Wānaka Mountain Guides

Winter Mountaineering Course

Late winter and spring is the prime time for ski mountaineering in NZs high mountains. Seasonal snow depths are high and crevasses are generally well bridged with supportive snow allowing fast travel and easy access to the classic peaks. Mountaineering on skis or splitboards require a good working knowledge of the full range of mountaineering skills including crevasse rescue, avalanche awareness and ropework.

Snowcraft

Walking on snow

Before resorting to using crampons or for short sections of snow without consequence, it may be quicker to stay in boots. On low angled slopes, stiff boots with a good edge can swipe into the snow to create a secure platform even if it is firm. The most efficient way of ascending moderate slopes is to zig-zig. On steeper slopes, the toe of the boot may be able to be kicked straight in and the slope ascended directly.

When snow becomes softer, crampons do not add more security and it may be better to remove them. Particularly in soft wet snow when it can build up between the points of crampons rendering them useless, known as balling. Plastic anti-balling plates, supplied with all modern crampons, help to avoid this becoming a problem but it still needs to be monitored and dealt with if need be.

In soft snow conditions, whether in crampons or not, it is most efficient to descend slopes facing out and directly down the fall line. Plunging heels into the snow will provide a positive platform. Alternatively facing in will be slower, less comfortable but feel more secure.

Crampon techniques

When climbing snow or ice, every step counts. When using crampons, good technique must be well practised and intuitive to avoid dangerous mistakes, especially at the end of a long day in the mountains. Attention must be maintained especially on easier slopes where complacency can lead to catastrophic results.

When using crampons feet should be parallel to each other about shoulder width apart. This will help reduce the likelihood of a crampon catching the other leg and causing a trip. Ensure loose straps are secure and tidy. Having a crampon come off whilst climbing can be disastrous.

Crampons must be put on securely at the beginning of the day and checked periodically throughout the day.

When descending firm snow, all the crampon points must be engaged. Leading too much with the heel points (which is the usual technique for soft snow) may cause the heel points to skid.

Flat-foot technique (also known as French technique) maximises the number of crampon spikes that are in contact with a snow slope and can be used on low and moderate angled snow (up to 45º). When flat-footing it is important to roll ankles so that all vertical points are penetrating the snow, which can feel awkward at first.

Mixed technique (also known as American technique) uses one foot flat-footing and the other foot front-pointing (see below). Mixed technique is an efficient way to move directly up moderately steep snow (30° to 45º) that is too steep to comfortably flat-foot with both feet, and for which front pointing would be tiring. It is commonly used in combination with the daggering ice axe technique (see below). The front-pointing foot can be alternated to minimise strain.

Front pointing is a secure method for ascending or descending steep snow, (steeper than 45º) and ice but requires stiff soled boots otherwise it quickly becomes tiring. The two front points of the crampons are kicked into the snow. Feet should be parallel, shoulder width apart, perpendicular to the snow, and the soles of the boots should be horizontal. On snow, this technique is often used with the daggering ice axe technique.

Ice axe techniques

Walking with the ice axe

When walking on low angled snow where a slip or stumble could lead to a slide, the axe is held in the uphill hand with the adze facing forwards and the pick backwards. This is the best position from which the self-arrest position can be easily adopted (see below). How much the axe is used for support and balance will depend on the angle of the slope and the hardness of the snow. On moderate slopes a slightly longer axe is useful as it encourages a balanced, upright stance.

Ascending low and moderated angled snow with an ice axe requires a stable rhythm that keeps two points in contact with the snow at all times. This means the ice axes are placed then both feet are moved up in turn before moving the ice axe again.

When ascending low and moderated angled snow it is most efficient to zig-zig. To change direction, stand in a secure and stable position before swapping the ice axe into the other hand and manoeuvring your feet round to point in the other direction. The leash must be used or stowed around the shaft of the axe to avoid getting it snagged on crampon points.

Self-arresting

Self-arresting is the process of using an ice axe for stopping an uncontrolled slide on snow. Good movement skills and situational awareness should avoid ever having to do it for real but it is still a fundamental skill for moving safely on snow. There is no substitute for practising a range of scenarios in a safe location until it becomes instinctive.

In the event of a slip:

1. The initial reaction should be to dig everything in to stop the slide accelerating;
2. If this does not arrest the slip and it accelerates into a slide, manoeuvre into the self arrest position with chest facing the snow and head pointing uphill. If you have a tool in each hand or a walking pole, these need to be discarded so that both hands can be used on the axe. Especially on firmer snow, crampons can catch and cause a falling climber to catapult uncontrollably down the slope. It is therefore important, after committing to a self-arrest, to lift your feet and point your toes in;

3. Place the head of the ice tool under your shoulder and hold the shaft near the spike with your other hand;
4. Arch your body with knees apart and use your weight to drive the pick in and slow you down. The spike must be lifted clear of the snow, and to protect your face, look away from the head of the ice axe.

A slide can initiate from a variety of positions, on the back or front, head facing uphill or downhill. It is therefore important to practise getting into the self arrest position from all these variations. A key step is to use a widely placed ice axe to pivot legs around so they are pointing downhill and to roll towards the hand holding the head of the ice axe to get into the front on self arrest position.

Step cutting

Cutting steps with the adze of the ice axe can also increase security in firm snow with or without crampons. Especially to change direction when zig-zagging up a slope. With each swing, cut the step away so that the ice is free to fall out of the step. The same techniques can also be used to create rest ledges when climbing steep snow or more comfortable stances when doing pitched climbing. If donning crampons is inevitable, It is much easier to stop early to put crampons on rather than persevere without.

Daggering

Daggering (also known as north wall technique) is commonly used in combination with mixed crampon technique or front-pointing on steep snow (40° to 60°). The ice axe or axes are held near the top of the shaft, just under the pick, and the pick is 'punched' into the snow at waist level, about shoulder width apart. Once the snow becomes too steep to keep your balance or too hard to push the pick into the snow then it is time to resort to swinging the axe above the head as for ice climbing.

Snow protection and anchors

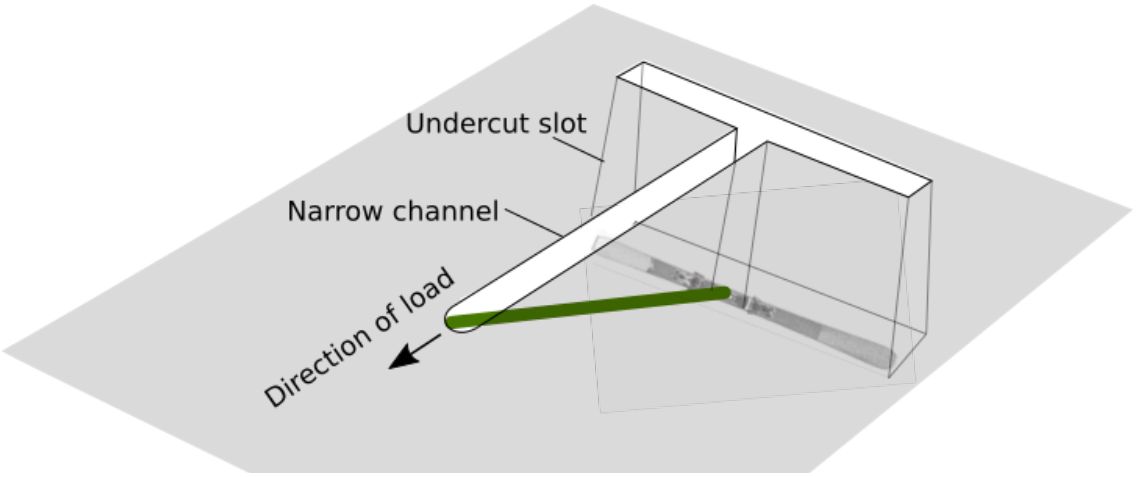
Snow protection is most commonly used in NZ to abseil or belay over crevasses and bergschrunds and in the event of a crevasse fall, building rescue anchors. They are occasionally used for pitching moderate angled snow slopes but climbers need to be aware of the anchors limitations in this application. In the event of a fall, forces generated could exceed the maximum strength of any snow anchor. It is therefore important to understand likely loads, be able to recognise the factors that affect snow strength and be able to choose the best solution from a variety of snow protection options.

Unlike rock protection, the strength of snow can vary to a large degree and can change on an hourly and daily basis. Snow can be hard and almost ice through soft powder or wet snow. The

only way to develop an awareness of snow anchor strength is to practise building and testing them in different snow conditions over and over again. Any snow anchor relies on experience and judgement. As they are often used singularly, when they fail, they do so catastrophically.

Buried object

In soft snow, the strongest possible anchors are created by placing an object with the **biggest surface area as possible, as deep as possible**. In the ski touring context, skis are the most obvious solution in a T-slot. Two skis should be placed with bases facing each other or using skins or some other padding to protect the sling from getting damaged on the edges if using one ski and with a sling hitched around the midpoint of the ski for an attachment. Other options include burying backpacks, stuff sacks filled with snow.



Buried object (or ski T-slot)

Whilst digging the slot, observe the snow hardness and any weak layers that will affect the strength of the placement. The channel for the attachment must be as narrow as possible and the front face of the slot can also be undercut. The channel must be deep enough for the attachment sling to run straight and not inadvertently pull upwards on the skis.

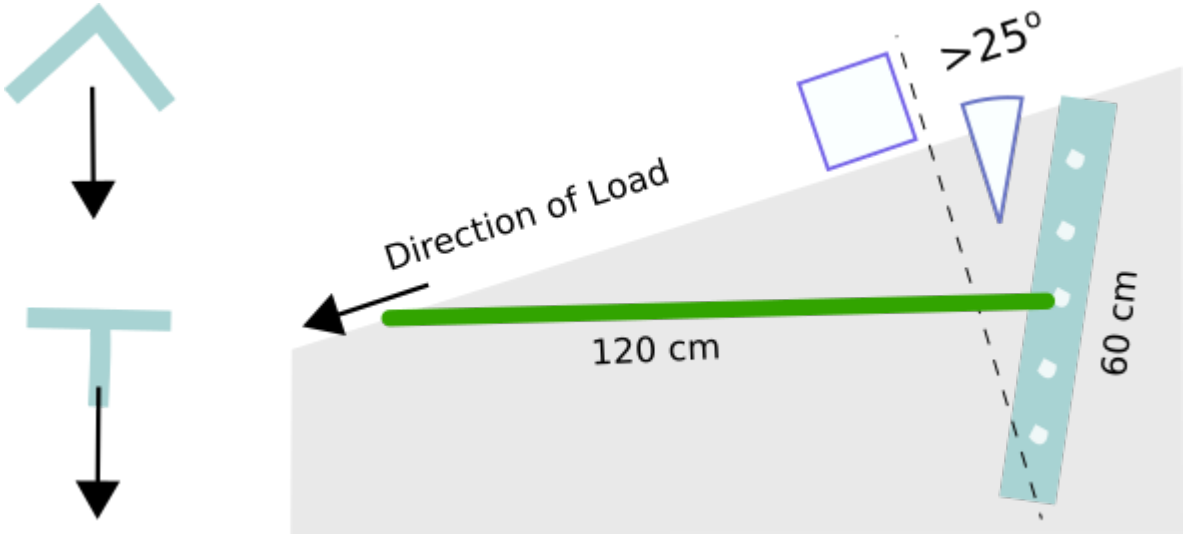
If wet snow can be formed into a snowball, it can be made stronger through compacting with hands. Otherwise, or if the snow is dry, it is best not to disturb the snow in front of the anchor. Unless the snow is compatible, the snow in front of the T-slot should not be disturbed. Backfilling the slot does not increase the strength of the placement. Whilst digging the slot, observe the snow hardness and any weak layers that will affect the strength of the placement.

