SLINGS AND ANCHORS OF OUTRAGEOUS FORTUNE

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Over the past few weeks, I've been following some threads in a very well known UK based climbing internet forum. In them they were discussing, amongst many other subjects, how strong Dyneema slings were and whether we should be using slings to link anchors. It made me realise, looking back at some of the other threads on this forum, that a great many climbers were unclear as to how 'strong' was the gear they used and the implications this had for its use.

In March 2005, along with others from Glenmore Lodge and Plas Y Brenin, independent instructors and guides, and staff from the Mountain Leader Boards and MLTUK, I attended what was billed as a 'Sports Technical Equipment Forum' at the Lyon Equipment Tebay warehouse. The forum aimed 'to explore the capabilities of technical equipment by semi and permanent destructive testing and discuss findings with outdoor experts (Staff).'

The first part of this article is based on some of the findings from that testing day. I've added some more images to my original article (published in the old AMI newsletter that year) to better illustrate what was going on. I've also made clearer the outcome of the tests by adding, where appropriate, the practical implications of these tests and their conclusions.

I should stress that this article is based on notes I made at the event about the tests and results. Any errors and inaccuracies are entirely my own!

About the Lyon Equipment tests and how they were conducted

Before testing began, it was made very clear these were not laboratory standard UIAA/CE tests but rather an attempt to put together several possible and likely events that may/would happen in a normal climbing situation. As such they were informal tests.

All the tests were made on isolated sections of the 'safety chain' in an effort to reduce variables such as belay error, rope slippage, friction of rope through runners etc. Because they eliminated the energy absorbing properties inherent in the harness, human body, belayer and the anchor tie in points (knots) the resulting forces were much greater and degraded (or damaged) equipment much faster than would actually occur.

Most of the tests used an 80kg steel mass. This mass was connected to an electronic load cell to record the forces generated in the tests, which were then illustrated using graphs (examples of which are used to illustrate each test in this document).

Ropes used throughout were Beal 10.5mm full ropes. Not because there is anything unusual or special about these ropes, just that the guys had loads of them available. Also the ropes did not have any special treatments to enhance performance such as dry treatment, 'programme' design etc.

Other ropes/brands will produce different results. It's worth noting that ropes with a higher impact force ie. those that are less stretchy than those used, are likely to result in higher impact forces on the top anchor, climber, and belayer.

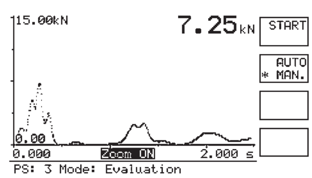
Interpreting the graphs

The black and white diagrams showing the loads are the graphs from the actual tests. During testing the load cell records the forces generated by sampling the shock load. Each sample is represented by a dot. The dots linked up give the shapes shown in the graphs. Note that if no shape is shown on the +ve axis this is where no load is measured. In the case of the example shown, this means the rope is now rebounding after being loaded, hence no load is visible.

Load is measured at the anchor point, which in this case also reflects exactly the force on the climber/mass. The vertical scale (top left) of 15kN has been set for this test. The scale was set for each test and is not always the same. The peak load achieved in this example was 7.25kN.

Now back to school and mechanics or physics lessons...

One Newton = One kilogram accelerating at one metre second².



example only

This is not a weight (think of a 1 litre Nalgene bottle of water accelerating at 1m/s^2 – its weight is always the same (c 1kg) but if it's accelerating at 10 m/s^2 it's a force of 10 Newtons).

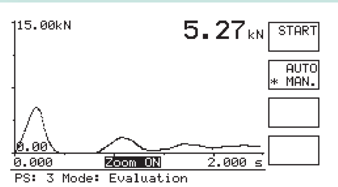
Fall Arrest Impact Forces. What is the impact force and how is the rope affected by repeated falls?

This test was set-up to look at what happens to your figure of 8 knot tied into your harness when you take a fall. This series of tests used a 1.5m lanyard made from a 10.5mm Beal rope with figure of 8 knots at both ends.

Due to time constraints, there was no opportunity to compare the energy absorbing properties of different knots (ie. clove hitch and bowline).

The first test used the equivalent of a Fall Factor 1, then subsequent tests (after a suitable period to allow the rope to regain its elasticity) involved the equivalent of a Fall Factor 2.

