
Photo: Petzl

Pitons (aka pins or pegs) are the most common form **Destructive Semipermanent Anchors** in use today. They were the standard type of artificial anchors for years until the "clean climbing revolution" in the 1970s. Since then their use has decreased significantly and outside of the big wall and alpine climbing communities, most modern climbers have never placed one. They are considered destructive because their placement and especially their removal, damages the rock. Pitons can also fall into the permanent category if they are left in place after the rescue or used at fixed belay or rappel stations.

Most pitons in use today are made of chrome-molybdenum steel and come in several different designs. **Knife Blades** are the thinnest of all pitons and **Lost Arrows** are a thicker, heavier version of the same up to 1 cm in thickness. **Angle Pitons** are pieces of thick sheet metal folded into a U, V or Z shape. They come in a wide range of sizes from shallow *Baby Angles* to large *Bongs*.

To place a piton, find a suitable crack in good rock. Ideally it should be clean and run perpendicular to the angle of pull. Constrictions on both sides of the chosen area are desirable if the crack is in line with the pull. Inspect the rock around the area for fractures or weaknesses. Test the rock by light tapping or bouncing with a hammer; it should be solid without hollow sounds. Choose a piton the will fit snuggly into the crack at about 1/2 to 3/4s of its length. Set the pin firmly by hand then drive it in with a hammer. In good, clean rock, the piton should "ring" with a rising pitch with each consecutive blow. Continue driving it in until the eye touches the rock. When done, test the pin with a slight tap or bounce of the hammer. It should not move and feel and sound solid.

Once the rescue is over, if the piton is to be removed, pound it back and forth parallel with the crack. Blades and Arrows can be driven all the way from side to side while Angles should only be hit with a few blows in each direction, alternating sides. Once loose, the pin can be jerked out with a cable *Funkness Device* or lifted or levered out by hand.

Anchor **Bolts** are considered a last resort for some rescuers due to the fact that they are **Destructive Permanent Anchors** and because they may take a considerable amount of time to install. However, sometimes they are the best and only option available.

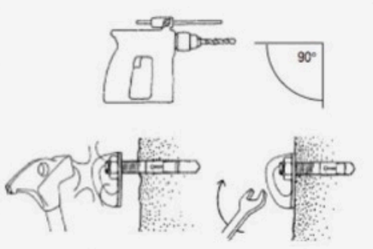

Photo: Petzl

While there are many different designs of bolts and methods of placement, most rescue teams favor some form of mechanical expansion bolt (sleeve, 5-piece, wedge, etc.). Use bolts that are at least 12mm (3/8-inch) in diameter and no shorter than 6 cm (2 1/2-inches) long. Longer bolts may be needed for softer rock like sandstone. Hangers should be made of stainless steel and specifically manufactured for use as climbing anchors.

Bolts are strongest when loaded in shear so find a solid, flat surface with mass that allows the hanger to be placed perpendicular to the direction of pull. Test the area with a few hammer blows. It should feel solid with no hollow sounds. Avoid convex domes, fissured surfaces, and stay well back from the edge.

When using a battery powered hammer drill, start the drill and allow the bit to turn for a few seconds without engaging the hammer function to make a starter hole. When ready, engage the hammer function and drill straight in. Back the bit out every now and then if needed. Once the hole is deep enough, blow out the dust. Lightly chip away any surface irregularities that would prevent the hanger from sitting flush on the rock's surface. Place the hanger on the bolt and install the bolt in the hole by driving it in with a hammer. Use a wrench or ratchet to tighten the bolt down. You should feel a distinct increase in the "tightness" of the bolt. Stop then; don't over tighten. Inspect the bolt, the hanger, and the surrounding area for any damage.

A working knowledge and extensive experience with placing artificial climbing anchors is mandatory for those teams that perform cliff rescues.



