NZ CANYONING ASSOCIATION

BOLTING CODE OF PRACTICE

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AUTHORS

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Originally published in 2017, this document was revised in 2021and now includes additional information including covering the use of thread anchors and temporary/removable bolts.

For comment or amendment to this document, contact standards@nzcanyoningassociation.org

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Cover photo Kaiate Falls (Bay of Plenty) 2018 by Pete Smith.

ABOUT THIS DOCUMENT / DISCLAIMER

Canyoning involves an inherent risk of death or severe injury. The ultimate responsibility for these risks remains with the individual canyoner. Whilst every effort has been made to ensure the accuracy of the information in this document, the authors and the NZCA accept no responsibility or liability for loss or damages in relation anyone's interpretation or use of this code of practice.

This document is **not** intended to provide definitive advice on canyon anchors. The extreme variability of rock characteristics in the natural canyon environment makes that impossible. Installing safe anchors requires considerable knowledge, judgement and skill.

This document is **not** a substitute for the practical training and experience which is required to gain that knowledge, skill and judgement. The purpose of this document is to raise the awareness of those who are considering bolting of the known issues, and to offer guidance on good practice to address those issues.

A summary of this document is also available at www.nzcanyoningassociation.org

PART ONE: CONTEXT OF THE BOLTING CODE OF PRACTICE

BACKGROUND

Locals and visitors alike have been exploring NZ's canyons for decades and in some cases, have chosen to place bolt anchors. In other cases, explorers have been forced to place bolted anchors, where no other alternative anchoring options exists to escape or descend the canyon.

The international canyoning community has become aware of the opportunities for canyoning in New Zealand. There are many foreign canyoners who enjoy our established routes, or who come here with the sole aim of descending and bolting as many new canyons as possible.

Many of New Zealand's canyons have bolted anchor stations; however, the quality and legitimacy of these anchors varies markedly.

As more people visit established canyons and more expeditions seek out new canyons, it is important to establish good practise for the establishment of permanent anchors to ensure bolting is Legitimate, Ethical and Safe.

LEGITIMACY

CONSERVATION LEGISLATION

The Conservation Act 1987 established the Department of Conservation (DOC). This Act is the over-arching legislation for our Public Conservation Land, which is where the majority of canyoning takes place. The Act requires DOC to create 'Conservation Management Strategies' (CMS) for a conservancy (i.e. region) which outline the broad intent for public conservation land management. From the intent of the CMS, subordinate and specific management plans are written. These are either a National Park Management Plan (NPMP) under The National Parks Act 1980[1] or a 'Conservation Management Plan' (CMP) under the Conservation Act 1987 for other designations of conservation land.

Each parcel of public conservation land is held under a specific section of the Act, and certain rules apply. Legislation is available online, and statutory management documents are available from the DOC website.

Among many other policies for the appropriate management of our conservation estate, these Acts state that it is an offense to willingly damage any stone (i.e., by placing a fixed anchor) within the park/area without permission from the Minister of Conservation.[2]

For practical purposes, the authority to give 'permission from the Minister' is delegated to DOC, who can grant permission through the policies in the NPMP or CMP.

CONSERVATION POLICIES FOR BOLTING

The policies regarding fixed anchors vary from plan to plan. In some, such as the Aspiring NPMP, bolting may be authorised provided it meets several requirements, including minimal adverse effects and in line with a Code of Practice[3].

[1] _(National Parks Act 1980, n.d.)
[2] _(Conservation Act Section 39 para 1e, 1987)
[3] _(Aspiring National Park Management Plan, 2011)

In other plans, such as the Westland Tai Poutini NPMP, the policy states that DOC should 'Discourage the use of permanent bolts'[4] but that a 'Code of Practice be developed in conjunction with the climbing fraternity' because DOC acknowledges that a pragmatic approach is required and it is better for bolting to be managed with the support of those who place the bolts, rather than trying to totally prohibit their use.

Management Strategies and Plans are written for 10 year periods and updated by DOC, taking public consultation into account. These documents are large, complex and cover a huge range of subjective and conflicting issues. As a result, they are slow to be updated, and many are overdue for revision. NZCA will advocate during all strategy and plan consultations which may affect canyoning.

CMS NATIONAL CONSISTENCY - BOLTING (FIXED ANCHORS)

Due to the inconsistency in park management plans DOC created a document to provide guidance when reviewing CMS to provide national consistency for Bolting policies[5].

This guidance has been followed in the current Canterbury, Southland and Otago CMS[6]. The Otago CMS intent for bolting is pragmatic, and allows for bolting to be authorised, in some areas and not others, provided it meets reasonable criteria. The criteria involve liaison with the NZ Alpine Club (NZAC) and consideration of the NZAC position on bolting and Bolting Technical Guidelines where the bolts are permitted for climbing.

Where bolting is permitted for activities other than climbing liaison with a 'relevant organisation' is expected. The NZ Canyoning Association is the relevant organisation which represents the interests of the members of the NZ Canyoning Community.

LIAISON WITH DOC CONSERVANCIES

Appointed representatives of NZCA should liaise with DOC to ensure CMS and CMP allow the use of bolts for canyoning where appropriate.

PRIVATE LAND

Bolting on private land must only take place with the permission of the land manager. In a canyoning context, this could be a freehold or lease hold farm, or local government reserve where a canyon is located.

The Health and Safety at Work Act 2015 (HSWA) and its Adventure Activity Regulations 2016 legislate the duties required when work is performed at a place. Land managers have duties to manage hazards associated with work activities, and a duty to inform any person entering that 'work place'. These duties have made some landowners reluctant to grant access or permission to bolt.

WorkSafe, the government department which applies the HSWA, has issued specific guidance aimed at recreational access to private land[7]; which clearly states that recreational visitors must manage their own risks of the activity as well as of any 'safety fixtures'. The land manager only has a duty to inform the visitors of any extraordinary hazards associated

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[4] (Westland National Park Management Plan, 2001)
[5] (NZ Alpine Club Bolting Philosophy & Standards (For Route Developers), 2020)
[6] (Otago Conservation Management Strategy, 2011)

[7] Health & Safety in Work Act 2015

with current activities on the land (i.e., blasting, earthworks, helicopter operations etc..) It is worth referring to the WorkSafe guidance document when discussing access with any land owner.

ETHICAL STANDARDS

The presence and placement of fixed anchors is one of the most controversial issues in technical mountain sports world wide. Canyoning is no different, with very strongly held opinions as to whether or not bolts should be used.

This discussion was inspired by the original NZAC Position on Bolting as many of the wider themes are similar. However, it is important to note the different use of anchors between canyoning and climbing. Climbers use protection (temporary or fixed anchors) during ascent of a climb, which is the focus of their activity.

Although many climbers' descents involve abseiling/rappelling and therefore the leaving behind of an anchor (be it a bolt, sling or other item), many others only require walking or scrambling. The sport of canyoning focuses only on descent, and as such any technical canyon (involving ropes) also involves some type of anchor which generally must be left behind.

RATIONALE ON THE USE OF BOLTS IN CANYONS

The opinions for and against the use of bolts generally relate to the impact of bolting on the environment, and the impact on the practise of canyoning by people.

