Module 4 – Ropes, Tapes & Slings

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4.0 Introduction – Ropes, Tapes & Slings

The following precautions must be followed in the care and handling of abseiling ropes.

- Prior to jumping, an inspection of rope is to be carried out by both the Jumpmaster AND the Site Controller.
- During the activity, ropes and anchor points are to be inspected for damage by an Abseiling Leader after approximately fifty (50) jumps and any time the site has been left unattended.

4.1 Selection of Ropes

There are two types of kern-mantle design ropes, one is a dynamic rope and the other is static. Dynamic rope is designed to absorb the sudden shock of a falling climber and will stretch approximately 7% (max 12%) over the total length of an 11mm rope. Static rope will stretch less than 2% (max 5% dependant upon brand) of the total length and is designed for Abseiling and caving.
The suggested and recommended Abseiling lines are 11mm. Synthetic static Kernmantle ropes. i.e. "Bluewater 2+", "Black Marlow", "Donahues" and "Kinnears 13mm Arapaline".

The following conditions apply to the use of ropes:
Nylon / Polyester laid rope is NOT to be used for Abseiling at any time.
Reason: Nylon / Polyester rope has no shock loading and cannot handle a sudden load and the friction given off from a figure 8 descender will cause the rope to melt.

Climbing ropes are NOT recommended for Abseiling.
Reason: Dynamic rope is high in elasticity causing difficulty in braking and control and is not recommended for Abseiling.

Natural fibre ropes, (Manila and Sisal), are NOT to be used for abseiling or as a safety / belay rope.
Reason: Natural fibre ropes are not a uniform strength and give no warning when they break.

Most of these lines are constructed in a kernmantle design which is formed by two basic parts, they are as follows:

The Kern - The inner part of the rope which is made from continuous nylon filaments may be either twisted for dynamic rope or lightly twisted / braided for static rope, and is the main load bearing section which is responsible for the major strength (80%) and stretch of the rope.

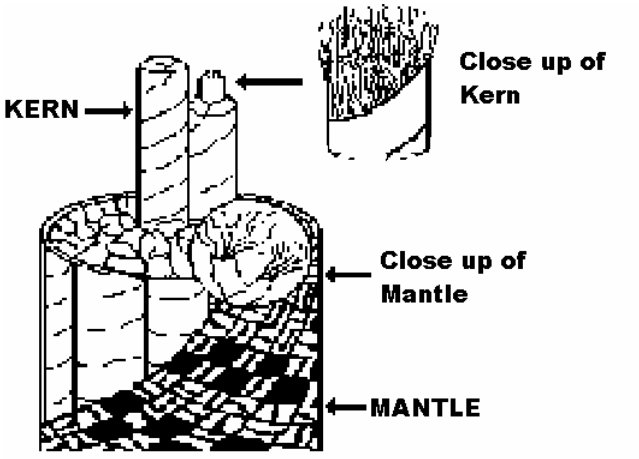

Figure 4-1 Rope showing Kernmantle design.

The Mantle - The outer part of the rope which is a braided cover which protects the kern from abrasion and provides the feel of the rope. On Abseiling and caving ropes the mantle is more tightly woven than dynamic rope to prevent grit from entering into the kern. The balance of the ropes strength (20%) is in the Mantle.

- The maximum length of continuous line commonly available is 200 metres (656ft). The normal length that we use is 50 metres (164ft) - This is mainly due to the weight, line control and tangle factors.

- Be careful if anyone offers you a rope, in most cases you may not know its full history or the reason that they want to get rid of it. Be aware of sailing rope, sailing rope is a kern-mantle design rope that looks and feels like static rope and quite often has a different safe working load. Sailing ropes are normally replaced every couple of years because of the salt eating at the nylon filaments in the kern.

