# Concrete screws – testing for caving use

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## Summary

1. I use concrete screws whilst caving. I wanted to test smaller, stainless screws, so I bought and tested Multi Montis in a size that use a 6mm drilled hole and fit an 8 mm hanger.
2. One screw was tested axially, and five screws were tested radially. All the tests achieved around 20kN, which I consider sufficient for my needs.
3. I hope sharing this work encourages others to consider using stainless, removable anchors.

## Introduction

Cavers use concrete screws for temporary SRT anchors. Galvanised screws are sold in caving shops[1]. Testing data is available for some products tested axially[2]. I didn't find any testing of anchors radially.

I wanted an SRT and climbing anchor for temporary use in exploration. I thought it advantageous to use a small screw that would fit through the hole in 8mm hanger plates, which had a 13mm hexagonal head, and which was stainless.

## The screw being tested

The HECO MULTI-MONTI MMS-S-7,5x75-A4 meets these requirements. It is manufactured by HECO-Schrauben GmbH in Germany and has ETA approval ("ETA-05/0011")[3]. The 7.5 mm x 75 mm version has a shank diameter of 5.7 mm and an outer thread diameter of 7.5 mm. It requires a 6 mm hole of 75 mm depth. A4 signifies that it is made primarily of grade 316 austenitic stainless steel (i.e. the same as conventional caving anchors and hangers). The ETA approval document gives a characteristic resistance to steel failure of 23 kN in tension and 12.3 kN in shear.

I bought a box of 50 online for £20 and decided to test a few in various ways. I was most interested in testing radially, and testing with the type of hanger I expect to use underground (Raumer Minox 8mm plate hanger[4]).

Heco Multi Monti MMS-S-7,5X75-A4


Raumer Minox 8mm

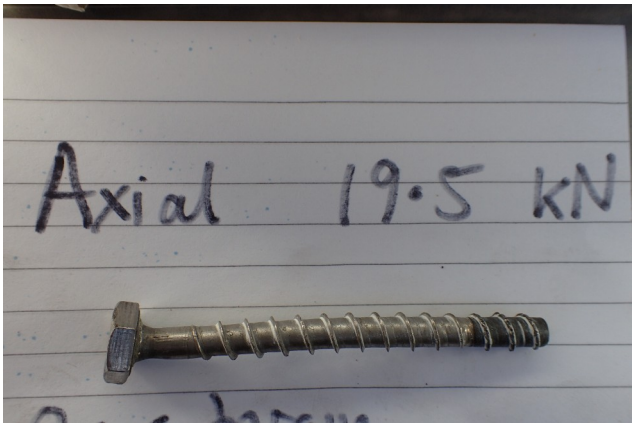
1 https://www.inglesport.com/product/multi-monti-rock-screw/
2 https://cncc.org.uk/file/3aa51cae-4851-c59a-1f42-93e366425a6e
3 https://www.dibt.de/pdf_storage/2018/ETA-05%210011%288.06.01-555%2118%29e.pdf
4 https://www.raumerclimbing.com/en/products/classic/stainless-steel-plates-anchors/plate-minox-a316l-d-8/

# Axial testing

A new screw was installed into a limestone block with a Raumer Minox plate hanger. Using the CNCC Hydrajaws hydraulic axial pull tester[5], a load was applied axially and increased to 19.5 kN (the limit of the tester).

The screw and hanger held the load without breaking. Both were permanently deformed plastically (I.e. did not return to original shape), but after slackening with a spanner, the screw and hanger could be removed by hand.

Inspection of the screw shows that the head is bent slightly to one side, indicating a bending stress, due to the off-centre pull from the plate hanger.