REASONS FOR PLACING BOLTS IN CANYONS

Impact on the Environment	Impact on Canyoning
Minimising impact on non-durable surfaces **Bolts can be situated in a wide range of places. Well situated bolts can ensure canyoners remain in the watercourse and travel on durable surfaces.** **Natural Anchors can only be constructed where the environment allows (e.g. suitably strong tree or correctly oriented crack).** **This may require canyoners to exit the watercourse to create an anchor, trampling surrounding vegetation surrounding the canyon. Due to the location of the natural anchor, canyoners may have no option but to descend on non-durable surfaces.**	**Encouraging safe route selection** Well situated bolts encourage canyoners to descend the safest possible line, minimising hydraulic and vertical dangers. Bolts can encourage the use of a variety of common canyoning techniques to descend a canyon e.g. hand/approach lines, guide lines.
Preventing damage to trees **Bolts remove the requirement to sling trees, which are likely to be damaged with repeated use.**	**Decreases the commitment of a canyon** A well bolted canyon can be more readily descended, including by less experienced groups, ensuring safer passage at higher waterflows and ensuring a wider range of visitors can enjoy the sport.
Minimising visual impact / litter **The visual and physical impact of well installed bolts is much lower than the practise of leaving slings, nuts or pitons which degrade over time and may end up as litter within the canyon.**	**Descent of high quality slot canyons** The highest quality canyoning descents exist where the canyon is deeply gorged, and the rock walls are polished smooth. In many places within these types of canyons, bolts are the only possible method of establishing anchors.

REASONS AGAINST PLACING BOLTS IN CANYONS

Impact on the Environment	Impact on Canyoning
Permanent alteration of the rock Bolting requires permanent alteration of the rock. Although the practise of 'over drilling' allows a bolt to be hammered beyond sight into the rock, the alteration cannot be un done.	**Bolts require less skill and judgement to use**. This may encourage less experienced people into canyons beyond their ability. Anchor creation and problem solving is an aspect of canyoning that is valued by many within the canyoning community.
Visual Impact Bolts can create a visual impact which reduces the natural values of an area. Although only canyoners will be able to view these bolts, they are the only people directly affected by the visual impact.	**Bolts are easy to incorrectly install.** Poorly installed anchors may have very low strength. Poorly situated anchors may increase exposure to objective risk.
Bolts encourage use A bolted canyon is likely to receive more users, which has the potential to increase impact to the canyon and access route if not properly managed.	

BOLTED ANCHORS IN THE INTERNATIONAL CANYONING CONTEXT

It is worth considering the use of bolted anchors for canyoning in the major canyoning regions of the world.

These regional communities may be generally more pro-bolt or anti-bolt, depending on the nature of the rock in the canyon, the nature of the canyon's surrounds, the amount of water flow through the canyon and the cultural attitudes towards mountain sports.

NORTH AMERICA

In the USA, the sport developed based on the sandstone desert canyons of the Colorado Plateau. These slot canyons generally have little to no water flow, sheer walls, minimal vegetation and soft rock. The prevailing ethic is anti-bolt. There are usually sufficient natural anchor options, conservation and minimal impact values are strong and bolts are of low integrity in sandstone. Due of the lack of water flow, complex natural anchors are possible, making anchor problem solving one of the key challenges and values of the sport. The USA has the Coalition of American Canyoners[8] which is a community group which seeks to advocate the sport and deal with issues such as bolting.

In more recent times, high-flow mountain canyons in the north-western USA and western Canada are being explored. These canyons are similar in style to some NZ canyons and the prevailing ethic is pro-bolt due to the high-flow conditions and lack of other anchoring options.

AUSTRALIA

The sandstone canyons of New South Wales' Blue Mountains have low to moderate water flows, reasonable amounts of vegetation and reasonably soft rock. The ethic is generally anti-bolt among recreational canyoners, but there are several canyons that have been specifically bolted by the NSW Parks and Wildlife (NSWP & W) department due to commercial pressure or public safety concerns. There are usually natural anchor options, and the low flows mean there are few restrictions on where natural anchors could be situated. The popularity and/or commercial use of some canyons have led NSWP & W to place significant glue-in anchor stations (which many describe as grossly over-engineered) as natural anchors wear out with frequent use. In 2020 The NSW Canyoning Association (2018) became the Australian Canyoning Association[9] which aims to foster an appreciation for and co-operate to pursue safe, responsible canyoning and related activities by promoting a code of ethics for canyoning, being the voice for the Australian canyoning community and caring for the environment. Outside of the Blue Mountains, there has been a rapid growth in canyoning activity. Here, the harder rocks and higher flows are more similar to parts of NZ, and have resulted in generally a pro-bolt ethic.

EUROPE

The canyons of the Alps are moderate to high flow, through very solid and often polished rock. The ethic is strongly pro-bolt. Due to the high numbers of people that practise canyoning, the emphasis is primarily on safety and sport rather than exploration or natural values. Bolts are suitable due to the high water flows, strong rock and amount of use. Bolting practises are generally moderated through various national canyoning associations. District councils often provide funding for the bolting of canyons in the same way NZ councils provide money to establish mountain biking areas; for increased visitor use.

[8] (Coalition of American Canyoneers, 2021)
[9] (Australian Canyoning Association, 2021)

USE OF BOLTED ANCHORS IN THE NEW ZEALAND CONTEXT

New Zealand's canyons vary in character throughout the country. The water flows vary between regions from low to extreme, with most falling in the moderate to high category. The rock in our canyons is generally solid and suitable for bolting. Whilst many canyons can be descended without the use of bolts, there is a good proportion where bolting is the only option at certain places.

Visitation of canyons is likely to continue to increase in the future. Well-placed, quality bolts are generally considered acceptable in most circumstances by the canyoning community, but inferior, unsafe or excessive bolting is not.

This Bolting Code of Practice will help the pragmatic and ethical management of the bolting issue in NZ's canyons.

VISITING CANYONERS AND INTERNATIONAL EXPEDITIONS

As the ethics of bolting vary considerably between regions of the world, it is important this code of practice is easily available online for visiting canyoners and international expeditions to reference.

The NZCA and canyoning community should proactively engage with visiting canyoners to inform them of the local ethics, so that the values of canyoning in NZ are maintained.

PART TWO: THE NZCA BOLTING CODE OF PRACTICE

INTRODUCTION

It is essential to the safe and responsible development of the sport that a canyon Bolting Code of Practice is followed.

This document provides guidance for bolting in recreational canyoning situations. For guidance on bolting for commercial canyoning, see the relevant section of the Canyoning Activity Safety Guideline[10].

This guideline should be read in conjunction with the relevant DOC Conservation Management Strategy or National Park Management Plan.

Anyone considering bolting for recreational canyoning is encouraged to contact The NZ Canyoning Association (NZCA) for further guidance, or assistance with stakeholder liaison.

Those considering placing bolts in NZ canyons should ask themselves these questions:

- Are we allowed to bolt?
- Should we bolt?
- Who should do the bolting?
- How do we bolt?

PUBLIC LAND

Bolting should only be carried out in consultation with Department of Conservation or other relevant Territorial Land Authority, with due consideration to the Conservation Management Strategy, Conservation Management Plan or National Park Management Plan. Local iwi should be consulted where relevant.

PRIVATE LAND

Bolting on private land must only take place with the permission of the landowner. Local iwi should be consulted where relevant.

[10] _(Canyoning Activity Safety Guideline V3.0, 2019)

SHOULD WE BOLT?

TEMPORARY BOLTS

In some situations, it may be considered appropriate for temporary bolts to be used. If the canyon is likely to be used in the future, any temporary bolts must be removed or upgraded to permanent bolt standards as soon as possible.

These situations include emergency bolting, and exploration/first descent bolting, which are explained below;

EMERGENCY BOLTING

Due to the dynamic nature of canyon environments, events such as floods and rock fall can render bolts useless or destroy them. As such events may occur without the knowledge of the canyoning community, most canyoners carry a lightweight hand bolting kit for emergency use.

It is ethically acceptable to place emergency bolts as a **last resort**, where there is no other practical means to descend or escape the canyon.

Placing a bolt by hand is a slow process. In the context of emergency, where hypothermia, rising water levels or other significant hazards need to be managed, the time taken to create an anchor needs to be minimised. Therefore, the practical standard of the bolt anchor is generally lower (Shorter, thinner, quicker to place bolts) and commonly only one bolt is placed.

Though these anchors may be sufficiently strong for the party that places them, they are unlikely to be suitable for long-term, frequent use. They should be notified to the community, so that they may be removed or replaced with suitable high strength, long life bolts.

