



NVE

Norwegian Water Resources
and Energy Directorate

Glacier safety – method guide



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Purpose of the method guide

Working on and around glaciers present numerous hazards - crevasses, sudden glacier floods, harsh weather, and ice avalanches to name a few. It is therefore essential that all those conducting fieldwork on glaciers have sufficient knowledge and equipment when in the field.

This method guide is an English translation of a glacier safety description that is originally written in Norwegian and meant for employees of the Norwegian Water Resources and Energy Directorate (NVE) conducting glacier field work. The method guide includes a short summary of essential equipment, knots and skills required for safe glacier travel. The description is meant as is the basic knowledge for employees who perform fieldwork on glaciers. If fieldworkers have knowledge and experience with equivalent or better function, then these techniques can be used.



Regular training is essential to master field techniques and equipment. All field workers have a basic 1-week glacier course as basis. NVE arranges annual rehearsals on snow and biannual rehearsals on glaciers with skilled instructors.

Personal safety equipment for work on glaciers

- 1 rope (30m x 9mm). Minimum «rando»-rated (marked 0), preferably rated as a half rope (1/2). Age max 10 years.
- 2 progress-capture pulleys
- 1 rope-clamp (Tiblock)
- 2 short slings(30cm) (or small ropes for tying in/friction hitch -1,2m x 5mm). Age max 10 years
- 2 long slings (120cm) (or rope sling of 9mm rope adjusted for body length). Age max 10 years
- 6 locking-carabiners; 5 screw-lock-carabiners and 1 HMS-carabiner
- 2 ice screws ca 21 cm
- 1 harness. Age max 10 years
- 1 pair of crampons
- 1 snow anchor
- 1 gear bag

Knots you need to know

- Figure-eight-loop (Roping inn, anchoring), see [figure eight](#)
- Double or single fisherman's knot (for joining ropes), see <http://www.animatedknots.com/doublefishermans>
- Friction-knot (prusik, French prusik) - roping in/self-belay, see <http://www.animatedknots.com/prusik>
- Munter-hitch (descent, rappel), see <http://www.animatedknots.com/muntermule>
- Double-half-hitch, see <http://www.animatedknots.com/clovehalfhitches>

Recommended gear for the harness

- Travel on foot on bare ice: minimum one ice screw and one long sling for self-securing when falling into a crevasse or when stuck.
- On skis or foot on snow: minimum one ice screw and one long sling for self-securing when falling into a crevasse.
- Helicopter sow/ice: empty harness, with all gear easily available inside the helicopter.
- Snow Scooter: empty harness, with all heat easily available inside the scooter.

Important field techniques

- Setting up anchoring points
- Securing buddies from anchoring points
- Intermediate anchoring
- Hauling systems for crevasse rescue
- Rappelling
- Two-person rope teams for snow

- Rescue in two-person rope team
- Rope ascending using friction-knots
- Moving in and out of a helicopter on glaciers

Anchoring point setup

- Anchoring points should be set up in a safe place with respect to crevasses, avalanches, and movement
- Anchoring points need to have two independent anchors. On bare ice – two ice screws. On snow – Snow anchor and an ice axe (or a ski)
- The independent anchors need to be placed so they don't weaken each other. This is a subjective assessment - On bare ice they should be at least half a meter apart
- The anchors should be placed so that tension is distributed as evenly as possible between the two when load is applied. Anchors can be attached with the rope end or with a long sling, with no more than 60 degrees angle. The anchors must be attached so that if one fails, the other can take the load. Use an Overhand-knot or Double-Half-Hitch on the carabiner. Ice screws can also be placed in one line, with at least half a meter distance



Ice screws should be screwed all the way in (here there was thin ice over the grass), and the sling should be attached by carabiner to the screws

Securing a buddy from an anchoring point

Securing from an anchoring point can be useful when passing critical points like a snow-covered crevasse or when accessing a crevasse.

Alternative 1: Grip-knot on an HMS-carabiner connected directly to the anchoring point. The load is transferred directly to the anchoring point. This is a good solution when the direction of the load is constant.

