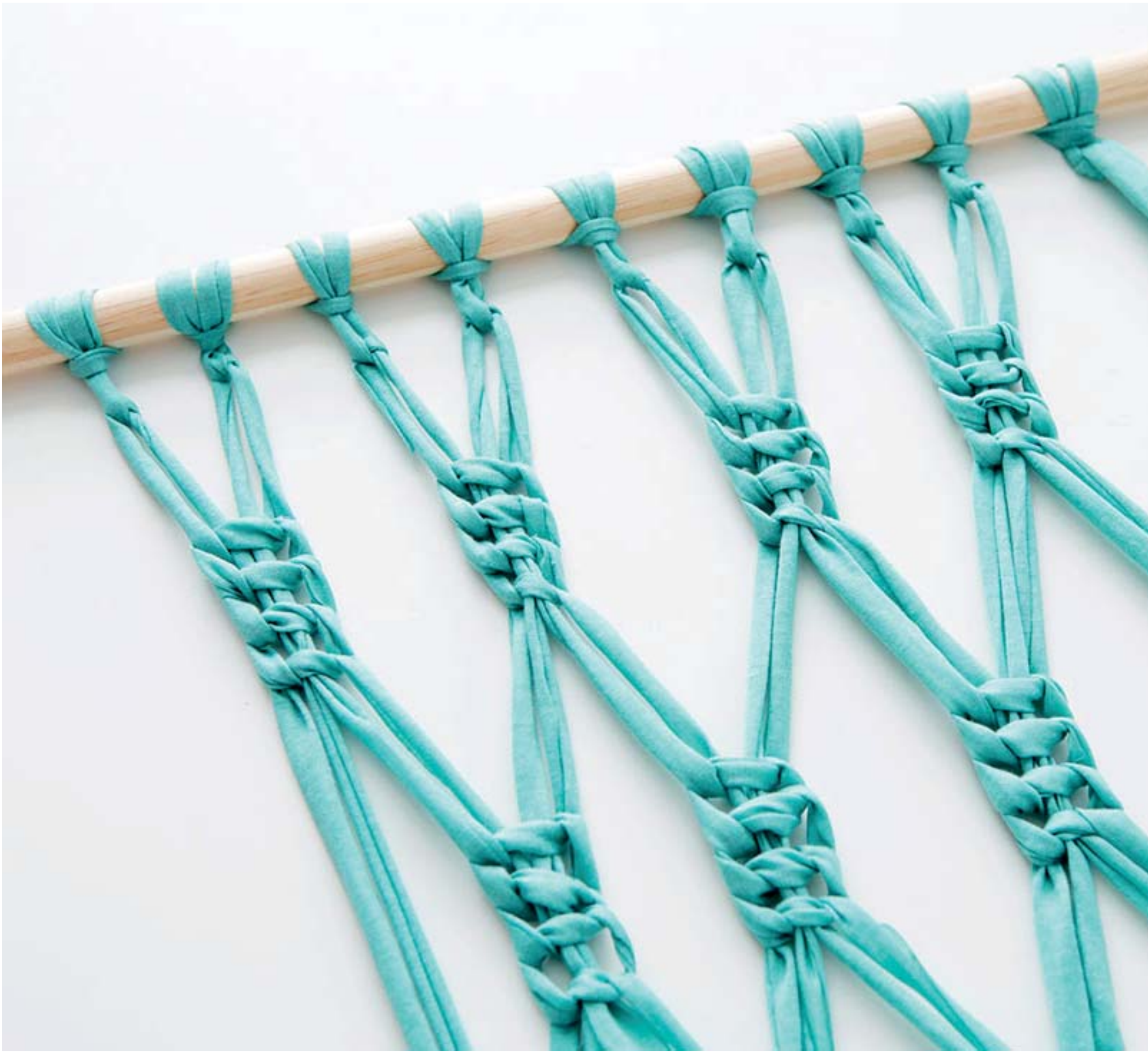


Figure 4.1. Hand knotted macramé (Taghavian, 2014).

material overview

CHAPTER 4

"Indeed, I am not sure but it would be safe to state that the real difference between civilized and savage man consists largely in the knowledge of knots and rope work. No cloth could be woven, no net or seine knitted, no bow strung and no craft sailed on lake or sea without numerous knots and proper lines or ropes; and Columbus himself would have been far more handicapped without knots than without a compass."

-Verril, 1917: 2

This chapter situates rope and rope-like materials within the realm of textiles and textile production. The discussion includes a set of precedents illustrating hand-knotted textiles as space-defining elements. Next, the chapter investigates the construction and physical structure of rope and introduces rope and knot terminology. Knots are further unpacked by introducing the various knot categories and uses of each of these main types of knots. Furthermore, rope and knot strength is discussed. Overall the chapter serves as an introduction to rope and rope-like material and knotting as fabrication method.

rope and rope-like materials

4.1.
ROPE AS TEXTILE

See section **4.1.1. Rope as textile,** on poster 8 (opposite page) for **full definition of rope as textile.** Further, refer to definition of terms in **Section 1.6, (**page 9).

