The British Caving Association
Minutes of the Equipment and Techniques Committee

Date: 8th October 2011, 10.40am

Location: Windmill, Dudley

Attendees: Nick Williams (NW) Chairman
Andy Lewington (AL) CCC representative
Roger King (RK) DCUC representative,
Bob Dearman (BD) DCA representative
Glenn Jones (GJ) CNCC representative
Les Sykes (LS) co-opted member
David Cooke (DC) CSCC observer
Faye Litherland (FL) CSCC representative
Bob Mehew (RM) Rope Test Officer
Damian Weare (DW) BCA Secretary Observer
Andy Eavis (AE) BCA Chair Observer

1.0 Apologies: Dewi Lloyd

2.0 Chairman's Opening Remarks: NW thanked everyone for attending. He asked for a volunteer to take minutes. RM agreed to do so. NW stated that for the avoidance of doubt, whilst every one could speak at the meeting, those persons who were observers could not vote.

3.0 Notice of Items to be raised under AOB: 2012 Budget

4.0 Minutes of Previous Meeting 12 March 2011 & Matters Arising:

4.1 Minutes: NW noted some minor editorial corrections by FL. The meeting accepted the minutes so corrected.

4.2 Matters Arising:

5.1.1 NW to refer to National Council at next meeting (March26th) – Done

5.1.2 FL to provide detail of CSCC position to NW before next National Council meeting - Done

5.1.3 GJ to provide detail of May 2nd 2006 CSCC payment to CNCC and check previous E&T minutes re anchors given to CSCC – GJ agreed the anchor question had been sorted (see minutes of 5/7/08). DC had sent details to GJ but GJ not received. NW asked about remaining issues. Several items of equipment were mentioned. NW proposed as arbitrator (see Annex 1 Proposal 2) that the value of these items was zero and hence they should be written off from BCA's inventory. The meeting accepted this. NW noted that other points of concern were covered by other items on the agenda.

Action 4.2.1 GJ to provide detail of May 2nd 2006 CSCC payment to CNCC - DC to resend details to GJ.

8.1.1 NW to confirm heat treatment of the very first batch of PECO anchors that have now been deployed – NW had been unable to confirm any details other than the 1st "prototype" batch had been manufactured by a different company. The action was closed.

8.1.2 GJ to send pdf of initial Hilti/PECO test results to NW – Done.

8.1.3 GJ to provide detail of May 2nd 2006 CSCC payment to CNCC and check previous E&T minutes re anchors given to CSCC – see 5.13 above.

10.1.1 RM to create second draft of the document, in consultation with NW – Done.

10.1.2 LS to send NW loading stats on other parts of SRT "system" – Done.

10.1.3 BD/RM to document 32 standard deviation requirements for result analysis for next test phase – Done.

12.1 All to provide a list of potential fixed aids to NW – nothing received – Action Ongoing.

Action 4.2.2 All to provide a list of potential fixed aids to NW

13.1 FL to send details of Hitachi drill to NW/DC – FL noted it was a Bosch Compact and details had been sent to RC. The action was closed.

AOB 1 BD & LS to produce a validation process to NW by no later than end of May – Discussions had been held. Action continues.

Action 4.2.3 BD & LS to produce a validation process to NW

NW asked if there were any other matters arising from the minutes but none were identified.

5.0 Rope Test Report: RM noted that he had obtained the rope for the Long Term Rope Test Part 2. Council had approved spending on the Fixed Aid project but no rope had been selected. Work continues on the Bradford rope test rig. NW noted that RM had given an interesting lecture at Hidden Earth.

6.0 Anchor Scheme Admin Report: GJ had issued a note, see Annex 2. GJ raised the topic of Accredited Installers being individual members of BCA. It was noted that they were nominated by RCC's and so could be considered to be officers of the RCC. DW noted that there had been a member of Council who was not a BCA member. NW noted that from an insurance view point being a member of BCA was preferable since they would be better covered but they did have cover by being an officer of the RCC. A view emerged that they should be members.

Proposal "Equipment and Techniques Committee consider that in order to be appointed as an Accredited Installer, that person shall be an individual member of BCA" by BD, seconded FL. The meeting **agreed** the proposal without objection.

FL asked what insurance cover would exist if BCA folded. NW replied that the cover was on a claims made basis and thus only covered claims arising during the year. If BCA folded, then some of BCA's assets could be used to purchase a "closing" policy which would provide cover for subsequent claims.

7.0 Update on PECO Anchors:

7.1 CSCC status: GJ noted that given CSCC had withdrawn from the BCA Anchor Scheme and sought opinion on whether they should be allowed to contribute to this agenda item. NW recessed the meeting and on return said he was of the opinion that CSCC could observe the debate but not comment unless specifically asked. GJ asked for NW's determination over his arbitration on the topic (see Annex 1 Proposal 1). NW recessed the meeting and separately consulted FL and DC on behalf of CSCC and LS, GJ and RD on behalf of CNCC & DCA. Following these consultations, the meeting resumed, and NW informed the meeting that the parties had agreed to the following determination:

"As a result of the process of arbitration, CSCC have agreed to the IPTD including a requirement for SRT competence, on the basis that the document will become copyright of BCA and subject to future revision as agreed by the E+T Committee".

The meeting resumed with all present participating.

7.2 Background: NW recalled that 200 anchors were provided in the 1st "prototype" batch several years ago, followed by 2000 in the 2nd "production" batch this year. Because concerns had been identified during the manufacture of this 2nd batch a rigorous program of testing had been agreed at the last meeting. BD reported that a first sample set of 32 anchors had been placed in Horseshoe (aka Furness) Quarry near Stoney Middleton by LS, GJ and himself. Results from this batch had been influenced by the poor quality of the rock due to spalling. Of more concern was the finding that the failure mode of two anchors was by metal failure as opposed to the expected mode of metal resin bond failure. A second sample set of 32 anchors was then placed in Ingleton Quarry. Again 2 anchors failed by metal failure. They concluded that it was difficult to see how the Peco anchor is of sufficient quality and consistency to replace the Eco anchor in the BCA scheme. NW commented that he had accepted that the 2nd batch of Peco anchors was not suitable for use. The meeting agreed with this decision. He had discussed the problem with the supplier and had decided to embargo the 2nd batch. GJ noted he still had some Peco anchors from the 2nd batch which he would return.

Action 7.2.1 GJ to return any 2nd "production" batch Peco anchors he held to NW.

