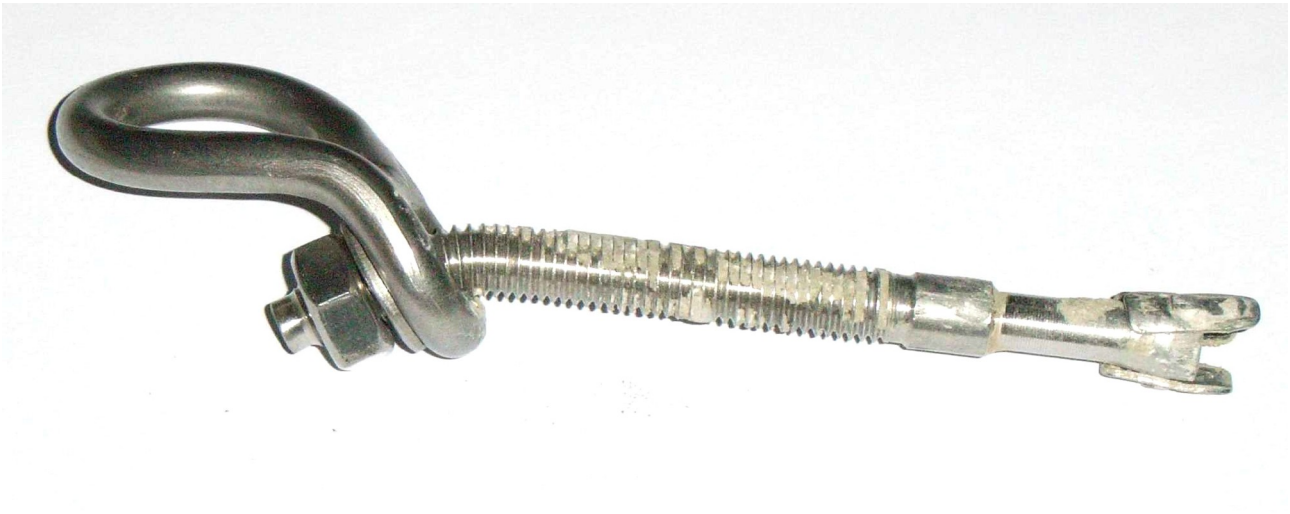
Bolting Conglomerate

We recently had the opportunity to perform some bolt tests in conglomerate, this particular type being a diamictite. This is a type of conglomerate where the pebbles are relatively unsorted (a mixture of various sizes) and with a large percentage of matrix material, the "cement" joining them together. These conglomerates are typical of those arising from glaciation as in the area we tested in the Allgau, southern Germany.
We tested in an area of particularly weak rock with areas of the cliff being unclimable due to the poor quality. The pebbles vary from walnut sized to grapefruit and embedded in a very soft, sandy matrix.
This is, as common in the area, a very steep cliff with roofs making the axial pull-out strength particularly important, the routes being in the upper 7´s and 8´s.

Bolt-in

The local climbers don´t use bolt-ins in this rock quality and for good reason but we though at least we would try. We only placed two bolts in an area of good quality rock with a water deposited sinter skin on it, basically the best bit we could find. These were 10mm X 100mm through bolts. Drillling we noted that the hardness varies dramatically depending on whether the drill is going through a pebble or the matrix (or sandy mud in places). If the drill hits the side of a pebble the bit wanders off to the side giving a hole of uncertain diameter.
Neither of the bolts could be tightened to the required torque (40Nm) as they just kept pulling out wards, one achieving ca 18Nm and the second ca 22Nm which represents a pull-out resistance of 9kN and 11kN respectively.
The first bolt was pulled axially and moved steadily outwards under ca 10kN load until 6cm had pulled out, it then held 26kN before completely failing as the clip pulled over the cone.



The second bolt pulled out with loads varying between 3.5kN and 10kN, nearly losing the clip on the way.

It has been noted by the locals that even in better quality rock areas bolt-ins don´t like repeated falls with failure after three or so falls and this really isn´t surprising!

Glue-in

This was the primary objective and we performed both radial and axial tests on a variety of bolts, all glued in using epoxyacrylate adhesive. The block we tested in was a fallen part of the roof at half

height on the cliff in an area considered just climbable.
Cleaning the holes was difficult with brushing appearing to enlarge the hole about as well as with the drill.
The placements were selected by an experienced local developer using a hammer to test by sound the suitability.

Radial Test (Sideways Pull)

For this we placed three Bolt Products twisted leg bolts made from 6mm stainless rod; 80mm long, 100mm long and 150mm long as well as an 8mm rod Buhler type bolt from Salewa and a 12mm x 80mm Hilti scaffold eye which were commonly used in Germany. The anchor for the tester was a glued-in 8mm rod x 150mm Bolt Products twisted leg bolt. Due to an oversight in the placement we could not radially test the 6mm x 80mm bolt and this was axially tested.

