

## Peco Anchor Test Report - 8<sup>th</sup> July 2011

### Introduction

As a result of the cessation of manufacture of the DMM Eco anchor it was decided by the BCA E&T Committee to run a full scale trial of the Peco anchor manufactured in China from 8mm 316 stainless steel bar as a replacement. The terms of reference were that a statistically significant random sample be taken from the batch of 200 currently in BCA's possession and tested to axial failure also noting the mode of failure and the load at which the eye started to deform. The initial tests were to be carried out at Furness (Horseshoe) Quarry, Stoney Middleton, Derbyshire with the permission of the owners, the British Mountaineering Council. The test equipment was to be the newly acquired BCA test rig and load cell.

### Horseshoe Quarry

#### Method

32 Peco anchors were installed in the limestone of the quarry floor. The anchors were installed in compliance with the BCA E&T Committee document "Permanent Resin Bonded Anchors – Installation Procedure, Training and Documentation" (IPTD). The holes were drilled to 100mm deep and cleaned using a blower and brush until all the limestone dust had been removed. The anchors were secured in the substrate using Resifix 3+ chemical anchor mortar which is a polyester resin. The anchors were left unloaded for 8 days until test to failure on 24<sup>th</sup> June.

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 thin laminations caused some placements to prematurely fail with resultant spalling. 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 N<sup>o</sup>. BCA 0182 and BCA 0004 suffered catastrophic metallurgical failure at 26kN and 16kN respectively.

As a result of the substrate failure it was decided to repeat the full test of 32 anchors at Ingleton Quarry - North Yorkshire.

## Ingleton Quarry

### Method

32 Peco anchors were randomly selected from the remainder of the batch and set in structurally solid limestone. The anchors were installed to the standards prescribed in the BCA IPTD. The holes were drilled to 100mm deep and cleaned using water spray, brush and dry cloth. The anchors were again secured in the substrate using Resifix 3+ chemical anchor mortar.

On the 28<sup>th</sup> June 2011 the BCA test equipment was used to test to destruction the 32 anchors. 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 anchor 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 N<sup>o</sup>. 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.



The BCA anchor test equipment loading a Peco anchor to destruction in Ingleton Quarry North Yorkshire



## Conclusions

Before the tests were carried out the operatives were unaware of the nature of the strata at Horseshoe Quarry until informed by John Beck (a geologist). To confuse the issue the BMC also has a test bed there. During testing it soon became obvious that the substrate was weak and not typical of either Derbyshire or Yorkshire limestone. However, the results proved that even in such strata acceptable loads can be achieved and that this may give some indication of the anchors performance in other less structurally solid substrates. The limestone in Ingleton Quarry was found to be more compact and produced results much more in line with those from historic Eco anchor tests.

The major problem was with the four anchors which exhibited catastrophic material failure. These failures, if projected, account for 6.25% of the batch. It is not clear whether these are a result of unacceptable quality assurance in the production of the steel or lack of control in the manufacturing process. Given that the E&T Committee has set a lower limit of 25kN on anchors in line with other components in the safety systems used by cavers i.e. ropes, karabiners etc. it is difficult to see how the Peco anchor is of sufficient quality and consistency to replace the Eco anchor in the BCA scheme.

Operatives:- L.Sykes (CNCC), G.Jones (CNCC), R.S.Dearman (DCA)  
Report compiled by L. Sykes & R. Dearman.  
Photographs G. Jones

