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Bolt Guidance Document

Part 1: A Users Guide

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BMC PARTICIPATION STATEMENT

The British Mountaineering Council recognises that climbing and mountaineering are activities with a danger of personal injury or death. Participants in these activities should be aware of and accept these risks and be responsible for their own actions and involvement.

DISCLAIMER

Neither the BMC nor the authors of this document accept any liability for the death of or injury to any person involved in bolt-protected climbing arising from equipment failure or otherwise or to any person involved in placing bolts and against whom such a claim has been made.

The purpose of this document is NOT to give definitive advice on what fixed equipment should be used or how it should be used. The great variation in rock types and condition, climate and environment render that impossible. Rather it is to alert the climbing public to those potential problems and risks that have been identified. Climbers must rely upon their own experience. Climbing is dangerous: it can damage your health.

SYNOPSIS

This work comes in two parts and is intended to increase the climber's knowledge of how these devices work. The first part is intended for users of bolts and the second is for those who place them, although both sections may well be of interest to all.

Part one contains information on the history of bolts, types of bolts likely to be encountered and problems to watch out for. The second section has more technical information on the choice and installation of equipment. It also examines the legal implications of placing bolts.

Please note that neither is an instruction manual. They are intended to be informative documents for those who wish to clip and go.

CONTENTS

INTRODUCTION

These documents have been produced by the BMC Bolts Working Group. This group brought together scientific expertise from chemists, mechanical engineers, metallurgists and geologists along with many years of practical experience from climbers who have placed bolts and, perhaps more importantly, examined old bolts during the process of replacement.

The aim of the project was to increase the knowledge base of the climbing population and to examine current practice. It comments on methods and materials to ensure that safety issues are clearly understood and available to activists involved in placing new, and replacing old, bolts on British cliffs.

We hope these documents will be useful in influencing the thinking and decision making of those about to embark on bolt-protected climbs, about to commit to an irreversible move above a rusting fixed relic of doubtful origin, or those who may contemplate placing bolts or pegs in the future.

In making recommendations we have suggested the systems that we consider to be the most appropriate. We have done this with the interest of the future of bolt-protected climbing in mind and to encourage thoughtful replacement as old gear becomes in need of renewal.

The term ‘bolt’ generally refers to any form of metal placement that requires a hole to be created unless otherwise stated. The term ‘glue’ includes all forms of chemical resins, adhesives and cements.

PERSONAL RESPONSIBILTY

All climbing is an exercise in personal responsibility. We climb because we enjoy it, whilst trying to minimise the risks involved. With hand-placed protection you judge for yourselves how reliable it might be and make your decisions in the light of (or despite) any doubt you may feel.

Few climbers would place bolts and then not climb the route themselves and so have a vested interest in ensuring the equipment is safe during their ascent. After all, falling is a far more common occurrence on bolt-protected climbs than on traditional routes.

A selection of modern bolts

The information contained in this booklet shows how time, choice of equipment and the nature of the rock can cause bolts to become less reliable. As a consequence of this, we think all climbers should familiarise themselves with the types of fixed gear they may encounter and the factors that could cause them to doubt the security they once provided. This should be a skill we all gain in the same way that we learn to spot the correct nut or cam for a particular placement and gain a sense of the security afforded by protection that we have placed.

When the gear holds a fall the climber can hit projecting ledges or take swings into or across the rock. The placing of bolts usually (but not always) prevents ground falls but there is no guarantee that they will prevent injury or even death.

Regarding the testing of bolts: It is impractical for bolts to be regularly inspected and tested in the field. The BMC has planned a test programme to compare the performance of different types of bolt, the results of which will be published when they have been completed.

A BRIEF HISTORY

Permanently fixed protection in the form of wedges, threads, pitons and bolts have played an ever-increasing part in British rock climbing for more than 50 years. These latter two, being manufactured from a variety of metals, have been rusting away on our crags for decades. Some seem to have stood the test of time better than others and still look good after many years. Some have rusted away completely and the only evidence left is a brown stain leeching from a corroded stump. There are, however, many examples in between these extremes. The question is, how do we know what to trust?

