Rope Testing – Some Thoughts

In answer to the question "What was the objective of the Long Term Rope Test (LTRT)", the document setting down the LTRT trial stated "To provide a long term test on a known samples of rope in order to provide cavers with reliable data on the effects of use and ageing on SRT rope". The results (considerable impact with both light usage and moderate life time) are not intuitively acceptable and require further work to support them. Such work requires several points to be considered.

a) impact of age of rope

The LTRT was conducted on rope which was tested at up to 8 years old (usage having taken place during its first 2 years). Repeating the test for low usage on a much quicker basis would at least determine if low usage is so detrimental.

b) acceptable criterion for drops survived

The average number of drops survived was 2.4. The average standard deviation (SD) for the spread of drops survived was 0.6 (range of 52 values was between 2 and 4). Using the simple approach of 3 SDs covering 99.5% of results, this would imply that one cannot confidently state such a rope would survive one drop.

Although 2 drops had previously been suggested as a suitable threshold, this was withdrawn on legal grounds. Also the British Standard (BS) uses 5 drops.

Further work could be conducted on the spread of drops survived along a used rope. It can be argued that usage will be less at the ends than in the middle (most pitches are rigged with surplus rope so the end is not used!). A number of used ropes have been acquired (number of trips is known but number on party is not) for testing. No doubt more ropes could be obtained.

c) other variations from the British Standard drop test procedure

The following table lists all of the differences between the BS and the rope test rig procedures.

BS EN 1891:1998	Rope Test Rig
Conditioned to 65% humidity	Soaked for at least 2 hours
Test at 23 degrees	At outside temperature
Start test within 10 minutes	
Sample made with 2 figure of eight knots, not specify whether active rope inside or outside	Sample made with 2 figure of eight knots, use active rope inside in one knot and outside on other knot
Check rope in knots lie parallel in knots and hand tighten	Check rope in knots lie parallel in knots and hand tighten
Overall length 2m when supporting 100kg load	Overall length 800mm when supporting 100kg load
Knot and loop length 175mm	
Attachment diameter not specified	Attachment diameter Top 20mm Bottom 12mm
Suspend for 60 seconds	
Raise 600mm (Fall Factor FF 0.3), drop load and measure peak force	
Release the load from sample within 1 minute	
Carry out first dynamic performance test within 3 minutes	

Raise load to same height as anchorage point (FF 1.0) and release load	Same being 1st drop
	Measure overall length of sample
	Re wet rope
Release the load from sample within 1 minute	
Carry out next test within 3 minutes	
Raise load to same height as anchorage point (FF 1.0) and release load	Same being 2nd drop
	Measure overall length of sample
	Re wet rope
Release the load from sample within 1 minute	
Carry out next test within 3 minutes	
Raise load to same height as anchorage point (FF 1.0) and release load	Raise load to height equivalent to FF 1.1 and release load 3rd drop
	Measure overall length of sample
	Re wet rope
Release the load from sample within 1 minute	
Carry out next test within 3 minutes	
Raise load to same height as anchorage point (FF 1.0) and release load	Raise load to height equivalent to FF 1.2 and release load 4th drop
	Measure overall length of sample
	Re wet rope
Release the load from sample within 1 minute	
Carry out next test within 3 minutes	
	Repeat raise with further increments in FF value

There is work showing wet ropes are weaker than dry, so this difference is justifiable.

The effect of temperature is an unknown, though rope does expand and shrink with temperature variation. Whilst ropes are not tested in freezing weather, the temperature range is probable around 15 C. This parameter is not controllable.

The sample length is much smaller. This variation could be investigated using the Bradford rig which is understood to take a 2m sample.

The FF 0.3 drop can be considered to be replaced by the first FF 1.0 drop and can be argued to reflect usage before a drop occurs. (The French Cows Tails work used a FF 0.3 drop to pre tension the knots. The FF 0.3 drop is not included in the 5 drops survived criterion.) This variation could be introduced.

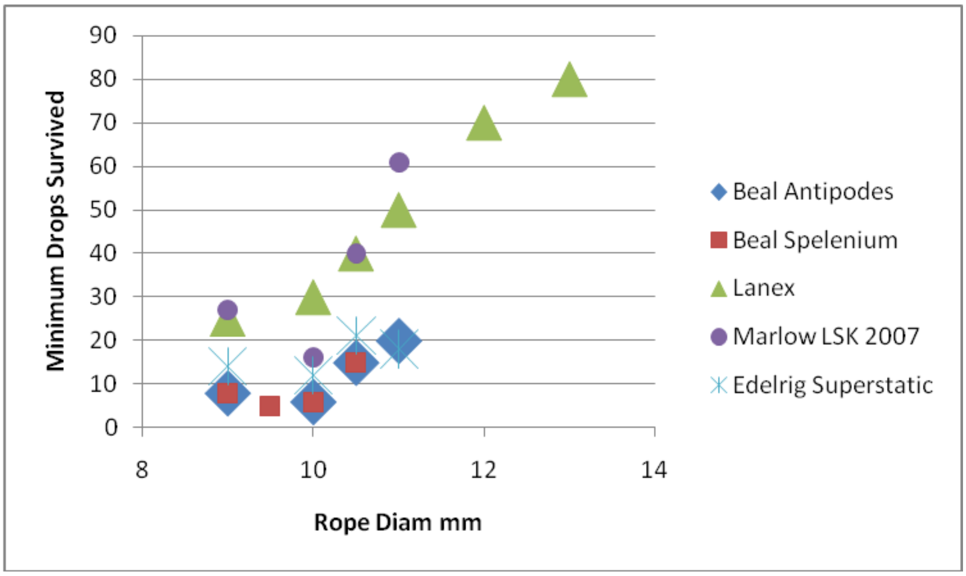
The time requirements between drops can be introduced. There are some indications that leaving the rope for even 10 minutes seems to allow it to recover some elasticity.

