Climbing Rope Tests. This investigation originated from my personal curiosity regarding the advantages of the various types of ropes available and the special attributes of each. For instance, was there a rope in existence suitable for climbing which would hold knots better than nylon? Which rope provided the maximum strength for its weight? And finally, were there any ropes designed for other purposes which would be suitable for climbing? I began to gather facts and figures, then samples of climbing ropes. Through the help of an acquaintance who has access to machinery for test purposes, we began our experimentation to try to find out more about the action of these various ropes in climbing.

Although we attempted to be as accurate as possible, these tests were not as complete as we wished for two reasons. One was the high cost of climbing ropes and the other, the human element involved. In testing these ropes we found that it was impossible to tie a bowline in exactly the same manner each time, no matter how proficient we were.

It was fairly evident from the start that strength figures advertised by manufacturer were accurate. These, for the most part, stress average strength but in some instances list minimum strength, which seems to me to be of greater interest. In order accurately to assess the claims of the manufacturers it is necessary to understand their test procedures. Ropes to be tested are first preconditioned at carefully controlled temperatures and humidity so that all the samples will be in the same condition prior to the test. Then the rope is spliced and the resulting eyes are placed around large hooks. These hooks are moved by a drive which can be regulated as to speed. Normally, a fairly slow speed is used and the strain on the rope at the breaking point is recorded. While it is evident that this will produce accurate results, especially as more than 100 breaks are recorded to arrive at an average, it does not even approximate the conditions under which these same ropes are used in the field. A climbing rope is knotted at each end and sometimes in the middle. We know from many sources that a knot will weaken a rope by about 40 percent and therefore we must deduct this percentage from the stated strength before figuring its strength for climbing. There is quite a large variation in the loss of strength caused by different knots. While the figure of 40 percent applies to the bowline, the Englishman's knot will cause a loss of strength amounting to only 25 to 30 percent.

We considered, in our tests, two types of rope, each of which is produced with several varieties of fibers. The first was the standard twisted rope produced in the conventional manner. The second was the core and sheath construction which is composed of a core of parallel fibers covered with a braided jacket. The jacket is designed to protect the core from damage. In this latter class was a rope which was designed primarily for use on boats and was still experimental at the time. This contained a nylon core with a dacron sheath, the dacron to give higher resistance to abrasion, the nylon to carry the greater part of the load. While this rope performed well in most respects it lost too high a percentage of strength through a knot, probably due to the difference in elasticity between the nylon and the dacron. The manufacturer is working at present to correct this. If he is successful, this might well prove to be an excellent rope. At present, the only rope of this type available is produced in West Germany and is composed of perlon, a nylon type synthetic.

Originally, of course, all climbing ropes were of natural fibers but, while they performed satisfactorily, they were none too strong and were short-lived. Then came nylon which provided much higher strength and, more important, greater elasticity. Under a 20 percent load, nylon has a working elasticity of 22 percent and under a shock load, 25 percent. Nylon rope of 7/16 inch diameter was rated at between 3200 pounds and 3600 pounds. Now, with an improvement in fibers, the average strength of this rope under laboratory conditions is between 4800 pounds and 5400 pounds. Dacron has been tried for climbing ropes but, while this synthetic is as strong as nylon, it does not have the elasticity. Under a 20 percent load, its working elasticity is only nine percent and under a shock load is ten percent. This can mean a great deal in stopping a fall as, generally, the greater the elasticity of the rope, the higher the tension that can be sustained without breaking. Recently, another fiber has been used which is produced in rope under the name of Goldline. This rope has the same characteristics as nylon except that it is slightly stronger in any given diameter. It also seems to lose less strength through normal use than nylon, although our tests of this were inconclusive. No two ropes receive exactly the same amount of wear and tear during a climbing season and therefore the comparison was made only between two ropes which, in our judgment, had received approximately the same treatment for the same length of time. The nylon rope had lost 30 percent of its strength and the Goldline showed a loss of only 22 percent. This seems to bear out the manufacturer's assertion that this newer fiber is better for climbing.

In addition to the fibers described, climbing rope has been manufactured from terrylene, a dacron-type synthetic produced in England, and from several other synthetic fibers produced overseas. The only one of these that would seem to be equal to nylon is perlon which has approximately the same strength and elasticity as nylon.

The following figures show the results obtained with four different types of rope. The Nylon and Goldline are of conventional design. The Perlon is of core and sheath construction and the "Other Brand" is the experimental nylon-dacron yacht rope, also of core and sheath construction.

TYPES OF ROPE TESTED

Size	*Nylon*	*Goldline*	*Perlon*	*Other Brand*
1/4 inch dia.				
Minimum strength	1600	1700	7 mm 2490	
Average strength	1700	1825		
Strength through Knot (bowline)	1030	1100	1760	
3/8 inch dia.				
Minimum strength	3100	3550	9 mm 3920	4200
Average strength	3675	3775		4900
Strength through Knot (bowline)	1880	2150	2510	2050
7/16 inch dia.				
Minimum strength	4660	4800	11 mm 5440	
Average strength	5100	5300		
Strength through Knot (bowline)	3000	3100	3790	

After the ropes had been quite literally torn apart, we decided that all the ropes tested were certainly adequate for the purpose for which they were intended. With reasonable care, they will perform safely and have an adequate margin of safety available for the unexpected. The core and sheath construction, with its greater strength, seemed to us to have definite advantages. The loss of strength through abrasion would seem to be minimized and we liked the handling of this rope. In spite of the fact that it is a fairly hard rope, it held knots better than the average and retained a larger percentage of its strength through a knot. It is unfortunate that this rope is not produced in this country but present indications are that a similar rope will be available within a year.

As regards a choice between the Goldline fiber and the Nylon, the Goldline seems to have the advantage of longer life. Also, its greater strength when wet is definitely of benefit. It is still too early to tell what the newer nylon fibers will show after use but manufacturers predict that there will be little choice between the two.

As stated previously, the bowline will cause loss of strength in a rope of about 40 percent. The Butterfly knot showed somewhat less loss and the Englishman's knot, or Fisherman's knot, the least. As this knot is most often used in making loops in small-diameter rope for slings, this was a very comforting conclusion.

Personal preference and to some extent habit will dictate the type of rope you use. However, I hope that the information and figures given here, much of which is already known, may be of use. If it accomplishes nothing else, it will tend to increase your confidence in your rope, as it did mine. For many years I have taken the manufacturer's minimum strength specifications at face value and it is encouraging to learn that, subject to the introduction of weakening factors, such as knots, into the rope, I can trust these figures. The perfect rope has yet to be produced and perhaps it never will be. However, in talking with rope designers, they all stated that because of the limited market for this type of rope they cannot justify large expenditures of time and money for research and development. They would welcome comments and suggestions for improvement in their products. Most improvements made in the manufacture of climbing rope have come about as a result of research into other uses and designs. The improvements made in yacht rope may be incorporated into the design of climbing rope if they appear to be of benefit. One manufacturer stated that if a large enough cross section of the climbing fraternity could agree on exactly what was needed he could manufacture a rope to their specifications. I would like to express my appreciation to the various designers and manufacturers' representatives who took such an interest in my search for information. They were most generous of their time and energy.

IRVING MEREDITH, JR., *Appalachian Mountain Club*