Not all bolts are the same – new and old bolts

The time difference between the introduction of wide-scale pegging and the use of bolts seems to have been very short as is testified by the lines of old bolts once, and in many cases, still evident on the walls of Goat Crag, The Cromlech, Malham, the Cioch at Burbage and the Cow at Ilkley. Much of the equipment placed then and in the intervening years has, where appropriate, either been replaced or removed but it should be remembered that quite a bit still remains.

Many early pegs and bolts were home made and commercially available items were, and still are, manufactured from a wide variety of metals. On top of this, corrosion is a complex chemical process, which may act very differently on the same metal in different situations or rock types. Environment may have an influence and a peg or bolt that may last twenty years with little sign of decay on a dry section of an inland crag may corrode to dust within 3 years on a sea cliff, or crag within a few miles of salty sea air.

It is probably fair to say that most climbers with a few years of outdoor experience generally treat all pegs with a degree of suspicion. It is known that an un-corroded head and eye is not, per se, evidence of lack of corrosion on the stem buried in the dank depths of a crack. Nor can even the most experienced climber always judge the length of the shaft or the quality of the placement.

The relatively recent boom in pure bolt-protected climbing appears to have given rise to a false sense of security. These climbs usually rely on mechanical bolts of various types or bolts held in place by glue. For a number of reasons, most climbers more trustingly rely upon bolts than other fixed equipment.

Protection points on bolt protected climbs are often quite close together and usually (but not always!) placed in apparently sound, compact rock. There are normally two fixed points placed close together at the top of a pitch to form a belay. However, one should always remember, as you lower-off and remove your quick-draws on the way down, that you are staking your life on these two bits of metal that may be of unknown age and quality.

A chain-linked twin bolt lower off. The rope is threaded through the lower ring.

There have been several accidents due to pegs breaking or pulling out, but very few accidents in Britain due to failure of bolts – so far! However, as the bolts get older, how do we know what corrosive forces are at work inside, what microscopic hair-line cracks may be developing or what, if any, degenerative processes are at work within the chemistry of our glues?

The reality is that often, we don't know. We just trust to fortune, if it looks OK we risk it and of course we all accept risk as a part of our sport. As with all protection, we can never be 100% certain of the quality of the rock in which we place our bolts and over time, just as our cliffs and crags decay and crumble, so will our bolts.

We can, however, seek to minimise, manage, and highlight some of those risks for the benefits of the placers of bolts and more importantly you, the users. We hope the above won't deter anyone from bolt protected climbing in the short-term future. As mentioned earlier, accidents due to bolt failure or bad placement are very rare and the rewards of a successful red-point of some soaring, overhanging line of compact rock can be immense.

BOLT TYPES & STYLES OF PLACEMENT

The following section describes and illustrates how the placing of bolts and the bolts themselves have evolved. It is intended to give you some idea of what may lie within the rock, and how it is intended to hold any force you may apply to it.

Malham - The 1958 Directisimma *F.A Barrie Biven, Trevor Peck.*

"The prospect of the final overhang was so unnerving that, in order to give myself confidence, in case I came off and ripped out a series of ring screws, I descended about fifteen feet to the sounder rock and spent over an hour chiselling a hole deep enough for a 2½ inch channel peg, which would hold a dozen falling bodies of my weight."

Barrie Biven

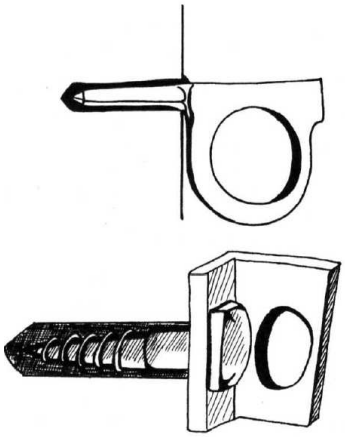
"Graded A4 and quoted as the only piton climb (in the country) without violating free climbing possibilities. As the first half of the climb took five days to complete, the prospects of a repeat ascent are remote - the minute size of the rawl bolts are enough to deter all but the most fanatical of peg climbers."