EXPLORATION/FIRST DESCENT BOLTING

In the context of exploration, where small groups of expert canyoners are descending canyons for the first time, bolts may be placed where no other practical means is available to descend or escape the canyon.

When the location, length and difficulty suggests it is probable that the canyon descent may be repeated in the future, these bolts should either be readily removable (temporary) or meet the technical standards for permanent bolts. Lower strength or quality bolts that cannot be removed are not acceptable for exploration of canyons which are likely to be repeated. For example, an extremely high and long canyon route in a very remote area is very unlikely to receive many (if any) repeat descents. Whereas a moderate canyon within day-trip range of the road will get plenty of visits if it is of reasonable quality.

Temporary anchors are not suitable for long term, frequent use. The moral responsibility lies with the person who placed the anchor to remove and replace it with suitable high strength, long life bolts. At the very least, the community should be notified, so that others who may repeat the trip are able to assist in the upgrade of anchors to the minimum permanent anchor standard.

PERMANENT BOLTS

Any bolts placed in canyons which are likely to be repeated should meet the permanent bolt standard.

Permanent bolts must have a sufficient margin of safety for all reasonably expected uses of that anchor. It is impossible to test the strength of an anchor to a standard without specialised equipment, which generally makes assessment impractical for recreational users.

Because of this, any permanent bolts must be made of quality, long lasting materials and of sufficient strength to ensure a margin of safety for many years.

Permanent bolts that do not meet the legal, ethical or safety standards of this code of practice should be removed or replaced when practicable. Permanent bolts are placed during planned bolting.

PLANNED BOLTING FOR RECREATIONAL USE

Planned bolting is when it is intended, prior to the descent, to place high quality permanent anchors in a canyon. Planned bolting is normally done with a high power electric hammer drill, which is relatively quick and efficient.

The NZCA will assist in obtaining the views of the relevant canyoning community and other stakeholders on whether bolting is appropriate for a particular canyon or canyoning area.

Bolting may be considered appropriate if the benefits of bolting significantly outweigh the potential impacts on the environment and impact on the practise of canyoning in that canyon.

Bolted anchors should allow canyoners to safely descend in close proximity to the water. Canyons where the high flows require an excessive number of bolts to establish a contrived line clear of the water should not be bolted.

Planned bolting should only use high-quality, long life materials and techniques which meet the permanent bolt standard.

PLANNED BOLTING FOR COMMERCIAL USE

Bolting for commercial purposes is beyond the mandate of this document. (Refer to the Canyoning Activity Safety Guideline)[11]. In a commercial setting, consideration is often given to creating more substantial anchors, suitable for high intensity and frequency of use.

[11] _(Canyoning Activity Safety Guideline V3.0, 2019)

UPGRADING OR RETRO BOLTING

From time to time there may be value in replacing, upgrading or adding hardware in existing canyons. For example, replacing existing mechanical anchors with chemical anchors in a canyon that experiences a high volume of canyoners.

If a canyon is already established and has been accepted by the wider community for a period of time, consideration should be given to consulting with the first descenders/bolters/wider canyoning community before an individual or company undertakes any bolting that may affect the nature of the canyon.

Those who are considering retro-bolting a canyon are encouraged to approach the NZCA to assist consultation with interested stakeholders, and to help mediate in any disagreements.

AN IDEAL APPROACH TO CANYON DEVELOPMENT

With the advances in bolting technology and raising of standards, the canyoning community has the ability to bolt with the least impact to the canyon, the highest standard of safety and the longest-term sustainable solution.

In an ideal world, initial anchors would be easily removable (screws for medium to hard rock and sleeves for very hard rock) and carefully placed in the perfect position. In subsequent trips, these would be removed and the holes used again to place extremely long lasting and extremely strong chemical anchors.

The reality is that practical constraints of the time, foresight and cost required of those who bolt mean this ideal will not be followed everywhere. This document takes a pragmatic approach to progress the currently acceptable minimum standards, whilst encouraging the community to strive towards the highest possible standard for the future.

RECORDING OF BOLTING

The type of bolts and year of installation should be recorded, so that the information can be included in canyon topo diagrams and descriptions to aid in monitoring of the scope and quality of bolting in NZ Canyons. Information can be recorded and shared with the community by submitting a canyon topo to the Kiwi Canyons website or by logging a trip report for existing canyons.[12]

INSPECTION OF EXISTING ANCHORS

The minimum standard for anchors in this document provide at least a 10:1 safety factor based on maximum anticipated loading as well as redundant construction utilising durable materials. Therefore, not only is it impractical to load test most recreational canyon anchors, but it is also unnecessary. Bolts and permanent artificial anchors should only be installed by suitably experienced and competent people adhering to this standard however, the responsibility should be on individual canyoners to inspect every anchor before it is used. A thorough visual inspection should be carried out taking in to account the following,

- **ROCK** - Check the rock looks in sound condition with no cracks radiating from the bolt or loose sections of rock
- **BOLTS** - Check the bolt and attachments and see if it is bent or otherwise malformed.
- **NUTS** - Check the nuts and other connectors are tight and secure.
- **CORROSION** - Check for corrosion.
- **WEAR** - Check for significant wear greater than 10% of original stock size.
  REPORT - Report any faulty bolt anchors to canyoning community via trip report on Kiwi Canyons website.

[12] (Kiwi Canyons Website, 2021)

WHO SHOULD DO THE BOLTING?

COMPETENT PEOPLE WHO TAKE ON THE MORAL RESPONSIBILITY

Although individual canyoners must assume all personal risk when using a bolted anchor, those that place the bolts have a moral obligation to ensure anchors are as safe as is reasonable for the situation.

Bolts should only be placed by competent people with experience in the correct bolting techniques. Bolting is a task for canyoners with high levels of experience, judgement and technical expertise.

Those people should be familiar enough with the canyon, to consistently choose the most suitable location for an anchor. The location of the anchor station is a critical factor when considering safety, anchor longevity and environmental impact.

Bolting cannot be learnt from theory alone. Anyone considering bolting should approach a suitable mentor/instructor to gain practical experience in the art and science of bolting.

A bolt only takes a few moments to place, but the impact on the rock is permanent. Where the rock space to place a suitable anchor is limited, there might be only one chance to get it right.

HOW DO WE BOLT?

BOLTING CONSIDERATIONS

When bolting, we must ensure that the anchors,

- Meet the minimum construction standards,
- Are placed using the correct installation principles,
- Are placed in suitable rock; and,
- Are placed in a suitable position.

These considerations are discussed below.

MINIMUM CONSTRUCTION STANDARDS FOR ANCHORS

TEMPORARY ANCHORS

- The complete anchor system must have a minimum ultimate strength of 15 kN.

Justification: This strength aligns with the minimum UIAA 105 standard[13] strength for harnesses (15 kN) and exceeds the static strength with termination standard for UIAA 107[14]/EN1891 type B ropes for abseiling (12 kN). This demonstrates that 15 kN offers sufficient safety for use by the party placing the anchor.

This strength is not sufficient for rescue loads, and does not give enough excess safety margin to remain strong enough for frequent or long-term use.

PERMANENT ANCHORS

- The complete anchor system must have a minimum ultimate strength of 20 kN.
- Two bolts must be used for abseil anchors or initial handline anchors.
- All anchor components must be constructed of the same material, being 316 (or better) Stainless Steel.

Justification: 20 kN conforms to UIAA123[15].which is the most relevant accepted standard for recreational climbing anchors. In practise, most 10mm diameter stainless steel bolts will meet this standard.

By way of comparison, The New Zealand Canyoning Activity Safety Guideline[16] (for commercial canyoning) sets a 22 kN minimum, whereas EN959 (2018)[17] sets a 25 kN minimum. AS/NZS 1891.4 (2009) (for industrial rope access) states a minimum of 21 kN for two person freefall situations. In practice, 12mm diameter stainless steel bolts would be required for these commercial and industrial standards practically.