There are other quicker ways of using skis as snow anchors but require more experience to be confident in their strength.

Snow stakes

If firm conditions are expected, usually encountered early in the morning during an established spring diurnal or melt-freeze cycle before the snow surface has released, snow stakes may be carried for snow anchors. The strongest possible orientation of snow stake anchors is the vertical mid-clip requiring a sling or cable to attach to the middle of the stake.

The stake should be placed at least 25° back from perpendicular to the surface. For a V shaped snow stake, the open part of the V points in the direction of load. The channel for the attachment should be cut as narrow as possible with an ice axe pick or a snow saw and deep enough so it doesn't inadvertently pull upwards on the stake. Also try not to disrupt the snow in front of the stake unless the snow in front of the stake can be compacted to increase strength.



Vertical mid-clip

The wire cables and double length slings are both 120cm long, twice the length of a typical snow stake. This is useful because if the top of the snow stake and the end of the wire/sling is flush with the surface of the snow and the wire/sling is not kinked, the stake will be positioned at the correct angle back from perpendicular.

Bollards

Other snow protection commonly used include snow bollards, body stances such as bucket seats dug in the snow and quickly and efficiently counter balancing terrain features such as bergschrunds, wind scoops and ridge crests.

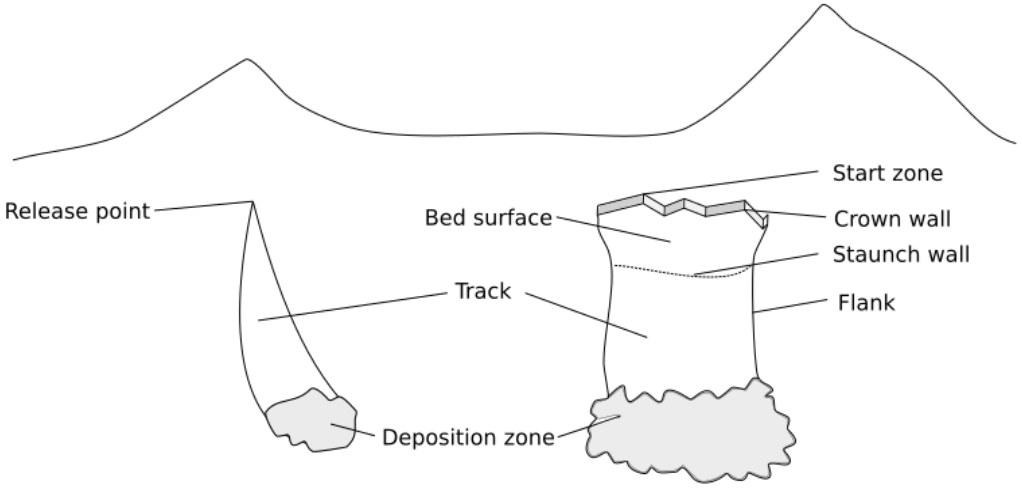
Avalanche Skills

Avalanches are a fascinating and complex science. Luckily learning how to avoid them is a whole lot simpler. You can avoid exposure to avalanche hazards by being confident in identifying and avoiding avalanche terrain and being able to assess the indicators of dangerous avalanche conditions. It is only when the decision is made to push into steeper or more complex terrain that a tacit agreement is made to accept a certain amount of risk. Having our eyes open to gather information, and being aware of our uncertainty and limitations allows us to make good decisions to manage this risk. Finally, being well practised in rescue techniques may help minimise the consequences should a member of your party get caught in an avalanche.

Basics

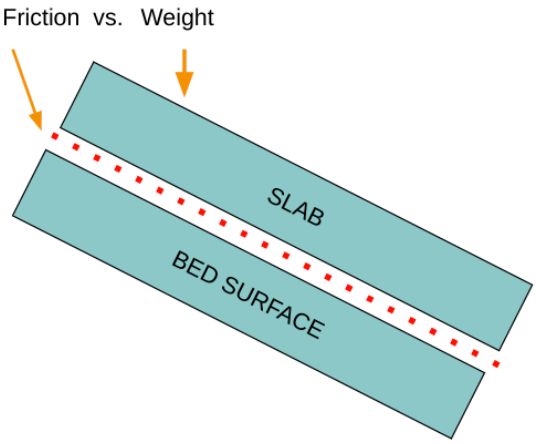
There are 2 main types of avalanches:

Loose avalanches are also known as point release avalanches as they initiate at a single point and fan out. They are often relatively small, involving either very wet or very dry snow in the upper layer of the snowpack, and can be easy to predict. Even a small one can be dangerous if they carry a person into a terrain trap such as rocks, gullies, or over cliffs. They are usually triggered naturally by new snowfall or rapid warming from the sun or rain and are distinctive in appearance by their teardrop shape.



Slab avalanches are generally bigger, posing a bigger danger to backcountry users and can be more difficult to predict. A typical winter snowpack is made up of many layers and an obvious indication of a slab avalanche danger being present is a snowpack structure that includes denser cohesive layers of snow above weaker, less dense layers. Slab avalanches can be triggered by additional load from new snow, rain or the weight of the person, overcoming the friction of the

weak layer and resulting in the slab fracturing into chunks and travelling down the track or path to the deposition zone.



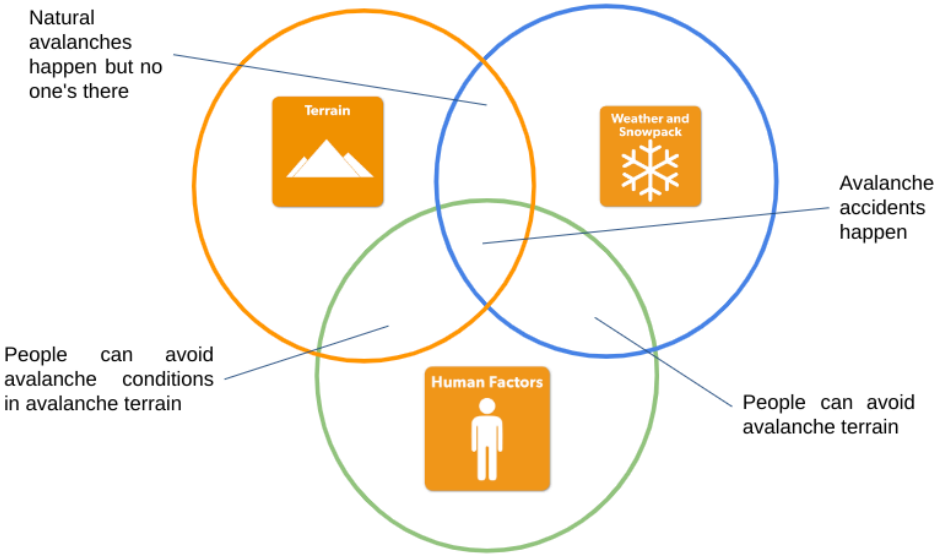
Slab avalanches that have released are easily spotted because the top of the avalanche will have a crown wall, an easily discernible horizontal line across the slope at the top of the slab. The crown wall can be anywhere from a couple of centimetres to several metres in depth depending on the depth of the weakness. Below the crown wall there will typically be a smooth slope, known as bed surface, bounded on each side by the flanks.

Avalanche character

Avalanches are further categorised by their character. Characters can be slab or loose, wet or dry and these are used within avalanche forecasts to provide more information on where the danger is likely to exist, how to identify the problem, and how to manage the risks. Different characters will exhibit different parameters on the extent of the problem, what terrain to favour or avoid, which observations are most useful, the expected size of the avalanches, perceptibility to triggering, and how long the problem is likely to persist.

Risk management

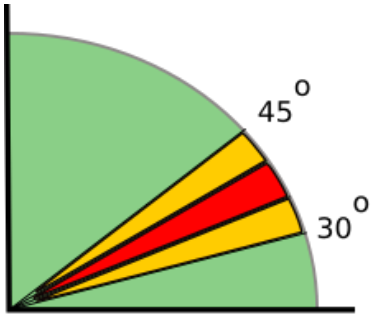
Avalanche may be encountered whenever the appropriate snowpack conditions exist in areas of avalanche terrain. As backcountry travelers, we only expose ourselves to danger by entering avalanche terrain.



Terrain

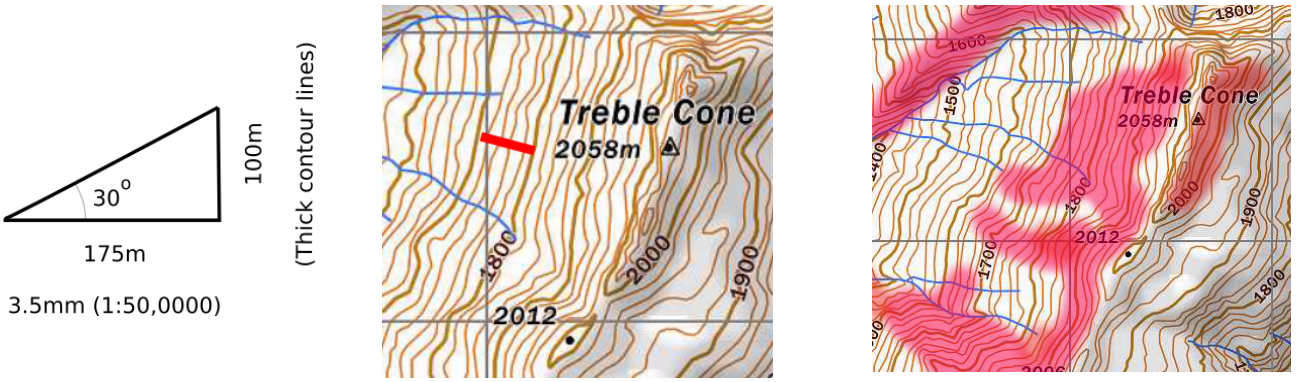
Being able to identify avalanche terrain is the most important skill in avoiding avalanche danger. Avalanche terrain is classified as areas that are either areas where avalanches can occur or areas that are exposed to avalanches from above. There are 5 main characteristics that can be used to identify avalanche terrain and the first line of defense from avalanche risk is avoiding avalanche terrain.

Angle



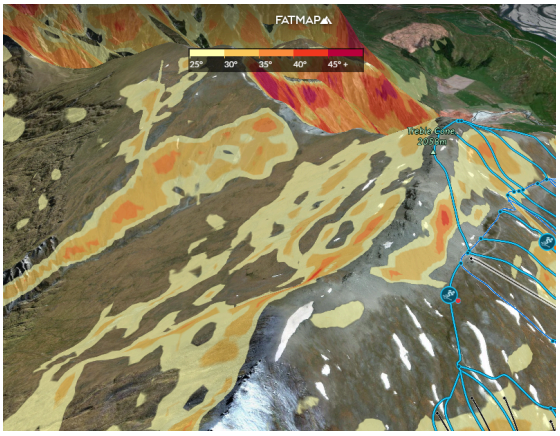
Slope angle is the most important characteristic of avalanche terrain. Avalanches most commonly occur when the slope angle is between 30º and 45º with slopes between 35º and 40º being the most common. Shallower are generally not steep enough for the snow to slide unless in unusual circumstances whilst on steeper slopes, snow will constantly slough and does not tend to accumulate.

