ADVISORY COMMITTEE FOR ROOFWORK

Materials Standard

ACR [M] 002:2009

TESTING OF ROOF ANCHORS ON ROOF SYSTEMS

(*being Part 2 of the Magenta Book*)

FOREWORD

One of the main causes of deaths and injuries at work each year is falling from height, particularly through or from roofs. To ensure safety during roof work requires the commitment of all those involved in the procurement process.

Where collective protection is not possible personal protection equipment must be used. Many of these rely on horizontal safety lines fixed, using 'top fix' anchors, to the roof sheeting rather than through them to the roof support structure.
This has raised concerns about the adequacy of testing of such systems.

This material standard addresses this issue and gives practical advice on what the ACR considers is 'current best practice' for the testing of Roof Anchors on Roof Systems. It concentrates on profiled roofs. This publication should be read in conjunction with ACR [CP] 007:2008 'Recommended practice for use of horizontal safety lines in roofwork'.

Those engaged in other similar activities would benefit from the advice given as many of the principles do apply and offer good practice.

The delivery of improvements in the prevention of falls from height will only be achieved with the full involvement of all those with a role to play, i.e. clients, employers, workers, trade unions, trade associations, manufacturers, training providers and others.

I thank those involved for their valued input and the often lively and wide-ranging debate, in producing this guide
.
Ralph N Bennett, Chairman of the ACR.

CONSTITUTION OF THE TASK GROUP

The following people represented the Associations and Manufacturers invited to the task group:

David Thomas	Formally HSE
Tim Bisset	Latchways plc
Simon Luke	Uniline Safety Systems Ltd
Simon Rood	Roodsafe
Peter Davis	Roodsafe
Steve Jervis	Capital Safety Group
Scott Bennett	Dunn & Cowe
Steve Ball	Kingspan Panels
Jim Atwood	Safeline UK Ltd
Lee Davies	CA Group Ltd
Derek Cowe	Dunn and Cowe
Peter Baker	Corus Roof Panels & Profiles
Chris Chapman	BSI

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INTRODUCTION

The Advisory Committee for Roofwork (ACR) was set up in 1998, at the instigation of the Health and Safety Executive (HSE), to consider the safety implications of fragile roof assemblies. It is made up of nominees from trade associations and organizations involved in roofwork that, together with HM Specialist Inspectors, produce documents that provide advice based on sound technical knowledge and many years' collective experience of roof work.
Concerns have been expressed to the ACR about the reliability, adequacy of testing and overall performance of horizontal lines and single point

anchors (particularly those using 'top fix' anchors) being installed on different roof types.
In response, the ACR convened a Working Group which included representatives of:

- the ACR (including the HSE);
- safety equipment manufacturers;
- safety equipment installers; and
- UK representatives on British and European standards committees dealing with relevant product standards and codes of practice

To produce a test specification for "top fix" style roof anchors and fall protection systems that could be used by manufacturers and contractors to verify that products sold in the market met required performance standards.

0. DEFINITIONS

For the purposes of this document the following definitions apply:

0.1 Competent person or persons

Person [or persons] who can demonstrate that they have sufficient professional or technical training, knowledge, actual experience and authority to enable them to:

a) Carry out their assigned duties at the level of responsibility allocated to them;
b) Understand any potential hazards related to the work (or equipment) under consideration;
c) Detect any technical defects or omissions in that work (or equipment), recognise any implications for health and safety caused by those defects or omissions; and
d) Be able to specify a remedial action to mitigate those implications.

In this context, for assessing suitability of roof anchors on a roof system, a competent person is one who can demonstrate that he/they has/have:

a) Thorough knowledge of roofing and of the mechanical and physical properties and behaviour of the particular product and assembly when subjected to this test; and
b) Extensive knowledge and experience of installation of the product, its usage limitations, behaviour and mode of failure in service.

Note: The competent person's responsibilities include ensuring that the worst-case scenario has been covered when:

a) Defining roof assembly to be tested (4.5 & 4.6)
b) Defining test position(s) (4.4.7 & 5.0)
c) Determining the samples to be tested (4.7 & 4.4.7)
d) Deciding the number of tests necessary to ensure results are statistically significant (5)
e) Determining the number of profiles/anchors to be tested (4.7)
f) Evaluating the damage to the assembly (7.1 & 7.2)
g) Together with signing of the test report (8.1 (b))

0.2 Inspection

0.2.1 Visual exercise, which is not carried out at close-quarters.

0.3 Examination

0.3.1 Thorough inspection carried out at close-quarters, which may, at the discretion of a competent person, be more than just visual.

0.4 Other definitions

0.4.1 Other definitions are as described in Terminology paragraph 16 in ACR[CP}007:2008 Best practice for use of horizontal safety lines in roofwork which should be read in conjunction with this document

1. SCOPE

1.1 This ACR book prescribes a method for testing fall protection anchor devices used to support cable horizontal lifelines and single point anchors that are connected only to the top sheet or underlying metal, hollow concrete or wooden deck of the roof assembly and receive no support from the underlying building structure. Hereafter referred to as "**Top Fix Anchors**".

2. RESPONSIBILITIES

2.1 The responsibilities of the key parties are as follows:

NOTE: *Where a party fulfils more than one role they assume the responsibility for each.*

2.2 Roofing manufacturer

2.2.1 Responsible for providing

- the components of a roofing assembly and supporting information and
- technical assistance to help in the construction of that roof assembly in order to support the fall protection system manufacturer in their testing programme.
- authoritative information and advice to architects and designers on the suitability and reliability of 'top fix' fall protection systems when used on their product(s).