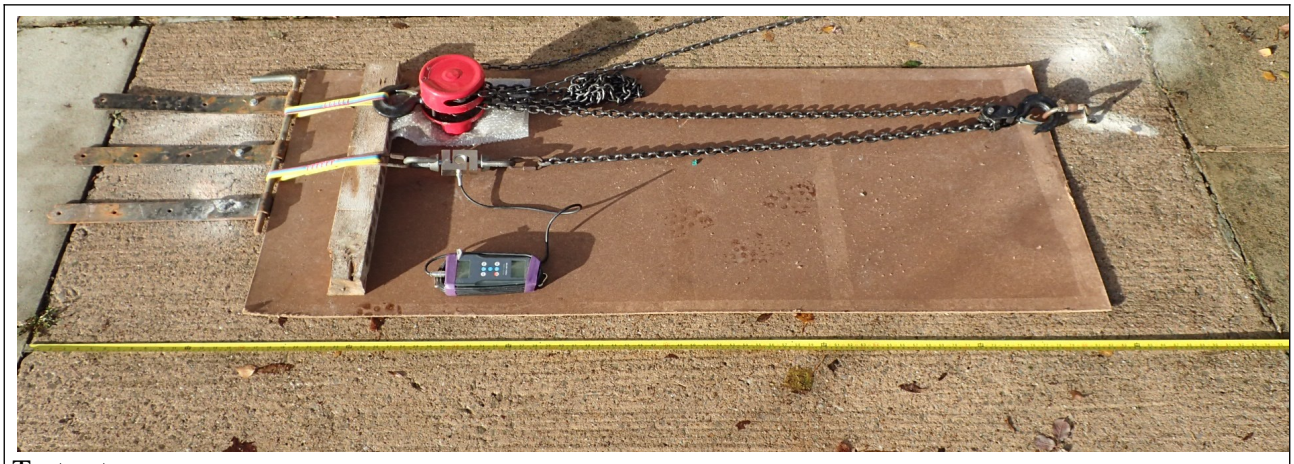


Axial test


Axial test

# Radial testing

These tests were undertaken in a concrete driveway of unknown composition and strength approximately 90 to 100 mm thick. This was used as a proxy for Yorkshire Dales limestones. Detail of the test set up are given in an Appendix 1.


Test set-up

5 https://cncc.org.uk/about/assets/

## Radial Test 1 (re-use of axial screw)

To test the set up, the same screw used for axial testing was reused in a new hole with the same used hanger. The load was increased to the limit of the test cell, and held whilst photographs were taken of the loaded screw and hanger. Afterward the screw was removed, labelled and photographed in detail. This screw withheld 1089 kg on the load cell (21.4 kN load).

The screw was now very bent below the head, but could still be uncrewed by hand. The bend was pronounced a short distance down the shank, indicating that although the caving term for such loading is “in shear”, in practice this included a tension and bending load.


Radial test 1


Radial test 1

## Radial Tests 2,3,4 (three new screws)

Next a new screw was installed in a new hole with the same used hanger. This was loaded above 8kN and reduced to below 0.5kN 10 times within 10 minutes. Then the load was increased to the maximum of the load cell.

This test was conducted on a further two new screws in new holes with the same hanger. The results were 20.0 kN, 19.8 kN, 19.8 kN, all with no failure. These hangers also could be unscrewed by hand. These radial-only screws were noticeably less bent than the axial-then-radial screw.


Radial test 2 (tests 3 and 4 similar)


Radial test 2 (tests 3 and 4 similar)

An additional radial test was undertaken with an old (non-stainless) ring hanger – see Appendix 2 for details.

Following the tests each of the screws and holes from all the tests were labelled and photographed, so each screw and hole can be revisited if required.

The holes were cleaned with water, and inspected for spalling and cracking. There was very little observed damage. This was taken as a sign that the concrete was not a limiting factor in the strength of the anchors tested.

# Results

1. One screw was tested axially and withstood about 20 kN without failure.
2. Five screws were tested radially and withstood about 20 kN without failure.

# Interpretation

1. I am satisfied that the tests conducted show that these screws are amply strong for my intended use as a temporary SRT and climbing anchor. The results compare favourably with other equipment used in similar circumstances (e.g. caving rope 15 kN, see Appendix 3).

2. I expect any failure in use would be due to installation error (e.g. poor choice of placement, poor rock quality, over torquing), and that is well mitigated by standard rigging techniques (e.g. multiple anchors, semi-static ropes). I feel the residual risk is tolerably small when compared with other accident risks, for example descender error, or the rope being damaged.

3. The head of the screw is marked clearly with the product details, so if left in a cave over a period of time other cavers can identify it before choosing to use it.

