# Belays on snow

**by Gottlieb Braun-Elwert**

Snow stakes are a Kiwi invention and have been around since the early 1970s. It is a piece of aluminium alloy profile with a tape attached to the top end. Mostly the V profile has been used, occasionally the U profile. As mountaineers always look for gear that serves more than one purpose the snow stake comes in handy. It served me well when digging out the dirt under a bivy rock in the Betham Valley when our tents got blown down – that was before the arrival of the now no longer existing Betham Hut – and then served as a gutter to channel the drips away from my sleeping bag. The snow stake was particularly welcome to save our ice axes from being hammered into the frozen snow; the ice axes didn't particularly like it, to say the least, nor did their owners.

Basic belays on snow have been neglected badly over the years in manuals and by equipment manufacturers. May be this has been a result of the perception that when you travel on snow you are not on technical ground, as the going is easy and quick. Yet, many tragic accidents have happened exactly on that terrain. In the 1960s the "deadman" anchor came into being, also referred to as the "T-slot", where an ice axe with a tape attached to it is buried horizontally in the snow at right angles to the direction of the pull. This is a laborious method as it involves quite a bit of digging to place the anchor and to get it out again. Not my favorite option when tired and under pressure of time. 4WD enthusiasts have used this method for a long time: Dig a hole, bury the spare wheel with a cable attached to it, and winch yourself out of the mud. If in need a climber can also bury his pack to place an anchor for a crevasse rescue, or fill a stuff bag with snow to use as a tent peg.

We often see climbers just sitting in the snow and belaying off their waist, with a snow stake behind them as a back-up anchor. What they are really doing is acting as a "deadman" themselves, literally turning into one when things go wrong. The well publicised "Touching the Void" drama in the Andes is a good example for this. I avoid belaying off my body like the plague, it does nothing for holding power, one gets easily caught in the middle and then needs to "escape from the system". When the expected pull is downhill I always belay off the anchor. If we place a decent anchor in the first place and belay off the anchor we can avoid a lot of trouble.

Following a number of accidents in the early 1980s involving the failure of snow anchors I had a discussion with a Swiss colleague of mine on how to improve belays on snow. The outcome of this discussion and extensive testing during the 1984/85 summer resulted in a paper published in the CMC News June 1985. The paper is available online at

http://www.alpinerecreation.com/Snow%20Belays%201985.pdf

The guts of the paper describes really just a small change to the good old snow stake, a combination of what has been around in other areas and a bit of Kiwi ingenuity: Attach a cable midway to the snow stake and place it upright, not horizontally. An amazingly efficient and strong snow anchor was borne. Shortly afterwards it became available commercially as the "Snow Pig". I have used it ever since on all my major ascents. In 1985 I based my statements on basic physics and comparative trials, but was not able to back them up with hard figures. I am grateful to the Department of Conservation for having come up with these figures now. Don Bogie, the technical advisor for DOC, spent a great deal in the field over the 2004/2005 summer destroying aluminium profiles, measuring the exact forces that snow stakes are able to hold in various types of snow and in different types of placement. His paper is available at

http://www.mountainsafety.org.nz/assets/images/Snow%20Anchors0705.pdf

**Holding power**. Two factors influence the holding power of a snow stake, the structural strength of the profile and the snow strength under shear or compression stress. Since the latter depends on the surface area of the snow stake in the direction of the pull, it makes sense to go for wider profiles. The standard 5cm x 5cm V-profile used in New Zealand works out to be effectively 7.1cm wide. This is considerably wider than the T profiles used in the United States, marketed by MSR as "snow pickets" that have a width of 5cm. No comparative figures are as yet available regarding the structural strength of T versus V profile.

As explained in my paper in 1985 it is obvious that a mid-clip attachment of a snow stake yields a far higher holding power than a top-clip attachment. Fig 1 & 2. This is supported by Bogie.

