A Look at Knot Strength in a Dynamic Situation

Presented by:
Douglas Hansen

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Ever wonder what would happen to various knots if they were suddenly loaded to the breaking point, like might happen when anchor fails, or your primary line fails and the safety line must catch you? Well, this is what we want to look at. Knot failure during a quickly applied load.

Is one knot going to perform much better in this situation?

If so, which knot?

Does the position of the Knot in the length of rope make a Difference?

A while back I was talking with Arnor Larsen, and he mentioned that there has NOT been any dynamic testing of knows, and that he figured that the knot strengths that we are currently using is invalid because, in most cases, our knots will end up failing in a dynamic situation. I have not heard of any dynamic testing of knots either, and I also feel the same as Arnor. Another item that may come out in this testing is a specific knot that does better than another in a dynamic situation. In slow pull tests, a few things can happen that actually may change the rated strength: (1). the dissipation of heat. (2). the way the knot seats and settles in. (3). the dynamic, verses more static properties of a knot may make it able to hold a greater impact.

We plan to do something like this. We will choose several knots (figure 8 follow through (live to live bight configuration), double fisherman, Square knot, ? ?. We will then tie all 4 knots in one length of rope i.e.: let's say first will be the figure 8, then double fisherman, etc. We will quickly (in less than 2 seconds) break each of these five of these sections with the knots in the same place. Then we will change places with the knots, first the double fisherman, then the square knot, and then lastly the figure 8. We plan to video the tests and also use infrared in hopes of seeing where the primary heat build up is. When we get done we believe will have some very useful information. Ultimately, our primary goal is to determine if a dynamically broken knot will break a greater or less amount, then comparable slow pulled ropes and tests.

Questions to be answered and hypothesis answers:

1. Do knots have more or less efficiency when tested in a dynamic situation? (Less)
    a. How much more or less efficiency in general? (10 to 20%)
2. Do some knots perform better in a dynamic situation than other knots? (Yes).
    a. If so, what is their dynamic efficiency?
3. Does the manufacturer of a rope of similar size and type have significantly better performance than another? We will measure the percentage of original strength (Yes)
    a. If so, is it significant. (Yes)

About the Presenter

In 1969 **Douglas S. Hansen** became actively involved in the vertical environment. Since then his life has essentially been High Angle Work, Engineering, Rescue, Emergency Response, and Equipment sales. Experience and training include: Military 1972, he enlisted in the 19th Special Forces Group. He graduated as an Army Medic (91B20) from the Army Medical Training Center in Fort Sam Houston, TX. In 1975, he was hired by the National Park Service to work as a Park Ranger. His duties included training park personnel in climbing and rescue procedures, and organizing and directing rescues within the Park. Due to a busy schedule Hansen transferred for the 19th S.F. Group to the117th Engineers Corps. At this same time he established International Mountaineering, a Professional Organization that focused on teaching climbing, rescue, high angle skills, doing work in high places, and selling high angle equipment. In 1976, Hansen was invited to join the Utah County Sheriffs Mountain Rescue Team and eventually became captain and operational leader of the Rescue Unit. Work experience includes for U.S. Steel Corporation, Safety Department, and Professional Fireman/EMT. 1984 he opened a full time High Angle Business: Hansen Mountaineering, Inc., which he sold in 2000. In 1992 he organized and lead an Expedition to the North Face of Everest. In the early 90's he formed a business called High Angle Technologies, Inc. that focused on high angle work, teaching and equipment sales. He has produced several videos that deal with the vertical environment. Including: "Vertical Rope Skills, recipient of the Telley Award. He has served as an instructor for a number of different universities and schools, governmental organizations (U.S. Forest Service, National Park Service, Bureau of Reclamation, National Guard, U.S. Army, many sheriffs department rescue teams, etc. He is a noted author with nearly 100 publish articles, several videos, and a DVD dealing with the vertical rope work, rescue, and safety. He currently works full time in his high angle business writing, teaching, doing specialty high angle projects, lectures at various conferences and seminars. AND most of all he loves to learn, and he keeps his cup only part way full.

Dynamic Knot Testing Research Project

11mm Blue Water II Static Rope	#3 drop	#4 drop	#5 drop	#6 drop	#7 drop	Average Breaking
Peak load at failure (Mfr 8,500 lbf)	1,995	2,440	2,075	2,085	2,325	2,184
Failed at	Cow tail	Cows tail	Cows tail	Cows tail	Cows tail	

11mm Blue Water II Static Rope: 20 feet with a Figure 8 on bight, Butterfly, Figure 8 on bight (cows tail) 1 1/2 Fisherman. Falling about a factor one fall (about 23.5 feet per second) with 450 lbs of steel on the end.

Dropping and accelerating at the speed of gravity reduced the strength by almost 2,000 lbs. over the moderately slow pull of about 0.5 feet per second.

11mm Blue Water II Static Rope	Nmb2A Pull	Nmb3A Pull	Nmb4A Pull	Nmb5A Pull	Nmb9A	Average Breaking
Peak load at failure (Mfr 8,500 lbf)	2,950	3,505	3,330	2,815	2,070	2,894
Failed at	Cows tail	Cows tail	Cows tail	Cows tail	???	