BD reported that this then raised a question over the 1st "prototype" batch of Peco anchors. Of the 200 supplied in the 1st batch, 83 had been installed in caves, a large number had been used in training and some awaited use. In total, all bar 5 of the 200 anchors had been accounted for. Those awaiting use had been recalled. BD then tabled a Test Report, see Annex 3. A first sample set of 15 from the recalled anchors had been placed and tested some 24 hours after placement by them. The mean peak load before failure was 34kN with a range of 18 to 41kN. However it was noticed that the two lowest peak loads (of 18 and 26kN) that the chemical anchor mortar was granular which could indicate that thorough mixing had not occurred or that the mortar required longer curing time. As a consequence a second sample set of 17 anchors was placed by them and left for 4 days before testing. The mean peak load before failure was 34kN with a range of 25 to 41kN. The report concludes that "it is not necessary to remove any batch 1 Peco anchors that have been installed using the BCA ... IPTD".

FL asked how these tests compared to those done when the 1st batch was first received. LS reported that the results were limited because the tester broke at 28kN. NW asked if the load cell was calibrated. RM replied that a certificate of calibration had been supplied on purchase in January. LS reported that the load cell matched the reading on a calibrated Hydrajaws tester up to 10kN. NW

asked how the behaviour of the 1st batch of Peco anchors compared to the DMM anchors. GJ noted that head deformation of the 1st batch of Peco anchors occurred around 16 to 18kN which was within the 10 to 19kN span observed with DMM anchors. RM noted that there was no information based on a statistical analysis of the results from the two batches to demonstrate that there were no rogue anchors in the 1st batch.

NW noted that there were a number of factors in setting a safe working load including the required load capacity, the material, the corrosion and life expectancy, manufacturing variability and inspection. He wondered if there were credible mechanisms which might affect the Peco anchors over long period of time compared to DMM anchors. FL commented that there were two such credible mechanisms one related to potential contamination of the weld area during welding which could lead to brittle behaviour. The other related to the visual inspection of the 1st batch of Peco anchors which identified several with cracks (caused by the metal tearing in the process of being bent) in the metal in the head. This indicated an inconsistent process so that there could well be some other anchors in that batch which had cracks not visible to the eye. Such cracks could provide a location for stress corrosion cracking. FL went to admit that the same mechanisms could apply to the DMM anchors, though it was noted that no such cracks had been observed.

LS asked on what basis we had confidence in DMM anchors as the testing which had been undertaken on DMM anchors covered fewer anchors than the number of Peco anchors tested. AE reported that it was well known that stainless steel made in China had a variable quality. NW suggested there were three alternatives, do nothing, taking immediate action or somewhere in between. The meeting agreed that taking no action was not acceptable but there was no need to take "panic" measures.

NW went on to ask if testing the installed 1st batch Peco anchors was feasible. LS responded that it was not realistic to test all of them given the range of locations and the maximum force one could use with the Hydrajaws tester, of 10kN, would demonstrate very little. BD noted that where the anchors were in pairs, the risk was reduced.

LS noted that there was a conservation issue if the anchors were ground off together with a safety issue of using a grinder when hanging by ropes.

DW commented that because we could not be sure that no 1st batch Peco anchors were rogue which would undermine the confidence in the Eco anchor scheme, he considered that it was necessary to replace as many as possible of the installed 1st batch Peco anchors and grind off those not replaced. He accepted that this represented a lot of work. He also noted that he did not feel that the situation was such that it was necessary to start the replacement work immediately.

LS stated that he felt a single anchor failure would probably not be catastrophic. RM commented that the observed minimum value of 14kN for the metal failure was no demonstration of the true minimum failure value for rogue anchors. NW noted FL's previously expressed view of a potential corrosion mechanism which suggested the installed Peco anchors would perform worse than the DMM anchors. FL agreed. NW went onto observe that the potential failure should only be a problem when using 1 anchor whilst normally a caver should be using two anchors. But the result from the testing the 2nd batch informs our view of the 1st batch. GJ observed that the view of the meeting appeared to be that there was a need to replace the anchors, so the next question was time scale. After a short discussion, it was generally agreed that setting a timescale was difficult. NW asked what initial actions could be taken. DW suggested that the Committee should make cavers aware of where the installed 1st batch of Peco anchors were located. RM noted that such an action can be considered as part of the process of replacement. BD noted that where anchors were in

pairs, the risk was lower and hence the degree of urgency less than for anchors located singly. NW suggested that the schedule for replacement should be agreed on a risk assessment basis. AL expressed concern that the demand could lead the committee to rush into making a choice of a replacement anchor which subsequently gave rise to a similar problem. BM suggested that the aim should be to replace within 2 years.

Proposal "The aim would be to replace all installed 1st batch Peco anchors within 2 years" proposed by NW, seconded by GJ. The meeting agreed the proposal without objection.

NW then observed that he felt experience showed that the data should be published to avoid criticisms from others. GJ suggested that, subject to their approval, the CNCC web site could be used. DW emphasised the need to say where the anchors were located. There then followed a discussion on the choice of words for a statement. NW pointed out that it would be useful to have the statement available for BCA Council meeting on 15 October. RM commented that preparing a statement would take a lot of time and perhaps could be done after the meeting. Agreement could be achieved by email.

Proposal "A statement be prepared covering the points that there was lower confidence in the installed 1st batch of Peco anchors and hence a need to replace them; that no single point of belay should be relied on for applications where a failure of the belay could result in serious injury or death and that the affected caves should be named" proposed by RM seconded by NW. The meeting agreed the proposal without objection.

DW offered to place notices at the cave entrances. GJ reported that the 83* anchors were located in six caves, Stream Passage Pot, Disappointment Pot and Marilyn at Gaping Gill, Roaring Hole and Rowten Pot in Yorkshire and Rana in Assynt, Scotland. Not every anchor is affected in some of these caves. GJ went on to offer to post the details of which anchors are to be replaced on the CNCC web site. There was a discussion as to whether notices should be placed at the entrances of each cave. It was accepted that this should be done, subject to the agreement of CNCC. GJ agreed to seek CNCC's agreement.

**note: subsequent to the meeting it was identified that the number placed was in fact only 77, all in the Yorkshire Dales.*

There was a brief adjournment for lunch.

NW summarised the results of the discussion as:

1 A statement would be made at Council, the content of which would be agreed by email between attendees;
2 Details of the affected anchors would be placed on the CNCC web site; and
3 CNCC would discuss whether notices should be placed at the entrance to the affected caves.

GJ stated that he would seek to obtain CNCC's view before Council meeting.

Action 7.2.2 NW to draft a statement and seek agreement of attendees by email for presentation to Council meeting on 15 October.

Note: a copy of the wording which was circulated is appended to these minutes for the convenience of members.