R.B.Evans 1962.

The climb became extremely popular and many of the bolt stubs are still there!

EARLY BOLTS

Golo & Coach Screws



Two bolt types that were once common but you would be lucky (or unlucky!) to find them these days. They are fixed into shallow, chiselled holes by some form of malleable attachment. For instance the ones that once led all the way up the North Buttress at Kilnsey were old coach screws bedded into a strip of zinc that lined the holes.

Self-Drilling Bolts

Something of an anachronism these days, since the introduction of the battery powered drill to the sport. The sheer effort involved in hand drilling may have been the reason for the more minimalist style bolting in the past since a lot of effort is required to make a hole by hammering the jagged cutting edge into the rock**.**

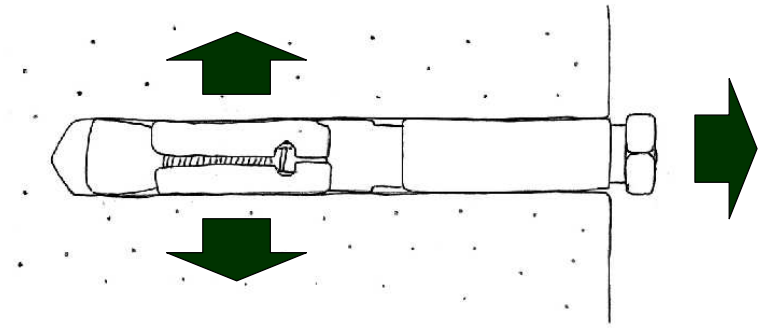
8mm Self Drill Bolt or Spit. Note the depth of the fixing!

Understandably the holes these bolts go into are usually very shallow. The diameter of the bolt placed can be either 8mm or 10mm. Many of the older bolts are only 8mm in diameter and less than 20mm deep.

MECHANICAL BOLTS

There are 4 commonly used types of mechanical bolt, in a variety of alloys, lengths and diameters. Some models are manufactured specifically for climbing, others are general construction fixings, which may or may not be suitable for the purpose they have been put to.

All mechanical bolts work in a similar way, by gripping the inside of a drilled hole. If the force applied externally to the bolt (in a fall for instance) exceeds the gripping force, the bolt will pull out of the hole and fail. In soft rock the gripping force is likely to be greater than the compressive strength of the rock, in which case the rock will fracture allowing the bolt to cut its way out. For this reason mechanical bolts are not generally suitable for softer rock types.



A mechanical bolt expands, gripping the inside of the bolt hole

The Through or Wedge Bolt

Probably the most commonly used mechanical bolt. One end of the bolt is machined into a tapered cone shape, just above which lies a small collar of metal. Tightening the bolt draws the whole bolt out of the hole slightly, pulling the cone into the clip and causing it to expand and grip the sides of the hole.

A typical through bolt, in this case a Petzl Coeur Goujon 10mm.

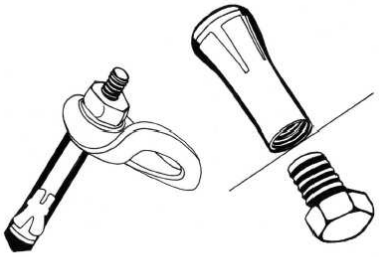
When well placed in hard rock, this bolt type is generally strong and reliable. Once placed they are not removable. Over tightening can pull the collar over the cone, leading to failure. In theory this type may be more susceptible to fatigue failure (failure after repeated loading) due to the presence of external threads.

The Sleeve Bolt

Sleeve bolts, in this case Fixe Triplex, which are reusable.

A less commonly used bolt in the UK, generally more expensive than through bolts. Tightening the nut screws the cone into the sleeve, causing it to expand and grip the side of the hole. Unlike through bolts, sleeve bolts can be removed by slackening the bolt, and they can also be retightened. This does mean though that they can potentially be loosened over time, especially if the hanger is twisted. Those made with external threads can be rather weak for climbing use. Models made specifically for climbing tend to feature stronger internal threads, and there are even reusable versions available.