Alternative 2: The belayer is secured in the anchoring point - directly on the belay rope with a double-half-hitch in one of the attachment points (not in the central point) or with a long sling (this reduces mobility to see how your buddy is doing). The belayer uses a grip-knot with an HMS-carabiner in the harness. The load then goes via the belayer so the load on the anchoring point is reduced. The direction of the load is flexible in this arrangement.

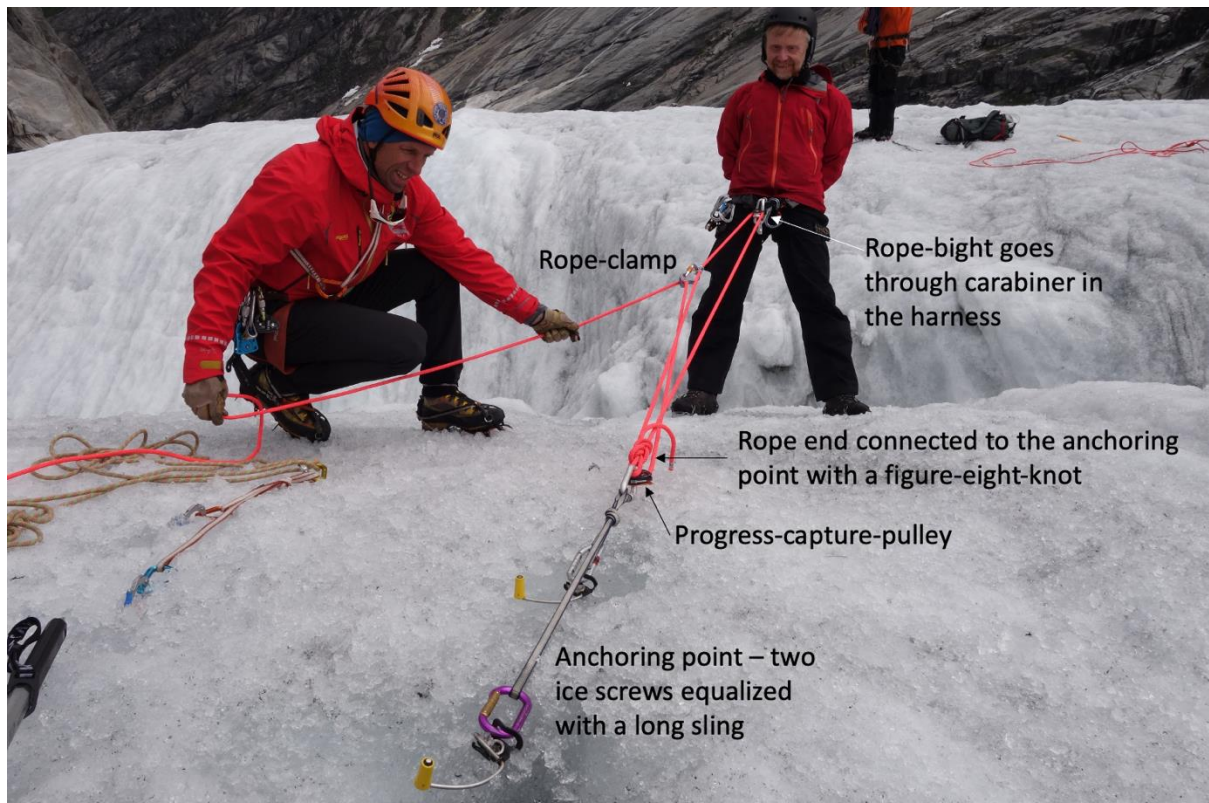
As an extra safety measure a friction knot can be placed on the rope towards the buddy – either from the anchoring point or from the harness.

