PRM 426 Lab Test – Rescue Equipment – Test to Failure

Author: Baron Draughon
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Abstract

While using ropes for swift water rescue it is very important to know how strong the ropes are and which ropes to use. Manufactures give the suggested weight limit for ropes but what are the limits after the ropes are used for many years?

Different varieties of ropes were tested to see how many pounds it took to break them. Conclusions can be made from this testing to know what type of ropes are stronger than others and what and what not to look out for.

1.0 Synopsis

Ropes and carabineers were supplied by the instructor of PRM 426, Sam Fowlkes M.A. Ed. The test was conducted at Western Carolina University in Belk Building room 255. A tensile testing machine was used to pull small lengths of ropes and carabineers apart and record the max amount of loaded pounds before breaking.

In brief, these conclusion and observations can be made based on the test:

- All carabineers tested surpassed their manufactured standard by at least 200lbs.
- Webbing loops were stronger than the carabineers and were not able to be broken. This would suggest that using webbing correctly for anchors will be more dependable and last longer than carabineers-rated around 6000lbs.
- Testing for the some of the ropes did not have desired results due to the machines distance limitation, although many were broken above factory standards.

2.0 Background

The equipment tested were samples of equipment that has been used in the field of rescuing and rescue training. The samples were chosen because they have been exposed to the elements in the field and it was hoped that this would give accurate results to reflect the capabilities of the equipment being used now.

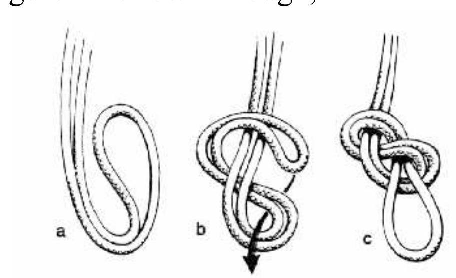
The tensile tester is a machine designed for testing the tensile strength and compression strength of material like plastics, metals and concrete samples. This machine is not designed for testing ropes, so it had some limitations such as its distance to pull the ropes, which made it unable to successfully break some ropes due to their stretching and the knots setting.

3.0 Terminology

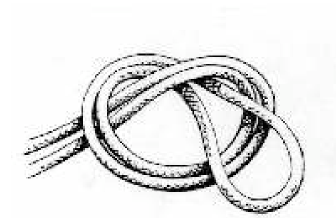
The following terms are used in this report.
3/8, 5/16, _: size of rope, 3/8 inches diameter.
5mm, 7mm: size of rope, 5 millimeters diameter.
Oval carabineer: carabineer with a design and shape of an oval, tested carabineer was made by Black Diamond USA
Locking carabineer: carabineers with a screw lock to keep the gate from coming open when being used, old tested carabineer was made by SMC USA and new tested carabineer was made by Omega Pacific
Waterline: Sterling Float Rope 3/8 or 5/16 diameter
Spectra, Poly (Polypropylene), Static Line, Prussic Cord, Sterling: different materials and designs for the ropes

Knots used in testing:

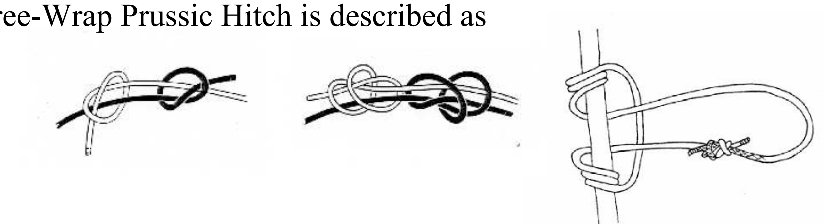
Figure 8 knot: also known as "Figure 8 on a Bite" and "Figure 8 Follow-Through," a suggested knot used with most ropes in rescues and rope systems, it is known to be a better knot because it does not damage the rope due to it has larger bends, Figure 8 on a Bight is described as follows;



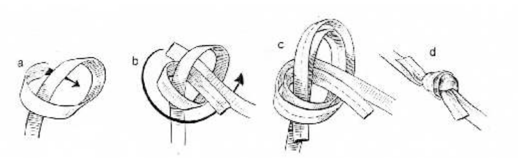
Overhand knot: a suggested knot used as a safety precaution to keep tails of knots like Figure 8's from being able to slide through, although it can be misused as a primary knot in a rescue situation or rope system, this is dangerous because the knot has tight bends which pinches the rope and makes it weaker, Overhand on a Bite is described as follows;