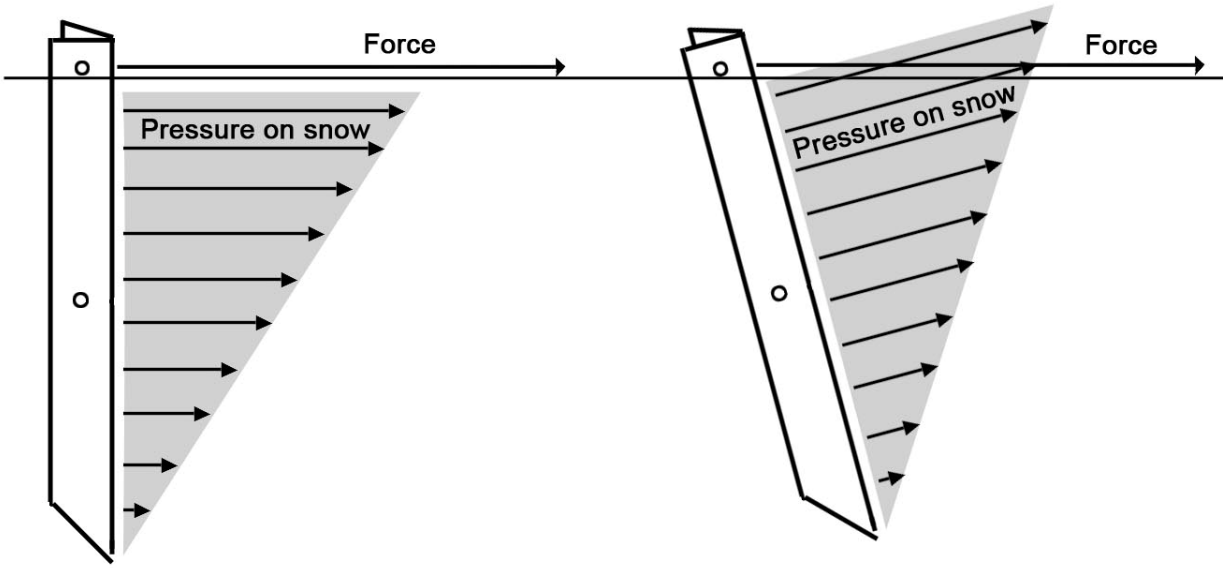


Fig 1. Top-clip attachment puts highest stress on snow where it is weakest

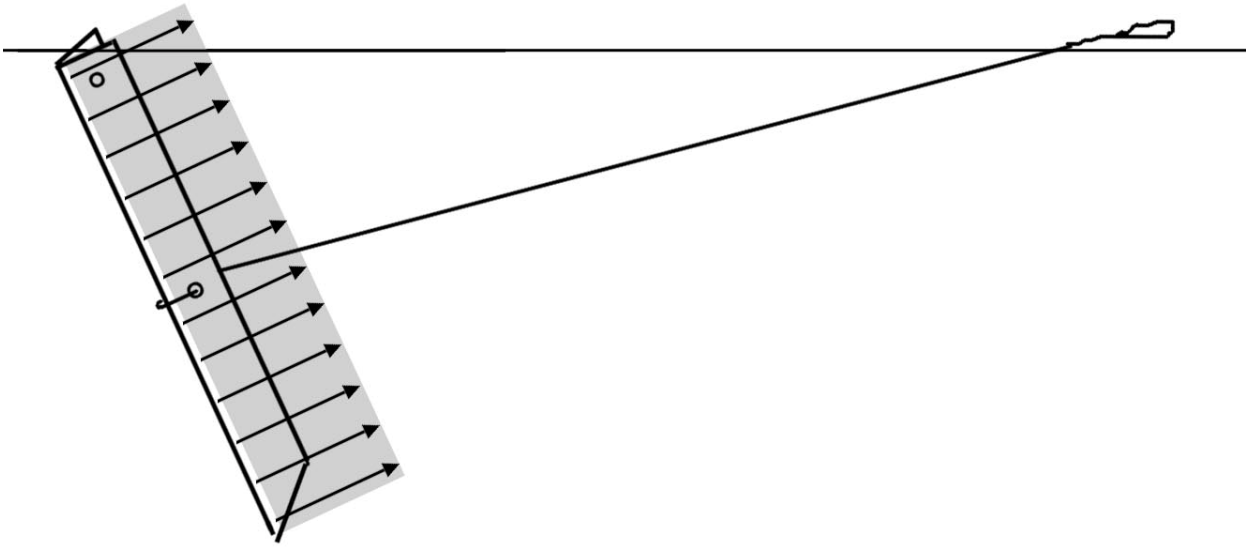

Fig 2. Mid-clip attachment, upright placement, distributes pressure evenly

However, what has come as a complete surprise in his report is that the mid-clip attachment upright placement outperforms the mid-clip, horizontal placement (T-slot), unless the T-slot is placed as deep as the tip of the snow stake in upright placement. This is good news, since it takes a fraction of the effort and time to place an upright snow stake compared to digging a T-slot!

