COOL PROTECTION FOR COLD CLIMBS

An appreciation of current thinking about ice protection, its uses and limitations

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If your only use for ice is, as Tom Patey once said, ' pouring whiskey on…' then this article will be of little interest. If on the other hand you are one of those poor souls for whom ice means the screaming hot aches and extended periods of trouser filling terror then read on!

Ice climbing has become incredibly popular in the past ten years or so. With winter climbing conditions in the UK becoming even more fickle, the advent of cheap flights, improved equipment and the popularity of venues such as Rjukan and Cogne, more and more UK based climbers are starting to head off during the winter for a steep ice fix. It is thus more than likely that we as mountaineering instructors will come into contact with students/clients who will be planning their own trips away and are looking at some technical input to prepare them for their trip.

This article brings together the results of various tests, current thoughts about ice screw protection and their practical implications for us, as climbers. Some of the information being presented here is not new (some of the tests discussed were done over ten years ago) but it does appear there is still some confusion as to what is what with ice protection.

For you sceptics that don't think ice protection is all that reliable on Scottish ice, or any ice for that matter, take a look at Figure 1. It shows a DMM Snarg I placed on the ice climb 'Big De'il' over on Hell's Lum many moons ago. Fifteen feet


Figure 1

or so past this I cut loose from the ice, not intentionally I should add, and fell over thirty feet onto this, my sole piece of protection, which was clipped with a DMM Screamer. This Screamer fully ripped which luckily allowed the other screamer to come to a shaken, but otherwise unharmed, stop. As you can see the Snarg is slightly bent but that was due to the ice around the placement crushing and fracturing. Still the Snarg did it's job holding a fairly substantial fall. So without further ado here we go – all you need to know about cool protection for cold climbs.

Ice Screw Protection

Back in the late 90s, several groups independently did some testing on ice screws to examine whether conventional wisdom at the time was right and whether ice-climbing protection could be improved. The groups involved were Black Diamond (who did static lab tests using ice cells – steel buckets filled with tap water which is then frozen), engineers from REI (who tested in glacier ice), Craig Luebben and Chris Harmston (who used ice falls at Ouray and Boulder). It was noted that the trends found during the lab testing were similar to those found in the highly variable conditions found on the outdoor ice. What the tests confirmed, and it is perhaps a bit of a no-brainer, that ice protection is only as good as the ice it is placed in. So poor ice equates with questionable protection, whilst good ice equates with, well good protection. However, the tests did challenge some accepted views about ice protection particularly as to how we place ice screws.

Does length matter?

As in life – yes it does. I guess if we had a choice between placing a short ice screw or going for a longer one we would all intuitively opt for the long one (provided we could hang around long enough to place the thing). The Black Diamond tests did confirm that in dense solid ice this intuitive approach was correct. For example, a 22cm tested had a high failure strength of 41.04kN and a low of 12.5kN, compared to a 17cm screw, which had a high of 37.1kN and a low of 8.8kN.

These results should then be viewed in the light of reality. Assuming the ice is thick enough, and good enough to take a long ice screw then yes, the placement should be stronger with the longer ice screw. However, in good ice shorter screws might well hold just as well for what really counts is the number and depth of threads on the ice screw (see the comments about angle of placement). Also shorter ice screws are quicker to place. Longer ice screws when placed are more likely to penetrate any rotten or soft layers and bite into the good ice underneath, although ideally you should take time to clear the rubbish on top to expose the good ice. In actuality longer ice screws take longer to place. This is OK is you are standing on a wee ledge nice and comfy, but perhaps not so good if you are hanging off a flaming left arm. Other factors might be – is this the only good piece you might get for while? If it is it might be worth taking the time to set a good piece of pro before launching out. The same holds true if just setting out from the belay. The less rope out the higher the potential impact forces. Thus it makes sense to place the strongest protection when close to the belay.

Angle of Placement?

