Supplementary guidance on the use of flexible bolts in reinforcement systems for coal mines

This guidance is prepared, in consultation with HSE, by the Deep Mined Coal Industry Advisory Committee which was appointed by the Health and Safety Commission as part of its formal advisory structures. The guidance represents what is considered to be good practice by the members of the Committee. It has been agreed by the Commission. Following this guidance is not compulsory and you are free to take other action. But if you do follow this guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

This web-only version replaces the 2000 edition of this guidance.

Introduction

1 This supplementary guidance relates to the use of flexible bolts in strata reinforcement systems for coal mines. It should be read in conjunction with the booklet *Guidance on the use of rockbolts to support roadways in coal mines* (www.hse.gov.uk/pubns/web24.pdf). It gives guidance on the use of flexible bolts and on the presence of bolts of differing lengths being installed as part of a systematic support system at the face of headings.

2 Revised paragraphs and new text are shown in italics.

Definitions

3 The following definition applies:

*'**Flexible bolt:** a steel rope strand used in conjunction with fully encapsulating resin grout or some other appropriate substance to provide reinforcement of a mine roadway roof or side or other working place at a mine.'*

Geotechnical assessment and site investigation

4 The requirements to determine bond strength are extended where the flexible bolt length exceeds the rockbolt length. Paragraphs 6-13 of the rockbolting guidance apply to flexible bolts, subject to the following modification to paragraph 10(e):

'10 The site investigation also needs to include reference to the following:

(e) ***bond strength**: measured by short encapsulation pull tests using the proposed flexible bolting materials and components (see Appendix 1). The tests need to be carried out for all major roof horizon changes within the length*

of the proposed flexible bolt. The average bond strength over 50% of the tested horizons needs to exceed 130 kN for a bond length of 300 mm and where the flexible bolt exceeds the rockbolt length, at least one of the tests undertaken above the rockbolt height needs to have a minimum value of 130 kN for a bond length of 300 mm.'

Support system design

5 Paragraphs 14-17 of the rockbolting guidance apply to the use of flexible bolts subject to the following amendments to paragraph 15 to include references to flexible bolts:

'15 A design engineer will prepare the initial design of the roof support system on the basis of the results of the site investigation. As a minimum, the design needs to take into account the following:

(a) the profile of the heading;

(b) the length of the rockbolts and flexible bolts to be used in the roof and ribs (the recommended minimum length in the roof is 1.8 m);

(c) the density of support in the roof. The recommended minimum density of support is 1 rockbolt/m^2 but site investigation may indicate a need for higher densities. This minimum density refers to rockbolts only and does not include flexible bolts. Where the design shows any requirement over and above the 1 rockbolt/m^2 this may be fulfilled by flexible bolts;

(d) the placing of flexible bolts. It is recommended that flexible bolts to be used in the roof are installed as close to the face of the heading as possible and as soon as practicable after exposure of the roof;

(e) the type of flexible bolt. All flexible bolts to be used in the roof should be full-column bonded;

(f) holes drilled for roof holes. They need to be formed in such a way that the bond strength parameters are achieved and the finished hole diameter does not exceed the nominal flexible bolt diameter by more than 7 mm;

(g) a system of support for roadway sides, where the initial assessment indicates the provision of such support.'

Design verification monitoring

6 Paragraphs 18-24 of the rockbolt guidance apply where flexible bolts are used.

Routine monitoring and recording scheme

7 Paragraphs 25 to 61 of the rockbolting guidance apply to flexible bolts subject to the amendments described below.

8 Paragraph 25 is modified in relation to flexible bolts as follows:

'25 Where flexible bolts are to be used in conjunction with rockbolts as part of a system to support mine roadways, the manager needs to prepare a Scheme for the routine monitoring of roadways and needs to recognise the use of flexible bolts in the scheme.'

9 In paragraphs 29-43 the rockbolting guidance lays down the standards for routine monitoring devices (dual height telltales etc). Where flexible bolts are used and they do not exceed the length of the rockbolt then the rockbolt standards will apply. However, if the flexible bolt is longer than the rockbolt then triple height telltales should be installed in place of the dual height types. In this event new guidance detailed below outlines recommended procedures when using triple height telltales:

Triple height telltales

Recommended horizons for triple height telltales are:

(a) ***Telltale A*** *- 0.3 m below the top of the rockbolt (ie 2.1 m for a 2.4 m bolt)*

(b) ***Telltale B*** *- 0.5 m below top of the flexible bolt (ie 3 m for a 3.5 m flexible bolt)*

(c) ***Telltale C*** *- minimum 5 m above the roof horizon or 1 m above the flexible bolt if they are longer than 4 m.'*

10 Paragraph 35 is modified as follows:

'35 The senior official's attention needs to be drawn to any telltale movement in excess of 25 mm on any indicator or at the action level set by the manager within his rules, whichever is the lower figure. Manager's rules should also detail actions on the rates of movement appropriate for the specific mine site.'