Intermediate anchors

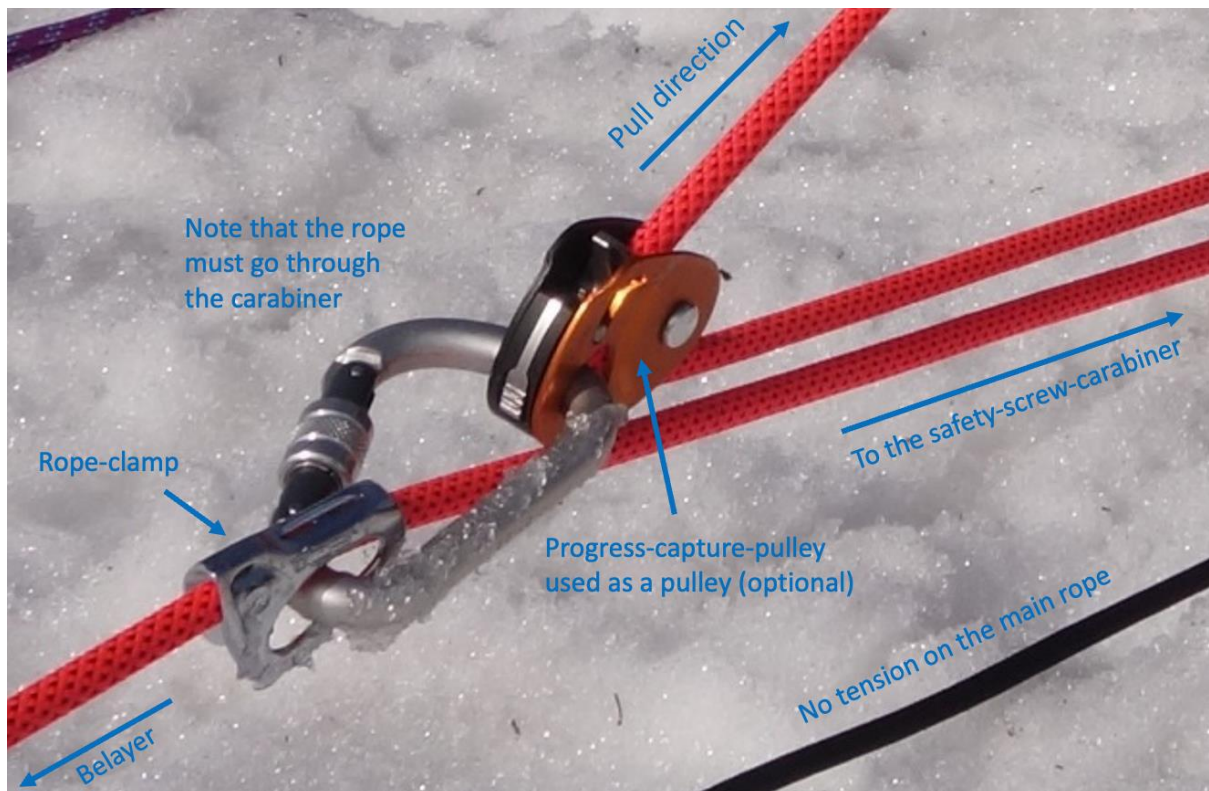
- a. Place intermediate anchors to reduce the consequences of a fall and to control the load on the rest of the rope team.
- b. Place intermediate anchors in a safe place just before a difficult stretch.
- c. When there are more than two people in a rope team one should be secured when clipping by an intermediate anchor.

Hoisting up a buddy – rope has not been used

1. Establish an anchoring point in the ice (two ice screws equalized with a long sling). See “Anchoring point setup”
2. Attach the end of the rope to the anchoring point with a carabiner.
3. Lay out enough rope for a double rope from the anchoring point to the person who needs to be hoisted.
4. Extend the rope bight down to the person who is being hoisted up.
5. Put the loose rope end through the progress-capture-pulley.
6. Attach a carabiner to the progress-capture-pulley and clip into the attachment point.
7. Check that the rope slides in the correct direction through the progress-capture-pulley
8. Attach a rope clamp to the rope, as far ahead of the progress-capture-pulley as possible.
9. Attach a carabiner in the rope-clamp so the rope is pressed towards the barbs.
10. Put the loose rope end in the carabiner or through a progress-capture-pulley locked in the pulley position.
11. Hoist by pulling the loose rope end of the rope.
12. When the rope-clamp is pulled almost to the anchoring point, push the rope-clamp back. The progress-capture-pulley will hold the load while the rope-clamp is disengaged.