Action 7.2.3 DW to prepare text of statement for posting at entrances of affected caves and check with GJ & LS.

Action 7.2.4 GJ and LS to canvass CNCC committee for agreement to place statement at cave entrances

Action 7.2.5 Subject to CNCC's agreement, DW & RM to place statement when agreed at entrances to affected caves.

7.3 Replacement Anchors: BD reported that the Bolt Products 100mm long 8mm twisted leg anchor had been selected as a potentially suitable replacement anchor. 40 anchors had been obtained and 33 installed with a RAWL resin (this is different from the normal one used). The mean peak load before failure was 38kN with a range of 32 to 47kN. He claimed that the results were more consistent. One problem identified by the work is that the eye was not as large as the DMM eye. BM noted that the mean was lower than the value quoted on Bolt Products web site for axial pull out according to EN 959 of 39kN. LS noted there was a problem with the supplied resin which he wanted to come back to but it probably had influenced the peak load values. He went on to note that the installation procedure required a 16mm diameter hole which was almost filled by the anchor. As a consequence, there was no room to drill down in the resin to facilitate the extraction of the anchor. He predicted that the only option would be to grind off the head of the anchor and place a new anchor nearby. GJ reported that the multiple twist in the anchor legs causes the anchor to repeatedly twist on extraction placing a torque on the load cell to eye bolt joint which is relieved by the thread slipping. LS reported that the head deformation was around the same as for DMM anchor though BD suggested it might be a tad higher. BM asked at what load the first lifting of the head occurred. BD said that this had not been recorded.

NW observed that the results indicated the anchors seemed suitable. FL asked if any other anchors had been looked at. NW noted there had been some previous work undertaken on Singing Rock anchors. LS reported that no other anchors had been investigated. BM noted that he had been advised by a member of the BS EN 959:2007 committee that in order to claim compliance with the standard, the resin must be specified. LS stated that no resin was so specified. BM noted that in addition to Singing Rock there were a while ago, Petzl and Fixe anchors available on the market. GJ noted they had discounted Singing Rock and Petzl anchors. NW asked if there was a need to look at other anchors. The meeting agreed that there appeared to be no need.

NW asked FL about her discussions with Bolt Products on quality matters. FL reported she had asked a range of questions and following a dialogue, she had acquired an acceptable set of answers.

Action 7.3.1 FL to produces notes on her dialogue with Bolt Products.

NW reported that he also had been in contact with Bolt Products on the resin question and understood that the claim was the anchor was acceptable to use with any CE marked resin. NW had also pursued the Product Liability insurance cover and had been pointed to the Terms and Conditions for the sale of the anchors which placed responsibility on the user. He felt that this area was weak and that BCA may have to accept both the responsibility and liability for the use of the anchors. This required the Committee to undertake a due diligence check before agreeing to use the anchors.

FL suggested that the first step was to define a User Specification which could be put to Bolt Products which would include various requirements including that the anchor shall meet the various minimum load values of BS EN 959:2007. She also recommended that the Committee consider

carrying out an onsite audit because of the enhanced duty of care given Bolt Products would potentially be a sole supplier. NW asked if FL would be prepared to carry out an audit. FL indicated she would, provided BCA covered her travel and subsistence costs.

Action 7.3.2 FL to provide indicative T&S costs for an audit of Bolt Products.

NW asked if development work on the anchors should be cease until the User Specification and audit had taken place or should it continue in parallel. LS suggested it should be held until they had sorted out whether the anchors were suitable. NW enquired if a mill certificate should be included in the specification. FL pointed out that that would only be available for newly manufactured anchors. FL indicated she could draft a specification but it could take more than a month due to other demands on her.

Action 7.3.3 FL to draft a User Requirements Specification for the potential purchase of anchors.

BD wondered if we could negotiate with Bolt Products to supply a batch of anchors free for the testing work. NW observed that we could not make a commitment to purchase a bulk quantity at this time. FL noted that Bolt Products had supplied her with a TUV certificate for previous work, so if we supplied the resin, perhaps we could get him to undertake the testing.

7.4 Resin: LS reported that Bolt Products had suggested another resin manufactured by RAWL. A concern with this resin was that the colour change on mixing and on curing was slight even in day light. It was therefore unlikely to be observable underground. As had been previously commented, the RAWL resin obtained had been observed to not fully cure, even after one week. However he emphasised that the anchor with part cured resin had withstood a peak load of 36kN. Bolt Products had admitted that they had experienced some problems so he had then approached RAWL. RAWL were now conducting some tests on the batch to see if there is a problem associated with the specific batch. Mixing the resin by hand did produce a mix which cured very quickly but using the applicator did seem to produce a mix which was slow to cure. LS recalled he had experienced similar problems with other resins.

GJ observed that the RAWL resin only came with one nozzle which he felt would be a major limitation for underground use. He asked if we could switch to our preferred resin. LS pointed out that because our preferred resin contained styrene, Bolt Products who were based in Germany could not import it as styrene based resins had been banned in Germany. GJ suggested we might try to get Bolt Products to underwrite a series of tests with our preferred resin. FL suggested that given they could not use our preferred resin, they would be unlikely to agree. NW asked about using Hilti resins. LS noted that Hilti resins were sensitive to dampness and recalled they had produced lower peak strength results. RM suggested that perhaps we should move to using Bolt Product anchors and our preferred resin and seek acceptance either by ourselves or by Bolt Products. NW suggested this would probably not prove acceptable to Bolt Products. BD proposed we acquire some more anchors and conduct a range of tests. One area of difference was that DMM anchors used a 18mm hole whilst Bolt Product used 16mm. It was agreed that a program of work should be devised and more anchors should be acquired to implement it.

Action 7.4.1 BD & LS to produce a program for testing and obtain Bolt Products anchors to match requirements.

NW asked if there was an EC Declaration of Conformity for the RAWL resin. BD confirmed that he had seen one.

Action 7.4.2 BD to supply NW with copy of Declaration of Conformity for resin.

8 Update on Anchor Tester: BD gave a brief description of the puller and noted several modifications which were desirable, the main one being replacement hydraulics. BM noted that the frame would require replacing if the puller were to be used at higher loads. BD noted that the Bolt Product anchor did not take the shackle system used to couple the puller to an anchor. NW proposed that he and BD reviewed the work needed, made an estimate of the cost and sought committee agreement by email. The meeting accepted the proposal.

Action 8.1.1 NW & BD to produce plan of work for upgrading puller and seek agreement from Committee by email.

9 Installation of Anchors in Substrates other than Limestone: NW reported that he had not made as much progress on this work as he would have liked and sought volunteers. AL and RC agreed to help.

