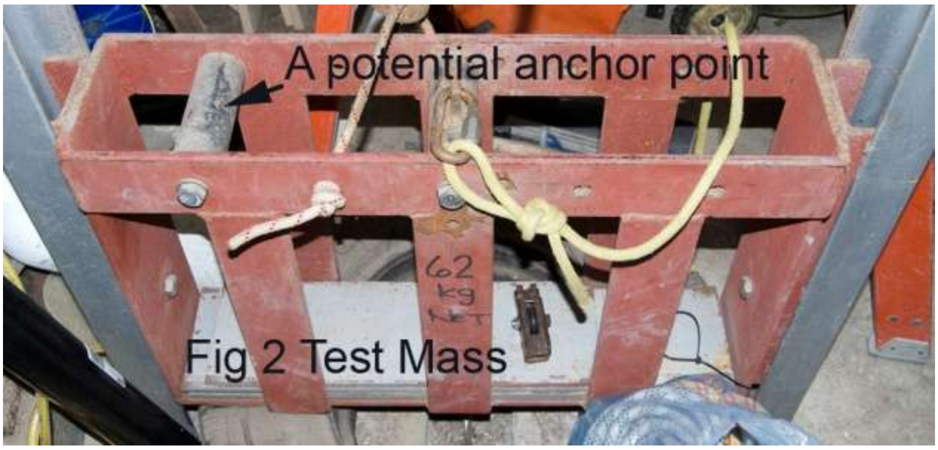
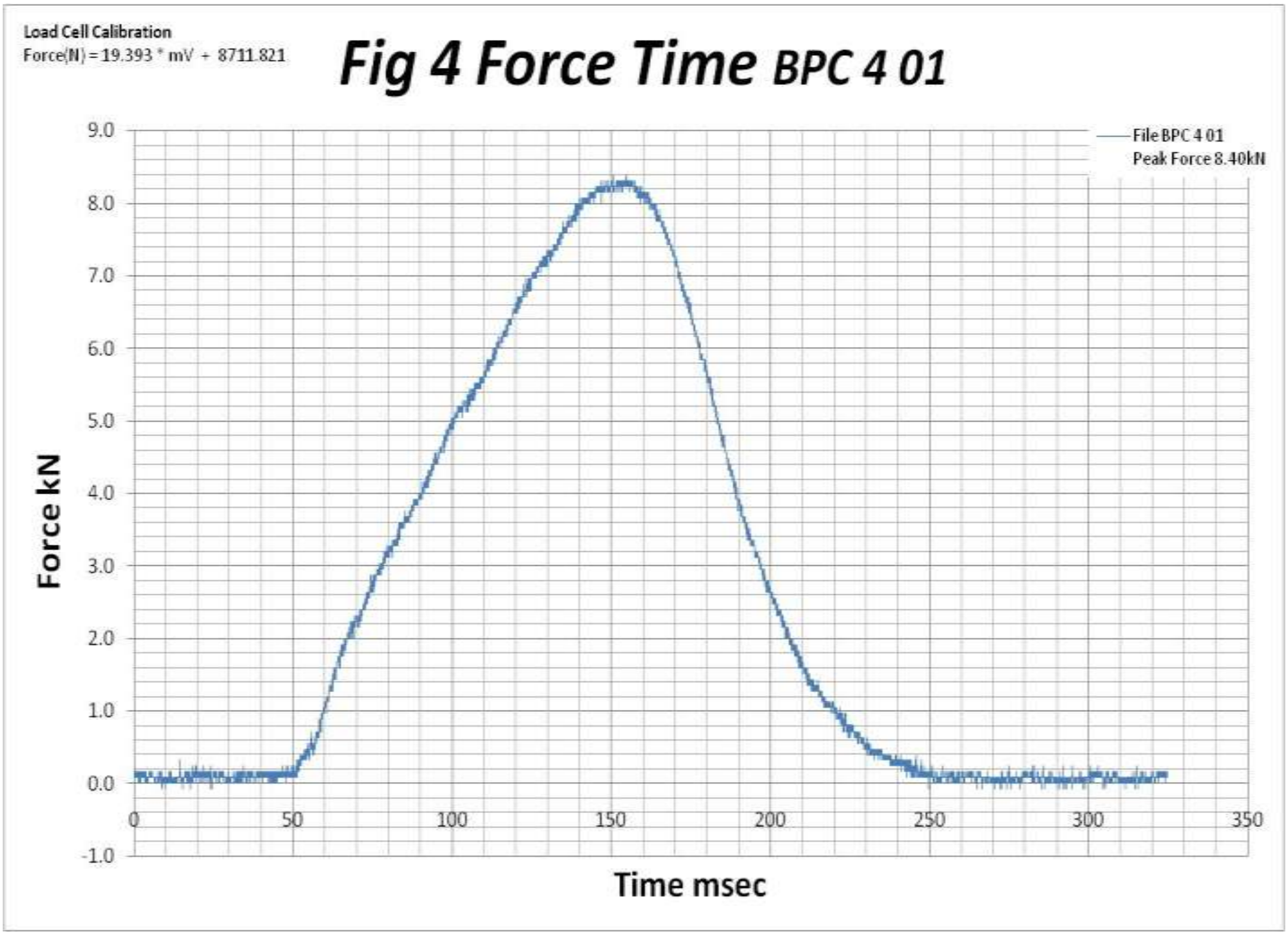
Dynamic Rope Testing – Developing the Equipment