INSTALLATION PRINCIPLES

- Bolts must be installed according to the manufacturers' guidance.
- Tools used must be suitable for the task.
- Ensure the anchor site is in sound rock, at least 1.5x a bolt length away from any fissures or cracks.
- Check the rock surface before drilling, to ensure hangers will sit flush with the rock.
- Hangers must not be loose or able to spin.
- The bolt stud should not protrude excessively.
- Two bolts should be used on any abseil anchor, or the start of a safety line anchor.
- A single bolt is acceptable for intermediate anchors for safety lines.
- Double bolts must be at least 2x the bolt length or 200mm apart (whichever is greater).
- Always use like material on anchors. For example, use a 316 stainless bolt with a 316 stainless hanger to avoid galvanic corrosion.

[13] (UIAA 105 Harnesses V4, 2018)
[14] (UIAA 107 Low Stretch Ropes V4, 2018)
[15] (UIAA 123 Rock Anchors V4, 2020)
[16] (Canyoning Activity Safety Guideline V3.0, 2019)
[17] (British Standards EN 959, 2018)

ASSESSING THE SUITABILITY OF THE ROCK

Rock strength and suitability for placing anchors can vary greatly within a canyon. Assessing the suitability of the rock is perhaps the most difficult aspect of placing a bolt. It relies heavily on judgement and experience. This aspect of anchoring must be learnt from an experienced and skilled mentor. An anchor is only as strong as its weakest component, and therefore the rock must be assessed as strong enough to support a safe, strong anchor.

When assessing the suitability of the rock;

- Verify the hardness and uniformity of the rock using a bolting hammer. Feel for the 'bounce back', listen for the noise and watch for any deformation/cracking.
- Ensure you have a clear view of the rock surface, then visually scan within an arm length circle around the intended site to look for deformities, cracks or weak layers.
- Check that the rock is part of the canyon, not a loose block or detached flake.
- Ensure you understand when rock is soft enough to require chemical anchors instead of mechanical ones, and when the rock is too soft for any type of bolting.

WHAT COUNTS AS 'SOFT' ROCK?

Practically all sources of information on bolting for vertical sports state that mechanical anchors are acceptable for 'hard' rock, but only chemical anchors are suitable for 'soft' rock. However, the authors of this document found very little scientific guidance on what counts as 'soft' rock, where mechanical anchors (of the size that canyoners might use) are no longer suitable.

The EN959/UIAA123 standard for rock climbing anchors use 50MPa (megapascal) compressive strength concrete as the substance the anchors are tested in.

A thesis by an Australian civil engineering student[18] assessed that 10mm glue in eye bolts just exceeded the EN959 standards for 25-30MPa sandstone.

We can therefore be comfortable to conclude;

For rock greater than 50MPa
- Suitable mechanical anchors will likely meet the strength requirements.

In rock between 25-50MPa
- 10mm eye bolt chemical anchors will likely meet the strength requirements.

Less than 25MPa
- There is insufficient evidence to be able to give a good recommendation.

But how can we tell the compressive strength of the rock we find in the canyon?
The short answer is that we cannot with any degree of certainty.

A paper by Engineering Geologists[19] gave a table which suggest some tests to estimate the strength of various types of rock. Whilst the word pictures for assessing the categories are helpful as initial assessment techniques, the only firm conclusion we can draw from this table is that assessing the strength of rock in a canyon is highly subjective, and whenever there is any doubt that the rock is hard enough for mechanical bolts, then chemical bolts should be used.

[18] (Hawkshaw, 2003)

[19] (Marinos & Hoek, 2000)

When installing a collar stud anchor, if the collar does not grip, or takes an excessive amount of tightening to grip, that is a good clue that the rock is too soft for expansion type mechanical bolts.

Table 1: Field estimates of uniaxial compressive strength of intact rock.[3]

Grade*	Term	Uniaxial Comp. Strength (MPa)	Point Load Index (MPa)	Field estimate of strength	Examples
R6	Extremely Strong	> 250	>10	Specimen can only be chipped with a geological hammer	Fresh basalt, chert, diabase, gneiss, granite, quartzite
R5	Very strong	100 - 250	4 - 10	Specimen requires many blows of a geological hammer to fracture it	Amphibolite, sandstone, basalt, gabbro, gneiss, granodiorite, peridotite , rhyolite, tuff
R4	Strong	50 - 100	2 - 4	Specimen requires more than one blow of a geological hammer to fracture it	Limestone, marble, sandstone, schist
R3	Medium strong	25 - 50	1 - 2	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single blow from a geological hammer	Concrete, phyllite, schist, siltstone
R2	Weak	5 - 25	**	Can be peeled with a pocket knife with difficulty, shallow indentation made by firm blow with point of a geological hammer	Chalk, claystone, potash, marl, siltstone, shale, rocksalt,
R1	Very weak	1 - 5	**	Crumbles under firm blows with point of a geological hammer, can be peeled by a pocket knife	Highly weathered or altered rock, shale
R0	Extremely Weak	0.25 - 1	**	Indented by thumbnail	Stiff fault gouge

* Grade according to Brown (1981).
** Point load tests on rocks with a uniaxial compressive strength below 25 MPa are likely to yield highly ambiguous results.

SCHIST HAPPENS

It is worth a discussion on bolting in Schist, which is the rock type around the popular canyoning areas near Wanaka and Queenstown. Schist comes from sandstone which has been metamorphized by intense heat and pressure. The pressure leads it to form layers, which give its characteristic appearance. The amount of heat and pressure roughly corresponds to the hardness of the rock. This varies roughly according to the distance away from the Alpine Fault, from soft rock in certain areas around Wanaka and Queenstown, through to medium Schist around Makarora/Glenorchy and then hard Schist (or even Gneiss) around the Dart Valley/Haast Pass area.

Soft Schist close to Queenstown/Wanaka can often be too soft for mechanical anchors; Chemical ones should be used instead where there is any doubt that the rock is strong enough for mechanical expansion anchors.

When selecting a bolting location in schist, the anchor stud should be oriented so that it can penetrate vertically through multiple layers, rather than being in-line with the strata. ie. for the best placement, the rock surface should be uniform, without evidence of multiple layers. If you can see many exposed layers/strata on the face of the rock, the placement will be considerably weaker and may not meet the required strength standard.

POSITIONING OF ANCHORS

The location of an anchor station is critical to maximise safety and anchor longevity and to minimise environmental impacts.

Anchor stations should be positioned such that:

- They are easily reached by a canyoner of average height and with appropriate skill for the grade of canyon.
- The anchors should be reachable across a durable surface, in all reasonable flow conditions*.
- They are positioned such that it is difficult for a careless canyoner to shock load or incorrectly load the bolts.
- The bolts are oriented in a way that allows the use of single rope technique, minimises wear on the rope and allows for easy retrieval.
- They encourage a line of abseil descent which is on a durable surface and minimises the risks of hydraulic danger in all reasonable flow conditions*.
- They are protected from damage in floods by being clear of the anticipated current and flood debris.

**__Reasonable flow conditions__ mean up to the highest water levels which a competent group could descend the canyon. This is higher than the levels where a group would intentionally enter the canyon, but below flood levels. It allows for use of the anchors/descent line in the event that water levels rise during a descent, to allow the group to continue.*

Before placing a bolt, we must also consider:

- If the bolt needs to be replaced in the future, can it be easily removed?
- If the bolt can't be easily removed, is there space for new holes to be drilled in a suitable location for the pitch?

In some situations where space on a suitable rock surface is limited, there may only be one chance to get it right. Think extremely carefully before acting; your actions will have permanent impact on the canyon!

GUIDANCE ON ACCEPTABLE ANCHOR TYPES

The types of anchor which usually meet the minimum construction standards, practical considerations and ethical standards varies for each situation, and is summarised in the table below.

Green is usually acceptable, Red is usually unacceptable. Orange indicates that the anchor type may be suitable in certain circumstances. These circumstances are discussed futher below.

