Stationary Rope Technique (SRT) Work Positioning
A United Kingdom (UK) Perspective

Ben Rose and Robert Knott

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Foreword

Simon Richmond, Senior Technical Officer of the Arboricultural Association

The Arboricultural Association has been pleased to support this important work to help inform the technological developments in our sector. As a growing industry, with passionate and highly motivated practitioners collaborating with research and innovation, it is essential that we can rely on evidence-based data when planning and evolving new and improved techniques. Tree climbing is hard, physical work, carried out in a range of challenging weather conditions, working in organic, three-dimensional structures, at height, often using cutting tools within the vicinity of textile support systems. Arborists are great thinkers and visionaries and it is important that any improvements in ergonomic working systems are proven to be safe, efficient and effective. This document sets out the parameters of safe use for Stationary Rope Work Positioning (SRWP) for tree work and makes an important contribution to the standards and basis for good practice.

During the period of this research new guidance has been developed by the Arboricultural Association, which has incorporated technical aspects of this study. The new guidance is provided at management and operator levels, and clarifies many of the uncertainties from a regulatory and practical perspective:

- *Industry Code of Practice for Arboriculture – Tree Work at Height* (ICoP) (2nd edition, 2020) sets out the principles and protocols for managing tree work at height;
- the technical guide *Tree Climbing and Aerial Rescue* (2020) provides detailed guidance for climbing arborists and their supervisors. An associated Safety Guide is also available.

One of the key clarifications in these documents is the requirement under the Work at Height Regulations 2005 for Personal Fall Protection Systems to include a backup safety line or alternative protection in the event of main line, component or anchor failure. This research document is primarily concerned with the design, compatibility and effective use of SRWP systems and does not extend to the application of integrated backup systems. However, the subject is addressed comprehensively in the guidance documents mentioned above.

It is our belief that for the future successful integration of this body of work into the UK legislative framework it will be important that it is read and understood in conjunction with the *Industry Code of Practice* and the technical guide, *Tree Climbing and Aerial Rescue*.

Acknowledgements

The authors would like to give huge thanks to those who have facilitated this project. Firstly, massive gratitude is owed to the Arboricultural Association, which has supported this project financially. Without its grant of funds, the project would simply have not been possible. Also, we thank those who have generously donated their time: Chris Cooper-Abbs, who has guided this project from conception to completion; Simon Richmond, who has supported, consulted and shown endless patience with the process of conducting and documenting this work; Paul Poynter and Kei Kinoshita, who kindly shared their test data; Adam Davies from ISC, who generously donated so much hardware for the testing phase of the project and shared relevant data; and the staff at English Braids, for donating their time and kindly giving us access to their test facilities. Thanks to the peer review group, Geoff Pugsley, Terry Banyard, Paul Poynter and Michael Popham, who all generously gave their time and considerable knowledge to progress the project into its final editing stages. Finally, a monumental thank you to everyone who completed a survey or attended the group research day.

1.0 Project outline

1.1 Aims

- To appraise Stationary Rope Work Positioning (SRWP) techniques and equipment commonly used within the United Kingdom's arboriculture industry and their relationship and relevance to legislation, good practice and European Union (EU) equipment test standards.

1.2 Objectives

- To research the equipment currently being used by SRWP climbers and how it is applied in the workplace.
- To analyse the relationship of the tools and techniques used to the UK framework of legislation and good practice.
- To gain understanding of the forces experienced by climbers in SRWP practices and the forces that equipment may be subject to.
- To compare the forces equipment is subject to against commonly accepted EU PPE test standards.
- To assess whether equipment application matches the currently accepted test criteria and manufacturers' recommendations for use.

1.3 Intended outcomes

- To develop a broader understanding of the extent of SRWP use within the UK arboricultural industry.
- To provide an assessment of the applicability of SRWP to current UK good practice.
- To assess whether equipment used in SRWP meets current EU standards and whether equipment or standards require updating to meet our legislative framework.
- To instigate a review of how SRWP may be dovetailed into an updated guide to good climbing practice and/or technical guide.

1.4 Structure and composition

- Research current equipment and techniques.
- Research the current legislative framework and supporting documents.
- Analyse whether current techniques fall within current legislation and good practice.
- Research manufacturers of equipment and source relevant equipment and materials.
- Compare equipment application with current EU testing standards.
- Create a series of relevant test criteria.
- Conduct performance testing of commonly found configurations.
- Analyse test results.
- Publish findings.

2.0 Stationary Rope Technique: an introduction

SRT classically stood for Single Rope Technique, referring to climbing on a fixed length of rope, enabling a 1:1 energy exchange, unlike the 2:1 exchange of conventional climbing in arboriculture – previously known as DdRT or Doubled Rope Technique. For clarity, the authors suggest that the name of the technique is defined by whether the rope is moving or stationary. Hence, MRT (Moving Rope Technique) and SRT (Stationary Rope Technique).

The history of SRT is a relatively long one and is not solely confined to the arboricultural industry.

For years arborists used SRT, climbing with ascenders to access trees. They then had to switch to a descender or separate climbing system to descend or perform work in the tree. This method of access largely developed from a pooling of techniques from many disciplines including caving, big-wall sport climbing, industrial rope access and high-angle rescue.

Inventors such as Morgan Thompson and Kevin Bingham (creators of the Unicender and Rope Wrench/Runner respectively) started to develop devices or systems which could ascend and descend on the rope without the need for any kind of changeover. This allows a much more fluid type of work positioning to take place, which is helpful for tree climbing. The Operational Circular (OC200/31) provides advice to visiting staff (HSE & LA) on the interpretation and enforcement of the Work at Height Regulations 2005 (WAHR). OC200/31 defines work positioning as: 'A Personal Fall Protection System (PFPS) which normally includes a body holding device connected to a reliable anchor to support the user in tension or suspension in such a way that a fall is prevented or restricted.' The availability of these inline ascender/descenders resulted in an increase in the use of SRWP techniques in UK arboriculture. Many devices, anchor systems and techniques have been improvised without major technical review, and this has, in part, been motivation for this project.

Within the UK arboricultural industry these techniques have developed outside the training syllabuses and legislative framework and have grown into a new suite of techniques for working in the tree rather than just to access it. Concern has arisen that this creates the potential for employers and employees to have little or no legal support in the event of an accident. It is only very recently that the UK industry has started to develop training courses for these techniques.

Because of the way in which these innovations have been developed, it seems essential to gain a better understanding of how SRWP is carried out in the UK. It is for this reason that the project was initiated, alongside frustration with the lack of acceptance of, guidance about and information regarding SRWP.

3.0 Scope and limitations of the project

The project assessed equipment and techniques commonly used within the UK arboricultural industry, alongside analysis of the current legal framework that guides the industry. The findings have the potential to instigate an update of current test standards and good practices.

SRT climbing practices have developed on a worldwide stage but the scope of this document is limited purely to these practices within the UK. Although this document draws some conclusions about good SRWP practices, it is not a 'how to' or a training manual. It is important to note that although a variety of configurations have been tested, this document does not ratify or condone anything specifically. It is merely a research-based project aimed at developing a better understanding current practices.

The types of testing and the number of samples were limited due to both financial and time constraints. Nonetheless, the data collected is useful in guiding decision-making for those choosing to use SRWP. All survey results and secondary test data are available to view in the appendices. Summary test data is shown within the main body of this document.

4.0 Selecting SRWP climbing system components

As always, it is important to use properly compatible components within climbing and harness systems to facilitate safe work at height. Good component compatibility reduces the risk of misconfiguration and complete or partial system failure. For example, this is relevant to rope choice as all SRWP devices can be used on double braid ropes but this is not good practice for toothed cam devices.

5.0 Overview of equipment commonly used in UK arboriculture and its relevance to this project

A range of equipment and components were selected for testing on the basis of prevalence of use, ease of access and budget, based on the importance/relevance of each item. The information regarding the prevalence of particular equipment and configurations came from the results of surveys and a group research day attended by 15+ experienced SRWP climbers. We focused on testing the Rope Wrench system, commonly used redirects and commonly used anchor systems.

5.1 Climbing equipment

5.1.1 Rope

Appropriate research already exists regarding CE-certified ropes as a result of the test criteria for climbing ropes (**EN1891**). However, there are many ropes used for SRWP within the UK industry that are not CE approved. These are primarily the more static ropes that SRWP climbers seem to favour in order to minimise energy wastage in ascent. Nonetheless, those working in the UK should use CE-approved ropes and as a result only those types have been tested in this research.

5.1.2 Friction hitch cordage

This should be heat and abrasion-resistant to ensure the safety of climbers, whether they are climbing using MRT or SRWP. A piece of simple polyester accessory cord may easily become damaged in the course of just one tree climbing operation and if the user is unaware of this happening mid climb, there is potential for a serious accident. The authors suggest that users should select friction cords appropriate to the task in hand. Factory-made friction hitch cordage is commonly tested to comply with **EN566 and/or EN795B**.

5.1.3 Slings, webbing and tethers

These should be rated appropriately for the application and be of an appropriate material; this applies also to basal anchor slings. The function of tethers is to enable the engage/disengage aspect of the Rope Wrench, but as part of a PPE system they should still be rated. The relevant test standards are **EN795B and/or EN566.**

5.1.4 Mechanical ascenders and ascent-only systems

When 'open shell' ascenders are used for primary life support connections, a backup such as another ascender or a friction hitch is required. Consideration should be given to using dynamic connections based on the particular task or application of the ascenders; the aim should be to reduce potential peak forces to below 6kN. It is a sensible precaution for the climber to carry a descender and to have a ground-based rescue system (GBRS) in place. Modern SRWP systems negate much of the need for a ground-based rescue because there is no need for a changeover to another device to descend. The relevant test standard is **EN12841 B**. Foot ascenders are not for life support.

5.1.5 Self-braking descenders

Such as the ISC D4 or Petzl I'D and Petzl Rig. These are preferable to devices such as the Figure of 8 as the default mode is stopped. It may also be useful to incorporate an anti-panic feature (present on the I'D and D4) for less experienced operators. Descenders are tested in accordance with **EN341.**

5.1.6 Non-redundant friction-based descenders

These should be used with an appropriate autoblock such as a friction hitch. However, there are few applications for these in arboriculture since the invention of self-braking descenders (such as those mentioned above) and inline ascender/descender-type devices such as the Taz Lov2 and Rope Wrench system.

5.1.7 Connectors

All connecting links should be of appropriate size, shape and strength for the desired application. When a carabiner is to be used in a location remote from the climber, it should be positioned so that it does not make contact with the tree structure, even as the angle of the climbing rope changes when the climber moves around the tree. It is quite possible for a triple-action carabiner to be 'rolled' open when it contacts tree stems. The authors therefore suggest a sensible precaution is to use a carabiner with a suitable gate mechanism for the task, such as a DMM Durolock for remote applications. These carabiners should be tested to **EN362.**

5.1.8 Harnesses

Must meet existing industry standards. Some harnesses are available with fixed ventral, dorsal and sternal attachment points. These are often used for attaching climbing equipment during rope access operations and are rarely used in the arboricultural industry. Arborists tend to use work positioning harnesses with a sliding rope or webbing ‘bridge’. This provides a greater range of movement and more comfort in taxing work positions.

AFAG 401 *Tree-climbing Operations* states 'a work positioning sit harness for tree climbing should have a pelvic attachment point and leg loop straps (to comply with **EN813 and EN358**)’.

5.1.9 Lanyards

Work positioning and restraint lanyards must meet existing industry standards detailed in the **EN358** test standard. Fall arrest lanyards are covered by **EN353, 354 and 355** and are rarely used in arboriculture.

5.2 SRWP devices currently in production

5.2.1 The Unicender

An inline ascender/descender invented by Morgan Thompson and currently manufactured by Rock Exotica. It can be used in MRT or SRWP. There are two modes of descent. Tested to ANSI (American National Standards Institute) standards.

5.2.2 Singing Tree ISC Rope Wrench climbing system

Combines a Rope Wrench (invented by Kevin Bingham), tether, friction hitch, pulley, and a carabiner of appropriate size and shape. The Rope Wrench is tested to **EN12278** when both Rope Wrench and tether components are sold and used together. However, a complete kit is available which is compliant with **EN353-2** when used in the approved configuration.

5.2.3 Hitch Hiker

Unlike the Rope Wrench, the Hitch Hiker adds friction below the friction hitch by means of a dog bone – a steel bar that allows the rope to be squeezed between it and the steel carabiner.

5.2.4 Rope Runner

Invented by Kevin Bingham and made by Singing Tree or CMI (depending on the version), the Rope Runner is a mechanical inline ascender/descender and is adjustable for different size ropes.

5.2.5 Bulldog Bone

A mechanical inline ascender/descender custom made in the USA.

5.2.6 The Akimbo

Made by Rock Exotica, the Akimbo is an inline ascender/descender that allows climbers to ascend and descend a stationary or moving rope without changing equipment and without detaching the device from the harness. Adjustable settings allow for a range of climber weights and rope diameters.

5.2.7 Zigzag, Zigzag Plus and Chicane

The Zigzag and Zigzag Plus are mechanical inline ascenders/descenders made by Petzl for MRT and SRWP when used in conjunction with the Chicane. The Chicane works on the same principle as the Rope Wrench. It has not been tested during this project because it was not available in the marketplace at the equipment test phase. This device pairing is tested to **EN12841: 2006.**
https://www.petzl.com/INT/en/Professional/Descenders/ZIGZAG-PLUS

Throughout this document we have included photos taken on the research day attended by a group of 15+ UK-based SRWP climbers, to enable us to gain an understanding of the most commonly used systems and techniques. Some non-CE-approved products are featured for illustration purposes only. They are left to right: an ISC Rope Wrench system using tied eyes with an unknown friction cord material, a Hitch Hiker 2 system and the Singing Tree Rope Runner device.

5.3 Rope angles, forces and loads

The physics of load angles, vector forces, lever arms and the angle rule are well documented. If you would like to read more about rigging/climbing physics, go to the following:

- 'Working the Angles', Joe Harris, Victorian Tree Industry Organisation, 2010: http://vtio.org.au/wp-content/uploads/2010/07/Working-the-Angles-i.pdf
- *The Art and Science of Practical Rigging*, book and DVD, Peter Donzelli and Sharon Lilly, ISA, 2001
- RR668: *Evaluation of current rigging and dismantling practices used in arboriculture*, prepared by Treevolution and Brudi & Partner TreeConsult for the Health and Safety Executive and the Forestry Commission, 2008: https://www.hse.gov.uk/research/rrpdf/rr668.pdf

This subject is critically important to all work at height and the user should have a good understanding of the physics involved.

Important points for consideration are:

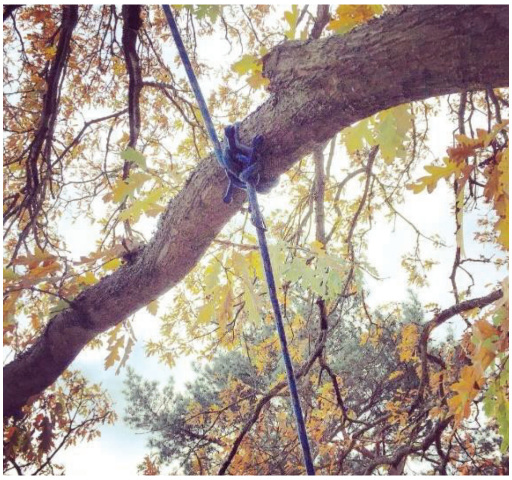
- Configuration forces within the system and rope angles – the angle rule.
- Avoiding the parallel effect, where the load is multiplied at the high point.
- Load angle and length of lever arm.

5.4 Redirects currently used in SRWP

The appendix folders contain a selection of photos of redirects currently used by industry practitioners. The most common practice is to use a webbing sling and an appropriately shaped carabiner. The climbing rope may be clipped into the carabiner (although this has the potential to create an undesirable vector force on the tree structure, depending on branch size and species), or a knot or cinching hitch may be tied onto the carabiner, such as an alpine butterfly or a clove/girth hitch.

There are also a wide range of 'retrievable redirects' which are constantly changing and evolving.





Some of the redirects discussed during the group research day. Left to right: a carabiner/ring cinch redirect, a tape sling and carabiner redirect using a clove hitch and the Simarghu Imp redirect in standard configuration.

5.5 Anchoring

5.5.1 Fixed-base anchor systems, including the use of rescue alpine butterflies: ropes should be anchored by means of an appropriate knot or anchor sling so that they do not slip or shift, regardless of whether slack or tension comes into the line repeatedly.