...The term textile consequently refers to any filament, fibre or yarn that can be processed into cloth or fabric as well as the resultant material.

The emphasis and eventual outcome of the investigation is specifically aligned toward the application of rope and rope-like materials in the fabrication of textile space-defining elements. The use of rope allows the investigation the opportunity to apply textiles in an alternative manner within the interior. This yarn-based material is well situated within the realm of textiles. It displays the character of textiles and takes on textile functions.

See precedents **4.1.2. Hand knotted playground** and **4.1.3. Beaded curtain** on poster 8 (opposite page) as examples where rope is employed to create textile space-defining elements.

4.2.
ROPE CONSTRUCTION AND STRUCTURE

Textile manufacturing is a major industry. At present most commercial textiles are produced by industrial production methods (Peopletree, 2014). However, textiles are still produced by means of pre-industrial processes, otherwise known as traditional manual fabrication techniques. The process of manual textile production follows the same basic steps as that of the industrial process. These steps involve the manufacturing of fibres, which are then processed into yarns. Whereafter yarns are fabricated into textiles (Kadolph, 2007: iii). Industrial textile production methods include knitting, weaving, tufting and fusion bonding, braiding, twisting, combining fibres as well as extruded polymer solutions (Yeager & Teter-Justice, 2000: 97-105). Manual fabrication techniques are limited to weaving, knitting, crocheting and lace making (Peopletree, 2014). **The dissertation introduces knotting as an additional manual fabrication technique.** See Figure 4.4. Pre-industrial textile production techniques, on poster 8 (opposite page).

Knotting as manual fabrication technique is pure in its capacity to be hand-crafted, whereas other manual techniques such as knitting, crocheting and lace making require additional, albeit basic, mechanical equipment. Before taking up the matter of knot making, it is necessary to first consider rope (otherwise known as cordage) in general, as both it and the materials that it is made of, help determine its knot-making properties (Animated knots, 2012).

The structure of the cordage can also have an effect it's capacity to stretch, its flexibility, abrasion resistance, handgrip, aesthetic and more (Penn, 2015; Animated knots, 2012). The three basic types of cordage are classified according to the method of construction (How products are made, 2015). See section **4.2.1. Main rope types** on poster 8 (opposite page) for a list of the main rope types.

rope as textile

MATERIAL OVERVIEW

4.1.1.
ROPE AS TEXTILE

The term textile does not refer only to classical textile materials comprising of flat fabrics. The term textile is derived from the Latin *textilis* and the French *texere*, which means 'to weave' (Whewell, 2015). Originally the term represented only fabrics produced by means of weaving. Later however, the term also encompassed fabrics produced by additional methods. Therefore lace, embroidery, nets, threads, cords, ropes, braids and fabrics made through methods of weaving, knitting, felting, bonding and tufting are considered textiles (Whewell, 2015). The term textile consequently refers to any filament, fibre or yarn that can be processed into cloth or fabric as well as the resultant material.

Refer to section 4.1. for further discussion.

4.2.1.
MAIN ROPE TYPES

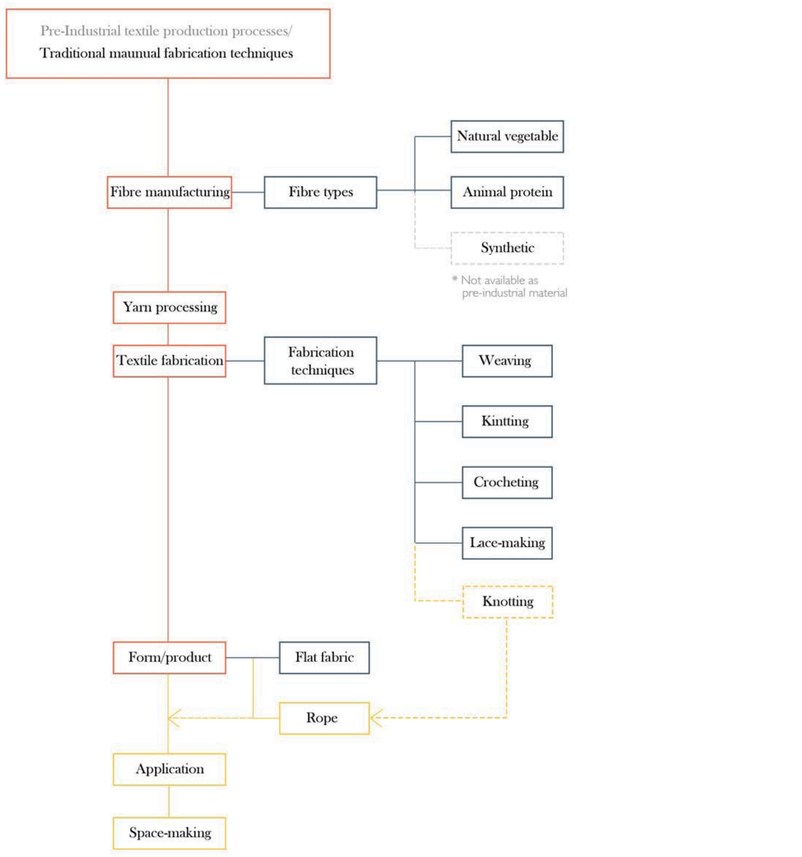
Refer to section **4.2. Rope construction and structure** (opposite page, document). Knotting as manual fabrication technique is pure in its capacity to be hand-crafted, whereas other manual techniques such as knitting, crocheting and lace making require additional, albeit basic, mechanical equipment.