Regardless of this guidance, the manufacturers specifications must still be checked to ensure the anchor used has sufficient ultimate strength to meet the minimum construction standards.

**Note: Commercial Anchors are not included in the scope of this document*

	Temporary 15 kN MBS	Permanent 20 kN MBS
Self-Drilling Anchor	**May Be suitable** Only when not carrying a power drill	**Unsuitable** Very difficult to remove
Sleeve Anchor	**May Be suitable** Sometimes hard to remove	**Unsuitable** Easily removed
Screw Anchor	**Ideal** Easy to place & remove	**Unsuitable** Repeated Use can Loosen in hole
Petzl Coeur Pulse	**Ideal** Very quick to replace & remove.	**Unsuitable** Expensive. Easily Unlocked & Removed
Drilled Thread	**Ideal** Low Impact. Lightweight	**Ideal** Easily replaced. Ideal for flood zone
Collar-Stud (wedge) Anchor	**May Be suitable** Not removable. Must be placed carefully	**Ideal** Easy to place & long lasting
Chemical Anchor	**Unsuitable** Not removable. Glue takes long time to set	**Ideal** Best solution. Long lasting & suitable for soft rock

MECHANICAL ANCHORS

SELF-DRILLING ANCHOR

Such as Petzl Cheville Autoforeuse 15 kN or Raumer 18 kN

These are a light weight anchor option and are the quickest bolt to place by hand. However, they are next to impossible to remove or cover up when they are no longer required and there is very little margin for error when placing them. Even though they cannot be removed they may be considered for emergency or exploration bolting, specifically when it is not anticipated that bolts would be needed, and a lightweight hand drill kit is carried for use as a last resort. There are definitely more modern options available now that are a much better alternative to the self-drilling anchor which should be considered an absolute last resort option.

- Drilling depth is critical.
- Bolt must be flush with surface of rock.
- Bolt must be perpendicular to rock
- Not suitable for soft rock
- Not a preffered anchor solution.

Petzl Autoforeuse self drilling anchor and Hanger.

SLEEVE ANCHOR

Such as ClimbTech Power-Bolt Sleeve Anchor

A suitable temporary anchor. Sleeve bolts can usually be removed, although damage to the hole is possible. The load bearing part (stud) of the bolt is thinner than it appears, meaning that generally a 10mm sleeve bolt may not meet the strength requirements for permanent anchors which must be considered if using this type of anchor.

- A practical minimum bolt diameter of 10mm, gives an 8mm stud and approximately 15 kN ultimate strength.
- Bolts should be at least 75mm in length
- The hole may be usable again by a permanent anchor.
- Not suitable for soft rock.
- All components of the bolt must be the same metal, to minimise galvanic corrosion.

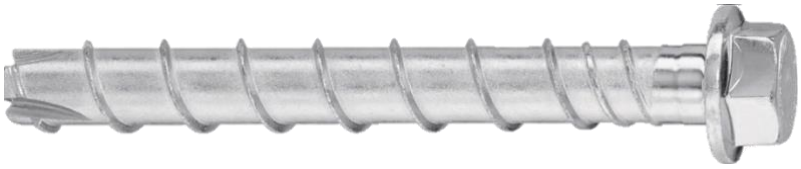
Climbtech Power-Bolt Sleeve anchor

SCREW ANCHORS

Such as Raumer Multi Monti or Hilti HUS3

A suitable temporary anchor. They can be used for exploration or emergency bolting and removed at a later point. The same hole can then be drilled again with a full diameter bit, and then used to place a permanent bolt if required. All concrete screws are not created equal and care should be taken to ensure that reputable brands are favoured that meet the minimum strength requirements.

- For the Hilti HUS3-H, A practical minimum dimension of 8mm x 60mm corresponds to 19 kN shear strength[20]. The HUS3-HR (Stainless Steel) 6mm x 55mm has a remarkable characteristic resistance of 17 kN in shear[21](refer to the manufacturer data for other brands and dimensions of screw anchor to ensure they meet the minimum standard).
- Overtightening can lead to deforming (weakening) of the metal between the head and the shaft. This is where the greatest rappelling load is applied.
- Screw anchors are the recommended solution for temporary anchors in hard to medium strength rock. This is because they are simple to remove, and the holes can be re-drilled to a suitable dimension for permanent solutions. However, they are not suitable for very hard rock, as it can become impossible to rotate the anchor, or lead to overtightening.
- Do not require a hammer for installation, only a wrench.
- Although some manufacturers say that the bolts can be used more than once, any wear of the thread could lead to lesser holding power, so re-using it multiple times is not recommended.
- Repeated use of a screw anchor can cause it to loosen and the hole to degrade making unsuitable as a permanent canyon anchor.



Hilti HUS3 10mm Screw in anchor

[20] Hilti HUS 3 Technical Information

[21] Hilti HUS3-HR Technical Information

COLLAR-STUD (WEDGE) ANCHOR

Such as Ramset TruBolt™

Collar-Stud bolts are not easily removable. They can be rendered unusable and hidden (by tapping in to an over-drilled hole), but the same location cannot be used for future permanent bolting.

Therefore Collar-Stud bolts should be avoided for emergency or exploration use in any canyon which is likely to be repeated. An acceptable exception is if they are extremely carefully situated, so they can be used for the long term by future canyoners.

- In stainless steel bolts, 10mm is a practical minimum diameter to meet the permanent anchor construction standards of 20 kN.
- Bolts should be at least 70mm in length for very hard rock, longer in less hard rock.
- Not removable without severely damaging the rock.
- The hole drilled for an expansion bolt should be over-drilled by 15-20mm (for potential hammering in and hiding of the bolt after re-bolting in the future).
- When installed correctly, there should be between 3-6mm of the stud extending beyond the nut.
- Overtightening can lead to damage of the collar, or crushing of the rock. This reduces the axial strength, but not the shear strength. ie., the bolt may pull out, but the metal shaft is unlikely to break.
- Not suitable for softer rock.

Ramset Tru Bolt

PETZL PULSE (8 MM) AND COEUR PULSE (12 MM)

The Petzl Coeur Pulse is quick to place or remove with simple, rapid installation and removal without tools, allowing it to be reused making it ideal as a temporary anchor. The Pulse is composed of either an aluminium hanger (8 mm Pulse) or a stainless hanger (12 mm Coeur Pulse), and a stainless steel shaft. It includes a locking function that limits the risk of involuntary removal. These bolts are particularly useful as emergency anchors, can be used to construct temporary rigging such as redirects & bottom anchors for guided rappels.

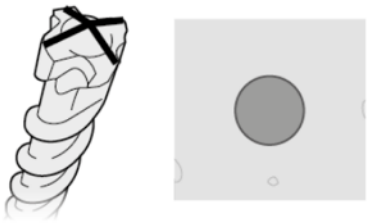
- Hole must be clean and dry
- Shouldn't be used as a single point anchor
- Will start to deform at 3 kN for 8 mm & 6 kN for 12 mm
- Check for a gap between Plunger & hanger[22]
- Not suitable for prolonged use in a marine or corrosive environment

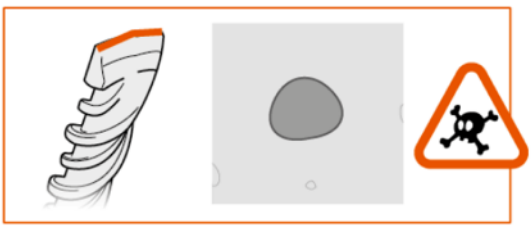
PETZL COEUR PULSE	8 mm Couer Pulse	12 mm Couer Pulse
Drilling depth	5.0 cm	6.5 cm
Drilling diameter	8 mm	12 mm
MBS In Shear (50 MPa Concrete)	15 kN	25 kN
MBS In Tension (50 MPa Concrete)	12 kN	20 kN
Max Load before Deformation	3 kN	6 kN