5.5.2 Aerial rescue on SRT basal anchor systems: may be pre-installed before ascent by means of a descender (such as an ISC D4 or Rescue Figure of 8 and appropriate autoblock) rigged for rescue. **The total amount of rope should meet or exceed three times the height of the primary redirect/primary support point.** But this may not always be the case; it is possible to rig a GBRS with only twice the length of rope to the primary redirect if the system is tied in a loop. Another option is to tie at least one suitable midline knot, such as an alpine butterfly, above the anchor knot/system. This facilitates the attachment of another rope to lower the injured climber in the event of a rescue.

5.5.3 Cinched rope canopy anchor systems: SRWP systems may be anchored in the canopy by means of a simple rope connection such as a bowline, running bowline, running alpine or almost any combination of knots and hitches. This method often is not retrievable from the ground or may be very difficult to retrieve after loading.

5.5.4 Hardware-based canopy anchor systems: some climbers choose to use combinations of hardware and slings or rope to create more easily retrievable canopy anchors such as those tested in this research – for example, cambium savers, anchor rings, multi-slings etc.

A selection of canopy anchors discussed during the group research day. Left to right: knot blocking with a cambium saver, a midline attachable multi-sling knot block and a running alpine butterfly with a ring as a thimble in the eye. Further consideration should be given to the set-up in the middle picture: opening connectors are used at a remote location for an anchor point. Although the gates are opposed, this still causes an unnecessary risk. It would be better to anchor as either the left or right image shows, or using any other closed anchor system.

6.0 The process of the project – testing and results

With a research grant from the Arboricultural Association, the authors set out to achieve the aims, objectives and outcomes listed in section 1.

In order to better understand the use of technique and equipment in current UK SRWP practice, we conducted a paper and online survey. This was distributed at the ARB Show and via various online forums, such as Arbtalk and some of the SRWP Facebook groups. In addition to this, we also conducted a group-climbing day with 15+ practising SRWP climbers from the south of England. As a result of the 119 survey responses and the group-climbing day, a shortlist of systems and anchor/redirect configurations was drawn up. This list informed the draft framework for the configurations that we went on to test later.

6.1 Testing and results

6.1.1 What to test, how to test and against what standards

The next stage was to decide what was to be tested, how it would be tested and against which guidance and equipment standards these results would be compared. Naturally, the types of tests influenced the nature of the test facility required and as a result there was a long period of discussion and research into which test facilities would be appropriate for the task. Funding restricted our options but we negotiated as much support for the project as possible in terms of donated equipment and access to test facilities.

In due course, we performed some static pull testing at English Braids in Malvern. The configurations tested were simulated canopy anchors, simulated redirects and some straight pull tests of rope and slings only, in order to get some baseline numbers.

Several tests we wanted to carry out were simply not possible at this facility. Therefore, we also performed some non-destructive testing at a woodland site in Surrey. At this session we tested the loading at the top and bottom of the tree when base anchoring a rope. We also tested the amount of friction a fully engaged Rope Wrench creates, compared to that on the friction hitch.

The tables below set out the results for all testing, including the canopy anchors, simulated redirects, base anchors and Rope Wrench friction tests. Externally sourced data is available in the appendix files, in addition to relevant photos and videos. The externally sourced data is from research carried out by Paul Poynter and ODSK Japan, covering knot blocking for canopy anchors and slip testing of climbing systems/devices. In addition to this, there is also data from dynamic drop testing of Rope Wrench systems performed by Adam Davies from ISC Wales, in accordance with the **EN353-2** standard.

6.1.2 Test methods

Canopy anchors and simulated redirects were tested at the English Braids facility. Each configuration was tested on a 70mm steel anchor pin, with approximately 3 metres of rope in the system. The exact amount of rope in the system varied slightly between configurations. The constraints of the facility meant that we were unable to test these configurations with more realistic lengths of rope in the system. Redirects were pull tested as anchors with the section of rope that would normally lead back to the main anchor system or next redirect tied off behind the test rig. This enabled each redirect to be tested in a manner as close to reality as possible, with all parts coming into and out of the redirect sharing tension to some degree.

Left: Simulated redirect with a girth hitch on the carabiner. The line is anchored behind the redirect to the anchor pin of the test rig. Above: The Pinto anchor using the most heavily abused pulley that it was possible to source.

Base anchors were tested in the field using Dynafor and Rock Exotica Enforcer load cells. In order to measure the loadings and achieve any meaningful results, a minimum 10 metres of rope were required within the base anchor system to simulate a realistic scenario. This kind of test is impossible on any of the test rigs we had access to, hence the decision to test in the field.

We used a method of testing involving a load cell connected to the base of the tree to act as an anchor and a load cell in the tree to act as a primary redirect. The test was performed using a new ISC 70kN swing cheek rigging pulley. The test was then repeated using a small oak fork hanging from the load cell. The fork selected was close in size to the 70mm anchor pin used in the tests at the English Braids facility. This represents a worst case, but realistically possible, scenario.

The set-up used to test base anchor loadings.

The friction created by a fully engaged Rope Wrench was also tested in the field, using load cells. By weighing the total mass and also the mass supported by the Rope Wrench, the friction as a percentage of the total mass was calculated.

6.1.3 Results

In this section are a series of tables and graphs showing the data we have collected during this project. Below are the results of the destructive testing, Rope Wrench friction tests and testing on the forces applied by using base anchors.

Table 1: Failure loading of commonly used equipment configurations in tests carried out at English Braids, Malvern, UK (17/6/2019) – 70mm Pin/Steel carabiner. Where neither Y nor N is present in column 3, no 15kN hold was performed

Test Number	Configuration description	15kN 3 mins (Y/N)	Peak load at failure (kN)	Comments
1	Running bowline (in)	Y	28.1	Failed in the bowline.
2	Running bowline (out)	Y	24.8	Failed in the bowline.
3	Running alpine	Y	23.2	Failed at the centre of the alpine.
4	Pinto anchor/alpine	Y	26.3	Failed in the centre of the alpine/no damage to pulley or carabiner.
5	Pinto anchor/alpine (abused Pinto Rig)		23.7	Failed at the centre of the alpine/pulley side plate bent (presumably after failure).
6	Alpine/ring	Y	24.5	Failed in the centre of the alpine.
7	Bunny alpine/ring		25.5	Failed in the centre of the alpine.
8	External girth alpine/ring		24.2	Failed in the centre of the alpine. External girth hitch collapsed.
9	F8 captive ring	Y	26.8	Failure of the rope at the opposite side of the ring to the F8.
10	Alpine/maillon		25.6	Failed in the centre of the alpine. Herniated core at the maillon.
11	Alpine block cambium saver (CS)	Y	20.6	Failed in the centre of the alpine.
12	Bunny alpine block CS		21.0	Failed in the centre of the alpine.
13	F9 bight block CS		20.3	Failed in the centre of the 9, closest to the climber.
14	Ring cinch alpine block	Y	25.2	Failed at the rope contacting the ring opposite the alpine (cover damage in alpine).
15	Ring cinch bunny alpine block		28.0	Failure of the rope contacting the ring, opposite the alpine (cover damage in alpine).
16	Imp redirect – anchored behind pin	Y	24.5	Failure at the rope exiting the anchor (climbers strand broke).

Test Number	Configuration description	15kN 3 mins (Y/N)	Peak load at failure (kN)	Comments
17	Ring cinch carabiner block redirect – anchored behind pin	Y	23.3	Failure at the rope exiting the anchor (climber's strand broke).
18	Redirect alpine – anchored behind redirect	Y	17.8	Failed at the alpine.
19	Redirect clove – anchored behind redirect	Y	16.3	Failed exiting the clove, towards climber.
20	Redirect girth – anchored behind redirect	Y	17.5	Failed exiting the girth, towards climber.
21	Redirect Munter – anchored behind redirect	N	15.4	Failed 5 secs into 15kN hold. Broke at the exit of the Munter towards climber. The Munter crept through to add tension to the loaded strand behind.
22	Splice – carabiner		29.6	Failed at whipping/end of core taper.
23	F8 – carabiner		19.5	Failed in the top half of the 8.
24	22kN DMM Dyneema sling – carabiner		26.8	Failed at contact with carabiner – girthed to 70cm pin at the other end.
25	22kN DMM Nylon sling – carabiner		18.8	Failed at contact with carabiner – girthed to 70cm pin at the other end.

Graph 1: Peak load failure of all tested configurations. Numbers on the Y axis refer to test sequence as per Table 1 above; the X axis is measured in kN.

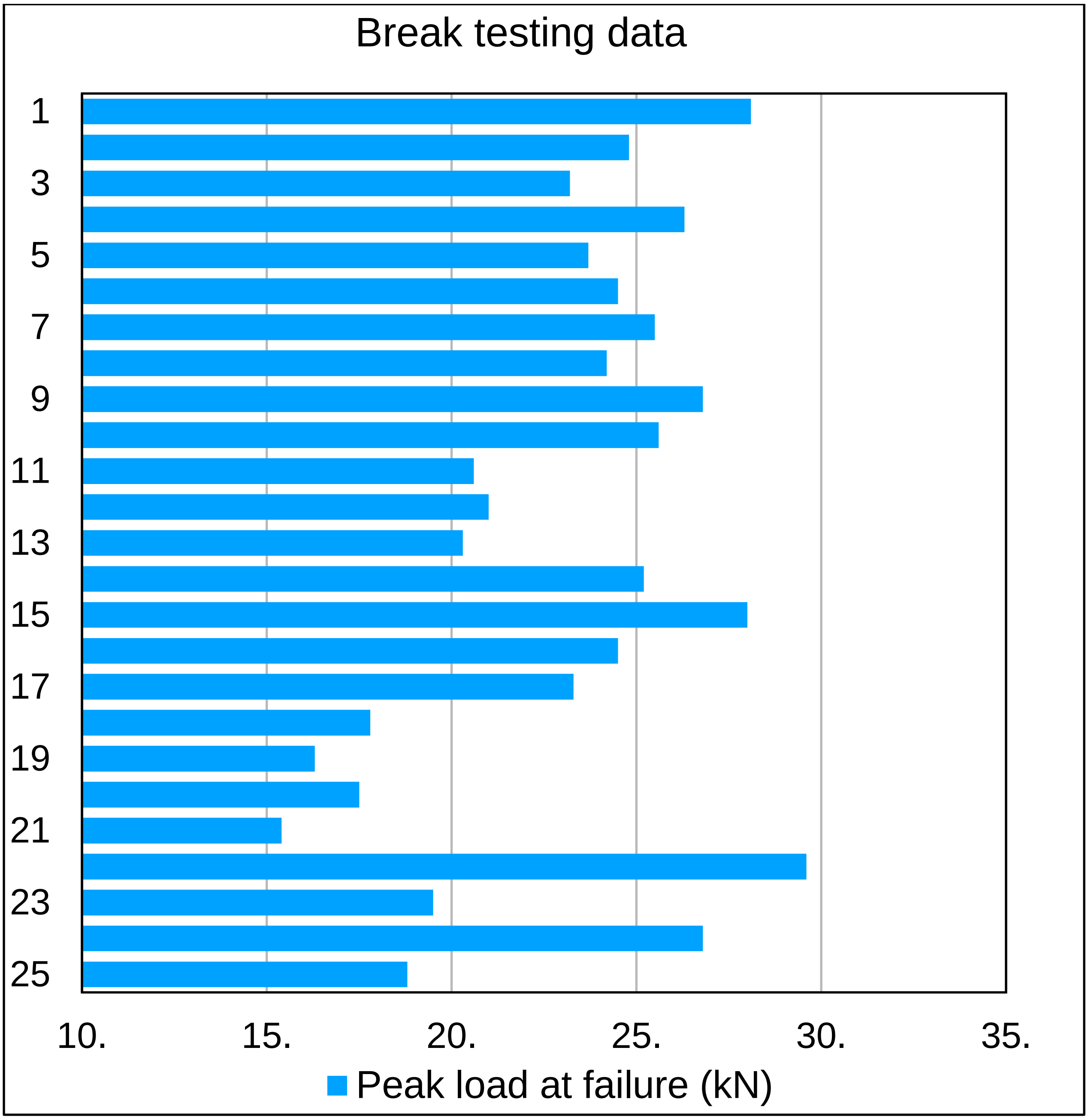


Table 2: Rope Wrench friction tests.

	Total mass (kg/daN)	Load supported by Rope Wrench when fully engaged (kg/daN)	Percentage of load supported by Rope Wrench
New England 12.7mm	76	56	73.68
Cousin 12.3mm	78	50	64.10
Cousin 12.3mm	90	62	68.89
Cousin 12.3mm	90	64	71.11
Cousin 12.3mm	76	56	73.68
Beal 11mm	76	42	55.26
Mammut 10mm	76	42	55.26

Graph 2: Percentage of the mass supported by the Rope Wrench versus rope type used for the test. The results are in the same order as the table above, omitting some labels to allow a less cluttered view.

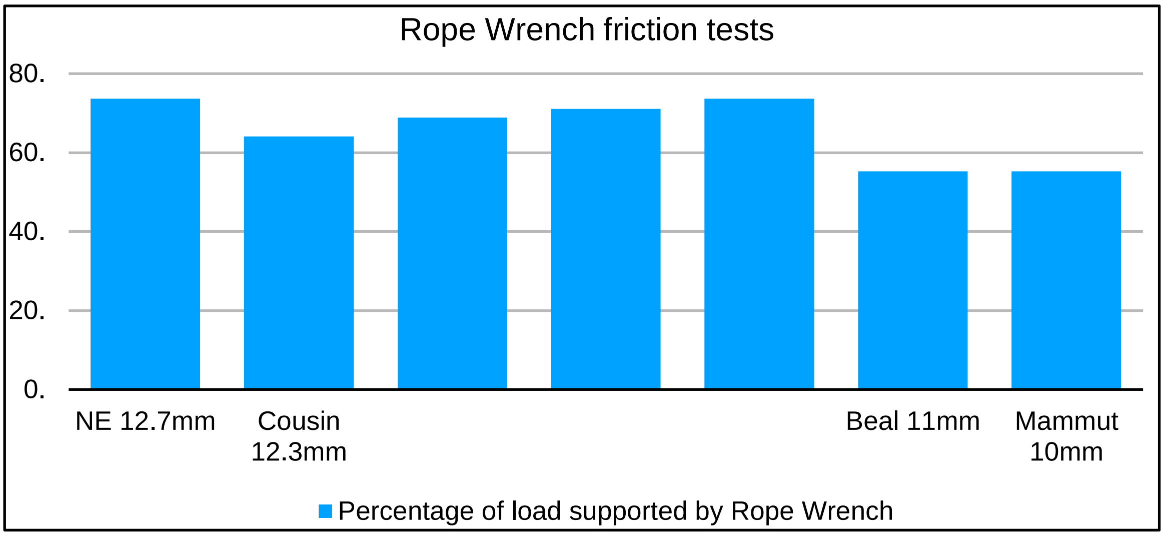


Table 3: Changes in load distribution as wraps around the stem are added to base anchors. Using ISC swing cheek pulley. Table 3 relates directly to Graph 3 below.

Amount of twist at ground anchor	**Ground load cell (kg/daN)**	**Top load cell (kg/daN)**	**Ground load as % of mass**	**Top load as % of mass**
0	72	166	78.26	180.43
0.25	68	166	73.91	180.43
0.5	60	168	65.22	182.61
0.75	54	166	58.70	180.43
1	38	166	41.30	180.43
1.25	26	166	28.26	180.43
1.5	14	166	15.22	180.43
1.75	10	166	10.87	180.43
2	4	162	4.35	176.09
	Mass = 92kg			

Graph 3: Loadings base anchored through a pulley (kg/daN).