The three main rope types are:

- **Twisted rope:** Yarns twisted into strands, and strands twisted into rope.
- **Braided rope:** Yarn is braided together instead of twisted.
- **Plaited rope:** Plaited rope is made by braiding twisted strands together.

See also section **4.2.1.1. Twisted rope** (following page, document) and section **4.2.1.2. Braided and plaited rope** (following page, document) for a discussion on these rope types.

Manual fabrication techniques are limited to weaving, knitting, crocheting and lace making (Peopletree, 2014). **The dissertation introduces knotting as an additional manual fabrication technique.** See Figure 4.4. Pre-industrial textile production techniques, below.



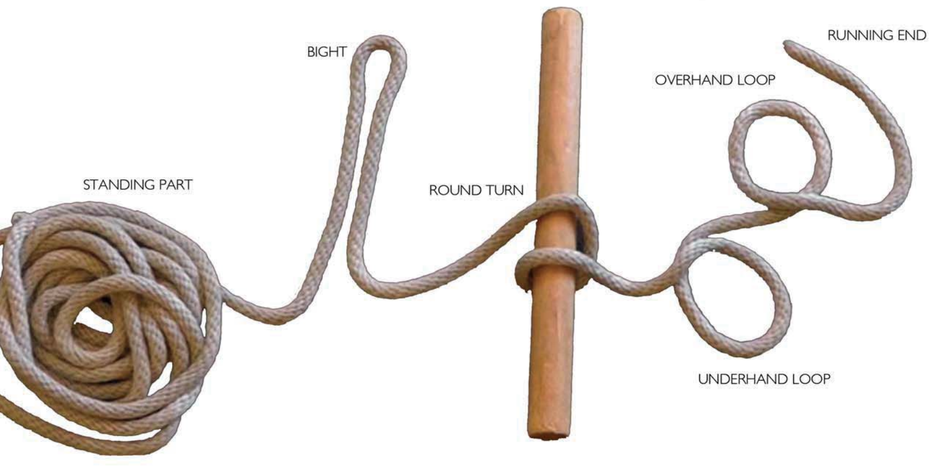
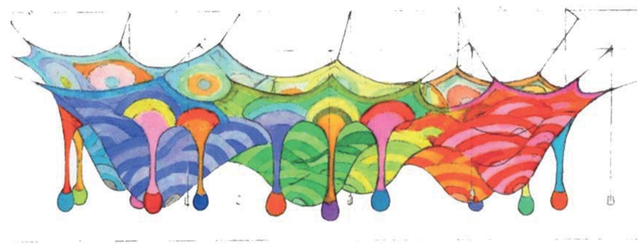
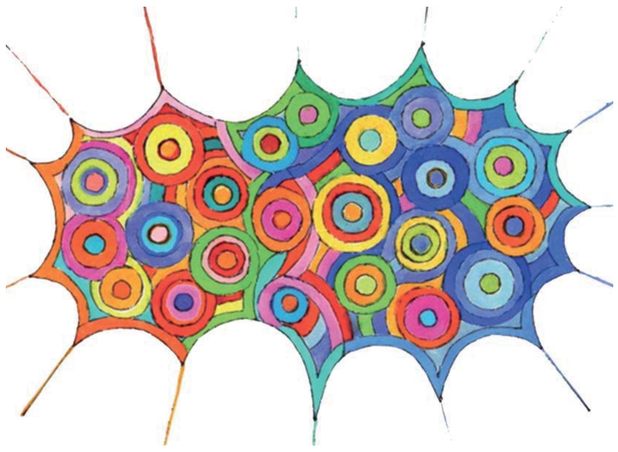


Figure 4.7. Rope terminology

4.1.2.
HAND KNITTED PLAYGROUND
'WOODS OF NET' PAVILION
Toshiko Horiuchi MacAdam
Hakone Open Air Museum, Hakone, Japan
Textile Installation
2009-2010





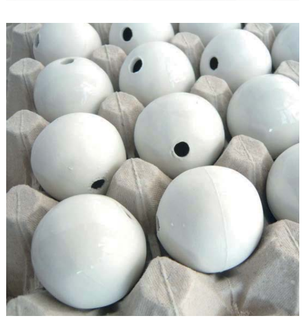
Toshiko Horiuchi creates spatial zones using fibre and textile structures. The production of the hand crafted playgrounds involve the translation of traditional architectural space-defining elements, ideas and references into alternative space-defining elements that respond to principles of tension and the forces of gravity.

