BCA Equipment and Techniques Committee

Meeting held at various locations linked by Webex on 1 December 2016 commencing at 19.45

Present: Colin Bunce (SUI) CB, Faye Litherland (CSCC) FL, Bob Mehew (Rope Test Officer) BM, Stephan Natynczuk (ACI) SN, Getting Thomas (N Wales) GT (who joined at 20.30, Nick Williams (Convenor) NW, Richard Vooght (DCUC) RV, S Wilson (CNCC) SW (who joined at 20.10)

1. Apologies for Absence: Jules Barrett (DCA) had sent his apologies.

2. Chairman's Opening Remarks: NW welcomed CB as SUI's rep to his first meeting of E&T.

3. Notice of Items to be raised under AOB: BM requested his paper on updating advice on Inspection of Anchor by Users be considered.

4. Minutes of Previous Meeting: NW noted there were two sets of minutes, those for the 15/11/15 and some notes for the meeting on 20/3/16. He noted those for 15/11/15 had not been accepted at the meeting on 20/3/16 since only two persons participated. Those draft minutes had not been circulated prior to this meeting but had been available on the web site and had been circulated prior to the 20/3/16 meeting. The draft notes for the meeting on 20/3/16 had been circulated prior to this meeting. FL proposed they be accepted and RV seconded the motion, motion passed nem com.

5. Matters arising not covered elsewhere including review of actions in progress:

5A Actions from Previous Meetings

Action 5A.1 FL & BM to produce a set of bullet points of key requirements for an anchor.

BM suggested as nothing had progressed the action is deleted. FL agreed. Action closed.

Action 7C.1 – NW to write to Bolt Products seeking assurances on material selection and production process providing a repeatable product, why passivation was required given polishing would remove it (if indeed it was applied to the HCR anchor) and whether the HCR anchor had been tested by TUV Sud.

NW admitted he had made little progress but noted BM had made more progress which would be discussed under item 7. Action closed.

Action 7C.2 – RV agreed to extract the shaft of the titanium anchor, take a series of photos and circulate them to E&T and return the bits plus the remaining 9 anchors to NW.

RV noted work done and report issued by separate email (see Annex 1). NW asked what is the case for not going to titanium anchors for use in high corrosion locations? He noted the metallurgy of titanium is difficult to understand, that they are very expensive compared to alternatives and the manufacturer's response to him was not overly helpful (see item 7C p4 minutes 15/11/15). FL said that the photos indicate considerable difference from what she would have expected from titanium metal. BM reported that he had received comment on the macro photo which supported FL's comments about inclusions. Another manufacturer had supplied a couple of their titanium anchors to us. BM proposed that these plus the remaining titanium anchors be tested when time permitted. He commented that we may just have had one which is poor. FL observed that brings into doubt the quality of the material used by that manufacturer. NW noted the situation was similar to the Peco

anchor situation where metal failures caused the process to be abandoned. FL suggested that E&T should not abandon titanium but forgo using that manufacturer. NW summarized the current position was that E&T have looked at using it but we remain to be convinced that it will meet our requirements, we have had problems with the first set supplied to us but we now looking at an alternative manufacturer. In response to a query, BM suggested we tested the rest with photographic and video evidence and then communicated those results to the first manufacturer. FL expressed the view that we should not do more work on the first manufacturer's anchors but we should share the macro photo.

The action was closed.

Action 5A.1 – BM to share macro photo with manufacturer.

Action 5A.2 – BM to organise testing of second manufacturer's titanium anchors as a low priority task.

Action 7E.1 – BM to produce a summary on the North Wales anchor in slate work for NW to agree.

NW noted covered in March notes. Action closed.

Action 8.1 - JB to inform BM as to whether the 7 reported loose anchors had used Hilti resin.
(Post Meeting Note – JB reported after the meeting that only 3 anchors used pre 1996 and thus presumably Hilti resin, whilst the other 4 were positively identified as using Resifix R3+ resin.)

Action closed.

Action 8.2 - BM to seek copies of records from the regions and extract data on replaced anchors.

BM reported that he had taken the point up with L Sykes on acquiring CNCC data. Mr Sykes was treating this as a secondary priority as his company was keeping him very busy. BM stated he would keep up contact. Action Continues.

Action 5A.3 - BM to seek copies of records from the regions and extract data on replaced anchors.

(Post Meeting Note –CNCC data was provided post Xmas. A similar request has now been sent to all other regions.)

Action 8.3 - BM to produce a draft program for agreement by the Committee on removal and replacement of BP anchors by email and then for NW & JB to help undertake it.

See Item 10. Action closed.

Action 9.1 - FL & BM to draft a specification for fatigue testing of anchors placed in rock.

FL noted that as nothing had progressed the action is deleted. Action closed.

5B Other Points Arising: There were none.

6. Report on anchor activities in the regions:

6A SUI: CB note 2 loose anchors in Poulelva had been replaced and a third had its head removed and the hole remaining covered with resin. 2 remain to be done. CB confirmed they were placed in mid to late 90s and the anchor heads were not recessed. Some Bolt Product anchors had been placed on a traverse in Polnagollum. He noted they had use a chain to connect 2 anchors and wondered about comments in other documents. BM suggested the topic was dealt with under item 9. 2 others had been placed on Poll Gonzo using the supplied Bolt Product anchors and resin. NW raised a point of the due date but CB reassured him the resin was in date.