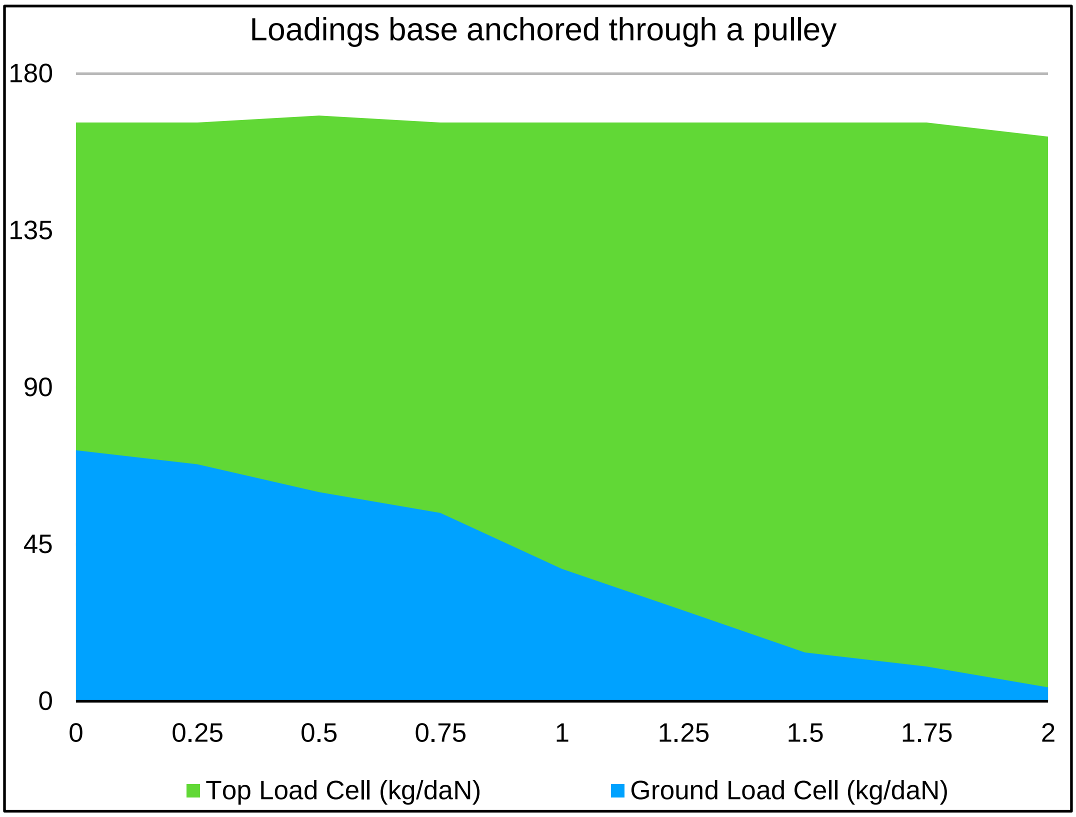
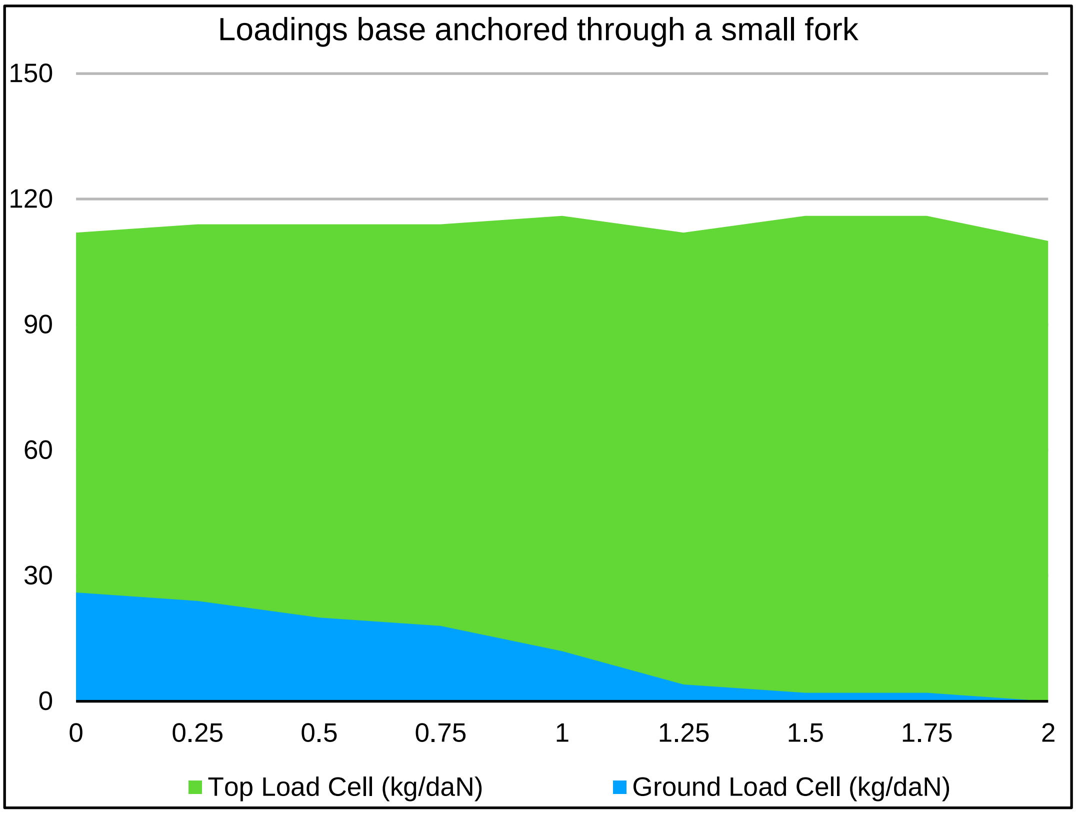


Table 4: Changes in load distribution as wraps around the stem are added to base anchors using 70mm symmetrical oak fork. Table 4 relates directly to Graph 4 below.

Amount of twist at ground anchor	Ground load cell (kg/daN)	Top load cell (kg/daN)	Ground load as % of mass	Top load as % of mass
0	26	112	28.26	121.74
0.25	24	114	26.09	123.91
0.5	20	114	21.74	123.91
0.75	18	114	19.57	123.91
1	12	116	13.04	126.09
1.25	4	112	4.35	121.74
1.5	2	116	2.17	126.09
1.75	2	116	2.17	126.09
2	0	110	0.00	119.57
	Mass = 92g			

Graph 4: Loadings base anchored through a small fork (kg/daN).



6.2 Analysis of results

6.2.1 Canopy anchor configurations

It was observed that all of the canopy anchor configurations tested met the 15kN hold for the 3-minute requirement of **EN1891**. The configurations were then pulled to failure to ascertain the breaking strains of each configuration. The weakest anchor systems were direct knot blocks on cambium savers and the strongest were those that incorporated friction around the anchor stem. The strength of the Pinto anchor was found to be greater than some of the more commonly used, 'weaker' anchor systems such as knot blocking on rings. Nonetheless, it is important to consider that no matter how 'weak' any of the anchors may be deemed, the strength of all configurations in these tests are in excess of the forces the human body and/or the anchor point within the tree structure are likely to be able to withstand.

6.2.2 Redirects

All redirects tested were able to withstand this same test, except for a Munter/Italian hitch on a carabiner (this failed 5 seconds into a 15kN hold). It is worth considering the risk of this type of hitch creeping through under a significant load and causing the rope to fail due to heat build-up and internal fusing of fibres. It is possible that the Munter hitch may also act as a form of progress capture between a main anchor point and redirect, potentially causing a failure of the tree structure.

6.2.3 Slings

Interestingly, the webbing slings tested performed quite differently. Although both the DMM Dyneema and Nylon slings were rated to 22kN, both were girth hitched onto the same 70mm steel pin and used the same type of steel carabiner on the opposing end; they had quite dramatically different results. The Dyneema sling broke 8kN higher than the Nylon sling (which did not meet the rated strength; this may point towards a slightly anomalous result). Both slings failed at the steel carabiner. However, it would be interesting to see the results of the same slings in a dynamic test scenario. For those who are interested in this subject, here is a link to some information regarding sling material: https://dmmclimbing.com/Knowledge/June-2010/How-to-Break-Nylon-Dyneema%C2%AE-Slings

6.2.4 Base anchors

From the testing performed on base anchors, it was observed that adding friction (through points of contact on the tree stem) to the side of the rope between the anchor and primary redirect does indeed reduce the loading at the ground anchor. However, in order to reduce the loading at the primary redirect there must be an increased amount of friction, so much so that it would be impractical to achieve this in day-to-day work. If the integrity of the primary redirect is in question, other methods are required to reduce the loading, such as opening the angle or simply taking a lower primary redirect.

It is worth noting that the 'doubled force' applied to the high point/primary redirect that is so often spoken of (with regard to base anchors) was observed to be a slight exaggeration. When a pulley was used, the force on the primary redirect was around 1.8× the mass of the climber. When a small natural fork was used, the loading was around 1.2× the mass of the climber. Although these numbers are less than the 'doubled force' often mentioned, it is still a useful way to consider base anchors with regard to the selection of a high point because it allows for a worst-case scenario and therefore some contingency.

6.2.5 Rope Wrench

In testing of the friction created by the Rope Wrench, it was observed that the diameter of climbing rope has a significant influence on the friction created; the larger the diameter of climbing rope, the more friction is created. Depending on diameter and rope type, users can expect the Rope Wrench to support between 55% and 75% of the load when it is fully engaged. Obviously, when in the neutral position, the entire weight of the climber is supported solely by the friction hitch (unlike in MRT where the hitch theoretically only supports half of the climber's weight). This highlights the importance of a properly tied, dressed and set friction hitch and that the material of the hitch cord is appropriate too. As such, it is recommended that climbers use a friction hitch rated to **EN566** and/or **EN795B**, made of cordage with heat-resistant properties, i.e. Kevlar/aramid.

6.2.6 Outcome of this section of testing

In the opinion of the authors, if the climber is working in accordance with current industry good practice there is not a specific risk caused by climbing using SRWP as opposed to using MRT. Fundamentally, the techniques and equipment configurations are suitable, yet care should be taken to select equipment that is compatible with neighbouring components and that is suitable for the task at hand.

7.0 Overview of test criteria for equipment commonly used in practical arboriculture

The European standards for work equipment are known as European Norms (EN) and cover, amongst other products, Category III Personal Protective Equipment (PPE), which is designed to protect the user from falls from height. In this category all equipment must be independently tested by a Notified Body and once a Certificate of Conformity has been issued to the manufacturer, the item receives its CE approval and can be sold throughout the European Union without the requirement for further checks or testing, other than those required periodically to maintain approval.

All equipment passing such tests is required to be marked with:

(i) The appropriate EN standard.
(ii) The CE mark.
(iii) The identification of the notified body that carried out the testing.
(iv) A logo indicating that the user guide should be read prior to use.
(v) In many circumstances further information is also required.

The testing should be carried out in line with the comprehensive documents that govern the individual standard applicable to the item's usage. The practical use of equipment should match with its intended purpose and therefore its test procedure should reflect its purpose. In some areas of equipment use, the test does not match with a particular application or vice versa, especially in the area of friction hitch use where the accepted test procedure clearly does not match the intended use.

These standards should be read alongside current industry good practice and manufacturer's user guidance in order to glean the maximum understanding of each document's content and therefore how the details they contain interact with one another and the UK legislative structure. Test standards in the USA, Australia and New Zealand are not the same as in Europe. This should not preclude the use of equipment that is not CE marked; however, due care should be taken to understand the extent and limitations of all equipment used within practical arboriculture. In many cases there is no single EN standard that adequately matches the use to which equipment is put and therefore it becomes unverifiable within the EN standards framework.

In many cases, manufacturers have adopted the approach that because the predefined standard does not exist, they will create a 'Manufacturer's Standard' that adheres closely to elements of one or more other standards. In this way it has been possible for equipment to receive a Certificate of Conformity under the Machinery or PPE Directive. Due to the fast-developing nature of arborists' equipment relative to the EN standards, this would seem a sensible approach for manufacturers to take in order that their products are not only received favourably within the arborist community but, importantly, meet predetermined criteria that are accepted throughout the European Union.

7.1 Summary of test methods for EN standards applicable to arborist equipment

7.1.1 **Standard:** EN795:2012 (Class B)

Name: Anchor Devices – Transportable Temporary Anchor Devices

Equipment scope: Cambium savers, friction savers

Summary of test method: The sample anchor device shall be tested with forces applied in line with expected service. The configuration for a test shall be in accordance with the manufacturer's instructions.

Static test: A test force of 12kN shall be applied and held for 3mins in the direction of use in service. Observe that the anchor device remains stable and holds the force. If material durability information is not provided, a test force of 18kN shall be applied for 3mins.

Dynamic test: A test lanyard of 2000mm (+-100mm) length, made of 11mm single mountaineering rope, which conforms to EN892. Terminations are formed using a bowline knot no longer than 200mm. The lanyard is connected at one end to the anchor device using an appropriate connector and at the other end to a 100kg mass. The mass is dropped to ensure a free falling travel distance that will generate a fall arrest load of 9kN (+-0.5kN). Observe whether the mass is arrested and that the device is stable.

Other: Due care shall be taken to assess the suitability of a transportable anchor device and any associated fixings for the application in which it is to be used. The viability of any installation should be verifiable by a qualified engineer.

7.1.2 **Standard:** EN1891:1998

Name: Low Stretch Kernmantle Ropes

Equipment scope: Climbing ropes between 8.5mm to 16mm diameter.

- Type A – designed for general use.
- Type B – lower performance than type A, requiring greater care in use. Materials must have a melting point >195°C.

Summary of test method: EN1891 has a complex set of material parameters and methods to calculate whether the test sample meets those criteria. These include calculations for rope diameter, knotability, sheath slippage, elongation, shrinkage, mass per unit of length (metres), mass of outer sheath material (as % of total) and mass of core material (as % of total).

Static test:
If tested with no terminations it is required to sustain the following:

- Type A rope = 22kN
- Type B rope = 18kN

If tested with terminations the force must be held and maintained for a duration of 3mins:

- Type A rope = 15kN
- Type B rope = 12kN

Fall arrest peak force test: Using a test sample of length 2000mm (+-100mm) attached at one end to an anchored load cell and at the other end to the appropriate mass (Type A = 100kg, Type B = 80kg). The mass is lifted 600mm (+-20mm) before being released. The peak force must not exceed 6kN. The dynamic test must begin within 3mins of the peak fall arrest test.

Dynamic test: The test must begin using the same sample and apparatus as the peak force test and must begin within 3mins of its completion. The appropriate mass (Type A = 100kg, Type B = 80kg) shall be lifted to a level with the anchor before being released. Within 1 minute the load shall be relieved from the test sample. This process is continued for five consecutive drops with an interval between each test of 3mins (+-0.5mins) or until the test sample releases the mass.

7.1.3 Standard: EN358:2000

Name: Belts for work positioning and restraint and work positioning lanyards

Equipment scope: Waist belt with restraint rings (side Ds) and adjustable lanyards of a maximum length determined by the manufacturer.

Summary of test method: A waist belt and work position lanyard shall be tested in combination and shall not allow the test dummy to be released.

Static test:
Waist belt: a force of 15kN shall be applied for a duration of 3mins.

Detachable work positioning lanyard with a length adjustable element: with the adjuster engaged at 300mm from the lanyards end apply a force of 5kN and hold for 3mins. Slippage of the adjuster element cannot exceed 50mm. The adjuster is then moved to the end stop and a force of 15kN is applied for further 3mins. There can be no fracture or failure within the components.

Dynamic test:
Waist belt: using a 1 metre lanyard of 11mm mountaineering rope meeting EN892 standard. A test torso dummy is fitted to the belt and lifted to level with the anchor. Once released the torso must travel feet first a minimum distance of 1 metre before tension is taken up. The torso dummy must not be released.

Detachable work positioning lanyard with a length adjustable element: using the test sample, a 100kg mass is attached to the lanyard. The mass is lifted to level with the anchor. Once released the mass must travel a minimum distance of 1 metre before tension is taken up. There can be no fracture or failure within the components.

Other: There are a variety of tests depending on the exact nature and configuration of the waist belt and lanyard interface, the determining factors for the choice of test mainly being whether the lanyard length is fixed or adjustable.

7.1.4 Standard: EN354:2002

Name: Lanyards

Equipment scope: Fixed length rope lanyards not exceeding 2 metres with preformed terminations.

Summary of test method: Test shall be carried out with no separating, tearing or rupture of any lanyard element.

Static test: A force of 22kN shall be applied from the terminations for a duration of 3mins.

Dynamic test: A 100kg mass is attached to one termination and the other termination to a fixed anchor with load cell. The mass is raised to 2 metres above the fixed anchor or to the full extent of the lanyard should it be shorter than 2 metres. The mass will be dropped and observe that the mass is not released.

7.1.5 Standard: EN362: 2004

Name: Connectors

Equipment scope: Carabiners, snaps and maillons

Summary of test method: EN362 is a complex standard due to the extensive variations in connector design. Some of the tests include gate resistance, gate function, major and minor axis and corrosion tests.

Static test: Minimum static strength requirements for connectors as tested using tensile load apparatus.

Type	Description	Major axis, gate closed, unlocked	Major axis, gate closed, locked	Minor axis, gate closed
Carabiners	Basic connector (class B)	15kN	20kN	7kN
Snap hooks	Termination connector (class T)	15kN	20kN	Not applicable
Maillon rapide	Screwlink connector (class Q)	Not applicable	25kN	10kN

Other: Connectors should not have sharp edges or burrs that may cause injury to the user, or that may cut, abrade or otherwise damage webbing or rope.

7.1.6 **Standard:** EN564:2014

Name: Accessory cords

Equipment scope: Used to tie Prusik loops and eye-to-eye slings and generally used as friction hitches

Static test: Using tensile strength apparatus the cordage is break tested and must meet the criteria within the table below. A length of cord must measure no less than 200mm.