Test 1

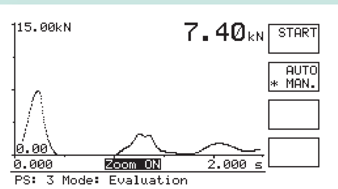


fall factor 1

- *Knot showed signs of loading with core just visible through sheath weave.*

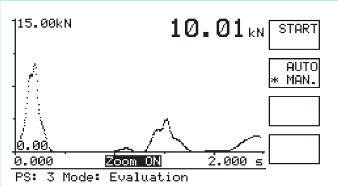
Test 2

Same set-up as Test 1. This time four consecutive falls with around two minutes between each fall.

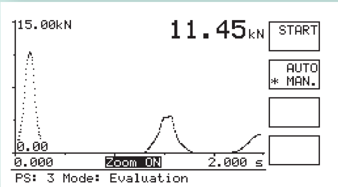


fall 1: fall factor 2

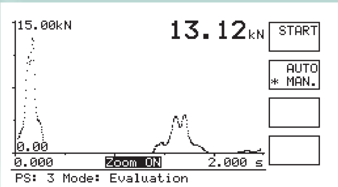
- *Fall 2: rope at load knot felt warm.*
- *Fall 3: What looked like abrasion appeared beside the start of the knot. This was probably at least partly due to rope slippage through the knot and the heat created by the movement during the absorption of the forces. Heat was obviously occurring as we could feel the rope was warm here. What looked like abrasion could instead be where rope sheath fibres were damaged.*
- *Fall 4: This last fall appeared very violent as there was little elasticity left in the rope.*



fall 2: fall factor 2



fall 3: fall factor 2



fall 4: fall factor 2

Observations

The figure of eight knots were most active in absorbing energy in the first fall in any series. They absorbed energy in the initial shock load and were not changed ie. they were not untied or readjusted in any way between drops. The knot (figure of 8) added to the energy absorbing properties of the rope.

Practical Implications

After a fall it may be advisable to retie the knot, in a slightly more advanced position, as the knot will have absorbed a lot of energy and, if not retied in a slightly different position, cannot absorb the same amount of energy again. On a practical note it is also (slightly) easier to undo a knot after one fall than after multiple falls.

Slings vs Rope

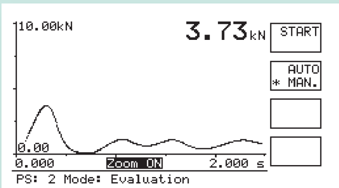
This issue has exercised a lot of climbers' minds on the interweb thingy! In many respects it's a no brainer – climbing rope stretchy, slings in comparison less so. So two tests were set up, one using slings to attach a climber to the belay, the other using the rope. Rather than use a real person and have them fall off the stance, or the steel mass used in the previous tests, these tests used an 80kg rope access dummy with harness, helmet and obligatory blue boiler suit.

This dummy gave different results, more true to life, as the dummy was attached with the rope tied into a harness. The 'softer' nature of the dummy, knots tightening and the loading of the harness all allowed for increased shock absorption.

Simulate person falling off belay ledge but attached to anchor by different methods

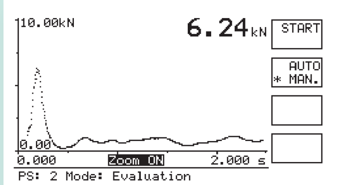
Test 3

This test recreated a climbing student sitting on a ledge attached to the main belay with 1.5m of rope. As they shuffle across they fall off the stance – this fall was partially a swinging pendulum.



fall 1

- *Reduced impact due to:*
Body absorbing force
Harness moving
Knots tightening



fall 2

As above except student clipped into main belay with cows tail of 120cm long (12mm dia) dyneema sling clipped into harness loop with krabs.

NB: It's worth noting that some daisy chain webbing, although having a minimum strength of 22kn end-to-end it can have individual 'ladders' or 'pockets' of stitching with strengths far, far lower than that. If a ladder or pocket were being relied upon in above tests it possibly would have failed.

Observations

When comparing Fall 1 to Fall 2 we can see that the peak impact force generated in the fall, involving the student clipped into the anchors with a sling, was nearly double that when they were clipped into the anchors with the rope.