Action 9.1.1 NW, RC & AL to develop document on Installing Anchors in substrates other than limestone.

10 Updates to Anchor Scheme: BD noted given the resin mixing concerns which they had experienced, whether the IPTD should be updated to require installers to pre stir the resin in the hole. GJ suggested an alternative of spinning the anchor. BD agreed to conduct some experiments and come back with the results.

Action 10.1.1 BD to run some tests on "spinning bolt" to ensure thorough mixing of resin in hole and report back to Committee.

11 Development of Policy for other Fixed Aids: NW reminded members of the action to provide a list of fixed aids.

12 Date & Location for next Meeting: It was agreed that the next meeting shall be on 17th March at 10:30 at the Windmill, Dudley.

13 Any Other Business:

13.1 Progress on Replacement Anchors: RM asked how the Committee should progress any decisions it might be required to make on replacement anchors before the next meeting. NW proposed that this should be done by consulting via email. The meeting agreed to this proposal.

13.2 Budget: NW noted a number of heads for the budget covering: Anchors, Puller, Germany audit, Rope Test Rig, Drill for DCUC, Meeting costs and Anchor Testing costs. He sought estimates before 15 October.

13.3 BCA Anchor Scheme: GJ asked if CSCC had agreed to come back with the scheme. NW stated that as a result of the arbitration he considered CSCC were back within the scheme.

The meeting closed at 15.15.

Action List

4.2.1 GJ to provide detail of May 2nd 2006 CSCC payment to CNCC - DC to resend details to GJ.

4.2.2 All to provide a list of potential fixed aids to NW – None received, Action continues on ALL By next meeting.

4.2.3 BD & LS to produce a validation process to NW

7.2.1 Action GJ to return any 2nd "production" batch anchors he held to NW.

7.2.2 NW to draft a statement and seek agreement of attendees by email for presentation to Council meeting on 15 October.

7.2.3 DW to prepare text of statement for posting at entrances of affected caves and check with GJ & LS.

7.2.4 GJ and LS to canvass CNCC committee for agreement to place statement at cave entrances

7.2.5 Subject to CNCC's agreement, DW & RM to place statement when agreed at entrances to affected caves.

7.3.1 FL to produces notes on her dialogue with Bolt Products.

7.3.2 FL to provide indicative T&S costs for an audit of Bolt Products.

7.3.3 FL to draft a User Specification for the potential purchase of anchors

7.4.1 BD & LS to produce a program for testing and obtain Bolt Products anchors to match requirements.

7.4.2 BD to supply NW with Declaration of Conformity for resin.

8.1.1 NW & BD to produce plan of work for upgrading puller and seek agreement from Committee by email.

9.1.1 NW, RC & AL to develop document on Installing Anchors in substrates other than limestone.

10.1.1 BD to run some tests on "spinning bolt" to ensure thorough mixing of resin in hole and report back to Committee.

AOB.1 RM to estimate 2012 budget for Rope Test Rig.

AOB.2 FL to estimate cost of trip to Bolt Products.

AOB.3 NW to draft outline for Budget and seek agreement by email from committee.

Annex 1 - Extract from Minutes of BCA Council Meeting 26 March 2011

Item 10

Proposal 1: “Council authorises the E&T Convenor to act as an arbitrator in the concerns of the IPTD, provided the document is made available on the web in a non-printable format at the earliest convenience.”

Prop: LW Sec: IW agreed unanimously

Proposal 2: “Council affirms the authority of the Equipment and Techniques Committee to retain control of equipment and supplies which are held by it in the name of the Association. Council requests CSCC to respect the content of the letter dated 21st October 2010 from the E+T Convenor, and return the equipment if requested by the arbitrator.”

Prop: NW Sec: FL agreed unanimously

Action 70: NW to oversee the implementation of resolutions relating to the E&T Committee.

Annex 2 –

Anchor Scheme Administration Report to E&T Meeting 8th Oct 2011

The day to day administration of the anchor scheme is now being managed by the BCA Membership Administrator
- managing the stocks of anchors
- primary point of contact for ordering resin and other consumables
- deal with simple administrative and technical queries arising from outside the E+T Committee
- organising training and re-validation for installers
- manage spreadsheet of accredited installers
- issue cards to accredited installers
- collate and distribute course documentation

Anchor Scheme:
The accreditation of 4 anchor installers expires on 6th June 2012 and a further 3 expire on 31st November 2012.
Accreditation of the remaining installers expires on 6th February 2013 (5 installers), 2nd May (7 installers) and 12th June (5 installers).
Question for this meeting: *A small number of accredited installers are not members of BCA, I would appreciate if this meeting could confirm that this remains an acceptable position (given that installers are nominated by the Regional Councils).*

Anchor/Resin Stock and Project status (03/10/11):
Following the decision to change anchor supplier, I can confirm that no batch 2 PECO anchors have been installed. 83 batch 1 PECO's have been installed and 32 of the remaining stock of batch 1 PECO's have been returned and installed in a test bed in Ingleton. It is anticipated that the results of the batch 1 testing will be available at Saturday's meeting.
I understand that an order has been placed with the new anchor supplier, but these have not as yet arrived.
Question for this meeting: *Given the change of anchor and resin, is there a requirement for retraining workshop(s) given that the process remains the same.*

Glenn Jones
BCA Membership Administrator
3rd October 2011

Equipment & Techniques Committee

BRITISH CAVING ASSOCIATION

Anchor Tests 2011

Scope

This report details the complete series of anchor tests designed to find a replacement for the DMM Eco anchor carried out by the BCA Equipment & Techniques Committee during 2011.

Introduction

Following the cessation of production of the DMM Eco anchor it became necessary to source a replacement which would fulfil all the criteria decided by the Committee during their consultative process. The main requirement was that the anchors should attain an axial load of at least 25kN before failure. The logic for this standard was that most, if not all, of the other components in the equipment safety chain would have failed at this loading. As the vast majority of natural caves are in carboniferous limestone it was decided that the initial tests would be carried out in this substrate.

An identical looking product to the DMM anchor was offered by Jonathon Sims who had manufacturing contacts in China. An initial test batch of 200 anchors was acquired and designated "Peco Batch 1". Subsequently, a further production batch of 2000 anchors was ordered designated "Peco anchor Batch 2". As will be observed later in the report, four out of a sample of sixty four Batch 2 Peco anchors suffered catastrophic metallurgical failure below the 25kN threshold.