Nominal diameter (mm)	Minimum tensile strength (kN)
4	3.2
5	5.0
6	7.2
7	9.8
8	12.8

Dynamic test: There is no dynamic test for accessory cords.

Other: Must be of a kernmantle construction.

7.1.7 **Standard:** EN12841: 2006

Name: Rope adjustment devices

Equipment scope:

Type A devices are for use on safety lines to prevent a fall in the event of failure of the working line or its components. These would generally be known as back up devices, i.e. DMM Buddy.

Type B and C devices are for ascending and descending a working line respectively, but also have a fall prevention function. These devices often function in both directions, i.e. Petzl I'D.

Summary of test method:
The selection of test methodologies depends on the device's function and may involve an arrest distance test, braking force test, hands-free and panic-locking elements and heat build-up/dissipation as well as static and dynamic strength tests. If the device is intended for use within a range of rope diameters then the test shall be replicated with the both the higher and lower diameters.

Static test:
Type A:

- A force of 1kN shall be applied to the device in configuration for 3mins (+- 0.25mins) with maximum slippage of 100mm.
- Shall withstand a force of 15kN for 3mins (+- 0.25mins) when applied to the device in configuration.

Type B: a force of 4kN shall be applied to the device in configuration for 3 mins (+- 0.25mins) with maximum slippage of 100mm.

Type C: a force of 12kN shall be applied to the device in configuration for 3 mins (+-0.25 mins) with maximum slippage of 300mm.

Dynamic test:
Type A: shall have a maximum braking force of 6kN and an arrest distance of a maximum of 2 metres. The fall distance of a 100kg mass is determined by the manufacturer's intended use, i.e. with or without a lanyard.

Type B: shall have a maximum braking force of 6kN and an arrest distance of maximum 2 metres. Using a lanyard that meets EN892: Mountaineering ropes of 1 metre length. Fixed at each end with a suitable connector and attached to the device and the mass. The mass is raised by 1 metre and released. The mass must not fall and must be arrested within 2 metres; part of the line may fail in the arresting process.

Type C: using a lanyard that meets EN892: Mountaineering ropes of 1 metre length. Fixed at each end with a suitable connector and attached to the device and the mass. The mass is raised by 1 metre and released. The mass must not fall and must be arrested within 2 metres; part of the line may fail in the arresting process. Immediately following the dynamic test, the force is increased to 3kN and held for 3mins (+- 0.25mins).

Other: These devices are designed for use within a rope access system; work positioning in a rope access system is a specific technique and is not intended to conform to work positioning in accordance with EN358.

7.1.8 Standard: EN566:1997

Name: Slings

Equipment scope: Loop slings and eye-to-eye slings

Summary of definition: Sling = tape, accessory cord or rope joined by stitching or other means of fastening. The shape and length are not specific.

Static test: A tensile strength of at least 22kN shall be reached.

Other: When webbing is used, the weft shall be locked by an additional locking thread, which guarantees that the edges cannot be unravelled when one of the yarns breaks. Threads are intended to provide safety and strength and, where visible, must contrast with the tape/webbing (e.g. colour or surface appearance).

7.1.9 **Standard:** EN813:2008

Name: Personal Fall Protection Equipment – Sit harness

Equipment scope: Sit harness used for restraint, work positioning and rope access with fixed or sliding ventral attachment point for connectors and usually combined with EN358 side connection points.

Summary of test method: There are both static and dynamic testing methods as well as protocols covering the type of material and thread used, the location of attachment points, load-bearing parts that create a direct force onto the body, some form of back support, fastening and adjustment elements, materials' corrosion resistance and accessibility to the product for periodic inspection.

Static test: With the harness fitted to a torso test dummy, a force of minimum 15kN and up to 10× the manufacturer's rated load is applied to the front connection point for 3mins. During the test, no load-bearing part shall break or rupture and no elements of the harness may come detached.

Dynamic test: Using a lanyard that meets EN892: Mountaineering ropes of 1 metre length, terminated at each end with a bowline knot and attached to a fixed anchor point and the torso test dummy. The torso test dummy is raised by 1 metre above the fixed anchor at a sideways distance of 300mm and released. The torso test dummy must be held and no load-bearing part shall break or rupture and no elements of the harness may come detached.

Other:
Ergonomics are also tested and a harness most be shown to:

a) be capable of adjustment to enable correct positioning on the user;
b) support the user in an upright sitting position while in suspension;
c) allow the person wearing the sit harness to undertake a specified range of movements without undue discomfort;
d) consist of metal fittings with no contact with the groin, the inside of the thighs, the armpits or the small of the back; and
e) remain correctly adjusted.

8.0 How the project objectives have been achieved

8.1 To research the equipment currently being used by SRWP climbers and how it is applied in the workplace.

A survey and a group-climbing day were organised to understand the equipment used and how it is being applied in the workplace by a group of experienced SRWP climbers. Although climbing techniques are constantly evolving, there have been no significant changes in technique since the start of this project.

8.2 To analyse the relationship of the tools and techniques used to the UK framework of legislation and good practice.

For the duration of this project there has been a lack of clarity surrounding parts of UK legislation and good practice, so the decision was made to focus the main body of the work on the subject of practical testing and understanding rather than analysis as set out in the objective mentioned above, in order to best utilise the resources of this research grant.

8.3 To gain understanding of the forces experienced in SRWP practices and those the equipment may be subject to; to compare the forces equipment is subject to against commonly accepted EU PPE test standards.

In addition to existing research, after measuring the forces in the field with load cells and destructive testing, we can make some informed decisions about how appropriate some prevailing applications of certain pieces of equipment are within the scope of current test standards. In almost all cases the configurations of equipment fell within the parameters of relevant parts of the current EN test standards, the exception being a Munter/Italian hitch on a carabiner, used as a redirect.

8.4 To assess whether equipment application matches the currently accepted test criteria and manufacturers' recommendations for use.

By understanding the equipment and commonly used applications and configurations, along with developing an in-depth knowledge of the EN test standards and their requirements, we can see that in some cases equipment test standards are not appropriate to the way the equipment is being used in reality. For example, the manner in which friction cords are tested is mostly irrelevant to the way in which they are used. Most factory-made eye-to-eye cords are tested to **EN566 or EN795B**, both of which are completely irrelevant to the way a friction hitch is used in the field by climbing arborists.

Another case is the dynamic test for **EN795B**. A test lanyard of 2000mm (+-100mm) length, made of 11mm single (dynamic) mountaineering rope, which conforms to **EN892** is used. The lanyard is connected at one end to the anchor device using an appropriate connector and at the other end to a 100kg mass. Arborists in the UK rarely use ropes tested to **EN892**, nor would many UK climbers be likely to use them in single leg configuration, as stated.

The use of dynamic ropes for dynamic tests is also the case in **EN12841** (this is the test standard for rope adjustment devices and covers backup devices, ascenders and descenders). This seems rather irrelevant to arboriculture as the only time (when using work positioning techniques) that a fall is likely to occur is when the climber is working on semi-static ropes (**EN1891** compliant) above his or her transportable temporary anchor device.

In addition, the Rope Wrench and tether as a standalone device is tested to **EN12278**, which is the test standard for pulleys. This is not how the device functions or is designed to be used. As a system, it is tested to **EN353-2**. This is the standard for guided type fall arresters and a requirement of the standard is that the system is made up of a line intended to be fixed (either temporarily or permanently) to a structure at the top only, on which a travelling device (Rope Wrench system) is attached. This is much more appropriate to the use of equipment in arboriculture than the pulley standard.

9.0 Conclusions

As a result of this project some suggestions can be made about how to utilise Stationary Rope Techniques safely in the work place:

9.1 Incorporate some margin of error into the primary redirect that is selected from the ground when base anchoring. If the primary redirect is in question, open the angle of the rope or take a lower primary redirect until it can be assessed from in the tree. These two techniques are the most effective in reducing the loading in the canopy. **Whilst adding wraps or twists to the 'down leg' (or anchored side) of the rope does reduce the loading at the ground anchor, it does not significantly reduce the loading on the primary redirect at the top of the tree.**

9.2 **Set a cinching base anchor that incorporates a rescue alpine and a twist or wrap around the stem, to aid release of said anchor in the event of a rescue.** Climbers and rescuers should train for this ground-based rescue situation because although potentially beneficial in certain situations, it may also pose a significant risk if the technique is improperly executed.

9.3 Select a compatible, suitably configured climbing system of your choice. If you are using a friction hitch, ensure it grabs reliably but does not bind or grip too hard. **A hitch with some ability to extend and slip under a heavy load may add some slight shock absorbency during a fall.** In the testing by Adam Davies of ISC (see the appendix folders), it has been observed that the choice of hitch could assist in keeping peak loading below 6kN in the event of a fall.

9.4 Preferably use a method of advancing the climbing system that does not risk strangulation in the event of the climber becoming unconscious – for example, a chest harness or the use of a lanyard over the shoulder instead of a neck-based tether.

9.5 **Set an appropriate canopy anchor(s) and leave a rescue/access line in the tree.** If pruning, select anchor types that reduce the amount of cambium damage from rope contact such as a knot blocked cambium saver.

9.6 Use appropriate redirects or other aids to ensure good work positioning and reduce the chance of a pendulum swing. **When an opening connector is used, employ the safest and hardest-to-open connector (that is still practical to use) you have for remote anchors or redirects.** Ensure, carabiner gates do not come into contact with the tree, even as the rope angle changes throughout the climb. A cinching knot on the redirect such as a clove hitch may help with this. **Climbers should have a good knowledge of tree species, vector forces and loadings changing throughout the climb.**

9.7 **Be aware of the potential for semi-static redirects (i.e. Munter or spine wraps) to creep** through under heavy loads and act as a progress capture, potentially loading tree structures excessively.

9.8 **Use appropriately rated and tested equipment that is fit for the methods you plan to employ. Whenever possible used 'closed' systems at remote anchors.**

9.9 Manage ropes at all times, so that you can get to the ground in the event of an emergency.

9.10 In addition to these suggestions the authors feel that a review of how equipment is tested within the UK arboricultural industry would be highly beneficial. When the original standards were formed there was little or no direct consultation with the arboricultural industry and this has continued to be the case for the interim period. Practical arboriculture holds a unique place within the 'at height' industries and should be consulted more thoroughly in such matters. **Test standards do not always accurately simulate the applications of equipment that have historically existed in climbing arboriculture, let alone those developed within the industry over the past 5 to 10 years.**

9.11 **As a result of the research and testing within the body of this project, it is the authors' opinion that the SRWP techniques tested (that are used regularly throughout the industry) are no more inherently dangerous than any other climbing technique, if the climber adheres to current published good practice.** The significant difference between moving and stationary rope techniques is the mechanics of movement for the operator and as such, the two techniques should not be classed differently as rope access or work positioning.

9.12 **All work at height is work positioning** by the simplest definition. An operator gets into a ***position*** to safely perform ***work***. All of the following exist under the broad umbrella of work positioning: fall arrest, work restraint, rope access and arboricultural climbing (which often combines all of these). **Therefore, tree workers should be trained and covered under legislation specific to the unique work methods and scenarios that exist within UK arboriculture.** Current training does not train climbers to have an adequate knowledge of many MRT and SRWP techniques or anchorage forces. There is also no difference in tested competency between a newly qualified climber, an experienced climber and an experienced climber who has an in depth understanding of the forces and performance of our systems.

Glossary: Abbreviations, Terms and Definitions

For further or more detailed definitions of the terms listed here please refer to the *Industry Code of Practice for Arboriculture: Tree Work at Height*, which includes clear standardised definitions.

16- strand ropes: a type of rope construction where a 16-strand braided cover sits over a core that is not load bearing but gives shape to the rope. This type of rope is also known as ‘cover dependent’.

AFAG: Arboricultural and Forestry Advisory Group

Ascender: a device that can be clipped to a rope to grab onto the rope in one direction whilst sliding in the other direction, capturing progress.

Certificate of Conformity: is granted to a product that meets a minimum set of regulatory, technical and safety requirements.

Closed shell ascender: a type of ascender (such as a the ISC RP203 rope grab) that fully captures the rope and is closed securely.

Descender: a device that can be connected to a rope to lower a load or for a climber to move down the rope.

Dorsal attachment point: a load-bearing point on a harness at the back, around shoulder height, that keeps the user supported in an upright position.

Double braid ropes: a type of rope construction that utilises a braided core and a braided cover that share the load.

Durolock: a type of gate mechanism on some DMM carabiners.

Dynamic: a property of a material (usually rope or sling) that stretches a large amount under any significant load. Typically used for fall arrest situations such as recreational rock climbing.

EN: European Norms referring to European Standards.

Fall arrest: a type of fall protection that involves the safe stopping of someone already falling.

Friction hitch: a type of knot tied with a piece of cord around a main climbing rope, which slides in one direction and then grabs onto the host rope when loaded.

GBRS: ground-based rescue system

Good practice: conventionally agreed (by industry experts) as the safest and most appropriate way of operating a device or performing a task.

Inline ascender/descender: a device (or system) that connects to a rope in a relatively straight line, allowing the use of foot (and/or knee) ascenders below the device to propel the climber and device directly up the rope and reliably capture progress whilst also allowing descent without any need for additional equipment.

Kernmantle ropes: (from German *kern*, meaning 'core', and *mantel*, meaning 'sheath') is a rope construction with an interior (often parallel strands) core protected by a woven exterior sheath designed to optimize strength, durability, and flexibility. Mostly used in the rope access industry and designed for use with ascenders and descenders.

Knotblock: using a midline or end termination knot to block against a ring or other piece of hardware.

Notified Body: is a conformity assessment body that has been notified by a member state of the European Commission to carry out conformity assessment activities for a given directive.

MRT: Moving Rope Technique – previously known as Doubled Rope Technique (DdRT) where a rope is doubled over or through an anchor point.

Munter: another name for the Italian hitch, useful for belaying and lowering but also redirects as it self-adjusts.

Non-redundant descender: a device designed to descend a rope or lower a load by friction and force applied from a break hand, that has a default position of go if it is not used with a type of additional failsafe that grabs the rope in the event of the climber letting go (known as an autoblock, this may be a friction hitch).

ODSK: Outdoor Shop K (Japan)

Open shell ascender: a type of ascender (such as a chest ascender) that does not fully capture the rope, allowing easy clipping and unclipping from the rope.

PPE: personal protective equipment

Rope/webbing bridge: a type of ventral attachment utilising a rope or webbing to allow a floating attachment connector. This allows excellent range of motion.

Self-braking descender: a device designed for descending ropes or lowering loads that has a default mode of stationary. They may also incorporate a panic feature (this is a failsafe system built into the device in case the load descends too fast).

Semi-static: a type of rope (Type A or B) that is generally used for industrial work such as rope access or arboriculture.

Slaice: a factory-made version of a splice combining a partially stitched eye and a splice.

Splice: a method for making a fixed eye in the end of a rope.

SRT: Stationary Rope Technique

SRWP: Stationary Rope Work Positioning

Static: a property of a material (usually rope or sling) that does not have much stretch or elongation under load.

Sternal attachment point: a load-bearing point on a harness at the front of the chest that keeps the user supported in an upright position.

TCIA: Tree Care Industry Association

Ventral attachment point: a load-bearing point on a harness at waist height allowing good freedom of movement.

VTIO: Victorian Tree Industry Organisation

Work positioning: the techniques and process of getting into (and transferring between) the necessary positions required to perform work; where the user is supported in tension by personal fall protection systems.

Work restraint: the means by which a person is prevented from being able to get into a place or position where a fall can occur.

Bibliography of Reference Material used in the Compilation of this Report

The Art and Science of Practical Rigging, book and DVD, Peter Donzelli and Sharon Lilly, ISA, 2001

Best Practices for SRT in Arboriculture, Donald Coffey and Tchukki Andersen, TCIA, 2nd edn

EN testing standards – these can only be purchased from BSI and cannot be viewed online for free, although some websites do have abbreviated versions to view.

A Guide to Good Climbing Practice, Arboricultural Association, 2005

Industry Code of Practice for Arboriculture: Tree Work at Height, 1st edn, Arboricultural Association, 2015

RR668: *Evaluation of current rigging and dismantling practices used in arboriculture*, prepared by Treevolution and Brudi & Partner TreeConsult for the Health and Safety Executive and the Forestry Commission, 2008: https://www.hse.gov.uk/research/rrpdf/rr668.pdf

'Working the Angles', Joe Harris, Victorian Tree Industry Organisation, 2010: http://vtio.org.au/wp-content/uploads/2010/07/Working-the-Angles-i.pdf

Further Reading/Guidance

Industry Code of Practice for Arboriculture: Tree Work at Height, 2nd edn, Arboricultural Association, 2020

Technical Guide 1: *Tree Climbing and Aerial Rescue*, Arboricultural Association, 2020

Appendices

Please see the appendices that follow for further information and data regarding:

- survey questions and results;
- group research day photos;
- photos of destructive and non-destructive testing; and
- external data sources.