The knitted playground is not only a sculptural museum piece but also an experiential area for children to touch and feel. Toshiko firstly imagines an image, draws it and calculates the area, amount of material and the rate at which she works. Then she sets a plan and works on it diligently until it is completed. The hand knitted playground is constructed of 650kg of Nylon 6 rope which Toshiko dyed in lots of 1kg within a time span of three months. The completed piece took Toshiko one year to crochet and assemble. Conceptually the project is based on the idea of an infant cradled in the womb. The crocheted form resembles the mother's womb and the fluid wave-like motion that the net makes when children play on it, mimics the rocking and floating motions inside of the womb (ArchDaily, 2012b).

The hand crafted playground is a prime example of how ideas of traditional hard, static space can be re-imagined into alternative textile space. Further, the hand crafted playground illustrates how the manual textile fabrication technique of crocheting with rope can be applied large scale to form impressive decorative and useful spaces.

Canopy

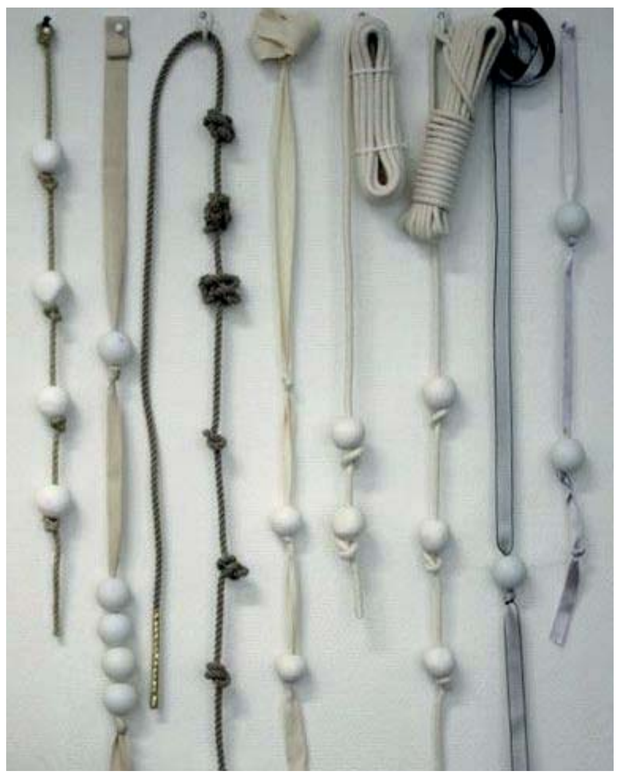
4.1.3.
BEADED CURTAIN
NORTH DELEGATES LOUNGE
Rem Koolhaas, Hella Jongerius + Irma Boom
United Nations Headquarters, New York, USA
Renovation
2009-2013



The renovation of the North Delegates' Lounge at the United Nations building in New York was completed by a team of Dutch creatives that included architect Rem Koolhaas, Designer Hella Jongerius, graphic designer Irma Boom, artist Gabriel Lester and theorist Louise Schouwneberg. The main lounge area, designed by architects Oscar Niemeyer and Le Corbusier in 1960 was spatially reconfigured and enhanced through the addition of new furniture (Bernstein, 2013; Dezeen, 2013).

The main feature of the new lounge is a beaded curtain designed and made by Hella Jongerius. It consists of hand knotted yarn and 30 000 porcelain beads. The curtain acts as a space-defining element and enhances the view through the opening towards the East River. Jongerius also designed two new furniture pieces for the lounge area, introducing a revitalised colour palette to the space (Dezeen, 2013).

The beaded curtain in the UN building demonstrates the way in which rope can be knotted to form space-defining elements. The use of porcelain beads in combination with rope illustrates how hard elements can appear soft due to the pliable and flexible nature of rope. Although the rope curtain acts as a soft textile space-defining element, it still mainly communicates the characteristics of a traditional, vertical, single plain space-defining element.



Curtain wall

Section 4.1.2. (from top to bottom)
Figure 4.2.a. Hand Knitted playground, elevation (archdaily, 2012B).
Figure 4.2.b. Hand Knitted playground, plan view (archdaily, 2012B).
Figure 4.2.c. Hand Knitted playground (archdaily, 2012B).
Figure 4.2.d. Hand Knitted playground, hand knitting procedure (archdaily, 2012B).
Section 4.1.3. (from top to bottom)
Figure 4.3.a. Beaded curtain, North delegates lounge (Dezeen, 2013).
Figure 4.3.b. Beaded curtain, image 1-4 process of making (Jongeriuslab, 2013).
Figure 4.3.c. Beaded curtain, Material selection (Jongeriuslab, 2013).

4.2.1.1.
TWISTED ROPE

The rope making process is very similar to the process of textile construction.