6B Devon: RV noted a need for installers to renew their training. NW suggested T Chapman on Mendip should be able to provide training. RV noted he had some new anchors to test which would come up under item 7. He reported that no new anchors had been placed. RV note that a couple of loose anchors of unknown manufacturer had been reported in a slate mine for which there was no access. CB enquired about time limits on installers. FL thought it was up to the region to set such detail. On Mendip it was left without time limit but two persons were required to be present at an installation, one of whom must have been appointed by the region and other with some knowledge. BM referred to Section 5 from the anchor policy and quoted *"The list shall be reviewed annually with a view to deleting from the list persons who have insufficient recent training or experience in designated anchor placement or are no longer Members of BCA".*

6C Wales: VA noted he had removed & replaced one anchor from Pant Mawr pot due to reports of it being loose. He requested 12 more tubes of resin.

6D Mendip: FL noted that practical work was being done by Andrew Atkinson. They had taken a decision to not place any more Bolt Product twisted shaft anchors on conservation grounds until they were confident that they could remove them. Andrew was looking at alternative anchors to see if there were any which would be easy to remove. FL also enquired how far away S Wilson was from being able to make the IC anchors available to other regions. BM suggested they discussed alternative anchors under item 9.

6E Dales: NW noted that SW was still attempting to get connected and would come back to this heading when he was successful. (SW provided his report between items 7 & 8.)

Installation of approaching 300 IC anchors has taken place within the Dales. SW had used Euro Speleo to look at a number of anchors in caves and found loose anchors in a few caves (Juniper Gulf, Swinsto, Hardrakin, Alum and Diccan). Recently a report had been received of a loose anchor in Bull Pot. On investigation he had found 12 loose. They have now been replaced. A topo guide had been produced which would be published on the web site.

He had also attended a meeting with CRO in Clapham to discuss anchors which may have been installed for rescue purposes. They had identified that there were a few caves which had eco anchors installed for rescue purposes which were not in the record set. CRO indicated they would now use Petzl P38 long life anchors if there was a need. SW had suggested that they should use an easily removed anchor which can be replaced subsequently by a resin anchor. CRO had expressed a view that 'Thunder Bolts' / self tapping masonry anchors might be the way forward. SW expressed an intention to test some anchors from reputable manufactures at some time in the future. BM noted the topic of self tapping masonry anchors had been discussed at the previous meeting. NW noted that self tapping masonry anchors were probably manufactured for construction purposes rather than supporting people. NW felt quality control would be the issue of concern. Whilst he felt it would be worth testing some, there would remain a question of whether the manufacturer's batch

control would ensure consistency in quality of product. FL noted the popularity of this type of anchor with diggers and supported doing some work. RV noted a prevalence of removable Rawl Bolts in Devon which wore the hole out. VA noted that some 30 to 50 year old Rawl Bolts had been removed from OFD which were found to be rusty. The committee agreed to fund the expenses of some work by SW into self tapping masonry anchors.

Action 6E.1 - SW to test some self tapping masonry anchors as a low priority task and reclaim expenses from E&T.

GT joined the meeting.

7. Sea Water Anchors

BM reported he had issued an email on 14 November, see Annex 2. He reported that Bolt Products were considering giving up manufacturing both HCR and Sea Water but had supplied 50 off 6mm rod Sea Water twisted shaft 10cm long anchors to RV. BM summarized his email and added that one of the features of the 8mm anchor was its mechanical bond to the resin / rock which is why it does so much damage to the rock.

SW joined the meeting at this point.

BM suggested RV test a batch size of 10.

FL asked if the smaller diameter rod meant more rod was present and hence larger surface area. She also suggested starting with 5 since we had a limited number. BM noted one could not do the normal distribution check on a batch size of 5; using the data from the South Wales resin tests he found he could confirm normal distribution with a batch size of 10. CB noted they had placed some 6mm rod Bolt Product twisted shaft anchors in two caves so would be interested in the results. FL enquired as to what the material was and the influence of its ductility and on failure mode.

(Post Meeting note Bolt Products claim their Sea Water series is made from 1.4462.)

She suggested the work should look at the mode of failure. NW suggested a set of photographs of the work. RV indicated he could do that. RV went onto ask about the pass criterion. BM stated that it was that 95% of the samples were above 15kN. He offered to compute the statistics for RV and confirmed a batch size of 10. NW asked if there were any identifying marks. RV replied they were all blank. BM proposed that highly precise installation records were made so as to not require stamping which he was concerned might create a problem.

Action 7.1 - RV to test a batch of 10 Sea Water Bolt Product anchors, BM to compute the statistics, and RV to take photos.

8. Loose Anchors

NW noted for SW benefit that DCA had reported "*that only 3 anchors used pre 1996 and thus presumably Hilti resin, whilst the other 4 were positively identified as using Resifix R3+ resin.)*". SW noted he had just found one loose anchor at Dr Banister's Hand Basin which had a recessed head and thus was unlikely to be placed with Hilti resin. BM noted some records were available but SW commented those did not give the location. BM suggested they needed to be read in conjunction with the test records as well as the published topos in the CNCC rigging guides. He did admit that the guides would not cover every cave covered in the records we hold and it was unlikely that the

topos had the anchor code. BM accepted that little progress had been made and referred SW to the position on Action 8.2 (now 5A.3). He agreed to discuss the topic with SW outside the meeting. NW expressed some concern over the state of records and expressed a desire to hold copies of them centrally.

SW noted prior to the Dr Banister's Hand Basin anchor resin, all the others he had found were buff coloured which he presumed was Hilti resin. He also expressed concern over the amount of looseness which was allowable. He noted that in Bull Pot they had removed all suspect loose anchors and replaced most with IC anchors as some locations were considered to be surplus to needs. NW noted this was work in progress. SW said he would raise at the next CNCC meeting the topic of allowable looseness as he was of the opinion that none should be tolerated. He was intended to write a report on the topic. BM noted inspecting for loose anchors was an item under AoB.