Owen Clark adopted an incremental FF to make rope testing reasonable. New ropes often well exceed the minimum number of drops at a constant FF of 1.0 survived requirement (typically between 10 and 20 with an outlier of up to 60). The incremental FF sequence is in fact two initial drops at FF 1.0, followed by the 3rd drop at FF 1.1 and so on. The testing sequence could be modified to 5 drops at FF 1.0 followed by incrementing to reach a definitive break. Alternatively, development of the Bradford rig could introduce other criteria such as peak force measurement or degree of elastic stretch exhibited by the rope. Further work might determine a relationship between incremental drops survived and constant FF 1.0 drops survived; though it is doubtful if this would be reliable.

e) bias of Rope Test Rig

A question has arisen as to whether the small differences in the attachments on the rope test rig make a difference (the top attachment is 20mm diameter compared to 12mm for the bottom attachment). In addition, there are at least two different ways of tying a Figure of Eight knot which might cause differences in testing (whether the active rope is on the inside or outside as it leaves the knot influences the degree of bend that the active rope experiences). Data to date suggests there is no bias between top and bottom knot breaking. However, there is a small indication that the active rope on inside configuration of a figure of eight knot might be weaker than the active rope being on the outside.

f) impact of rope diameter



Note the 9 and 9.5mm rope is Type B rope and hence tested with a 80kg mass. 4 samples of 9mm wet rope tested with a 100kg mass using FF 1.0 only survived 4.3 drops (values between 3 and 6). But Beal, Mammut and Edelrig publish life time usability data which is the same for all of their SRT ropes. So is there value in going for larger diameter ropes? There is also an increase in use of 9mm (and even 8mm) rope which raises the question as to whether the testing should be expanded to cover different rope diameters.

RECOMMENDATIONS

These are presented in sequential order.

1 Adopt time limits between drops and a FF sequence of FF 0.3, followed by five FF 1.0 and then increment the FF in steps of 0.1.

Aim – to see how rope performance differs with different test ssequence.

*RTR - Test say 5 samples using old incremental FF sequence and 5 with new FF sequence, requires 50m new rope which hold. Estimate 5*8 + 5*11 = 95 drops.*

2 Sample length variation be investigated using the Bradford rig which is understood to take a 2m sample.

Aim – to see if Rope Test Rig gives different drop survived result from BS set up.

*Brakenbottom rig - Say test 0.8m (2.5m) and 2.0m (3.5m), need minimum of 10 tests of each length requires 50m new rope which hold. Estimate 20*11 = 220 drops. (May need to extend number of tests to prove no difference.)*

Assume outcome shows can continue to use Rope Test Rig! If not, then sample length increases by factor 1.4 and need to use Bradford rig.

3 Investigate variability in drops survived for a new rope of small diameter using Rope Test Rig.

Aim – to obtain statistics on drops survived from large number of tests

*RTR - Using 9mm and 100kg mass, use 40 samples. Require to purchase 100m 9mm new rope. Estimate 20*5 = 100 drops.*

4 Repeating the LTRT for low usage on a much quicker basis would at least determine if low usage is so detrimental.

Aim – to determine effect of usage on rope strength

*RTR - Try 50 / 100 / 200 usages with 10mm rope, based on 3 off 30m lengths plus 10m as new gives 100m at 2.5m sample length means 40 samples for testing. Require to purchase 100m rope. Estimate 40*10 = 400 drops.*

5 Investigate variation of drops survived along a rope.

Aim – to show if used rope strength is meaningfully different between end and middle

*RTR - Hold 8 ropes (of age between 21 and 15years old) 270m length overall equivalent to around 100 samples for testing. Estimate 100*5 = 500 drops.*

6 Look at strength of different knots

Aim – to show if there is a knot stronger than others

*RTR - trail Fig 9 v Fig 8 knot use 6 samples as initial test. Hold rope. Estimate 5*5 = 25 drops. Proof of difference may require large number of samples. (This test could also be done on other combinations of knots.)*

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