Most avalanche terrain can be identified simply by using the contour information available on topo maps. To measure slope angle from a map measure the distance between the thick 100m contour lines on a 1:50,000 scale topographic map. Slopes less than 30º, will have a 3.5mm spacing between these thick contours. Areas with a similar contour spacing will have a similar slope angle. A useful exercise is to shade all slopes that are between 30º and 45º as a prompt to assess the avalanche danger before travelling into these areas.



Assessing slope angle using a topo map

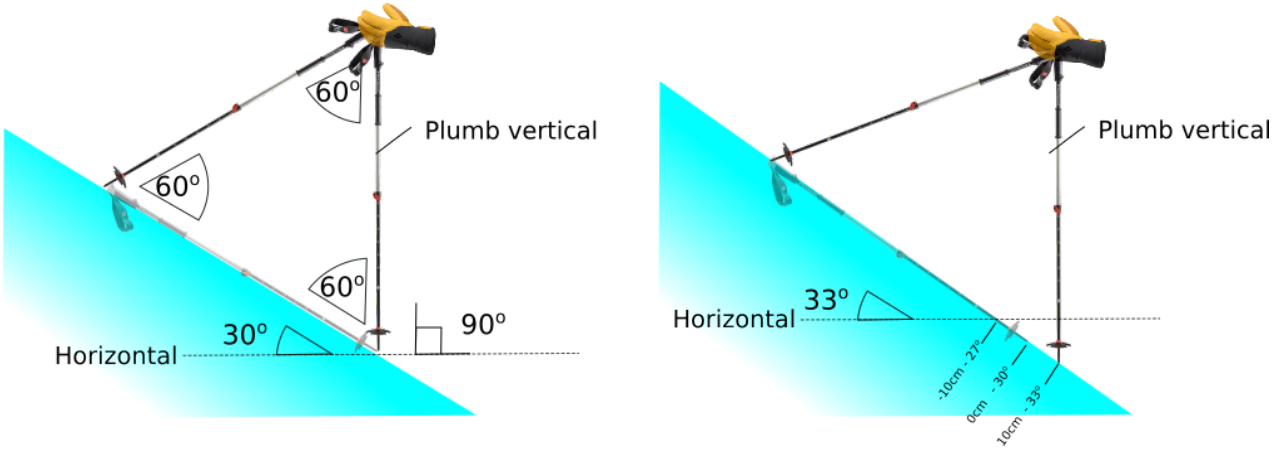
Websites and smartphone apps such as Fatmap® provide powerful tools for assessing avalanche terrain. These can be used as a guide to identifying the complexity of avalanche terrain using terrain overlays that highlight slope angles between 30º and 45º.



This terrain analysis can be used as a guide for avalanche decision-making and can be further refined out in the field by observation and measuring. Inclinometers or smartphone apps provide accurate slope angle measurements. Otherwise using two ski poles of equal length works well:

1. Lie a pole down on the snow making an indentation;
2. Place the tip of the first pole at the handle end of the indentation;
3. Hold the handle of the other pole next to the handle of the first pole and let it hang plumb vertically;
4. If the tip of the plumb vertical pole meets the tip of the indentation, the slope is 30º.

For every 10 cm beyond (down the hill) the plumb vertical pole hits the surface of the snow, add 3º to the steepness. Subtract 3º for every 10 cm it lands above the tip of the indented pole.



Measuring slope angle in the field

Aspect

The aspect of a slope will determine the slope's position relative to important conditions factors such as loading from the wind or warming from the sun (see Observations below). In NZ north facing slopes will generally be warmer and have more effect from the sun than cold and shady south-facing slopes. This is opposite to the Northern Hemisphere. An awareness of a slope's aspect is vital and can be determined by studying the map beforehand and having a compass handy when out in the field to confirm the aspect. You can also use the position of the sun and shaded areas to identify common aspects across a slope. Local slopes of the same aspect will likely have similar snowpack characteristics.

Altitude

The air temperature will determine at what elevations precipitation has been falling as snow or rain. Higher elevations will generally receive higher levels of precipitation, stronger winds, and colder temperatures. Temperatures will influence how the structure of the snowpack has changed whilst it has been on the ground. During precipitation, the temperature will reduce by 0.6 degrees per 1000m of elevation. This is known as the wet lapse rate. Information from the danger forecast will determine at which elevation there is likely to be an avalanche problem.

Terrain traps

Terrain traps are features below that increase the consequence of an avalanche involvement. They include gullies, cliffs, rocks, benches, crevasses, etc. Terrain traps can make even small avalanches have big consequences.

Trigger points

Trigger points are terrain features or areas within slopes where there is an increased likelihood of triggering an avalanche. Slopes that are gradually getting steeper (convex), especially if the slope is unsupported and ends in a cliff or crevasse, are common trigger points.

Exposed rocks or trees (not common in NZ) provide good anchoring to the snowpack. Buried rocks can however present hidden trigger points being locally weak due to thinner snow depth.

Weather and Snowpack

Gathering information about previous and current weather and observations of the snow surface or snowpack structure can provide an indication of an avalanche danger being present. Take particular note of observations that are contrary to the perceived avalanche danger forecast, giving an indication that the actual conditions might not match those that were forecasted.

Recent avalanches

Evidence of recent avalanches will give good evidence of a current potential avalanche danger. Slab avalanches that have released within the last 48 hours are very significant since the instability that caused them will most likely still exist in other slopes with similar terrain characteristics. Evidence of slab avalanches can remain for many days or even weeks.

Signs of instability

Signs of snowpack instability include shooting cracks, ‘whumpfing’, pinwheels, or glide cracks. Weak layers within a layered snowpack are sometimes so unsupportive that when they are walked or skied over them they will suddenly settle making a ‘whumpfing’ sound. This can occur on flat or low-angle slopes where there is no avalanche danger but it does give an indication of similar snowpack conditions in avalanche terrain and may even remotely trigger avalanches on adjacent slopes. Sometimes they are accompanied by cracks appearing on the snow surface. On steeper slopes, this sudden settling can trigger avalanches.

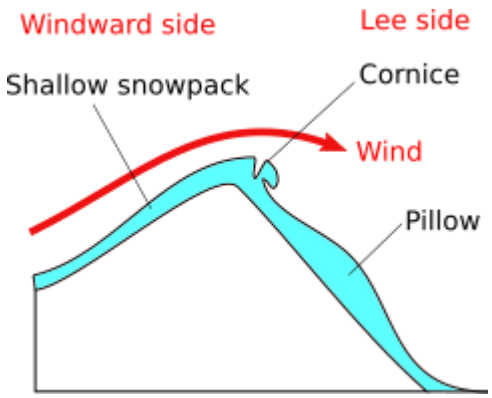
Loading

Avalanche danger will increase whenever additional weight is added to the existing snowpack. This could include new snow, rain, and particularly wind (see below). The additional load may overload, or bring the snowpack close to overloading, weakness within the old snow, or at the boundary between the new and old snow.

Wind

One of the most common causes of avalanches in NZ, which should be of particular concern to climbers and skiers, is wind. Wind scours snow off the slopes facing into the wind, known as the windward side, leaving a shallow snowpack with an often textured surface. This snow is deposited on the slope facing away from the wind, known as the lee side in a pillow of *Wind slab*. Windslab will often have a smooth surface and feel hollow when encountered. If there is loose snow that can be shifted by the wind then there does not need to be new snow for there to be new loading. A small amount of new snow or lots of snow available for transport combined with moderate winds can result in a meter or more of freshly loaded snow on the lee side and a significant avalanche danger. Any time snow can be seen blowing off ridge tops then there is likely new snow loading, and this is very common in NZ.

Along pronounced ridges running perpendicular to the wind direction, snow will often form into cornices, often overhanging the lee side. Any obvious cornice formation should be regarded as an indication of likely wind slab formation on the lee side. Cornices should also be given a wide berth as they can fracture a surprisingly long way back from the crest.



Wind slab formation

Textured surface of windward slopes

Rapid temperature changes

If the upper snowpack is wet due to the warming effects of the sun, above freezing air temperatures, or rain, especially if the change has been rapid, then the snow can become unstable. These problems are commonly an issue during the afternoon in late winter.

Rain will add warmth to the snowpack tending the temperature of the snow towards 0ºC. The easiest observations of this type of instability are known as pinwheels- little snowballs that roll down the slope, or glide cracks- cracks forming as the snowpack slowly slides down the slope under its own weight. Rain events are common in NZ and whilst people tend not to be traveling in the mountains while it is raining, traveling immediately after a rain event should be avoided, giving the snow time to settle and refreeze.

Sun on snow has a big effect, especially during late winter and spring. Snow warming from the sun will be aspect related. Slopes facing North will be hardest hit. Plan travel routes to avoid these slopes when they warm up later in the day, particularly when there is freshly loaded snow or when warm temperatures of cloud cover has prevented the snowpack from refreezing overnight.

Human Factors

Having an understanding of where and when avalanches are likely to happen is a start but they are an incredibly complex phenomenon and making an accurate assessment of the danger can be difficult and subjective. Making good decisions is therefore the most important part of backcountry travel.

Decision-making

Purely rational decisions would involve weighing all alternatives such as potential costs against possible benefits. While we strive to make rational choices, human judgment is subject to limitations such as the amount of time and the amount of available information. In an effort to reduce effort, simplify complexity, and increase speed in everyday life, we are often guided by rules of thumb. These rules of thumb often include unconscious motivations and biases that can lead to decision-making traps, also known as heuristics, that can cause us to make unsafe decisions.

F	Familiarity	Something that is more familiar to us feels safer. This looks like a slope we've skied dozens of times before, with no bad consequences.
A	Acceptance	This is the desire to fit in. This trap is often seen in mixed-gender groups. Mixed-gender groups are found to expose themselves to more obvious hazard indicators than single-gender groups.
C	Commitment or consistency	We've come all this way, we can't turn back now. You've committed to friends, you've spent hours, and good money to be here.
E	Expert halo	Someone in your group with high knowledge or expert skiing ability, or simply the confidence they exude can influence the entire group and dampen all other concerns. If there is a perceived expert in the group, other group members might not speak up if they have alternative opinions, thinking that the "expert" must know what they're doing.
T	Tracks/ scarcity	The race for first tracks can cloud our judgment. In addition, the thought that the resource (fresh powder) is quite limited and you must go now while the getting is good.
S	Social proof or social facilitation	Previous tracks on a ski slope will give you a false sense of security and therefore does not mean it is safe. Just because other people are in the same zone, does not mean that zone is safe.

Accessing and recognising the information that is available to make good decisions depends on maintaining a situational awareness. This includes a perception of what hazards we are exposed to, beneath our feet, from above, and consequences below, as well as comprehending this information and projecting it into our decision-making. One or two pieces of sensational 'information' may distract from other critical data or reasoning or cause you to be distracted from making a realistic assessment. We can often fall into the trap of ignoring or dismissing information that conflicts with pre-established opinions or augmenting and prioritising any information that confirms those opinions.

We need to be cognitive of any inherent uncertainty and apply this to the margin of error within our decisions. This ensures that risk is kept within acceptable levels whilst acknowledging differences between the actual and perceived risk.