SRWP Project – Appendix 1: Questionnaire and Results

Dear Colleague,

We were wondering if you wouldn't mind sparing us just a moment of your time, to help provide us with information relating to the climbing system, equipment and techniques that you may be using for SRT work positioning (SRTWP).

Why?
A research project has started with the aim to appraise Stationary Rope Work Positioning (SRWP) techniques and equipment commonly used within the United Kingdom arboricultural industry, and their relationship and relevance to legislation, good practice and EU equipment test standards.

Research Objectives:

1. To research the equipment currently being used by SRWP climbers and how it is applied in the work-place;
2. To analyse the relationship of the tools and techniques used against the UK framework of legislation and good practice
3. To gain understanding of the forces experienced in both SRWP practices and those equipment may be subject to;
4. To compare the forces equipment is subject to against commonly accepted EU PPE test standards;
5. To assess whether equipment application matches the currently accepted test criteria and manufacturers recommendations for use.

Research Outcomes:

1. To develop a broader understanding of the extent of SRWP use within the UK arb industry;
2. To provide an assessment of the applicability of SRWP to current UK good practice;
3. To assess whether equipment used in SRWP meets current EU standards and whether equipment or standards require update to meet our legislative framework;
4. Instigate a review of how SRWP may be dovetailed into an updated guide to good climbing practice and/or technical guide.

We would be most grateful, once you have completed this short questionnaire that your paper is returned to either a member of staff at the Treeworker trade stand, or a member of the demonstration team during the Tree Climbers Forum.

Q1. If you use a ground anchor/basal anchor, what equipment forms your set up?
A:
Q2: If you use a tie off within the tree canopy, what set up would you use and do you include any hardware items e.g. Running bowline?
A:
Q3: Which rope do you use for SRTWP?

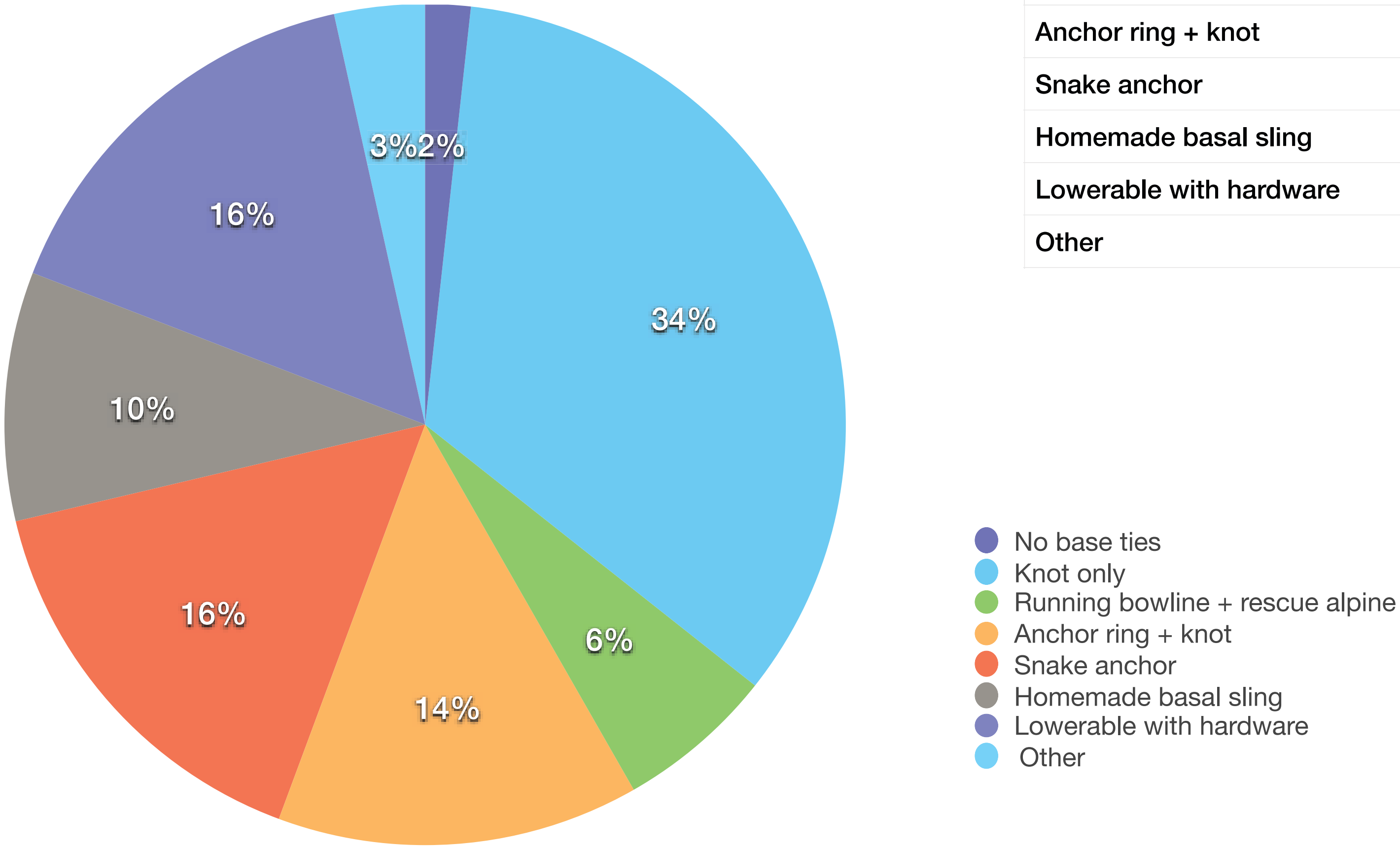
A:
Q4: What climbing device do you use as part of your SRTWP system?
A:
Q5: Do you use the same system for both access and work positioning?
A:
Q6: Can you please describe the system set up that you use for access?
A:
Q7: Can you please describe the system set up that you use for work positioning?
A:
Q8: Do you use any sort of technique to trail a climbing device e.g neck elastic, lanyard?
A:
Q9: Are you employed or self employed?
A:
Q10: Are you allowed to use SRTWP techniques within the workplace?
A:

Q11: Does your system incorporate any form of back up or redundancy, such as a separately anchored or separately acting line?
A:

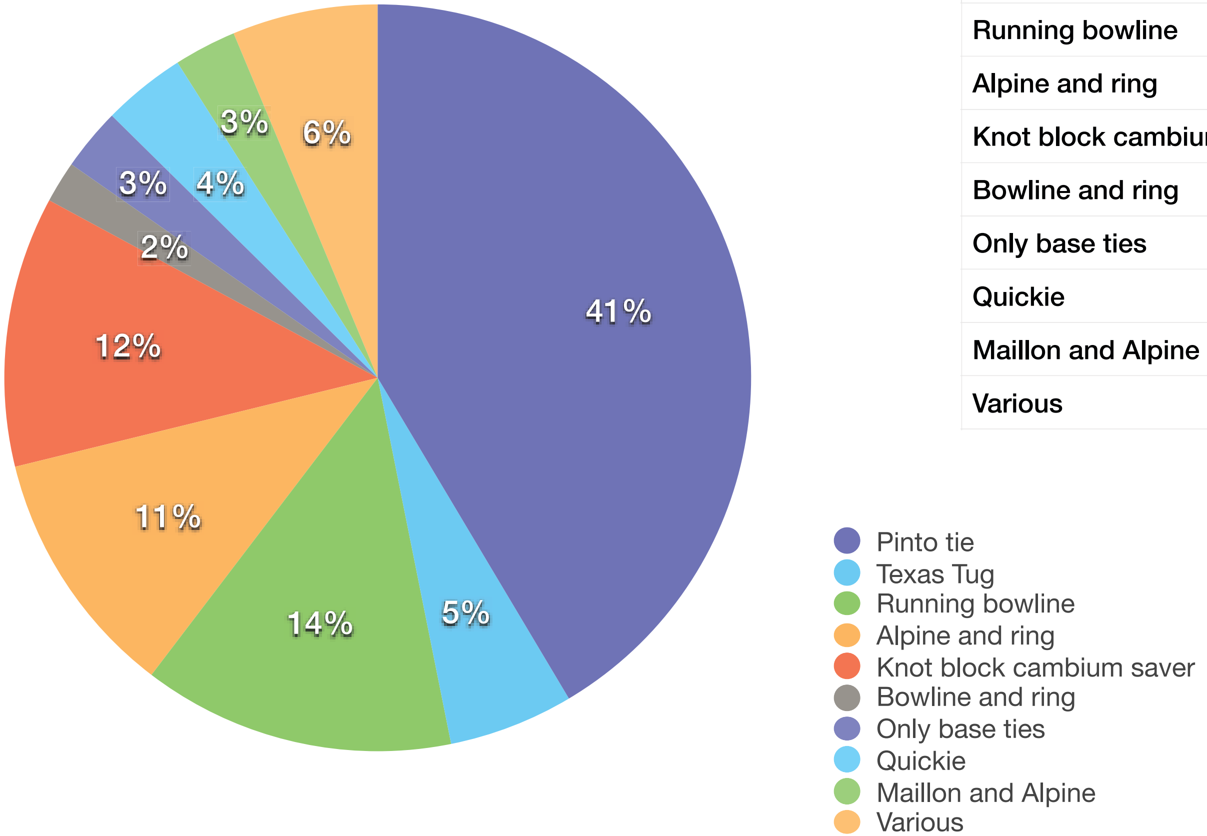
Q1. If you use a ground/basal anchor what equipment forms your setup?

Question 1

ANSWER	COUNT
No base ties	2
Knot only	39
Running bowline + rescue alpine	7
Anchor ring + knot	16
Snake anchor	18
Homemade basal sling	11
Lowerable with hardware	18
Other	4



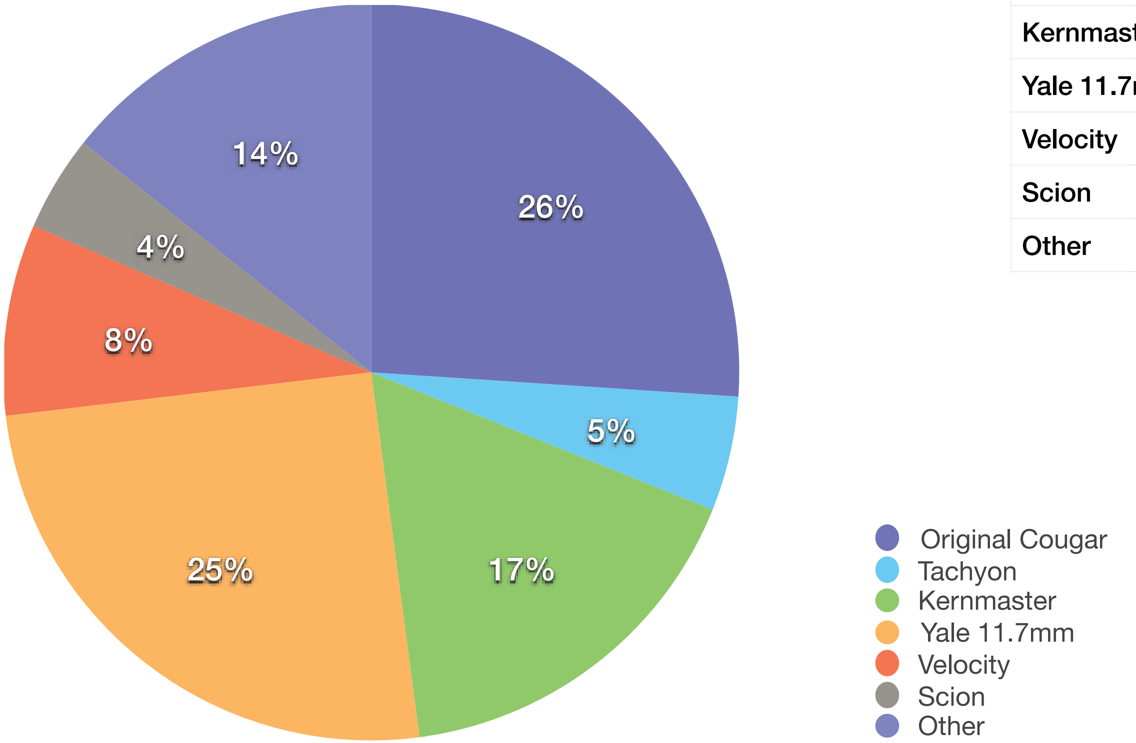
Q2. If you use a canopy anchor what equipment forms your setup?



Question 2

ANSWER	COUNT
Pinto tie	46
Texas Tug	6
Running bowline	15
Alpine and ring	12
Knot block cambium saver	13
Bowline and ring	2
Only base ties	3
Quickie	4
Maillon and Alpine	3
Various	7

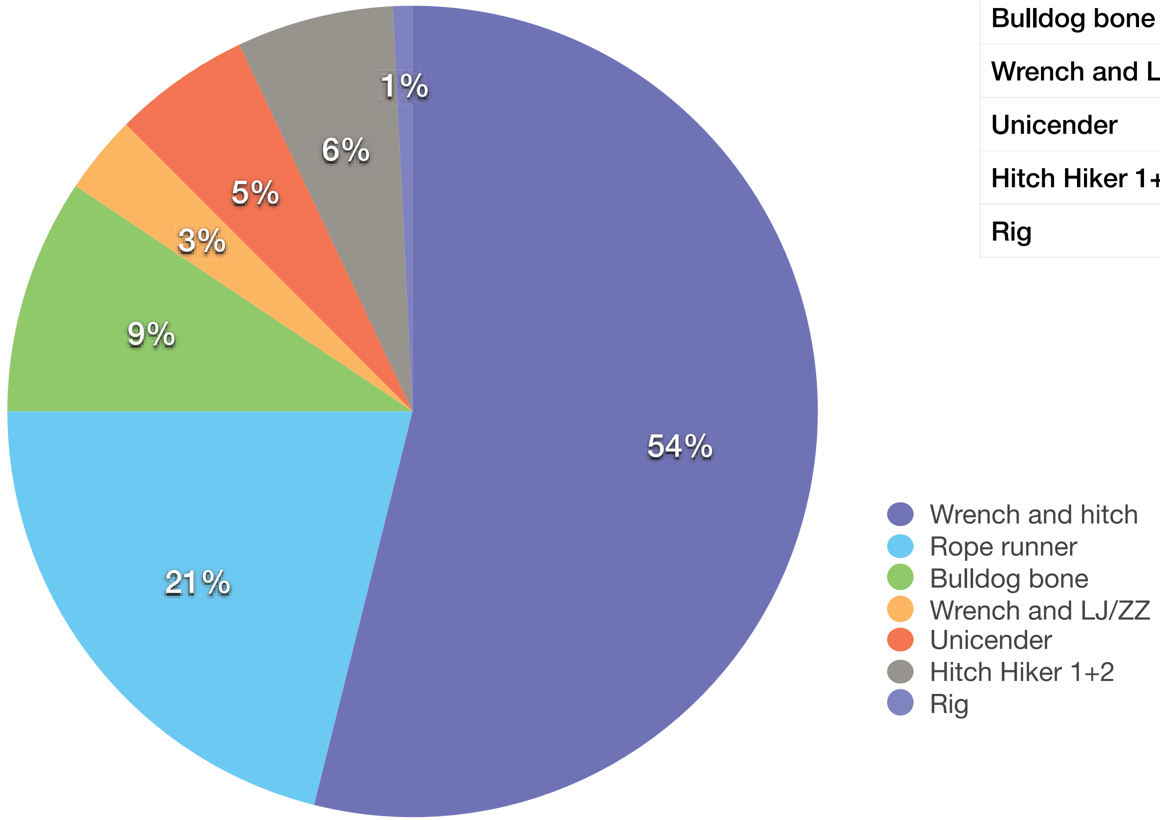
Q3. What rope do you use for SRWP?