It should also be noted that the V-profile is structurally stronger in inverted V position towards the load in mid-clip application, whereas it is strongest in V position towards the load in top-clip application.

Large holes drilled into the stake for the purpose of weight reduction considerably weaken its structural strength. Hence only one set of small diameter holes should be drilled to accommodate the mid-clip cable attachment.

**Angle of placement**. As Bogie's report shows the depth reached with a mid-clip vertical placement of the snow stake is of great importance. Hence the angle of placement is critical.

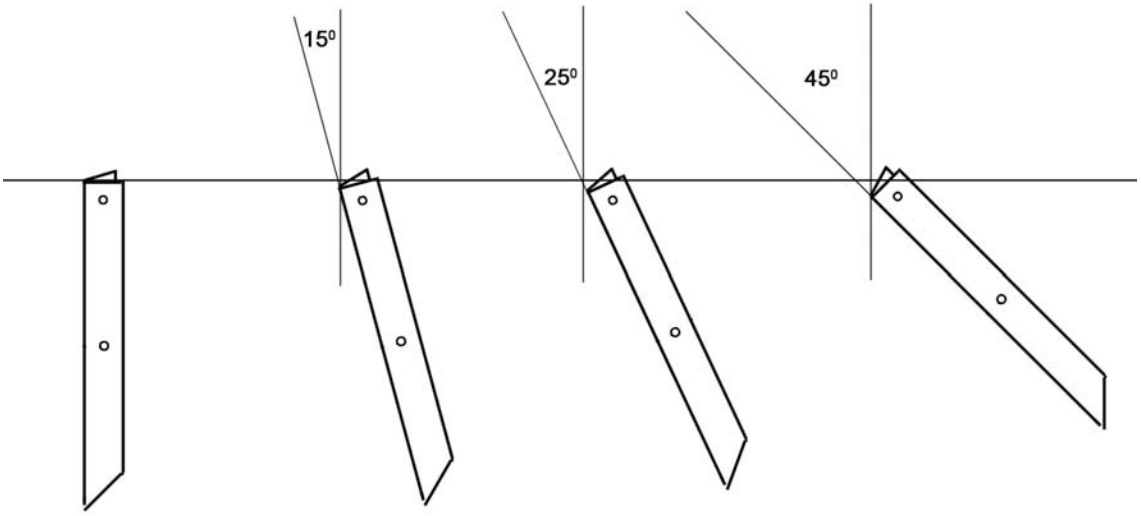


Fig 3. The depth of the snow stake depends on the angle it is placed against the vertical.