Following some debate over the validity of dynamic tests undertaken using Fall Factors (FF) greater than 1 and also on using short sample lengths on the BCA Rope Test Rig, work started to develop a facility which would record the dynamic forces placed on the rope sample. The Bradford Pothole Club rope test rig (**Fig 1**) had been built by Dave Elliot to take a load cell to measure forces. The rig is capable of testing rope samples up to 1.5m long, compared to 0.8m on the BCA Rig and 2m in the standard (Ref 1), using a FF 1.0 drop.

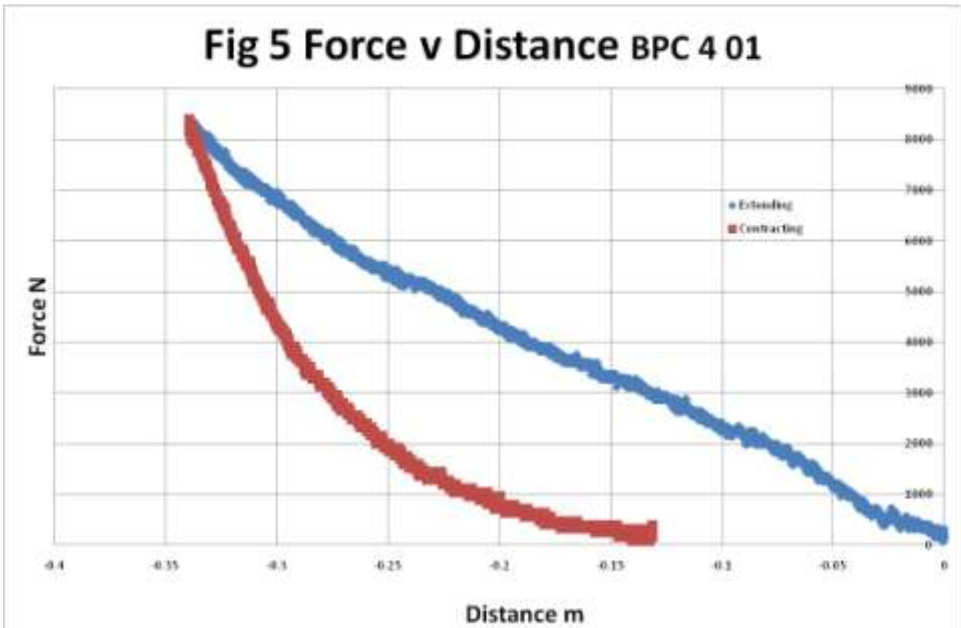


The rig uses a restrained test mass. A set of drop time tests have shown that the friction of the system is acceptably small according the requirements of the standard (Ref 1), equivalent to retarding the acceleration due to gravity to 9.7 m/s^2. The test mass (**Fig 2**) can be configured with more than one anchor to test 'Y' hang scenarios.