Further research identified another possible alternative supplied by Bolt Products manufactured in Germany to BS EN 959. The major difference with this anchor is that whilst it was still made with 8mm 316 stainless steel bar the two tangs of the anchor were twisted unlike the parallel bars of the Eco and Peco anchors. Another difference was that the eye of the anchor was slightly smaller than the Eco and Peco anchors although it was still of adequate size.

Method

All anchors were tested in batches of 32. The two types of chemical anchor mortars (i.e. resins) that were used for installing the anchors were RAWL R-KER Epoxy Acrylate Styrene free resin manufactured by RAWL fixings and Allgrip KMR-RES resin which is manufactured by Exchem UK. This is the unsaturated polyester resin in styrene that has been previously used for the setting of Eco anchors.

Test 1 - Peco Anchor Batch 2 – Allgrip KMR-RES - Horseshoe Quarry - Stoney Middleton
Test 2 - Peco Anchor Batch 2 – Allgrip KMR-RES - Ingleton Quarry
Test 3 – Peco Anchor Batch 1 – Allgrip KMR-RES - Ingleton Quarry
Test 4 - BP Anchor - RAWL R-KER - Ingleton Quarry
Test 5 - BP Anchor – Allgrip KMR-RES - Ingleton Quarry
See Appendix 1 - Test 1 (Purple) - Test 2 (Red) – Test 3 – (Green) – Test 4 – (Blue) – Test 5 - (Black)

All the anchors were installed in carboniferous limestone in compliance with the BCA E&T Committee document "Permanent Resin Bonded Anchors – Installation Procedure, Training and Documentation" (IPTD); which is the same as the recommend procedure by both resin manufacturers. The Peco anchors were installed into holes 18mm diameter x 10mm deep. The Bolt Products anchors were installed into holes 16mm diameter x 100mm deep. The holes in Ingleton Quarry were cleaned using water (pressure wash), brushed and washed until all the limestone dust had been removed. They were then dried using absorbent cloth. The holes in Horseshoe Quarry were dry cleaned using a brush and a blower until all the limestone dust had been removed.

Results

Test date: 24th June 2011
Anchor type: Peco Batch 2 (production batch)
Resin: KMR-RES
Location: Horseshoe Quarry - Stoney Middleton
Substrate – Black Layer – Stoney Middleton Sequence
During the test period it became apparent that the substrate was not as uniform or as structurally strong as was initially thought. There were areas where the thin substrate microstructure caused some placements to fail prematurely with resultant delamination. However, even with substrate failure the tests did indicate that the anchor placement system would give reasonable test results in thinly bedded and relatively weak bituminous limestone strata. More concerning was that two Peco anchors failed by fracture of the metal at the lower curvature of the eye. The load at deformation was consistent within a range of 10-16kN giving a mean of 13.6kN. The ultimate failure load i.e. the peak load at which the anchor started to egress from the resin or the load required to extract the anchor from the resin, whichever was higher, was within the range 16-35Kn with a mean of 27.44kN. Although the fracturing of the substrate did result in some low readings the mode of failure was consistently the anchor to resin bond except for the two anchors which fractured at the lower curvature of the eye. Peco anchors No. BCA 0182 and BCA 0004 suffered catastrophic metallurgical failure at 26kN and 16kN respectively.

Test date: 28th June 2011
Anchor type: PECO Batch 2 (production batch)
Resin: KMR-RES
Location: Ingleton Quarry
Substrate – Yorkshire Limestone
32 Peco anchors were randomly selected from the remainder of the batch and set in structurally solid limestone. As there was only one small area of the test bed where substrate failure occurred the results were generally in line with expectations. However, as in the test at Horseshoe Quarry, two Peco anchors fractured at the lower curvature of the eye. The load at deformation was consistent within a range of 11-15kN giving a mean of 13**.**28kN. The ultimate failure load, as described above in the tests at Horseshoe Quarry, was within the range 14 - 47kN. Giving a mean peak load force of 33.22kN. Although the fracturing of the substrate did result in some low readings the mode of failure was again consistently the anchor to resin bond except for the two anchors which fractured at the lower curvature of the eye.

Peco anchors No. BCA 0069 and BCA 0153 both fractured at 18kN and 14kN respectively. The main concern is that the lowest fracture load (14Kn) would technically make the anchor placement the weak link in the rigging system. The anchor in the photograph was cut to remove it from the placement.

Test date: 24th September 2011
Anchor type: Peco Batch 1
Resin: KMR-RES
Location: Ingleton Quarry
Substrate – Yorkshire Limestone

During the test period it became apparent that the chemical anchor mortar had not thoroughly mixed during application into the hole. This resulted in two relatively low readings. Anchor test number 10 was extracted at 26Kn. and anchor test number 13 was extracted at 18Kn. On closer inspection of the chemical mortar it was found to be granular which could indicate that thorough mixing had not occurred or that the resin required a longer curing time. The load at deformation was consistent within a range of 14-18kN giving a mean of 16.3kN. The ultimate failure load i.e. the peak load at which the anchor started to egress from the resin or the load required to extract the anchor from the resin, whichever was higher, was within the range 18-45Kn. with a mean of 34Kn.

Date: 22nd October 2011
Anchor type: Bolt Products 8mm x 100mm twisted stainless steel anchors
Resin: RAWL
Location: Ingleton Quarry
Substrate – Yorkshire Limestone

Thirty three Bolt Products anchors were installed in limestone (somebody couldn't count). During the test period it became apparent that the chemical anchor mortar had not thoroughly mixed during application into one of the holes. The peak load to remove this anchor was 36kN. RAWL have been contacted and from the information supplied by us have initiated an investigation. The failure mode is initially similar to a DMM Eco anchor with elongation of the eye towards the direction of the applied load. However, unlike an Eco anchor as it is extracted from the substrate the anchor twists, and along with it the load cell, until the load is released as the anchor suddenly and violently egresses from the resin. The load then gradually increases until the anchor starts to twist and the process is repeated. This behaviour continues until the anchor is extracted from the substrate. Generally the anchor's failure range was consistent; however anchor test numbers 20 and 26 were below 30kN. As the failure mode is anchor to resin bond this is probably due to poor mixing and adhesion of the resin. The deformation range was 18-23kN. The ultimate failure load i.e. the peak load at which the anchor started to egress from the resin or the load required to extract the anchor from the resin, whichever was higher, was within the range 24 - 47kN with a mean of 35.5kN. From the data gathered from these tests it is evident that the anchor and peak load forces are consistent and similar to the DMM Eco and Peco anchors.