Petzl Pulse 8 mm

Petzl Coeur Pulse 12 mm

NB. For optimal use, the hole must be perfectly cylindrical. To this end, opt for a drill bit with 3 or 4 cutting edges.[25]





[22] (Petzl Couer Pulse Technical Notice, 2021)

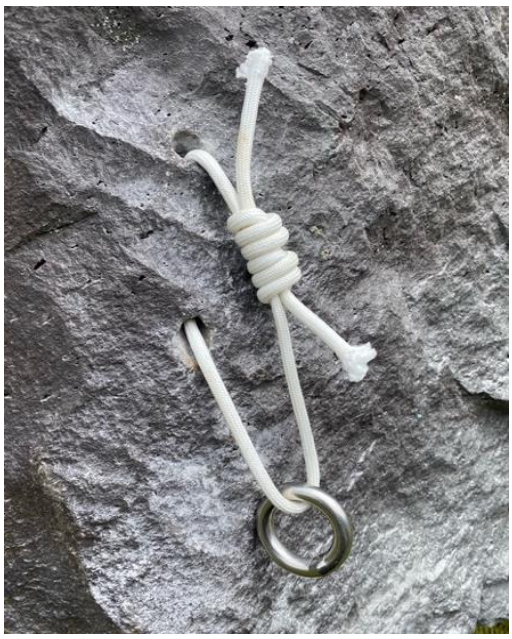
DRILLED THREAD ANCHORS

Using 5mm+ Dyneema Cord (15 kN+)

The drilled thread in rock is a low impact and more sustainable way to create an anchor without leaving behind bolts & requires only minimal material to construct. In a canyon, Threads are ideal for areas affected by high flows and flood as If damaged, can be easily replaced.[23]

Threads can be created using a suitable corner or fin of rock and drilling a hole straight through. Alternately by drilling two intersecting holes, to create a 'V' (also known as an Abalokov Anchor as used in caves and in Ice.[24]) a thread can be formed in a flat face of rock. As you are working at edges, the rock may be less robust so care must be taken and consideration given to joining together two or more threads.

- A single thread which might be expected to have MBS of 12-18 kN may be considered acceptable for ***exploration*** or ***emergency*** anchors.
- For **permanent** abseil and safety line anchors an ultimate anchor strength of 20 kN should be achieved meaning that at least 2 separate threads should be used.
- Holes should be drilled to a depth of at least 75 mm from the surface and spaced at least 75mm apart from each other and from the edge of the rock. (Resulting in an angle approximately 50-70 degrees)
- Hole diameter only needs to be large enough to fit the cord however the larger the diameter, the easier it is to line up the 2 holes and thread the cord meaning that as a general principle, a 12 mm hole is practical diameter.
- Cord should be carefully examined before every use to ensure its integrity.
- Due to its super static properties, care should be taken not to shock load dyneema



A V-Thread using 5mm Dyneema
Photo: S. Fraser

Using a spare drill bit as a guide to align the second hole.
Photo: S. Fraser

[23, 23] (Rock Thread & V Thread Testing Report V1.0 By Grant Prattley, 2021)
[24] (Rigging with Dyneema NSG by Richard Bramley, 2015)

CHEMICAL ANCHORS

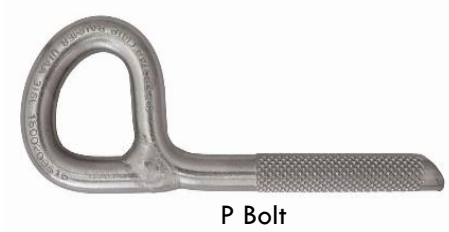
CHEMICAL ANCHOR BOLTS

Chemical anchors are only practical for permanent bolting situations. They are the best solution for soft rock anchoring. They rely on a chemical adhesive bond to secure the stud to the rock.

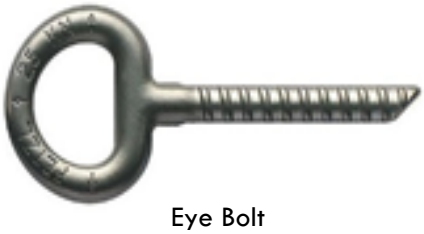
- They require a practical minimum diameter of 10 mm to meet the permanent anchor construction standards.
- The minimum recommended bolt length is 70 mm[25] in hard rock, 100mm in soft rock.
- P bolts and Eye bolts which are specifically designed for climbing anchors are the most appropriate types of chemical anchor.
- U bolts are generally trickier to place and as such are not common in NZ canyons.

U Bolt

Threaded Rod



P Bolt



Eye Bolt

ADHESIVE GUIDANCE

The adhesive used should be a high-quality adhesive specifically designed for structural anchoring applications. The manufacturer's specifications must be checked to ensure they are suitable for anchoring.

- The adhesive must bond well with stainless steel to provide a secure fixing.
- Generally, cannot be used under 5 degrees Celsius, as the curing process is affected.
- Adhesive must be mixed correctly.
- Attempt to minimise excess adhesive, as it leaves an unsightly mark on the rock.
- New anchors should be left to cure as per the manufacturer's instructions.
- Ensure you fully understand the product application, precautions and limitations before installing a chemical anchor.
- If practicable inform other canyoners when anchors shall become useable. This can be done via online forums or a note attached to the anchor.

[25] (British Standards EN 959, 2018)

CHEMICAL ANCHOR INSTALLATION PRINCIPLES

- The drilled hole should be 2 mm larger than the shaft of the bolt to ensure there is enough glue between the rock and bolt.
- The hole should be thoroughly cleaned; the strength of the bolt is proportional to how well the hole is cleaned.
- The head of an eyebolt or P bolt should be recessed into the wall to reduce the likelihood of the bolt rotating thus breaking the glue bond. This is done by drilling a groove above and/or below the hole, allowing the bolt to slot in.
- Some bolts with welded eyes must be installed with the weld in a certain orientation to meet the manufacturer's strength ratings. Check the manufacturer's instructions before installation.
- Check the expiry date, do not use expired glue.
- If possible, reuse existing bolt holes when placing glue-in bolts.
- The stem of the bolt must be both notched and ground to ensure a good mechanical bond and be cleaned to ensure a good chemical bond.

Photo by British Mountaineering Council

OTHER ANCHOR COMPONENTS

All other anchor components must meet the previously stated minimum anchor construction standards for their intended use (temporary or permanent). The components meeting the following guidelines are acceptable when creating an anchor system.

QUICK LINKS (MAILLONS) AND RAPPEL RINGS

- These must be manufactured specifically for climbing and have been tested by the manufacturer to meet the appropriate (temporary or permanent) anchor construction standard.
- Practically for permanent anchors, components should meet UIAA121/EN12275 – Mountaineering Equipment: Connectors. This corresponds to an ultimate strength of at least 25 kN[26]
- Chain links, D-shackles or quick links which are not rated against a above standard are not acceptable. (The display of labels such as WLL (working load limit) only means an item has a recommended working load, which is some fraction of the ultimate strength. The fraction depends on the engineering use. In contrast, UIAA121/EN12275 requires a tested ultimate strength/minimum breaking strength.)
- When used as the focal point to thread the rope through, the internal dimension should be large enough to allow common rope diameters (9-10mm) to be threaded and retrieved easily, but small enough to prevent a carabiner passing through (i.e. when using a carabiner block). For this reason, a carabiner of any shape or rating is not a suitable focal point for an anchor.
- The gate on a quick-link should be tightened just beyond finger tight with a spanner to avoid opening due to vibration or cyclic loading overtightening can lead to metal deformation and a loss of strength.