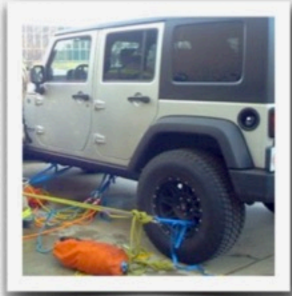
Courtesy of Petzl

Artificial Anchor Points **Minimum CE Strength Ratings**		
Bolt Hangers (UIAA)	=	25kN
Spring Loaded Camming Devices	=	5kN
Wired Chocks, Stoppers, etc.	=	2kN

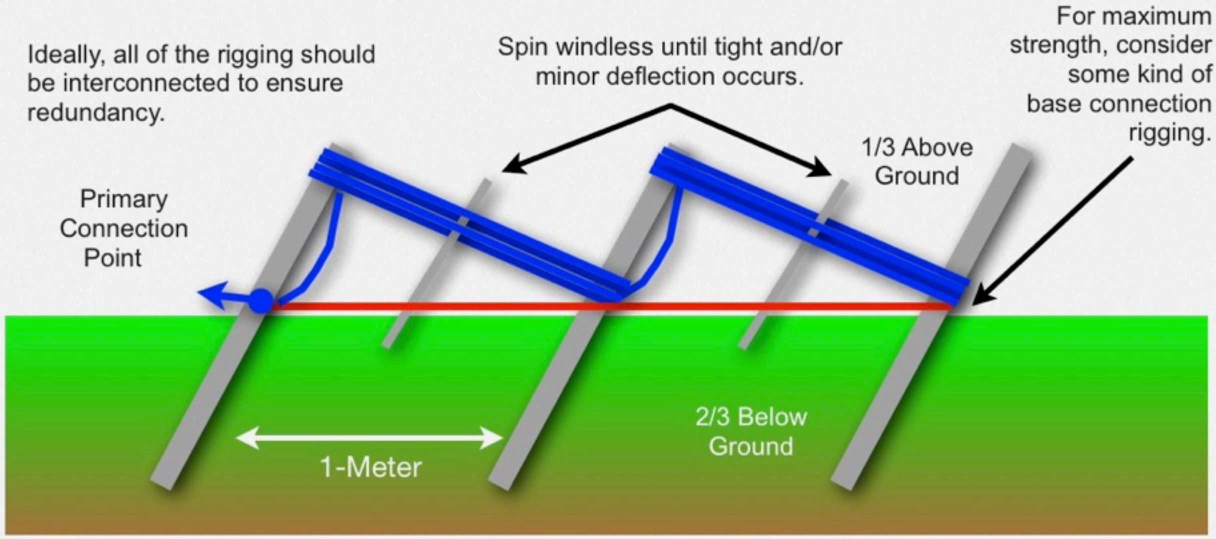
Specialized Anchor Points are those anchor points that are less obvious upon initial inspection and are usually constructed or improvised at the scene by rescue personnel. They may include vehicles, pickets, stimples, tripods, ladder A-frames/bridges, cranes, aerial ladders, etc.

Pickets should be made of steel. The typical picket is at least 2.5 cm in diameter and 1-meter long. Separate each picket by its length (1-meter). At least two (ideally three) pickets properly connected with a cordelette or webbing Spanish Windlass, or ratchet straps and driven deep into firm ground at a 15° angle away from the direction of pull create one anchor point. Use the "two-to-one" rule when placing pickets; two-thirds of the picket under ground, one-third above ground. In soft ground, individual pickets can be bundled in groups and placed as one unit. Systems can be built as 1-1-1, 2-1, or 3-2-1 triangle. Tension the system until a minor deflection is seen in the picket. Ensure that the rigging for the pickets is interconnected so that if the front picket fails or pulls out, the remaining pickets will stay connected. Pickets can also be tied off in their center and buried horizontally, perpendicular to the direction of pull in a trough like a "deadman" anchor.

