SPRA
Single Ply Roofing Association

TECHNICAL GUIDANCE

SITE PULL-OUT TEST PROTOCOL
FOR FLAT ROOFS

ENSURING THAT CLIENTS OBTAIN HIGH QUALITY POLYMER-BASED SINGLE PLY ROOFING, THROUGH A PARTNERSHIP OF QUALITY ASSURED MANUFACTURERS AND CONTRACTORS

S15/19

SPRA TECHNICAL GUIDE S15/19
SITE PULL-OUT TEST PROTOCOL FOR FLAT ROOFS

1.0 INTRODUCTION

European Assessment Document *(EAD) 030351-00-0402 Systems of Mechanically Fastened Flexible Roof Waterproofing Sheets* was introduced in February 2019, replacing *ETAG 006, Guideline For European Technical Approval of Systems of Mechanically Fastened Flexible Roof Waterproof Membranes,* which has subsequently been withdrawn. This SPRA protocol on site pull-out testing will replace the guidance offered by the former Appendix C of ETAG 006 which has not been reproduced within the new EAD 030351-00-0402 standard. This protocol should be read alongside the *SPRA Protocol for Wind Load Calculation (S11b-19),* for which site pull-out testing is an important task required in the determination of the fastener pull-out admissible design value (W_{adm}).

2.0 WHY ARE SITE PULL-OUT TESTS REQUIRED?

Site pull-out testing is required to confirm both the behaviour and ultimate pull-out load at failure of the fastener, when used within specific roof deck constructions. The resulting values attained by the pull-out testing can be used in conjunction with an appropriate safety factor to calculate the fastener pull-out admissible design value (W_{adm}) when used into a specific substrate on a given project.

Pull-out testing is required for all refurbishment projects and for concrete decks on new build projects. Testing must be undertaken prior to installation commencement.

Testing will confirm the following information:

- That a mechanically fastened system is practical
- That suitable fasteners are available
- That suitable performance can be achieved

3.0 EQUIPMENT

Figure 1 shows a typical site pull-out tool. A basic pull-out test unit will comprise of the following:

3.1 BASE PLATE

This supports the unit on the roof surface and should have a reasonable surface area. Typically, 140mm diameter.

3.2 PULLING PLATE/JAW

This fits under the head of the fastener. Due to the wide range of fastener types it often has interchangeable inserts for different shank diameters and head sizes.

3.3 TENSIONING DEVICE

Usually a threaded high tensile steel screw and handle.

3.4 MEASURING SCALE/GAUGE

Usually hydraulic and measures the force applied by the tensioning screw. The test unit shall be calibrated by an approved third-party test house at a maximum interval of 12 months. A calibration certificate including the machine serial number must be available for inspection prior to any testing being undertaken.