The making of rope involves the twisting of fibres (Figure 4.5: A) to form what is known as a yarn (Figure 4.5: B). The combined twisting of two or more yarns, form a strand (Figure 4.5: C). Three or more strands twisted together form a rope (Figure 4.5: D), and finally when three ropes are combined, a cable is formed (Figure 4.5: E) (Verril, 1917: 3). See also Figure 4.6. Types of rope, (1) for an example of twisted rope (opposite page).

In order to form a strand, the yarns are twisted together in the opposite bearing from that in which the initial fibres were twisted. Similarly, in order to form a rope, the strands are twisted in the opposite direction from the yarns of the strands. This ensures that the natural tendency for each yarn, strand, rope or cable to untwist, instead serves as a manner of binding it (Verril, 1917: 3). **Twisted ropes are mainly constructed using natural fibres. The following terms are commonly used within the category of twisted rope:**

- **Three-strand twisted rope** (also four-strand twisted).
- **Lay:** The lay or direction of slant, is the direction in which the strands of a rope twists
- **Right hand lay or Z-twist:** Strand progresses away from the viewer, and rotates clockwise like right hand thread. Right hand lay is typically used for most three-strand or four-strand rope.
- **Left hand lay or S-twist:** Left hand lay or cable laid, is typically used for steel cables.

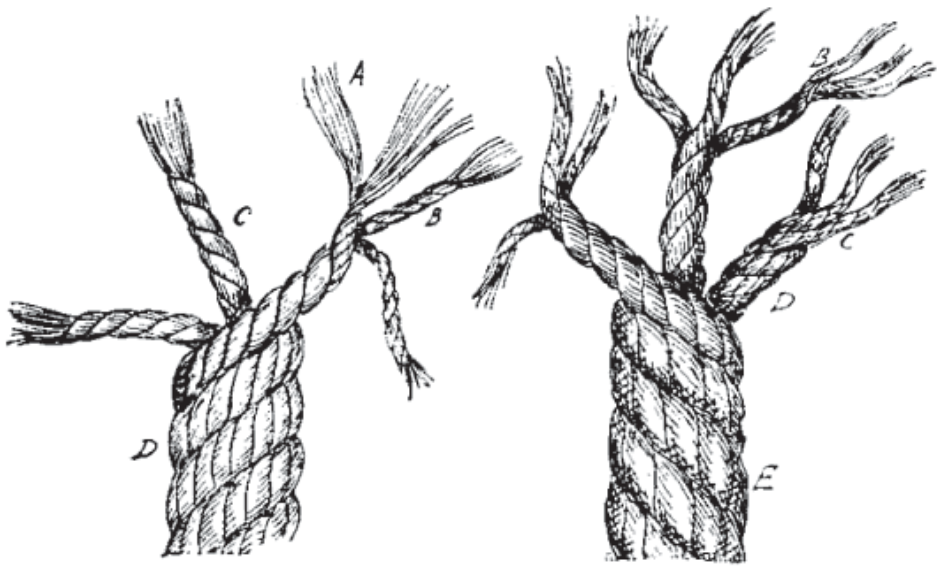


Figure 4.5. Composition sketch of twisted rope (Verrill, 1917: 8).

4.2.1.2.
BRAIDED AND PLAITED ROPE

The use of modern machinery and the advent of synthetic fibres allow for additional rope construction beyond that of twisted rope. Plaited and braided ropes, woven on machines are available in a range of decorative patterns, are tightly woven and don't untwist as easily as twisted rope (Penn, 2015; Animated knots, 2012). See Figure 4.6. Types of rope (2) for an example of plaited rope and (3-6) as examples of braided rope (opposite page). The following rope structures for braided and plaited ropes are described by Randy Penn (2004) in his book The everything knots book:

Single braid ropes include various braids which have no second layer. These include:

- **Hollow braid:** The construction consists of two sets of fibres that progress around in opposite directions and weave into each other. Hollowbraid refers to the behaviour of the rope as it readily opens up to become 'hollow'. This allows the tail or standing end of the rope to be passed through the rope to form a knotless loop.
- **Solid braid (simple weave):** The construction of the rope consists of two sets of fibres that rotate in opposite directions but with a tighter weave than that of the Hollow braid structure. This structure is mainly applied to smaller diameter general-use lines.
- **Solid braid (solid weave):** The structure of a solid braid, solid weave rope contain fibres that do not progress around the rope. Instead the fibres spirals from the exterior of the rope toward the interior. The solid weave structure is commonly found in general-purpose rope but is not applied to high performance or specialty purpose rope.

Double braid (braid-on-braid) rope consists of a braided interior core surrounded by a braided outer sheath. The load is thus shared between the sheath and the core. The protection offered to the core by the braided sheath is desired but can make it difficult to detect any possible damage to the inner core. Some core and sheath ropes contain cores that are not braided, such as a three-strand rope. The core can also be a composed of different material than the outer sheath attributing the rope with different properties.