Vehicles are always on scene in the urban environment. They can be easily positioned and located to aid in the rescue. The larger the vehicle, the better (there have been reports of smaller vehicles sliding on smooth or muddy surfaces during rope rescue incidents). As with other anchor points, mass and contact surface area is helpful. Vehicles also offer a number of easily accessible anchor points from which to rig.



Windless 1-1-1 Picket System



Through-bolt systems

Also known as stud anchors, these use a solid threaded bolt that goes into the hole and also sticks out so a conventional hanger can be attached using a nut. The bottom of the bolt incorporates an expansion system - in some it's the same calking idea as used in sleeves, and a conical wedge is pushed into a set of fingers, but usually there's an inverted cone lathed onto the end of the rod and above that is a collet. Under tension the collet expands and the bolt grips the rock - so these are also sometimes called a 'non-calking stud'. Of course you need to drill the hole first, and in most cases it's a lot deeper than the sleeve-based designs, but the idea behind non-calking through-bolts was that if you remove the hanger and hammer the bolt *inward* you can release the collet and get your bolt back - either to take home and cherish or to inspect for corrosion. The drawback of non-calking studs is that to set them you need to apply a specific torque. Hilti produce a specialist high-strength through-bolt (the HDA-TR) with an 'undercut' expansion system that digs into the side of the hole, providing excellent grip even in very hard rock and with dynamic loads. The fact the entire diameter of the hole is filled with the bolt and the way the collet is progressively expanded means through-bolts are a lot stronger than a sleeve insert of the same size. You should still be using at least an M10 though, to allow that hefty spannering.

All-in-one Expansion Hangers

This beastie is rarer, and pretty much the only widespread sales are of the Petzl models. They simply combine an expansion-sleeve insert and hanger into a single item, with a pin-drive system instead of a threaded bolt. They're designed to be a little more reliable than the 'separates' system as there's no guesswork about torque, but their main selling point is they can't be stolen - an important point on popular rock climbing crags, but pretty daft underground in Lechuguilla. Unlike with the other expansion systems, the All-in-one can't apply tension to compress the hanger against the rock face, so they make up for it by having a hanger that fits over the entire diameter of the insert.

Drawbacks of expansion anchors

All of the anchors based on expansion suffer in long-term placement because the hole isn't waterproof. Even with stainless steel you can get corrosion, and in some countries ice forming inside the hole can lead to frost shattering. With sleeve-and-bolt systems there have been several injuries caused by very old installations, where cavers repeatedly fit and remove their own hangers, as the thread inside the sleeve is worn away. Probably the most common 'mistake' in the use of threaded anchors is underdrilling - the strength depends a lot on the correct depth of placement, and even a few millimetres too short can halve the strength of the anchor. The photo to the left shows a typical "caver installed" expansion anchor, in this case an M8 self-drill that's about 10 years old. A combination of over-enthusiastic setting, side loading and corrosion has cracked the rock, leaving about 3mm of the sleeve visible - there goes at least 50% strength!

Expansion anchors also apply a preload to the rock - even without anything hanging on them, they're pressing outward on the hole and so the rock is under stress. The more aggressive the expansion, the more preload stress is applied - and rock can only take so much before it breaks. It can sound contradictory to some people but an expansion mechanism that opens a long way is often weaker than one that only opens a little!

Probably the worst thing a rescue rigger can be faced with is a home-made anchor - a random offcut of metal and a rusted-up bolt. If the installer's cut corners with the hanger then you can assume they've done the same with the sleeve or through-bolt as well, and many of these will use mild steel "DIY" fittings designed to hold up your kitchen cabinets. In the photo someone has added a new resin anchor, but foolishly didn't remove the old one!

the rear bag.