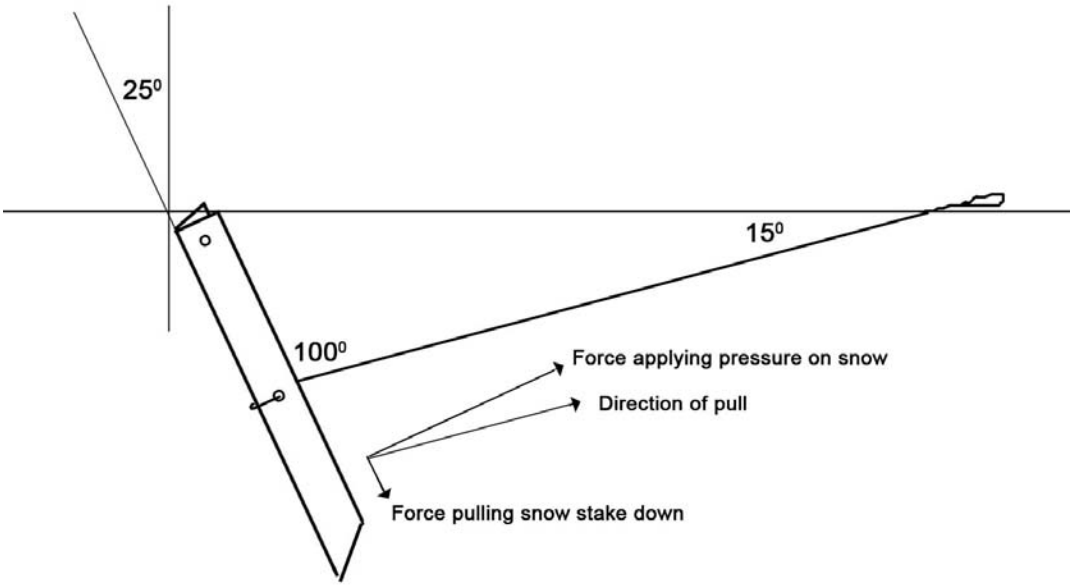


Fig 4. At $25^0$ the depth of the stake is not affected much. With a cable twice the length of the snow stake the attachment angle is greater than $90^0$. This provides a resulting downward force. This is the best angle of placement.

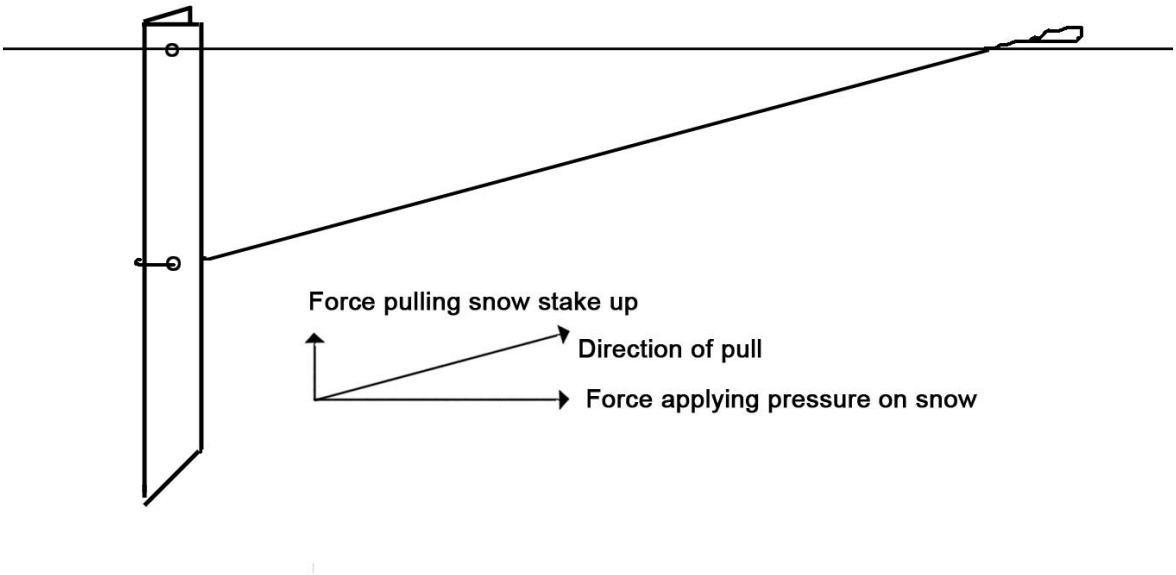


Fig 5. Placed vertically, the snow stake gets pulled out.