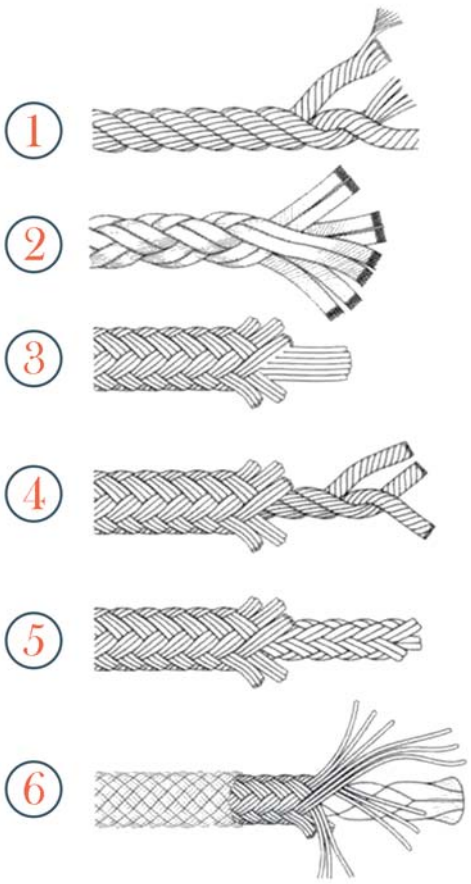


Figure 4.6. Types of rope (adapted from Knotsguide, 2008).

4.3.
ROPE TERMINOLOGY

NOTE: The following terminology pertaining to rope and the tying of knots, is a direct selection from the American army field manual section FM 3-05. 70 (Mongabay.com, 2015). The selected terms will be applied continuously throughout the document.

STANDING PART: The static part of the rope or rest of the rope besides the running end.

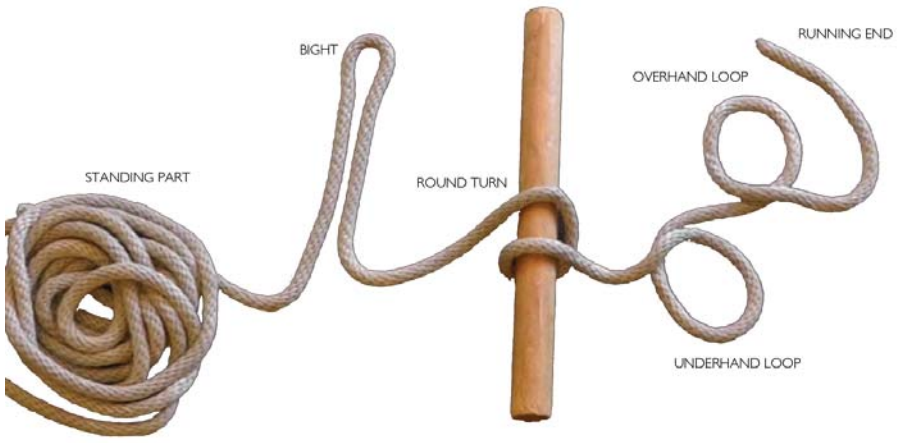
BIGHT: A simple bend in a rope in which the rope does not cross itself.

TURN: A loop around an object such as a post, rail or ring, with the running end continuing in the opposite direction to the standing end. A round turn continues to circle and exits in the same general direction as the standing end.

LOOP: A loop is formed by crossing the running end over or under the standing end to form a ring or circle in the rope.

RUNNING END: The free or working end of the rope. This is the part you are actually using to tie the knot.

DRESSING' THE KNOT: The orientation of all knots parts so that they are properly aligned, straightened, or bundled. Neglecting this can result in an additional 50% reduction in knot strength. This term is sometimes used for setting the knot which involves tightening all parts of the knot so they bind on one another and make the knot operational. A loosely tied knot can easily deform under strain and change, becoming a slipknot or worse, untying.



Duplicate of Figure 4.7. Rope terminology (poster 8)

4.4.
KNOT CATEGORIES

According to Pettigrew (2013) in A few good knots & hitches and bends, knots can be divided into various categories. These basic categories are: Hitches, Loops, Noose, Bends, Binders, Stopper knots, Friction knots, and Lashings (Pettigrew, 2013). Pettigrew (2013: 4) refers frequently to ABoK when describing knots.

The acronym, ABoK refers to Ashley's Book of Knots (AcronymFinder; Pettigrew, 2013: 4). This book was first published in 1944 and later reprinted in 1993 with amendments. The book contains 7000 drawings representing more than 3800 different knots. It is the principal reference work for knotting as each knot illustration is identified by a number (Pettigrew, 2013: 4). According to Pettigrew (2013:4)

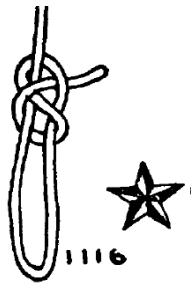
> "With many knots having more than a single name in any one language, the reference number from ABoK has become the equivalent of the Binomial or Latin name in Zoology and Botany."

However, new knots and some that do not appear in Ashley's Book of Knots lack an ABoK number.