<b>BCA Test Results - Peco Anchors - Batch 002</b>							
<b>Furness (Horseshoe) Quarry - Stoney Middleton - 22/06/2011</b>							
Installed LS & RSD 14.6.2011 - Tested to failure LS,RSD,GJ 22.6.2011							
Substrate -Black Layer (Bituminous) Stoney Middleton Sequence							
No.	Anchor No.	R. B. No.	Deformation kN	Failure kN	Failure Mode	Comments	
1	150		14	28	A/Re		<b>Deformation</b>
2	145		13	23	A/Re	Spalling & substrate failure	Mean = 13.16kN
3	182		16	26	Anchor failed	Anchor snapped on lower curvature of the P	Range = 10 - 16
4	41		15	24	A/Re	Spalling & substrate failure	
5	148		13	32	A/Re	Spalling & substrate failure	<b>Failure</b>
6	4		11	16	Anchor failed	Anchor snapped on lower curvature of the P	Mean = 27.44kN
7	21		13	31	A/Re	Spalling & substrate failure	Range = 16 - 35
8	31		15	28	A/Re	Spalling & substrate failure	
9	98		14	29	A/Re	Superficial surface spalling	
10	168		13	30	A/Re	Superficial surface spalling	
11	84		13	32	A/Re	Superficial surface spalling	
12	121		13	33	A/Re	Superficial surface spalling	
13	55		14	33	A/re	Spalling & substrate failure	
14	55		14	29	A/Re	Spalling & substrate failure	
15	108		13	28	A/Re	Superficial surface spalling	
16	198		14	27	A/Re	Superficial surface spalling	
17	128		12	30	A/Re	Superficial surface spalling	
18	5		12	28	A/Re	Extensive and deep spalling	
19	166		12	27	A/Re	Superficial spalling	
20	11		15	25	A/Re	Spalling & substrate failure	
21	184		15	22	A/Re	Spalling & substrate failure	
22	124		13	25	A/Re	Substantial substrate failure	
23	133		12	24	A/Re		
24	61		13	32	A/Re	Superficial spalling	
25	63		13	24	A/Re	Spalling & substrate failure	
26	3		12	19	A/Re	Spalling & substrate failure	
27	64		10	22	A/Re	Spalling & substrate failure	
28	22		15	22	A/Re	Spalling & substrate failure	
29	7		16	35	A/Re	Massive substrate failure	
30	72		11	31	A/Re	No spalling or substrate failure	
31	56		11	32	A/Re	No spalling or substrate failure	
32	59		11	31	A/Re	Superficial spalling	

<b>BCA Test Results - Peco Anchors - Batch 002</b>							
<b>Ingleton Quarry 28/06/2011</b>							
<b>Installed LS &amp; GJ 25.6.2011 - Tested to failure LS,RSD,GJ 28.6.2011</b>							
No.	Anchor No.	R. B. No.	Deformation kN	Failure kN	Failure Mode	Comments	
1	37		13	46	A/Re		Deformation
2	146		13	37	A/Re		Mean = 13.28kN
3	71		13	47	A/Re		Range = 11 - 15
4	23		14	32	A/Re		
5	45		13	41	A/Re		
6	69		12	18	Anchor failed	Anchor snapped	Failure
7	157		11	37	A/Re		Mean = 33.22kN
8	131		14	36	A/Re		Range = 14 - 47
9	142		13	31	A/Re	Superficial spalling	
10	30		13	38	A/Re		
11	57		13	33	A/Re		
12	93		14	40	A/Re		
13	86		14	37	A/Re		
14	159		16	26	A/Re	Spalling	
15	2		14	35	A/Re		
16	192		13	37	A/Re		
17	175		14	28	A/Re		
18	51		13	45	A/Re		
19	28		13	37	A/Re		
20	158		13	41	A/Re	Video	
21	161		14	35	A/Re		
22	67		14	34	A/Re		
23	125		15	32	A/Re		
24	73		13	27	A/Re		
25	177		13	22	A/Re		
26	153		13	14	Anchor failed	Anchor snapped @ lower curvature of P	
27	46		14	34	A/Re		
28	39		13	39	A/Re		
29	107		14	22	A/Re	Massive substrate failure	
30	12		13	31	A/Re	Substrate failure	
31	26		11	28	A/Re	Substrate failure	
32	94		12	23	A/Re	Suspected inconsistent mixing of resin	