11mm Blue Water II Static Rope: 20 feet with a Figure 8 on bight, Butterfly, Figure 8 on bight (cows tail) 1 1/2 Fisherman. Fast pull at approximately 6.33 to 9.5 feet per second.

Dropping and accelerating at the speed of gravity reduced the strength by almost 1,000 lbs. over the moderately slow pull of about 0.5 feet per second

11mm Blue Water II Static Rope	Nmb1A Pull	Nmb6A Pull	Nmb7A Pull	Nmb8A Pull	Average Breaking
Peak load at failure (Mfr 8,500 lbf)	4,915	4,085	3,910	4,005	4,229
Failed at	1 1/2 fisherman	Butterfly	Butterfly	1 1/2 fisherman	

11mm Blue Water II Static Rope: 20 feet with a Figure 8 on bight, Butterfly, Figure 8 on bight (cows tail) 1 1/2 Fisherman. Slow pull at approximately 1.4 feet per second.

12.5 to 13mm NFPA Rope	Nmb2B Pull	Nmb4B Pull	Nmb3B Pull	Nmb5B Pull	Average Breaking
Peak load at failure	3,850	3,835	4,155	3,940	3,970
Failed at	Figure 8 bight	Figure 8 bight	Bowline	Double fisherman	
Manufacturer:	PMI	Sterling	Petzl	Blue Water	

12.5 to 13mm NFPA Rope	Nmb6B Pull	Nmb8B Pull	Nmb9B Pull	Nmb7B Pull	Average Breaking
Peak load at failure	4,450	3,835	3,815	3,845	4,036
Failed at	Figure 8 bight	Figure 8 bight	Bowline	Bowline	
Manufacturer:	PMI	Sterling	Petzl	Blue Water	

Relatively fast pull (8 feet per second) when compared to the pull below, but quite slow when compared to gravity.

12.5 to 13mm NFPA Rope	Nmb1B	Nmb1C	Nmb2C Pull	Nmb3C Pull	Average Breaking
Peak load at failure	6,240	5,920	4,585	4,530	5,319
Failed at	Figure 8 bight	Double fisherman	Bowline	Bowline	
Manufacturer:	PMI	Sterling	Petzl	Blue Water	

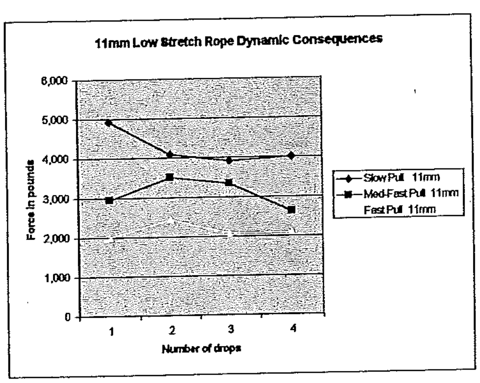
Had a bowline on one end, a double fisherman and a figure follow through in the centern, and a figure on a bight in the other end. It was pulled relatively slow at less than 1 foot per second:

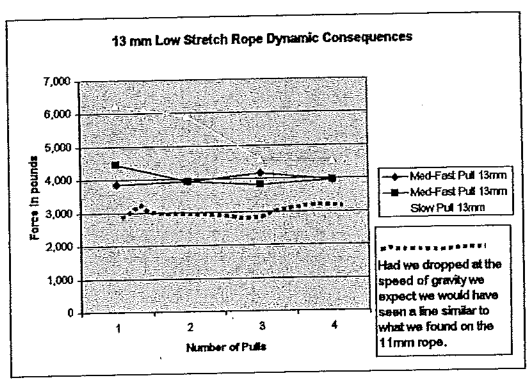
**Once again, Dynamics reduced the breaking strength over 1,000 lbf, Next year we plan to do more "at Gravity Speed" drop tests. Which we believe will be the at least 2,000 lbf less that our slow pull and possibly as much as 50 % less than the manufacturer numbers.

Testing Carried out by: Douglas Hansen, Paul Hansen, Jennifer Dain, Shay Lelegrin.

Slow pull 11mm	4,815	4,085	3,810	4,005	
Fast pull 11mm	1,995	2,440	2,075	2,085	2,325
Med fast pull 11mm	2,950	3,505	3,330	2,815	2,070
Fast Pull 13mm	3,850	3,935	4,155	3,940	
Fast Pull 13mm	4,450	3,835	3,815	3,945	
Slow pull 13	6,240	5,920	4,585	4,530	

Slow Pull 11mm	Med-Fast Pull 11mm	Fast Pull 11mm	Med-Fast Pull 13mm	Med-Fast Pull 13mm	Slow Pull 13mm
4,915	2,950	1,995	3,850	4,450	6,240
4,085	3,505	2,440	3,935	3,935	5,920
3,910	3,330	2,075	4,155	3,815	4,585
4,005	2,615	2,085	3,940	3,945	4,530





Douglas Hansen's
HIGH ANGLE TECHNOLOGIES INC.
72 WEST 600 NORTH · OREM, UTAH · 84057 · USA
(801) 221-0398 Fax (801) 221-0393 Web Site: www.HighAngleTech.com
"Your High Angle Work, Training, Equipment, and Rescue Professionals"