NOTE: ***Roof anchor testing is undertaken at the risk of the safety system manufacturer and does not guarantee approval by a roofing manufacturer. Roof manufacturer approvals are given at the manufacturers discretion and may be***

influenced by other elements including, but not limited to product quality, product appearance, weatherproofing, compatibility of materials, CE Approval, Manufacturers quality system, installation training programmes, technical competence, method of predicting system loading, instructions for use and guarantees.

2.3 Designers & Roofing contractors

2.3.1 Responsible for:

- selecting a properly designed and tested fall protection system to meet clients needs in accordance with the roof manufacturer's instructions and guidance, supported by evidence of testing

2.4 Anchor device manufacturer/supplier

2.4.1 Responsible for:

- designing and manufacturing fall protection system(s) and for the preparation and issue of all necessary installation and user instructions;
- ensuring that product(s) meet relevant standards and 'industry best practice' and have been independently type-tested against the requirements of relevant standards by a Notified Body;
- ensuring that product(s) are CE-marked; and
- that the anchor device (e.g. horizontal line or single point anchor) has proved satisfactory when tested in accordance with this book (and upon each roofing type to which it is intended it will be installed).

3. NORMATIVE REFERENCES

BS EN795: 1997 – Protection against falls from height. Anchor devices. Requirements and testing

BS EN364: 1993 – Personal Protective Equipment against falls from height. Test Methods

4. TESTING REQUIREMENTS

4.1 Principles of the Test

4.1.1 An impact load, which is intended to simulate a person or more than one person attached to a lifeline or single anchor point falling, is applied to the anchor device. The test investigates the ability of the anchor device and roof system to which it is attached to resist these impact loads and arrest the fall of the person(s) falling from the edge of the roof or through a fragile element of the roof. e.g. rooflight.

4.2 General

4.2.1 In order to facilitate the satisfactory design, construction and testing of a top fix single point anchor, or a horizontal anchor line supported by top fix brackets, that is to be installed on top of a roof, the roofing manufacturer should provide the manufacturer of the safety system with full details of the technical specification for the roof system concerned, and should provide a roof sample (or samples) as may be required for test purposes.

4.2.2 All necessary installation or adaptation of the roof sample during the course of setting up, or conducting tests should be undertaken by individuals that are acknowledged by the roof manufacturer to be competent for the task(s) concerned.

4.2.3 Testing by the safety system manufacturer may be undertaken by the safety system manufacturer 'in-house' or 'externally' and should be either witnessed by a representative of the roofing manufacturer or as a minimum requirement be recorded on video.

4.2.4 The results of all testing should be documented and submitted to the roofing manufacturer for their consideration in a format which is readily understood and that imparts all of the information required in accordance with the test protocol.

4.3 Test Apparatus

4.3.1 The apparatus for the dynamic and static testing recommended in this document should with the exception of the rigid test mass and test rig conform to the requirements of BS EN 364 clause 4.4.2, 4.5 and 4.6.

4.3.2 Force measuring equipment should be calibrated annually.

4.3.3 The test mass to be used in the testing recommended in this guideline should constitute a mass of 100kg x n, where 'n' is the number of users.

4.4 Test rig

4.4.1 The test rig should be capable of accommodating a properly made up roof panel of a minimum size '6-metres x 6-metres'.

4.4.2 The rig should comprise 2 steel universal beams (i.e. I-beams: typically 305 x 165 x 40 section), each 6-metres long and mounted horizontally on a rigid base.

4.4.3 The beams should be parallel to each other with 6-metres between centres.

4.4.4 The rig should have the facility to apply horizontal forces parallel to the rigid base, both along and across the orientation of the beams.

4.4.5 The test rig should be fixed down such that the application of the dynamic force and static force referred to in this document should not cause any permanent plastic deformation.

4.4.6 Test rig details are shown in Figure 1.

4.4.7 Where the safety system manufacturer permits the use of the anchor device on a smaller area of roof then additional testing should be carried out. In this case the roof construction and test rig should reflect the smallest permissible area of roof.

4.5 The Test Roof

4.5.1 The test roof should be as recommended or advised by the manufacturer of the roof system or where project specific testing is required, as advised by a structural or other such suitably qualified engineer.

4.5.2 Where purlins are required, unless otherwise advised by the roof manufacture, they should be cold rolled, of a depth of 140mm and of a maximum thickness of 1.5mm.

4.5.3 The purlin spacing will be determined by the roof manufacturer and should be installed to the largest permissible span between purlins for the specific roof system. Typically this span may be 1.8m.

4.6 Roof sample

4.6.1 The roof system used as a test sample should meet the roof manufacturers minimum specification and be a properly made up roof panel/section 6-metres x 6-metres. The test sample should meet the minimum requirements for material construction of the particular roof type as specified by the roof manufacturer with purlins of the type specified above.

4.7 Anchor device samples

4.7.1 The test method requires a minimum of three top fix anchor devices of each type permitted in the system to be tested for each roof profile on which they are to be used.

4.7.2 Anchors should be taken from a production batch.

4.7.3 Anchors employed in horizontal lifeline systems for supporting corners that do not incorporate energy absorbing elements within the anchor, must be tested without any additional inline energy absorbing components.

4.8 Single point and Intermediate Anchors

4.8.1 Single point anchors and anchors used only as supports for intermediate components should be tested in accordance with BS EN795 class A2 Anchor Devices.