The Undercut Bolt



A specially designed drill bit excavates a hole that is has a greater diameter at the end deepest into the rock. The bolt consists of a unit with a cone shaped metal piece that when driven home expands the split end of the bolt so that it fills this void and locks the bolt into the rock. They tend to be short in relation to other bolts. The design concept of these bolts is good but those currently commercially available are neither cheap nor ideally sized for climbing situations.

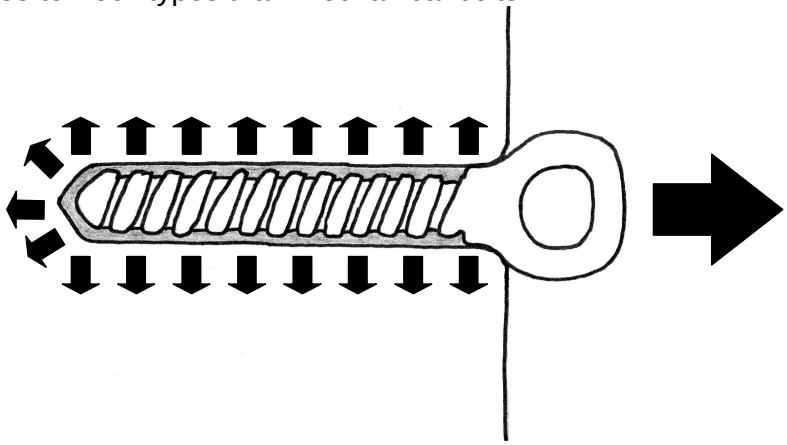
Nail Drive

Petzl Longlife bolt

An alternative expansion mechanism is for a metal spike to be driven down a hole that runs the length of the body, expanding the sleeve and causing a permanent fixture.

CHEMICALLY BONDED BOLTS

There are five main types of glue-in bolt all requiring a thorough and considerate approach to their installation. Well placed glue-in bolts are the strongest rock bolts available. They do not stress the rock when unloaded, and as the load is applied over the entire drilled hole, they are stronger in softer rock types than mechanical bolts.



A good glue-in bolt will spread the load over the entire drilled hole.

It is difficult to gain good adhesion to most metals without pre-treatments which are mainly unsuitable for use on the crag, therefore bolts should have features that key into the glue, to give some mechanical interlocking. To achieve this, the drilled hole must be larger than the bolt to allow room for the glue. Manufacturers normally specify an optimum clearance.

Correctly chosen glues are mechanically strong, resistant to impact loadings and are long lasting. They should also be resistant to the effects of any chemicals that may be present, and should infiltrate the rock so that a strong bond is formed. A feature of many glue-in designs is that the smooth eye allows the rope to be threaded directly into the bolt. This allows retreat without leaving equipment behind, but can also lead to problems with worn eyes from lowering off especially on belay bolts.

The Staple

A typical Staple bolt

One of the most popular types of glue-in bolt found its origins on the continent but was initially used in large quantities in Portland and on the coastal cliffs of Swanage. Since then, these bolts have flourished all over the UK.

The staple consists of a piece of (usually 8mm) bar of stainless steel bent through a 180 degree curve to form a ‘U’. The arms of the ‘U’ are generally even in length, bent at the end and notched to form a key for the adhesive. The vast majority of staples are home made, this means the leg length, bend and degree of notching can vary.

Eye Bolts, P Bolts & Eco Bolts

Home made and commercially available versions abound. Forged as a single unit with a leg and eye, or formed from bent bar stock. In this latter case a weld usually joins the end of the formed eye back to the bar. Where practicable it is thought to be good practice to create a small top and bottom groove in the hole into which the eye sits. This inhibits rotation of the unit when in use.