With reference to both Pettigrew (2013) and Ashley (1993) knots are categorised as:

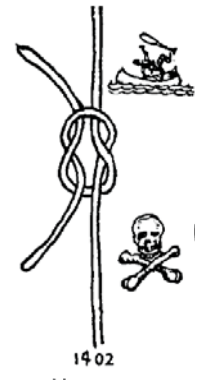
- Noose
- Loops
- Friction knots
- Lashings
- Binders
- Hitches
- Bends
- Stopper knots

These knot categories are described in more depth on the opposite page. All illustrations from Ashley's Book of Knots (Ashley, 1993).

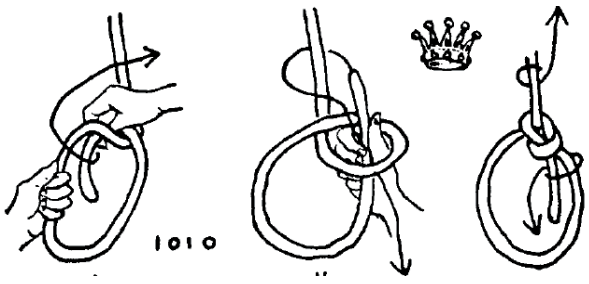


NOOSE: A Noose or snare, sometimes called a Running Knot is a variety of Loop Knot that is tied in hand, and, when placed around an object, renders and constricts when the rope is pulled on. It serves a purpose similar to a hitch, but a hitch is tied directly to its object (Ashley, 1993: 203). Figure 4.8. The Figure-Eight Noose, ABoK #1116 (Ashley, 1993: 203).

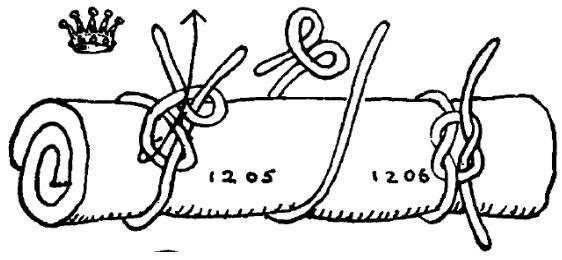
LASHINGS: Lashings is a broad term that covers several somewhat different practices. A lashing may wrap and bind, or else bind only with a multiplicity of turns, a bale, parcel, box, chest, or other container, either for transportation of for storage. It may secure something movable to something that is fixed, with various turns and hitches, so that it cannot shift from its position (Ashley, 1993: 335). Figure 4.11. The Loop Knot, ABoK #2068 (Ashley, 1993: 335).



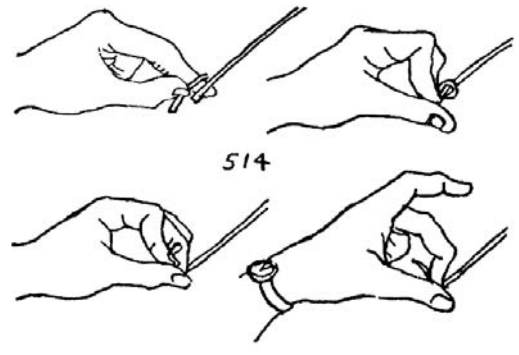
BENDS: A bend unites two ropes, or two parts of the same rope, generally at the ends. Its purpose is to lengthen the rope (Ashley, 1993: 257). Figure 4.14. The Reef or Square Knot, ABoK #1402 (Ashley, 1993: 257).



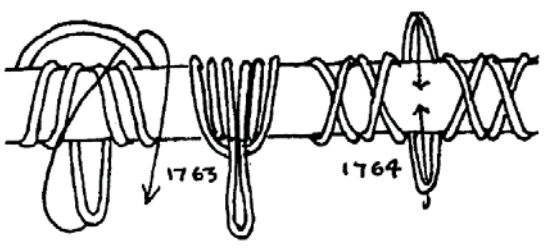
LOOPS: A Loop Knot is a closed bight that is tied either in the end or in the central part of a rope. It serves much the same purpose as a hitch. However, a Loop Knot is a rigid knot that is tied in hand and placed over an object such as a peg, post, pile, hook, or the lug of an archer's bow, while a hitch is made fast directly around an object (Ashley, 1993: 185). Figure 4.9. The Bowline, ABoK #1010 (Ashley, 1993: 185).



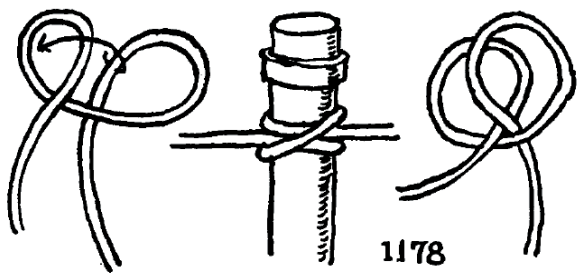
BINDERS: Binders or Binding Knots are of two sorts. The first sort passes around an object or objects two or more times and the tow ends are snugly tied together; the second passes around an object or objects two or more times and the ends are stuck under the turns. The knots serve two purposes. Either they confine and constrict a single object, or else they hold two or more objects snugly together (Ashley, 1993: 219). Figure 4.12. The Granny Knot, ABoK #1206 (Ashley, 1993: 219).