Note: *These anchors are not required to be tested to the Magenta Book standard where EN795 testing of these products has been carried out by a Notified Body.*

4.8.2 Where the anchor is an intermediate anchor the static strength test shall be to a minimum of 12kN.

4.8.3 Roof systems should be constructed in accordance with the rules laid out in this document.

5. TEST METHOD

For end and corner anchors incorporating integral energy absorbing elements and end anchors incorporating inline energy absorbing elements.

Note*:For corner anchors without integral energy absorbing elements, test in accordance with section 6.0*

5.1 Dynamic test parallel to the seam of the roof (refer to Figure 2 & 4)

5.1.1 Install the roof sample onto the test rig in accordance with the roof manufacturer's installation instructions.

5.1.2 Install an anchor device, including any separate energy absorbing components that is a component of the horizontal lifeline system. The anchor device should be as close to the front edge of the sample roof system as may be permitted in the system design by the safety system manufacturer. Ensure that the test force to be applied to the anchor device will be parallel to the seam of the roof sample.

5.1.3 Attach a force-measuring device (load cell) to the connection point of the anchor device or energy absorbing component as appropriate.

5.1.4 Connect a length of 10mm diameter steel wire rope to the force-measuring device. Where necessary to provide adjustment a chain may be used between the force measuring device and the wire rope.

5.1.5 Connect the opposite end of the wire rope to a rigid test mass representing the maximum number of users recommended by the manufacturer of the anchor device (e.g. 2 users = 200 kg; 3 users = 300 kg, etc). Anchors that support horizontal lifeline systems should be tested for a minimum of 2 users.

5.1.6 Use a system of pulleys to guide the wire rope and raise the test mass so that it can fall freely through 1.5 m and suspend it by means of a quick release device.

5.1.7 Release the test mass by means of the quick release device.

5.1.8 Check that the test mass does not strike the ground or test apparatus and record the peak force measured at the anchor device.

5.1.9 Retain dynamic load tested anchor as fixed and tested on sample roof system for Static Load test

5.2 Static test parallel to the seam of the roof (refer to Figure 3)

5.2.1 The anchor device or energy absorbing component should remain attached to the sample roof system used in the dynamic test by the fixings used in the dynamic test. The assembly of energy absorbing, anchoring components and sample roof system should not be adjusted or altered between the dynamic and static test.

5.2.2 Attach a load cell and winch to the anchor device or energy absorbing component previously used in the dynamic test. Ensure that the test force to be applied to the anchor device will be parallel to the seam of the roof.

5.2.3 Apply a static force to the anchor device equal to twice the peak force recorded in the dynamic test or twice the maximum permitted arrest load in the system proven and controlled by verifiable calculation. Hold the load for 3 minutes. The anchor and its fixings shall not yield.

5.2.4 Record the static test force.

5.2.5 Examine the roof structure and note any damage.

5.3 Dynamic test perpendicular to the seam of the roof (refer to Figure 2)

5.3.1 Install a new anchor device, including any separate energy absorbing components. The anchor device should be as close to the front edge of the roof as may be permitted by the manufacturer. Ensure that the test force to be applied to the anchor device will be perpendicular to the seam of the roof sample.

5.3.2 Repeat actions 5.1.3 to 5.1.9 inclusive.

5.4 Static test perpendicular to the seam of the roof (refer to Figure 3)

5.4.1 The anchor device or energy absorbing component should remain attached to the sample roof system used in the dynamic test by the fixings used in the dynamic test. The assembly of energy absorbing, anchoring components and sample roof system should not be adjusted or altered between the dynamic and static test.

5.4.2 Attach a load cell and winch to the anchor device or energy absorbing component previously used in the dynamic test. Ensure that the test force to be applied to the anchor device will be perpendicular to the seam of the roof.

5.4.3 Repeat actions 5.2.3 to 5.2.5 inclusive.

5.5 Dynamic Test at 45 degrees to the seam of the roof (refer to Figure 2)

5.5.1 Install a new anchor device, including any separate energy absorbing components. The anchor device should be as close to the front edge of the roof as may be permitted by the manufacturer. Ensure that the test force to be applied to the anchor device will be at 45 degrees to the seam of the roof sample.

5.5.2 Repeat actions 5.1.3 to 5.1.9 inclusive.

5.6 Static Test (refer to Figure 3)

5.6.1 The anchor device or energy absorbing component should remain attached to the sample roof system used in the dynamic test by the fixings used in the dynamic test. The assembly of energy absorbing, anchoring components and sample roof system should not be adjusted or altered between the dynamic and static test

5.6.2 Attach a load cell and winch to the anchor device or energy absorbing component previously used in the dynamic test.

5.6.3 Ensure that the test force to be applied to the anchor device will be at 45 degrees to the seam of the roof sample.

5.6.4 Repeat actions 5.2.3 to 5.2.5 inclisive.

6. TESTING OF CORNER ANCHORS – ALTERNATIVE METHOD

***Note**: This test method is only to be applied to anchors used for the installation of corners, where there is no integral energy absorbing element.*

6.1 Dynamic Test

6.1.1 Install the roof sample onto the test rig in accordance with the roof manufacturer's installation instructions.

6.1.2 Install a corner anchor device. The anchor device should be 2m x 2m from both edges of the roof system. Install a further two end anchor devices of the type used in the manufacturers safety system at right angles to the corner anchor 5m from the corner anchor.

6.1.3 The anchors should be elevated so that they are level with the anchor installed on the roof

structure. (See Fig 5 - Corner Test Arrangement). The means for elevating the anchors should comply with the requirements of BS EN:364: 1993 clause 4.4.1.

