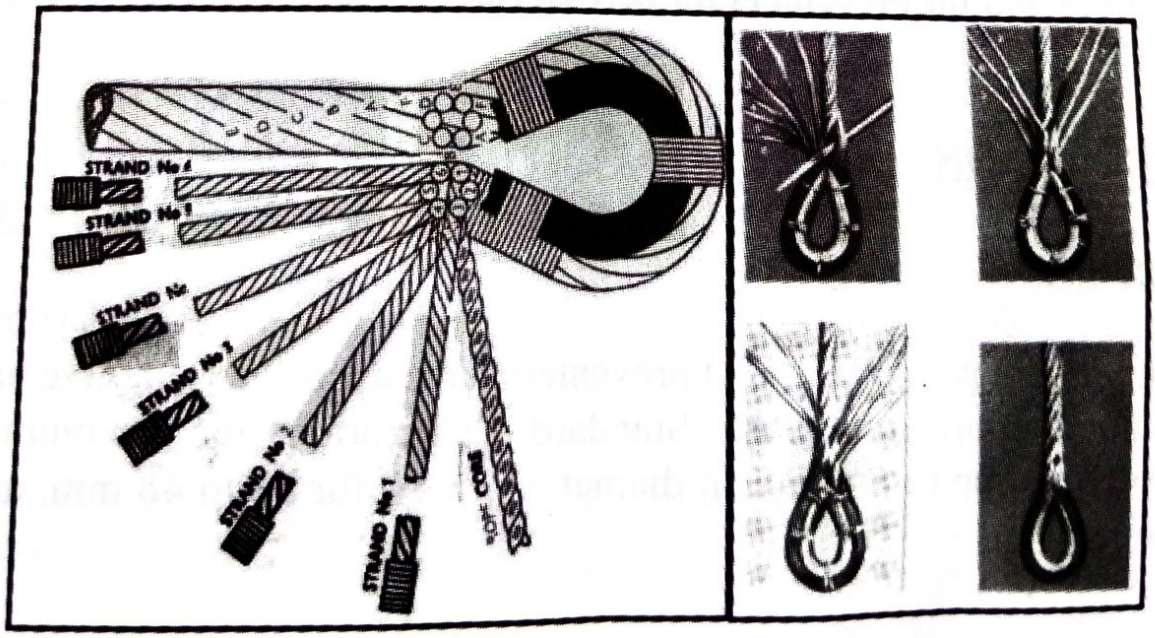

Figure 6.1

Wire ropes are referred to by two numbers, the first indicates the number of strands, including strands which maybe used for the central heart, and the second indicates the number of wires to the strand

6.2 TYPES OF LAY

1. **Ordinary Lay**

   The wires are twisted in the opposite direction to the strands. Right-hand rope is normally used in which the wires are twisted left-handed in the strands re-twisted right-handed.

2. **Lang's Lay**

   The direction of twist of the wires is the same as the direction of the strands. This lay provides a greater wearing surface but should only be used when both ends of the rope and the load are secured against rotation. It is not likely to be used for marine purposes.

3. **Performed Rope**

   Each strand of this type of rope is performed into a helix so that it will be easier to handle and less likely to kink.

4. **Spring Lay**

   This is a combined rope consisting of three galvanized wire strands and three fiber strands laid up around a central fiber core. The rope is cable laid, each main strand being made up of three-fiber strands and three 19-wires strands over a fiber strand core. Spring lay rope is four times stronger than fiber ropes and 50% stronger than nylon. It is much easier to handle than ordinary wire rope and is very suitable for mooring ropes and for preventers for derrick rigs.

6.3 APPLICATION

Standing Rigging

Wire ropes used for stays, shrouds, and preventers have a steel core to give extra strength, flexibility is not important. British Standard Publication 365 recommends *7 x 7* construction for wires up to 28 mm. In diameter, *7 x 19* for 32 to 48 mm, and *7 x 37* for over 52-mm rope.

Cargo Lashing

6 x 12 ropes are recommended for sizes 8 to 16 mm and *6 x 24* construction for larger sizes.

Cargo Handlings

6 x 24 construction is usually used but *6 x 19* ropes are also suitable for ropes up to 24 mm.

Mooring Ropes

Wire ropes *6 x 37* construction are recommended for general used but for powered winches, *6 x 36* ropes with a wire core should be used for sizes up to 40 mm and *6 x 41* for sizes 44 to 60 mm.