Bolts and Pitons

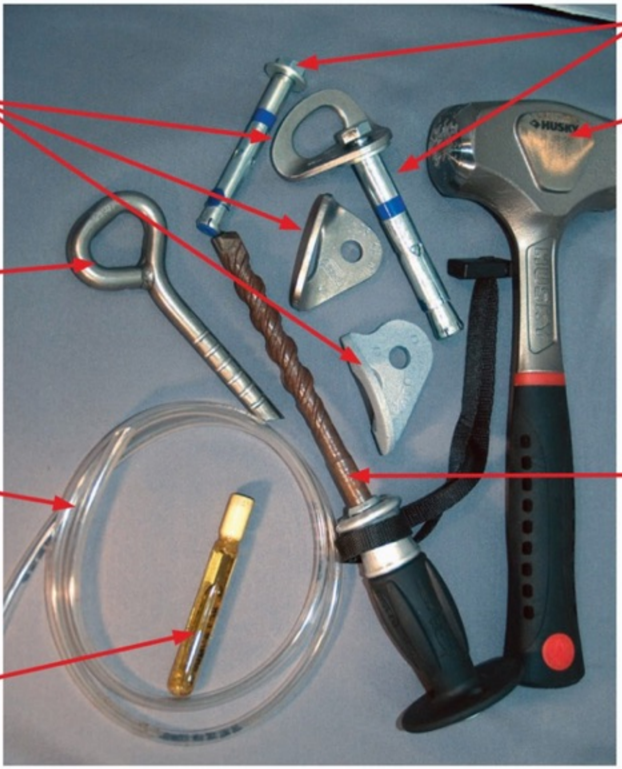
Be very clear about bolts: Bolting is still controversial in many American canyoneering venues. The climbing world long ago gave in to the laziness and lack of creativity implied by over-bolting, but the canyoneering world remains divided. Non-bolters in America are losing the fight. Europeans still tend to bolt everything, whether it needs it or not, and Americans are not far behind. Even so, the following is still the prevailing code:

- Don't place bolts if you want the canyon to remain wild and uncrowded.
- Don't place bolts unless you have the experience, knowledge, and equipment to place bolts that are bombproof and durable.
- Don't place bolts anywhere there are sufficient natural anchors that don't require large amounts of webbing to be left behind.
- Don't place bolts in areas that remain boltless by tradition.
- Don't place bolts that will anger somebody and be used to make you look like an idiot.

Using Fixed Bolts

Using a bolt left behind by a previous party is a bit of a gamble. Because only the head of the bolt is visible, the next user will probably have no clue about the trustworthiness of the bolt or the way it was placed. All bolt anchors are not created equal. Some are stronger and more durable than others. Strength and durability varies with the material the bolt is made from, the type of rock it's placed in, and the amount of fragmentation that has occurred around the bolt as a result of placing it. A bolt's reliability also depends on the susceptibility of the bolt hole to weathering—especially the effects of acidic solution that can eat away the rock inside the hole—not to mention the length and diameter of the bolt, the number of times the bolt has been stressed, the method that was used to tighten the head, and so on.

Before you use the bolt, grab it with your fingers and give it a shake. If the bolt moves or the hanger flops around or isn't lying flat against the rock, consider the bolt bad. Also, all seriously rusted bolts should be considered bad, even if they appear and feel solid.



Typical bolt kit items. With expansion bolts, add the appropriate wrench(es) to complete the kit.

Placing Bolts

Practice at home on cement blocks before you deface the canyons with sloppy bolts. Read the manufacturer's instructions. Do some Internet research on specs and placement techniques for specific products. Get some coaching from old-timers.

Placing a bolt with a hand drill takes fifteen to thirty minutes in medium-hard rock. Cordless electric hammer drills are faster and make sharper, more defined holes. Power drills that are efficient for bolting are heavy and bulky and will short out if they get wet, so many canyoneers opt for hand-drilling. If you decide to buy a cordless drill, get some advice from experienced climbers, not from your local hardware store. Unless you've landed some sort of miracle deal, plan on spending anywhere from US $500 to $1,000.