As you would expect the rope, being dynamic, has a greater ability to absorb the energy of any fall. It would therefore make sense to use the rope to clip people into the anchors.

If you have to use a sling eg. when clipping into abseil anchors prior to abseiling, then you can reduce the impact force by ensuring that the sling attachment between the person and the anchors is tight ie. no slack, and is in line with the fall line. Since the Lyon tests, Dyneema slings were the subject of a variety of scare stories. The next section explores the use of Dyneema slings and the myths that sprang up about them.

Dyneema® Slings and Some Climbers Urban Myths

In the past few years dyneema (note Dyneema is the trade name for a superstrong polyethylene fibre made by a firm called DSM) slings appear to have picked up a bit of bad press in the general climbing public from unsubstantiated stories about dyneema slings allegedly failing at lower than expected loads. Other attitudes about dyneema slings appear to have come from individuals misinterpreting the results of tests.

With the advent of skinnier slings such as the Mammut Contact slings made out of 8mm Dyneema, then more urban myths appear to have popped up that the slings are not strong enough (even although they are rated to 22Kn the CE minimum requirement).

Dyneema and Spectra are high strength polyethylene fibres which have a tensile strength about 15 times greater than steel. The fibres have a long life span and a high resistance to abrasion, moisture, UV rays and most chemicals. Dyneema is also ‘hard and sharp’ under load which means it can increase the risk of it cutting when directly attached to other slings. (Try wrapping thin twine around your finger then pulling, it’ll cut deep – that’s what 8mm Dyneema does to other wider diameter slings. Now wrap another finger around your finger and pull – far more comfortable).

During the Lyon testing day, two tests were carried out on a 10mm Dyneema sling rated at 22Kn (or 2200kg). The first involved a static pull test on the sling where it failed at 2814Kg. The next used another 10mm Dyneema sling that was mildly abraded along approximately 40cm (so it looked like an old used sling ie. one of these hairy things everyone has on their rack!). This abraded sling failed at 1485Kg. The third and last test was on a 10mm Dyneema sling that had a nick out of one side of it’s axis (done using a very sharp knife) this sling failed at 2336Kg. This pronounced difference is due to the fact that the fibres in the sling are woven together. By abrading the sling you weaken the longitudinal fibres hugely affecting the sling strength. Whereas cutting the sling will only affect the fibres you cut eg. cut half the sling affects half the fibres. So watch out for furry slings!

So here are some of the urban myths I’ve picked up on...

Myth No1 – Dyneema slings when knotted break at really low loads.

Myth No 2 – Never join two dyneema slings together using a larks foot (head) as they can fail at very low loads.

I’m sure you’ve got all your variations on the above. What I’ll do here is provide the FACTS about Dyneema slings and their uses so you as instructors and climbers can make your own decisions about how to use them, and hopefully educate the wider climbing public to the real usefulness of these slings. I’ve summarised a test report from Mammut which provides evidence that can be used to prove or disprove the above myths.

Breaking of a Girth Hitched Sling (Larks Foot or Larks Head)

On the 22 October 2006, John Sherman, a well known Colorado climber broke a Mammut 8mm Dyneema Contact sling. The slings had been part of an anchor used to fix a rope so he could clean a climb. It would appear that the way the anchor was set up was such that the girth hitched 8mm Contact sling was taking the majority of the load. The rope was directly attached to what appears, from the photos, to be a thread, whilst the two girth hitched slings (one 8mm diameter and the other 15mm diameter) were attached to another thread and then attached to the rope using a krab and clove hitch. After the incident John forwarded an email to many of his friends warning them not to girth hitch (Note: we would call this a larks foot or head) skinny slings together. This email very quickly found its way worldwide to many internet forums and chat rooms. One major UK website even ran it as a story. About two weeks later, John sent the still girth hitched slings to Mammut for further analysis.

From industry testing (Alpin-Lehrplan 6, Alpenverein/BLV – ‘Gergrettung’ by Toni Freudig and Adalbert Martin; and informal tests done by Kolin Powick at Black Diamond*) it’s well known that knotted slings lose a significant amount of their strength – a strength loss of 50% is the generally accepted ball park figure. Mammut themselves did tests in 2004 and 2006 measuring the tensile strength of slings girth hitched together which confirmed this. Black Diamond’s own informal tests also gave back a figure of around 50%.