Question 2

ANSWER	COUNT
Original Cougar	31
Tachyon	6
Kernmaster	20
Yale 11.7mm	30
Velocity	10
Scion	5
Other	17

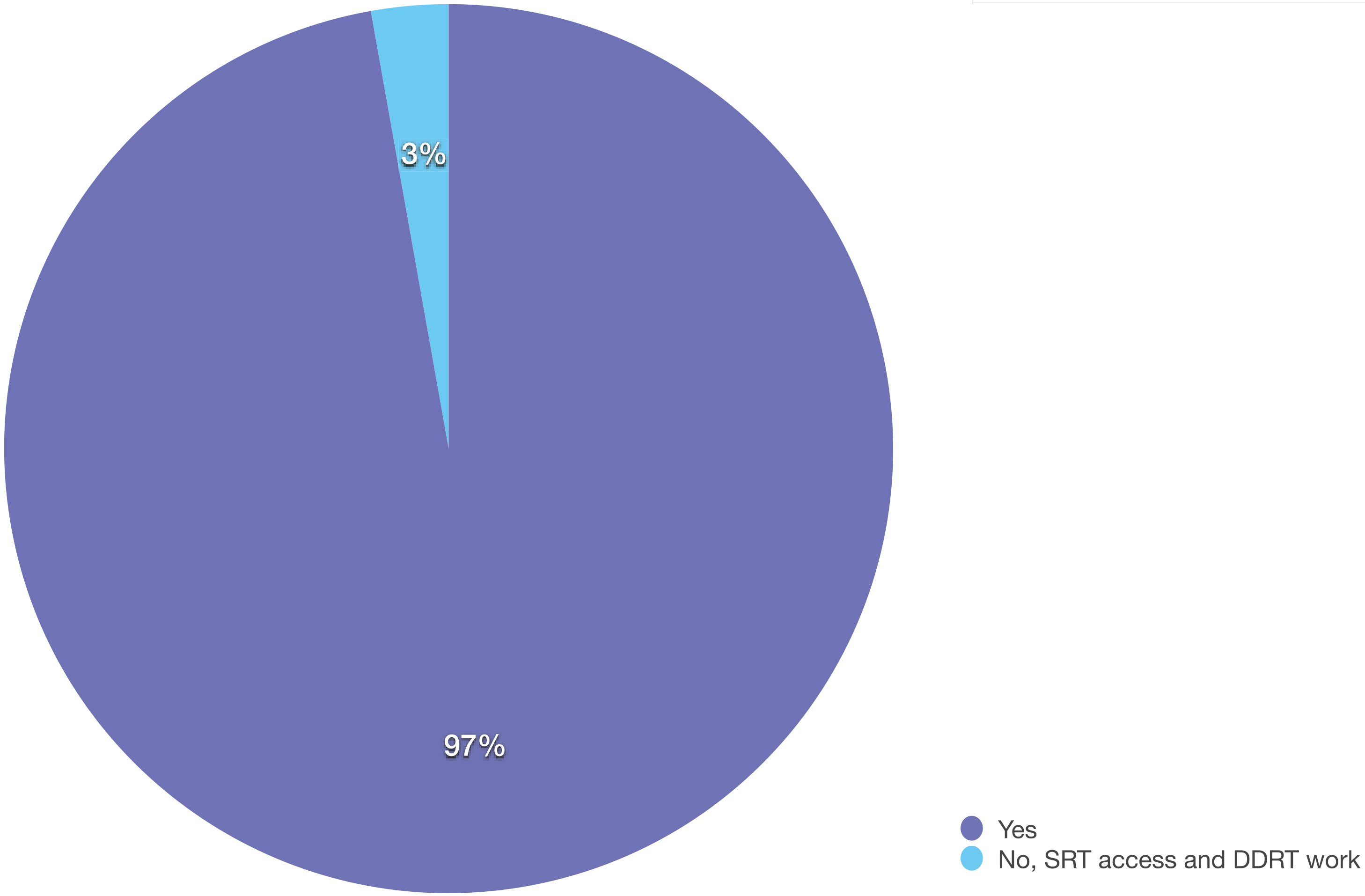
Q4. What climbing device do you use as part of your SRWP system?



Question 4

ANSWER	COUNT
Wrench and hitch	69
Rope runner	27
Bulldog bone	12
Wrench and LJ/ZZ	4
Unicender	7
Hitch Hiker 1+2	8
Rig	1

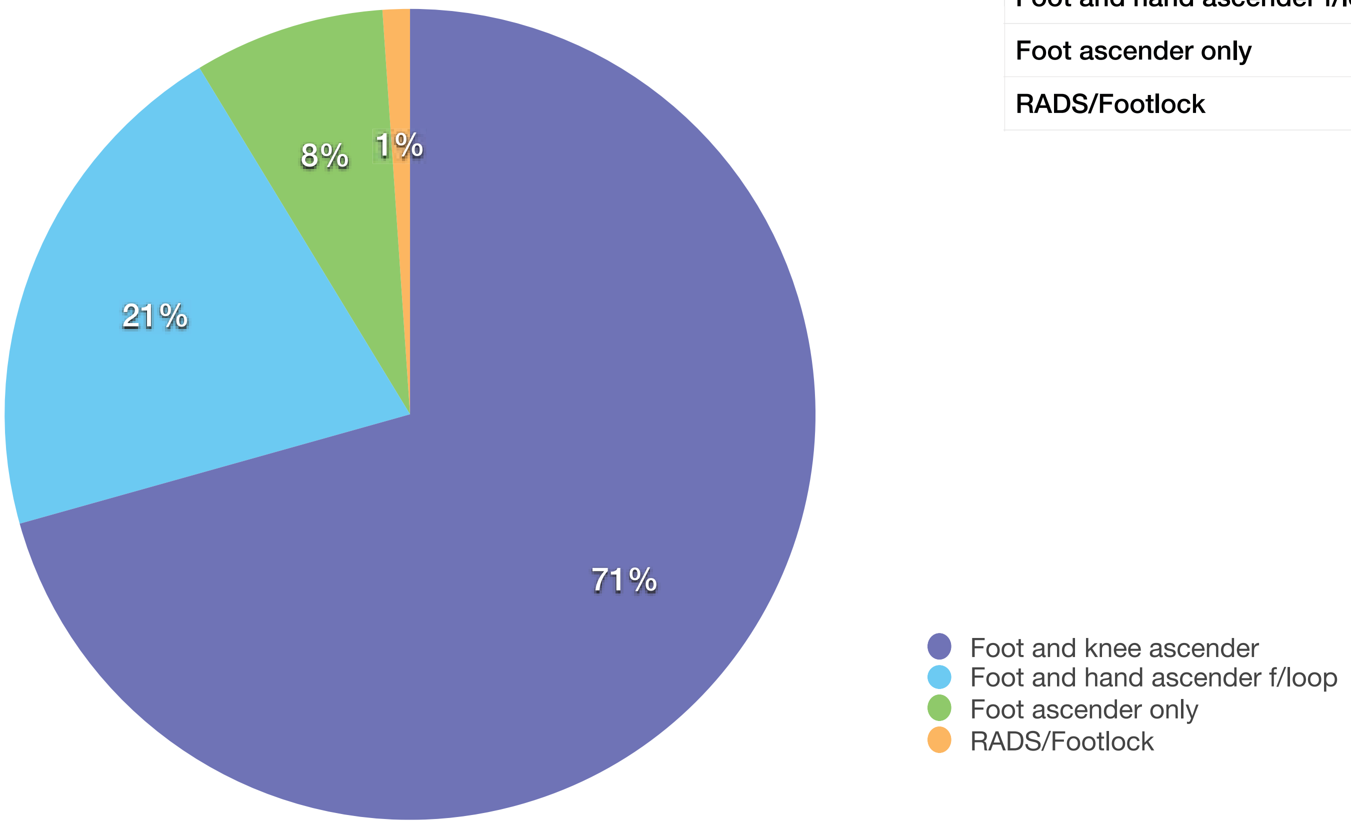
Q5. Do you use the same system for access and work positioning



Question 5

ANSWER	COUNT
Yes	104
No, SRT access and DDRT work	3

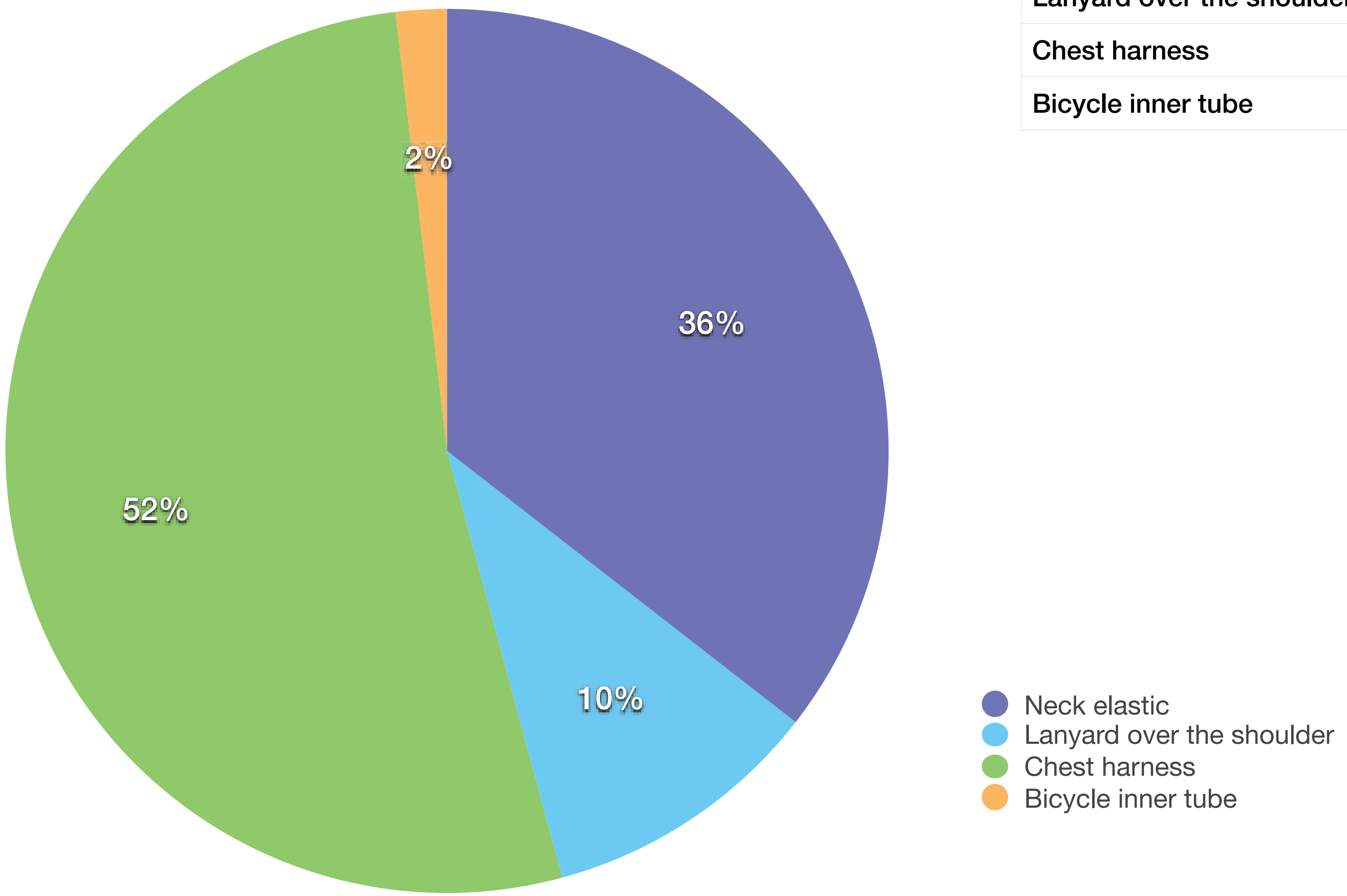
Q6. What climbing aids do you use to ascend the rope?



Question 6

ANSWER	COUNT
Foot and knee ascender	65
Foot and hand ascender f/loop	19
Foot ascender only	7
RADS/Footlock	1

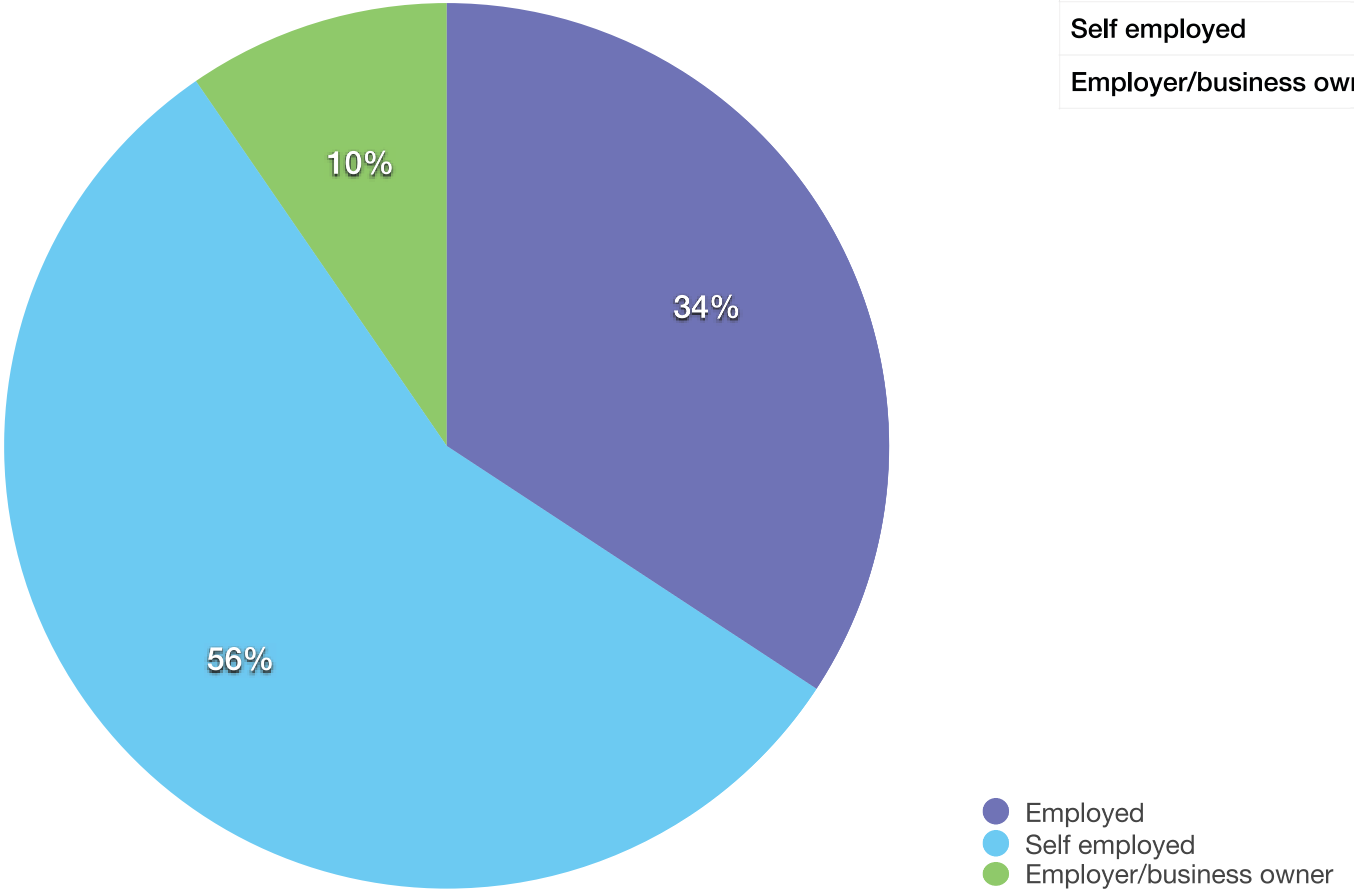
Q7. How do you advance your climbing device when ascending? e.g.. chest harness/neck elastic



Question 7

ANSWER	COUNT
Neck elastic	38
Lanyard over the shoulder	11
Chest harness	56
Bicycle inner tube	2

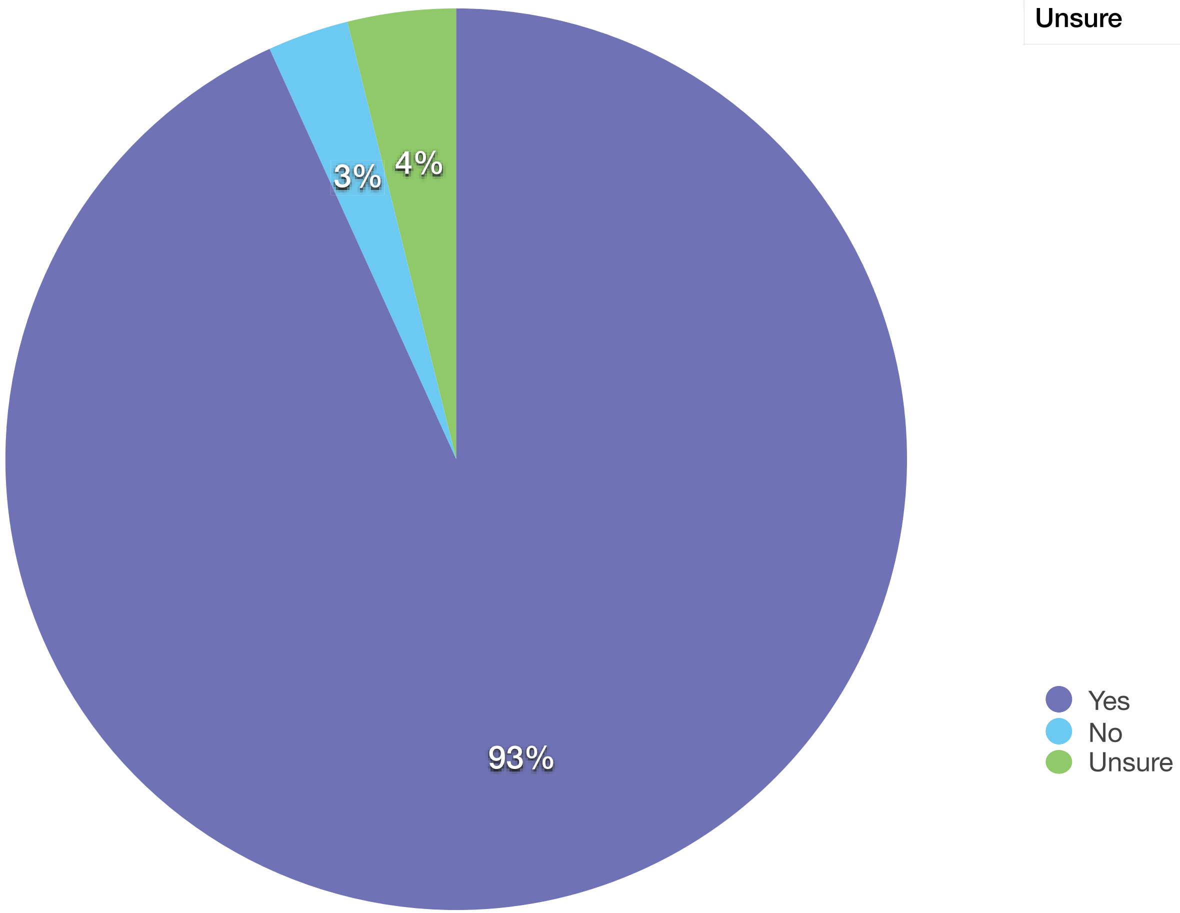
Q8. Are you employed or self employed?