Planning

Good decision-making can be supported by thorough planning. This includes reviewing and understanding the weather and avalanche forecast and analysing terrain and possible routes to determine what areas may be safe or dangerous.

We are particularly interested in the previous 24-48 hrs of weather and the forecast for the time we are in the field. This includes:

- Wind strength and direction
- Precipitation type and amount
- Temperature at different elevations

This information is used to form a picture of what conditions to expect, what information to target to confirm or challenge this picture, and where would be good points to gather this information. These are all important considerations when planning routes. Timing is also often critical as patience will allow for danger to reduce after, for example, new snow, rain, or wind.

Depending on how much and the quality of the information is available to make an avalanche danger assessment, there will be an inherent degree of uncertainty. During times of higher uncertainty then it is appropriate to maintain a wider margin of safety and be conservative with decision-making. Trip plans should identify critical decision points (time or location) and have contingency plans in place. This pre-loads decision-making so you are not having to make things up in the field when you may be tired, cold, wet, or subject to other heuristic traps.

Finally, you should understand your group's goals, experience, abilities, strengths, weaknesses, and risk acceptance level so that you can choose objectives appropriate to the group and match expectations and approach before going into the field

Communication

It is always important to communicate well within your group. Communication should ideally be conducted in a safe and comfortable place, out of weather and with hoods down. Well-matched teams should be able to share observations and opinions, encourage discussion, and make consensus decisions where everyone can have a veto. Often nominating a 'devil's advocate' can help to test any safety critical decision.

Identifying a common group mindset for any trips, helps align decision-making. This should be agreed upon daily by the group somewhere warm, dry, and comfortable before you head out. A group mindset helps to look at the facts and information without outside influences like awesome snow, perfect conditions, and weather (hot, cold, windy, snowy) affecting your thought process. Mindset is a mental attitude or disposition that would evolve from hazard assessment, local knowledge, and personal level of risk acceptance, perception of conditions, terrain, and level of uncertainty or confidence in the forecast. These can include keeping it mellow, avoiding avalanche terrain, checking things out, or acknowledging improving confidence in an assessment of conditions.

Discipline

Following a disciplined and systematic approach to your planning, preparation, and travel in the backcountry will minimise your exposure to risk. Whilst we try and make good assessments of avalanche danger, we have to recognise that we can be wrong and discipline will avoid us getting caught out if taking shortcuts.

Safe travel techniques

The terrain you choose will greatly affect your safety in avalanche terrain. Avalanche involvements are mostly triggered by another member of the party so regardless of the perceived avalanche danger, discipline in applying the precautions of safe travel techniques will further mitigate any risk when traveling in avalanche terrain.

Space out so that no more than one person is exposed to avalanche hazards at one time. The spacing will therefore vary depending on the complexity of the terrain and the size of avalanche paths.

Maintain visual contact at all times. This may mean positioning a spotter for blind pitches of skiing and looking back to the last person skiing the slope.

Regroup in safe spots or islands of safety that are not exposed to hazards from above or have terrain traps below. These depend on the nature and expected size of the current avalanche danger.

Choose safe routes that are low angle or follow ridges.

Follow good communication protocols within your group. Communication will be more difficult with bigger groups, when fatigued, or when environmental conditions are challenging.

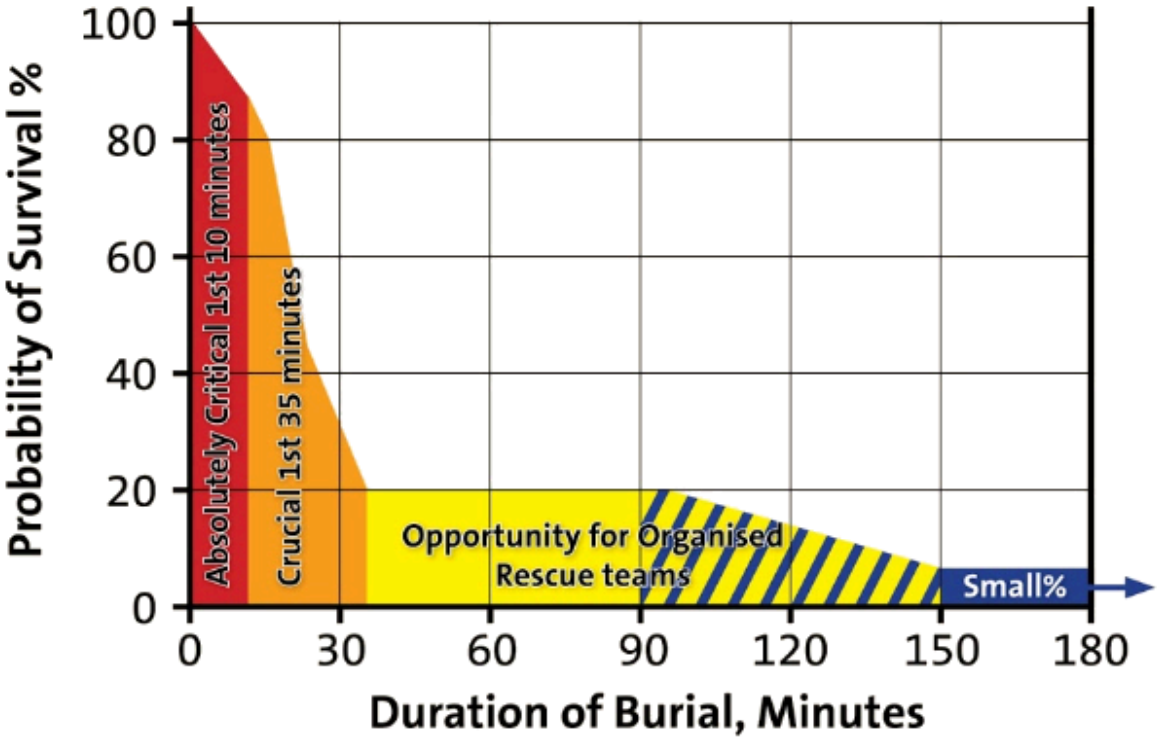
Before entering avalanche terrain, identify escape routes that can be followed in the event of an avalanche to attempt to get you out of and away from any further danger.

Companion rescue

Survival

In order to minimise the consequences of an avalanche involvement, it is vital that all members of the group carry rescue equipment and are trained and practiced in avalanche rescue regardless of the perceived danger.

Rescue within the first 10 minutes of a burial is essential for the largest chance of successful recovery. Due to this tight timeframe the only chance of live rescue of a buried subject realistically lies with the group on site. Beyond 10 minutes, the probability of a live recovery decreases quickly the longer they are buried.



Underlying generic principles of avalanche rescue

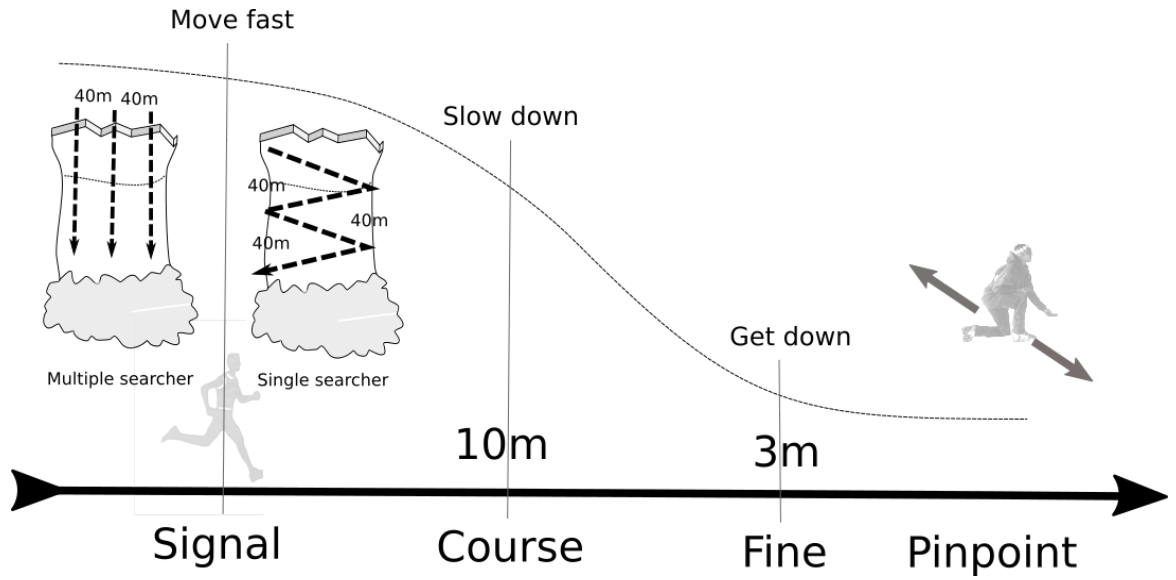
Rescue procedure

In order to quickly recover a person, efficient procedures have been developed:

1. **Coordinate** - Make sure all members of the team are aware of the situation and keep visual of the victim for as long as possible. Make note of the last seen point as this will narrow down the most likely burial areas. Appoint a leader and other rescue roles. Depending on the number of available rescuers, everyone should be involved in the initial response to maximise the chance of survival. Define your search area and likely burial areas through interrogating witness(es), identifying last seen point, surface clues, and terrain traps;

2. **Risk assessment** - Assess safety. Is there a risk of further avalanches? Limit more people becoming exposed to risk;

3. **Transceiver search** - Turn all transceivers to 'SEARCH'. Turn all electronic devices off or separate them by 10m from searched transceivers. Assign the minimum number of transceiver searchers for the size of the site based on the search strip widths of their transceivers. Begin a *Signal* search. Move as fast as possible during this phase not looking at the transceiver but for clues on the surface and listening for the transceiver to beep indicating that it has detected a signal. Then begin the *Course* search following the direction arrow of the transceiver. Move fast. At 10m, slow down. At 3m move the transceiver to the knee and begin a *Fine* search and slow down further. Go back and forth along the trajectory, avoiding rotating the searching transceiver to pinpoint the point of the lowest transceiver reading;

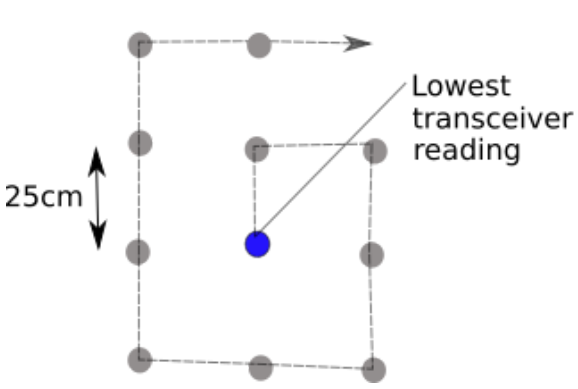


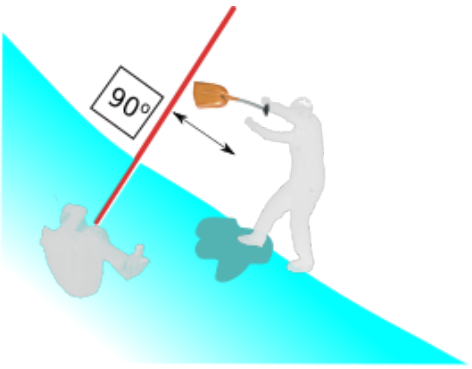
Transceiver search procedure

4. **Gear up** - Remaining rescuers that are not searching for transceivers can get ready with probes and shovels and do a visual search or probe clues on the surface;

5. **Probe** - Once conducted a fine transceiver search or the transceiver reads within a meter start probing perpendicular to the snow surface. If unsuccessful on the first probe strike, go 25cm uphill and systematically probe outwards in a grid spiral pattern until the buried subject is struck. On a successful probe strike, leave the probe in place;

Avalanche rescue equipment - Transceiver, shovel, and probe (Ortovox®)





Grid spiral probing 90° to the snow surface and conveyor shoveling

6. **Dig** - Start digging one shovel length downhill from the probe. Do not lift the excavated snow but scoop and paddle it backward. If it is hard, chop blocks. With more than one

rescuer, use a systematic conveyor shoveling technique with the other rescuers in a single line a shovel length below each other, rotating every 2 to 4 minutes;

7. **Patient care** - Dig towards the head and uncover the airway. If the buried subject is not breathing, identify evidence of snow in the mouth or an ice lens. Initiate CPR.