Training

11 The training requirements in paragraph 62 and Appendix 8 of the rockbolting guidance extend to flexible bolts.

Consumable items

12 Where flexible bolts form part of the roadway support system as specified in Support System Design they should be shown to be suitable under paragraph 63(c) of the rockbolt guidance document.

Appendix 1 Underground determination of bond strength for a steel flexible bolt/resin system. Short encapsulation pull test

Appendix 1 of the rockbolting guidance applies to flexible bolts. The following revised information should be used when flexible bolts are to be applied.

Introduction

The short encapsulation pull test is used to measure the performance of a flexible bolt/resin/rock system. The test is performed underground and is the ultimate proof test of a flexible bolt/resin/rock system. It should replicate the procedures, consumables and equipment in use for the support.

Brief description

A series of holes are drilled to varying depths and flexible bolts of the required length are installed with a short resin capsule to give an encapsulated flexible bolt length of not more than 300 mm. The pull test needs to be performed after a

curing period of at least one hour and not more than 24 hours. After this time an axial load is applied to the end of the flexible bolt and the flexible bolt extension measured. The load is applied up to a maximum of 220 kN.

Procedure

Equipment

The short encapsulation pull test equipment for flexible bolts is the same as for rockbolts.

Number of tests

A minimum of two tests need to be carried out at each of the chosen roof horizons. As an example, for a 4 m flexible bolt these horizons would normally be at 1200, 1800, 2600 and 3800 mm. If significant changes in geology occur within the bolted horizon, further tests need to be carried out at other horizons to determine their influence, if any, on the bond strength of any proposed flexible bolt reinforcement system.

Flexible bolt preparation

The flexible bolt length needs to be longer than the hole length to allow full engagement of the drawbar on the bottom end of the flexible bolt. All test bolts, including full length bolts, need to be cut square to the flexible bolt axis. The flexible bolt should be prepared to ensure that the resin is confined to the upper 300 mm of the flexible bolt to be tested. This can be achieved, for example, by using insulating tape wound around the flexible bolt, 300 mm from the top of the flexible bolt, to increase the effective diameter of the flexible bolt to that of the drilled hole.

Location

Pull test locations are the same as for rockbolts.

Capsule preparation and measurement of embedment length

Method

- Drill hole to length using standard bit.
- Measure: drilled hole diameter; flexible bolt diameter; resin capsule diameter. Note - the flexible bolt diameter is the effective diameter as specified by the manufacturer.
- Determine the resin capsule length to produce not more than 300 mm flexible bolt encapsulation using the formula:

$$\textbf{Capsule length} = \frac{(\textbf{hole diam}^2 - \textbf{flexible bolt diam}^2)}{\textbf{Capsule diam}^2} \times \textbf{encapsulated length}$$

- Prepare test resin capsules of the calculated length from the resin used in the heading using the tie wraps and removing the excess capsule.