9. Welds & Chloride Stress Corrosion Cracking

NW noted a paper had been circulated by BM, see Annex 3 and asked BM to summarise it. BM noted the paper covered an anchor system with an incorporated welded chain which was slightly different from CB's set up (re item 6A above). The weld was poor and had almost certainly subsequently cracked by Chloride Stress Corrosion Cracking (ClSCC). He noted ClSCC required three condition to be meet, the presence of stress, that the chloride ion concentration exceeded a certain threshold and temperatures were also above a threshold. He expressed a concern that poor welding can create high residual stresses within the material as would seem to be the case in the example.

When E&T discussed the topic several years ago it agreed to work on the defensive assumption that sufficient stress was present since it was extremely difficult to assess stress in welds or in bent material. BM observed that the threshold for 304 was around 200ppm and for 316 1000ppm chloride ion in water. BM noted that the typical 11C temperature in UK caves were way below the lowest reported threshold temperature (25C) though not necessarily at the entrance.

Since writing the paper it had come to BM's attention that work was being conducted on Mendip testing a 316 anchor with a weld. He had commented about ClSCC to the manufacturer of Bolt Product anchors, Jim Titt and his comment was "*No idea about SCC in the welded bolts, in any normal environment it won´t occur anyway especially a cold cave. We are currently building a test rig for salt-water testing but to get results would take ages like 3 or 4 months. We have a lot of welded stuff right on the coast in Sicily and don´t see any problems though*." BM felt that whilst the problem of ClSCC in welded 316 was unlikely to occur, there was not sufficient evidence to rule it out. Hence he was concerned that Mendip were looking at a welded 316 anchor though he accepted a single shaft made extraction much easier.

FL admitted she shared the concerns but she had been informed by Jim Titt some years ago that he barreled annealed his welded anchors which she claimed would relieve the stress. She accepted there was need to better understand both that annealing process and how it is controlled along with how the quality of welding was maintained. FL went on to observe that the carbon and phosphorus levels in the faulty component were above that specified for 304. FL commented that reassurance cold be obtained from X raying samples, dye penetrant testing and also obtaining the weld procedure used. NW whilst accepting what FL had said expressed concern that whilst choosing a steel was demanding, moving onto considering welds made the topic considerably more complicated. He felt it seemed to be common sense to avoid welds so as to avoid these additional complications. BM proposed FL produced a short note listing the areas of testing, checking and

other measures that she suggests should be done before E&T moves towards welded anchors. FL accepted the action.

Action 9.1 - FL to produce a list of testing, checking and other measures that she suggests should be done before E&T moves towards welded anchors.

NW noted that he felt most of things which would be needed to get welding right were quality control processes which E&T was not capable to undertake. FL accepted the point. She explained that they went to this because they felt Bolt Product twisted shaft anchors were not acceptable from a conservation point of view. NW noted that the Eco anchor had a localized MIG weld though it was positioned such that it was not critical to the strength of the anchor. BM noted that the existing information on conservation aspects comes from work which was not done to minimize forces in the rock as the feet on the anchor puller are specifically located well away from the anchor. He said that Jim Titt had suggested that we would have little problem if we were using something likes SW's extractor tool. He therefore suggested E&T should do some work on alternative means of extraction which was the next item 10.

NW asked if fluoride was a potential Stress Corrosion Cracking problem. FL confirmed it was. NW noted that there were caves in Derbyshire which have fluorspar in them.

10. Extracting Anchors and Use of Over Sized holes:

NW noted he was now the possessor of six 1.5 ton boulders which could be used for testing anchors.

BM noted that he had circulated a paper on the topic, see Annex 4. NW commented he had forwarded copies of images to all which had been sent by SW, see Annex 5### of him using his removal tool to extract a Bolt Product twisted shaft anchor. BM proposed to place five off 8mm rod (hence 16mm hole) Bolt Product 100mm twisted shaft anchors and then try and to core drill them out with either a 22mm core drill (which seemed to have a tight ID of 15.5mm) or a 28mm core drill having cut the head off. A further five oversized holes will be drilled and then 8mm rod Bolt Product 100mm twisted shaft anchors will be placed in all ten oversized holes without any roughening of the hole. These will then be pulled. (The purpose of this is to check how significant smoothed surface were in oversized holes.) If the results were poor, then the holes would be redrilled with a percussion SDS drill and more 8mm rod Bolt Product 100mm twisted shaft anchors would be placed for testing.

BM also noted an image of Jim Titt's portable extractor was included in the paper, see Annex 4, though it did not show the collar he used, being a small ring plate to spread the load across the surface of the rock next to the anchor. Jim Titt had also suggested a sleeve device to 'fill' the oversized hole to reduce resin consumption. BM went onto request from SW either if he would manufacture E&T a copy of his extractor tool or else send a sketch. SW noted he had just updated his web site on this topic and which showed better photos of the revised removal tool and some details on it, together with some photos on removing spits. NW asked SW for his view on the differences between his and Jim Titt's extractor tool, noting that it was more complicated by including hydraulics. NW noted when he tried a hollow ram hydraulic system, the internal diameter was insufficient size to permit a strong enough bar to couple to the anchor. SW asked if it would work in an underground environment noting for example the pressure gauge. BM commented Jim Titt had indicated he had used it on tests beds in the field. SW said he would put up a sketch with details in his web site but noted his one was wearing at the thread. NW commented about the difficulties of obtaining the threaded bar at the heart of the design but observed that making an extended nut was relatively straight forward. SW noted that he used M16 fine threaded bar which

was quite common to buy. NW said that if it was an effective tool then eventually E&T would want one for each region. SW commented he did not have the time to make them. NW commented that BCA had the funds to pay someone to make them if we were sure they were usable.

NW asked if people were interested in an anchor weekend placing and extracting anchors. Some interest was expressed. NW indicated it would not take place until the Spring as it would be weather dependent. It was suggested we might invite Jim Titt to the event.