4. This document is shared for information only. Each installer and user must satisfy themselves of the equipment they choose before using it. I hope sharing this work encourages others to consider using stainless and removable anchors.

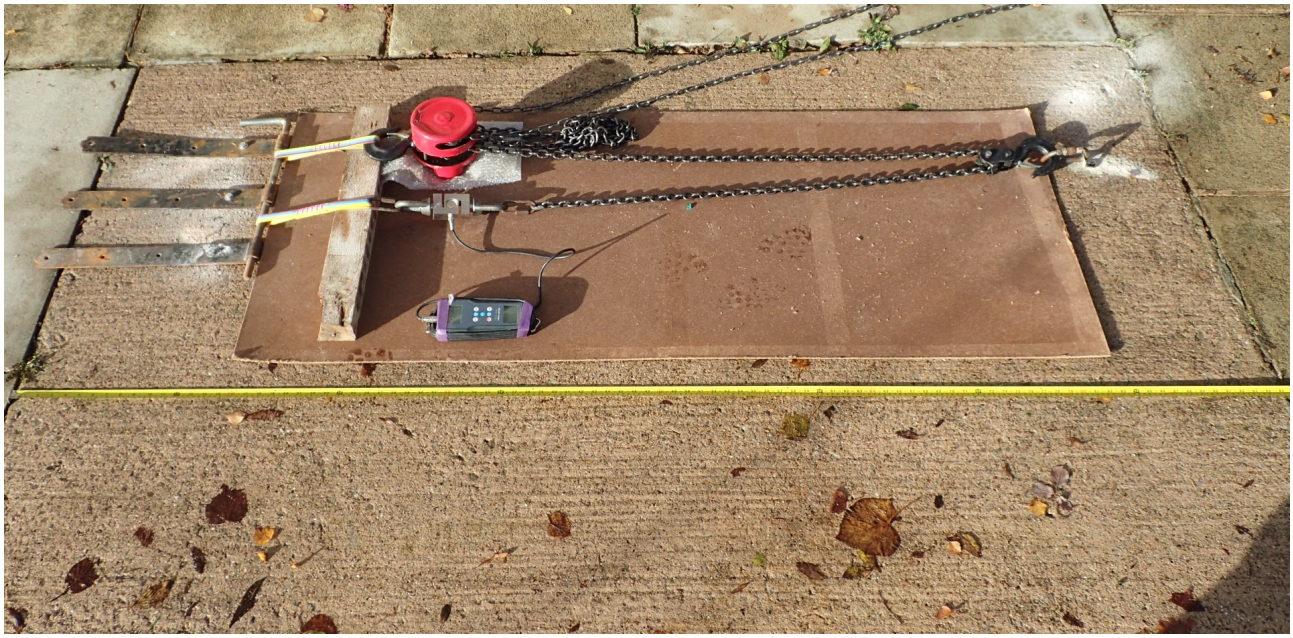
5. Stainless concrete screws are available in 8 mm hole size to suit a 10mm plate hanger. This work should give confidence that these are highly likely to be acceptable for caving use.

