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THE SAFETY FACTOR OF WIRE ROPE — by J. EYRE

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Cave safety has often been stressed in the past but familiarity often breeds a certain degree of apathy until a serious accident shocks one back to reality. Most caving accidents are avoidable and ninety-five per cent are the result of human error, lack of judgement or carelessness; failure of equipment falls into the latter category.

Considerable research has been done in the past on the construction of wire ladders by the C.P.G. (C.L. Railton) and a C.R.O. sub-committee (Leader J.O. Myers) and their recommendations were published. Two distinct methods of ladder construction were suggested; swaging and the plug-and-pin method.

Specification of wire and alloy tubing etc. were also included and a reasonable safety margin was allowed, yet today many clubs' ladders fall well below these standards, and perhaps a re-appraisal is needed as it is several years since these recommendations were published and some younger cavers may not be aware of the facts.

Haphazard construction, inferior materials, poor maintenance, insufficient supervision and abuse when in use can make ladders totally unsafe for the loads and stresses to which they are subjected, until the safety margin becomes non-existent.

It is an elementary point but an important one, that if a wire rope has a breaking strain of ten hundred-weight it cannot be reasonably put to work in conditions where it may be subjected to this load or anywhere near it. If a rope breaks at ten hundred-weight then to load regularly at eight or nine hundred-weight will soon lead to eventual failure, whereas a ten hundred-weight rope used with a five to six hundred-weight load will give safe service for years. The amount by which a rope must be safeguarded varies, depending on the service it has to do and is known as the 'factor of safety', and obviously where human life is at stake, the factor of safety is high.

The following standards are observed; the marine use of ropes requires a safety factor of five to one, engineering six to one, mine hoists ten to one and passenger lifts fifteen to one.

What safety factor does the average caver put on his own life?

Wire ropes used in caving vary enormously from one ton ult. tensile strength down through various grades to ultra lightweight "piano wires", and in many clubs ropes of known inferior construction are used purely on a cost basis with expense taking preference over safety. How much is a caver worth - a few pounds? Of course not - better to have a few good quality ladders than many inferior ones. On the other hand too little knowledge plays a part in the selection of wire with complete novices using fencing wire and in one extreme case reputed to have used barbed wire with the barbs cut off.

A few extremely "knowledgeable" cavers have got the construction of wire ladders down to a fine art using fine acro cord that barely supports two hundred-weight with fine pencil rungs widely spaced, difficult to grip and fragile with the whole ladder relying on inertia to hold it together. There are three major factors in ladder

failure; expense, ignorance and indifference.

The choice of wire needs to be assessed in terms of strength and flexibility as wire of too fine construction is more prone to mechanical damage and makes the wire ladder less rigid and more difficult to climb, whilst the less flexible wire rope of coarser construction is more prone to metal fatigue as the thicker strands refuse to bend without weakening.

Wire ropes with a hemp core are unsuitable for caving as the constant contact with water eventually rots the rope strand and a chemical reaction produces acid which attacks the wire. Wire of this construction is also a soft wire, kinking and flattening very easily and is deceptively weak. It should not be used with a talurit swage as the wire becomes flattened and deformed as the swage is applied, the rope core is spread into the talurit to rot and break down at a later stage, leaving the swage corroded and weak. Also the rope core compresses as the swage is applied resultin in an imperfect fixture which could pull out at a later date. There is also some danger of corrosion and electrolysis as the rope core eventually begins to absorb and hold moisture and accelerate failure.

Wire ropes recommended for ladder construction are (C.R.O. sub-committee recommendation).

Galvanised aero cord 7 x 14 a/10" dia. ult. tensile 0.5 tons
or Galvanised aero cord 7 x 19 0.15" dia. ult. tensile 0.75 tons
preformed ord. lay.

(C.R.G.)
Galvanised aero cord 0.11" dia. 7 x 16 ult. tensile 0.5 tons

Many wire rope firms and other specialists recommend a slightly stronger rope which in view of various factors may be more advisable especially for belay wires:

Drawn galvanised special plough steel wirecable
7 x 19 5/32" dia. ult. tensile 1 ton

Many methods of rung fixing in current use seem to be a case of deliberate weakening of the wire rope by opening the wire strands, screwing sharp screws into the wire, deliberately kinking or bending the wire or introducing corrosion in the form of nails and in an extreme case knots have been observed in the wire. All these methods of fixing rungs constitute a malpractice by causing unnecessary weakening of the wire without giving a firm fixture and the two methods which should be adopted are:-

1. C.R.G. recommendation, the plug and pin method, using a soft aluminium or araldite plug inside the end of the rung with the wire passing through both and held by a stainless steel pin which passes through the rung, plug and wire. The fine pin opens the wire strands just enough to form a tight bend inside the plug. This is minimal so no appreciable loss of strength takes place in the wire as a whole. This method is the oldest of the two recommended and ladders which have been in use for twenty years have been bisected and shown no wear or corrosion and no slipping has occurred. A more up to date and quicker method of construction can be done by using araldite for full specification of the plug and pin method. Contact C.R.G.