For many years accepted wisdom was ice screws were placed at a 10 to 15 degree angle against the direction of pull – this approach relied on the mechanical strength of the tube of the ice screw to withstand the impact force of a load eg. a falling ice climber. To verify whether this approach was valid, Black Diamond tested screws placed at a variety of angles and came up with some interesting results.

In the tests, perpendicular was chosen as the reference point (and is labelled as 0 (in the illustrations). Figure 2 shows an ice screw placed at the conventional 10–15 degrees against the angle of pull, which BD termed a negative angle. Black Diamond then changed the angle and placed the screws in the direction of load, termed a positive angle, as shown in Figure 3. Their results demonstrated that placing an ice screw in the direction of loading significantly increased it's holding power. These findings were also backed up by Craig Leubben's testing at Ouray Ice Park in 1996.

Now a word of caution. It should be noted (and stated by BD) that the results of the tests conducted by BD only hold true for – 'Black Diamond Tubular Ice Screws. In other words, for these results to

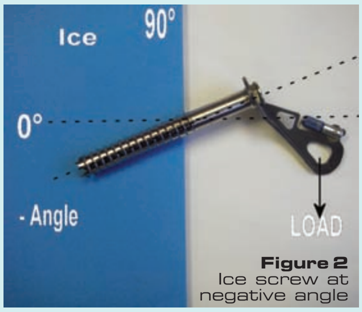


Figure 2 Ice screw at negative angle

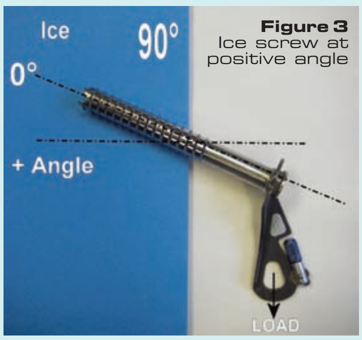


Figure 3 Ice screw at positive angle

ROBERT CLOTHIER CUTTING LOOSE ON A KANDERSTEG W15
Photo: George McEwan

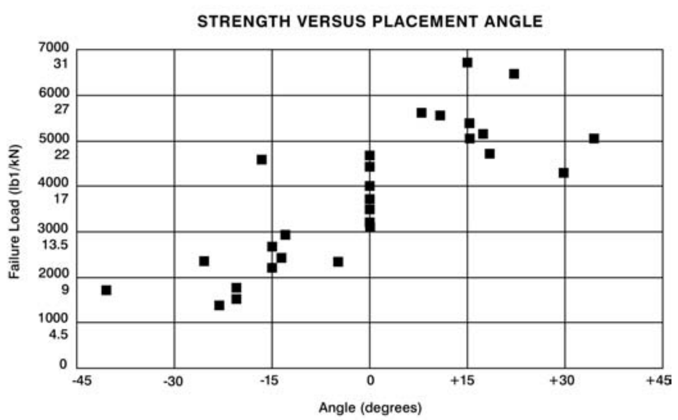


Figure 4
Black Diamond Test results

hold true the screw must have well-spaced, external, high relief threads that resists pullout.'*

Craig Luebben in his testing used a variety of proprietary makes, including BD screws, available at the time. Luebben also came up with similar findings to Black Diamond, with the screws he placed with the direction of load in good ice failing at loads of around 31kN, he also found that the same screws all failed at very low loads when placed in poor ice. One of the points he also made (as he tested a variety of manufacturer's ice screws) was what really mattered was the quality of ice rather than the brand of screw. Of course, some screws are easier than others to place so it makes sense to buy ice screws that are easy to place thus ensuring you are more likely to place them in the first place.

Many modern ice screws are similar to the design of Black Diamond ice screws ie. well-spaced, external high relief threads, and all ice screws on sale in the EU should have the appropriate CE mark (which echoes the UIAA standard that requires ice screws placed in artificial glacier ice to withstand a dynamic load of 15kN).