The image shows an approach with a 1:6 pulley



A simpler approach uses a 1:3 pulley where the person being hoisted has the rope end attached in their harness

Rappelling

1. Rappel from anchoring point.
2. Check that the rope reaches down to a safe place. Rappel on a double rope if possible.
3. Tie a figure eight loop in the rope end to prevent rappelling of the rope.
4. Tie a break-knot on an HMS-carabiner in the central loop of the harness. Pulling the rope end up locks the rope.
5. Use a friction-knot-sling on the rappelling rope as an extra safety (when using a double rope, use a friction-knot on both). The friction-knot-sling must be fastened to the harness with its own carabiner.
6. During the rappel – stay calm, move steadily, keep a wide stance for balance.

Note: With the rope end down the system gives as much friction as a standard rope-break, which is more than enough for a rappel. With the rope end up the system gives even more friction.

If one wishes to have the rope end down a French prusik can be attached to the leg-loop (held in the breaking hand) as a security during a rappel. The advantage of this method is that the knot is easy to untie under a load.



Two-man rope team on snow

The rope team moves with a double rope (two ropes). One main rope with knots for breaking a fall, and one longer rescue-rope for hoisting, rappelling or self-belay. As a rule of thumb there should be about 20 meters of rope between the two persons in a snow-

covered crevasse-field (16-17 meters between the two persons). However, the recommended distance is dependent on the terrain.

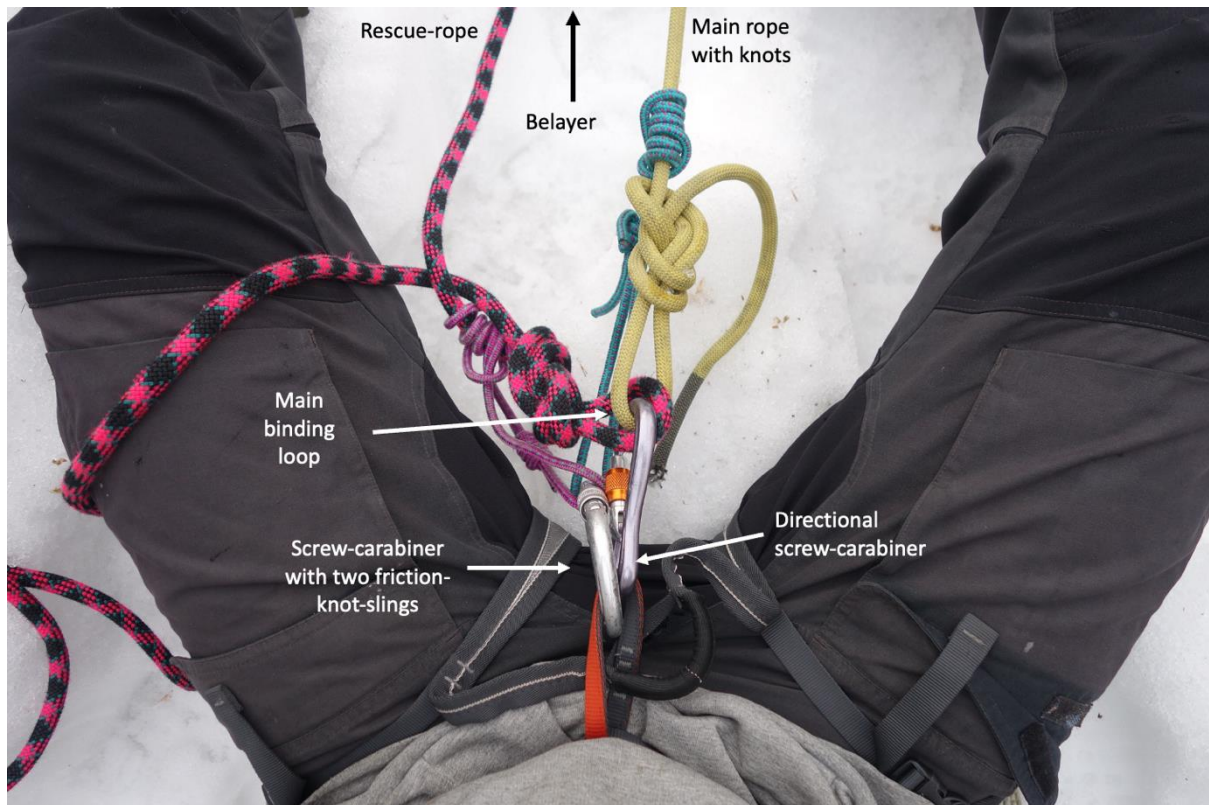
On the main rope, tie a figure-eight loop approximately 20 meters from the end. On the rescue-rope, make a figure-eight-loop at the end of the rope that is tied into the loop of the main rope so that the ropes are connected even if the binding-carabiner is opened. Repeat this for the other end of the ropes so they are connected in both ends. Coil leftover rope around the shoulder or a backpack. Make sure the loops in the figure-eights are small so that the friction-knot-slides don't tighten when the rope is under tension.