Considerations for Mountaineers

Avalanches are most commonly associated with winter but throughout the summer mountaineering season, there are times when there is a high avalanche danger in the mountains. By midsummer, the snowpack has gone through a number of cycles of warming and cooling and the layers within it have broken down resulting in a single consolidated layer. When new snow falls, there are only weaknesses in the interface between the new and old snow and within the new snow that may be of concern.

Large snowfalls can happen in summer, often with significant wind, and the avalanche danger will likely increase during and after the event. The generally warmer temperatures during summer will mean that avalanche concerns will stabilise quickly. Staying out of avalanche terrain for at least 24 hours after a summer storm will give a high likelihood of avoiding the worst of the avalanche danger.

Many accidents have happened when mountaineers have not been concerned about avalanches due to the time of year and therefore ignored the warning signs. The nature of terrain accessed and the equipment carried by mountaineers means that even small avalanches can have significant consequences. This includes being carried over cliffs or bluffs, being tied together by a rope, or being anchored by ice axes.

Mountaineers are exposed to avalanche hazards and have the potential for high consequential outcomes for a number of practical reasons.

Avalanche terrain

A characteristic of avalanche terrain is that it has a slope angle between 30 and 45 degrees or is in the path and threatened by such terrain above. A lot of climbing and climbing approaches fall within this range. This suggests that mountaineers can spend more time exposed than ski or splitboard tourers. When the avalanche danger is elevated, tourers can still have a good day out by sticking to low-angle terrain but climbers do not always have this benefit if focused on a particular objective. Despite the attraction of steep skiing and riding, this is only likely to be carried out by a minority of backcountry travelers at times when conditions are very favorable.

Also relating to terrain, climbers can often seek shelter from wind on lee sides of ridges and therefore expose themselves to areas of wind-deposited snow.

Terrain traps

Mountaineering terrain is characteristically exposed to terrain traps. Mountaineers are frequently travelling in terrain where any fall is unsurvivable. These increase the consequence of even small avalanches such as narrow gullies, cliffs, crevasses, etc. In all reported avalanche fatalities over the last 20 years in NZ, trauma has been the main cause of death rather than burial asphyxia. In multiple North American studies published over a similar timeframe, based on a much larger data set than available in NZ and where skiers and snowboarders are much more represented in the statistics, asphyxia is by far the main cause of death.

Mobility

Practically, mountaineers moving on foot are much less mobile than skiers and riders. They may also be roped up, which further limits the ability to move quickly through threatened areas or out of the way of triggered avalanches. Coupled with terrain traps, this reiterates that even the smallest of avalanches can have serious outcomes for climbers.

Safe travel techniques

A fundamental lesson of avalanche skills courses is to spread out when traveling in avalanche terrain. This is to minimise exposure to avalanche hazards and, in the event of an avalanche, to ensure more rescuers are available. Mountaineers may be roped up to manage a crevasse or a fall hazard and as a result, traveling close together. Mountaineers must therefore be very aware that they are often managing multiple simultaneous hazards and may need to correctly identify the most significant risk at any particular time and choose the most appropriate control method.

Equipment

Airbags contribute to less serious injuries by increasing the volume and therefore helping the involved person to move toward the top of the moving debris. Items like skis have the contrary effect and, unless successfully jettisoned, can drag persons involved in avalanches down into the debris. This is also an issue for snowboarders in avalanche terrain without releasable bindings. Mountaineering equipment, such as ropes connecting members of the party together and ice tools connected by umbilical leashes, will have similar anchoring properties. In addition, being attached to items such as crampons and ice axes can increase the potential trauma in the event of an avalanche.

Monitoring conditions

Mountaineers should have the advantage over ski and snowboarders in that they are moving more slowly and even plugging their way through the snow. It is much easier to gather information on the snowpack layering and snow surface conditions. Mountaineers will be

routinely assessing and managing multiple hazards. This reiterates the importance of maintaining situational awareness and adjusting risk management, travel techniques, and use of equipment as required.

Weather windows

As the conditions in the mountains are changing, the climbing season for classic snow and ice routes has moved earlier in the year. This can coincide with unsettled spring weather patterns. Weather windows may be short and pressurise climbers to venture out immediately after a storm. Avalanche problems will stabilise quickly during the warmer summer months but simple rules of thumb, such as avoiding avalanche terrain for 24 to 48 hours and dramatically reduce exposure to avalanche hazard. It is also important to be aware that unusual weather events at any time of year will result in unusual avalanche conditions.

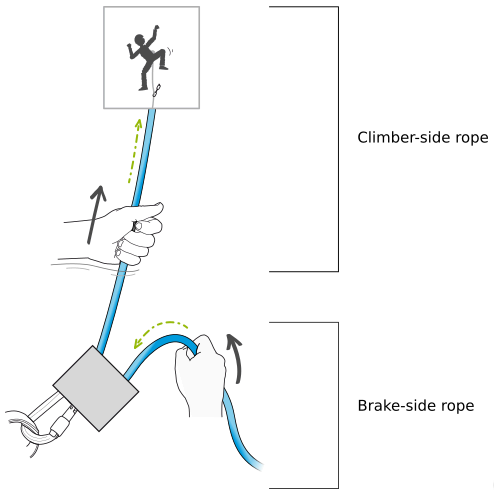
Applying the avalanche forecast to mountaineering

When interpreting the avalanche forecast, foot based mountain travelers should think about what conditions you are expecting and how it will feel. If you expect the danger to be low but you find yourself stepping into knee-deep snow or punching through a crust, it might be time to slow down and assess. If you are expecting new snow and you encounter a slick old snow surface, think about when the new snow has been moved to as it likely has. Ropes can provide security but they can also cause more damage so consider how they are used. Snow anchors will not be strong enough to secure the mass of snow released in even a small avalanche.

Ropework

Belaying

Belaying is the process of controlling the length of rope in a roped climbing system using a belay device.



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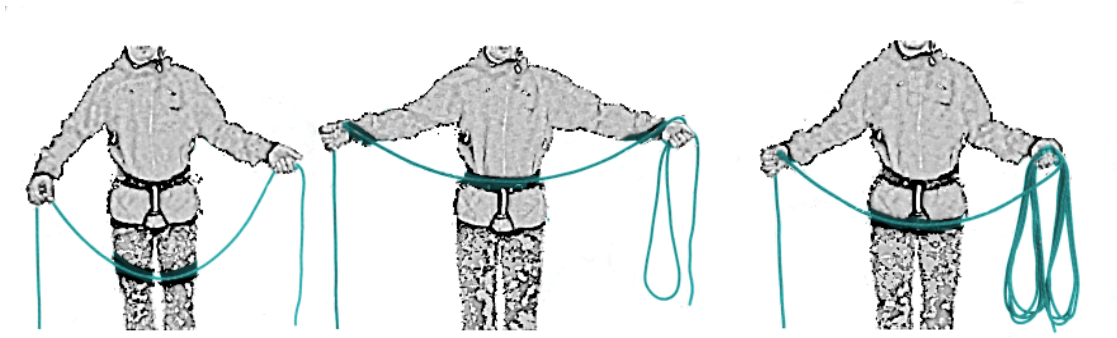
Top roping is commonly used at crags with fixed anchors at the top of the established climbs. The rope is attached to these fixed anchors either by accessing the top of the crag from above or by the first climber lead climbing upwards from the ground. Subsequent climbers are then belayed from the ground or bottom belayed.

The live or climber-side rope refers to the length of rope between the climber and belay devices and the dead or brake-side rope refers to the rope that is on the other side of the belay device. It is important to have at least one hand on the dead rope at all times regardless of the device being used.

Coiling ropes in loops introduces twists that can make handling difficult. It is preferable to lap coil or flake ropes in a back and forth motion across the hand or shoulders so that there is always a gap in the loops. These coils can then be tied off into a rucksack coil for carrying or a single butterfly coil that is useful for strapping the rope to a pack for carrying.



Lap coiling rope

Anchors

Anchor systems principles

Two or more pieces of protection can be combined into an anchor system that can be used for pitching or abseiling. In these situations reliability is paramount as climbers will often have their entire weight on an anchor and its failure can be catastrophic.

When creating an anchor system the following 5 principles apply:

Secure - Each piece of protection used within an anchor system must be secure. This means that there is good confidence in its strength and reliability.

Independent - Each piece of protection must be independent.

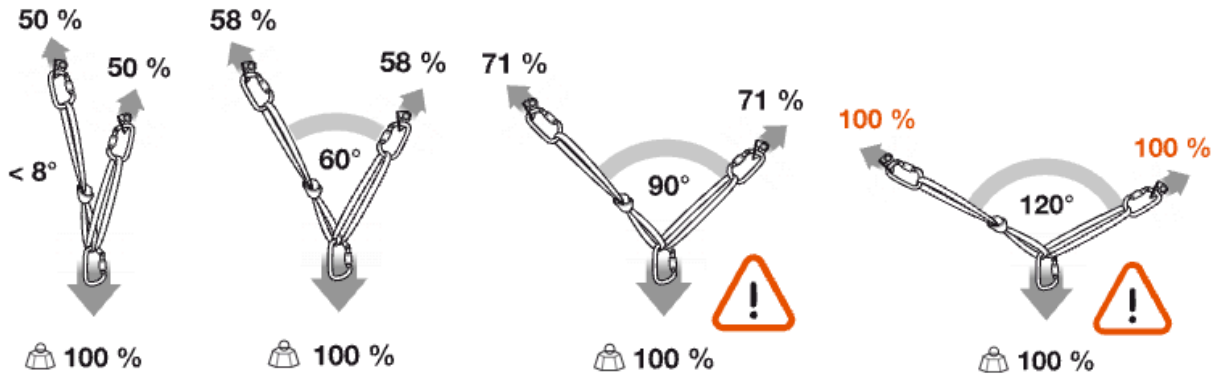
- This means that for rock protection, each piece should be in separate cracks (ie, if the crack widens, only one piece of protection is affected).
- For snow anchors maximum strength and independence is achieved by separating each piece of protection by at least twice the depth of the deepest piece.

- On good water ice, 2 well spaced ice screws are usually sufficient to create a suitable anchor. To avoid the ice screws affecting the strength of each other and the ice fracturing around the entire anchor system, separate each screw by at least 2 screw lengths and in different horizontal and vertical planes.