So I think it is not unreasonable to assume that screws of a design similar to that described by Black Diamond should behave in a similar way to that found in their tests.

Figure 4 is taken from the original Black Diamond test report and shows the spread of failure load versus the placement angle. The results that Craig Luebben arrived at in his testing were broadly similar in that screws were stronger when placed at a positive angle of 0 to 20 degrees in good ice i.e. the screw was placed perpendicular to or with the direction of loading. Both sets of test found that if screws were placed at a negative angle i.e. placed against the load, then the screws failed at significantly lower loads. This was due to the fact that a tube when loaded across it's axis is not a strong structure. When an ice screw is placed at a negative angle in the ice then the load can cause the ice around the head of the screw to crush, causing the ice screw to bend and then either pull out or fail.

Nice Ice Baby?

So does this mean that screws should always be placed at a positive angle ie. with the direction of loading? Well, not always. The findings in this case only hold true for screws with well-spaced external high relief threads in good ice. Of course this begs the question what is good ice? Figure 5 (overleaf) lists some of the qualities associated with good ice. Conversely the same tests found that in poor ice it was more advantageous to place the screw at a negative angle, thus relying on the hooking/lever resistance ability of the screw rather than the holding power of the threads.

As the strength of ice can vary hugely – with factors such as the temperature, density, crystal structure, type of placement and thickness all having a crucial influence – the onus is still on each individual climber to assess the quality of the ice and then decide what type of placement and length of screw offers the best protection options.

Looking at the current Black Diamond literature they recommend 'for the majority of ice conditions the tube should be placed perpendicular to the ice surface with the hanger flush to the ice.' (see Figure 6) I have found that in reality

MIKE B PLACING ICE SCREW
Photo: George McEwan

when placing an ice screw whilst leading on steep ice, it is far easier to place an ice screw at this angle. Given the test results we have seen you will still get a reasonable holding strength. I guess that this approach requires climbers to make less of a call about whether they should place the screw at a positive or negative angle. Placing an ice screw perpendicular to the ice 'averages' out the potential holding strength of the screw. Obviously though what the ice screw will hold depends on the, you've guessed it, the quality of the ice. As I said at the start ice protection is only as strong as the ice you place it in.

Tying Off Ice Screws

All the above tests deal with ice screws that are well placed in good ice with the hanger flush with the ice surface, regardless of the angle. What happened when the screw hanger was proud of the ice surface? For example what about tied off ice screws, or screws that had the hanger clipped despite being proud of the ice surface?

Both Luebben and Black Diamond tested screws that were tied off, and those that despite being proud of the ice had the hanger clipped. For tied-off ice screws, the mechanism of failure was typically the screw bent at the sling, the sling then slid down the bent tube to the hanger, was cut on the hanger, and breaks. This failure range (where the sling cuts on the hanger of the screw) in the Black Diamond tests was around 8.9 to 15.6kN. Testing suggested that Spectra slings were stronger in this situation compared to nylon. Although this range means that these tied off placements would probably have held your average 'lob' it would be possible in a fall involving a high impact force e.g. Fall factor 2 for the tied off ice screw to fail.

From the research I've done it should be noted that the jury is still out on this one as far as I can see, as it appears the data collected is rather limited. More testing is being done but at the time of writing this (January 2007) I couldn't find any more up to date info.

So what does this mean to the ice climber? Both Black Diamond and Craig Luebben state that if the screw is proud of the ice surface by less than 5cm then clip the hanger (Figure 7). More than 5cm, then you have a choice either remove the screw and place another, shorter screw that can be placed up to the hilt OR tie-off with a sling, accepting the fact that your piece of protection might not be as strong (Figure 8).