SW commented that he had extracted one Bolt Product twisted shaft anchor with the first version of his removal tool which used a 54mm OD / 48mm ID tube. The tube was applying the reaction force back into the rock quite close to the anchor and pulverizing the rock to dust and gravel both underneath and outside the tube. The depth of the cone was the diameter of a 50p coin and in his opinion the location would not be reusable. SW confirmed that he doubted if his removal tool would remove a Bolt Product twisted shaft anchor leaving a reusable location.

BM suggested that implied the Bolt Product twisted shaft anchor was not the way forward. SW observed that he thought the problem was the Bolt Product twisted shaft anchor applied the load back into the near surface region of the rock rather than deeper down. He suggested that if the twist started further down the hole possibly as much as two thirds down the shaft, then that might ease the problem and transform the design to our needs.

FL noted that this was the underlying reason for looking at a welded anchor in order to deal with a conservation problem. BM noted that there were several 304 anchors with apparent suitable design available on the market. SW spoke favorably of the Edelrid glue anchor and noted he had no problem in extracting one. BM commented that we would need to accept a single line of defense against ClSCC to permit us to go to using 304. NW asked as to how much of the problem of ClSCC was due to the weld rather than anything else which the Bolt Product twisted shaft anchor did not have. FL observed that similar issues arose with bending. BM noted that Jim Titt was claiming that the material he obtained could be bent to a certain minimum radius without creating a problem of cracking. Presumably he used a jig to limit the bending. Whereas with welding, there were a large number of features with the potential to cause elevated stress which were under far less control. He went back to the point that there were 304 anchors which appeared to deal with our problem. FL indicted that she would be prepared to accept a 304 anchor made well in preference to a 316 anchor made badly. BM suggested E&T make contact with Edelrid. BM asked if FL would be prepared to accept 304 anchors. FL commented that location would be significant and BM stated that obviously 304 anchors would not be used at entrances and certain caves which were known to take road or other high chloride ion containing effluent. NW summarized by commenting it was ongoing work.

11. Rope Testing

BM apologized for not providing a written report but he had been overloaded with other work. He had taken the BCA rope test rig to Euro Speleo and also ran what he felt was a successful workshop on the Bradford instrumented rig with 12 delegates. He had intended to put together a budget but had had no time to do so.

12. Static Test Rig

BM reported that the extended static rig was brought back to the Bradford Pothole Club's garage in June following a comprehensive upgrade by Paul Thorn. He had used it in June to test some digging buckets and a rock net manufactured by Dave Brook. The key feature of the design was a 15mm copper tube ferrule 'crushed' onto a rope to act as a 'stop' which he attached onto a 25 liter plastic

container with the bottom cut off. The digging bucket was quite robust in use and on testing failed at around 5kN / 500kg which compares favorably with a potential load of around 60kg. The rock net used a similar basis of design but incorporated a large number of ferrules to link together the rope into a net which could be rolled around a boulder. The net took a much higher load of 22kN or over two tonnes before the first partial failure occurred. This high value is in part because the load is shared between a number of ropes making up the net linked by the copper ferrules and that the partial 'failure' mode was the ferrule ripping apart.

The rig was also demonstrated at Euro Speleo as part of the workshop.

The static rig incorporates both a hydraulic pressure sensor and a displacement measuring device hence measure energy required to destroy things. There are still a few question marks over their operation which are being sorted out, the latest one being that the pressure transducer does not closely track a load cell.

NW queried if anything had been heard from Bob Dearman about testing maillons. BM indicated he had not spoken with Bob Dearman for some while.

13. AoB

13.1 Inspection of Anchor by Users Update

BM stated that a document had been circulated, see Annex 5, entitled 'Proposed change in Anchor Inspection Routine'. He explained the background was that he had been tasked with providing a theme for a BCA Information advert in Descent and following discussions with the editors recognised that improvements could be made to the advice to users on pre use inspection. He therefore proposed the Pre Use Inspection advice be represented as:

Before use check each anchor:

- *That there are no clear signs of wear or damage to the anchor*
- *That there is no looseness or fracturing of the rock within 20cm of the anchor*
- *That the anchor has no apparent movement with respect to the resin in any direction (less than 1mm in twist, side to side or in / out)*
- *That the resin has no movement with respect to the rock (twist, side to side or in / out).*

BM noted that SW had earlier suggested no movement should be tolerated but the reason for doing so was stop people reporting looseness which was in their fingers rather than in the anchor. BM asked what criterion SW used. SW stated that movement between resin and rock was obvious. He accepted anchor to resin was not so easy. SW noted that he had had only one report since he asked on ukCaving a year ago for people to report all loose anchors and ignore the 1mm criterion. He was unclear as to why people were not reporting them when on descending Bull Pot he found 12 loose anchors. He would prefer to get any report even if this mean they were snowed under. NW expressed a view that he thought it was not feasible to specify any value of 1, 0.25, 3 or even 5mm given conditions in a cave and felt specifying a value was not useful. He went on to comment that if it was not likely that people would incorrectly report loose anchors, then there was no reason for removing the 1mm value.

NW suggested the first bullet point should be "That there are clearly no signs of wear…". BM noted this was based on Derbyshire experience. NW asked if there was a need to use 'clear'. FL agreed

feeling that 'clear' was superfluous. NW suggested the point be "*That there are no signs of wear or damage to the anchor*".

FL stated she agreed with removing 'clear' as well as '+/-1mm' and also would like to see a reiteration that the decision to use the anchor was the responsibility of the user and on using two anchors. NW agreed about not using a single anchor.