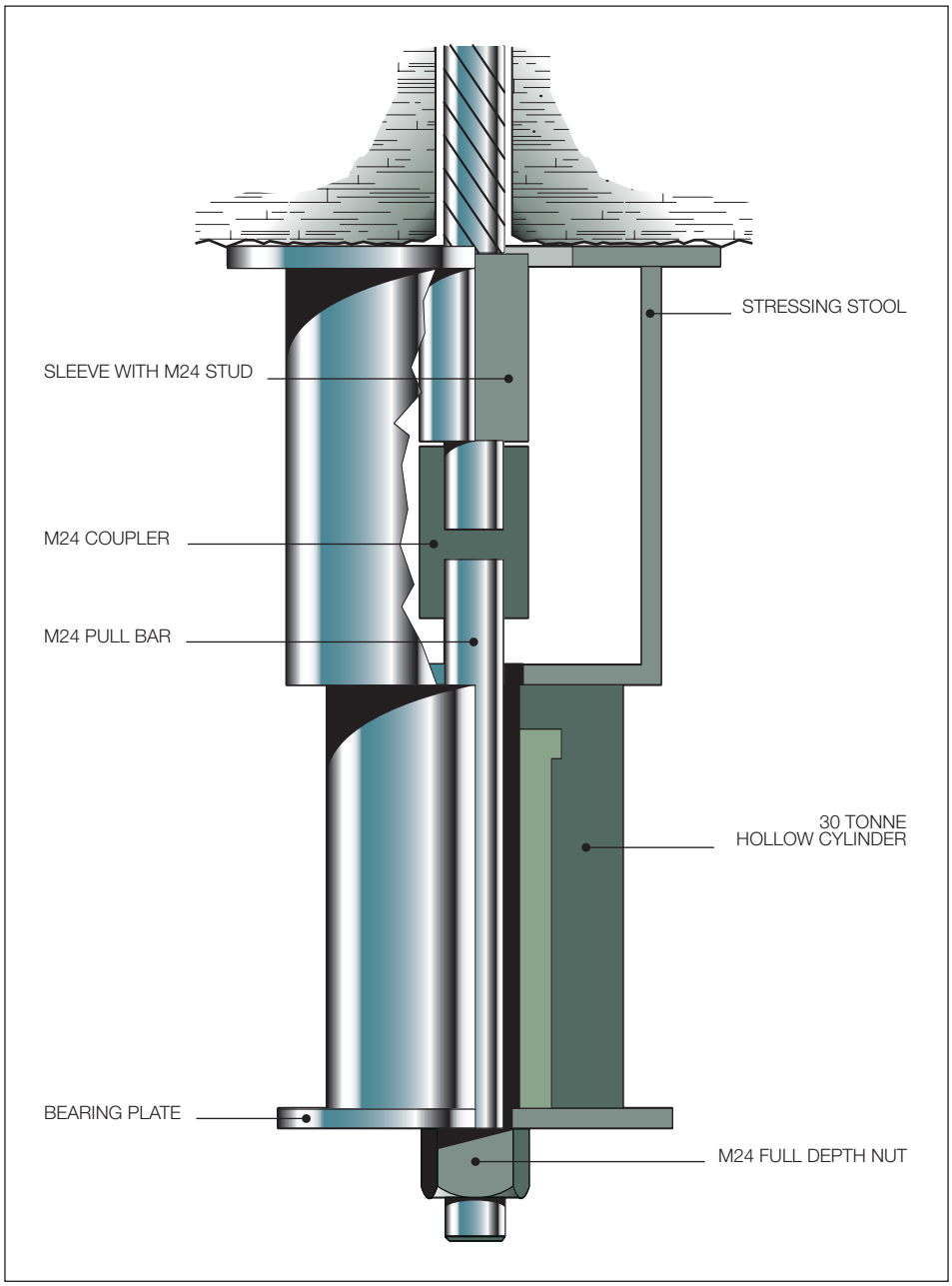

Figure 1 Arrangement for pull testing of a flexible bolt

Hole preparation

Use the same procedure as outlined in the rockbolting guidance.

Flexible bolt installation

Follow the same procedure as outlined in the rockbolting guidance.

Pull testing

The procedure is substantially the same as that detailed in the rockbolting guidance using either set of equipment as detailed in Figures 1 and 2. Note that flexible bolt extension will depend upon an applied load, free length of bolt, and type of bolt. Flexible bolt extension is specific to the type of bolt used.

Analysis

Same procedure as for rockbolts to be followed.