According to Sherman’s statement the girth hitched slings had not sustained any dynamic falls and had been subject only to the sort of forces normally associated with someone hanging on a rope doing some cleaning of a climb.

Mammut did extensive tests on the two slings which were girth hitched together. One a Misty Mountain 15mm Spectra sling, the other the Mammut 8mm Contact sling. These tests echoed what earlier tests had found, that the strength of the girth hitched slings was reduced by about 50%. In the context of Sherman’s incident this reduced strength was still within acceptable safety parameters. So Mammut then took the broken Sherman sling along with the broken test samples to a textile proofing company called Testex. After exhaustive testing they concluded that Sherman’s sling had been cut with a very sharp object. The only difference between Sherman’s cut sling and a tested sling that was cut was Sherman’s sling had a pulled thread. The theory being that this thread was enough to hold the anchor in place so it appeared intact and then finally pulled under a low load.

Observations

Mammut and Black Diamond both came to very similar conclusions. In both tensile strength tests (static pull) and drop tests (Fall factor 2 with 80Kg mass) joining two slings together reduces the ultimate strength by up to and in some cases over 50%. Although with dynamic loading in all cases it took more than one severe drop to induce failure.

Note: CE requirement is a minimum breaking strength of 22Kn (2200Kg) so this 50% reduction gives an average strength of around 1100Kg.

Joining a narrow sling to a wider sling results in slightly greater reduction in strength (approx over 57%). So based on the CE minimum strength of 22Kn (2200Kg) an average strength of 8.8Kn (880Kg).


8mm Dyneema girth hitched to 10mm Dyneema. Not good!

In both these situations these strengths would still be enough to cope with the loads anticipated in a STATIC situation such as a bottom roping, self lining etc. HOWEVER, add a dynamic element to that, which would generate an increased load eg. when self lining you manage to get some slack into the system then slip and fall shock loading the system, and it could cause the girth hitched slings to fail.

Both Mammut and Black Diamond recommend that you use a longer sling which negates the need to join slings together (or a rigging rope?) and if you need to join slings together, using a karabiner is stronger.

In the Black Diamond tests a couple of conclusions are worth noting. If you must join two slings together then it is better to use slings of the same material and width.


Two slings girth hitched or larks footed together


Two slings strop hitched together

Use a symmetrical knot such as the Strop Bend. In Black Diamond’s testing they appeared to perform better than a standard Girth Hitch (or Larks foot/head) when joining two slings together. The qualifying factor is that you have to take into account that the overall reduction in strength is still in the order of 50%.

So, looking at our urban myths we can see that in Myth No1, where the Dyneema slings break at very low loads is a fallacy. Used correctly they are as strong as the manufacturer says they are. Myth No2 on the other hand has some truth in it. However, although there is some additional strength loss when connecting skinny slings to


Dyneema sling larks footed to harness belay loop. OK

wider slings all slings joined together using girth hitches should be treated with caution, in that they all weaken the slings by at least 50%.

Implications

So in what situations do we connect slings to other slings or webbing and do we need to change our thoughts or practice? Well the obvious one is when setting up a cows tail using a long sling. This is a method commonly used when setting up clients on a stacked abseil. I've seen this done several ways. One way is to girth hitch or larks foot the sling through the harness (belay) loop, as shown below. The other is to girth hitch the sling through both sections of the harness as shown.

In the Mammut tests two experiments using dynamic loads in a drop tower were done to evaluate slings loosely knotted, and then tightly knotted. The forces involved were those equivalent to that associated with bouncing on a rope whilst ascending or descending. In the first cycle no failure was experienced. In the second cycle using a larger force on untightened girth hitches, they saw that the knot slipped under load, and generated higher temperatures through friction finally leading to superficial burning of the slings. It was noted this only had a small effect on the strength of the slings. This would suggest there is little to choose between having the slings girth hitched tightly or loosely.