GT noted they teach on LCMLA training course about looking for fracture marks in slate due in part to the awareness that the slate had been subject to blasting and thus a need to avoid areas close to shot holes when installing anchors. Experience has found this can seriously impact on the strength of he placed anchor. They then go onto looking at the anchor for wear, damage or deformation. They also talk about any movement. Finally they cover the responsibility of the user to decide if they want to use the anchor or not. SN commented that he trained people along the same lines as GT. SN did however wonder f the request for report should not just be about loose anchors but also worn ones. BM suggested that this should cover any anchor which fails the pre use check.

GT noted that in mines, they see a wide range of anchors and raised a concern about recognising if the anchor was a good one, especially with the self tapping masonry anchors where the head looks very similar to other better anchors. BM noted this advice was for anchors under BCA's scheme which highlighted another problem. BM suggested that this should go back to a fundamental level that if whilst down a cave one saw something unsafe, be it an anchor, ladder rock or whatever, then one should report it. NW suggested the meeting should remain focused on anchors there being a separate need to shift the culture towards not only looking after one's own safety but also that of other cavers.

NW summarised that the conclusion was remove the words 'clear' and '1mm'. FL suggested removing '(twist, side to side or in / out)'. She also suggested a need for some words about taking own responsibility and always using two anchors. BM pointed out that there were a number of places where having started with two anchors at the top, down the pitch were single anchor rebelays. NW suggested that in such cases the load was spread across more than just the rebelay anchor. BM asked then what words should differentiate between rebelay and pitch head. NW asked if there were words already in use within the Training community. VA suggested the golden rule was never trust your life to a single anchor. GT said they always teach never be suspended from a single anchor, always use two anchors. NW suggested that it would be better to keep it simple and ignore the rebelay case. BM asked for a suggested set of words for a sentence on this point. NW suggested 'if one anchor fails, then there should be a second one to back it up'. CB suggested the words could be 'there should always be at least two anchors above you'. BM suggested that the meeting was unlikely to produce an agreed set of words and that he would issue an email requesting suggestions. NW asked BM to send out a specific email on the topic and seek peoples comments.

Action 13.1.1 - BM to issue an email with the so far revised Pre Use Inspection routine plus the responsibility statement and ask for drafts of a statement on using two anchors.

SW asked if BM was writing an article for Descent on the topic. BM replied that he was not but he had been party to an advert which dealt with the topic. SW asked why were we talking about if it had been published. BM pointed out that the topic was also covered on the BCA web site and elsewhere which needed changing. SW expressed disappointment at the lack of reports on loose anchors.

NW commented that he felt it would be good to have this revised statement sitting alongside the 'participation' statement on the BCA web site would be a useful feature speaking with his Insurance Manager's hat on.

FL suggested that a presentation on the scheme should be made at Hidden Earth making the point it was reliant on the information coming back from the general caving community on the state of anchors. NW suggested it could also cover work on extraction / conservation aspects. SW suggested it also needed to cover the history to counter the casual attitude to placing anchors being contrary to conservation. NW commented that there would be a further meeting before Hidden Earth and that could discuss the content of such a lecture. He would be looking for volunteers to make the presentation. FL said she would be happy to do so.

13.2 IC Anchor Web Site

SW mentioned his new web site and the new page containing detail on removing spits. BM asked if the spit site was reusable. SW stated they were. FL asked about the cone stress of the spit. SW noted that this was located roughly 30mm into the rock compare to 90mm for the IC anchor. BM agreed to put a link on the BCA web site.

12. Date and Time of next meeting:

NW proposed a date sometime in March or April which would be selected by a Doodle poll as before. It was agreed to doodle poll for a date which would take place over the internet on a week day evening.

The meeting finished at 22.06.

Action List from E&T meeting on 1 December 2016

5A.1 – BM to share macro photo with manufacturer.

5A.2 – BM to organise testing of second manufacturer's titanium anchors as a low priority task.

5A.3 - BM to seek copies of records from the regions and extract data on replaced anchors.

6E.1 - SW to test some self tapping masonry anchors as a low priority task and reclaim expenses from E&T.

7.1 - RV to test a batch of 10 Sea Water Bolt Product anchors, BM to compute the statistics, and RV to take photos.

9.1 - FL to produce a list of testing, checking and other measures that she suggests should be done before E&T moves towards welded anchors.

13.1.1 - BM to issue an email with the so far revised Pre Use Inspection routine plus the responsibility statement and ask for drafts of a statement on using two anchors.

Annex 1 - Action 7C.2 – RV agreed to extract the shaft of the titanium anchor, take a series of photos and circulate them to E&T and return the bits plus the remaining 9 anchors to NW.

BM wrote:
Richard supplied some photos of the metal break in situ to me. A macro image of the head side of the break was produced by Nick Chipchase. They are attached. (see below)