6.1.4 The end anchors in this arrangement must not be installed with any additional energy absorbing elements or components.

6.1.5 Attach a force-measuring device (load cell) to the connection point of the end anchor device of the span in which the load is to be applied.

6.1.6 Install a cable safety system of the type supplied by the manufacturer between the anchors and attach a mobile attachment device in the middle of the span for connection of the steel wire test rope. Tension the system to the level specified by the manufacturer.

6.1.7 Connect a length of 10mm diameter steel wire rope to the mobile attachment device. Where necessary to provide adjustment a chain may be used between the mobile attachment device and the wire rope.

6.1.8 Connect the opposite end of the wire rope to a rigid test mass representing the maximum number of users recommended by the manufacturer of the anchor device (e.g. 2 users = 200 kg; 3 users = 300 kg, etc).

6.1.9 Horizontal lifeline system corner anchors should be tested for a minimum of two users.

6.1.10 Use a system of pulleys to guide the wire rope and raise the test mass so that it can fall freely through 1.0 m and suspend it by means of a quick release device.

6.1.11 Release the test mass by means of the quick release device.

6.1.12 Check that the test mass does not strike the ground or test apparatus

6.1.13 Record the peak force measured at the end anchor device.

6.1.14 Examine the roof structure and note any damage.

6.1.15 Retain dynamic load tested anchor as fixed and tested on sample roof system for Static Load test

6.2 Static test parallel to the seam of the roof (refer to Figure 3)

6.2.1 The anchor device or energy absorbing component should remain attached to the sample roof system used in the dynamic test by the fixings used in the dynamic test. The assembly of energy absorbing, anchoring components and sample roof system should not be adjusted or altered

6.2.2 Attach a load cell and winch to the mobile attachment device previously used in the dynamic test.

6.2.3 Apply a static force to the mobile attachment device equal to twice the peak force recorded in the dynamic test or twice the maximum permitted arrest load in the system proven and controlled by verifiable calculation. Hold the load for 3 minutes. The anchor and its fixings shall not yield. Should it be necessary the static load may be applied between two mobile attachment devices.

6.2.4 Record the static test force.

6.2.5 Examine the roof structure and note any damage.

7. TESTING – PASS CRITERIA

7.1 Dynamic Test

7.1.1 The roof anchor and roof system retain the fallen suspended mass.

7.2 Static Test

7.2.1 The anchor and roof system shall hold the applied load for a period of 3-minutes.

8. TEST REPORT

8.1 The report for this test should contain at least the following information.

a) Name and address of test house or place that test took place

b) The name, address and dated signature of the competent person(s), including a statement confirming evidence of compliance with the requirements of 0.1.

c) Type and name of roof assembly under test

d) List tests carried out

e) A statement that the test was carried out in accordance with this document

f) The mass allowed to free fall

g) The direction of application of the load

h) A statement that the device satisfies the pass/fail criteria including details of the dynamic and static loads