The Bolt-Placing Sequence

1. Find a location that best fits the intended use of the bolt. Look for a dry area out of the streambed, convenient to rope retrieval and the direction of load. If you're going to place bolts, make them accessible. Place them out of the water but not so high they can't be reached when the water level goes down.
2. If you're going to place one bolt, you might as well place two so we're not tempted to use your single questionable bolt. Try to place them at least 18 inches apart, and preferably in a line in the direction of load rather than perpendicular to it.
3. Choose a site that is solid. Tap the rock with the hammer to check. Avoid bolting within 6 inches of a crack.

4 Use tape or nail polish to pre-mark the bit to the minimum depth the hole must be drilled. Be accurate. Better to drill a hole slightly too deep than not deep enough.

5. Drill the hole:

   Hand drill: Strike the drill several times, then turn the bit a quarter turn and strike again. Repeat. Pause occasionally to blow dust from the hole to prevent the bit from jamming.

   Power drill: Make sure the drill is set to "hammer." Start at a low speed until a straight hole is established perpendicular to the surface the hanger will be lying on. Once the hole is established, switch to a higher speed to finish it. *Make sure the hole is deep enough to accept the bolt.*
6. Use a small bulb syringe or a piece of plastic or rubber tubing to blow dust from the hole. A small toothbrush or a test-tube brush can be helpful in sweeping dust from the hole. Get it as clean as possible.
7. If you're putting in a glue-in bolt with a ring eye, drill a notch that the eye can rest in. This will keep it from rotating and cracking the glue.
8. Place the bolt.
9. Test the bolt by hand and by loading it with body weight. If all looks good, it's ready to use.

What size bolt? If you're going to take time to put in a bolt, use one that will be strong for a long, long time. Place the thickest and longest bolt possible. For canyoneering rappels, a 3/8-inch bolt at least 31/2 inches long is recommended in medium-hard rock. In soft rock a 1/2-inch bolt at least 41/2 inches long is recommended. You may have to do some serious searching to find bolts this long. Typically 33/4 inches is the longest available in climbing shops and catalogs.

Glue-in or expansion? It's believed that glue-ins work better in soft rock and highly vesicular harder rock (e.g., sandstone, soft limestone, basalt with many air bubbles). Expansion bolts (e.g., "blue dots") are said to work better in medium to hard rock (e.g., granite, non-vesicular basalt, quartzite).

Placing expansion bolts: Put a hanger on the bolt and add the nut if the bolt doesn't have its own hex head. Tap the bolt into the hole. Some bolts require the tap to expand the sheath over the cone. Others will pull the cone into the sheath while tightening the nut. If the hole is too short, pull the bolt out if possible and drill some more. Be sure to clean the dust out again. Tighten the nut. Hopefully you will have practiced this at home enough that you'll know when the nut feels properly tightened. Overtightening can actually weaken the placement. There is some controversy about whether glue should be added to seal the hole. It's possible that glue inside the hole will keep the expansion cone from engaging and allow the bolt to spin without tightening. There's also some speculation that glue will cause the hole to retain corrosive moisture. If the manufacturer's instructions don't recommend glue, don't glue it.

Placing glue-ins: Make sure the hole is deep enough to set the eye against the rock, but not so deep as to waste glue. Slide the glue capsule into the hole or squeeze the glue in as directed. With capsule glues, put an appropriate socket or bit on the power drill, and, in hammer mode, drill the bolt into the hole and through the glue capsule. If you're using a hand drill, you'll have to pound the bolt in to break the capsule, then clip a carabiner into the eye and use it as leverage to spin the bolt to mix the glue. With squeeze-gel glues, the bolt is gently inserted and slowly rotated in the hole. This will mix the glue. Clean off the excess and let the bolt cure for the time indicated in the glue instructions. The instructions will also tell you if you can use the bolt after set-time or if you must wait for the bolt to cure.

Bolts and pitons in soft rock: In sandstone and other soft rock, hand-drilling often makes a sloppy hole that is too big for the bolt it was drilled for. There are a couple of ways to solve this dilemma. The first is to drill a 3/8-inch hole to start with, and then a 1/2-inch hole in the same channel. The 1/2-inch hole will be cleaner and better defined. The second solution is to pound an angle piton into the hole. This should be a last resort. The piton makes an ugly scar and will not last as long as a good bolt.