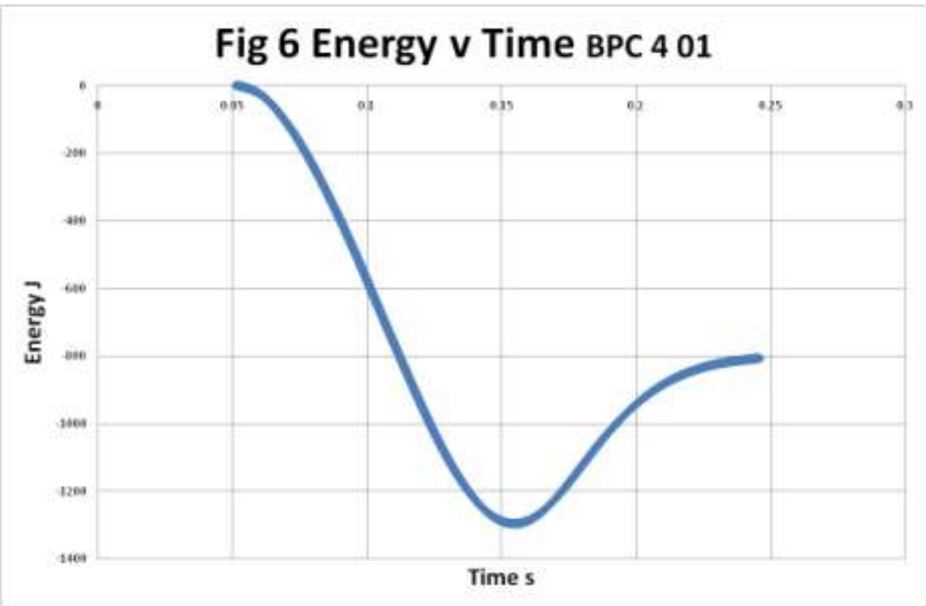
The load cell is a ring gauge device (**Fig 3**) using 4 Radio Spares strain gauges (Ref 2) in a full bridge assembly. The load cell is driven by a Radio Spares strain gauge amplifier (Ref 3). In order to see sub milli second events (Ref 4), the amplifier is operated without external capacitors other than one coupling the strain gauge input and the supply lines to the output's zero volt line. (This does lead to increased signal noise and interference from other equipment.) The output is then monitored by a Pico ADC 200/100 data logger.