i) A statement as to what damage the roof sustained

j) Photographs of the test set up and results

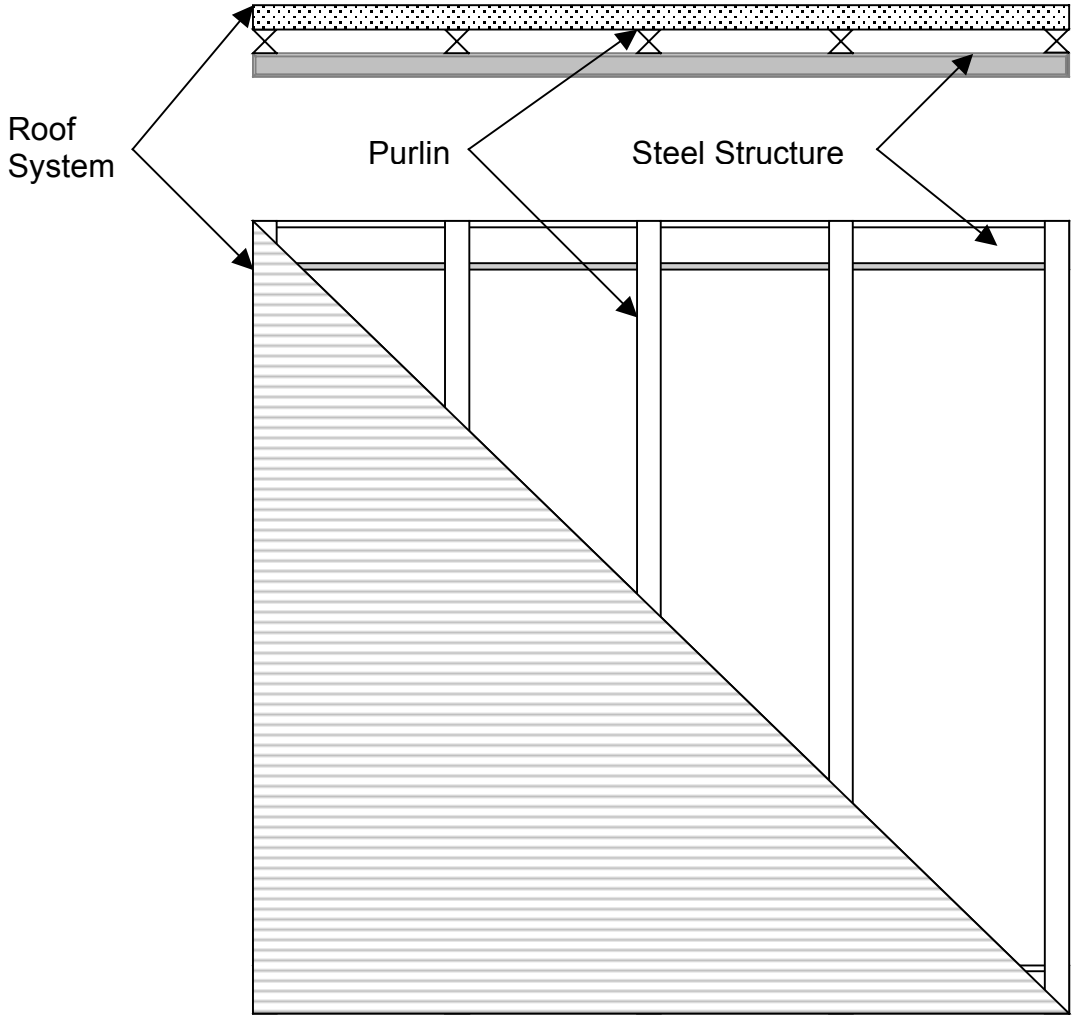


FIG 1 – TEST RIG SET UP

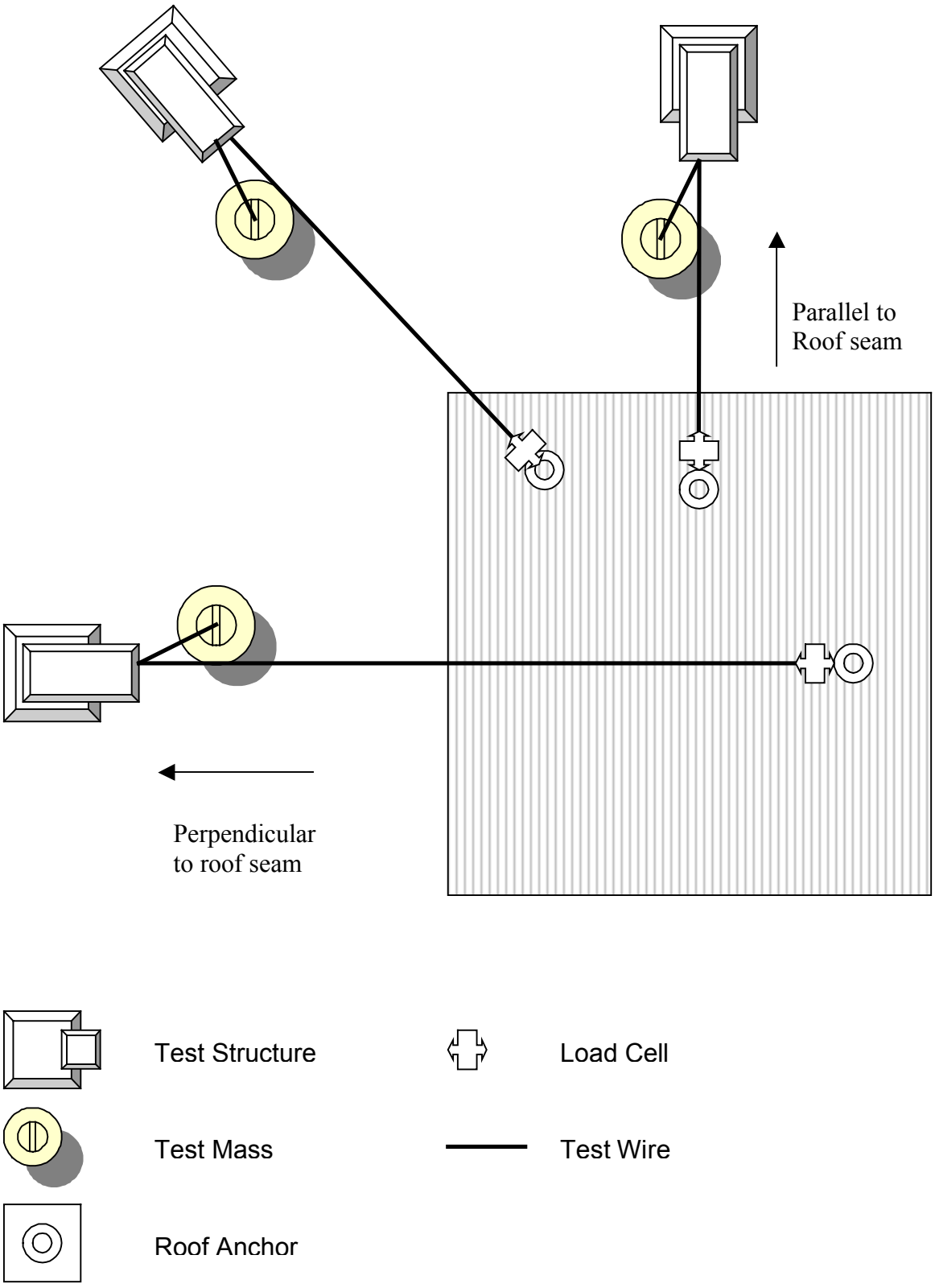


FIG 2 -TYPICAL DYNAMIC TEST SET UP - PLAN VIEW
showing all possible test orientations