Equalised - To minimise the force on individual pieces of protection and maximise the strength of an anchor system, it is important that the initial load is equalised or shared between all of the individual pieces of protection.

Redundant - If a protection piece within the anchor system fails, then there must not be a shock load on the other protection pieces of the anchor system.

Angle - The angle created at the focal point when equalising multiple pieces of protection points into an anchor system is of paramount importance because of the Magnification of Vectors. This always needs to be considered, especially if the pieces are separated.



Magnification of vectors (Petzl)

Anchor system configurations

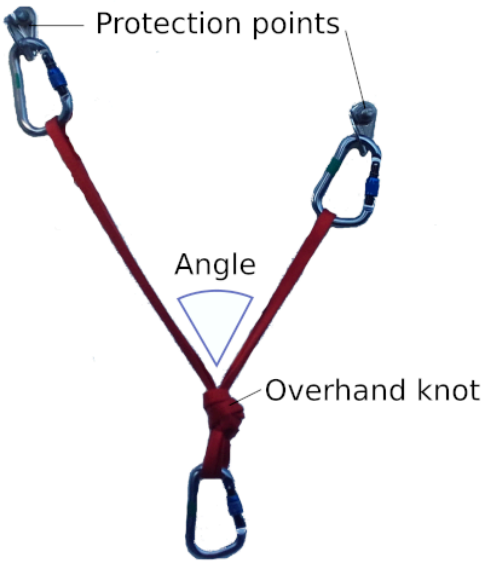
Anchor systems can be built using slings or whilst pitching, the climbing rope. Using slings is preferred and used with a direct belay as it keeps the rope and other members of the climbing party out of the system.

Fixed anchor systems

On long multi-pitch or alpine routes, using quick and reliable protection and a simple anchor system that are quick to assemble and disassemble will maximise efficiency.

Overhand

The simplest anchor system is the Overhand. A sling is clipped through 2 (or more) anchor points and an overhand knot on a bight is tied at a point in line with the direction of pull and equalised on each of the anchor points.

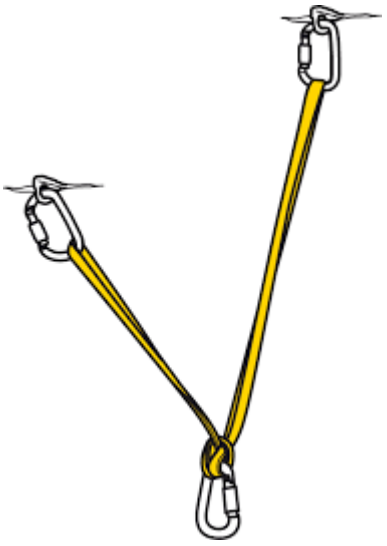


This provides 3 separate attachment points which can be used to keep the anchor organised and separated. These are the Shelf that captures both loops above the overhand knot, and each individual loop below the overhand knot.

This configuration does require anchor points that are relatively close together using a long sling to ensure the angle between the strands is within the acceptable range.

Sliding X Girth Hitch

The Sliding X Girth Hitch offers greater redundancy over a standard Girth Hitch anchor and is an efficient use of sling for more widely spaced anchor points. Of particular advantage in alpine climbing is that no knots need to be untied with cold or gloved hands which speeds up the process. This requires an additional Master Carabiner (abseil ring or bears paw) in the system that should remain closed with all other elements of the anchor and belay system clipped to it.



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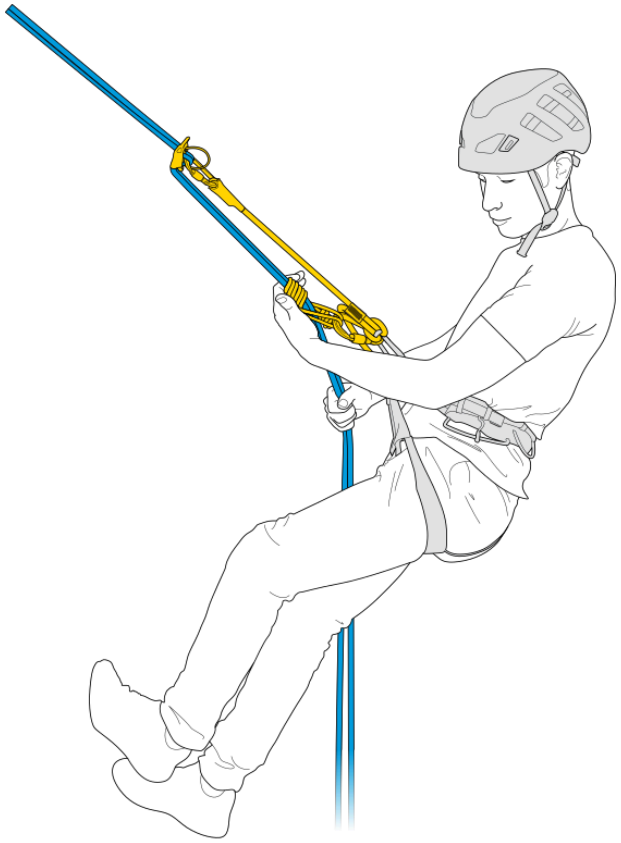
Abseiling

Abseiling (also known as rappelling) is a fundamental technique required for climbing and mountaineering. Whether abseiling on a single or doubled rope, the principles remain the same. For pitched climbs that require steep abseiling often two 50 or 60 metre ropes are usually carried so that full pitches can be abseiled.

Abseiling systems



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An extended abseil system is most commonly used with the abseil device extended above the belay loop with a short, knotted sling or a Personal Anchor System (PAS) and the backup prusik attached to the harness belay loop. Although dedicated PAS are commonly used for sport climbing, for mountaineering an extended abseil is only used during the descent and for weight efficiency can easily be improvised from a 120cm sling when required.

A backup is often used when abseiling in case of inadvertently letting go of the dead rope. A backup is also useful when having to clean a route, manage rope or to construct multi-pitch anchors whilst hanging on the abseil rope. a French prusik can be placed around the rope and attached to the belay loop of the harness. French prusiks are preferable in this situation as they are releasable when loaded. It is important that the abseil device is extended sufficiently so that the backup prusik cannot interfere with the device which could result in it failing to lock.

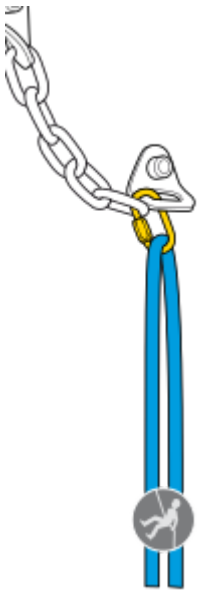
A prusik backup can be avoided if there is someone at the bottom able to hold the rope. If this backup belayer is ready to pull down hard on the rope, the abseil device will lock. This is known as a Fireman's belay.

On all abseils where the rope doesn't reach the ground, individual knots should be tied in each end of the rope. Alternatively the first abseiler can stay tied into the end of one of the ropes, providing the ropes are secured at the abseil anchor.

Before committing to an abseil:

1. Ensure that the anchors are secure and attached correctly, you are likely already attached to the anchors so this would have been done already;
2. Check that your harness is on correctly and the buckle(s) are doubled back on non-self-locking harnesses;
3. Check your belay device is threaded correctly and the carabiner attaching your belay device to your harness is locked (squeeze the gate to test it);
4. Check that the end(s) of the rope are touching the ground or have a knot tied in it/them;
5. If you are using one, check your abseiling backup is working correctly (see below);
6. If you are using a *Personal Anchor System* (PAS) to attach to the anchor, all your weight should be on the abseil device and rope with the personal safety is slack as a check before unclipping it from the anchor.

Retrievable abseils



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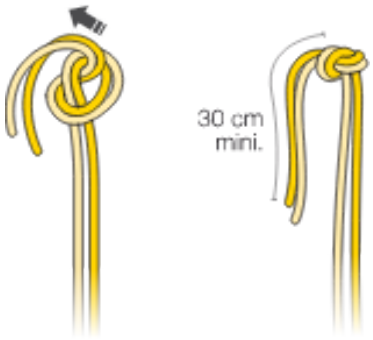
Most of the time when multi-pitch abseiling in the mountains a Retrievable abseil system is required. This allows the rope to be pulled down after use in order to continue onwards with the descent. This is done by threading the rope or ropes through an anchor that is left behind and then abseiling on two strands of rope. When the bottom of the pitch is reached, one strand can be pulled to retrieve the rope(s). If using a single rope only half its length can be descended at a time.

Once a retrievable abseil is set up, the ends of the rope can be lapped and thrown down. It is common for the rope to get caught on ledges so the first person down should backup their abseil system leaving their hands free to manage the rope if need be so as to never allow the ends of the rope to get snagged above them.

On steeper faces and in windy conditions is to lap the rope over a sling attached to the side of the harness in ‘saddle bags’ for the first abseiler to carry down.



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Two ropes are often carried on longer steeper and more technical routes to enable full rope length pitches to be descended. There are a number of options to join two ropes but the simplest for tow ropes of the same diameter is using an overhand knot. The knot must be neatly dressed with at least 30 cm of tail for each rope as in extreme cases it is possible for this knot to roll and undo itself. A major advantage of this knot is that it has a flat surface that rolls well over edges. The ropes must be of similar diameter or very near to it. If not, then use a double fisherman's knot.

To remember which strand of the rope to pull, the personal safety can be clipped around it. It is also important to remember to take the knots out before retrieving the ropes as they can get stuck at the anchor.

On lower angle broken ground it is best to keep abseils short to make the rope easier to manage. Many established abseil descents in NZ mountains are set up for 30m abseils.

Carrying a lightweight tagline (a thin 50m or 60m long 5.5mm diameter spectra chord or similar) allows full rope lengths to be abseiled without carrying a full second rope. The abseil is set up on the full rope and the tagline is used to pull and retrieve the rope.

Ice climbing

New Zealand Venues

Water ice climbing in New Zealand is mainly confined to cold, higher elevation and south facing aspects with a good supply of drainage. During the shortest days of early winter, these venues see little sunshine and later in the season, snow can accumulate, covering less steep climbs and more consideration needs to be given to the increased avalanche risk.

Great alpine ice can be found in the high mountains of the Aoraki/Mount Cook and Westland regions well into spring when longer daylight hours reduce the time pressure on longer routes. At this time, winter snows have consolidated to make firm cramponing conditions and more stable avalanche conditions. Classic areas and routes include the South Face of Hicks from Empress Hut and the South Face of Douglas and the Mallory-Barnicoat ridge from Pioneer Hut.

Ice climbing grading

Ice climbs are given a Water Ice (WI) grade from 2 through to 6 or 7. The grade that takes into account a number of factors including length, technique required and commitment. Routes are generally graded for normally expected conditions but variations in the amount and consistency of ice can greatly affect the difficulty of a route and judgement is required to determine the current condition of the route.

For more routes of WI 3 and above, 85° or steeper ice can be expected for longer sections and protection may need to be placed from less restful positions From WI 4 and above, protection will need to be placed on vertical sections and WI 5 and above will have prolonged sections of vertical climbing.

Grading for mixed climbing roughly follows the WI system with respect to its physical and technical demands and can be compared to rock climbing grades with M6/7 being the transition into the Eubank grade 20s.