# Further work

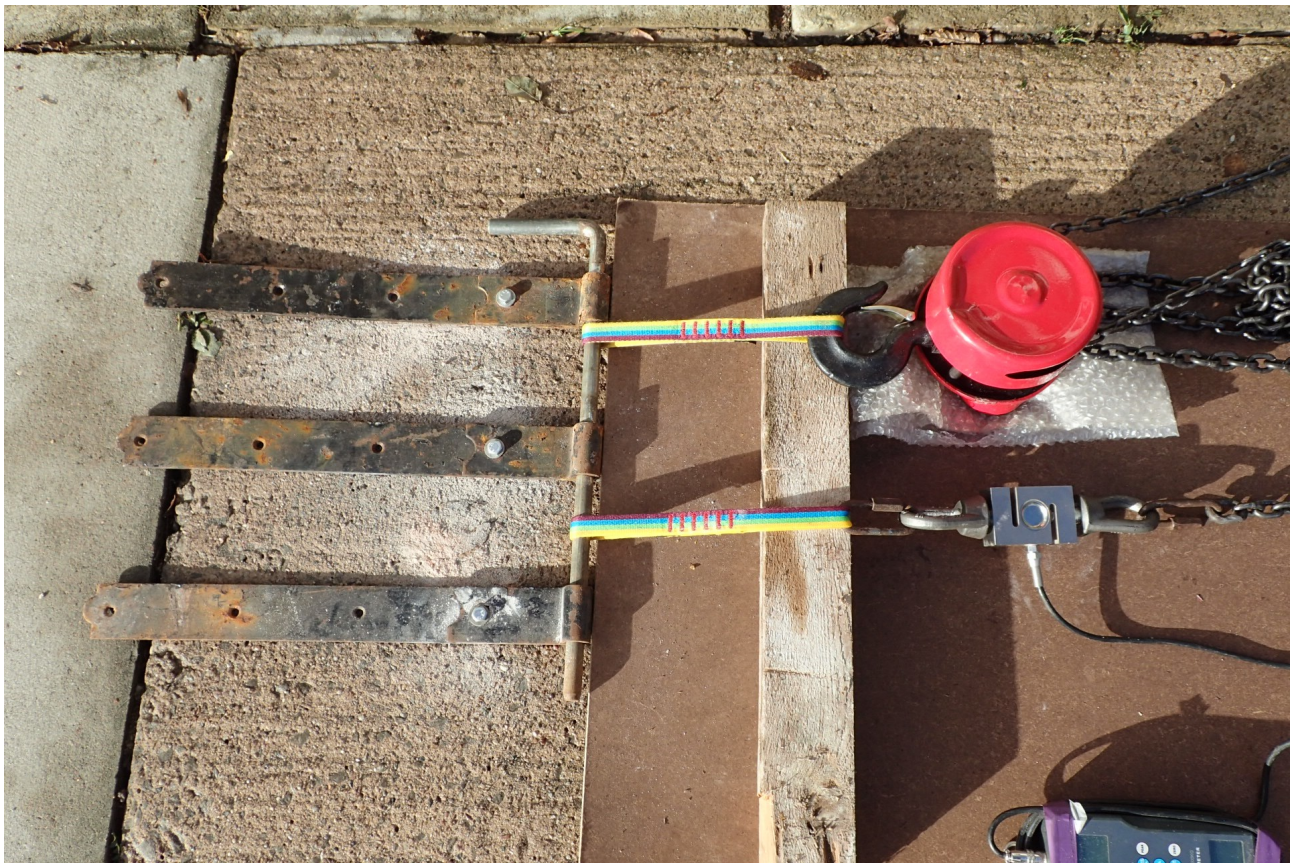
It might be useful to conduct further tests in limestone, larger sizes, galvanised (not stainless), different makes and models, and re-drilling in increasing size for resin-bonded anchors.

# Appendix 1 – Radial test set up

A 2 tonne ratchet chain hoist was installed horizontally:



The anchor was a load-sharing anchor formed of three 8mm concrete screws and scrap steel:



The chain from the hoist passed through a pulley, to which was attached anchor being tested:

From the pulley the chain returned to a 1 tonne load cell at the anchor. This was borrowed from a friend, and would have been a low cost and uncalibrated model:


The reading from the load cell would be doubled to approximate the test load. Although the pulley would not be a perfect 2:1 mechanical advantage due to friction, having the load cell on the static side meant that friction would add to load on the test screw, not reduce it.

The drill used for the test was a Makita DHR171 rotary hammer drill. The drill bit was a Hilti TE-CX 6mm bit with 4 cutters and a measured diameter of 6.3 mm. The screws were tightened by hand using a conventional ring/open spanner and/or a short handled ratchet socket driver

# Appendix 2 – Other tests

## Radial Test 5 (ring hanger)

Next a new screw was tested in the same hole as the previous test, but with an old Petzl ring hanger of unknown age and history. It was corroded and pitted and possibly deformed.

This was loaded up to the load cell maximum, without any preload cycles. It withstood 20.6 kN, although the load was observed to fall off. The hanger and load was observed but after 7 minutes the anchor was still resisting at a load of 18.8kN and so the test was terminated.

This hanger had a failure of the weld at the rear. The screw was a little bent like the previous tests.