Test date: 2nd November 2011
Anchor type: Bolt Products 8mm x 100mm twisted stainless steel anchors
Resin: KMR-RES
Location: Ingleton Quarry
Substrate – Yorkshire Limestone

As a consequence of the high pull out loads experienced during these tests the mode of failure changed. Normally, in Eco & Peco anchors, the mode of failure is the anchor to resin bond. The Bolt Products anchors, in the majority of cases, experienced substrate failure and the resin/rock bond with it. On a number of the tests cone fracture and delamination of the substrate occurred followed by the failure of the resin to rock bond. However, as demonstrated in the photo opposite even with delamination the anchor placement still held 51.73kN. With the reduced hole size (16mm) the amount of resin in the placement is also reduced. This causes the resin to fragment and become almost pulverised by the load during extraction of the anchor. This pulverisation is more evident lower down in the placement.

An interesting observation was that the anchors were still holding only a little less than their peak loads when half to two thirds of their length had been extracted. In comparisons between the RAWL R-KER and the Allgrip KMR-RES the inclusion of styrene in the formulation means failure loads are 10kN higher with the Allgrip KMR-RES resin.

Another interesting observation was that the shank of the Bolt Products anchor unwound and elongated under loads approaching 50kN. (5th anchor from right picture below). The deformation loads were similar to the previous test. The ultimate failure load i.e. the peak load at which the anchor started to egress from the resin or the load required to extract the anchor from the resin, or substrate failure, whichever was higher, was within the range 32 - 63kN with a mean of 44.91kN.

Conclusions

From the data gathered from these tests it is evident that the combination of the Bolt Products 8mm twisted stainless steel bar anchor and the Allgrip KMR-RES produces strength well in excess of both the Eco and Peco anchors. Also Allgrip KMR-RES is far superior to the anchor manufacturers recommended resin. The reason the anchor manufacturer specifies the RAWL R-KER resin is that in Germany the use of styrene based resins is illegal for Health and Safety concerns. There is no such restriction in the UK.

The graph of ascending extraction loads in Appendix 2 demonstrates the difference in peak load force between the Bolt Products anchors installed with RAWL fixings resin and Allgrip KMR-RES. The graph of ascending extraction loads in Appendix 3 shows the comparative extraction loads of the two batches of Peco anchors and in Appendix 1 a comparison of all five test series.

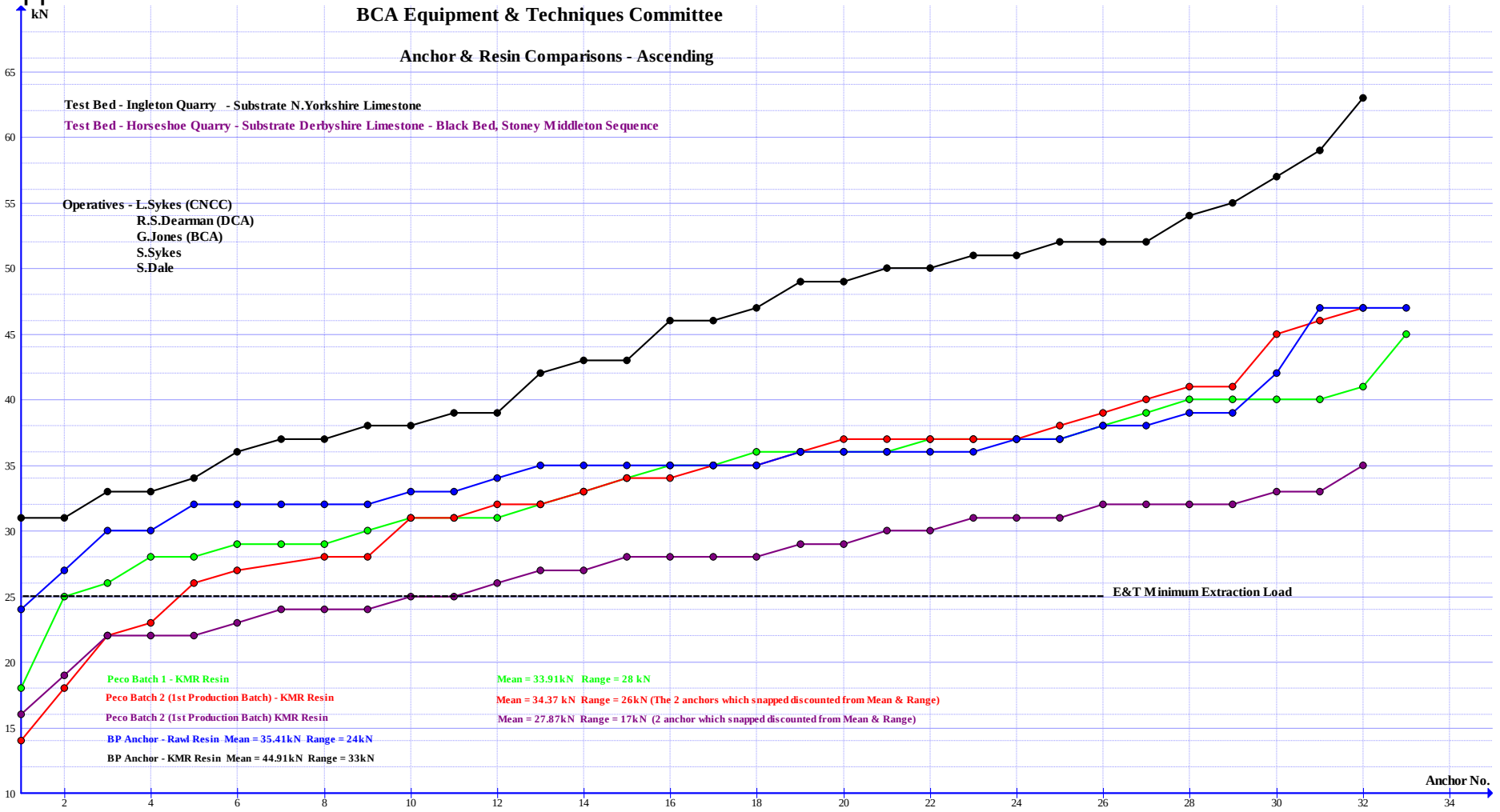
Future Objectives

1. To test a number of the Bolt Products anchors with KMR-RES in shear (radial).
2. To conduct tests of anchor strengths in other weaker substrates as defined by the Equipment and Techniques Committee.

