FIXINGS USED FOR SHELTERS MADE FROM FLEXIBLE FABRICS
ROPE TENSIONERS

a guideline on fixings used for shelters made from flexible fabrics and rope tensioners
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PART I

FIXINGS USED FOR SHELTERS MADE FROM FLEXIBLE FABRICS

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How to attach a fabric to a frame? Whoever tried to fix any textile cladding material to a frame, knows that this simple question does not come with a simple answer.

Do the plastic grips and clips or other kinds of fixings available on the market deliver the performance required in the field?

Are there any solutions that work well for shade nets?

Is there a smart system to connect two tarpaulins?

And how does the good old stone wrapped in the tip of a tarp, the bottle-cap washer, and other ingenious field solutions compare to what is available on the market?

How do eyelets along the edge of a tarpaulin compare to holes punched in the reinforced strip of a standard IFRC tarpaulin, in terms of performance and practical usability?

How does the reinforced band really perform when perforated by nails or other fixings? And what about the performance of the variety of tensioners and ropes that are used, particularly in emergency shelter operations?

**OBJECTIVE**

Since we could not find satisfactory information to answer these questions, we decided to dedicate a study to the subject of fixings.

One of the principal objectives of the IFRC-SRU is to test materials and items in view of their use in the field and to produce technical resources in support of the Red Cross Movement and the larger humanitarian shelter sector. Therefore, this study aims to provide an overview of existing products allowing to evaluate and compare their technical performances as well as their logistical parameters (cost, weight, volume) with the “traditional” field solutions.

The study emphasizes in particular the practical aspects of easy application - even by unskilled people - without the use of extra tools.

**SCOPE**

The scope of the test series conducted in our workshop focused on the fixing of flexible cladding materials to rope as well as to structural elements. A market study identified 59 fixings from about 40 suppliers. From these fixings, 16 different models from 11 suppliers have been selected as the most representative for that particular type of fixing.

The selected fixings are tested on up to 7 possible variations of fabrics and fabric edges. Typical fixings that are traditionally used in humanitarian sheltering have also been assessed including roofing nails, bent nails, nails with bottle-cap washers, ropes etc. as well as some new variations from IFRC-SRU that came up during the study.

In all, 725 different possibilities of fixings have been explored on a variety of fabrics including different tarpaulins, shade net or canvases, resulting in a total of 20,000 tests.

The concept was to provide a clear visibility on the behaviour and performance of different fixing systems available on the market or commonly used by humanitarian agencies. The challenge is to select and advise the most appropriate system for field implementers.
METHODOLOGY

Each fixing is tested 3 times on fabric samples of 50 x 10 cm in an identical test setup and with the same procedure of progressive stressing and documenting the charged load in kg as well as the displacement in mm.

The destructive test is terminated with the failure (breaking or sliding) of either fixing or fabric (tearing).

The maximum loading capacities of the different fabrics have been tested beforehand to know the maximum resistance of a 50 x 10 cm strip.

This allows identifying whether the weak point is in the fabric or in the fixing.

Of each fixing, the following data are analysed:

- Maximum loading capacity of the fixing on different types of fabrics
- Standard variation of the fixing performances in the three tests performed, to give an indication of the reliability of the fixing
- Fixing displacement (if it occurs)
- Usability indicators including comprehensibility, ease of use, ease of disassembly, reusability, and type of tools that are needed for installation, if necessary
- Logistic data: price, weight and dimension

All test results are registered on a single sheet summary for each fixing reflecting the complete data of structural performance, usability and logistics.

Finally, all results are compiled in a comparative graphic that allows understanding at a glance how each fixing scores on the different criteria.
RESULTS

After having performed thousands of tests on more than 50 different commercially available systems, we have encountered a few quite surprising outcomes.

Some fixings we intuitively thought would lead to extraordinary good results proved quite mediocre while others of which we had low expectations came out as promising candidates.

The same rule seems to apply to the costs as we noticed that the performance of a device is inversely proportional to its price (the most expensive ones proved less efficient).

Traditional fixings with an extremely good cost impact since they are locally available or on site had a better behaviour.

- A stone wrapped in a tarp edge performs up to 30% better than a common fixing device
- A bent bunch of folded fabric is a really excellent fixing system with a 25% better result than the best clamp available on the market
- An inexpensive solution (traditional fixing) works better
- Measurements show that the behaviour of both solutions is quite comparable and that there are no deviations for both used systems.