Petzl glue-in bolt

The DMM Eco Bolt can be seen in profusion across the Pen Trwyn Cliffs of North Wales and there are many in place in Yorkshire. It consists of a piece of 8mm bar bent into a single unit with the bar being joined and then reinforced by a welded joint. The protruding eye forms a ‘P’ and the ends of the body are deformed to create a fish tail wedge shape.

DMM Eco Bolt.

The Buhler Bolt

Similar to the Eco Bolt but with a much longer protruding eye that it is said helps to prevent karabiners from inadvertently unclipping from the bolt. Recent homemade models have the legs that form the body twisted around each other through 720 degrees providing a very secure key for the glue.

Buhler homemade bolt

Glued-In Bar

Often a do-it yourself solution, these consist of threaded bar, usually of 10mm diameter, that has been fixed using a suitable glue into a hole. Once the glue has set a hanger is held in place by a nut and washer. External threads can lead to problems with corrosion and cracking, unless stainless steel is used. Industrial fixings of this type are also available which are strong and durable. Unless the glue is visible it may be hard to tell the difference between this type and an expansion bolt.

Glued in bar bolt.

POTENTIAL PROBLEMS

When attempting an on-sight or working for a red-point we would all prefer if the bolts looked pretty new and reliable. The question is when to doubt their security? After all when was the last time you heard of a bolt failing? Well it does very occasionally happen and recorded cases suggest in some situations that are hard to predict. So what factors should we take into account? Some well worth considering are listed below:

Rock Quality

Like any other form of protection, a bolt is only as good as the rock it is placed in. The majority of the bolt-protected climbs in this country are on rocks that would be considered as soft on any geological scale of hardness. Commercially available bolts are tested in concrete, which not only is much stronger than most natural stone, but also is also much less variable in quality. Many rocks types weather to form a hard skin, with much softer material hidden underneath leading to a false impression of the hardness of the rock.

Alongside this some rock types not only have very well developed joint patterns, but also are likely to easily develop numerous micro-fissures when stressed. The drilling process and the forces exerted by mechanical bolts can result in fracturing that is not always evident behind the hanger. Look out for hairline cracks or crumbling around the bolt.

Rock fracture around a bolt

Always remember that the erosion that creates our crags has not halted. The weather and particularly cliff vegetation has great capacity to loosen and lever off even very large lumps of rock. Once sound placements have been known to change as the rock around them unexpectedly crumbles.

Depth & Position of Bolt

Bolts placed close to edges will have a reduced strength; 200mm is often quoted as a minimum clearance distance. Unfortunately bulging limestone doesn't usually accommodate bolts being placed with that allowable distance.

Likewise, bolts placed close to cracks, pockets or other discontinuities may well be reduced in strength.

Leverage could damage the karabiner; also the bolt is quite close to an edge.

The most modern installation techniques give relatively straightforward placements as long as you have a battery-operated hammer drill, though these aren't cheap. The quantity that can be placed depends on the size and power of the drill and the amount of money spent!

These tools hammer holes in the rock in an action that is quite unlike the drilling of holes in wood. Some rock types are quite easily fractured and susceptible to the development of micro-fractures under the hammering action - it has been said to a depth at least equal to three times the hole diameter.

This means that new European standards suggest bolts should have an installed depth of **at least** 5 times the hole diameter – requiring a longer fixing when the bolt has to allow for a hanger held by a standard washer, nut and some tolerance. Many older bolts wouldn't be that deeply installed.

Another problem is where the placement causes a karabiner to be pulled against an edge. In a fall the resulting leverage could damage the karabiner and hanger.

Evidence of Corrosion (Rust)

When a rock bolt is fixed to a crag, the metal must be strong enough to hold repeated falls over a long period of time. One of the factors that can weaken such a fixture is corrosion. All but a few precious metals will corrode and they are too weak and/or too expensive to be of any use for rock bolts. The most common materials currently used for bolts and hangers are: carbon-manganese steels (which include ‘mild steel’), alloy steels and stainless steels. The carbon-manganese steels and alloy steels can also be zinc coated. In the past other materials e.g., aluminium alloys, have been used for homemade hangers but this practice has now hopefully ceased.