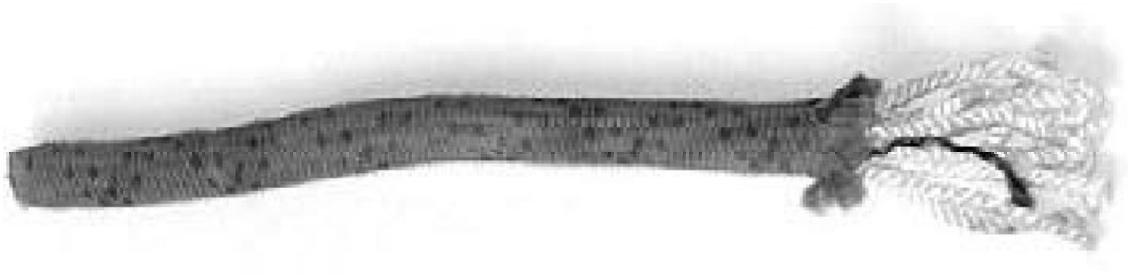

Figure 4-2 Example of an exposed Kernmantle Rope design.

4.1.1 Rope strengths

It should be noted that 11mm static rope has an approximate breaking strain of 3000kg or greater, depending on manufacturers specifications. However when there is a knot present, up to 50% of the total strength can be lost at the knot.

4.2 Static Rope tests

This information is based upon the manufacturer's destructive testing data, and therefore not recommended for general testing of ropes.

4.2.1 Test for maximum breaking strength

In the tensile test, the rope is checked for breaking strength and elongation under various strains. In this test, the rope is tensioned between two posts and stretched until it breaks. The posts have a large radius, so that the rope twisting does not influence the test results. The rope should break between the posts. Before the test, the rope is measured for length, and elongation is measured for different loads. This is not easy to achieve in practice, and so a representative test is that of breakage over edges and at the knot.

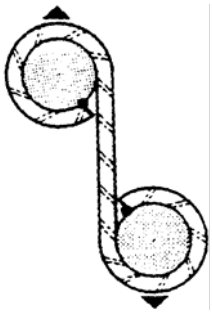

Figure 4-3 Test for Maximum Breaking Strength

4.2.2 Test for breaking strength over edges

On a vertically hung rope that is weighted, the load is spread across the full cross-section of the rope. All the rope fibres are equally stressed. If a rope is twisted the load varies on the fibres where the twist occurs. The fibres on the outside are stretched further than those on the inside. Therefore only a part of the cross section is available to absorb energy. The strength of the rope is correspondingly reduced. In general the sharper the angle, the lower the strength of the rope. A Karabiner with a radius of 5mm reduces the rope strength to about 70%. In the test, the rope is led at an angle of 150^{o} over an edge of 5mm radius, and loaded to breaking point. This radius corresponds to the diameter of the usual karabiner.

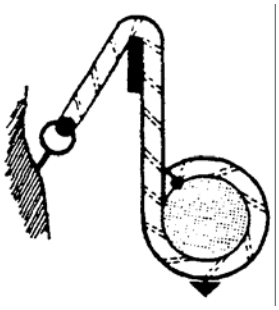

Figure 4-4 Test for breaking strength over edges.

4.2.3 Testing the breaking strength of knots

Knots are turns of the rope and reduce its total strength. The larger the turn, the less is the decrease of strength. This means in practice, that knots of a large radius (Figure of 8 knots) are stronger than knot of a small radius (fisherman's Knot). However, knots must be correctly tied. If they are incorrect then they may have additional turns, or the turns may be sharper than intended, so resulting in a greater loss of strength.

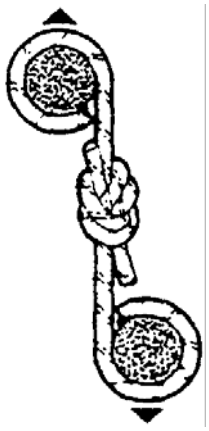

Figure 4-5 Test for the breaking strength of knots

Testing knots, one distinguishes between:

A. Knots for rope connection: The connecting knot is tied in the test rope, which is then put in tension between two bollards (pegs).

B. Rope loops: The rope end with the knotted loop is hung over a 10mm peg, the free rope end is taken round a pivot of large radius (By testing in this way, the strength at the peg is greater than at the knot).

4.3 Use of Ropes

The following points, that should be observed are:

A. Ensure that only suitable lines for abseiling are being used. (Refer to Section 4.2)
B. Select a suitable anchor system. (Refer to Module 7)
C. Identify a secondary anchor system for a safety line.
D. If there are any sharp / rough edges, a line sleeve / carpet should be used.
E. Leave all excess rope in the line bag and place the line bag right up against the wall or cliff face, this avoids line damage due to people landing on it and also from any falling debris.
F. Regularly check the total anchor system for any signs of damage to the line or loosening of knots.
G. You should never use the same anchor system for both your "safety line" and "main line".