FINAL CONCLUSION - RANKING

- The simpler the solution, the better the performance
- Locally implemented solutions are not only the best but also the cheapest ones
PART II
ROPE TENSIONERS
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INTRODUCTION

PROBLEM STATEMENT
To get a better knowledge of the maximum forces that can be manually applied to a guiding rope, several tensioning systems have been analysed. The maximum force will have a big influence on the structural behaviour of the tensioned membrane. Together with the positioning of the high and low points, the force will be one of the main actuators to provide sufficient tension to the shelter system.

METHODOLOGY
Three tests have been performed:

1. Rope tests
2. Manual tension tests
3. Maximum loading tension tests

1. ROPE TESTS
Four different ropes with a diameter of 6mm were examined.

*Documentation from manufacturers http://www.langmantouw.nl*
1.1. TEST RESULTS

The above graphs show that the polypropylene ropes have the largest extension for a given loading, whereas the braided polyamide rope has the least extension. When comparing both polypropylene ropes (strung and braided), we see that the braided rope shows less extension than the strung one.

The braided Polyamide and strung Polyester ropes have been selected for the tensioners tests. This will allow to have the smallest elongation for the ropes and to take into account the influence of the ropes’ surfaces (braided or strung).
2 MANUAL TENSION TESTS

A test has been set up, in which one single rope is manually tensioned and the force is measured. The following parameters have been tested:

- Type of tensioner
- Difference in rope
- Total length of the rope (l)
- Position of the tensioner (y)

**NOTE:** Keep in mind that the results from these tests are not conclusive. The manually applied force is not the average of the manually power exerted by people. However, these tests allow to compare different tensioners with one another.
2.1. TEST RESULTS

Tensioner test with **Braided Polyamide D:6mm**

Tensioner test with **Strung Polyester D:6mm**
3 MAXIMUM LOADING TENSION TESTS

This test procedure examines the maximum load the tensioner and rope can sustain.

The rope and tensioner are placed in a pulling bench. Each connection is made as in real life conditions.

The pulling bench pulls until the rope, knot or tensioner fails.
3.1. TEST RESULTS
4 OVERVIEW OF TENSIONING SYSTEMS

NITE IZE
- Price: 4 euro
- Weight: 29.5 gram
- Ease of use: Easy to tension but harder to lock; works also with other rope dimensions
- Understandability: Instructions printed on tensioner itself
- Reusability: The tensioner itself can be reused, the rope is damaged due to teeth on tensioner
- Max manual force braided polyamide: 256 N = 26.1 kg
- Max manual force strung polyester: 282 N = 28.8 kg
- Max force until failure (braided polypropylene rope): 2318 N = 236.4 kg
- Failure type: The rope slips through the teeth of the tensioner

LOOP CLEAT
- Price: 4.50 euro
- Weight: 18.3 gram
- Ease of use: Easy to tension, but difficult to lock
- Understandability: Difficult to understand the workings of the tensioner
- Reusability: Tensioner deforms when used
- Max manual force braided polyamide: 48 N = 4.9 kg
- Max manual force strung polyester: 116 N = 11.8 kg
- Max force until failure (braided polypropylene rope): 2362 N = 240.9 kg
- Failure type: Rope slips through teeth tensioner

EZ ADJUST
- Price: 0.43 euro
- Weight: 10 gram
- Ease of use: Difficult to lock it in position
- Understandability: Difficult to understand the proper working
- Reusability: After a high load the tensioner failed
- Max manual force braided polyamide: 102 N = 10.4 kg
- Max manual force strung polyester: 121 N = 12.3 kg
- Max force until failure (braided polypropylene rope): 908 N = 92.6 kg
- Failure type: Tensioner breaks

CAMRING
- Price: 2.55 euro
- Weight: 35.3 gram
- Ease of use: Difficult to tension further if there is already a basic tension on the rope
- Understandability: Difficult to understand the proper working
- Reusability: Damages the rope at the edges of the holes in the tensioner
- Max manual force braided polyamide: 112 N = 11.4 kg
- Max manual force strung polyester: 48 N = 4.9 kg
- Max force until failure (braided polypropylene rope): 2532 N = 258.2 kg
- Failure type: Rope breaks at the location of the tensioner
TENSIONER (TYPE 5)
- Price: 9.95 euro
- Weight: 112.5 gram
- Ease of use: Easy to tension, more difficult to lock
- Understandability: Difficult to understand the proper working
- Reusability: Tensioner and rope both reusable
- Max manual force braided polyamide: 145 N = 14.8 kg
- Max manual force strung polyester: 171 N = 17.4 kg
- Max force until failure (braided polypropylene rope): 3045 N = 310.5 kg
- Failure type: Bowel knot releases