Of far more concern is that joining slings to other slings (the harness loop is effectively a sling) weakens the slings by 50% giving us safe working loads of around 1100Kg, or if we join a skinny sling (in comparison) to the harness loop of 880Kg, then it would be possible in our abseil situation to generate forces that would exceed this. For example, when setting up your stacked abseil if for any reason someone climbs level with or above the anchor then falls onto it, you can generate substantially greater forces due to lack of elasticity in the sling. There was an accident on Ben Nevis a year or so back where I believe a similar event happened leading to one fatality. I know of another accident where two climbers were rappelling down the Voie des Suisses route on the Grand Capucin (Mont Blanc range, France). The climber who sadly was killed in this incident was at an anchor, awaiting his partner to finish a rappel. He was attached by a static sling around 100cm in length to one of the two anchor components – an in situ (and possible old) sling in turn attached to a piton. He was standing around 50cm above the anchor. Apparently he slipped from his stance, causing a shock load onto his personal sling and in turn onto the sling anchor component, which failed.

So if you are going to use a sling in such a manner, it would be wise to ensure all parties are tight on the anchors in between abseils and never in a situation where they are above the anchor(s) when clipped in (good practice on any stance in any situation I would suggest). As to how you larks foot the sling through the harness I'd go for the sling larks footed through the harness belay loop. Why? What concerns me is that with the other method, through both parts of the harness the sling is not tight, and there is a lot of movement of the sling should it be shock loaded. This could be sufficient to generate enough heat to compromise the Dyneema sling (Dyneema has a low melting point around 144 to 152 degrees C˚). Due to the above, many manufacturers now make slings that are specifically designed for use in situations where being clipped into anchors using a cows tail arrangement is common practice eg. caving, via ferratas etc.

dyneema urban myths

Fall Arrest Impact Forces and Friction

Okay, back to the Lyon Equipment tests. The next section takes a brief look what happens when we fall off when climbing and the impact this can have on the safety chain.

Two schools of thought about rope design:–

- Keep rope stretch to a minimum.

Pros: In the event of a fall there is a decreased chance of hitting something as you are travelling ('falling'!) for longer in the slowing down phase.

Cons: This creates potentially high impact forces the safety chain will have to absorb, especially the belayer where there is the risk of them letting go of the breaking rope due to high impact force), or runners etc failing due to high impact force.

- More rope stretch

Pros: More rope stretch therefore reducing impact force on safety chain and chances of belayer/gear failure.

Cons: Increased chance of hitting something as you are travelling for longer in the slowing down phase.

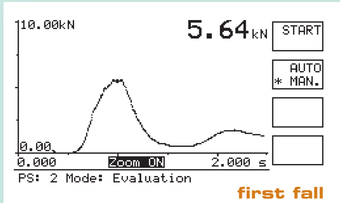
What effect does friction through runners have on impact forces?

The load cell is measuring the force at the runner and not at the climber (dummy) or belay device.

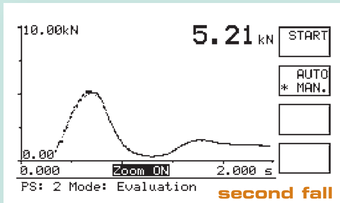
Test 4. Falling Climber

10m of Beal 10.5mm rope was anchored to a GriGri on the ground, run up through a runner, and attached to the dummy with a figure 8 knot into the harness. There was a small amount of slack in front of the GriGri. The runner was at 5.5m above the ground and was level with the dummy's feet.

- *First fall. Dummy fell off and touched the ground with its feet – although looking at it you would have guessed the dummy would have stopped short of the deck, the reality was the amount of give in the system was in excess of what the audience anticipated – in this case roughly about four times what the audience expected (Lyon staff expected this to happen, touching down was a good way of highlighting the demonstration).*

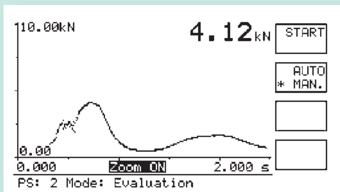


first fall



second fall

- *Second fall. Same length and type of rope attached to climber via harness and anchored through Gri Gri. This time the rope ran through two runners in a zig zag, dummy's feet again level with the same top runner at 5.5m above the ground. Note: Increasing the friction on the rope, by it going through runners beneath the dummy, was expected to cause a higher impact force at the top runner. This demonstration shows a lower impact force at the runner, not in line with expectations. The dummy didn't hit the ground, so fall distance has also reduced.*



third fall

- *Third fall. Same set up as second fall except top runner was extended with a low absorption Nitro 6790 (20cm) shock absorbing extender.*

The Nitro deployed at 2.5kN and when fully deployed acted as a sling, thereafter the force increased to 4.12kN. The images above show a fully deployed Nitro (not the one tested) which held a 20m fall onto an ice screw. The second image shows the Nitro in close up.

