DOES NYLON LOSE 15% OF ITS STRENGTH WHEN WET?

Many books, catalogs and instructors state that there is a 15 per cent loss of strength in nylon ropes when they are wet. Manufactures of polyester ropes claim minimal loss of strength vs. 15 per cent loss of strength for wet nylon ropes. Dupont has been quoted as stating that "a nylon rope's strength is reduced by 15 per cent when wet". And a presentation by John Mckently and Bruce Parker at ITRS in 2001 found a 2 per cent loss of strength after 30 minutes and an 18 per cent loss of strength after 3 hours in nylon ropes.

We come from northern Ohio where fire departments provide the primary rescue services. Many of these departments rely on manufactured anchor straps for their rigging. And like many parts of the nation we have seen an increase in flooding and water related rescues over the last couple of years. Department budgets have been stretched to provide funding for water rescue training and equipment with the bulk of the money being spent on boats, life jackets and personal protective equipment.

When a rope rescue occurs it is usually a single incident and the equipment needs are easily met. When flooding occurs there are multiple incidents and equipment like anchor straps become difficult to obtain. So many departments are turning to an inexpensive alternative and using one inch tubular webbing for anchor material.

So a question that we asked was "Do all nylon products lose 15 per cent when wet?" and "What is wet?" If one inch tubular webbing is dunked in a river, is that wet? If webbing or 8mm accessory cord is out in the rain for an hour is that wet? Or if it is submerged for 5, 10 or 15 minutes is that wet, and if so does it lose 15 per cent of its strength?

Does the construction of the material matter? The accessory cord that we use for our prusiks has a softer hand and a thinner sheath than our ropes. Does this make it easier for water to penetrate and saturate the core fibers? One inch tubular webbing has no protective sheath and is hollow on the inside. Does this make it easier for water to be absorbed throughout the material?

And what about the manner of function, does the way we rig the material have an affect on its strength?

With these questions in mind we decided to do some backyard testing in the hopes of finding some answers. We tested nylon one inch tubular webbing and nylon 8mm accessory cord in the manner that we use them.

The webbing was tied in a loop and secured with a water bend. It was submerged in a 5 gallon bucket of water. We started with two 5 gallon buckets and ended up using five, 5 gallon buckets. And instead of the webbing being in the water for 5 or 10 minutes, it soaked for 10 to 63 minutes. All the rigging was around a 4 inch diameter smooth steel pipe with the pull end of the webbing attached to an SMC steel carabiner.

We tested each rigging configuration 3 times, one group of dry webbing and 2 groups of wet webbing with the second group having a longer exposure time in the water. We tested all the dry webbing first to keep it separate from the wet test pieces. The temperature at the time of testing was 88 degrees Fahrenheit and the humidity was 75 per cent.

When the webbing was rigged wrap 3 pull 2 we did one test dry, and it failed at 9,935 lbf. We only did one test because we were short on material. We had previously performed this same wrap 3 pull 2 test and presented the findings here at ITRS last year. The breaking strength from those tests, of dry webbing, was 7,975, 9,445 and 9,510 lbf. As we go through this presentation you will notice large gaps between the low and the high number in each group of tests. This spread between the lowest and highest breaking strength is normal for material that elongates. We need to point that out so when you are comparing breaking strengths you will have a better understanding of why that is. The two groups of wet webbing, rigged wrap 3 pull 2, were submerged for 10 and 32 minutes respectively and these are their breaking strengths: 8,195 lbf, 9,050 lbf and 9,875 lbf after 10 minutes in the water. After 32 minutes in water they failed at 9,165, 9,265 and 9,985 lbf.

As you look at these slides showing the breaking strengths of the material you will notice they are listed from the lowest to the highest in breaking strength. This is not the order that the tests were conducted in; they are listed this way for ease of comparison.

When we tested the webbing dry and rigged as a basket hitch it failed at 9,355, 9,505 and 9,615 lbf. When we tested the webbing wet, we increased the length of time it was in the water. After 33 minutes the webbing failed at 5,765, 6,735 and 7,060 lbf. After 45 minutes the webbing failed at 7,740, 7,910 and 8,780 lbf.

This testing of the basket hitch gave us the greatest variance between the webbing tested dry and the webbing tested wet. I mentioned earlier that we were short on webbing. We used 4 different spools of webbing for our testing. All four spools came from the same supplier, and all four were one inch tubular webbing. But one of the webbing spools had multiple splices, felt much stiffer than the others and tore apart easily along one edge after the testing. That was the spool of webbing that the basket hitches came from and we wondered if this would affect its overall breaking strength.

When the factory was contacted they stated that there may have been a slight imperfection in the stitching, but didn't elaborate any further.

We performed 2 tests of the webbing girth hitched dry around the 4 inch steel bollard and they failed at 5,310 and 5,645 lbf. We continued to increase the exposure time in water and after 39 minutes the girth hitched webbing failed at 6,335, 6,605 and 6,805 lbf. After 60 minutes they failed at 5,795, 5,800 and 6,435 lbf. If you notice, all the wet tests had higher breaking strengths than the dry tests.