Ice climbing hazards

Avalanche

Whenever snow is above threshold above or at an ice climbing venue, an avalanche hazard may exist. Ice climbing areas are often found below slopes that provide drainage

to the ice formation. If these slopes are between 30 and 45 degrees, it is avalanche terrain and exposes the ice climbing venue. Similarly, approaches may cross avalanche terrain. It is well known that even small avalanches are severe for climbers due to the equipment used and carried and their inability to move quickly out of the path compared to skiers.

Climbers should be aware of the avalanche conditions from the public forecast and be cautious whenever there is change from new snow, rain or rising temperatures. Avalanche safety gear (shovel, transceiver and probes) and knowledge on how to use them are essential for most ice climbing venues.

Cooling

Ice expands when heated and contracts when cooled, which can introduce mechanical stress. If cooling is slow, the ice can adapt to the stresses and deform plastically. However, if cooling is quick, the ice becomes brittle and additional stresses, such as those created by an ice axe, can create cracks. During contraction, a free-standing column will shorten, creating strong vertical mechanical stresses in the structure.

Thaw

As can experienced at any point of the season in New Zealand, a spike in temperatures or strong winds can affect safe climbing conditions. Prolonged periods of mild temperatures above 0 °C, including at night, can cause running water behind the ice and can result in the separation of the ice from the underlying rock. Particularly early in the season when hanging daggers and freestanding ice forms that have not been connected to the ground can collapse with little warning. By late August, the sun is higher in the sky and can quickly lead to the deterioration of conditions. Under these conditions, avoid being under hanging or steep features that may come down on top of you.

Periods with stable temperatures of around 0 °C (little warming during the day, no drastic cooling at night) generally provide the most favourable climbing conditions.

Us and other climbers

Other climbers can knock off ice or ice daggers or drop (sharp) ice climbing equipment so helmets should also be worn when at the bottom of ice climbs. Belayers should position themselves away from the firing line, especially in multi-pitch situations where they are attached to the mountain and can't quickly move out of the way of anything falling. Similarly, never climb under another party.

Ice climbing uses sharp equipment so skin should be covered and some form of eye protection is good to prevent injuries from ice tools popping out of the ice.

Any lead fall whilst wearing crampons and using ice tools has the potential to cause injury. It is not sport climbing and climbers should climb within their limits focusing on good feet, often the first thing to blow during a fall, and good, secure sticks with tools.

Equipment for Ice Climbing

Boots

For technical ice and mixed climbing, a fully rigid (full shank) mountaineering boot is required. Single boots constructed from leather or more modern synthetic materials (some newer models have an integrated gaiter) are suitable for conditions encountered during winter and spring in New Zealand. Double plastic or synthetic boots, designed for higher altitude alpine climbing, do provide extra warmth and have the advantage of being easier to dry out on multi-day trips camping in the snow but are often excessively warm for New Zealand conditions. Whether boots have an integrated gaiter or not, a separate snow gaiter is useful for approaching through deep snow.

Crampons

While general mountaineering crampons and axes can be used for ice and mixed climbing, a range of specialist ice gear is available. Crampons used for ice climbing need to be sharp so if you are using crampons for general mountaineering in the summer months, they will need to be sharpened for use on the ice. This eventually reduces their lifespan so if you plan on spending a lot of time ice or mixed climbing, having specialist gear can save money in the long term.

Vertically aligned front-points penetrate harder ice more easily with less shattering. Dual vertical front-points provide a more stable platform to stand on but in hard and brittle ice they can cause the ice to dinner-plate or shatter, requiring several more kicks to ensure a secure placement. Mono vertical front-points excel on hard brittle water ice where the points can be placed in the holes left by ice tool placements and allow very efficient and positive climbing. They are also good for mixed climbing and provide good balance on small rock features.

Ice tools

On steep water ice, modern highly curved ice tools make a big difference, especially when making placements over bulges and generally minimising effort on steep terrain.

Dedicated ice tools are shorter than general mountaineering axes and the curve and any handle will make it more difficult to plunge into the snow for security on the approach and descent.

Leashes

When using curved ice tools with ergonomic handles, wrist leashes are often not used at all. This makes it easier to recover, place ice screws and open up a variety of techniques to make things more efficient on technical climbs. If climbing without a wrist leash, an umbilical leash is recommended as they provide the benefits of leashless climbing whilst still maintaining an attachment and limiting the potential to drop the tools. Dropping ice tools could be a potentially serious issue on a long mountain route.

Wrist leashes, whilst not as popular since the arrival of umbilicals. They provide support and can promote a more relaxed grip on the ice tools which conserves effort but makes placing ice screws more awkward. Clipper wrist leashes allow the leash to be quickly detached from the tools, providing the benefit of having wrist leashes while making it easier to place ice screws and shake out tired arms.

Gloves

Keeping hands comfortable ice climbing takes a bit of management when ice climbing. It is good to have a range of pairs available to swap between for different tasks and to keep your warm pairs dry. Thin softshell or freezer worker gloves are dexterous for leading, especially on mixed terrain, and usually warm enough for the duration of a pitch providing tools aren't gripped too hard. Warmer, more durable, leather palmed gloves can be swapped into for belaying and abseiling or mitts for long stints belaying a lead climber. In between use, gloves can be kept warm and dry inside a jacket.

Other useful items

A V-Thread tool, whether it is a purpose-made one or a homemade one from a wire coat hanger, is a vital piece of equipment for making V-Threads.

A good method for racking ice screws is also useful. The most popular nowadays are ice clippers. These are inverted plastic carabiners that can neatly rack a number of long handled ice screws. Other options that can be attached to the harness include flutes or tubes that hold an ice screw each.

Petzl Multihook®

Black Diamond® Ice Clippers

Gear considerations for mixed climbing

Mixed climbing can put considerable wear on hardware and if a lot of dry tooling and mixed climbing is expected, it is worth having dedicated crampons or ice tool picks. Picks are either B or T rated. B rated picks are optimised for ice climbing with a narrower profile at the expense of strength. T rated picks are stronger in order to withstand the higher forces put on them by mixed climbing. Mixed climbing and dry tooling does dull the points of tools and crampons and having dedicated equipment also means that points do not need to be sharpened as regularly and they will last longer. Sharp points are required on pure ice routes, especially in very cold conditions. It is still possible to inadvertently snap a pick when mixed climbing and on long, committing routes it may be worth carrying a spare.

Protecting ice and mixed climbs

Judging ice quality

Ice can vary greatly in its structure. At one extreme it can be little more than frozen snow with a white, opaque appearance caused by lots of small air pockets. This is known as Alpine Ice and is great to climb on with easy, solid pick placements but is not strong or reliable enough to provide good opportunities for protection. At the other end clear water ice can be hard but potentially brittle, especially when temperatures are very cold. Pick placements may be shallow but can still be very secure and ice screw protection is good.

When placing ice protection, climbers should look for areas of more mature ‘blue’ ice and features of compression rather than tension. Imagine that the ice is ‘flowing’, and areas

where it is flowing slower such as slabs offer stronger ice. Avoid areas of tension such as bulges.

Ice screws

Ice screws are used almost exclusively on pure ice routes. They come in a number of different designs but most modern options have a fold out handle that helps screwing them in and out. They come in a variety of sizes up to 22cm long. The strength of the ice screw placement comes from the thread so longer ice screws do not necessarily make for a strong placement, but just engages the thread deeper and through the softer surface ice.

In good quality ice, the placement can potentially be stronger placed 10° down in the direction of potential pull. In less reliable ice, a placement 10° upwards in the opposite direction will be stronger. Perpendicular placement can provide high strength protection in both circumstances so if unsure stick with this.

Placing and removing ice screws

To place an ice screw clean off the softer surface ice to reach the good quality ice underneath. It may be useful to use an ice tool to make a small indentation to help get the ice screw to bite initially. Push and rotate the screw into the ice, aiming to place the screw perpendicular (90°) to the surface of the ice. Once the screw has bitten, start cranking on the handle. The quality of the ice and the reliability of the placement can be monitored by feeling the resistance as it screws into the ice and the consistency of the core being bored out of the centre of the screw.

Placing ice screws is worth practising including placing them one handed, with either hand from the security of a top rope before having to place them on lead.

Before placing an ice screw, place ice tools securely and high in order to hang from a straight arm on the upper tool. Bent arms will accelerate fatigue. Ice screws should be placed at waist level or below. Too high above waist level is difficult, tiring and dangerous as it ends up pulling outwards on tools.

Place ice screws from restful positions in good quality ice, extending them with longer runners if required to keep the rope running direct. The best ice to climb may be different for the best ice for placing screws.

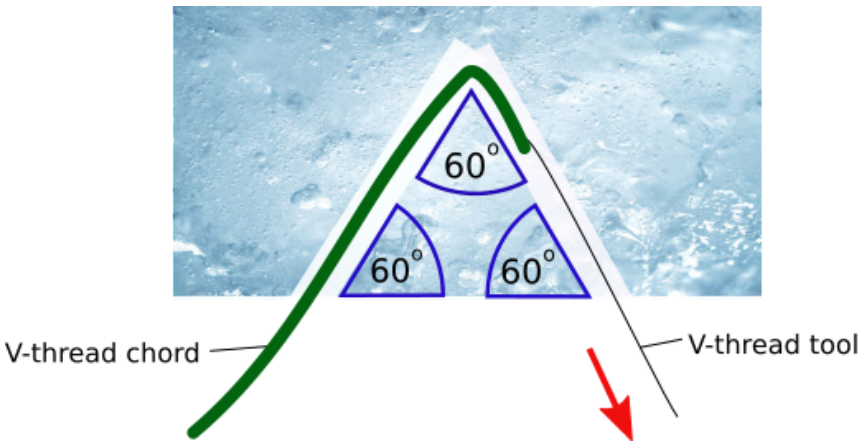
When removing ice screws, always clear the ice out of the inside of ice screws by gently tapping the top of the screw (not the thread or teeth!) against the head of an ice tool or blowing to prevent the ice core freezing in place which can make it very difficult to place the ice screw again.

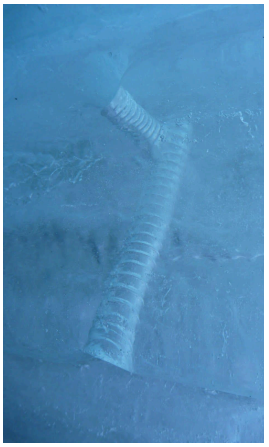
V-Threads

V-threads (also known as an Abalakov thread) are a strong type of ice protection that are often used as abseil anchors as it avoids leaving expensive ice screws behind. They can have a similar strength to a single ice screw placed in the same ice but their strength is usually limited by the breaking strain of the cord being used. V-Threads do take longer to build than placing an ice screw, but practice does improve the process. A piece of wire or purpose designed V-Thread tool is needed to pull the cord or tape through the V in the ice.

A V-Thread anchor can be built using a single ice screw. Begin with placing the screw 60° to the surface of the ice on the horizontal place. Remove it and measure out the position for the second hole using the length of the ice screw. The second hole will also need to be 60° and will need to be eyed up to intersect with the first hole. If all goes well and the holes meet up with the end of the cord can be poked into the first hole and using the V-Thread tool, hook and pull it out of the second hole. The cord can then be tied off with an overhand knot.