4.4 Protective Sleeves / Carpet

Protective sleeves are used to prevent damage to ropes. They are placed on the line and slid down the rope to protect it from any sharp protrusions on the cliff face (Fig 4.5)

Carpet can be laid down on the top of the cliff face, to protect the rope from sharp objects and stop dust and grit getting into the mantle. Although carpets have the disadvantage of hiding holes and protrusions from students, the protection of the rope far outweighs this problem. (Fig 4.6)

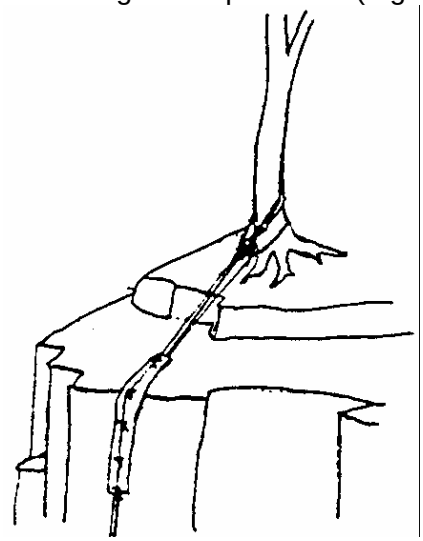

Figure 4.6 Illustration of a Line Sleeve

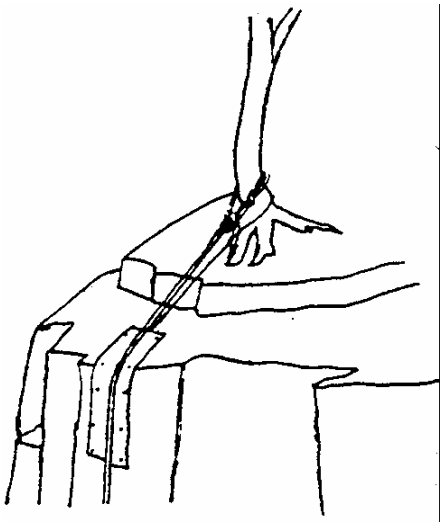

Figure 4.7 Illustration of carpet protection

Note: When using fire hose for protective sleeves beware of using the new type fire hose as the internal polyester lining may cause chemical reaction with the kernmantle rope. Use only the older style canvas / wet type hose. If in doubt, don't use it, also ensure that the hose has only been used for water.

4.5 Care and Storage of Ropes

Since the equipment for abseiling is expensive, due consideration of appropriate storage facilities to maintain its integrity is important, the following conditions are to be observed in the care and storage of ropes:

- Ropes are to be stored in a dry, well aired area, away from direct sunlight or any heat source.
- Ropes should not be stored directly on the floor or ground.
- Ropes are not to be stored near chemicals or other agents that may damage the rope.
- Ropes are not to be left tightly stretched for longer than necessary.
- Static ropes should be kept clean of dirt and dust and washed often to prevent damage to the kern and mantle.
- Ropes that are wet are to be hung out to dry in a well aired position, away from direct heat and sunlight.
- Ropes should have colour coded ends or be labelled to indicate the length of the rope. There is nothing worse than laying out a rope and discovering that the rope is 5 metres too short for the jump site. Line bags should also be marked to indicate the length of rope stored in them and the date purchased.

4.6 Line Bags

Line bags have three main purposes:

A. One to store and protect the rope from tangles and harmful substances. It is important to protect your investment of a rope, 200 metres of Bluewater rope cost up to approximately $800-$900.

B. Line bags make it easy to set up a jump site, just attach the rope to the anchor system, walk to the edge of the cliff and call "Rope Below" before throwing the bag over the edge. The line should easily sail down to the bottom, provided that the rope was coiled in correctly. Always ensure that the line is tied to the bag, so they do not separate if the rope is too short for the cliff. Before deploying the rope always ensure that you have a safety line attached.