2. The C.R.O. sub-committee recommendation is the use of swaging above and below each rung. A certain amount of free play is allowed on the rung and this eliminates the fatigue which could occur with a fixed rung; againthere is no loss of strength in the wire. The swaging should be done by competent labour with a precision jig

and press.

Methods of fixing the ladder ends have for many years been by a thimble and eye splice. A good splice kept well away from the top rung of the ladder will give good service even allowing for some reduction in the breaking strength of the ladder as a whole. However, in recent years the Talurit swage has superceded the splice on many light ropes used in industry. The Talurit swage consists of a soft collar of aluminium alloy which is fused into the lay of the wire by a steady pre-determined pressure. This is an ideal fastening for ropes in situ or fairly rigid use and the wire will fail before a correctly applied swage.

The Talurit swage should not be fitted by unskilled amateurs with ill fitting jigs and the aluminium alloy should be of a certain specification if it is to function correctly. The jigs and pressure should be correct, insufficient pressure can leave a swage loose, and too much pressure can crack the swage or damage the wire. Swaging by hammer blows should be avoided.

Extensive use by cavers of the talurit swage on ladders and wire belay wires has become accepted policy with little or no research having been done on the suitability of the swage in caving conditions, particularly on the possibility of metal fatigue, which could occur with the continual flexing of a wire rope next to a fixture. Fatigue has been observed where eye splices terminated too close to a rung where the increased rigidity of the wire fractured the wire strands and the point where the wire entered the rung so it is reasonable to assume that similar fractures will occur where a wire enters a talurit swage especially as ladders and belays talurits are hung in positions where excessive bending of the wire could occur.

This risk could be increased on ropes of coarse construction or cheap soft wires with rope cores of insufficient spring.

A ladder badly hung could accelerate failure and this happened recently on a thirty feet pitch in Gavel Pot. Fortunately a lifeline prevented serious consequences. A combination of rope-cored wire and ladder ends under tension at an angle resulted in the wire breaking inside the swage. Without fully realising the implications, blame was finally attached to the rope-cored wire, and the club withdrew tackle made of this wire. All other tackle was examined. Unfortunately within the space of three weeks a wire belay broke inthe same manner in Kingsdale Master Cave with tragic consequences, for one of our members sustained severe damage to the spine.

The wire belay was not amongst tackle examined at Greenclose and must be assumed to have been returned with other tackle or been fastened on a ladder and gone unnoticed. The belay looked in good condition and has been studied and X-ray photographs taken of the damaged end and the other sound talurit. A tensile fracture had occurred inside the swage, there was no sign of electrolytic corrosion which had at first been suspected. The sound swage was also subjected to X-ray and the photographs showed a diagonal fracture across the wire inside the swage, a few strokes with a file and the remaining few sound strands parted. The Gavel Pot ladder was sent to a wire rope firm for comment and the answer was metal fatigue, and from their subsequent enquiries metal fatigue with talurit swage is quite a common occurrence and difficult to detect. Other clubs have experienced cracking of wire adjacent to swages and some actual failures have occurred. These facts should

have been widely publicised, and this is another example of the lack of communication in caving circles. With this in mind and the severity of the accident which had occurred we must at all cost avoid a repetition, and until more information has been gathered the case for and against talurit swages cannot be fairly judged, but frequent inspection of this type of fastenings is advised.

A wire ladder, like a chain, is as strong as its weakest point, and one-ton U.T. wire is not serving much purpose when the ladder is joined with C links that open at 5 hundred-weight or C links that have been cut opposite the weld.

One often sees good ladders hung on belay wire of half the strength yet there is a strong case for making belay wires stronger than the ladders, for by its very nature the belay wire is the important link in the chain, and the failure of this is total unless a secondary safety measure is introduced, and there is a strong case for adopting a different technique and making the wire belay into a complete circle with the addition of another C link, or two separate wires to two separate points, then if one side breaks the ladder is still held. This is easier of course in theory than in practice and a stronger belay would seem the simplest, effective answer.