Tie eight knots (figure-eight-loop) on the main rope between the two persons in the rope team. During a fall, these knots can bury into the snow and help to break the fall. The loops must be large enough for an ice axe shaft to be pushed through during a rescue. After tying the knots, the main rope should be slightly shorter than the rescue-rope so that the main rope bears the load in case of a fall. The difference in rope length should not be such that the rescue-rope is in the way of walking or crampons (1-2 meters difference).



The binding-loops are connected to the harness, preferably with a directional-carabiner, alternatively with one screw-carabiner and a normal carabiner placed in parallel. Both members of the rope team connect a friction-knot-sling to each of the two ropes. The sling on the main rope is used in case of a rescue, while the sling on the rescue-rope is used when shortening the distance in the rope team.



Rescue in a two-man rope team

1. Stopping a fall
If the lead person falls, the second person must stop the fall. Sit down in the snow with weight on the legs. DON'T hold the main rope, let the harness carry the load.
2. Set up an anchoring point
Place a snow-anchor by the side. Remember to make a track for the wire.



Always use a carabiner in the wire from the snow-anchor! Transfer the friction-knot-sling from the main rope to the wire from the snow-anchor. It is important that the sling is long enough that it is not tight when the rope is put under tension. Here it is possible to use a long sling connected to the friction-knot on the main rope.