C. The other purpose of the line bag is for very long Abseiling jumps, the line bag is attached to the leg or harness of the Abseiler, so the entire weight of the line rope is not hanging from the descender acting like a brake, thus making the Abseil difficult and dangerous.

4.7 Storing of ropes

There are three recommended methods of storing kernmantle ropes used in Abseiling:

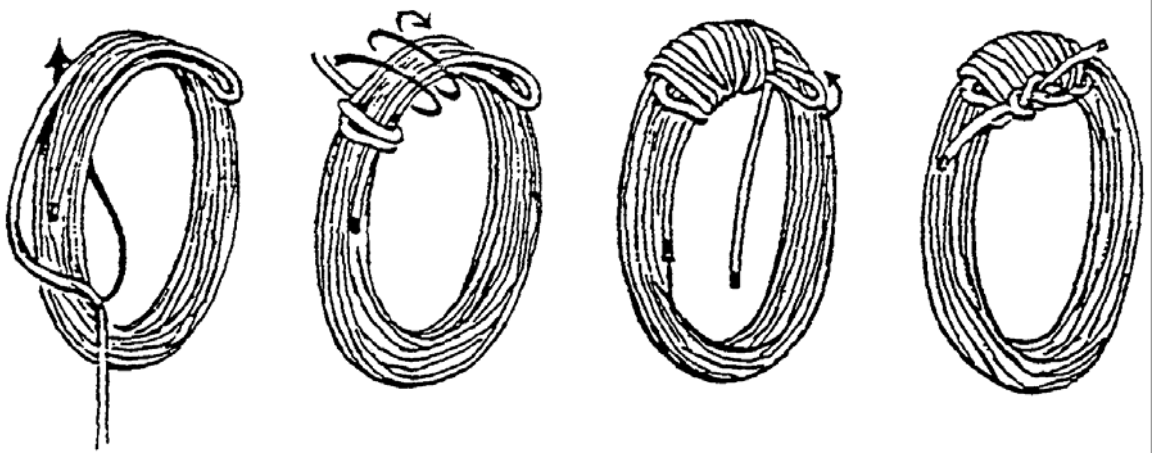

Figure 4.8 Mountain Coil

Mountain coil

Used for static ropes. The rope is formed into coils and one end is folded over to form a loop, the other end is wrapped around the coils and the loop 4 to 6 times, then the end is passed through the loop, then excess part of the loop drawn tight to hold the turns of rope around the coils.

Chaining a Rope

Chaining of the rope is simply a matter of making a series of overhand loops with the rope. This is particularly useful for when a rope is to be washed as it avoids tangles when the rope is taken out to be dried.

Stuffing Rope Bags

Rope Bags as the name suggests is for the storage and cartage of rope. The end of the rope is tied into the base of the bag so that when the line is deployed the bag is not lost. To avoid tangles, when the bag is stuffed the rope is laid into it following the outer

side of the bag for a normal stuff pack, or with the rectangular bags is laid from end to end within the bag. This is very important and is learned by doing. Do not be tempted to think of this activity being below the Abseiling Leader and the province of the Assistant. Everyone needs to be conversant in this task as a tangled rope can cost you hours on a site.

4.8 Washing of ropes

After a while most Abseiling rope becomes dirty and stiff from use, thus making a descent quite difficult and causing excessive wearing down of descenders. To wash the rope, use warm water and a small amount of natural soap. Natural soap is not as effective as mild detergents as natural soap does not contain the additives to suspend the dirt particles in the water. Do NOT use chlorine bleaches (including the brands with oxidising agents) as they will destroy the rope. Ropes should be either chained or loosely bundled into a mesh bag then loaded into a washing machine. Be careful of using top loading washing machines with a central agitator, the rope may tend to become tightly twisted around the agitator and damage may occur to the rope and the washing machine. With front-loading machines, make sure that the window on the washing machine is made of glass and not a soft plastic as it is possible to damage the rope form abrasion from the plastic lens.

Be careful when using washing machines as the next person's washing is likely to come out worse than when they started. This is due to the black aluminium oxides and fine dirt particles that form during normal abseiling activities. These materials can and will collect on the machine tub or remain in the water pump and spread in the next wash.