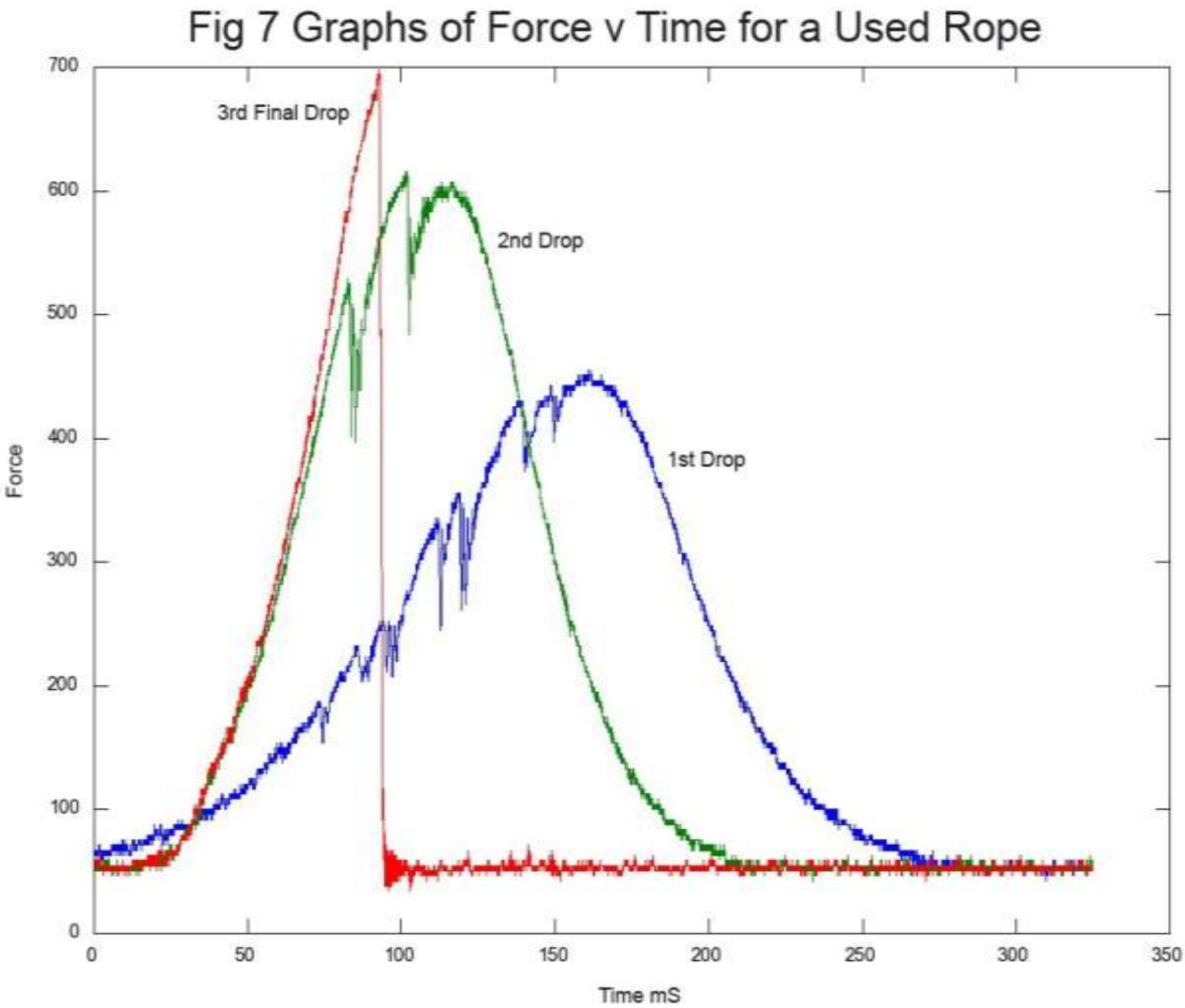
A program has been written to interrogate the Pico data file and produce a chart (**Fig 4**). This figure shows the data from the first bounce of the first drop onto a sample of new rope. The two Figure of 8 knots are tied, dressed by hand and then subjected to a 100kg 'static' load prior to the first drop. Note the asymmetry of the leading and trailing edge of the peak. This is considered to be due to energy being absorbed by the rope being deformed as well as being elastically extended and also in tightening the knot occurring on the leading edge. In contrast, the trailing edge is thought to just reflect the release of energy stored elastically in the rope as it contracts.



A program has been written based on the relationship that force equals mass times acceleration. A numerical double integration of the force time data derives the distance extended. Associating the distance at a given time with the force at the same time, enables a force distance relationship to be derived (**Fig 5**). Fig 5 shows a permanent extension of some 13cm after the first bounce on the first drop, calculated from the data of Fig 4. Experiments to confirm distance calculations are under development.



This data is numerically integrated to give the energy change which is plotted with respect to time (**Fig 6**). Fig 6 suggests that around 800J has been retained by the drop shown in Fig 4, possibly reflective of the substantial tightening of the knots by the first bounce of the first drop.



An early result is the response of a dry 1.0m sample of 9mm used SRT rope (**Fig 7**). (The load cell had not been calibrated at this time so the units are mV output from the strain gauge amplifier.) The substantial jaggedness on the leading edge of the first and second drop curves is postulated to be caused by abrupt knot tightening on a sub millisecond time scale (Ref 4). The rope broke on the third drop. Similar curves were obtained for 1.5m and 0.4m length samples from the same used rope. Note the contrast in jaggedness between these curves and those for a new rope (Fig 4) where it is assumed the knots tighten smoothly.

Also of note was that the 1.5m, 1m and 0.4m samples survived only 1, 2 and 8 drops. This suggests overall drop length rather than Fall Factor is significant in rope / knot systems of under 2m length.

It is clear that the rope knot system is not simple and will require substantial investigation to produce a model which might describe the rope and knots' performance in both new and used rope and hopefully produce some practical guidance to cavers.

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Ref 1 British Standard "PPE for the prevention of falls from a height – Low Stretch kernmantel ropes", Section 5.9 BS EN 1891:1998
Ref 2 Radio Spares Foil Strain Gauge type N11-FA-8-120-11
Ref 3 Radio Spares Strain Gauge Amplifier stock number 846 – 171
Ref 4 Unpublished High Speed Camera work, B Mehew, 2003

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