Anchor installation team: R.S. Dearman, L. Sykes, G. Jones, S. Sykes
Anchor test team: R.S. Dearman, L. Sykes, G. Jones, S. Sykes, S. Dale

Report compiled by L. Sykes, R.S. Dearman
Photographs: G. Jones, L. Sykes

Appendix 1


BCA Equipment & Techniques Committee
Anchor & Resin Comparisons - Ascending
kN
Test Bed - Ingleton Quarry - Substrate N.Yorkshire Limestone
Test Bed - Horseshoe Quarry - Substrate Derbyshire Limestone - Black Bed, Stoney Middleton Sequence
Operatives - L.Sykes (CNCC)
R.S.Dearman (DCA)
G.Jones (BCA)
S.Sykes
S.Dale
E&T Minimum Extraction Load
Peco Batch 1 - KMR Resin
Mean = 33.91kN Range = 28 kN
Peco Batch 2 (1st Production Batch) - KMR Resin
Mean = 34.37 kN Range = 26kN (The 2 anchors which snapped discounted from Mean & Range)
Peco Batch 2 (1st Production Batch) KMR Resin
Mean = 27.87kN Range = 17kN (2 anchor which snapped discounted from Mean & Range)
BP Anchor - Rawl Resin Mean = 35.41kN Range = 24kN
BP Anchor - KMR Resin Mean = 44.91kN Range = 33kN
Anchor No.
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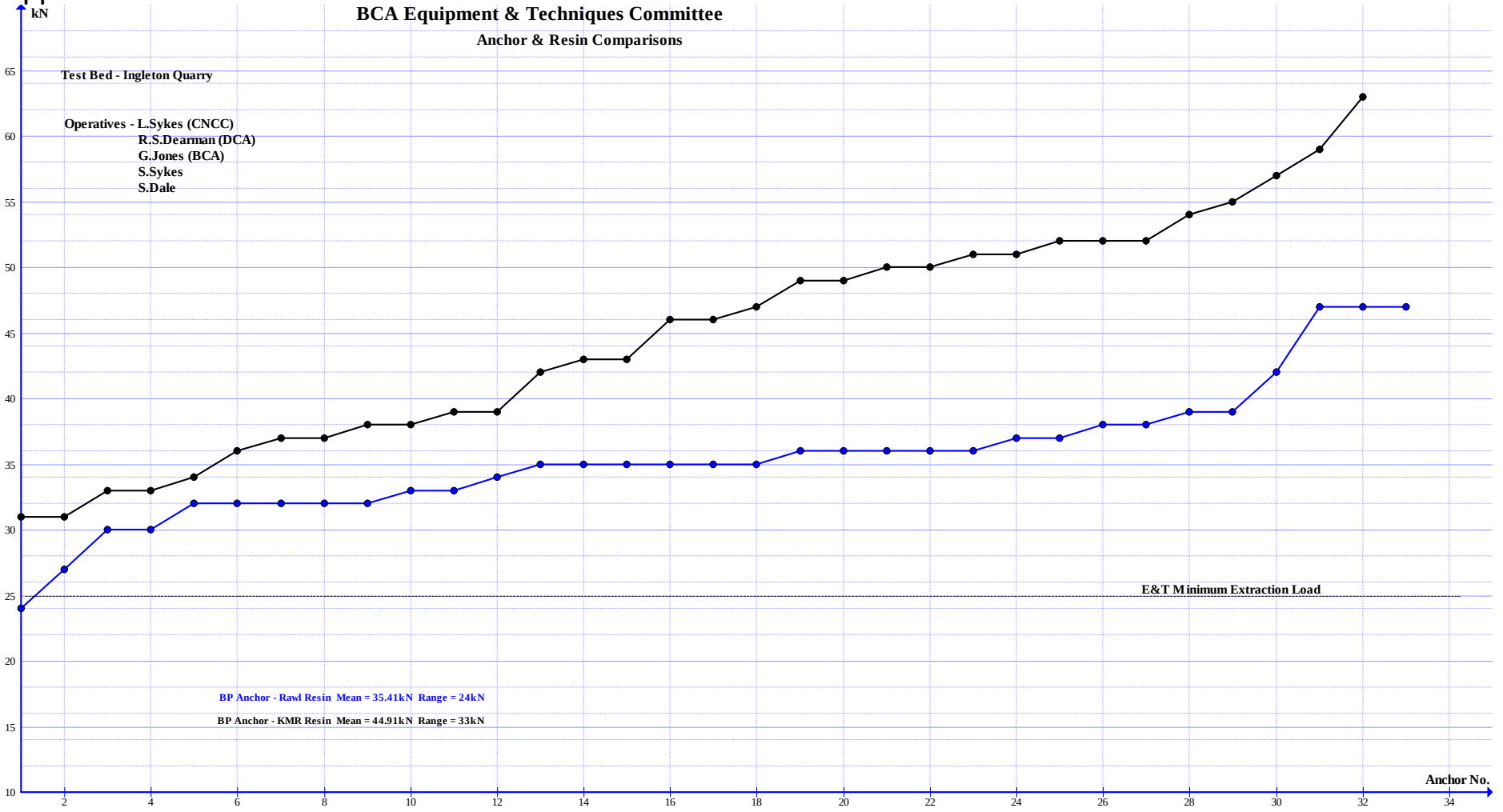
Appendix 2