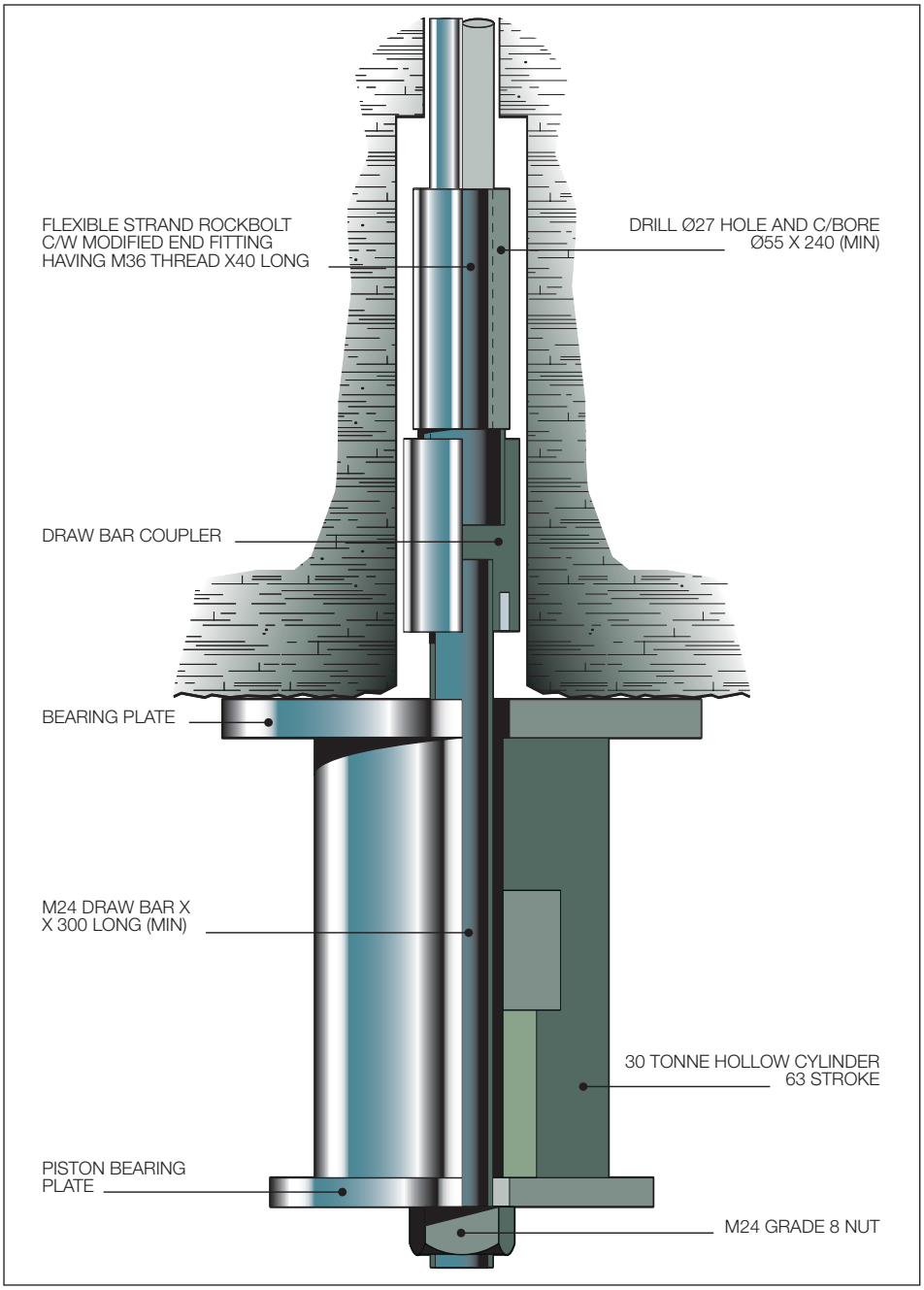

Figure 2 Arrangement for pull testing of a flexible bolt

Test requirements

The test requirements for flexible bolts are summarised below:

'The average bond strength should be no less than 130 kN, for a bond length of 300 mm, over 50% of the tested horizons.
Where the flexible bolts are to be longer than the rockbolts, at least one of the tests undertaken above the rockbolted height should produce a bond strength of at least 130 kN, for a bond length of 300 mm.'

Interpretation of results (for a 4 m length flexible bolt used in conjunction with 2.4 m length A.T. type rockbolts)

The following is text introduced to help with interpretation of results:

Test	Horizon (mm)	Bond strength (kN)	Average bond strength (kN)
1	1200	120	$\frac{120 + 100}{2} = 115$
2	1200	110	
3	1800	150	$\frac{150 + 160}{2} = 155$ (pass)
4	1800	160	
5	2600	150	$\frac{150 + 100}{2} = 125$
6	2600	100	
7	3800	170	$\frac{170 + 160}{2} = 165$ (pass)
8	3800	160	

Example 1

Two horizons out of four tested achieve a pass. This would satisfy the requirements of this guidance, as 50% of the horizons tested and at least one horizon above the rockbolted length have an average bond strength greater than 130 kN.

Example 2

Test	Horizon (mm)	Bond strength (kN)	Average bond strength (kN)
1	1200	150	$\frac{150 + 100}{2} = 125$
2	1200	100	
3	1800	130	$\frac{130 + 110}{2} = 120$
4	1800	110	
5	2600	150	$\frac{150 + 160}{2} = 155$ (pass)
6	2600	160	
7	3800	160	$\frac{160 + 90}{2} = 125$
8	3800	90	

Although five out of eight tests achieve a bond strength greater than 130 kN, only one horizon out of the four tested has an average bond strength greater than 130 kN. This would not meet the requirements of this guidance as only 25% of the tested horizons have an average bond strength of greater than 130 kN.

Further information

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