The requirement for EN959 is 25kN

BP 6 x 150mm	45,20kN
BP 6 x 100mm	23kN
Salewa 8 x 100mm	26kN
BP 8 x 150mm	45.2kN (Anchor bolt, no failure)
Hilti 12mm x 80mm	11kN

39kN on a radial pull, the rock has collapsed to about 5cm depth and now a pebble is taking the strain, luck of the draw. This bolt went on to hold 45.2kN

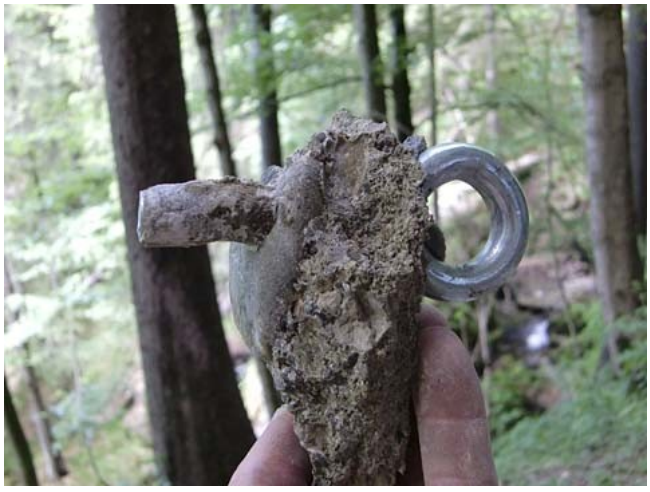
This one was not very impressive (Hilti eyebolt) in the radial tests coming out covered in sandy rubble at 11kN, as one can see drilling an accurate hole is difficult. The only bit that really held is the grey area down the bottom!

Axial Test (Straight Pull)

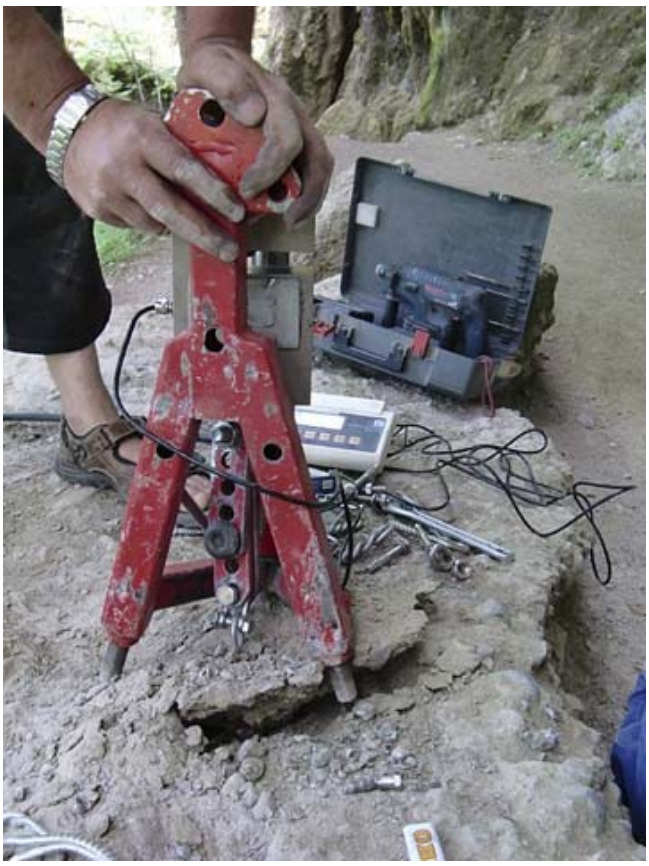
The same bolts as above were installed with the exception of the Salewa bolt as we had only one available. The 8mm x 150mm bolt used as the tester anchor was also pulled axially even though the rock in front of it had already suffered to some extent in the radial tests, additionally we pulled a second 6mm x 80 bolt as noted above.

The requirement for EN959 is 15kN

BP 8 x 150mm	47.6kN
BP 6 x 150mm	23.2kN
BP 6 x 100mm	13.6kN
BP 6 x 80mm	9.5kN
BP 6 x 80mm	27kN
Hilti 12mm x 80mm	12kN



This bolt's (Hilti) reputation was helped by the pebble we drilled through!



47kN on a 150mm bolt is too much for the rock, in a major way!

Conclusions.

Bolting in this poor quality of rock is a lottery, the only thing being to get the odds in favour of the climber!

If you get really lucky and drill through a pebble then you get suprisingly good results but if the pebble shatters under the drill then you get really poor results, since this is happening inside the rock where you can´t see this really is just luck.

The more responsible developers already place a lot more bolts than really nescessary and advise you clip them all, certainly they don´t like using bolt-ins much for good reason. While one of these bolt-ins we tested got an exceptional value it was already severely bent and pulled more then half of it´s length out of the rock, no climber in his right mind would have clipped it!
As you can see from the three 80mm glued-in bolts that were axially tested the results are very variable, two being well under the requirements for EN959 with the other being over twice as strong.

Clearly the answer is to stack the odds in your favour by using really long bolts, increasing the chance of getting near or into a pebble and anyway hugely increasing the amount of matrix in contact, all the 150mm bolts giving exceptional results, 100mm being more or less acceptable and everything shorter than 100mm being of extremely dubious value.