STOPPER KNOTS: Stopper Knots or Knob Knots are divided into various sub-categories, each with their own purpose. Stopper Knots are used for a variety of tasks, from holding up a shelf or attaching a swing, to preventing the rope from unreeving from a block, slipping through a Cam Cleat or running out of a belay/abseil device. They can also provide security to a knot by preventing the tail form pulling through. They are equally useful in providing handholds on a rope that is being pulled or climbed (Pettigrew, 2013: 32). Figure 4.15. The Overhand Knot, ABoK #514 (Ashley, 1993: 84).



FRICTION KNOTS: The Ashley book of knots classifies friction knots as '*right angle and lengthwise pull hitches'* (Ashley, 1993: 289, 297). Pettigrew (2013: 34) describes Friction Knots or Slide and Grip Knots as specialised knots. They are mainly tied using slings made of webbing or cord. The cord used is usually between 60% and 70% of the diameter of the rope it is to be tied around (Pettigrew, 2013: 34). Figure 4.10. The Prusik Knot, ABoK #1763 (Ashley, 1993: 289, 297).



HITCHES: The general purpose of a Hitch or Crossing Knot is to hold together the bights of two ropes, or two parts of the same rope that cross each other, or else to secure the bight of a single rope to another cylindrical object (Ashley, 1993: 213). Figure 4.13. The Clove Hitch, ABoK #1178 (Ashley, 1993: 213).

4.5.
ROPE AND KNOT STRENGTH

Every rope has a specific Breaking Strength. See definition of terms, **Section 1.6**, (page 9). This means that when a rope is placed under enough strain, it will break (Root, 2005). The safe working capacity or safe working load of a rope is generally considered to be one-fifth of the rope's breaking strength, or 15-25% of the tensile strength (BoatSafe, 2009). In other words, the breaking strength should be five times the weight of the object that the line will be holding. Even though a rope might have a safe working capacity when brand new aspects such as age, wear and tear, dynamic loading, excessive use, elevated temperatures or extended periods under load will critically affect the strength and safety of the rope (Root, 2005; JB Rope supply, 2015). The strength of a rope as stated by the manufacturer is for new or unused rope (Pettigrew, 2013: 6).

It is understood that all knots reduce the strength of a rope but some knots are stronger than others. However, considering how important ropes and knots are to a variety of people, sufficient research on the strength of knots within ropes is scarce. The available sources of data often do not indicate how tests were conducted, nor do they indicate the type of rope tested or the age and condition of the rope. As a baseline for this dissertation, The study of knot performance: Exploring the secrets of knotted cordage to understand how knots work by *All about knots* (2010), was consulted.

The paper examines knot strength and structures that may weaken natural-fibre knots. The author compares the relative strength of a selection of commonly used knots. A straight or un-knotted rope is assumed to have 100% strength (All about knots, 2010). The values listed in the table below refer to the remaining breaking strength of a rope after the specified knot has been tied (Root, 2005). See Table 4.1. Knot strenght comparison, below (The figure indicated does not represent an exact percentage but the general range of strength is accepted as an indication).

For the purpose of this dissertation the following is assumed:
According to *All about knots* (2010) the strength of a knot is determined by two characteristics of the first curve within the knot:

1. The relative proportion of the full load that falls on the first curve
2. The severity of the first curve, that is, how far it deviates from a straight line.

Further, it is also important to note that all components and rigging hardware used with rope or cordage should be suitable to the size and strength of the rope itself. The attachments should be properly installed and fixed and must have a safe working load capacity at least equal to the product with which they are used (Toolee, 2007). Rigging and hardware is covered in greater depth in **CHAPTER 5: Design application.**

KNOT STRENGHT		
Strong knots	Blood knot	85-90% (Barnes, 1947); 80% (Day, 1947)
	Flemish bend	81% (Frank & Smith, 1987)
	Figure eight loop	80% (Frank & Smith, 1987)
	Double fisherman's knot	79% (Frank & Smith, 1987)
Moderate knots	Butterfly knot	75% (Frank & Smith, 1987)
	Bowline knot	60% (Day, 1947)
	Overhand knot	60-65% (Leubben, 1995)
Weak knots	Overhand bend	50% (Allaboutknots, 2010)

Table 4.1. Knot strenght comparison (Various sources)

4.6.
CONCLUSION

Rope and rope-like materials stem from the same yarn based fabrication methods as textiles, and so can be classified as a subcategory of textiles. The formation of textile space-defining elements by means of hand knotting rope and rope-like materials imply a certain knowledge of the material. The chapter therefore introduced terminology specific to rope and knotting and discussed the main categories of knots and each of their applications. Further, the chapter illustrated examples of the use of hand knotted rope as textile space-defining elements.

The specific material selection and selected colour palette is discussed in **CHAPTER 5: Design application.**