A higher absorption Nitro 67800 (16cm) deploys 4cm sooner and may have kept the maximum force at 2.5kN but the increased deployment distance results in a longer drop.

(NB. remember that micro protection and some winter runners have low kN load failure figures).

Observations

If a climber takes a fall, the distance they end up falling can be more than just the length of the rope above the runner. Various dynamic factors in the system could mean the fall will be at least three to four times as long as you expected. So if the climber was two metres above their gear, you could expect them to fall at least six metres.

Having a lot of gear in a pitch, and the possibly increased friction, can reduce the dynamic element in a fall, thus reducing the distance you can fall. The above test is counter intuitive so further testing might suggest the impact force would or should be greater on the top runner, as you would expect.

Clipping protection with a load limiter such as the Nitro reduces the impact force on the protection, but it does not make a magic difference. So don't expect clipping poor protection with a Nitro or its equivalent to suddenly make it good protection. You still have to use your judgment and climb accordingly.

Other Demos

Two other demos were set up by Lyon in response to requests from attending participants.

Two anchors linked by self-adjusting sling – one anchor designed to fail during the demonstration.

Note. The first anchor failed at around 4.3knN – this is a circled dot. (it looks like 10kN on the graph.

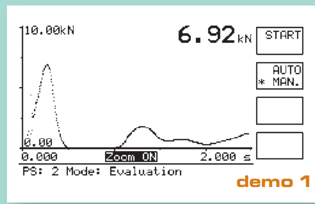
Observations

After the failure of the first anchor we can see that the second anchor experiences a higher shock load.

This test illustrates the need for anchors in a belay set up to be equalised and independent, such that in the event of a shock load on such a set up, the load is equally shared between the anchors and, in the event of one anchor failing, slack is not released into the system allowing the second anchor to be shock loaded.

It can be difficult when using a long sling to link multiple anchors together to ensure the whole rig is equalised. Improperly done, an anchor set up linked together with a long sling (as you might choose to do say when leading all the pitches on a climb) can have only a few pieces of the belay loaded, potentially having all the impact force onto a limited number of anchors hence possibly compromising them. Care needs to be taken that ALL the anchors in your belay are independently linked, equalised and that they are set up for the direction of anticipated load. It makes life easier if the anchors you place are also far enough above you.

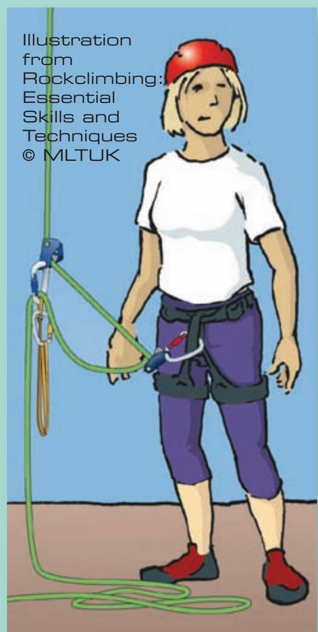
There has been talk about Dyneema slings (them again – see above!) not being strong enough to use to link multiple anchors together. Okay so you use a figure of 8 knot in the sling to isolate and equalise the anchors. So how much does that reduce the strength of the sling by? Well according to the 'CMC Rope Rescue Manual'* a figure of 8 reduces a sling or ropes strength by 20%, whilst an overhand reduces its strength by 15%. So if we assume our sling has a CE minimum strength of 22Kn (2200Kg) then that gives us a working range between 1760 and



1890Kgs. Given that any load in excess of 1600Kg will kill you, I guess we don't need to concern ourselves too much with slings snapping or breaking due to shock loads.

demo 1

Instructor self-lining on dynamic rope using set up as shown in the illustration.