Radial test 5 (before)

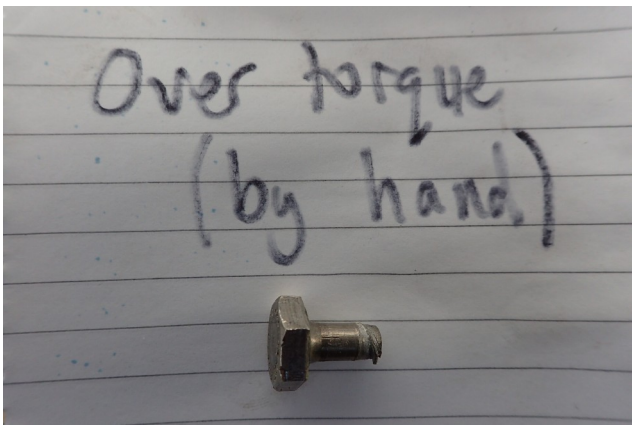
Radial test 5 (during)

Radial test 5 (after)

Radial test (after)

## Test X - Torque test (ie. over tightening on installation)

One new screw in a new hole was tightened by hand with a conventional 13mm ring/open spanner until failure. This took significant effort as many turns were required at a high load. Failure in this way in use would be highly unlikely with a competent installer.

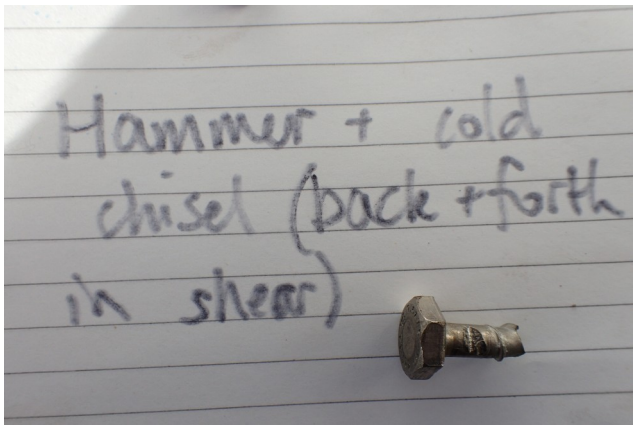



## Test Y - Shock test with hammer and chisel

Another new screw was installed in a new hole but without a hanger and showing a short length of shank above the concrete surface.

This was then struck repeatedly with a hammer and cold chisel in an attempt to 'shock' load the screw in shear as a result of which the screw bent over sideways. The blows were then alternated to bend the screw back and forth.

The screw was snapped after some considerable effort. Failure in this way during caving use would be highly unlikely.




# Appendix 3 – Equipment strengths

## Rock anchors

Requirements for permanent rock anchors are provided for in the following standards:

| | Axial | Radial |
|---|---|---|
| EN959 | 15 kN | 25 kN |
| UIAA-123 | 20 kN | 25 kN |
| BCA E&T anchor approval[6] | 15 kN | No requirement |

## Semi-static ropes

- Type A 15kN knotted
- Type B 12kN knotted

## Caving anchors and hangers

Petzl sell anchors and hangers specifically for caving (SRT) use:

| | Axial | Radial |
|---|---|---|
| Petzl Pulse 8mm (anchor) | 12 kN | 15 kN |
| Petzl Vrillee (twist hanger) | 0 | 15 kN |
| Petzl Coudee (bend hanger) | 0 | 15 kN |

## Climbing equipment

Since the concrete screws would be used in a caving context as a temporary anchor for SRT and climbing protection, comparison with other products that could be used in this way may be useful:

| | Axial | Radial |
|---|---|---|
| Chocks (nuts) | 12 kN (typ) | N/A |
| Hexes (rockcentrics) | 12 kN (typ) | N/A |
| Cams (frictional anchors) | 14 kN (typ) | N/A |
| Ice screws | 5 kN | 10 kN |
| Pitons (safety piton) | N/A | 25 kN down, 10 kN up, 15 kN laterally |

## Connectors

- Karabiner (EN12275 / UIAA121 Type B) 20kN
- Maillon Rapide (EN12275 / UIAA121 Type Q) 25kN

6 https://british-caving.org.uk/documents/et-minutes-05-04-14/?tmstv=1700428158