6.4 HANDLING A WIRE ROPE

1. When uncoiling a wire rope, it is important that no kinks are allowed to form as a kink is made, no amount of strain can take it out and the rope becomes unsafe to work. If possible, a turn-table should be employed (an old cart wheel mounted on a spindle makes an excellent one) with this the rope will then lead off perfectly straight without kinks.

2. If a turn-table is not available, the rope maybe rolled along the ground

3. In no case must the rope be laid in the ground and the end taken over or kinks will result and the rope will be completely spoiled.

4. The life of a wire rope depends principally upon the diameter of drums, sheaves, and pulleys, and too much importance cannot be given to the size of the latter. Wherever possible, the diameter of the sheave should not be less than 20 times the diameter of the wire rope. The diameter of drums, sheaves, and pulleys should increase with the working load when the factor of safety is less than 5 is to 1.

5. The load should not be lifted with a jerk as the strain may become equal to three or four times the proper load, and a sound rope may easily be broken.

6. Examine ropes frequently, a new rope is cheaper than the risk of killing or maiming employees.

7. One-sixth of the ultimate strength of the rope should be considered a fair working load.

8. To increase the amount of work done, it is better to increase the working load than the speed of the rope. Experience has shown that the wear of the rope increases with the speed of the rope.

9. Wire rope should be greased when running or idle. Rust destroys as effectively as hard work.

10. Great care should be taken that the grooves of drums in sheaves are perfectly smooth, ample in diameter and conform to the surface of the rope. They should also be in perfect line with the rope so that the latter may not chafe on the sides of the grooves.

6.5 WIRE SPLICING

The Docks Regulations of the Factories Act requires that a thimble or eye splice should have at least three tucks with the whole strand of the rope and two with half the wires cut out of each strand. The strands must be tucked against the lay of the rope. The "Liverpool Splice" is relatively quick and easy as after the first tuck, each end is passed with the lay around the same strand, four or five times but such a splice should never be used if the end of the rope is free to rotate. If the splice is made with the lay, rotation will cause the tucks to draw and the splice to pull out.

A long tapering steel marline-spike is required. After placing it under a strand, do not withdraw it until the tuck is made and all the slack of the strand drawn through. Wire splices should be parceled with oily canvas and served with Hasbro' line.

6.6 SPLICING THIMBLES UNDER AND OVER STYLE

Ordinary type of wire rope serve the rope with wire or tarred yarn to suit the circumference of the thimble. Bend around thimble and tie securely in place with temporary lashing until splice is finished. Open out the strand taking care to keep the loose end of the rope to the left hand. Now insert markline-spike, lifting two strands and tuck away towards the right hand (that is inserting at the point and over the spikes) strand no. 1 pulling the strand well home. Next, insert markline-spike through next strand to the left only lifting one strand, the point of the spike coming out at the same place as before. Tuck away strand no. 2 as before.

The next tuck is the locking tuck. Insert markline-spike in next strand and missing no. 3, tuck away strand no. 4 from the point of the spike towards the right hand. Now, without taking out the spike, tuck away strand no. 3 behind the spike towards the left hand. Now insert spike in next strand and tuck away strand no. 5 behind over the spike no. 6. Likewise, pull all the loose strands well down.

This completes the first series of tucks and splice will, if made properly, be starting with strand no. 1 and taking each strand in rotation, tuck away under one strand and over the next strand until all the strands have been tucked three times. The strands should at this point be split, half of the wires being tucked away as before and the other half cut close to the splice shows the finished splice ready for serving over.

It will be noticed that this style of splice possesses a plaited appearance and the more strain applied to the rope, the tighter the splice will grip and there is no fear of the splice drawing, owing to the rotation of the rope.

The illustrations of the first series of tucks for the "Five-Tuck Splice" or "Boulevant Splice" are reproduced with permission of British Ropes Limited from their publication "Terminal Splicing of Wire Ropes." Subsequent tucks are made against the lay under one strand and over the next as in the previous case.

6.7 STRENGTH OF WIRE ROPE

The breaking stress of flexible steel wire rope in tonnes is given, approximately, by the following formulas:

$$6 \times 12, \frac{15D^2}{500} \text{ tonnes}$$

$$6 \times 24, \frac{20D^2}{500} \text{ tonnes}$$

$$6 \times 37, \frac{21D^2}{500} \text{ tonnes}$$

D is the diameter of the rope in millimeters.

The safe working load may be taken as one-sixth of the breaking stress.