Nylon rope can stand being soaked in water with a temperature of 82^{o}C with no deterioration. However shrinkage of the weave of the mantle may occur. To prevent this set the water temperature between cool and warm for a very dirty rope. The water in most Laundromats is about 60^{o}C, but check this first. Be aware also that many Laundromats will not approve of the use of their machines for washing ropes.

All indications point to the fact that fabric softeners are not good for nylon compound rope. From time to time fabric softeners have been recommended as a way of softening well used stiff rope. But tests on aging rope have indicated a substantial weakening of the rope. It is thought that the weakening is due to the bonding of free hydrogen molecules from the fabric softener to the nylon polymer, thus changing the molecular structure of the nylon in the rope.

After washing the rope, dry the rope out in the open air in a shaded place to prevent ultraviolet radiation damage. Always ensure that the rope is completely dry before packing away as the rope can be affected by mould. Never use a clothes dryer to dry out ropes as the heat will damage the nylon filaments in the kern and mantle.

4.9 Internal damage

Do not assume a rope is safe just because it appears to be in good condition. Ropes frequently deteriorate from the inside out. Damage to the rope may be from internal or external sources.

This can be caused by:

A. Flexing of the fibres as the rope passes through a sharp bend.
B. Cutting of the fibres by grit forced into the fibres.

C. "Fracturing" of the fibres as they stretch under excessive load.
D. Chemical damage through accumulation of salt and other substances.

The first two are particularly relevant to abseiling, so despite the low loading factor, an abseil rope is subjected to quite high stress. To minimise damage, keep ropes clean. Wash dirty ropes in warm water containing a small amount of natural soap.

A disadvantage of braided and kernmantle ropes is that they are very difficult to check for internal damage.

4.10 External abrasion

All ropes become "furry" after a short time, this is caused by the breaking of the filaments of the mantle. This will not cause a great loss of strength and may even improve the handling and friction of the rope. When the mantle of a rope has a 50/50 ratio between the unbroken and the broken filaments, the rope should be retired. Regard any cuts, nicks, distortion of the lay, surface melting or permanent stretch, as serious damage and retire the rope. Both polyester and nylon ropes have a moderate resistance to external abrasion. A sharp edge will, however, cut and damage a rope under load. So protect ropes wherever they run over rocks, particularly where a rope leaves a cliff. Good protection can be provided by using a carpet strip or a rope protector on the edge of the cliff. (refer to Section 4.5)

4.11 Inspection of Ropes

Abseiling ropes should be regularly checked for damage to the kern and to the mantle. To check the Kern, slide the rope through your hand and feel for any distortions in the rope. Be on the look out for lumps, bulges or thin spots, this indicates that some of the nylon filaments (kerns) have broken and may have slide back up the rope. Any visible change in the diameter of the rope, the rope should then be condemned. Also ropes that have damage to the mantle such as puffs of kern coming through the mantle should also be condemned. (refer to Section 4.17)

4.12 Overloading and Stretching

Permanent stretching and damage can result from heavy overloading on a rope. Any rope that has been placed under such stress should be rested for a minimum of 24 hours then measured. If any rope is stretched beyond 5% of its original length, it should be condemned and cut up. (refer to Section 4.17)

NOTE: Abseiling ropes do not make good tow ropes or flying fox ropes.

4.13 Sunlight

Ropes should not be left in strong sunlight, since prolonged exposure, indicated by bleaching will weaken them. Synthetic ropes are particularly susceptible, since Ultra violet light (for a prolonged length of time) will break down the chemical composition of the material used to make the rope. In extreme cases strong sunlight will cause charring or fusing. Mild heat will not cause deterioration but may well weaken a rope just the same. Any rope that has been subjected to or suffered from excessive heat, or has been bleached by sunlight or have a brittle feel about it should be retired. (refer to Section 4.17)

4.14 Water

Some forms of the Nylon brands of ropes may lose up to 25% of their strength when wet, although they regain full strength when dry. Dry out wet ropes as soon as possible by hanging them out in a dry, well aired area. Never use fires or electric heaters to dry rope as this may damage them. (refer to Section 4.17)

4.15 Melting of line

The "Achilles heel" of synthetic ropes is their low melting point (200 degrees Celsius). The use of an abseil friction device creates heat which can melt the outside of a rope, so ensure abseiling is done using the appropriate descender and technique for the length of drop to limit the build up of heat. Also don't let synthetic ropes run over each other as the heat generated will quickly melt through the static rope.