The rigging of a pitch and the choice of belay points and position of take-off and lifelining etc. are very important and have been dealt with elsewhere, but the following points can reduce the breaking strength of equipment by as much as fifty per cent; belay wires wound round a bar of small circumference, wires hung across another wire, eye splices without thimbles, belay wires hooked over the top rung, C links with the pull across the axis, wires hooked over ropes, ladders hung by the top rung, ladders hung on a singleend of a belay wire, ladders hung over a sharp edge etc. These are a few common malpractices that the equipment of any club has to stand.

Another factor of loss of strength is the insidious effect of corrosion, especially if the equipment is badly constructed or contains different types of metals; the effect on a caving ladder of different metals and the slightly acid cave water has yet to be fully appreciated by the layman. On one occasion recently I commented on some copper binding over a galvanised wire, and the owners of the ladder - well known "tigers" - came back with the quip that "it was handy for charging their batteries on."

The static weight of the average caver could be twelve stone; a man of this weight floundering about on a ladder could exert a three hundred-weight pull by missing a rung or forcing the ladder from under an obstruction. This is not excessive in itself but taking into account a badly hung pitch and a ladder suffering from corrosion and what safety factor remains? The fact that wires are breaking suggests that the safety factor is too low and the use of any wire below fifteen hundred-weight U.T. should be discouraged. This may seem excessive, especially by today's "spidermen," but consider how many years the average clubs' wire ladders have been in use and how often someone suggests a particularly shaggy-looking ladder is thrown out and how often another person answers "but we've had that one for years". How long should ladders be left in service? How much does wire deteriorate?

The life of a caving ladder is hard to assess but it depends entirely on what service it has done in what conditions and how it has been maintained, and there are many clubs today caving regularly on the original wire ladders that they first made.

(I used ladders twenty years old at Provatina). There is a great deal which we, the ordinary cavers, do not know about metal fatigue, and it would take an expert metallurgist to present all the facts, but like corrosion, fatigue can be slow, and in some cases undetectable to the naked eye, yet one never sees a wire ladder scrapped purely because of age. It may be relegated to smaller pitches (to be used without a lifeline!) but never scrapped. There is a sound argument for making ladders in batches and allowing so many years use before scrapping one batch and introducing the next.

Good ladders should perhaps be allowed a life of ten years, and then we would be saved the embarrassment of seeing cavers climb on ladders made before they were born, and in some cases, outliving them - - - - - !

In recent years there has been a tremendous influx of small clubs, groups and even individuals, all possessing cheap, poorly constructed ladders. It is only a matter of time before failure becomes commonplace.

Every caver should take a good look at his tackle and regardless of club policy should ask himself if it is really safe. Keeping tackle is rather like keeping a dog - you get quite attached to it - until it bites!!

REPORT ON THE FIRST MEETING OF THE FULLY CONSTITUTED NATURAL HISTORY SOCIETIES COMMITTEE, THE COUNCIL FOR NATURE. (N.H.S. COMMITTEE)

1. The meeting was attended by representatives of Natural History Societies from all over the British Isles, but the response had been a little disappointing; many Societies had not even replied to theinvitation to attend.

2. The Chairman reported that the new constitution was effective and the new Council accepted as a useful focal point for other bodies and a useful means of getting together but not a body with functions of its own. The position of General Secretary had been declared redundant. The work of the Council had been carried on by British Society for the Protection of Birds (R.S.P.B.) and the Society for the Promotion of Nature Reserves (S.P.N.R.). An Information Officer was to be appointed. He would be secretary to the N.H.S. Committee and would edit Habitat. The plan to merge with R.S.P.B. and S.P.N.R. is still under discussion. The R.S.P.B. had stated that the plan formed a basis for discussion; the S.P.N.R. had made no comment yet, as they had not had a meeting.

3. Mrs. Grace Hickling was elected Deputy Chairman. A vote of thanks was proposed and seconded to Sir Landsborough Thomas for his most unselfish efforts in publishing "Plan to Merger." It was suggested that there should be standard nomination forms and ballot papers for the whole country for the election of regional representatives. It was further suggested that in future the Council for Nature office should organise the regional elections, and they were asked to produce a list of affiliated Natural History bodies by regions. It was decided that members of the N.H.S. Committee could send a substitute to any meeting.