Just because a bolt is rusty it doesn’t mean it is dramatically weakened. However, if it is rusty it has lost some metal and consequently some of its holding capacity. It is not unknown for the nut to be of a different metal and to have corroded so that it no longer holds the hanger in place. Bolts where the hanger is fresh and shiny but the bolt itself is rusty may suffer from a particular form of corrosion and have been known to break with the lightest of load. It makes sense to inspect bolts that are placed in drainage lines. Unfortunately the wettest place part of a bolt is in the hole and behind the hanger making inspection difficult.

Galvanic corrosion between a stainless steel hanger and mild steel bolt causing the bolt to corrode.

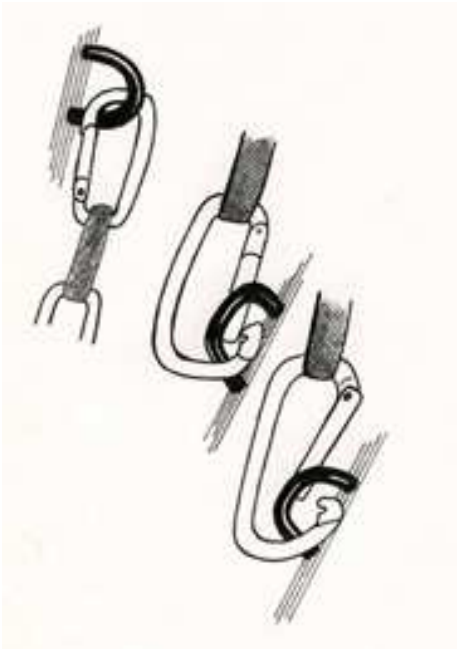
Another problem is where galvanised bolts and hangers have been used, particularly where the coating is thin and may have been scraped off allowing corrosion to concentrate on particular points.

"After 15 years the hanger was as good as new but the bolt quite rusted. The bolts don't get much stick at Yew Cogar so you can imagine my surprise when all it took was a pull with the spanner and the whole head of the bolt just snapped off! After talking to others that have re-geared routes it seems this problem is quite common."

Glues do not necessarily prevent corrosion and the body of an otherwise healthy looking glue-in might be corroding away – especially if any of the metal is exposed in the hole.

Accidental Unclipping

Hangers or eyes ideally should be of a size that they don't allow the karabiner to snag in such a way that the gate can be forced open and unclip. Correct orientation of the karabiner gate away from the direction of travel also helps avoid this.



Accidental unclipping is rare but does happen

Spinning Hangers

Hangers can spin because the bolt has moved in its seating or because the securing nut has become loose. If there is evidence of the former then the bolt is likely to be unsafe. If the latter is the cause then the nut should be immediately retightened. The leverage and wear caused by a weighted hanger rotating on the bolt body can give rise to weakening of the unit due to the formation of microscopic fractures.

"Martin hung on the bolt to take a rest and clean some holds. It was rusty but didn't look too bad though the hanger was spinning. As he reached upwards to clean a hold the bolt snapped sending him head first towards the ground. He stopped maybe a foot short of hitting it. Luck or good belaying counts for a lot."

Old Bolts

Despite the number of renewal programmes there are still many old bolts out there, especially ones used to protect blank sections on 80's trad routes. Common sense dictates that bolts have a limited useful life and it is always worth consulting the guidebook to see when the route was first done or, if the gear has been replaced, when that might have been done. Whilst stainless steel products are likely to be good for a lot longer, experience has shown that many bolts placed in the past are dangerously weak after 10 years. Some early staples had no notches on their legs making them prone to pulling out relatively easily if an outwards force is applied.

Old bolts may provide only an illusion of safety. When new this bolt was rated for aid only.

Wobbly or Damaged Bolts - Mechanical or Glue-Ins

It makes sense to doubt the holding power of any bolt that wobbles in its hole! With glue-in bolts a problem can arise if the drill dust is not thoroughly cleaned out of the hole or if it was placed in a damp hole. Some wobbly glue-ins have been found to take quite high loads but it's probably not sensible to test these with your own weight!