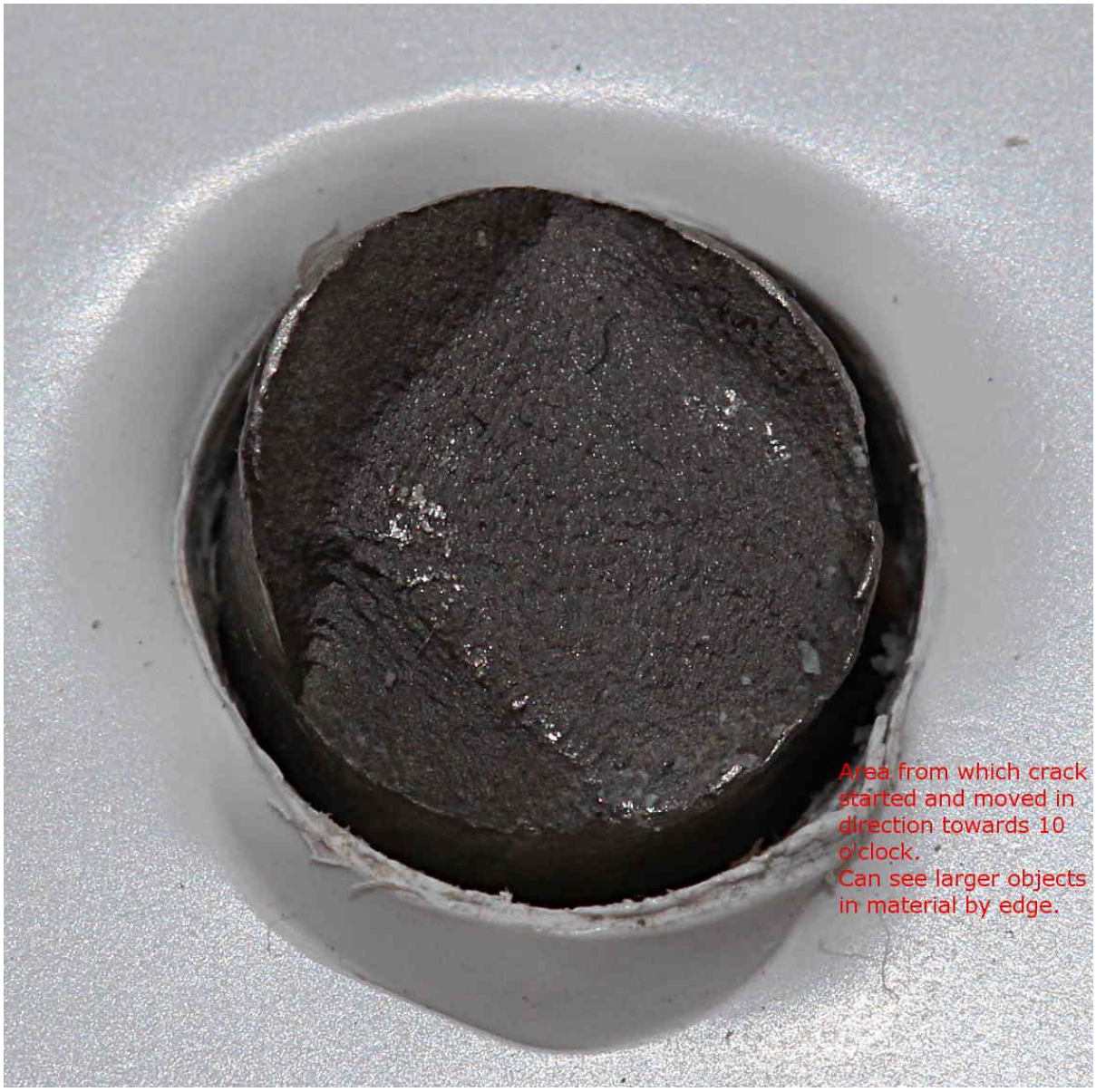
I now hold both the head and the shaft of the broken anchor plus the remaining unused titanium anchors.

For information, Bolt Products has supplied me with a couple of his Gr2 titanium anchors for testing. Jim Titt noted in response to sending him the photo titanium 4:

"The photo you attached certainly looks like a material flaw, titanium is very ductile and normally the failure point shows a huge amount of necking, something around 50% of the original diameter and with an extremely rough, torn appearance. It should have held about 40kN anyway!"

I intend to test his and the remaining titanium anchors sometime next year.

Bob Mehew


Area from which crack started and moved in direction towards 10 o'clock.
Can see larger objects in material by edge.

Annex 2 Testing Program for 6mm BP anchors Email BM to Committee 14/11/16

Hi

We are just about to take delivery of some 6mm dia 100mm shaft length sea water series twisted shaft bolts from Bolt Products. I gather there is a metal surface finish difference as well as the obvious difference in both the diameter of the rod (6 v 8mm) and of the twisted shaft (12 v 16mm) and thus hole size. Which draws into question how much can we read across from the testing work we have done on 8mm BP anchors. We have same shaft length but differing metal and hole diameters.

I believe we have shown the resin to rock bond is OK. Simon's work with his IC anchors into 18mm (instead of 12mm) holes indicates over sized holes and extra resin is also OK though if we ever get around to core drilling out 16mm BP anchors, we will need to go larger than 18mm holes to check this.

So that leaves the resin to metal bond. If the metal surface finish is different, then we have no option but to do a 'full' test. (It will be interesting to visually compare the two surfaces.) We clearly have a different physical size and because the 6mm dia bar means there is less resin to metal surface contact as well as less resin 'surrounding' the twisted shaft. So I sense we have to go to a 'full' test.

We decided in the E&T meeting on 14 April 2014 that:

The standard for acceptance of an anchor type on the basis of an axial load is based on the 15kN axial load value as cited in Section 4.3.1 of the Mountaineering Equipment – Rock Anchors – Safety requirements and test methods BS EN 959 : 2007, as computed as the 5% fractile value as specified in Section 4.2 (3) of the Euro Code Basis of Structural Design Standard BS EN 1990 : 2002 from the results of a batch test of a minimum of 5 anchors provided there is supplementary information showing the distribution of results follows a normal distribution, else the minimum size of the batch test should be 32.

Although it was argued on statistical grounds that batch size of 5 was sufficient, I think that as we are moving to a 6mm anchor we can't read across the normality of 8mm data to justify a sample size of 5 for testing 6mm anchors.

I have also taken data from the resin set of tests of 2014/15 and checked them for demonstrating normal distributions. Taking several random selections of 5 data points from that set, all failed the normality checking test. Taking several random selection of 10 data points from that set, two out of three sub sets did pass the test. (I should add that all the 5 and 10 data points sub sets resulted in a 5% value above 15kN.)