We continued by testing the webbing rigged wrap 2 pull 2 dry and it failed at 7,930, 10,010 and 10,625 lbf. After soaking for 50 minutes in the water bucket, the next group failed at 7,310, 9,345 and 9,850 lbf. After 63 minutes they failed at 8,305, 9,395 and 10,370 lbf.

Some rescuers and instructors have expressed concern with just using one piece of webbing such as the wrap 2 pull 2 or wrap 3 pull 2 and they prefer two separate pieces of webbing rigged wrap 2 pull 1. So we tested two pieces wrap 2 pull 1. Tested dry, they failed at 8,645, 9,070 and 11,935 lbf. We did not perform any tests wet.

There was some interest in webbing rigged wrap 4 pull 3 so we tested that also. Dry, it failed at 12,525, 13,705 and 13,880 lbf. Taken out of the water after 5

minutes it failed at 12,155, 13,520 and 13,550 lbf. After 43 minutes it failed at 11,350, 12,225, and 12,750 lbf.

(all the failures occurred in the bottom piece of stacked webbing, none occurred in the water bend)

The next day we tested the PMI 8mm accessory cord. It was tied in a loop and secured with a double overhand bend. The pieces were the same length as we use for our long prusiks. The 8mm was submerged in a 5 gallon bucket of water for a period of time ranging from 31-72 minutes. The 8mm was attached to an SMC steel carabiner at each end and pulled to failure. When we need a short piece of anchor material we use our prusiks end to end, rigged as a basket or doubled, so that is how we tested them.

As we did the day before, we tested all the dry pieces first and then the wet ones.

The temperature was 82 degrees Fahrenheit and the humidity was 74 per cent.

When tested dry and rigged end to end, the 8mm failed at 4,760, 5,120 and 5,185 lbf. After 31 minutes in the water the 8mm failed at 4,055, 4,505 and 4,520 lbf. And after 60 minutes they failed at 4,580, 4,585 and 4,755 lbf.

We then tested the 8mm rigged as a basket hitch. Dry it failed at 9,050, 9,245 and 9,360 lbf. After soaking for 37 minutes it failed at 8,485, 9,045 and 9,120 lbf. After 67 minutes it failed at 8,180, 8,420 and 8,690 lbf.

For our last set of tests we doubled the loops of 8mm. They look the same when under tension, but a basket hitch and a piece of material doubled are not the same. The difference is, that when you double the 8mm it crosses over itself at some point and rigged as a basket the material is separated at all points.

Tested dry and doubled, the 8mm failed at 8,090, 8,405 and 8,640 lbf. After 41 minutes in water they failed at 6,345, 8,060 and 8,645 lbf. After 72 minutes they failed at 6,895, 7,375 and 8,580 lbf.

Please remember that this is backyard testing. All the material was new and never used. The testing was performed in the manner of function that we use and other rigging techniques may give different results.

We did 45 tests on the webbing, 15 dry and 30 wet and we did 27 tests on the 8mm accessory cord, 9 dry and 18 wet. From the testing we presented today a case could be made that there is a loss of strength with wet one inch tubular webbing and wet 8mm accessory cord….., except when it comes to the girth hitch, the wrap 3 pull 2 and the wrap 4 pull 3. All the wet girth hitches were stronger than the dry girth hitches and the wrap 3 pull 2 and wrap 4 pull 3 were not 15 per cent weaker. We wondered, could the water be dissipating the heat created by the friction of the webbing crossing over itself, thus helping to prevent an early failure in these riggings? We don't know, but without further testing we would advise against assuming that wet webbing girth hitched around a 4 inch diameter steel bollard will always be stronger than dry webbing. This testing used a small sample base and may only offer indicators, certainly not any conclusions.

Looking at the PMI 8mm accessory cord, it's just as confusing. It appears the 8mm basket hitch did not lose 15 per cent of its strength, but the end to end rigging was very close to that and the doubled tests gave mixed results.

It does appear from this backyard testing that if a team is short on manufactured anchor straps, or they regularly use one inch tubular webbing or PMI 8mm accessory cord, that they can be used in a variety of rigging applications when wet or dry. This would be especially true for those teams using 11mm nylon rescue rope, as the breaking strength of all the rigging we tested DRY exceeded the breaking strength of 11mm nylon rope except the webbing girth hitched and of course the 8mm rigged end to end. When we compare the breaking strength of the 11mm rope to all the tests, wet or dry, ALL the tests exceeded or were equal to the strength of the 11 mm rope with a knot in it. For the purposes of this presentation we assumed a 33% loss of strength for a rope with a knot tied in it.

For those using 12.5 mm or ½ inch rope, the wrap 3 pull 2 webbing had 5 out of 6 of the wet webbing fail at 9,000 lbf or greater and the 6th failed at 8,195 lbf. With the wrap 4 pull 3 all the wet tests failed at numbers greater than the breaking strength of 12.5 mm rope. The wrap 2 pull 2 had 4 out of 6 wet tests

fail at 9,345 lbf or greater and the other two at 7,310 and 8,305 lbf, which is stronger than the ½ inch rope with a knot in it.

So when a student or team member asks how the material will perform when wet, the trick for us will be to factor in the wet material along with everything else when considering our static system safety factor. Hopefully this presentation will be of value when making that determination.

Thank you.

Jim Kovach