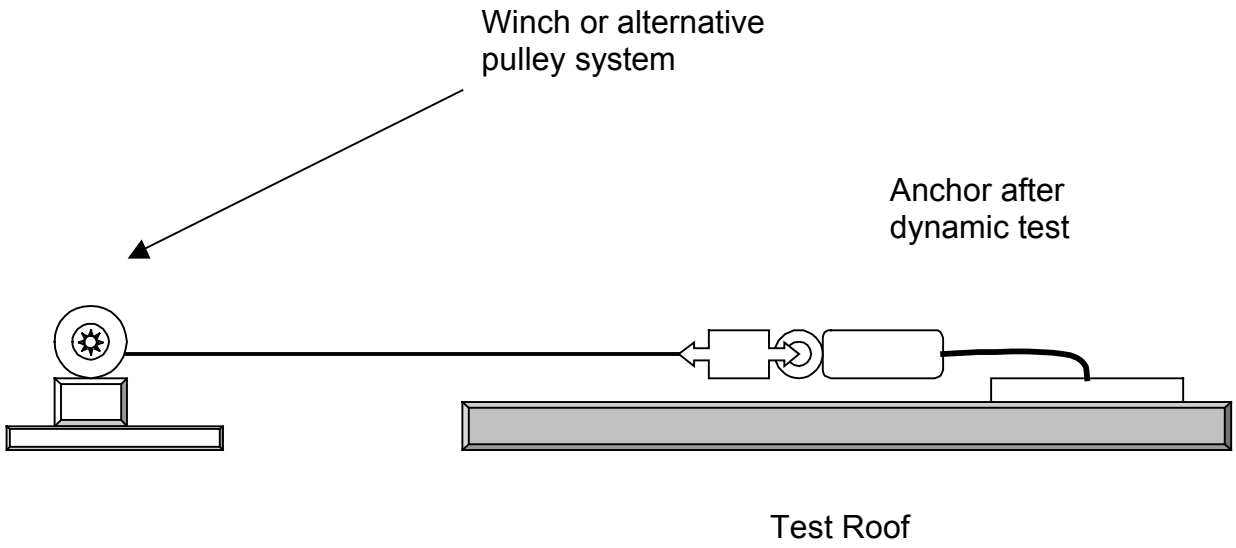


FIG 3 – STATIC TEST ARRANGEMENT - TYPICAL

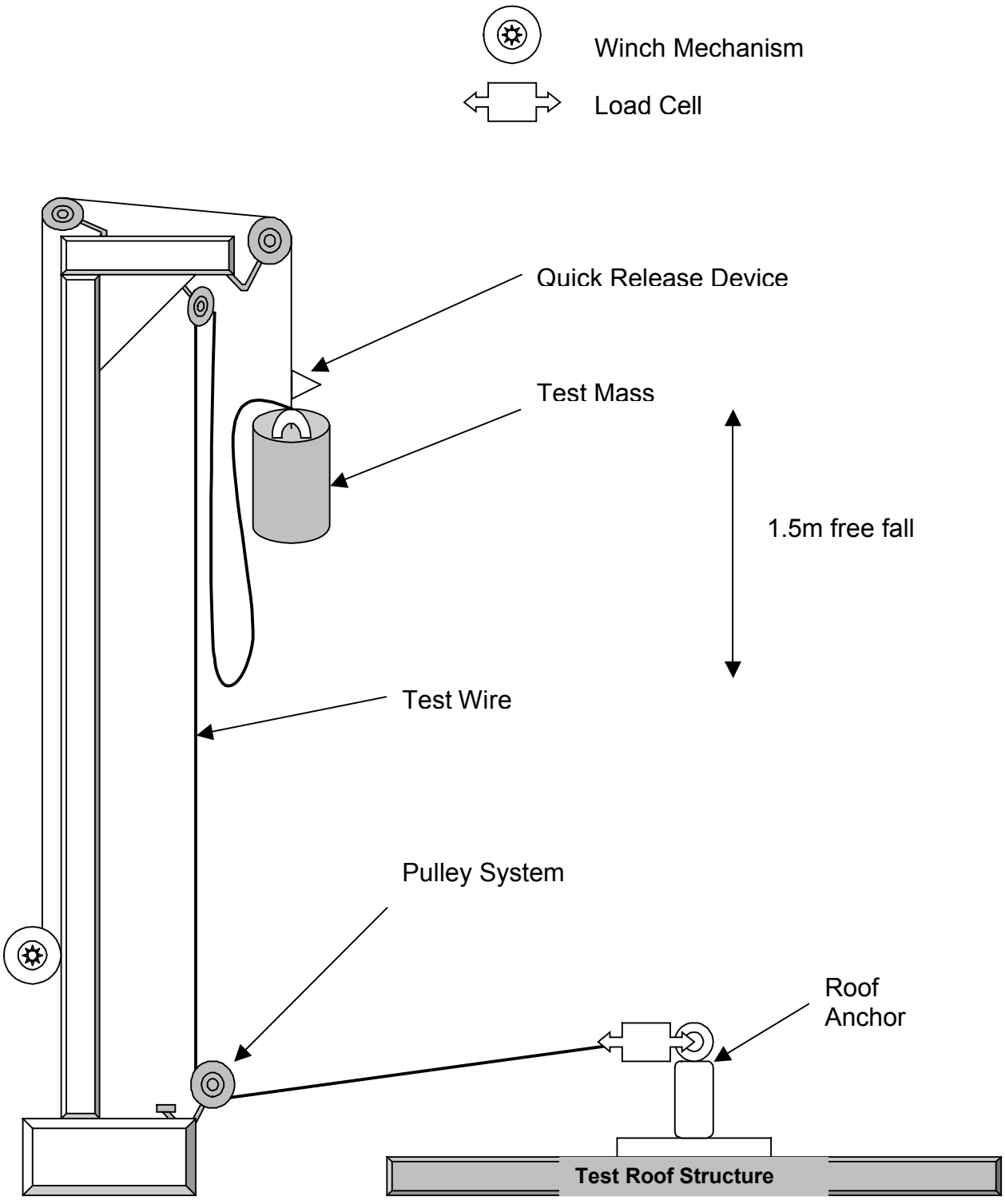
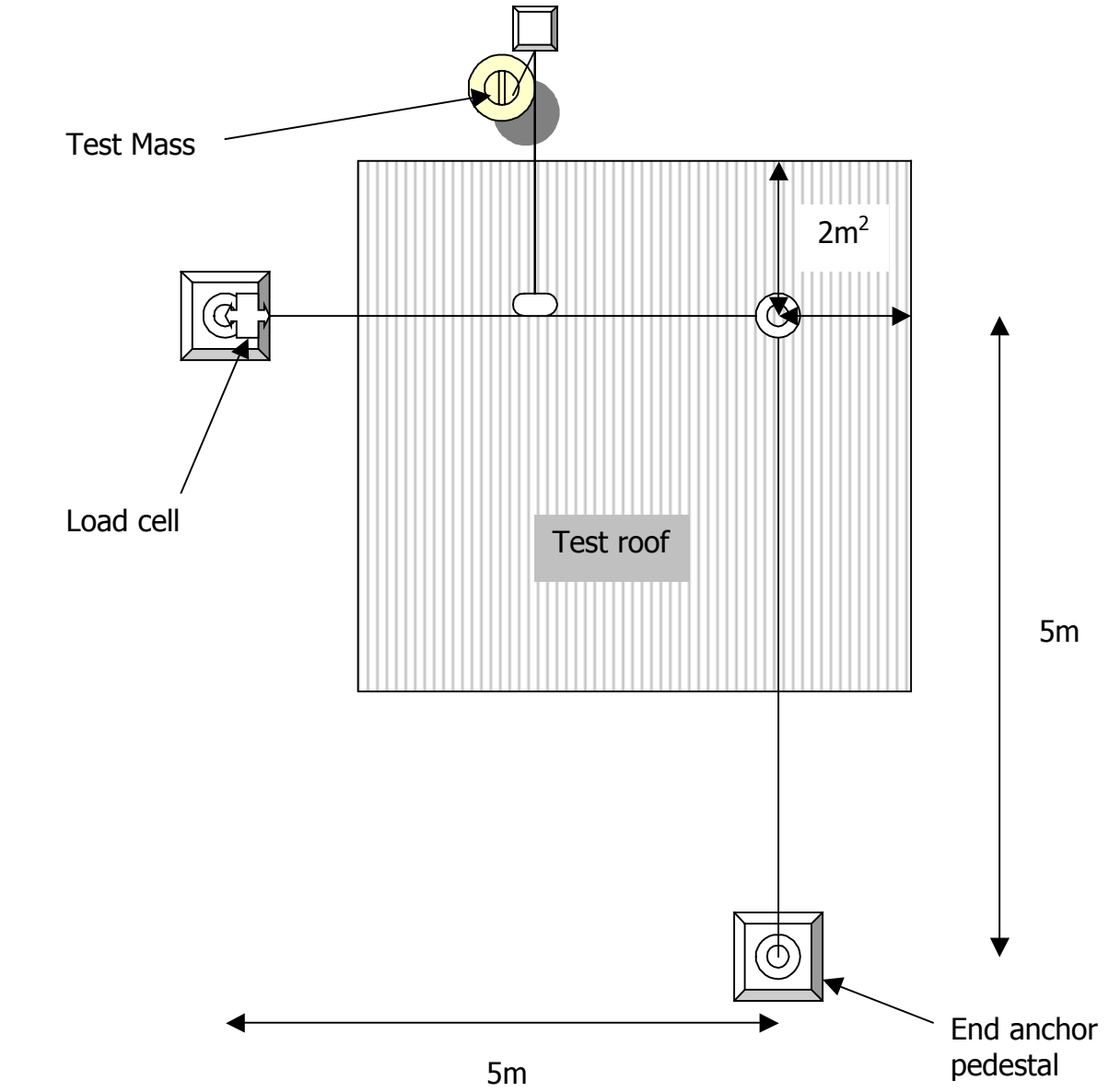


FIG4 – TYPICAL DYNAMIC TEST SET UP



Key

Cable horizontal lifeline

Roof Anchor

Mobile Attachment Device

FIG 5 – CORNER TEST METHOD

9 NOTES TO EXPLAIN THINKING BEHIND CORNER TEST - ALTERNATIVE METHOD.

9.1 When calculating the test mass and free fall distance for the individual anchor test methods, the worst case scenario was considered for calculation purposes, which was further examined through testing.

9.2 The basis for this when considering anchors employed in lifelines was a one, two or three user fall through a distance of 4 metres. In other words a fall factor 2 with a maximum length lanyard of 2 metres.

9.3 In arriving at the loads to base the corner anchor tests on, a multi-user fall in a 5m span provides a typical on site scenario and consistently delivers the worst system loading for one, two and three users.

9.4 This data was transferred into a calculation software program that simulates system loading

9.5 . This program has been validated by SATRA and Exam GmbH as being accurate against the requirements of EN795 and allows cable tension between corner anchors to be calculated for multi-user falls.