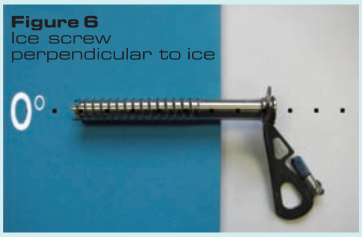


Figure 6
Ice screw perpendicular to ice

Other Types of Ice Protection

Placing ice screws is only part of the protection options open to the ice climber. Other options, which involve gear, are Drive-ins (commonly called Snargs although this was/is a trade name) and Ice Hooks. Natural anchors such as slinging the base of an icicle, using a natural ice thread etc and their relative strengths are outwith the scope of this piece in terms of how strong they are. Suffice to say they can be 100% bomber or as much use as a chocolate teapot – you decide based on the situation. Abalakovs which are threads made by creating an inverted 'V' shaped tunnel using two long ice screws are, in good ice, very strong. Over in the States and North America they've done tests*** that produced failure strengths of 1000kg (in 'plastic' ice), through to 1400kg (in cold brittle ice). Strong enough for even pie eating ice climbers to cut loose with a sense of security.

Figure 5 What is good ice?

Here is a very subjective list of qualities that tell me when ice is good – I'm looking to tick all the boxes here to ensure I have a good screw placement

Colour

Clear, blue, or green in colour.

Appearance

Thick and solid ie. NOT detached, aerated, chandeliered, slushy or cauliflowered.

Dense ice with little shattering (dinner plates) when picks are placed.

Effort

Ice screw is hard to place i.e. you need the mechanical advantage of the lever arm to turn it in.

As the screw is placed you should feel consistency of resistance.

Ice Hooks

Ice hooks are not a new idea. Their development can be traced back to the early seventies when expat Scots climbers Bugs McKeith and Dick Howe were creating similar shapes out of stainless steel plate to protect the thin verglassy ice of 'Nemesis' on Stanley Peak. It's thought the shape and design were influenced by the McInnes Terror-dactyl axe. McKeith and Howe named their creations '7-Ups'.

Although ice hooks were originally designed to protect thin ice climbs, the name is perhaps a misnomer as they are used more extensively on 'turfy' mixed climbs, or pounded into thin cracks (much like a piton).

I've not seen any test done on how these things perform in turf or rock placements but I have seen tests done on them placed in ice. Unfortunately these test results give ice hooks a less than glowing report with them being able to hold, at best a small lob. Typically ice hooks, on average, fail at loads as low as 2.7kN and as high as 6.2kN**. The bottom line is that due to the nature of their design and style of placement in ice their ability to hold falls is at best, variable. It is also worth noting that ice hooks are not PPE rated and therefore do not have any CEN certification.

Ice hooks are not designed, nor intended, to hold large forces such as leader falls (although I have heard of one Canadian climber that reported a half placed hook that held a twenty foot leader fall). They are designed more for the situation where any 'normal' ice protection is not viable (due to the quality of the ice, and/or it's thickness and ease of placement), and some sketchy unreliable protection is better than nothing. If you're looking for ice protection that will hold then an ice screw is your best choice. Ice screws come in a variety of lengths now, so by carrying a selection from say 13/14cm to 22cm, you should be able to place a screw that at least gives a better chance of holding a fall. Where I have found ice hooks useful on ice climbs is as a temporary piece, which can be quickly placed in an existing ice pick slot, buying you time to sort out something better.

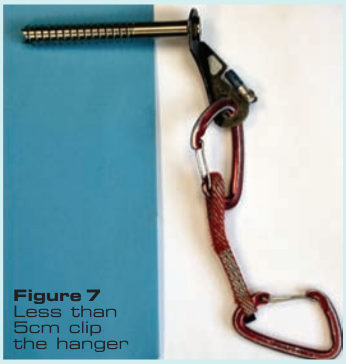


Figure 7
Less than 5cm clip the hanger

Figure 8
More than 5cm you can tie it off, but it may be better to replace with shorter screw

To get the best from an ice hook placement you do need to pay careful attention to how it's placed. First off you create a shallow starter slot for the hook to fit into. This is done by placing your axe pick or using an existing axe pick slot - take care that the ice around the placement/starting slot is not fractured as this may compromise