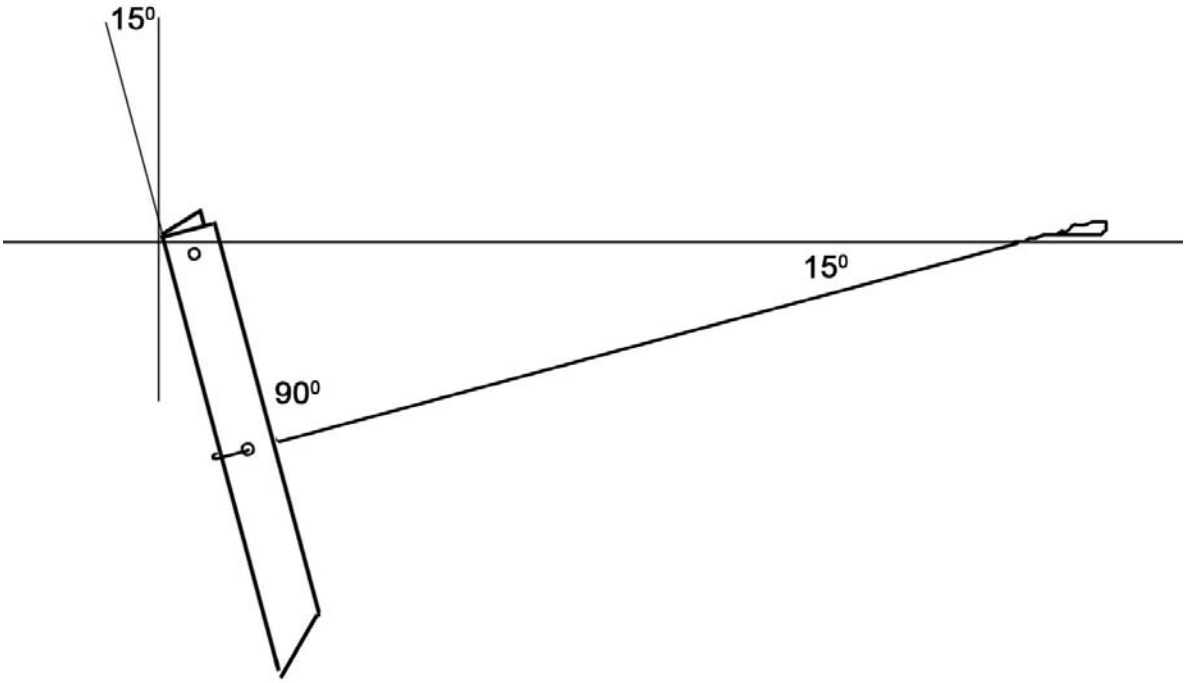


Fig 6. Placed at $15^0$ , and with a cable twice the length of the snow stake, the attachment angle is $90^0$. While this is the strongest position in theory it gives little margin for error.

When placed at $45^0$ the resulting depth is considerably lessened. The snow stake may dive under load, like a plough. However, one needs to consider that often in New Zealand we find ice layers alternating with softer snow. If a diving snow stake starts to move along such an ice layer the stake would be leveled, resulting in failure of the anchor.