Replacing Bolts

Old or damaged bolts should be replaced if you suspect future parties will be using them. The key to good bolt replacement is to do an expert job with quality equipment. The bolt should be replaced with the idea in mind that it will be there for a couple of generations.

The first task will be getting the old bolt out. Some suggestions:

- Some bolts are designed to be removable. Try unscrewing the head or nut to see if the sleeve will loosen enough to pull the bolt.
- Try driving a thin Lost Arrow or thick Knifeblade piton under the hanger.
- Pry it with a crowbar.
- Yank it with a carabiner chain clipped to the hanger and the hammer eye.
- Sometimes overtightening the nut will pull it loose.
- Avoid chopping the bolt with a chisel, which often leaves the end of the bolt exposed.

Once pulled, a 3/8-inch hole can be re-drilled for a 1/2-inch replacement.

If you do not plan to use the same hole, fill and conceal it by mixing some bolt glue or epoxy with sand from the same crag. Fill the hole and press some fresh sand onto the glue plug to completely disguise it.

Pitoncraft

Pitons are not commonly used in canyoneering except to take advantage of sloppy or worn-out bolt holes. Some canyoneers will carry one or two 1/2-inch angle pitons for that purpose.

Pitons are heavy and bulky, scar the rock, and necessitate carrying a hammer. Still, a few diehards will carry a small rack of various pitons (or "pins," as they are commonly called), especially in wet canyons carved through hard metamorphic and igneous rock.

The two major advantages of pitons are that they can withstand multiple directions of pull, and they are great in thin cracks.

Sequence for Placing Pitons

1. Test the surrounding rock by tapping it with the hammer.
2. Clean out the crack.
3. The piton should fit one-half to two-thirds of the way into the crack.
4. Drive the piton in with the hammer. A rising, ringing pitch as it's hammered in indicates a good placement. A dull "clack" indicates a bad placement. Pitons with rings and soft ("malleable") pitons are exceptions. Rings and soft metal tend to muffle the musical pitch of a good placement.
5. If a piton cannot be driven all the way to the eye, tie it off by girth-hitching a "hero loop" (a Prusik cord or a short runner) between the eye and the rock as close to the rock surface as possible. Clipping a carabiner into the eye can help prevent the hero loop from jumping off the piton if the load is suddenly released (for instance, if the rappeller suddenly steps onto a midway ledge).
6. To test the piton, attach a runner and jerk it hard in the likely directions of pull. Then lightly tap the piton with the hammer. If the pin "clacks," the ring pitch has changed, or the pin has shifted position, re-drive the pin and test it again. Test old fixed pins in the same manner.

To remove a piton, hammer it to one side until it stops moving, then to the other side until it stops moving, and repeat in this manner until it can be removed by hand.

Climber's Chocks

Commercial climber's chocks and "nuts" are easy to place and remove. Many are light and compact, others are bulky and heavy, and most are placed in crack constrictions, similar to natural chockstones and knotchocks. Many rely on a camming action that forces the chock to expand against both sides of the crack. Passive camming devices do this by virtue of their shape (e.g., tri-cams and cammed hexes). Active camming devices do it by combining a camming shape with a spring to assist the camming process.

These spring-loaded camming devices (SLCDs) are very versatile, but are bulky and very expensive. SLCDs are held like a syringe. The retractor bar is pulled back, the device placed in a crack or hole, and the retractor released. SLCDs work well in some places where other devices won't; for example, in parallel or slightly flaring cracks. However, they can be over-cammed and permanently stuck in the crack, and can also "walk out" of a crack unless extended with runners. With these disadvantages and the obvious expense, most folks don't take their SLCDs into the canyon but, rather, carry a very small selection of wedges and passive cams.