3. Transfer the load from the harness to the anchor
Push the friction-knot as far down the rope as possible.

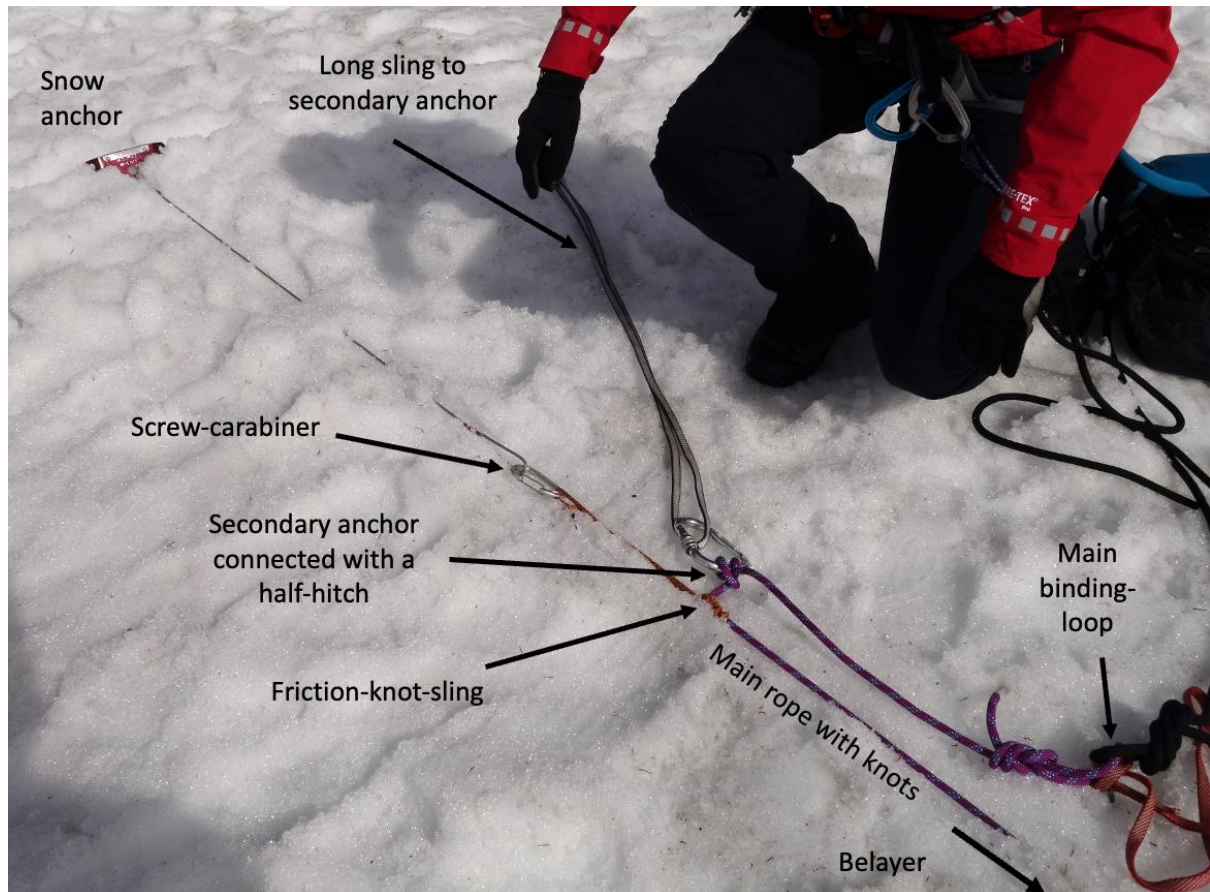


Transfer the load carefully from the harness to the snow-anchor.



4. Extra safety on the main rope

Place an anchoring point in the snow (ice axe, backpack, ski with a sling around). The anchoring point must be as close to the main rope so that the direction of the load is as similar to the main rope as possible. Connect the main rope to the anchoring point with a double-half-hitch on a carabiner in a long sling. Do this just behind the friction-knot. In this phase it is important to work to get as much slack on the rescue rope as possible, this makes it easier to make a pulley later.