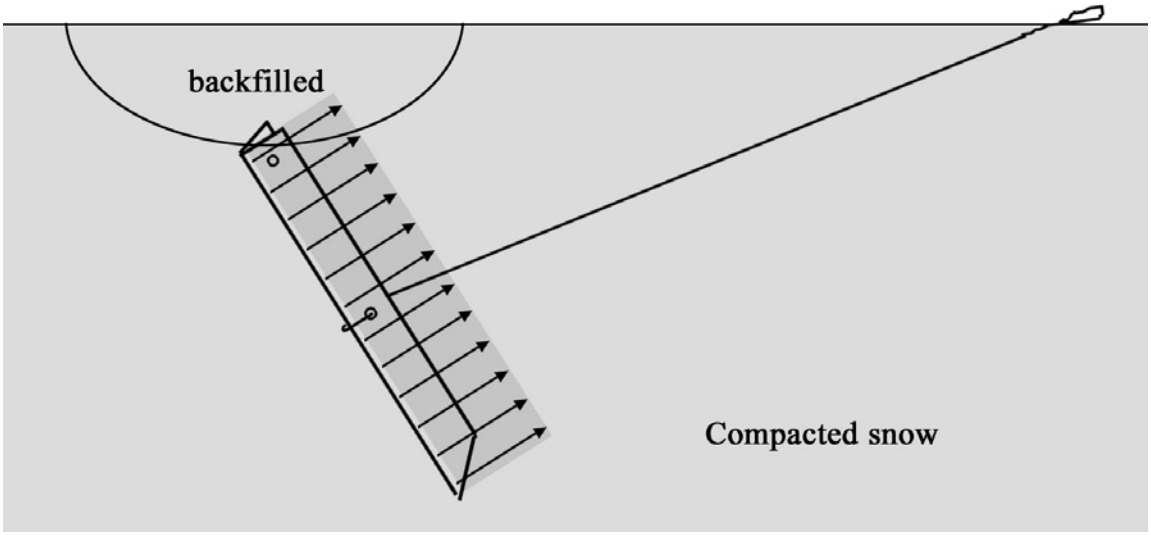


Fig 7. The resulting depth of the snow stake can be increased by punching / digging a hole into the snow, before placing the snow stake and back-filling it.

**Practical tips**

1. If possible, always compact the snow down first with your feet before placing the mid-clip upright snow stake.
2. Push the stake into the snow at $25^0$ against the perpendicular.
3. Simply pull the cable tight, placing a carabiner in the loop and pull hard. In soft snow the cable simply cuts through it. It will not work with a tape or prusik.
4. If necessary cut a thin grove for the cable with the pick of your axe.
5. Compact the snow again.
6. When on a slope, stomp down a step and place the snow stake as illustrated in Fig 8.
7. When pulling the cable tight allow for the fact that the cable will always run through the snow in a curve, Fig 9.
8. When the snow stake needs to be hammered in, it is advisable to use the mid-clip attachment and cut a grove for the cable with the ice axe. Even when only partially driven in it is still stronger than the top clip.
9. Always step well below the anchor and belay with a dynamic belay, e.g. Italian Hitch.

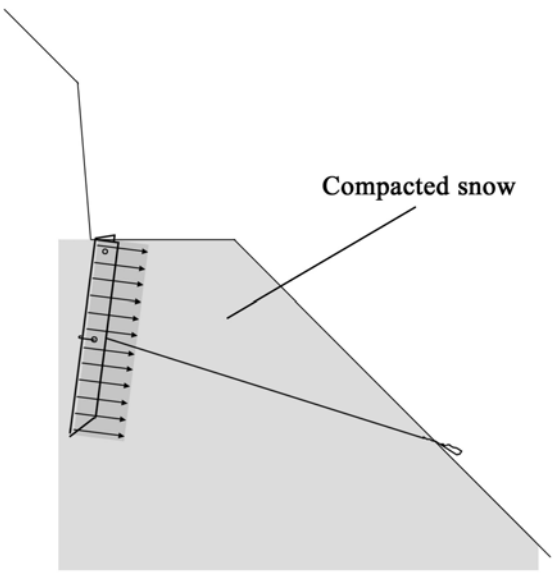


Fig 8.