The rope access dummy doubling up as our climbing 'student' had the instructor's cows tail (a 1m dynamic rope cows tail with figure 8 knots coming from the instructor's ascender) clipped into their harness belay loop. The student then climbed to a position level with the ascender and fell off.

Note: The instructor's mass was suspended on the GriGri, beneath the ascender.

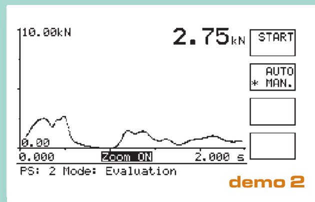
Observations

Surprisingly the ascender did not strip the sheath of the rope, which is what everyone present thought would happen. Although the rope at where the ascender was attached could have been damaged internally, and there was some indication something had happened internally, there was no visible damage to the outer sheath. It should be noted that the student fell onto the ascender and the rope above stretched. The instructor was hanging on the GriGri only.

To put this into context the length and dynamic properties of the rope above the ascender, which took the load, should be expected to make a difference to this test. If the length was extremely low, or a semistatic rope was used there would be less capacity to absorb the energy and the result might have been different ie. more serious damage to the rope.

In this situation, a dynamic rope when the student fell, made a positive difference to the impact force on anchors, rope, and student.

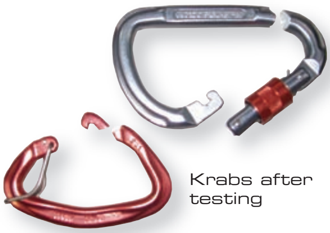
Before we all start to run and clip people to ourselves with cows tails when teaching leading. (Refer to my earlier article from June 2007 which covered teaching leading in more detail) it's worth bearing in mind that if your student is going to fall it will be more than likely unannounced, thereby giving you no time to swoop to the rescue and clip them in. Second, you have to be careful of having your student's



leading rope clipped into your self-lining rig. A leader fall onto your self-lining rope and rig could have catastrophic consequences, particularly if the self lining rope touches a sharp edge (of course you did ensure that the rope is not running over an edge or is protected...)

If you must clip your student into your rig, then clip the student's rope to ensure this effectively gives them a TOP ROPE, which is belayed by their buddy lower down on the stance. All you are doing here is giving them security whilst they, or you, place a piece of protection.

demo 2


Krabs after testing

Sources

Report on the breaking of a girth hitched sling with recommendations for useage of connected slings (online PDF) Mammut (www.mammut.ch/mammut/uploadedFiles /Full%20Report%20on%20Sherman%20Sling%20Break.pdf).

Connecting two slings together (online article) by Kolin Powick at Black Diamond (www.bdel.com/scene/beta/qc_kp_archive.php#110906).

CMC Rope Rescue Manual ISBN 0-1234567-8-9.

Destruction Testing of Equipment

These static tests involved pulling equipment apart using a portable hydraulic test rig with load cell.

Note: there is not a lot of difference when subjected to shock load.

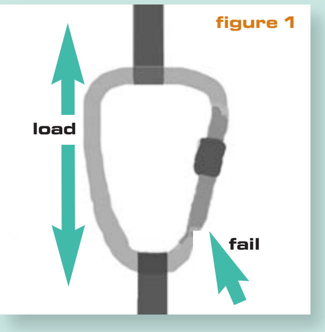

Destructive test rig

Test 4

HMS krab rated to 22Kn (gate undone. Note: in this context the gate locking system does not add any significant amount to the strength of the krab).

Loaded in line (figure 1). Failed at 2253kg (failure at gate nose).

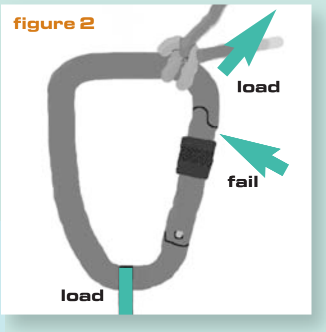
figure 1



Test 5

Same as above, except loaded slightly of line (figure 2). Note: Lyon Equipment was trying to simulate two clove hitches in an HMS with the one next to the gate being under greater tension. It's worth noting that a clove hitch has far less energy absorbing properties than a figure 8 knot. Failed at 1294Kg (failure at gate nose).

