NEWS OF THE P.A.T.C. MOUNTAINEERING COMMITTEE

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COMING EVENTS

10 June - Thurmont, Md.
17 June - Old Rag Mt., Va. Plan to leave from Hot Shoppe not later than 8:30 AM.
24 June - Boucher and Prospect Rocks, Va.

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KNOTS IN NYLON SLINGS, PART II

By R. J. Stirton and A.C. Lembeck

In the last two or three years there has been considerable interest among mountaineers on the question of suitable knots for use with nylon line. A note by Hart in APPALACHIA 1/ (summarized in MOUNTAINEERING 2/) called attention to a rappelling accident which was apparently caused by failure of a nylon braided sling tied with a square knot. This article indicated some tests of square knots which failed at 500 lbs. The author recommended, on the basis of the above tests and consultation with Boston Navy Yard rope experts, that knotted slings be made of manila or flax and that if nylon was desired it should be $\frac{1}{4}$" diameter or larger line joined with special splices. The article discouraged use of nylon braid.

Nylon offers a number of advantages over natural fibers including high strength with low weight, abrasion resistance, long storage life, and desirable shock loading properties. It seemed pertinent to investigate suitable knots for nylon line in order that this material could be used with confidence for rappel slings and other anchors. Some preliminary testing of knots was reported in UP ROPE 3/; the results of subsequent tests are given here.

Two types of line were used in the current series. Mountain Nylon rope $\frac{1}{4}$" diameter and braided nylon web $\frac{1}{2}$" wide, both purchased from Gerry Mountaineering, Ward, Colorado. A single length of $\frac{1}{4}$" rope was used as a source to make all slings of this material. Several lengths of webbing were used and it is not certain that they were all of the same lot.

A 60,000 lb. tensile testing machine was used in all tests and the loading was similar to that used in the previous tests, namely, the load was increased at such a rate that failure occurred in approximately 2 minutes. The sling or loop of the

knot or splice was attached to the machine with shackles having pins 1-1/8" in diameter. These pins were free to rotate, thus equalizing the tension on each half of the loop.

The following were tested:

A. ¼" diameter nylon rope

1. eye-splice in each end
2. bowline in each end
3. sling joined with square knot
4. sling joined with double carrick bend
5. sling joined with two Tarbuck knots. see note d, following table of test results

B. ½" wide nylon webbing

1. sling joined with two bowlines
2. sling joined with two Tarbuck knots

In all cases (except the eye-splice) the free ends of the line were secured with overhand knots drawn up snuggly against the main knots. The tension at the knots in the case of slings is approximately one-half the load applied to the sling. All failures except with the Tarbuck, occurred at the point on the line where it is first crossed by the knot, i.e., as the line first enters the knot. Failure with the Tarbuck, which slips a good deal upon loading, seemed to occur close to the point where the loops of the two knots crossed. The broken ends of the line, with all the knots and splices, showed evidence of surface fusion probably due both to internal friction and slippage as the knots or splices tightened upon loading. It is important to note that no knot failed by untieing or slipping apart.

ULTIMATE STRENGTH OF KNOTS AND SLINGS

I SINGLE STRAND ¼" DIAMETER MOUNTAIN NYLON EYE-SPLICE EACH END

1.	1420 lbs.	failure at or near eye-splice in all cases.
2.	1380	distance between splices 22".
3.	1530	
4.	1390	mean 1430 ± 75 lbs.[a]
5.	1510	
6.	1350	

II SINGLE STRAND ¼" DIAMETER MOUNTAIN NYLON BOWLINE EACH END [b]

1.	1140 lbs.	failure at knot in each case. knots tied against
2.	1200	the lay of the rope. length of strand 6" between
3.	1125	knots.
4.	1140	
5.	1120	mean 1155 ± 30 lbs
6.	1020 lbs.	failure at knot in each case. knots tied with the
7.	1020	lay of the rope. length of strand 6" between knots.
8.	1110	
9.	1070	mean 1060 ± 37 lbs
10.	1080	

III SLING OF ¼" MOUNTAIN NYLON TIED WITH SQUARE KNOT

1.	1900 lbs.	failure at knot in each case. length of sling 25"
2.	1890	(circumference).