9.6 Taking a typical scenario of a system, as laid out in Figure 6, calculations were performed.

9.7 Calculations revealed that for two and three user falls, cable tension was typically 27.5kN and 34.2kN respectively between two corner anchors. When shock absorbers were introduced at extremity end anchors, they had little or no impact on the cable tension between two corner anchors. The further away from an end anchor a corner is, the less influence any shock absorbing element has on the forces acting at the corner. This could be and is frequently the case in roof safety system design.

9.8 The proposed Alternative Test Method aims to replicate this situation within 10% accuracy.

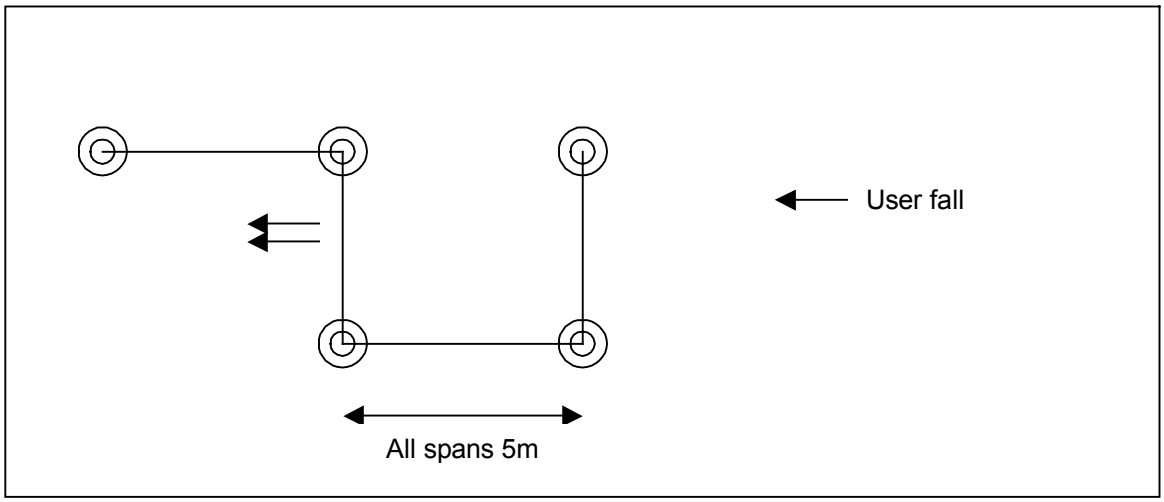


FIG 6 – TYPICAL FALL SENARIO

This document can be downloaded free of charge from the ACR website at http://www.roofworkadvice.info
Where the up to date list of members can also be found

British Constructional Steel Association [BCSA]
4 Whitehall Court
Westminster
London
SW1A 2ES
Tel: 020 7839 8566
www.steelconstruction.org
Contact: Mr P Walker

British Safety Industry Federation, Height Safety Group [BSIF,HSG]
93 Bowen Court
St. Asaph Business Park
St. Asaph
Clwyd
LL17 OJE
Tel: 01745 5856000
www.bsif.co.uk
Contact: Mr G Hook

Concrete Tile Manufacturers Association [CTMA]
60 Charles Street
Leicester
Leicestershire
Tel: 0116 253 6161
www.britishprecast.org
Contact: Mr C Nessfield

Engineered Panels in Construction [EPIC]
29 High Street
Ewell
Surrey
KT17 1SB
Tel: 020 8786 3619
www.epic.uk.com
Contact: Mr. P Trew

Fall Arrest Safety Equipment Training [FASET]
PO Box 138
Whitchurch
Shropshire
SY13 9AD
Tel: 01948 780652
Email:tony.seddon@faset.org.uk
Contact: Mr A . Seddon

Fibre Cement Manufacturers' Association [FCMA]
5A The Maltings,
Stowupland Road,
Stowmarket,
Suffolk,
IP14 5AG
Tel: 01449 676053
e-mail: fcma@ghyllhouse.co.uk
Contact: Mr A M Hutchinson

Flat Roofing Alliance [FRA]
Roofing House,
31Worship St
London,
EC2A 2DY
Tel: 020 7638 7663
e-mail info@fra.org.uk

Metal Cladding & Roofing ManufacturersAssociation [MCRMA]
18, Mere Farm Road,
Prenton,
Birkenhead,
Merseyside,
CH43 9TT
Tel: 0151 652 3846
Email: mcrma@compuserve.com
Contact: Mr C Dyer

National Association of Rooflight Manufacturers [NARM]
43 Clare Croft,
Middleton
Milton Keynes,
MK10 9HD
Tel: 01908 692325
e-mail: admin@narm.org.uk
Contact: Lorraine Cookham

National Federation of Roofing Contractors
Roofing House,
31Worship St
London,
EC2A 2DY
Tel: 020 7638 7663
e-mail: info@nfrc.co.uk
Contact: The Technical Officer

Rural Industrial Design and Building Association [RIDBA]
5A The Maltings,
Stowupland Road,
Stowmarket,
Suffolk,
IP14 5AG
Tel: 01449 676049
e-mail: secretary@ridba.org.uk
Contact: Mr A M Hutchinson

Single Ply Roofing Association [SPRA]
The Building Centre
26 Store Street
London
WC1E 7BT
0115 914 4445
www.spra.co.uk
Contact: Clive Johnson

Work at Height Safety Association [WAHSA]
3 Sherwood Road
Aston Fields Industrial Estate
Bromsgrove
Worcestershire
B60 3DU
Tel: 01527 577665
www.wahsa.org.uk
Contact: Mr M Griffiths

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