Question 8

ANSWER	COUNT
Employed	25
Self employed	41
Employer/business owner	7

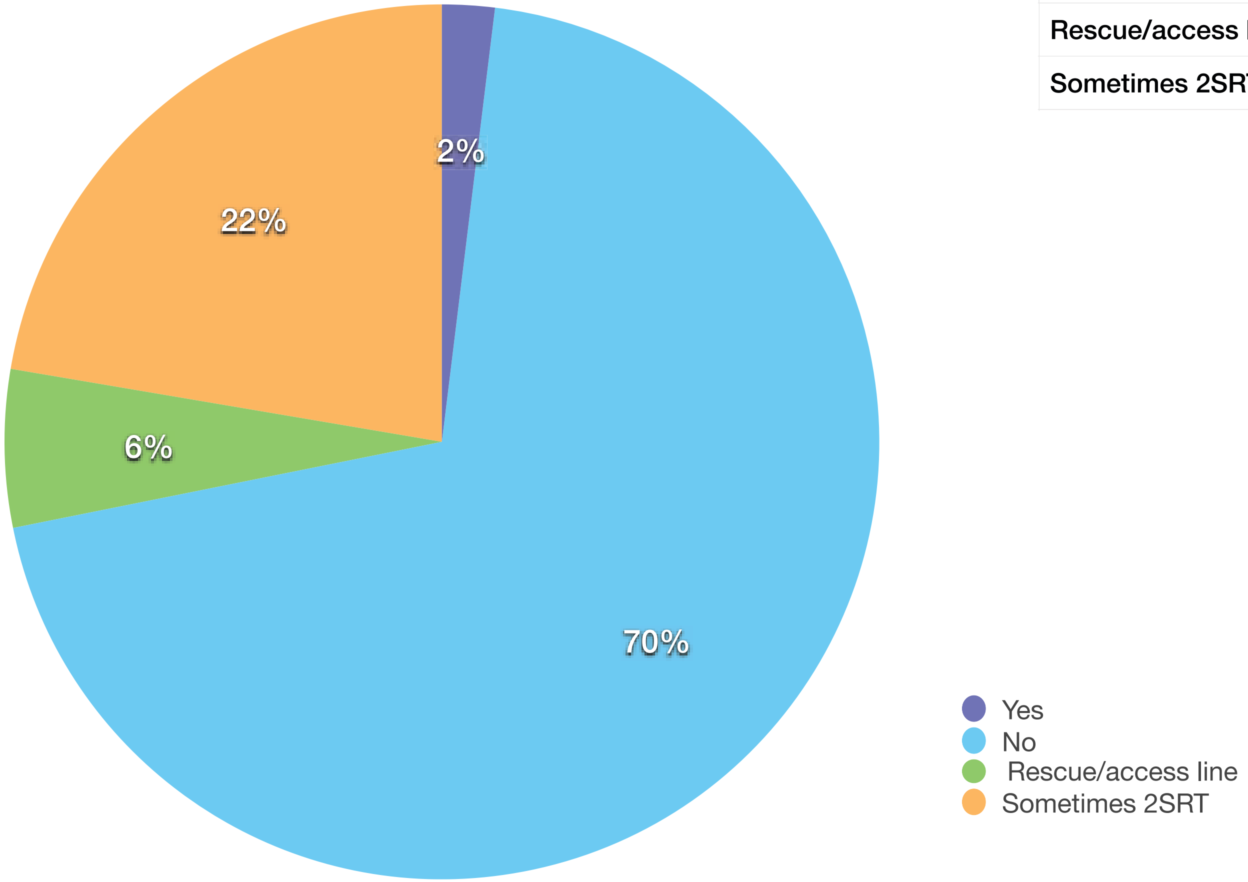
Q9. Are you allowed to use SRWP within the workplace?



Question 9

ANSWER	COUNT
Yes	96
No	3
Unsure	4

Q10. Does your system incorporate any form of back up or redundancy?



Question 10

ANSWER	COUNT
Yes	2
No	72
Rescue/access line	6
Sometimes 2SRT	23

SRWP Project – Appendix 2: Group Research Day Images

Adjustable base anchor – homemade

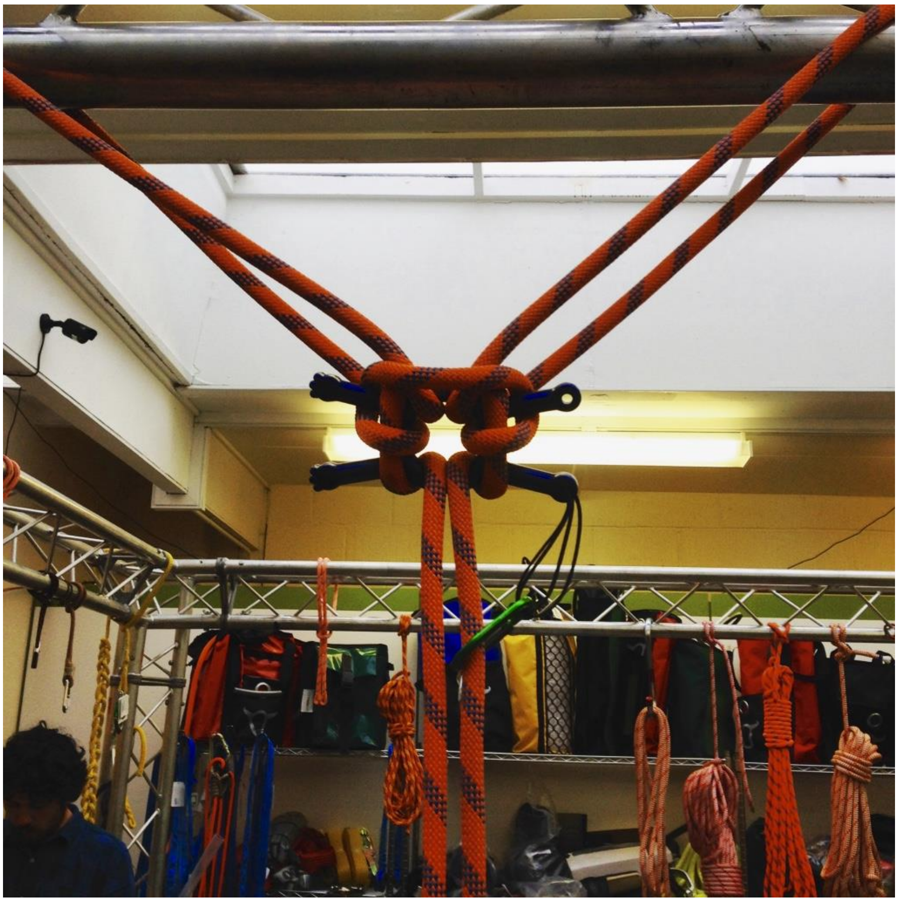
Cinching base anchor with rescue alpine

Cinching base anchor with ring

Fimblsaver knotblock

Floating pinto anchor

Hitch hiker 2



Imp load share fixed anchor

Imp redirect

Maillon alpine cinch with Texas tug

Midline attachable knotblock

Oval Wrench setup 1

Oval Wrench setup 2

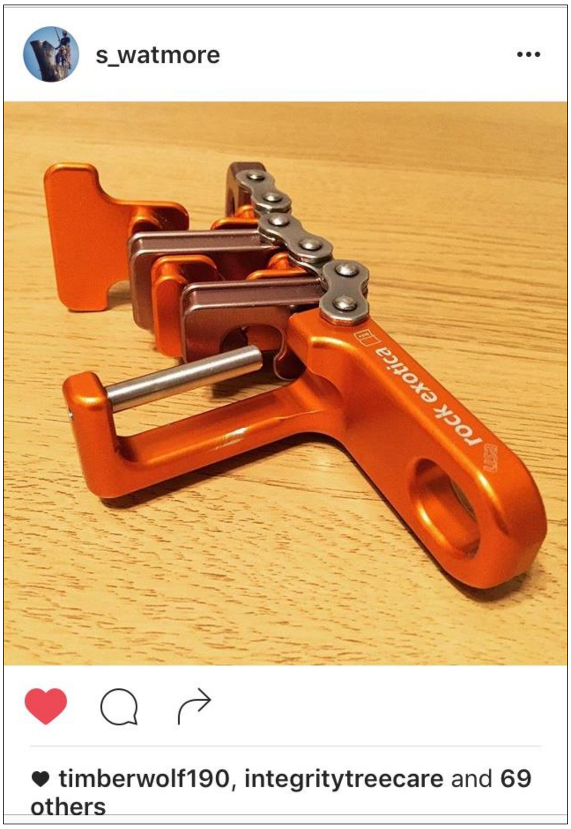
Redirect with clove hitch

Ring cinch redirect

Ring thimble alpine top anchor

Rope Runner

Rope Wrench



Unicender – modified

Zigzag RopeWrench

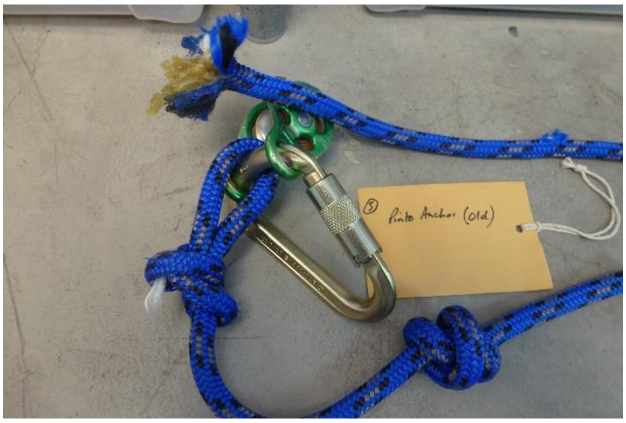
SRWP Project – Appendix 3: Destructive Test Images

1. Running Bowline (inboard)

2. Running Bowline (outboard)

3. Running Alpine

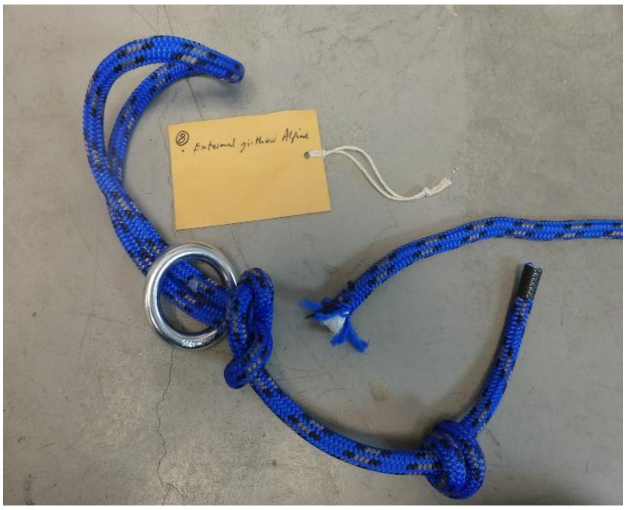
4. Pinto Anchor (new pulley)



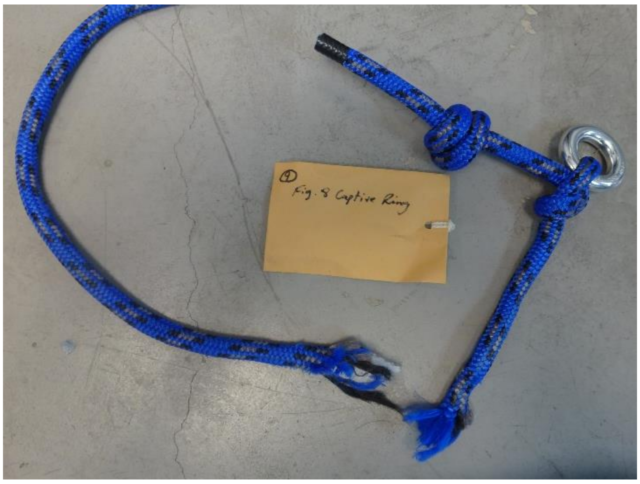
5. Pinto Anchor (old pulley)