3. 1820
4. 1860 mean 1860 ±30 lbs
5. 1840

IV SLING OF ¼" MOUNTAIN NYLON TIED WITH DOUBLE CARRICK BEND [c]

1. 2250 lbs. failure at knot in each case. length of sling 22"
2. 2210 (circumference).
3. 2150
4. 2160 mean 2140 ±120 lbs
5. 1910

V SLING OF ¼" MOUNTAIN NYLON TIED WITH 2 TARBUCKS [d]

1. 2230 lbs. failure at knot in each case. length of sling 27"
2. 2000 (circumference)
3. 2460
4. 2340 mean 2300 ±220 lbs
5. 2460

VI SLING OF ½" WIDE FLAT NYLON WEB TIED WITH 2 BOWLINES

1. 1860 lbs. failure at knot in each case. length of sling 18"
2. 1280 (circumference).
3. 1420
4. 1150 mean 1442 ±180 lbs.
5. 1500

VII SLING OF ½" WIDE FLAT NYLON WEB TIED WITH 2 TARBUCKS

1. 1110 lbs. failure at knot in each case. length of sling 21"
2. 1330 (circumference).
3. 1380 mean 1240 ±120 lbs

NOTES: a. Error given is the standard deviation.
b. Bowlines were tied both with and against the lay. See text for definitions of"against" and "with" the lay of the rope.
c. Tied by the first method described in reference 4/.
d. Tied according to directions given in references 5/ and 6/.

It is interesting to list the ultimate strengths of each knot in the ¼" nylon:

Eye-Splice	1430 ±75 lbs.
Bowline against lay	1155 ±15
Tarbuck	1150 ±110
Double Carrick Bend	1070 ±60
Bowline with lay	1060 ±18
Square Knot	930 ±15

Of the knots tested the bowline appears to be the best. The Tarbuck and double carrick bend, although having high strength, are less well known and more complicated than the bowline. The Tarbuck, incidentially, was designed as a slippable knot for anchors to take up some of the shock of falls (see note d and the reference list). The square knot is not desirable since it can be easily "upset" and slip.

There is also evidence that it will slip without upsetting, as indicated by Hart's article and in reference 7/. The fisherman's knot also appears useful for making slings; data concerning its performance was reported in reference 3/.

A significant gain in strength appears possible by properly tieing the bowline (i.e., against the lay) and a word about the definition of "against the lay" is in order here. Authorities of equal repute have defined this term exactly oppositely. We have therefore chosen arbitrarily the meaning that it tightens the lay of the rope. Then, of course, "with the lay" opens the strands of the rope. In the second series the bowlines were tied so that the loop on the running end of the rope either tightened or opened the lay. In the first series of tests the lay of the rope was not recorded when tieing the knots.

The bowlines and Tarbucks in the flat web gave ultimate strengths with large spread of values which suggests a greater margin of safety should be considered when using braided web for slings. This large spread was also noted in our previous article.

The results of the two series of tests indicate that nylon line, either braided webbing or rope, can be used for rappel slings if care is used in tieing the slings. Two bowlines or the fisherman's knot appear to be the most useful in light of the strength, simplicity, and ease of tieing. Knots should be drawn tight and for additional safety overhand knots around the loop should be snugged tight against each side of the basic knot. Knot tightening should immediately precede use of the slings. Square knots should not be used to make slings. This is advised both from consideration of the knot strength and the danger of upsetting or slipping.

REFERENCES

1. Knots in Nylon Rope, R.W. Hart, APPALACHIA, XXIX:598-601, Dec. 1953.
2. Knots in Nylon Rope, MOUNTAINEERING, II:6 pp 24-26, Sep. 1954 (British Mountaineering Council, H. Coates, Greystead, Milespit Hill, London, N.W.7.).
3. Knots for Nylon Slings, A.C. Lembeck and R.J. Stirton, UP ROPE, X:15 pp 2-4, 21 Jan. 1954 (Mountaineering Committee, Potomac Appalachian Trail Club, 1916 Sunderland Place, Washington 6, D.C.).
4. ENCYCLOPEDIA OF KNOTS, Raoul Graumont and John Hensel, Cornell Maritime Press, 1943.
5. NYLON ROPE AND CLIMBING SAFETY, K. Tarbuck (Publication No. 37, issued by British Ropes, Ltd., Leith, Edinburgh 6, Scotland).
6. Appendix in MOUNTAINEERING HANDBOOK by British Members of the Swiss Alpine Club, Paternoster Press, 1950.
7. Use of Nylon Ropes, J.B. Gardner, APPALACHIA, XXX:118, June 1954.

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NEVADA NEWS: Bill Welsh is setting up practice in Gabbs, Nevada and as he says, "...I have a house and office in this small mining town. My house is on the foothills of a mountain, overlooking a desert, in a very beautiful location for a man who likes mountains, desert, and solitude, as I do. Shyness on my part is easily overcome and, as you claim you need articles, I pres[illegible] planning the first one as it might reflect on UP ROPE since we have one rather staid exchange), one my own and one I vaguely dragged out of my memory, as far as the last line goes at any rate, and did over.

A lovely lass had old blue jeans with many patches and worn-out seams
On a practice rappel, a yelp and a yell were quickly followed by scandalized screams."

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