I therefore suggest we first try a sample set size of ten 6mm anchors but we may have to increase sample size if the results are badly scattered.

Any comments before Richard starts doing the work?

Bob

Annex 3 Chain Anchor – Report of a Stress Corrosion Cracking problem

Report

The BMC passed on a report to BCA from UIAA and elsewhere of a problem analysed as being caused by Stress Corrosion Cracking (SCC) in type 304 stainless steel component in an anchor system. The anchor system appears to be sold by Fixe and / or techROCK (it is not clear as to whether one company is a subsidiary of the other) and is labelled as Fixe SS 3/8 Draco V-Anchor, Product ID : 363-3/8 , see alongside.

Fixe's web site[1] state "The FIXE "V" Anchor sets the bar for limiting liability exposure for any climbing gym or university program. The "V" Anchor is the strongest, safest anchor for indoor use. Two DRACO carabiners placed in opposition eliminate the possibility of a rope escaping. The design equalizes the load between two attachment points." The location of the SCC was in the end chain link attached to the hanger plate which is attached to the wall.

It seems unlikely that the device is likely to be placed in UK caves given it uses two crabs to hold the rope. It is also understood to have been designed for use on climbing walls. The reason for interest for cavers is that the component is type 304 stainless steel which might be use in some caves.

The available information indicates that the problem was first discovered at a climbing wall in Germany and reported by DAV[2] (German Alpine Club) when a crack had been noticed in the final link, see alongside. A follow up inspection in response to a safety alert identified two more items in total as being affected. It is not clear if these were at the same climbing wall. The report indicates that the items were placed on an external wall, even though Fixe state 'for indoor use'.

techROCK commissioned a report on the items from Fundació CTM Centre Tecnològic, a Spanish technology centre. I await confirmation that the report can be openly circulated. The report indicates three test were conducted: chemical composition, microstructure analysis and fracture analysis. The reported chemical composition indicates the level of carbon and phosphorus exceed the European standard for a type 304 stainless steel. The report goes onto to state that an examination of the microstructure showed features that "are unequivocally characteristics of the Stress Corrosion Cracking (SCC) mechanism". The fracture analysis also provided "another clear indication that the SCC mechanism is the responsible".

The DAV report comments that manual welding of stainless steel can create such problems. I am given to understand that a high carbon level will cause problems with welding and that a low carbon version of 304 (maximum 0.3%) should be used to avoid them.

[1] See http://www.fixehardware.com/shop/anchors/fixe-ss-3/8-draco-v-anchor/ as at 10/9/15.
[2] See http://www.alpenverein.de/bergsport/sicherheit/fixe-umlenkung_aid_16119.html as at 10/9/15

Caving Considerations

SCC is caused when three conditions are met, namely the presence of stress, a chemical agent and sufficient temperature. It is known that welding can create high residual stress levels, sufficient to promote SCC without any additional stress. It is also understood that bending 304 material usually cannot build up sufficient residual stresses. Only DMM Eco anchors had welds on them which were spot welds. It is thought that such welds would not create significant stressed zones within the material. Also they were located down the shaft so in theory not exposed t the external environment. A number of resin anchors on the market do include welds which are located in the external environment.

Bending of stainless steel rod may create high stresses within the material, usually because the material is not properly pre or post stress relieved. BCA's abortive work on Peco anchors[3] showed that bending did create surface cracks in some anchors. Four of the 64 Peco anchors tested resulted in few metal failures when subject to pull out forces. The failure rate was such that these anchors were deemed unacceptable. It is understood that BP anchors[4] use an appropriate grade of 304 and 316 rod and ensure the bend does not exceed certain limits. Their claim is that the levels of stress induced by the forming process do not require relieving. It is thought that DMM Eco anchors were subject to heat treatment post bending.

There appears to be no evidence for the presence of a chemical agent in these reported cases. The usually suspect is the chloride ion which is a known concern at sea side locations. The location(s) of the climbing walls are not known, so possible aspects such as urban pollution are speculative. (Whilst the reports do not state the location of the climbing walls, they do include reference to sea side problems. So it seems reasonable to assume the walls were not near the sea.) Back in around 2004, a report was issued in the USA that Leeper anchors in remote non sea side locations were subject to SCC, though no mechanism was suggested. So the potential for an unknown airborne chemical agent seems real. In most cave environments, air will have been subjected to a scrubbing action by the associated stream. However this would not be true for anchors placed at the entrance.

Chloride SCC in 304 is not known to take place at concentrations below 200ppm[5]. (For 316 this rises to 1000pppm.) Such concentrations can be created in drops of water as they evaporate.

Chloride SCC is normally thought to only occur at temperatures above 40C though laboratory experiments indicate it can propagate as low as 25C. Within UK caves, the air temperature would be around 11C save for entrances. UK atmospheric temperatures may rise to over 30C but the UK maximum mean daily temperature is around 19C[6]. One web site[7] suggests daily average temperatures across German cities peak at 26C though a peak temperature of 40C has been recorded[8].

The time frame for SCC to occur is variable and dependent upon temperature. Rates of corrosion are high as the mechanism is to corrode along grain boundaries rather than across 'bulk' metal. So in the absence of evidence to the contrary, one must presume rapid SCC if the temperature is high enough.

[3] See http://www.cncc.org.uk/doc/9 as at 11/9/15
[4] See http://www.bolt-products.com/AboutBoltProducts.htm as at 11/9/15
[5] See http://british-caving.org.uk/wiki3/lib/exe/fetch.php?media=equipment_techniques:chlscc_v2_130909.docx as at 10/9/15
[6] See http://www.metoffice.gov.uk/climate/uk/summaries/actualmonthly as at 10/9/15
[7] See http://www.currentresults.com/Weather/Germany/temperature-july.php as at 10/9/15
[8] See https://en.wikipedia.org/wiki/List_of_extreme_temperatures_in_Germany as at 10/9/15

The use of 316 and 304 anchors in caves was justified on the grounds of low chloride ion concentrations qualified by the location of the cave and low in cave temperatures. This failure report suggests that anchors at entrances should not be made of 304. It is not thought that any 304 anchors have been placed in caves or by entrances under the BCA scheme.