7mm Maillon Rapide

Omega Pacific Rappel Ring

[26] (UIAA Safety Standards, 2021)

BOLT HANGERS

- Must be designed for height safety use.
- Hole in hanger must match bolt size.
- Must have written evidence that the hanger meets a required standard of strength. This could be either the manufacturer's name and rated strength, or UIAA/EN symbol/certification on the hanger.
- Ring hangers are the recommended standard for all permanent bolt anchor rigging points.
- A ring hanger is only slightly more expensive than a standard hanger plus a stainless steel maillon, but it is much easier to rig and retrieve ropes from

Singing Rock Hanger

Stainless Steel Ring Hanger

CHAIN

- Chain can be used to connect bolted anchors to create an anchor station.
- Sold by the meter 316 stainless steel chain must be grade 80 or above, 'approved for overhead rigging' and have a rated strength from the manufacturer. Purpose built climbing 'belay stations' must meet EN959/UIAA123 standards.
- Chain is not acceptable as a type of bolt hanger: Placing the chain directly between the rock and the nut/head of a bolt is not acceptable, even when using a washer. The width of the chain places an additional bending moment on the bolt stud, which results in a weaker anchor.

Rated chain used to create anchor station. Picture: G. Prattley

Rated Stainless steel chain

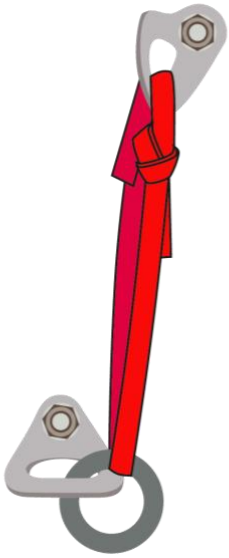
NYLON WEBBING

In General webbing is inexpensive, but requires replacing periodically so may it be more suitable for low use recreational canyons.

- Tubular webbing conforming to EN565
- When tied, the ultimate strength of webbing/anchor configuration must be calculated to ensure it meets the minimum anchor construction standards (temporary or permanent as appropriate).
- With modern hangers, webbing can be tied directly through hangers provided there are no sharp edges.
- The tail of the knot **must** be used to 'pad' the hanger when using the minimum width webbing. This gives a significant increase in the strength of the tied loop improving the breaking strength from around 7 kN to upwards of 15 kN[27]

Minimum webbing width

- 16mm for temporary anchors
- 25mm for permanent anchors



16mm Tubular Webbing used to link Inline Bolts. Picture: G. Prattley

27 (Webbing in hangers testing report Version 1.0 by Grant Prattley, 2021)

ROPE & CORD

- 8-10 mm rope is ideal for linking anchors (Assuming an 8.5mm Rope which is 12 kN with a knot, this would give a combined strength of 24 kN if configured as illustrated. below.
- Inexpensive as offcuts from existing ropes can be used
- When tied, the ultimate strength of the rope/anchor configuration must be calculated to ensure it meets the minimum anchor construction standards (temporary or permanent).
- Requires replacing periodically so may be more suitable for low use recreational canyons.
- As the hanger is unable to be 'padded' the use of Maillons is recommended between hanger and rope

An offcut of 10mm Rope use to create an anchor station.
Photo S. Fraser

DYNEEMA

Such as Beal Dyneema 5 mm Cord or Bluewater Titan cord 5 mm

The technical name for Dyneema (Also sold as Spectra) is ultra-high molecular weight polyethylene (UHMwPE). Dyneema fibre has a tensile strength 15x stronger than steel at the same weight, with as well as its extraordinary strength, Dyneema® excels in cut and abrasion resistance and has a high resistance to UV. Dyneema® fibre is so light that it floats on water

- 5 mm Dyneema cord is particularly suited to the thread anchor due to its high tensile strength (around 15 kN MBS and tested to destruction around 18 kN)[28] with relatively small diameter, and its abrasion resistant properties.
- Due to its low coefficient of friction compared to other materials, Dyneema should only be joined with a Triple Fisherman's Bend leaving tails of at least 5 cm. [29]
- Although highly resistant to UV, cord should still be monitored and replaced periodically.
- Due to its very low melting point, Dyneema knots must be carefully and fully tightened prior to loading.
- Dyneema has no stretch, so is susceptible to shock loading (i.e. a person slipping and falling on the anchor)
- Peak loads during shock loading of dyneema slings indicate fall factor 1 was sufficient to break those slings. Shock testing on threaded cords has yet to be completed, so we should assume at best similar results.[30]

A straight Thread using 5mm Dyneema Cord. Photo: Shanan Fraser

An emergency V Thread anchor in a canyon using 5mm Dyneema Cord.
Photo: Shanan Fraser

[28] (Rock Thread & V Thread Testing Report V1.0 By Grant Prattley, 2021)
[29] (Alpine Caving Techniques By George Marbach & Bernard Tourte, 2002)
[30] How to Break Dyneema Slings by DMM Wales (Wales, 2010)

AMARAGE NEPAL /SOUPLE

Amarage Nepal (Nepal Anchor) and Amarage Souple (Soft Anchor) are anchors designed for ultra-lightweight canyoning and caving expeditions. The anchors use 5mm Dyneema cord as part of the 'hanger'.

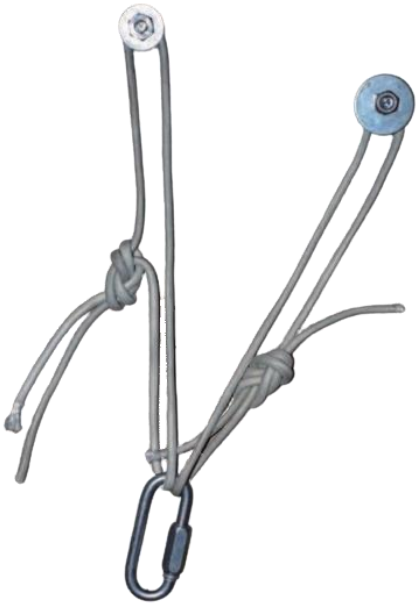
Amarage Souple (AS) uses a machined aluminium disk that has two smooth holes for the Dyneema to thread through. The disk is retained by the bolt head to form the anchor. Amarage Souple are designed for very long cave trips, where they are installed by the party, and then uninstalled during the same trip. Each AS aluminium disk is comparatively expensive, so they are not commonly left behind. A single or double-bolt configuration is used by cavers, depending on whether they are used for primary anchors or intermediate anchors (ie for traverse lines).

Amarage Nepal (AN) was developed for expedition canyoning by the French Federation for Speleology (FFS) in 2011. AN uses two 5mm Dyneema slings, usually tied with triple fisherman knots. Two 8mm collar-stud bolts are placed, with a 30mm washer over each nut. The bolt is tightened and collar expanded with the Dyneema in place beneath the washer. Testing by the FFS shows a minimum of 22kN for the double sling, side-by-side configuration Amarage Nepal. Of note, if the direction of pull loads only a single sling, the test results show a minimum of 11kN, which is below the standard for temporary anchors.

As the name suggests, AN was developed for extremely long, multi-day canyon explorations in Nepal, where the weight of a large number of anchors was critical. For an expert team that places them, in ideal conditions, they meet the temporary anchor strength standard. However, there is little margin: any corrosion in the small 8mm bolt or any loads which aren't directly shared between both strands would see the anchor below the minimum strength standard. Additionally, shock loading on a single strand could generate enough force to break the anchor.

For all these reasons, it is only acceptable for temporary (emergency or exploration) anchors, on very long and/or remote canyons where weight carried is a critical factor. For practical purposes, this means **at least one night is planned** to be spent in the canyon, making the canyon very unlikely to be repeated by the general canyoning community. Any expedition considering the use of such anchors should contact the NZCA to discuss their plans. Use in front country canyons which are accessible in a day is not acceptable, as there is no reasonable justification for needing to save that much weight.

CT Caving Anchorage .
Photo: CT (Climbing Technology)



Amarage Nepal Anchor
Photo: Daniel Clearwater

BOLT ANCHOR CONFIGURATIONS

Abseil or handline anchors must consist of two anchors to provide redundancy. These should be no closer than 2x length of the longest bolt used (or 200 mm whichever is larger) and be placed in a fashion that ensures that they share the load.