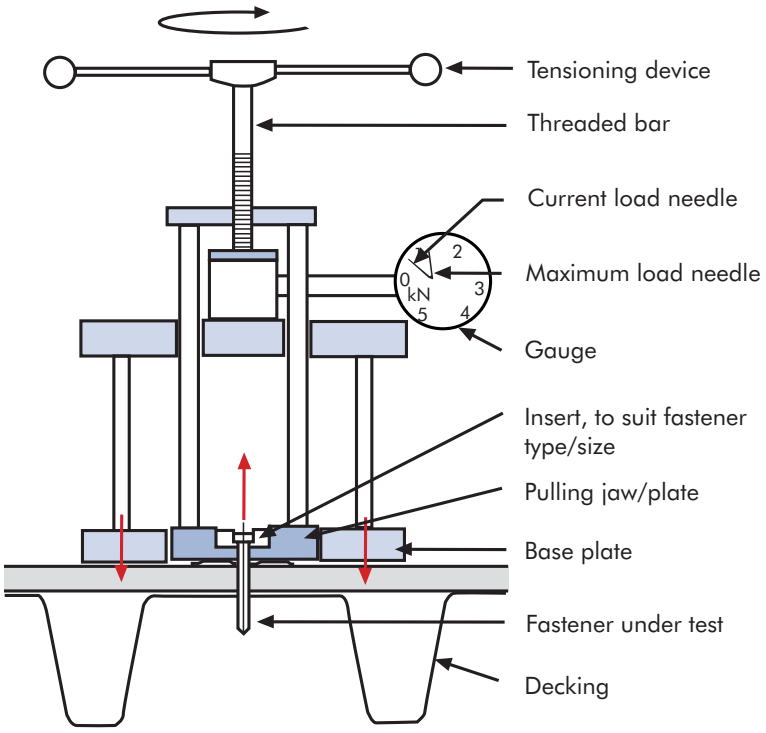

Figure 1. Typical site pull-out tool

4.0 METHOD

Pull-out testing requires a fixing with sufficient space beneath the head to insert the pulling plate. On a new build project or a refurbishment project involving new mechanical fixings, a partially driven fixing would be used. Any roofing material (e.g. membrane, existing insulation) that may influence the pull-out values shall be removed before the test is performed. The fastener shall be installed using the same method as will be used during actual construction (i.e. setting depth of the fastener, hole diameter, installation tools). Concrete fasteners should be embedded to a depth which will be repeated during installation.

A minimum of six samples per 1000 m^2 of roof area shall be tested. The tests shall be performed across the roof in various areas including corners and the perimeter, to provide a good cross section example of performance. The location of the tests should allow for 50% of these being in the corner and perimeter zones. Any area that is likely to have deck damage due to leaks shall also be tested. Where there are separate roofs, a minimum of six samples per 1000 m^2 of each separate roof area shall be tested. Should there be different roof deck substrates comprising the same roof area then a minimum of six samples per 1000 m^2 of each roof deck substrate must be tested. Should various fastener types be tested from one deck substrate, then a minimum of 6 tests for each fixing type per 1000 m^2 of roof area shall be undertaken.

The following data shall be recorded by the tester:

- Type of substrate from which the roof deck is comprised
- The pull-out test result in kN. (See section 5.0 PROCEDURE)
- The location on the roof area of each test using a sketch
- The type of fastener used
- The setting depth of the fastener tested
- The build-up above the deck of existing layers including the type and thickness of each
- For steel decks the crown width and mid crown to crown measurement
- For concrete decks the pilot hole diameter used (and setting depth of the fastener)
- Approximate area of each roof
- Condition of any existing decks

The tester should indicate in the report that fastener lengths tested may not be of the same length as that to be used in actual installation.

Should the results of the pull-out testing not be consistent then further testing is recommended including evaluation as to the reason for the variation of results.

The testing device will apply a downward force onto the roof so do not test with the base plate resting on soft, fragile or uneven surfaces.

After the testing is undertaken, all penetrations must be made good with a permanent waterproof repair.

5.0 PROCEDURE

- The correct insert or collar for the fixing to be tested is selected and fitted into the pulling plate
- If different indicator gauges are available, the most suitable is selected and the Maximum Load indicator is set to zero
- The testing unit is located over the fixing and the pulling plate insert is slid beneath to engage the head of the fixing
- The load is applied to the fastener by slowly turning the tensioning handle and the Current and Maximum Load needles are observed. The load is applied gradually, and the needle behaviour is noted until the Current Load needle starts to fall away
- The travelling Maximum Load indicator will remain at the highest position to identify the maximum pull-out figure.
- Alternatively, a digital meter can be used to provide a more accurate reading of the result
- The tension is gradually released, and the pulling plate is returned to its flush starting position and withdrawn from the fixing

6.0 CALCULATION OF THE CHARACTERISTIC ADMISSIBLE (DESIGN) LOAD PER FASTENER

6.1 TREATMENT OF RESULTS

The characteristic admissible (design) load is calculated from the following formula:

$F_{adm} = (Xm - K*s)/Ym$

Where

F_{adm} = Characteristic admissible (design) load per fastener
X_m = Mean value of all pull-out tests
K = Factor according to BS EN-1990 Table D1. See reproduced table below
s = Standard deviation
Y_m = Material safety factor. For the appropriate Ym values see section C.1
X_n = Individual test value
n = Number of samples

For the appropriate Y_m values see SPRA Wind Load Calculation Protocol (S11b-19), section C.1.