4.16 Rope Life

The Approximate life of an abseiling rope is:

2 - 4 Years	- Occasional use (Vacation)
2 Years	- Normal use (Weekend & Vacation)
1 Year	- Heavy use (Instructing / towers etc)

NOTE: Abnormal factors WILL shorten the life of the rope. (refer to Section 4.9)

4.17 Condemnation of Rope

A rope is to be condemned if any of the following apply:

- Where there is any sign of white tufts coming through the mantle which indicates that the inner core (kern) is damaged.
- When there is any doubt as to the strength or age of the rope.
- Where there is any sign of deterioration caused by contact with any chemicals or other harmful agents.
- Where there is any distortion in the rope. eg Noticeable flat spots and bulges.
- Where the rope has been stretched beyond 5% of its original length.

4.18 Disposal

The recommended procedure for the disposal of ropes is to cut them into short lengths, thereby making them unsuitable for abseiling.

4.19 Tapes

Nylon tape used for Climbing and Abseiling is constructed in a flat or tubular webbing weave in widths between 10mm and 50mm. Flat tape is usually available in two thicknesses, standard and super. Tubular tape is usually softer than flat tape, and 'feels' and handles well. It holds knots poorly, however, and is more prone to damage by abrasion and cuts than stiffer, tougher, and tighter flat tape.

When tying a tape knot in a sling, leave a tail of at least 100mm poking out from each end, then using some PVC / Electrical tape, tape down the ends of the tape. A commercially sewn sling is stronger at the join than a knotted one of the same tape and a sewn join is neater and smaller than a knot.

4.20 Slings

These can be used to attach a student to an Abseiling Leader if a student is unsure of the descent. This can be done to instil confidence in the student and is normally made from a length of 25mm (1 inch) tubular tape which is tied with a tape knot and is approximately 1 metre (3ft) in length. It is attached between both the "Leaders karabiner" and the "Student's karabiner" using additional karabiners.
Tapes can be used as a sling to anchor a rope around a tree in place of tying a knot in the rope. (Refer to Module 7)

Figure 4-9 Flat Commercial Sling

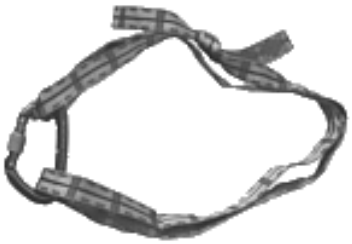

Figure 4-10 Tube Tape Sling

4.21 Care of Tapes and Slings

Replace tapes after about 3 years or immediately if damaged or involved in a fall or show wear. Keep clean by washing with warm water and a bit of natural soap, melt ends of the tape to prevent fraying. Never store Tape and Slings near petroleum or chemical products, direct sunlight or allow to remain wet. Tape slings will also harden with age and use. (e.g. sunlight and stretching) Store, clean and dry tapes and slings as for ropes.

4.22 CowTails

An alternative to slings which are used to connect elements together is the cowtail. These can be commercially purchased or made from a short length of rope and a karabiner. The uses are many, and some people may have regard them as a form of lanyard or type of climbing quickdraw in the past.

The method of making a cowtail is very simple. Simply take the end of the rope and put a barrel knot (one side of a double fisherman's knot) around the base of the karabiner firmly (slack can allow the knot to 'creep' due to movement). The other end can be tied in, be another cowtail, terminate in a connection or device of some kind.

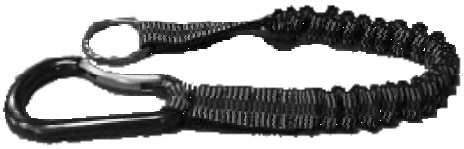

Figure 4-11 Commercial Cowtail

Figure 4-12 Made Cowtail

You will notice that the Cowtails in general use a clip karabiner rather than a screwgate. The reason is that they are generally used for the quick connection to items such as a stretcher or similar. This does not however mean that screwgates cannot be used.