Prussic knot: also known as "Prussic Loop," made by a "Double Fishermen knot" or "Overhand Bend knot" usually with a smaller rope like a 5mm prussic cord, a suggested knot used for making a "Three-Wrap Prussic Hitch" which can be used for a break in Zip Line system, a Double Fishermen and a Prussic knot being used in a Three-Wrap Prussic Hitch is described as follows;



Water knot: also known as a "Overhand Bend," made with tubular webbing, used for anchor systems, described as follows;



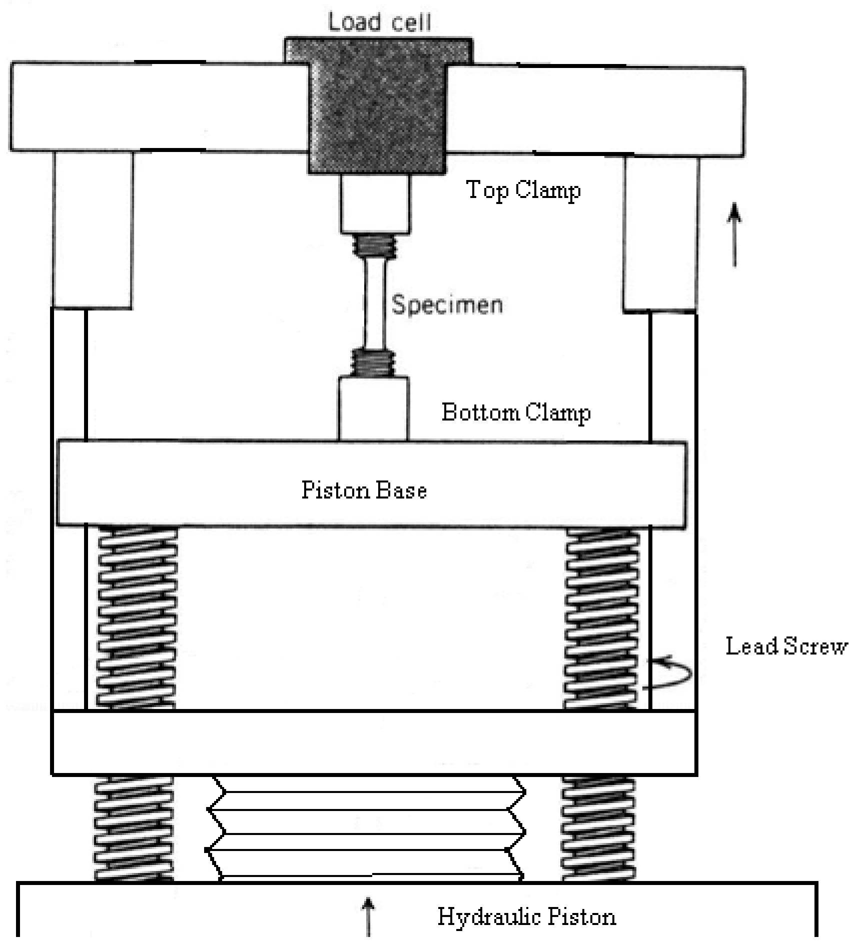
4.0 Testing Procedure

4.1 Testing Equipment

The tensile tester has two platforms that pull apart from each other by hydraulic pistons. It records the pounds necessary to make the platforms move to their position. There is a distance limitation because of the machines design. It has clamps on each platform that holds samples in place. The following diagram describes its design.

The Lead Screws turn to move the Piston Base moves up or down to attach clamps on the bottom end of the specimen.

The Hydraulic Piston starts at the lowest position with top clamp attached to the top end of the specimen and then moves the Load Cell up while pulling the specimen apart.



4.2 Testing Philosophy

4.21 Initial Approach

The author originally directly clamped the ropes into the machine and continued to pull the ropes and carabineers apart. It was found that this was not an efficient testing method because the clamps pinched the ropes. This damaged the ropes and made them break at lower results that would not accurately represent the ropes strength.

4.22 Adopted Approach

The author then tried to create a situation to closely simulate the way ropes would be used in the field. The author fabricated iron plates for attaching the clamps and hooking the carabineers. This allowed the ropes to be tied with to the carabineers with Figure 8 on a Bite knots which resembled their use in the field. See sketch for details.

5.0 Test Results

5.1 Load Measurement

The measurement of pounds needed to break the rope was recorded by the tensile tester. The Load Cell moves at a set rate and it measures the pounds required to keep it in position. When all or part of the rope breaks, the pounds drop because it requires fewer pounds at that time to keep the Load Cell in its position. This means that part of the rope or outside can snap but the core or inside can stay unbroken. The max pounds is recorded and it is assumed that if the recorded pounds of pressure was kept on the rope then the core would break and this is reported as its breaking point.