Suggestions

Consideration of anchors or other metal devices made from 304 or 316 stainless steel for use in cave with welds present in a location which is exposed to the cave environment should include a discussion with the manufacture about the potential for Chloride SCC.

E&T should reconsider the use of 304 anchors at entrances.

E&T should check with all regions as to whether 304 anchors have been placed in or at entrances to caves.

Bob Mehew
17/11/16

Annex 4 Extracting Anchors and Use of Over Sized holes

Concern has been expressed about being able to remove Bolt Product twisted shaft anchors and then reusing the location with a new anchor. This arises from experience from testing where spalling of the rock around the hole occurs in a substantial fraction of BP anchors removed during testing.

This concern may be unwarranted since the testing process used a puller which is designed to locate the reaction force into the rock at some distance from the anchor. Anchor extraction would use a smaller device which placed the reaction force back into the rock surrounding the hole, thus much reducing the possibility of spalling, see http://www.resinanchor.co.uk/5.html . However it seems prudent to look at other ways in removing anchors as well as reusing the location.

Bolt Products have developed a small hydraulic extractor, see photo attached. We await further details.

The other potential method for removing an anchor is to drill it out. For BP anchors, this would require cutting the head off near to the rock surface and then using a core drill without a centre drill to drill down into the rock surrounding the shaft to the depth of the shaft, some 100mm. A 22mm OD diamond tipped core drill with a notional 300mm depth has been procured for trials. On purchase it has been found to have an ID of 15.5mm which is an interference fit for a 8mm twisted shaft anchor using a 16mm hole. A 28mm OD diamond tipped core drill has now also been procured.

In order to reuse the location, the over sized hole will have to be filled with extra resin.

The only data we have so far is Simon Wilson's work which showed no apparent reduction in extraction force between 12mm and 18mm diameter holes. (18mm coming from using DMM Eco anchors; BP twisted shaft being 16mm.)

Concern has been expressed that resin could shrink on solidifying which in a large hole might bring into question the resin / rock bond. There is also a question as to whether the resin to metal bond may be less 'tight' as the mass of resin surrounding the anchor increases.

In addition, core drilling produces a moderately smooth surface and a major part of the strength of an anchor system is considered to be in the mechanical interaction between the irregular surface within a hole drilled by percussion and resin.

It is proposed that some experiments are carried out using BP 304 twisted shaft anchors. The first set will be to demonstrate if core drilling works at removing the anchor. It is suggested that a set of 5 anchors be placed and then drilled out. If the drilling operation is successful then another set of 5 holes will be drilled to provide a test bed of 10 for the next step.

The next step will be to place BP anchors in these over sized holes without any attempt to roughen the in hole surface and then extracting them using the anchor puller to measure peak force. If the set of 10 results are normally distributed and meet our criterion of the 5% fractile being greater than 15kN then we have a system. If the data is not normal, then further results will be obtained.

If the value is low, then we will need to assess failure modes and work up an appropriate response. One possible cause may be due to too smooth a surface of the hole resulting in resin / rock failure and pull out of the block of resin. That will require devising a means of roughen the hole surface such as by using a say 24 / 30mm percussion drill. Another possible cause may be due to resin shrinkage. No doubt there are other failure modes which will require thought.

Jim Titt has suggested using a sleeve device, to permit an oversized hole in the first instance which the core drill can go down in resin rather than rock. See http://www.fischer.de/en/Product-Range/Chemical-fixings/Anchor-sleeves/Injections-anchor-sleeve-FIS-H-K . ## test web site link ## No doubt it would reduce the bulk amount of resin at presumably some cost in peak axial strength. And it is not clear to me if drilling into resin is any easier than into rock.

Bob Mehew

Annex 5 ## photos by simon ##

Annex 6 Proposed change in Anchor Inspection Routine

As most will have seen in last Descent 252 p17, BCA placed an information advert on anchors which included the pre use inspection routine. In discussion with Chris, it became clear that our current set of bullet points viz:

Movement of the anchor - less than 1mm in any way is OK.

Clear signs of wear or damage to the anchor.

Movement of the anchor from the resin or resin from the rock.

Looseness or fractures of the rock within 20cm of the anchor.

were not clear to Chris or Judith and as a consequence they made some suggested modifications. I then accepted a further change as the info was for an advert rather than being the final word with the proviso that we needed to update the bullet points. So the two critical observations by Chris were as follows.

The order of the points was wrong. The first thing one does is view the anchor so the wear point should come first. Then one checks the surrounding rock and then check for movement. (One might ask whether surround rock comes before wear but I think the eye would be drawn to the anchor first and then you know where the 20cm diameter works from.)

The movement part was contradictory, it was OK for anchor to move up to 1mm for anchor with respect to resin but no movement for resin with respect to rock. (I finally agreed for Chris to coalesce the two for the advert.)

I therefore propose a revision of the wording to

STARTS

Before use check each anchor:

- That there are no clear signs of wear or damage to the anchor
- That there is no looseness or fracturing of the rock within 20cm of the anchor
- That the anchor has no apparent movement with respect to the resin in any direction (less than 1mm in twist, side to side or in / out)
- That the resin has no movement with respect to the rock (twist, side to side or in / out).

ENDS

I did wonder if we should make some comment about loss of surface resin but I think that would be a complexity too far as there is no clear finished state of the resin, every anchor is different.

Bob Mehew