For calculation of the characteristic admissible (design) load (F_{adm}) derived from site pull-out tests the standard deviation value of the results is required in order to ensure that variation between individual test results is taken into consideration. The methodology given in *BS EN 1990:2002 +A1:2005, (*incorporating *corrigenda Document 2008 and April 2010: - Eurocode - Basis of structural design)* should be followed. See next page.

Standard deviation s

$$s = \sqrt{\frac{\Sigma (X_n - X_m)^2}{n-1}}$$

k values

n	5	6	8	10	20
K	2.33	2.18	2.00	1.92	1.76

For design purposes the lowest of either W_{adm} derived from full scale or small-scale testing according to this Guideline or F_{adm} from the on-site pull-out test is to be used. Remember that the minimum admissible design value (W_{adm}) for all pull-out, pull-over and pull-through values is the authoritative design value for the system. See SPRA Wind Load Calculation Protocol Section 5.2 for further guidance.

F_{adm} derived at building sites reflects only the pull-out performance for that specific fastener type into that specific substrate on a given project and does not take into account other failure modes such as washer deformation or membrane tearing. Therefore, a value higher than W_{adm} determined according to this guideline may never be used.

6.2 WORKED EXAMPLE

Assume steel deck, thickness 0.7mm

(T1 = pull-out test 1, T2 = pull-out test 2 etc.)

Test number	T1	T2	T3	T4	T5	T6
Test results (kN/m²)	1.24	1.22	1.23	1.20	1.25	1.21

n = 6
X_m = 1.23 kN/m2
K = 2.18
Y_m = 2.0
s = 0.02

F_{adm} = (Xm - K*s)/Ym
F_{adm} = 1.23 - (2.18 * 0.02) / 2.0
F_{adm} = 0.593kN or 593N per fastener.

7.0 TESTING OF SPECIFIC ROOF DECKS

7.1 CONCRETE DECKS

- The pull-out test will also determine optimum pilot hole and setting depth required
- Testing should only be undertaken following curing of the concrete
- Pull-out testing should be undertaken into the base concrete deck and not into screed layers, even if they are reinforced. Mechanical fasteners must not be installed into screed layers, but through to the base concrete deck

7.2 STEEL DECKS

Should the pull-out values be low, the tester should check the following criterion:

- Is the deck aluminium and not galvanised steel?
  - Use a magnet or scratch test
  - If aluminium follow the guidance in section 7.4 below
- Could the deck thickness be less than 0.6mm thick?
  - If so then does the fastener specification cover this?
- The condition of the deck if this is refurbishment
  - Check the deck from inside of the building if possible. Is the deck corroded?

7.3 TIMBER DECKS

Should the pull-out values be low, the tester should check the following criterion:

- Is the plywood / OSB3 deck of lesser thickness than 18mm?
  - If so this deck is not suitable for screw fixings
- Has the deck deteriorated and is it saturated with moisture?
  - Remedial action is thereby required

7.4 ALUMINIUM DECKS

- Ensure that the fastener tested is suitable this for substrate
  - The fastener European Technical Assessment (ETA) document will confirm suitability

8.0 HEALTH AND SAFETY REQUIREMENTS

The tester shall always undertake a risk assessment prior to any testing being undertaken. A method statement should also be provided to the client.

9.0 COMPETENCY OF THE TESTER

The tester should be adequately trained to undertake the task of pull-out testing and should be in possession of third party accreditation in this respect, which may be requested for inspection by the client prior to or following testing.

BUILDUK
Leading the Construction Industry

RIBA

member of cpa construction products association

SPRA
Single Ply Roofing Association

SINGLE PLY ROOFING ASSOCIATION
Roofing House, 31 Worship Street, London EC2A 2DY
t: 0845 1547188 • e: enquiries@spra.co.uk • www.spra.co.uk