5.2 Failure Mode

Descriptions of Failures are described in the following modes:

- Rope Failure: "RF" the rope broke, part of rope or all, usually broke at or inside the knot
- Test Failure: a.) Carabineers Failure: "CF" while testing the carabineers broke before samples, this only happened with the Tubular Webbing

b.) Length Limitation: "LL" the limitation of the machines length is reached due to the ropes stretching and the knots setting

To work around the LL failure the author found two solutions listed bellow, not in sequential order.

1. Retie knots: "RT" the test reaches LL because as the knots set, the length between carabineers grows without adding significant pounds. So after LL is reached one knot is untied and retied as an Overhand knot closer to the other knot. An Overhand is used because it has less bends and uses less rope. This allows it to set and elongate less then a Figure 8 on a Bite.

2. Reset the test: "RS" after reaching LL the Load Cell was fully lowered and the Piston Base was lowered to the ropes extended length. Starting the test again allows the machine to add the amount of pounds of needed to break the rope without having to move over the same distance as before because the rope's knots are already set.

Even with these adjustments the some test still reached LL again.

5.3 Test Data

Type of Sample	Description of Results and Pounds (*MAX*) (**BROKE**)
1. 3/8 Spectra – new	***3200 lbs***
2. 3/8 Spectra – old	***2610 lbs***
3. 3/8 Poly – old - white	*1160* lbs–LL, RT-900 lbs-LL, RS-**860 lbs**
4. 3/8 Poly – old - yellow - lotus	***1370 lbs***
5. 3/8 Poly – yellow/orange – perception	*1070 lbs*–LL
6. 3/8 "Waterline" – new	840 lbs–LL, RT–2322 lbs–LL, RS–***2780 lbs***
7. 3/8 "Waterline" – old	580 lbs-LL, RT-1710 lbs-LL, RS-*2060 lbs*-LL
8. 5/16 "Waterline" – 1 year	*1180 lbs*-LL, RS-**1140 lbs**
9. 5 mm – Prussic Cord – old	1250 lbs-LL, RS-1430 lbs-LL, RS-***1870 lbs***
10. 7mm – Prussic Line – new	1480 lbs-LL, RS-2220 lbs-LL, RS-***4160 lbs***
11.1 inch Tubular Webbing – new Sterling	*4420 lbs*-CF, 4160 lbs-CF
12.1 inch Tubular Webbing – old – blue	***3820 lbs*** around carabineer
13.1 inch Tubular Webbing – old – purple	*4240 lbs*-CF
14. 3/8 Polypropylene – laid – old	*680 lbs*-LL
15. _ or less spectra – reach system – new	***1280 lbs***
16. Carabineer – oval – old	***4430 lbs***
17. Locking Carabineer – old	***6490 lbs***
18. Locking carabineer – new – 1 year	***7170 lbs***, snapped in two pieces at 3000 lbs
19. _ Waterline – old	*1030 lbs*-LL
20. 3/8 Static Line – old	***2560 lbs***
20. Carabineer- "Residential Life Department"	***260 lbs***

6.0 Analysis

When the RT had Overhand knots it seems that all broke had broken at the Overhand knot opposed to the Figure 8 knot.

7.0 Conclusions

The ropes did break at the Overhand knots enough to conclude that the Overhand knots weaken the rope. The majority of the ropes and carabineers exceeded the manufactures specifications by around 200 lbs even after their past abuse and exposure.

8.0 Recommendations for Future Testing

The first recommendation would be to find a way to test the ropes without having a limitation to the length the machine can pull or stretch them.

Second if possible find a way to keep constant pounds on the ropes so when they break the pressure doesn't reduce. This part of the testing will give it more accurate results.

Finally, it would be suggested to do a case study for at least one year if not more. The study would include at least two of the same ropes. When they are new, samples would be taken to find their limit of pounds. Then the ropes are put under the same stresses for a year. One rope would be kept clean and washed well, while the other would be abused and not taken care of. Then after a year test samples again to see if they match in their limits. This could prove or disprove that the condition of the ropes can change how they perform.

Acknowledgements

This testing was encouraged and supported by Instructor Sam Fowlkes who provided the samples that were tested. This testing was held in the Engineering Technology Department at Western Carolina University. The ET Dep. allowed access to the tensile testing machine used for the testing.

References

SA Climbing Info Network: http://www.saclimb.co.za/
Black Diamond Equipment: http://www.bdel.com
Pictures of ropes: http://www.cc.nctu.edu.tw/~mclub/meichu/teach/knot/knot.html