INITIAL RESULTS FROM A PRELIMINARY INVESTIGATION INTO Y HANG KNOTS

Following the recent publicity on the deficiency of the “standard” Bowline on the Bight when loaded across one of it loops, some preliminary dynamic testing has been undertaken into potential alternative Y hang knots. Three knots were selected for investigation, the Double Figure of Eight on the Bight (Bunny Ears), the Fusion and the Double Bowline on the Bight. In addition, the “standard” Bowline on the Bight and the ordinary Figure of Eight on the Bight were also tested for comparison purposes.

The Bradford Pothole Club’s Rope Test Rig was used with instrumentation to measure peak force and extension, from which energy can be calculated. Dry, new 9mm Type B SRT rope was used in order to limit the extent of this preliminary work as experience shows that 9mm rope has a lower capacity to surviving drops with a 100kg mass than larger diameter rope. The rope was manufactured in 2011 and was not conditioned in any way. The tests were undertaken at around 5°C.

Figure 1 Rig Set up showing Double Bowline on Bight

The knots were tied by one person, checked by another and then dressed on the rig, see Figure 1. Because of the nature of the rig, the test mass provides the two anchor locations whilst the load cell is located at the top of the rig, so the y hang knots are located “upside down”. The active end of the rope out of the y hang knot was connected to the load cell using an ordinary Figure of Eight on the Bight in each case. (Hence the ordinary Figure of Eight on the Bight sample was included to provide a base line comparison.) All connections between loops and the rig were made using 12mm Stainless Steel shackles.

The rope samples were pre loaded with the 100kg mass, adjustments made to the “overall” length of the sample so they were all similar to within 8cm in 1.25m and length measurements made of the various sections of the sample. The test mass was then raised up to a location equivalent to a Fall Factor 1.0 and released. Data from the load cell and extension devices was recorded using an Analogue to Digital Convertor on a lap top and subsequently processed to obtain peak force. The results are presented in the Table overleaf. Videos of the drops can be seen at http://www.youtube.com/playlist?list=PLCkzBQHq_YaJ4JTDYcVuZAyBgc5-bOnwK .

In addition, a simple test was carried out by dynamically loading each of the loops of Fusion and the two Bowline on the Bight knots. It should be noted that the rope from the active end enters into the Y hang knot and then forms a loop, hereinafter names the “Active Side” loop. The rope then passes back into the knot and then forms the second loop, hereinafter named the “Inactive Side” loop, before passing yet again into the knot and coming out as the inactive end of the rope. A well used 10.5mm Type A SRT rope of some 7 years age was used for these tests. This rope was difficult to bend and thus did not make “tight” knots when dressed, see Figure 2 for example. Loop sizes of approximately 200cm circumference were produced to mimic likely loop sizes in use (equivalent to 100cm length). The knot was initially dressed and then pre loaded at 82kg via its active end. One loop was then placed on the rig and the knot located so as to be approximately halfway between top and bottom. The test mass was then raised up to a location equivalent to a Fall Factor 1.0 and released. The increase in rope circumference within the loop was measured. A fresh sample was used for each loop of each knot. The results are also presented in the Table overleaf.

Figure 2 Fusion Knot pre drop on loop

Knot type	Units	Fig 8 on Bight	Fusion	Double Bowline on Bight	Standard Bowline on Bight	Fig 8
Drops Survived		4	4	8	3	2
Rope broke at		other (top) knot	within knot	Other (top) knot	just before entered knot in glazed section	within (bottom) knot
Peak Force in 1st drop	kN	9.9	10.2	10.1	9.7	10.4
Maximum Peak Force across all drops	kN	15	14.4	14.7	14.8	14.3
drop at which max peak force occurs		4th	4th	8th	4th	3rd
length of loop C pre drop	cm	23	21	24	21	-
length of loop D pre drop	cm	20	19	22	20	-
length of loop C pre final drop	cm	25	24	25	15	-
length of loop D pre final drop	cm	22	17	17	21	-
"Active Side" loop extension on 1st drop	cm		29	18	25	-
"Inactive Side" loop extension on 1st drop	cm		42	21	-	-

Being only one sample means that the results can only be taken as indicative at best. A comprehensive program of work would be required to demonstrate the superiority of any one knot. The presence of a Y hang knot extends the capacity of the rope to withstand the dynamic drop test over a simple set of figure of eight on the bight knots. The failure of the Fusion knot within the knot was not expected from theoretical considerations since the fusion knot is larger and hence expected to have larger internal bends. The glazing of the end of the active rope into the standard Bowline on the Bight occurred during the 1st drop. The changes in loop lengths, combined with observations of the movement of marks made on the rope at a knot, suggest to us that for the Fusion and Double Bowline on the Bight knots, the active side loop is being subject to loss of rope through the knot into the active rope between the top and bottom knots.

Of slight concern was the behaviour of the Standard Bowline on Bight which when subjected to a dynamic test across the loop, did not exhibit the catastrophic slip as found in the French work and also by one of us. This emphasizes the special need for caution in interpreting the measured extensions to the active and inactive side loops. The fact the loops of the knots held albeit with some slip, does not provide assurance that they would always hold whatever combination of rope and conditions may be used. As one of us has already stated "Cavers should be aware that the loading of parts of ANY KNOT other than via the designed load points (active ends) MAY result in the failure of the knot to hold the caver's weight".

We wish to acknowledge the Bradford Pothole Club's generosity in providing us with free access to their rig.

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