5. Prepare for rescue

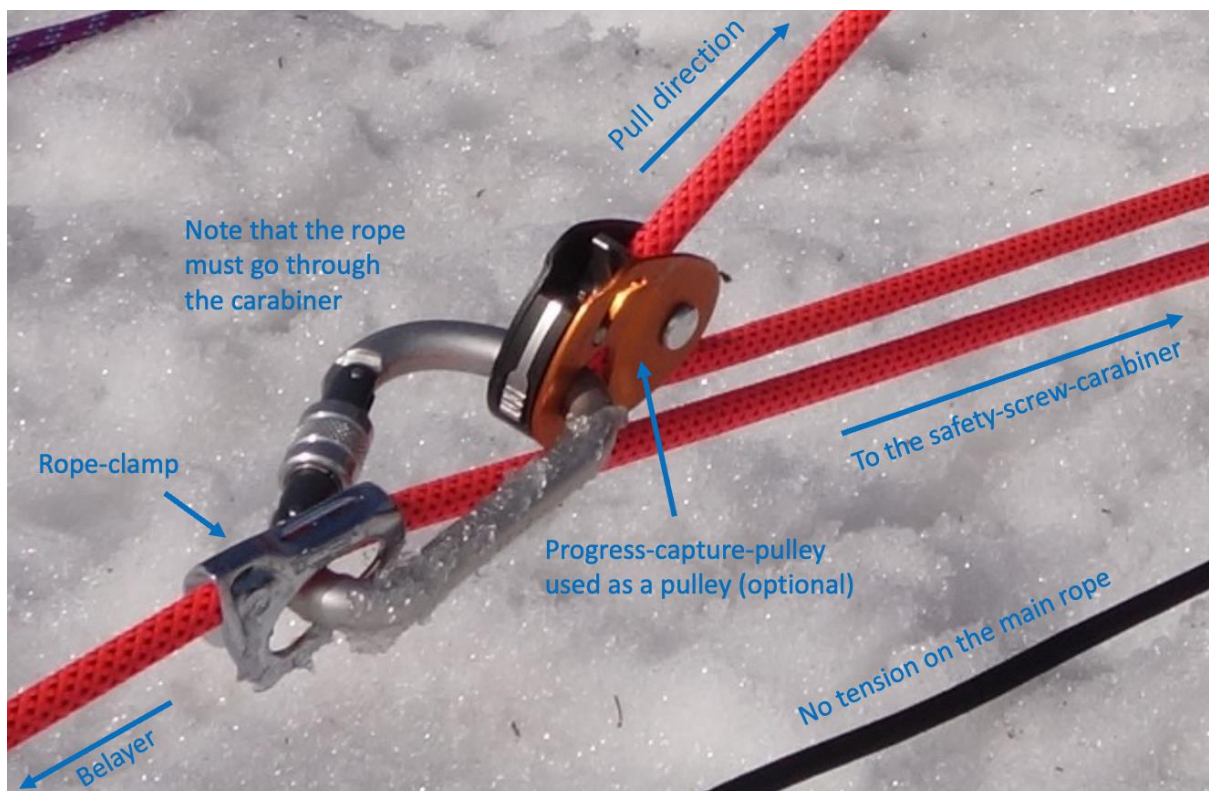
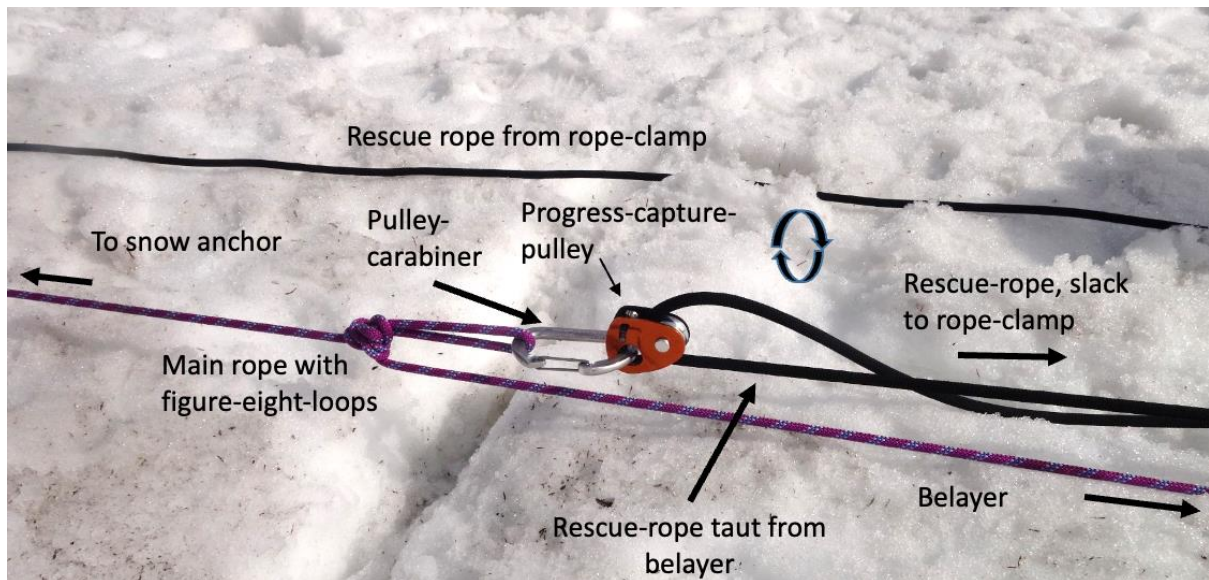
The rescuer can now detach from the main/rescue rope and move forwards along the rescue-rope using a friction-knot. To improve mobility a long sling can be attached to the friction-knot. When approaching the edge of the crevasse the friction-knot should be as far behind you as possible. Ideally it should prevent falling into the crevasse, not stop a fall. Establish contact with the person in the crevasse and make agree on how to proceed.

6. Prepare the rescue-rope

Prepare the rescue-rope by placing a backpack, ice axe or ski (steel edges down) under the rope so that it doesn't cut into the snow under tension. Backpack, ice axe or ski must be secured against the main rope.

7. Set up a pulley

Use one of the loops on the main rope as the base of the pulley. Alternatively, a long sling connected to the snow-anchor with a separate carabiner. Make a pulley from this point on the rescue-rope (as described in section: Hoisting up a buddy – rope has not been used). With good preparation there should be enough slack on the rescue-rope to proceed with setting up the pulley.