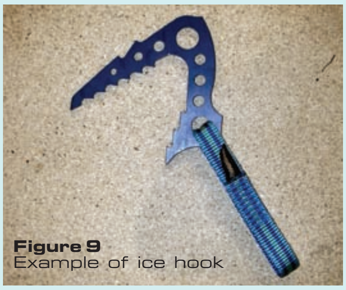


Figure 9
Example of ice hook

the placement. Then fit the hook into the slot and gently tap the hook home into the ice, that's tap not blooter! After it's placed clip an extender to the sling or base of the hook. This reduces any leverage on the hook so you are less likely to lift it out as you move past. Finally treat this as you would the smallest of micro wires i.e. it looks like pro, feels like pro but don't fall off onto it and expect miracles.

Drive-ins (Snargs)

Drive-ins or 'Snargs' are drive in/hack out protection. For a while back before ice screws became easier to place one handed, they were the only piece of ice protection that could be placed one handed by the leaded on steep ice. Although they have been superseded by more modern screw designs they still have niche in the ice climber's protection options box. They can be placed above your head which is one advantage or into small spaces where placing an ice screw might not be possible. Do mind that your poor second will need to be able to get at the thing to remove it...

In terms of placement you place them at a negative angle i e. angled up and away from the direction of load (Figure 10). To do this you will need to create a starting hole (you can either use and exiting pick placement), place the drive-in into the slot then hammer it home. Because these drive-ins do not have as pronounced threads as ice screws you are relying primarily on the strength of the metal tube and the integrity of the ice to provide the strength. As I mentioned at the start of this article though, I have fallen successfully onto a well-placed DMM Snag, so it proves they work! If you are wondering why you can't place drive-ins at a positive angle ie. in the direction of pull, it's because the threads on the drive-ins are very

Figure 10
Snarg placed at negative angle

shallow, so will offer very little resistance to being pulled out.

Placing Ice Screws

So as we have seen we can make the best of the available ice protection options by using careful and appropriate placement. There are several other options we can use that may extend the ability of our protection to hold falls. When placing ice screws make sure you clear away all the surface crud. By making use of a previous axe placement you not only have a starting hole, but the crap ice has been cleared in the process of making the placement. At this point you will have an idea as to how good the ice is, and can then decide at what angle to place the screw to optimise its potential holding strength. I'm not going to go into the detail of placing ice screws on the lead, but just to remind you, if you need reminding, that placing ice screws on steep ice can be strenuous even if you are using the latest shiny, sharp screws. To make this process as efficient as possible, you do need to ensure you, or your students have a system sorted for placing screws. Having screws racked up on a clipper system, being able to free a hand from your ice tools etc all make this process faster – the more efficient it is to stop and place pro, the more likely you are to do just that; the more pro you place the greater the likelihood you'll have gear that can hold a fall.

Using Load limiters or 'Screamers'

When the screw has been placed you can then extend the screw by using a shock absorbing extender (called a 'Screamer'). These load limiter extenders are designed to reduce the shock load on a screw by absorbing some of the energy of an impact force. Essentially load limiters are a length of tape with an eye at end (for clipping) which is then folded over itself and the folds held together by stitching. In the event of a high enough impact force the stitching is designed to consecutively fail. The theory being that the stitching failing helps absorb some of the energy of the impact force. Figure 11 illustrates what happens when the load limiter is subjected to a high impact force.

Different types of load limiter absorb different amounts of energy depending on how much webbing has been doubled over and stitched. For example the Charlet Moser 'Nitro' range has sacrificial stitching that is designed to fail at loads of 2.5kN. 'Nitros' are available in three lengths with the shortest having the most stitching and therefore the potential ability to absorb the most energy.