BCA Equipment & Techniques Committee
Anchor & Resin Comparisons
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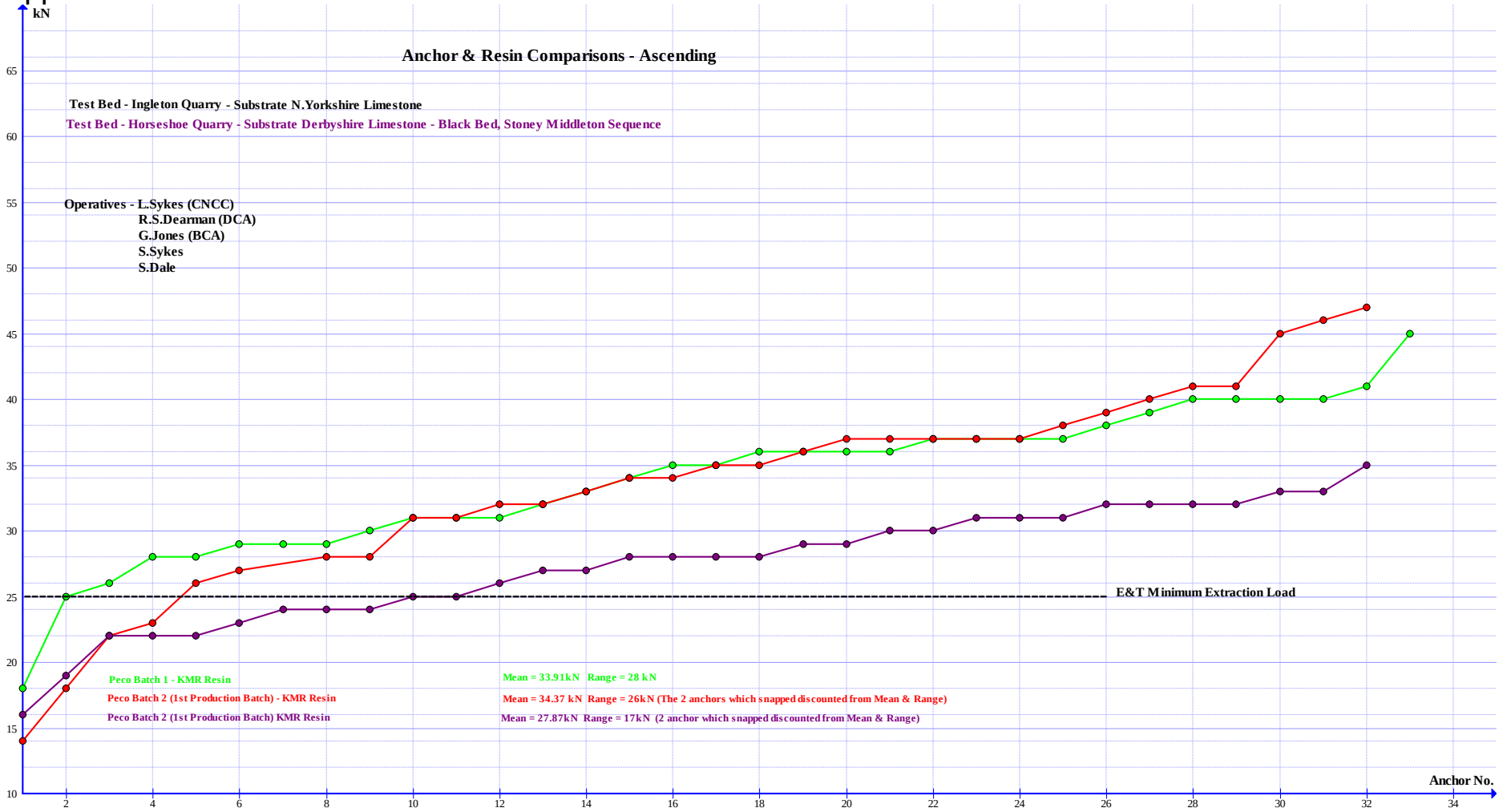
Appendix 3


kN
Anchor & Resin Comparisons - Ascending
Test Bed - Ingleton Quarry - Substrate N.Yorkshire Limestone
Test Bed - Horseshoe Quarry - Substrate Derbyshire Limestone - Black Bed, Stoney Middleton Sequence
Operatives - L.Sykes (CNCC)
R.S.Dearman (DCA)
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E&T Minimum Extraction Load
Peco Batch 1 - KMR Resin
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From: Nick Williams <nick.williams@hucklow.net>
Subject: BCA E+T Statement on anchors
Date: 11 November 2011 21:44:52 GMT
To: newsletter@british-caving.org.uk, descent@wildplaces.co.uk, speleology@bcra.org.uk
Cc: Damian Weare <dweare@supanet.com>, Andy Eavis <andy@andyeavis.com>

Mike, Chris, Erin,

I would be grateful if you would publish the following at your earliest convenience. This will also be published on the BCA and UKcaving.com web sites.

Please contact me if you have any questions.

Regards

Nick.

Statement begins:

"For some time, the E&T Committee have been searching for an alternative to the DMM Eco Anchor, which is no longer manufactured. Our preferred option would be to find an exact copy of the Eco Anchor since this retains all of the existing investment in testing, procedures and training as well as recognition of the scheme by users. Having been offered a supply by a UK caver with manufacturing facilities based in China, we believed we had found a source which would be able to provide anchors meeting our specification for the foreseeable future. A prototype batch of anchors indicated performance comparable with the DMM product and so we decided to press ahead with production quantities. Unfortunately, tests on the first production batch indicated problems with the material or manufacturing process. While the forces at which failures occurred were in excess of the limits which are required for anchors complying with the industrial standard for anchors, they are significantly below the safety margin which E+T have previously decided we should aim for.

Cavers may find some background historical and technical information useful at this point. It is generally accepted that the key measure of anchor performance is the axial pull out force. For anchors approved to BS EN 795 (the standard for industrial applications) the axial pull out force is required to be no less than 10kN. For mountaineering anchors (applicable standard BS EN 959) this figure is 15kN. The view of the BCA E+T Committee is that a figure of 25kN is appropriate for anchors placed in caves.

The choice of safety factor for any piece of equipment used for lifting or supporting a load is dependent on a number of factors. These include the expected maximum load, the likely frequency of over-load, the frequency of inspection, the susceptibility of the material to fatigue, the rate of wear and the expected life of the anchor. The higher safety factor chosen by BCA reflects the fact that it is expected that anchors placed in caves will undergo no regular maintenance or inspection in the caving environment and that, because they are used with single static ropes, they may occasionally be subjected to higher forces than those designed for use with dynamic mountaineering rope.

Anchors from the first prototype batch received from China failed at loads of between 25 and 45kN, with the failure mode being directly comparable to the DMM Ecoanchor (i.e. the anchor metalwork elongates and then pulls out of the resin, maintaining a peak force around the E+T's target value until the tang of the anchor is almost all out of the rock).

Anchors from the first production batch received from China failed at loads of between 14 and 47kN. Furthermore, the mode of failure indicated significant problems with the material/and or heat treatment during manufacture (some of the metalwork actually broke during the tests).

None of the production batch of anchors have been placed in caves but 77 of the prototype anchors have been

placed in locations in the Yorkshire Dales. These are located in six caves: Stream Passage Pot, Disappointment Pot and Marylin at Gaping Gill, Roaring Hole and Rowten Pot. They can be identified by the laser-etched marking "BCA01" on the anchor.

It is important to stress that not all anchors in these caves are affected. Precise locations of the anchors, and details of the tests, may be found on the CNCC website at http://www.cncc.org.uk/tg_tests.html. To put the number into context, there are over 5000 Ecoanchors installed in Dales caves.

Although the prototype anchors would appear to meet the BCA E+T performance criteria, the Committee has decided that they should be removed because the results of the tests on the production batch of anchors leave us with a lower degree of confidence in the long term performance of these anchors than is the case for the DMM product. Our intention is that all of these anchors should be decommissioned within two years of a suitable alternative anchor being identified. Work to select and confirm an alternative anchor is already well advanced.

The E+T Committee would like to remind cavers using anchors of any type that no single point of belay should be relied on for applications where a failure of the belay could result in serious injury or death.

Ends.