When choosing a configuration, consideration should be given to:

- The direction of the load.
- The location of suitable rock to place a bolt.
- Exposure to debris, flood water or air turbulence caused by flood waters.
- The ease of retrieval of the rope.

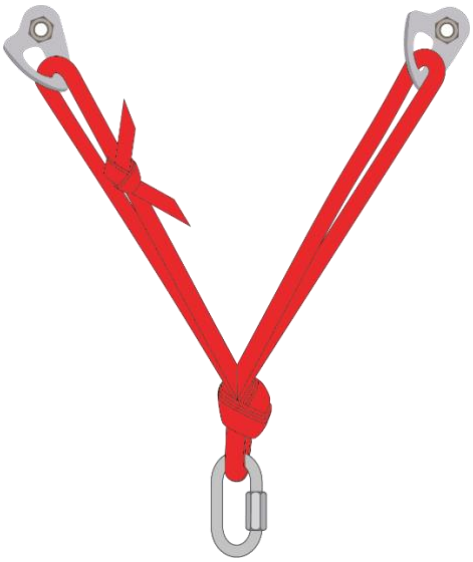
The following configurations are acceptable for canyoning anchors.

Y HANG CONFIGURATION

- Angle between anchor arms should be less than 60 degrees (60% on each arm).
- Can use a 'Sliding X' or create a master point by tying an overhand knot.
- Uses a lot of webbing, which later users may be reluctant or unable to replace.
- Can increase the load on one of the bolts if the direction of load changes.

This configuration allows the anchor installer to extend the focal point to a suitable place. This can allow for easier access (i.e. bolts up high, focal point in reach) or easier retrieval (bolts around the corner, focal point hanging free of any rock surface).

Y Hang configuration using rated 9mm rope
Picture: G Prattley



Y Hang configuration using rated 15-25mm webbing Picture G. Prattley

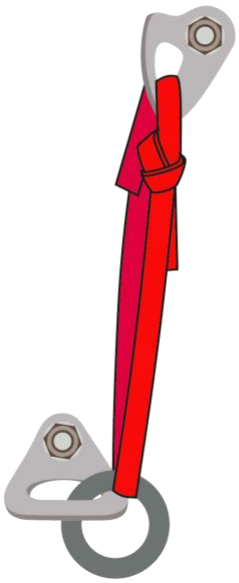
INLINE CONFIGURATION

- Using less linking material (chain or webbing) than the Y hang configuration, while still facilitating easy rope retrieval in most cases.
- Proximity of lower ring bolt to the rock may cause rope to be pinched on retrieval if not carefully situated. The installer should consider how the ring can hang during retrieval when selection a bolting location.
- Linking material should be attached to the lower maillon/ring, to keep the material tight between the anchors when loaded. This ensures the load is shared as evenly as possible between the anchors.

Future proofing: while nylon sling is acceptable, if stainless steel chain would be appropriate in the future, placing the anchors at the right spacing will allow for an easy upgrade. (A small wooden template can be used)

Inline configuration using rated chain, maillons and ring hanger

Picture G. Prattley



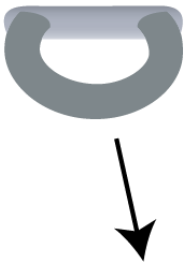
Inline configuration using rated 25mm webbing

Picture G. Prattley

INDEPENDENT CONFIGURATION

- This is the preferred configuration for chemical anchors, or anywhere the anchor is likely to be exposed to flood water (or air turbulence caused by flood waters). The lack of linking material minimises the possibility of the movement of the material working an anchor loose during a flood or from wind.
- When using P or Eye bolts, the lower bolt should be oriented 90 degrees to aid rope retrieval (see image; arrow indicates direction of load).
- This configuration may also be used with symmetrical ring hangers. Double bolts with maillons or parallel rings are usually not suitable as they hinder rope retrieval. They have relatively small holes and sit at 90 degrees to the rock, which makes rope retreival difficult due to friction.
- May require temporary linking with a quickdraw or similar to provide redundancy when using some techniques.

Independent configuration using ring hangers. Arrow indicates direction of load.
Picture G Prattley



Independent configuration using eye bolt chemical anchors. Arrow indicates direction of load.

Picture G.Prattley

THREAD ANCHOR CONFIGURATIONS

- While a single thread anchor can be constructed strong enough for a temporary anchor, for a more permanent solution or when additional security is desirable it is recommended to link 2 or more anchors in a redundant fashion.
- If using a single strand of cord to link multiple threads, It is recommended to use an isolating knot to ensure anchor integrity is maintained even if one strand were to fail.

The following are example of acceptable thread anchor configurations:

Two threads linked with a single piece of cord and isolated with an overhand knot.
Photo: S Fraser

Two threads set up at the start of a safety line.
Photo: S Fraser

Two threads tied with separate pieces of cord and linked through a central rigging ring to create an anchor station.
Photo S. Fraser

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REMOVAL OF BOLTS OR RENDERING THEM UNUSABLE

When an anchor is considered unsuitable, it should be removed, or rendered unusable. If you begin attempting to remove a bolt, you must not give up until the bolt is fully removed or rendered fully unusable. Leaving a half-removed bolt is a death trap to the next person.

Replacing a bolt involves either:

- Removing the unsuitable bolt and using the same hole for the new bolt, or
- Rendering the unsuitable bolt unusable and drilling a new hole for the replacement bolt.

The options available depend on the type of anchor used.

SELF-DRILLING ANCHORS

Render unusable

These anchors cannot be removed, so the only option is to render them unusable.

- Unscrew the hanger (which may be used again if it is in good condition).
- Destroy the threads by placing an expansion wedge, or a small bit of rock in the threaded hole. Use a hammer to smash the rock or wedge into the threaded hole.

EXPANSION BOLT (COLLAR-STUD)

Render unusable

For an over drilled hole:

- Remove the nut and hanger.
- Using a centre punch and hammer, tap the stud into the rock.
- Camouflage the hole by hammering in rock fragments, or using epoxy and rock fragments.

For a hole that is not over drilled:

- Remove the nut and hanger.
- Use an angle grinder to cut off the exposed stud as close to the rock surface as possible. This leaves an unsightly result, and is why all expansion bolt holes should be over-drilled.
- Other improvised methods also exist that can be fabricated with a little effort.

SLEEVE BOLTS

Removal

These can sometimes be removed, but it is possible to damage the hole whilst doing so.

- Use a wrench to remove the nut.
- Tap the stud further into the hole.
- Use needle nose pliers to remove the sleeve first, then the stud second.

SCREW ANCHORS

Removal

Simply unscrew the bolt.

CHEMICAL ANCHORS

Removal/rendering unusable

There are various methods for removing a chemical anchor, and results may vary.

It may be possible to crack the glue by inserting a long steel bar into the eye and exerting a twisting moment. Some epoxies are heat sensitive, using a blow torch to slowly heat the bolt over 10 minutes or more may allow the bolt to be levered out. If these methods fail, cut the head of the bolt off with an angle grinder. A core drill may be used to remove the bolt, though the hole is now too big to be re-used.

REPLACING BOLTS

DRILLING NEW HOLES

When drilling new holes, be aware of the location of the previous anchor holes. The rock has been weakened, and any old bolt holes must be regarded as a 'crack' in the rock. New holes must be at least 1.5x the depth of the hole away from old holes.

RE-USING A HOLE

Re-using the existing hole is the best option for minimising impact on the canyon. This is the reason that screw anchors are the preferred option for temporary bolts.

In some circumstances there may be no more suitable places to place a new hole, making re-using the old one the best option. Re-using a hole is generally only an option when the hole needs to be re-drilled to a slightly larger diameter to accommodate the new bolt. This is most common when upgrading to chemical anchors. Be wary of the possibility of damage to the hole and/or the surrounding rock from normal use, or during the removal process.

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