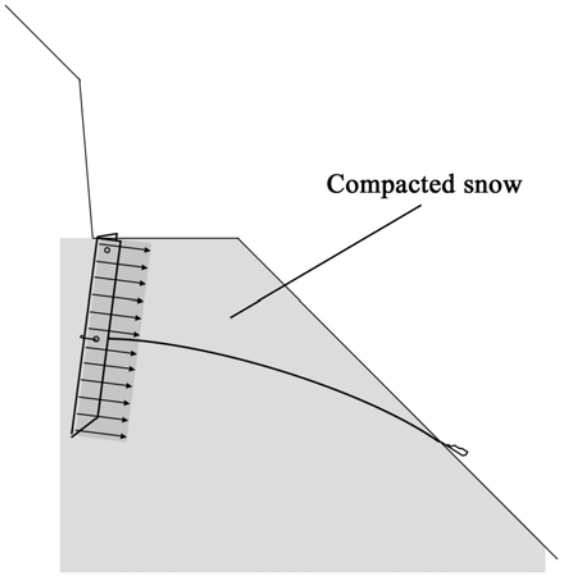


Fig 9.

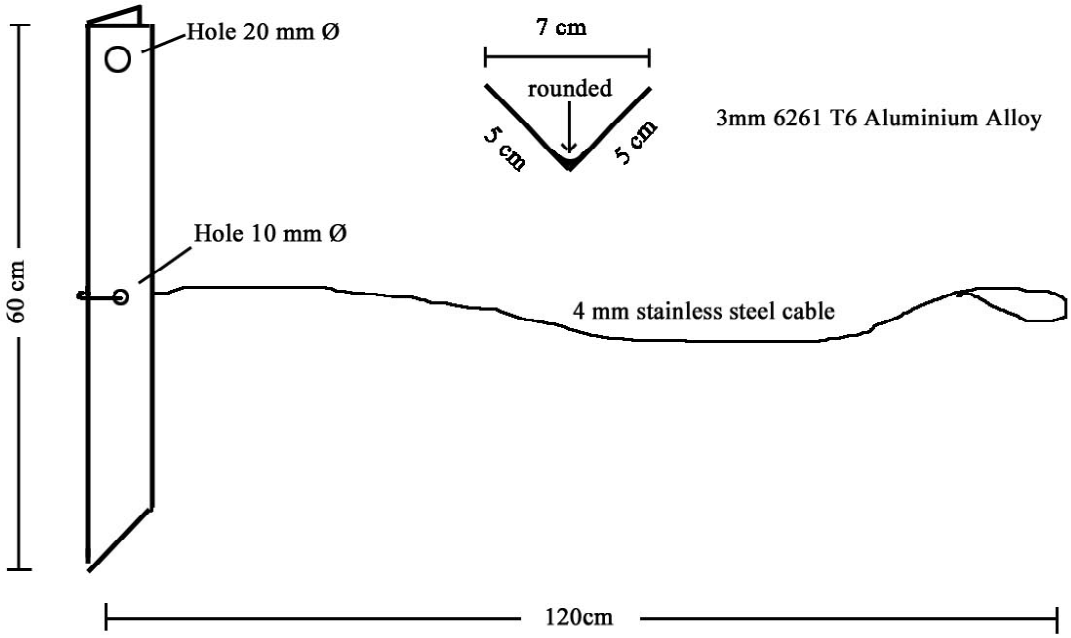


Fig 10. Recommended dimensions

Ensure correct alloy. The top hole should be large enough to hold a carabiner clipped through both sides of the stake. Round the edges of the hole. Alternatively a 8mm Kevlar / Spectra could be tied through. The mid-clip cable is permanently attached to the stake. The 4mm flexible stainless steel cable needs to have two loops that are swaged. The total length of the cable needs to be 120cm.

The mid-clip cable attachment of the snow stake provides not only greater holding power of the snow stake, it also streamlines its placement enormously compared to the traditional T-slot.

While improved equipment and belay methods contribute to climbers' safety in the mountains, please remember that the key to safe mountain travel will always remain secure footing and good judgment in route selection. There is no substitute for it.

Safe and enjoyable climbing!

Further reading on snow anchors, in particular the standing axe belay is available in my above mentioned paper published 1985.

Acknowledgments:
Thomas Wüschner, Switzerland, 1984
Don Bogie, Department of Conservation, 2005