WINGED SCREW
- Price: 2.7 euro
- Weight: 30 gram
- Ease of use: Easy to tension, but still difficult to lock
- Understandability: Easy to understand the tensioner
- Reusability: Tensioner and rope both reusable
- Max manual force braided polyamide: 149 N = 15.2 kg
- Max manual force strung polyester: 134 N = 13.7 kg
- Max force until failure (braided polypropylene rope): 1042 N = 106.3 kg
- Failure type: Rope slips through tensioner

WOOD BLOCK
- Price: --
- Weight: 30.9 gram
- Ease of use: Easy to tension just by pulling downwards; a lot of tension is lost due to the settling of the block
- Understandability: Universal concept
- Reusability: Wood piece splinters or dents at its holes
- Max manual force braided polyamide: 167 N = 17 kg
- Max manual force strung polyester: 181 N = 18.5 kg
- Max force until failure (braided polypropylene rope): 1495 N = 152.4 kg
- Failure type: Tensioner slips on the rope

PLASTIC BLOCK
- Price: 0.08 euro
- Weight: 11.8 gram
- Ease of use: Easy to tension just by pulling downwards; a lot of tension is lost due to the settling of the block
- Understandability: Universal concept
- Reusability: Plastic piece bends and dents at its holes
- Max manual force braided polyamide: 197 N = 20.1 kg
- Max manual force strung polyester: 252 N = 25.7 kg
- Max force until failure (braided polypropylene rope): 664 N = 67.7 kg
- Failure type: Tensioner slips on the rope
**PRUSIK KNOT**
- Price: Depends on rope choice
- Weight: Depends on rope choice
- Ease of use: Easy to tension just by pulling the knot downwards
- Understandability: More difficult if the knot needs to be made on site
- Reusability: Ropes can perfectly be reused
- Max manual force braided polyamide: 162 N = 16.5 kg
- Max manual force strung polyester: 212 N = 21.6 kg
- Max force until failure (braided polypropylene rope): 1104 N = 112.6 kg
- Failure type: Prusik knot slips over rope

**BLAKE’S HITCH KNOT**
- Price: Depends on rope choice
- Weight: Depends on rope choice but no additional cost
- Ease of use: Easy to tension just by pulling the knot downwards
- Understandability: More difficult if the knot needs to be made on site
- Reusability: Ropes can perfectly be reused
- Max manual force braided polyamide: 126 N = 12.8 kg
- Max manual force strung polyester: 139 N = 14.2 kg
- Max force until failure (braided polypropylene rope): Not measured
- Failure type: Not measured but it will probably slip like the Prusik knot

**TAUTLINE HITCH KNOT**
- Price: Depends on rope choice
- Weight: Depends on rope choice but no additional cost
- Ease of use: Easy to tension just by pulling the knot downwards
- Understandability: More difficult if the knot needs to be made on site
- Reusability: Ropes can perfectly be reused
- Max manual force braided polyamide: 115 N = 11.7 kg
- Max manual force strung polyester: 209 N = 21.3 kg
- Max force until failure (braided polypropylene rope): Not measured
- Failure type: Not measured but it will probably slip like the Prusik knot

**ONE LOOP KNOT**
- Price: Depends on rope choice
- Weight: Depends on rope choice
- Ease of use: Easy to tension but more difficult to lock the tension
- Understandability: More difficult if the knots needs to be made on site
- Reusability: Ropes can perfectly be reused
- Max manual force braided polyamide: 255 N = 26 kg
- Max manual force strung polyester: 331 N = 33.7 kg
- Max force until failure (braided polypropylene rope): 3653 N = 372.5 kg
- Failure type: Bowel knot loop releases
TWO LOOP KNOT
- Price: Depends on rope choice
- Weight: Depends on rope choice
- Ease of use: Easy to tension but more difficult to lock the tension
- Understandability: More difficult if the knots needs to be made on site; two consecutive loops make it more complex
- Reusability: Ropes can perfectly be reused
- Max manual force braided polyamide: 643 N = 65.6 kg
- Max manual force strung polyester: 651 N = 66.4 kg
- Max force until failure (braided polypropylene rope): 3493 N = 356.2 kg
- Failure type: First bowel knot loop releases

BELT FASTENER
- Price: 6.5 euro (tensioner+belt)
- Weight: 112 gram (only tensioner)
- Ease of use: Easy to tension by simply pulling tensioner downwards
- Understandability: Straightforward design
- Reusability: Tensioner fails after the max force is reached (however this value is quite high)
- Max manual force belt: 546 N = 55.7 kg
- Max force until failure (braided polypropylene rope): 8351 N = 851.6 kg
- Failure type: Tensioner breaks
Contact
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More information on the project: http://www.speedkits.eu

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