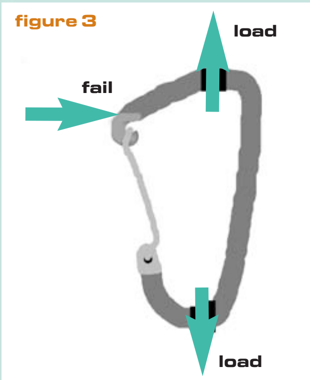
figure 2



Test 6

Wire gate snap link. Rated to 22Kn. This was a comparison/control test for test No 7. Loaded in line (see figure 3). Failed at 2351Kg (failure at gate nose).

figure 3



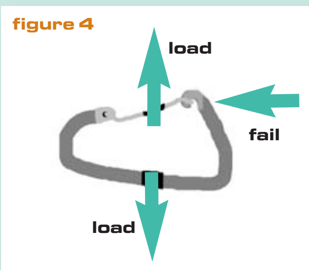
Test 7

Same type krab. Cross loaded (see figure 4). Failed at 896Kg (failure at gate nose).

Note: this test was very difficult to set up as the krab refused to stay in that position whilst being loaded. Eventually it had to be persuaded to stay in place with an elastic band.

In reality it's very easy to cross-load in a dynamic situation due to rotation of krabs in rebound.

figure 4



Summary

There is a great deal of info contained in this article. Attempting to summarise it all runs the risk of over simplifying it to the point where the information is meaningless. What I think it highlights is that if gear is used correctly and as the manufacturer intended then it'll do the job intended. As you would expect.

Where it starts to potentially unravel is when we as climbers and mountaineers encounter the weird, wonderful and peculiar in the course of our adventures and in the process of dealing with that situation create a use for some equipment that the manufacturer neither foresaw nor intended. In these situations we need to rely both on our experience, and judgement borne from that experience, to best decide how to deal with it. By using sound principles, like equalising anchors, keeping anchors independent, reducing the amount of slack in the system and anticipating where the potential impact force will come from, we are in a better position to avoid the 'Oh, never thought that would happen' exclamation as we hurtle to do our doom and become the next source of internet speculation. Posthumously.

So I'll run the risk of over simplifying this! What key points can we take from all the above?

- Figure of 8 knots are very good at absorbing energy in the event of an impact force.
- Slings are not as stretchy as rope (Errmmm bet you never knew that...) thus very high impact forces can be generated if they are the only means of fall arrest (approx double that compared to a climbing rope).
- When connected to anchors with a sling as a cows tail avoid any situation where you could take a short fall onto the rig as this generates very high impact forces which can cause anchor failure. Stay tight on your anchors at all times.
- Used appropriately, Dyneema slings are just as strong as ordinary nylon slings.
- Treat joining slings together with girth hitches (Larks Foot or Head) with a great deal of caution as this reduces the strength of the sling by 50% or more. It is better to use a longer sling or join them with a karabiner.
- Due to rope stretch and other factors the amount of 'give' in the system is greater than you think. Roughly about three to four times what you think. So if your feet are level with a runner and you fall off you can expect to fall at least four metres.
- Using load limiters on protection reduces the impact force but does not suddenly make poor protection good.
- When a self equalising belay fails, it creates a massive shock load on the other anchor. Better to use a rig that is equalised in the direction of anticipated load.
- Cross loaded karabiners have their strength reduced by nearly 70% ie. a karabiner that fails at 2351Kg when correctly loaded will fail at 896Kg when cross loaded.

I should stress that all the above information is my interpretation of other people's tests. I've given all the data and sources so you can follow up and do your own investigations. To the best of my knowledge and understanding the information presented here is correct, but ultimately you should use your own common sense and judgement to make your own decisions when on the mountains, crags and ice falls.

Acknowledgments

Many thanks to Roger Chaldecott who organised the Lyon Equipment Testing event, and to Ben Lyon and Lyon Equipment for arranging the day. Additional thanks to Roger and all the test staff at Lyon Equipment for feedback on earlier drafts of the original article.

All the graphs illustrating the various tests were reproduced from the CD provided by Lyon Equipment.

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Test Images 23 and 24 by Nigel Williams

Other diagrams and images by George McEwan.