Be warned though – these bits of kit are not miracle cures. Poor protection is still poor protection and just because it is clipped with a load limiter will not necessarily make a huge amount of difference to its ability to hold a large impact force. Used sensibly, load limiters can decrease the impact force on an ice screw eg. the Nitro 3 produced by Charlet Moser can reduce the impact force by up to 50%.

Stretchy ropes and dynamic belays

You can also reduce impact forces on your ice protection by using ropes that are designed to allow low impact forces on anchors/runners. Many manufacturers now produce skinny double ropes that designed to do just that. Also using a belay device that allows some element of dynamic belaying would also help, but you do have to take care here with using skinny ropes and belay plates or you might just find you have a bit too much dynamism in the system. Of course, arresting falls dynamically, whether you are using rope stretch, or dynamic belaying or all of the above does come at a price – the climber ends up falling for longer. This does increase the risk of hitting, or landing on something on the way down and the consequent risk of injury. At least there is a better chance the gear might hold though!

Conclusions

So what does this all mean for us as ice climbers? As we have seen well placed ice protection is able to do the job we would like it to do ie. hold a big whipper, there are still two inescapable facts. The first is that protection is only as good as the ice we place it in. The second,

Charlet Moser 'Nitro'

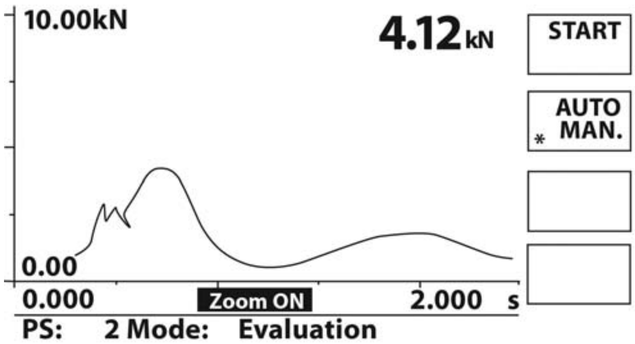
even if the ice screw is 'bomber' just remember that half of your equipment is metal and very sharp, whilst the other half is all flimsy material covering your squishy body. So even if the ice screw holds the fall, you will be very lucky to escape injury. Common injuries after falls are boot top fractures caused by the climbers crampon shod boots catching on an edge during the fall snapping the ankle just above the boot. Nasty! So despite all the advances in ice climbing equipment and protection we still share one thing with the pioneers of old – your key protection is good axe placements, a steady head, and the leader must not fall.

Summary and Conclusions

- ALL ice protection is only as good as the ice you place it in.
- Before placing ice protection, ensure you clear away any surface crud/poorer quality ice.
- Good ice is ice that is blue/green, dense, and homogenous.
- Place ice screws in the direction of loading only if the ice is good. If the ice is poor angle the screws against the direction of loading. If

Figure 11
Falling climber test using load limiter extender

The test was set-up using10m of Beal 10.5mm rope was anchored to a GriGri on the ground, and ran up through two runners in a zig-zag, and attached to an 80Kg dummy (used in rope access training to represent a casualty) with a fig. 8 knot into the harness. The top runner had a Charlet Moser Nitro 1 (20cm) clipped to it. There was a small amount of slack in front of the GriGri.
The Nitro 1 (20cm) deployed at 2.5kN and when fully deployed acted as a sling, thereafter the force increased to 4.12kN. This was compared to a peak force of 5.12kN with an earlier test which had no Nitro clipped to the top runner, a reduction of around 19%. This is around what Charlet state in the technical literature (they say a reduction between 15 and 25%).



Taken from 'Report on Sorts Technical Equipment Forum held at Lyon Equipment, March 2005' by George McEwan.

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you are not sure what the quality of the ice is place em perpendicular to the ice!

• Place longer ice screws (22cm) on belays and early on in the pitch.

• If a screw is proud of the ice by less than 5cm clip the hanger. If more than 5cm then you get a more reliable placement by removing it and placing a shorter ice screw.

* Ice hooks are, at best, unreliable.

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