6. Alpine, Ring

7. Bunny Alpine, Ring



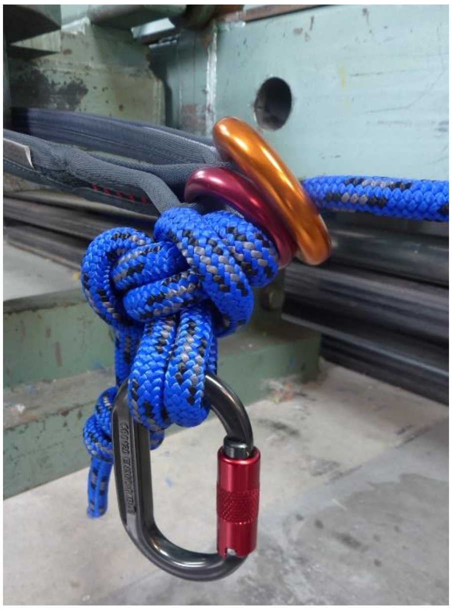
8. External girthed Alpine



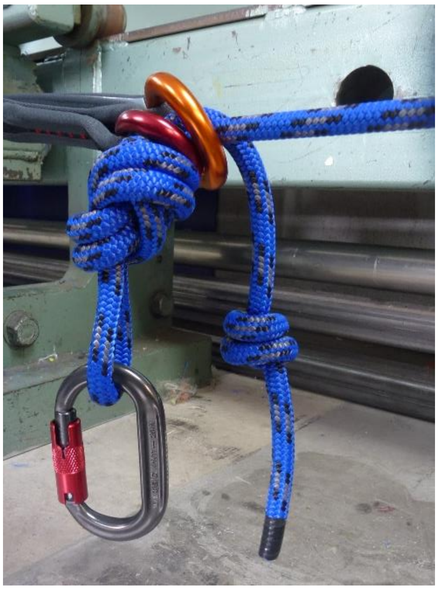
9. Figure 8 Captive Ring

10. Maillon Alpine

11. Cambium saver, Alpine block



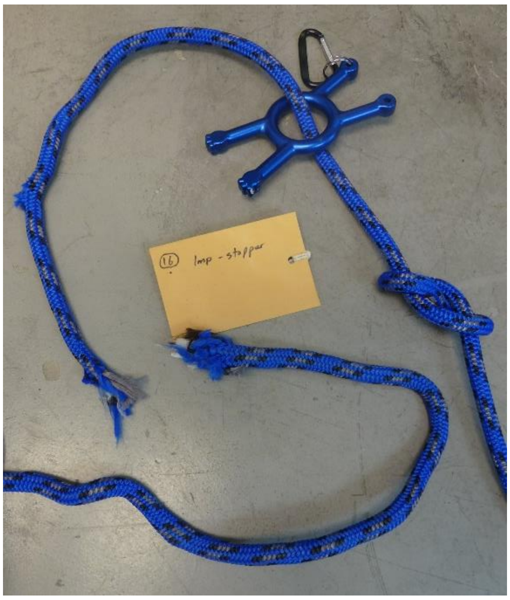
12. Cambium saver, Bunny Alpine block



13. Cambium saver, Figure 9 block

14. Ring cinch, Alpine block

15. Ring cinch, Bunny Alpine block

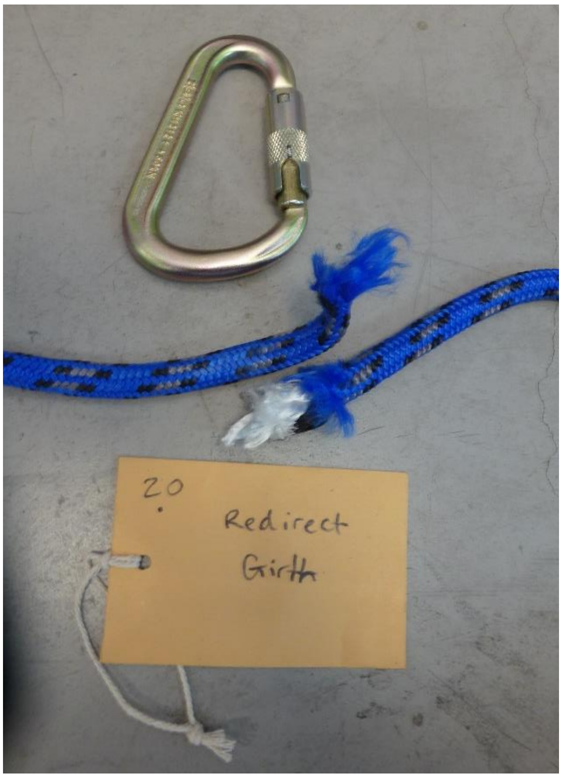


16. Imp blocker

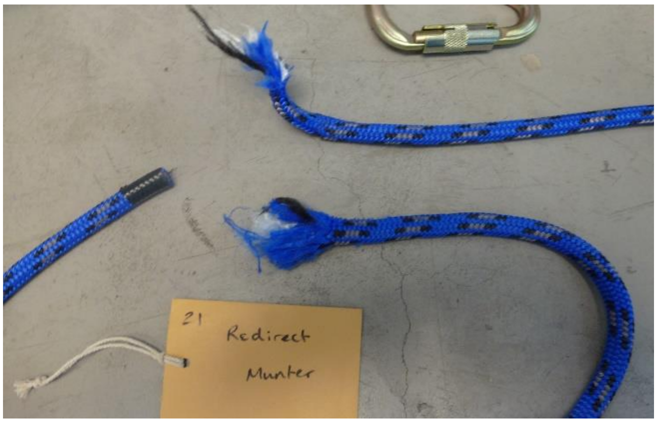
17a. Ring cinch redirect (with stopper)

18. Redirect Alpine

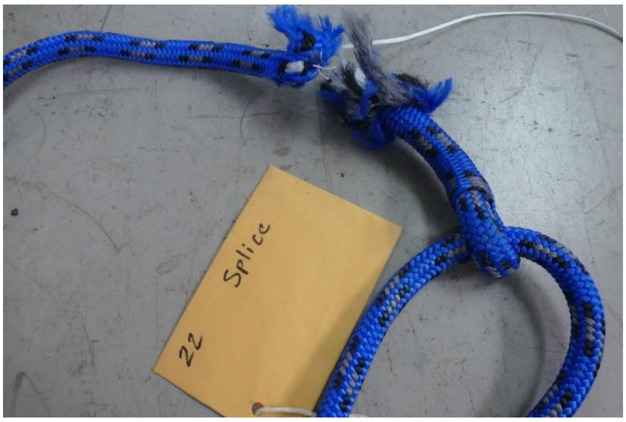
19. Redirect Clove



20. Redirect Girth

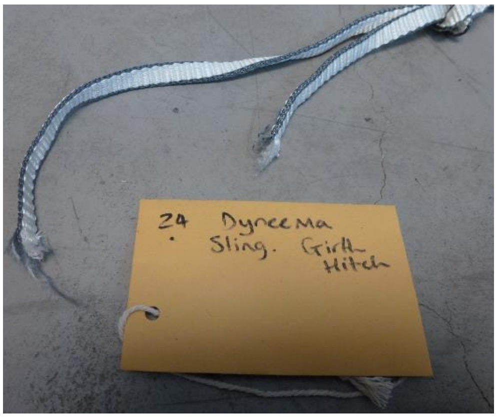


21. Redirect Munter

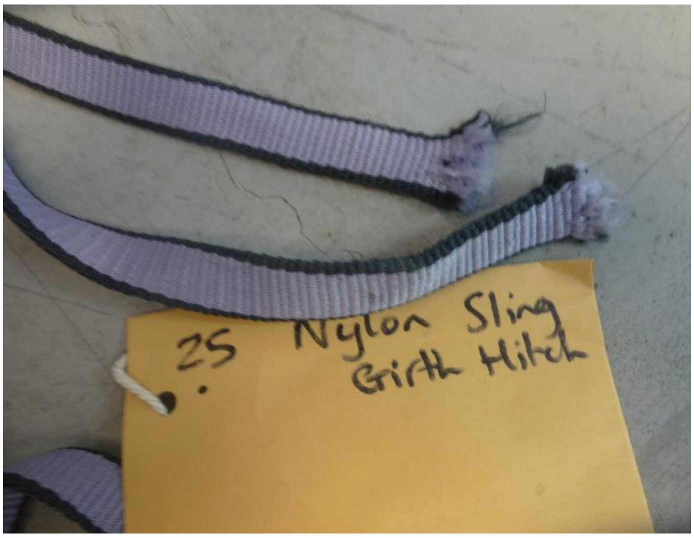


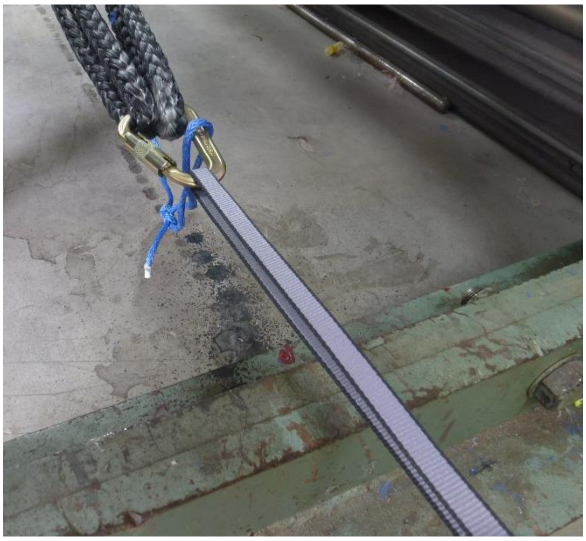
22. Double braid splice

23. Figure 8



24. Dyneema sling. Girth hitch





25. Nylon sling. Girth hitch

SRWP Project – Appendix 4: Non-Destructive Test Day Images

1a. Configuration for log crotch test

1b. Configuration for log crotch test with Dynafor

2. Configuration for wrap test

3. Configuration for friction hitch test

3a. Configuration for friction hitch test with Enforcer

SRWP Project Appendix 5a: External Data – ISC

Dynamic strength tests carried out by ISC Wales in accordance with the test methods as described in the EN353 standard. All forces are to be below 6kN for a PASS result.

Rope	**Yale Kernmaster**	
Hitchcord	**Yale Beeline Blue 10mm**	
Schwabisch		
	Result (peak force)	Pass /Fail
Dynamic Strength - 100kg (EN353)		
Sample 1	5.937	Pass
Sample 2	3.671	Pass
Sample 3	5.779	Pass
Sample 4	4.69	Pass
Sample 5	4.532	Pass
A*verage*	4.9218	**Pass**
V.T.		
Dynamic Strength - 100kg (EN353)		
Sample 1	3.671	Pass
Sample 2	3.75	Pass
Sample 3	3.51	Pass
Sample 4	4.045	Pass
Sample 5	3.285	Pass
Average	3.6522	**Pass**

Rope	**STEIN Acuda**	
Hitchcord	**STEIN Copius Armour Tec 10mm**	
Schwabisch		
	Result (peak force)	Pass /Fail
Dynamic Strength - 100kg (EN353)		
Sample 1	3.761	Pass
Sample 2	4.623	Pass
Sample 3	4.611	Pass
Sample 4	3.659	Pass
Sample 5	4.917	Pass
A*verage*	4.3142	**Pass**
V.T.		
Dynamic Strength - 100kg (EN353)		
Sample 1	3.81	Pass
Sample 2	3.51	Pass
Sample 3	2.9	Pass
Sample 4	5.58	Pass
Sample 5	6.17	Fail
Average	4.394	**Pass**

SRWP Project Appendix 5a: External Data – ISC

Dynamic strength tests carried out by ISC Wales in accordance with the test methods as described in the EN353 standard. All forces are to be below 6kN for a PASS result.

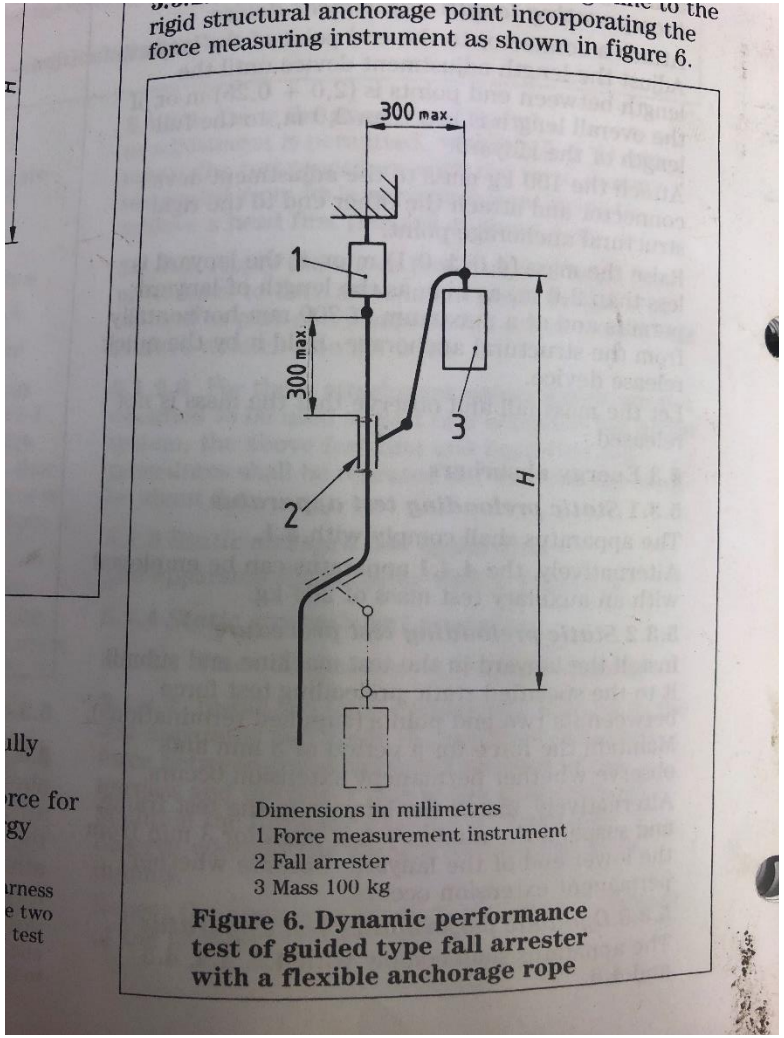
Rope	**Courant Kanopa Pro**	
Hitchcord	**Courant Phoenix**	
Schwabisch		
	Result (peak force)	Pass /Fail
Dynamic Strength - 100kg (EN353)		
Sample 1	6.175	Fail
Sample 2	5.541	Pass
Sample 3	6.323	Fail
Sample 4	5.461	Pass
Sample 5	5.562	Pass
A***verage***	5.8124	**Pass**
V.T.		
Dynamic Strength - 100kg (EN353)		
Sample 1	3.512	Pass
Sample 2	3.4	Pass
Sample 3	3.204	Pass
Sample 4	2.9	Pass
Sample 5	2.533	Pass
Average	3.1098	**Pass**

Rope	**Teufelberger DrenaLine**	
Hitchcord	**Teufelberger Ocean Polyester 8mm**	
Schwabisch		
	Result (peak force)	Pass /Fail
Dynamic Strength - 100kg (EN353)		
Sample 1	8	Fail
Sample 2	9.286	Fail
Sample 3	7.662	Fail
Sample 4	8.502	Fail
Sample 5	8.936	Fail
Average	8.4772	**Fail**
V.T.		
Dynamic Strength - 100kg (EN353)		
Sample 1	8.348	Fail
Sample 2	5.66	Pass
Sample 3	5.07	Pass
Sample 4	5.63	Pass
Sample 5	5.31	Pass
Average	6.0036	**Fail**

Dynamic strength tests carried out by ISC Wales in accordance with the test methods as described in the EN353 standard. All forces are to be below 6kN for a PASS result.

Rope	**Courant Japora**	
Hitchcord	**Courant Phoenix 8mm**	
V.T.		
Dynamic Strength - 100kg (EN353)		
Sample 1	6.1	Fail
Sample 2	6.4	Fail
Sample 3	5.5	Pass
Sample 4	7.1	Fail
Sample 5	5.9	Pass
Average	6.2	**Fail**

Rope	**Courant Squir 2**	
Hitchcord	**Courant Phoenix 8mm**	
V.T.		
Dynamic Strength - 100kg (EN353)		
Sample 1	5.9	Pass
Sample 2	6.4	Fail
Sample 3	5.3	Pass
Sample 4	6.2	Fail
Sample 5	6.8	Fail
Average	6.12	**Fail**

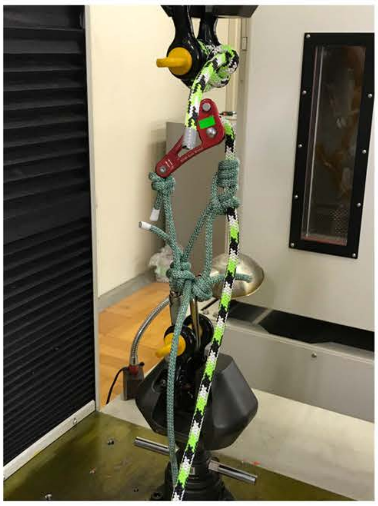


ISC EN353-2 Drop test diagram

7 July 2017 - ODSK, Ina.

The criteria of the test is to gain an understanding of the interface between climbing device cam and rope. (*cam* is used liberally and extends its meaning to rope hitch, please see the list of devices below).
To this date Arborist Ascending-Descending devices are still in their infancy, as is the general understanding of what SRT is and how it can be taught and understood and applied to work practice. There still remains a fully mechanical device to be tested under the European criteria. The ISC Rope Wrench has recently been tested to the EN 12278 Pulley standard. With this in mind ODSK hopes this small amount of information may be used publicly to develop and refine SRT working practice.
Each device was pulled at 40mm/minute on Teufelberger Tachyon and Teufelberger Platinum. The test was stopped at the first sign of slippage or 6kN, whichever came first.

	Unicender	**Compact Bulldog Bone**	**Rope Wrench Engaged**	**Rope Wrench Disengage d**	**Rope Runner**	**Hitch Hiker**	**Handle ascender**
Tachyon	Slipped at 4.7kN	Slipped at 1.2kN	Tiny movement of wrench. Zero movement of hitch	Zero movement	Movement at 2.8kN	Movement at steel parts only	Cut rope at 5.5kN
Platinum	Zero movement	Movement 1.3kn	Tiny movement of wrench. Zero movement of hitch	Zero movement	Movement at 2.8kN	Movement at steel parts only	Zero movement






Knot Block Static Strength Test - 3rd June 2016

	Vortex 12.8mm (Samson)	Kernmaster 11mm (Yale)	Tachyon 11.5mm (Teufelberger)	Platinum 11mm (Teufelberger)
Alpine Butterfly	26.7kn complete sever	1.7kn cover tore	18.5kn cover tore	23.3kn complete sever
3 twist Alpine Butterfly	21.5kn complete sever		16.9kn complete sever	19.4kn cover tore
Sinnet Chain	21.4kn complete sever			
Double Wrap Sinnet Chain	23.9kn nearly complete sever	16.8kn nearly complete sever	16kn cover tore	20.6kn complete sever