Although traditional practice was to build V-Threads in the horizontal plane, recent research has indicated that V-Threads built in the vertical plane (also known as A-Threads) have the potential to be slightly stronger.





Other ice protection

Threads can be constructed from a sling or cord threaded around features such as pillars of ice. Threads can potentially withstand loading in a number of directions so can be considered multi-directional. A V-thread tool can be useful for threading cord or slings around features. It is useful to carry long slings for this purpose. Depending on conditions or the nature of the route, more obscure pieces of protection such as Bulldogs and Warthogs can be useful to be used in mediums like frozen turf.

Rock protection

Rock protection is usually preferred where available the first choice for protection and anchors as it is easily placed and removed and can be more reliable.

Wires (also known as chocks, nuts Rocks® or Walnuts®) are a passive type of protection placed behind constrictions in cracks. Wires rely upon the strength of the rock around them and a sufficient amount of surface area in contact with the rock for their strength. Wires are usually only good for loading in a certain direction. A Nut key or ice axe pick is quite often necessary to remove wires.

Hexentrics (also known as Rockcentrics®) are another passive type of protection used in cracks. They have a hexagonal cross section and can be cammed or wedged into cracks. Although Hex's have largely been superseded by the invention of Cams they still offer cheap, solid protection, especially in winter when cracks can be iced up.

Spring Loaded Camming Devices, most commonly known as cams or by the product names of Friends® or Camalots® are an active form of protection using spring-loaded, cam-shaped lobes that expand outward until held in place by the rock around them. They have the outstanding property of actively camming in place in parallel-sided cracks. Ice in cracks can affect the holding power of rock protection such as cams and in some situations passive protection such as nuts, hexentrics and pegs provide more secure placements.

Pitons (also known as pegs or pins) – are steel wedges that are hammered into narrow cracks. There are a number of different designs each coming in a range of different sizes, known by names such as angles, knife blades and lost arrows. They can be especially useful in winter for mixed climbing when cracks can be filled with ice and can provide reliable protection in narrow cracks when no other options exist. If carrying pitons, a piton or ice hammer must be carried to insert and retrieve them.

Spikes can be used for quick pieces of protection. Slings can be hooked over the spike providing the spike is solid and that the sling sits well when loaded in the anticipated direction of pull.

Spikes are commonly used to construct abseil anchors only necessitating leaving behind an inexpensive length of cord.

Bolts are the most common form of fixed protection and often found in popular ice climbing areas where there is good but compact rock adjacent to the ice and especially useful for abseil anchors. Bolts in ice climbing areas should be checked for the tightness as the cold can cause the metal to contract slightly, eventually loosening the bolts. It is therefore useful to carry a spanner to tighten loose bolts.

When climbing in the mountains it is common to find pieces of protection, mainly slings or pitons, that have been left behind by previous parties, especially on standard abseil descents. It is important to thoroughly check any fixed protection of this nature before trusting it, especially old, worn or UV damaged slings.

Mentally use a rating system of 1 to 10 to help realistically assess the effectiveness of a piece of rock protection as a runner or component of an anchor. A piece of protection with a rating of 1 is not really worth the effort to place and retrieve it. A 10-rated piece of protection is commonly referred to as Bombproof and will have a high confidence of withstanding even the biggest lead climbing fall. Practice placing and testing protection in circumstances where no harm will result.

Climbing techniques for steep ice

Using ice tools

Swing tools from the elbow with a final rotation of the wrist to drive the pick in. If the picks get stuck, avoid pulling outwards on the handle and instead pull the pick out the way it went in, pulling upwards on the head. Tapping upwards on the head of the ice axe can help loosen it.

More reach can be achieved by choking the tool. This is moving the grip up the shaft and modern tools have grips for this purpose. Maintaining a low pull is vital when choking as it puts more outwards force on the placement that can pull it out of the ice.

On very steep ice that is very featured with lots of air pockets and hollows, it is possible to simply hook the picks of the ice tools into an ice pocket or existing tool placement without swinging. This can feel insecure initially in contrast to the picks being firmly embedded in the ice but can be much more efficient than repeatedly swinging the ice

tools. It is important to maintain a downwards force on the tools.

Swinging ice tools

Removing a stuck pick

Front pointing

When front pointing the soles of boots should be horizontal and shoulder width apart. If the heels of the boots are raised too high, the rubber toe of the boot will strike the ice first making it difficult to get a secure placement or front points will tend to shear downwards out of the ice. No amount of kicking will get a rubber boot to grip in the ice. If heels are too low, calves will become tired quickly and the points will not positively engage in the ice. With dual front points, the boots should be perpendicular to the ice to ensure both points are equally engaged.

It is common for beginners to kick too hard or repeatedly resulting in wasted energy. Usually a confident and well directed single kick is enough to get enough front point into the ice for a secure placement. Features of the ice can be used as when rock climbing, looking for edges and pockets to place the front points in to save effort.

Front pointing

On anything less than vertical most of the weight should be just on the feet and the stronger leg muscles with tools only being used for balance. Pulling excessively on tools may cause them to rip out. Keeping in balance and taking small steps will save valuable energy in the arms for when the going gets steeper.

The triangle position

At all times when climbing steep ice (75° or steeper), climbers should aim to adopt the triangle position with feet placed wide and tools placed as close to the centreline of the body as possible. Hips should be tilted inwards with knees slightly bent so they are over the front-points. In this position, the torso is leaning back which makes even vertical ice feel overhanging. This stable balanced position avoids swinging out of balance if one of the tools or feet were to pop out of the ice.

Triangle position - knees over toes and ice tools close to centreline

Progression on steep ice

Moving upwards on ice can be tiring and it is important to use an efficient and balanced technique that keeps the weight over secure feet and avoids pulling on bent arms. Good technique is the key to moving efficiently with the minimum of effort.

1. Point elbow at the ice, eye-up where to aim the pick placement at full reach above the head. Aim to place your tools close to the centreline of the body to maintain the stable triangle position;

2. Swing from the elbow and flick the wrist at the apex of the swing, using the weight of the tool to drive the pick into the ice. If any tool placement is in any way questionable then place it again until it sounds and feels secure but avoid potentially weakening a placement by repeatedly striking different points of the ice. The tool should be positioned so that the climber can hang on it with a straight arm. With a secure high placement, wiggle the lower tool loose but leave it hooked in the ice and pulling downward.
3. Move feet upwards which require moving the body away from the ice. Always move the lowest foot first and avoid big steps that will put excessive weight on the top tools and maintain a downwards pull on the tools. Use two or three steps finishing with feet placed level and equally spaced either side of the top tool making the stable triangle position.;
4. Stand up straight, using the legs to lift the body upwards and pulling the pelvis into the ice, bending the arms and pulling down on the tools;
5. Remove the lower tool and aim for a secure placement at full reach close to the centreline. Always aim to move the lowest tool when making upwards progress;
6. Move feet up and stand up, pulling pelvis into the ice and bending arms. Move the feet after every tool placement.

Progression on ice © George McEwan Collection

Transitioning from steep to lower-angle ice

There is a specific technique for transitioning from steep to lower-angle ice that avoids reaching too far with the tools, a manoeuvre that commonly results in the heels raising up and crampons shearing out:

1. Place tools in the low-angle ice, just above where the angle eases and careful to not reach too far;
2. Make a number of small steps up with the feet until one, then the other, can be placed on the lower-angle ice. Hands can be slid up the shaft of the tools but avoid pulling outwards on the pick. This will result in the centre of gravity sticking out from the ice and may temporarily feel precarious;

3. With both feet on the lower angle ice, in turn place each tool higher and stand up to reestablish a less strenuous standing position, balanced over your feet.

Strategies for leading on ice

Climbers should move quickly and efficiently through steeper sections between positions where they can rest and recover with weight on good feet. Mentally map these positions from the ground to plan a strategy for the route. Good foot placements will be relaxed and promote confidence.

The purpose of the mental map is also to ensure there are enough ice screws for the whole pitch without running out near the top of the pitch or for the belay.

Falling whilst leading must be avoided. Climbers should climb down to a rest position before falling due to fatigue. If arms are getting pumped, a solidly placed ice tool can be clipped into to rest or place an ice screw. Ice climbing should be in control and over gripping tools or climbing with bent arms accelerates fatigue.

Retreating off multiu-pitch ice climbs

A common practice when the intention is to abseil back down a multi-pitch ice climb is to spend time building V-Threads as one component of each anchor on the way up the route. This means that abseil anchors are ready to go for the descent and should be conveniently located a rope length apart. It is important that the V-Threads are placed well in good ice and haven't been weakened by the sun or elevated temperatures in the intervening period.

As V-Threads are commonly abseiled on individually, there should be high confidence in their strength. They should be tested whilst having the backup of a secure anchor and for all but the last person down, they can be backed up with a secondary ice screw anchor. It is important that this secondary anchor is not taking any of the load but backs up the V-Thread if it were to fail. The V-Thread and secondary anchor will not be equalised but the intention is to test confidence in the V-Thread. Excess slack should be avoided though as any significant shock load on the secondary anchor could cause it to fail as well.

If the ice is poor and there is insufficient confidence in a single V-Tread then a multiple number of V-Threads can be built and equalised together.


V-Thread, V-Thread backed up with an ice screw for abseiling

Mixed climbing

Mixed climbing combines ice and rock climbing techniques. A good repertoire of rock climbing movements are useful, such as layaways and bridging. Mixed climbs include alpine ridges and faces or crags in winter conditions where snow and ice conditions will dictate the difficulty of the climb.

Crampons on rock

Crampons can be surprisingly effective on rock, even if it's iced over with *Verglass*. Despite not having the feedback associated with climbing in soft rock climbing shoes, using the points on small rock edges and features, with some practice, can feel secure. As potentially only a small amount of metal and rock is in contact, feet must be kept steady during movements to avoid the points levering off. When this happens, it does so explosively. At all times, crampons should be placed accurately and confidently, with minimal scraping.

Dry tooling

Dry tooling is the use of ice tools on dry rock. Dry tooling techniques can use tools in a wide variety of placements and often requires imagination and creativity. Tools increase reach and can be used where there would be no purchase with hands or fingers.

Picks can be hooked on small positive rock features, such as flakes or chock stones, that are either too small to hold on to with hands or out of reach. When moving upwards, a downwards pull needs to be maintained on the tool.

A tool-cam (also known as a stein-pull) relies on keeping the pick in place on a rock feature by pushing or pulling the back of the axe against an opposing surface. This can put a lot of force on the pick and tool, so choking the tool can minimise the leverage.

Tools can also be torqued by placing the pick or shaft into cracks that are too small for fingers and twisting it to wedge it in place. Care must be given to maintaining the position and force throughout the movement to maintain the torque. As with tool-camming, the grip can be choked to adjust the leverage.

Excessive forces placed on tools when dry tooling can cause picks to snap.

At all times when using tools in rock, each placement must be checked before committing to it, especially if it can't be seen. It takes practice to develop a feeling through the tools for the integrity of placements. Weight must be kept low and close to the rock and kept steady during the movement to avoid the placement failing, similar to when using crampons on rock.

Hands and feet

On more subtle or sloping features, hands may be more efficient and useful. In this case, ice tools need to be stowed on the harness or backpack, draping it around the climber's neck or hooking the pick over the thumb of the climber's other hand. It is common to go leashless when mixed climbing. In some situations, thicker gloves may be removed for more purchase in which case a chord around the wrist is useful.