In tests on bolts placed in soft rock types a common way in which they fail is to cut their way through the rock when a load is applied. Any bolt that flexes (perhaps by being too thin or regularly loaded by falls) can apply pressure to the rock at the base of the hole entrance. It goes without saying that signs of damage should cause some concern.

Unset Glue

Glues have to be mixed properly. Failure to do as instructed can result in the mixture not curing, or hardening as was designed and not holding the bolt in place. Several serious accidents have happened when climbers have come across new bolts and attempted the route without checking the glue has set.

“The route was equipped with new, shiny bolts. Unfortunately the glue hadn’t set and an expected short fall actually resulted in the bolts coming out and led to serious injury. Later investigation showed that the second tube in the glue gun hadn’t popped so no hardener was added.”

Deteriorating Glue

Like the bolts themselves the glue can and will deteriorate with time though for appropriate glues this should be a very slow process. However, there is anecdotal evidence that some inappropriate glues have been used, that are not suitable for the alkaline solutions likely to be encountered in limestone rocks. Unfortunately this could mean that once sound bolts become less so, perhaps as little as two years after placement.

Worn Belay Bolts

Worn belay bolts as a result of top roping directly off the bolts.

If top-roping a route the climber can always arrange slings so that both bolts are weighted. This is good practice and climbers should be discouraged from top roping with the rope directly through the belay bolts, as significant wear on the eye can quickly result.

Home Made Hangers

Various types of bolt hanger were homemade during the 1950s and 60s. Usually these were simple angle iron (or aluminium alloy) with holes drilled in each side. A few may still be encountered on old aid routes today but generally they are now of little relevance and most have been superseded by modern bolts or other forms of protection

Stress Corrosion cracking

Although there is no evidence of this type of attack occurring in the UK, a number of bolts have failed by stress corrosion cracking (SCC) in Thailand and Cayman Brac so it's worth being aware of it if you're going sport climbing in the tropics. SCC can occur in stainless steels in aqueous chloride solutions (e.g., seawater) so the bolts on sea cliffs appear to be most susceptible. Luckily for us, there is a temperature (~50°C) below which it doesn't occur (except in very acidic conditions) so it shouldn't be a problem in the UK until global warming really kicks in. The corrosion is very localised and takes the form of cracks that can penetrate through the metal, reducing its strength to almost zero. These cracks can be very fine and difficult to detect on the surface and impossible to see how far they penetrate.

"My last month was spent climbing in Thailand on some very questionable bolts... About a week ago while I was waiting for a guided party to finish a second pitch on Thaiwand Wall, a leader broke a bolt by pulling on the quickdraw. This caused him to fall and break the next bolt. He was lowered off with a badly injured leg. Both bolts fractured in the shaft at the hanger."

The Devil and the Deep Blue Sea
John Byrnes, Skip Harper and Mike Shelton

Finally

A line of bolts that all look and feel good doesn't indicate a route that is lacking in risk. It is up to you to use your judgement if you choose to climb it. You should never assume that the quality of fixed gear is consistent throughout a route. Rock quality will almost always vary, and particularly on older routes a variety of different bolts may be in place.

FURTHER INFORMATION

Hilti
Manufacturer of mechanical and chemical anchor systems, drills and testing meters.
A good starting point if choosing to source industrial fixings and drills. Product specifications and installation instructions.
www.hilti.co.uk

American Safe Climbing Association
US based anchor replacement and education initiative.
Practical advice on removing old bolts, and placing new ones. Some destructive test data.
www.safeclimbing.org

UIAA
International Mountaineering and Climbing Federation.
Technical information on UIAA and EN standards for rock anchors.
"To bolt or not to be" the UIAA declaration on the ethics of redeveloping alpine regions.
www.uiaa.ch

Fixe
Manufacturer of bolts, hangers and lower off's.
Installation instructions.
www.fixeclimbing.com

Petzl
Manufacturer of bolts and hangers.
Installation instructions.
www.petzl.com

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