Self-belay

Important!

How many slings one needs for self-belaying varies by the individual. It depends on height and flexibility.

Alternative 1.

1. Tie two friction-knots to the tight rope.
2. Connect a long sling and a short sling together. Pass the short sling under the foot, then through itself to make a loop. Thread the free end of the sling around the outside of the knee, through the inside of the thigh and inside the belt of the harness.
3. Connect the lowermost friction-knot in the HMS-carabiner in the harness. Connect the top friction-knot to the long sling.
4. Apply a load to the lower friction-knot and move the top friction-knot as far up as possible and stand up. When standing in the sling, move the lowermost friction-knot up to the top one.
5. Sit down in the harness so that the load is applied to the lower friction-knot and repeat the process.



Alternative 1

Alternative 2

The advantage of this method is that one stands higher when reaching the lip of a crevasse, making it easier to pull oneself over the edge.

1. Attach a progress-capture-pulley to the rope, the pulley is attached to a screw-carabiner in the central loop of the harness.
2. Partition a 120cm sling in two with an overhand knot. Connect the uppermost loop of the sling in the central loop of the harness without a carabiner.
3. Place a carabiner with a rope clamp around the partition knot (a progress-capture-pulley can also be used).
4. Stand in the lowermost loop.



Moving in and out of a helicopter on glaciers

The most important safety measure when using a helicopter on glaciers is the landing site. It needs to be safe to land and safe to move out on the ice. On bare ice it is best to depart the helicopter on concave formations without crevasses. For the pilot it may be best to land on convex formations to have the best possible clearance from the rotor blades to the ice.

Generally, one should use crampons on sloping ice. Consider the need for crampons from the angle of the slope and roughness of the ice. Pilots may be averse to carrying passengers with crampons on. A compromise is to wear one crampon and to put the other one on when on the ice. If the topography requires securing with a rope from the helicopter, the landing site should not be used.

If there is a danger that persons or equipment can begin to slide when they come out of the helicopter, secure these. Only a small slope is needed for things like metal boxes to begin sliding on ice. Remember that with all forms of securing the helicopter must not be tethered to the ice. The terrain should be so flat that securing is only necessary to prevent sliding.

Agree with the pilot that the helicopter moves away while the first person on the ice prepares the landing site to receive personnel and equipment. When returning it is important that the helicopter lands close to the prepared site.

1. The first person on the ice brings an ice axe, ice screws and slings(120cm), ready on the harness.
2. The person departs the helicopter, hacks the ice axe into the ice and puts on crampons. At this point the helicopter can move away while the person on the ice prepares the area.
3. The person on the ice screws in one or more ice screws close to the landing site.
4. The person attaches to an ice screw with a sling and locking-carabiner.
5. Prepare slings that the rest of the team can attach to.
6. The next person sends out equipment that is then attached to slings on ice screws.
7. The rest of the team receives a sling to attach to the ice screw as they depart the helicopter. If the sling is not long enough to reach the helicopter it can be held in the elbow pit (not the hand) until one is close enough to attach to the ice screw.
8. If multiple teams are departing, clear the landing site before the next team departs. One person remains at the landing site and receives the next team with slings.

Remember:

- When using slings or rope close to a helicopter, a knife or scissors need to be available in the harness to cut slings or rope if they get stuck to the helicopter.

- Agree beforehand that a helper in the helicopter does not go out of the helicopter to help.
- One should never be secured to the helicopter when departing unless this is planned in detail with the pilot.
- If it is not possible for the first person to depart securely without holding on to the helicopter, a new landing site should be used.

On a snow-covered glacier one should choose a flat landing site with a good distance to convex formations or steep slopes, because they increase the chance of open crevasses.

In the summer, snow covered crevasses are often visible as lines in the snow because snow bridges begin to sink. Make sure to land between crevasses and with no crevasses between the landing site and the destination on the glacier.

In the autumn with thin snow-cover, probe the snow close to the helicopter before departing. Continue probing in the perimeter around the landing site. Make sure there is enough space in the probed area to unload the helicopter.

Always: Consider sending the helicopter away while work is being done on the ice (100 meters away or circling above). Signalise for the helicopter to return by waving or using a radio.

