

Anchor testing on site - to determine Allowable Loads

an article for the CFA website by

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Introduction

The testing of anchors on site can be a crucial link in the chain of ensuring they fulfil their role in any safety critical application.

Mark Salmon explains why tests may (or may not) be needed and outlines one approach to determining allowable loads from tests carried out on site.

Tests on site may be required for two distinct purposes:

Tests to determine suitability or Allowable Loads These are done before the specification of anchors is finalised to ensure anchors are suitable for the base material concerned and have an adequate Allowable Load* – usually when the strength or precise nature of the base material is unknown and no Recommended Load* data is available from the manufacturer, e.g. in brickwork, blockwork or stonework. These tests will be done on anchors NOT to be used on the job. Two approaches are possible **Preliminary Load tests*** or **Ultimate* Load tests** which are outlined under the heading “Allowable loads”.

Tests to check correct installation. Carried out on anchors which are used on the job and after they have been installed to ensure they have been installed correctly. These tests are called **Proof Tests**.

For each of these purposes the requirements are different in terms of sample size, magnitude of load, rig dimensions etc. Full details of test procedures are given in the CFA Guidance Note – [*Procedure for Site Testing Construction Fixings*](#). (Downloadable from the Guidance Notes section.)

Tests are not needed - if anchors are specified with a European Technical Approval and have been designed (selected) and installed in accordance with the requirements of the ETA.

Testing in tension and shear

Anchor performance in tension depends on the anchor being suitable for the base material, well designed and correctly installed. Testing in tension is therefore justified for both reasons outlined above. The shear performance of anchors in concrete is dependent primarily on the strength of the anchor rod and is little affected by installation quality. It is rarely justified in concrete but may be required when edge distances are closer than recommended by the manufacturer and if edge reinforcement is present. Discuss with the manufacturer. Shear tests may be justified for anchors to be used in masonry to determine allowable loads which will often be limited by displacement.

Test procedures and recording of results

Whatever their purpose it is vital that any tests are carried out to the correct procedures and that the results are presented in the correct manner such that the tests fulfil the objectives of the client. CFA Approved Testers will do tests to the CFA procedure and record results in accordance with CFA reporting recommendations.

For the definition of the terms used to describe loads see the appendix to this article.

Allowable loads – how they are determined from site tests.

Allowable Loads may be determined from site tests by two methods – both involve carrying out 5 tests (at least) prior to the start of the job proper on fixings which will not be used on the job itself.

A) Preliminary load tests.

This is a relatively simple approach designed to minimise the number of tests required to produce an Allowable Load that is safe while involving calculations that are not too complicated. It also avoids, as far as possible, the need to take tests to failure. This approach is not covered in the Guidance Note “Procedure for site test testing Construction Fixings” (it will be included in revision) so is described here.

B) Ultimate load tests.

This method involves taking all tests to failure, with the potential for damage to base materials, and requires a statistical analysis of the results. This approach is outlined in the Guidance Note “Procedure for site test testing Construction Fixings” so is not elaborated here.

A) Preliminary load tests - procedure.

In the following procedure various factors are referred to for determining Allowable Loads. They are summarised in the table below:

Application	Anchor material	Test factors*
		γ_{test}
General Purpose anchor testing (long term loading)	Nylon**	5
	All Other	3
Steeplejacks & Scaffolders Guidance Notes (short term loading)	Nylon**	3
	All other	2

* For definitions of factors see Appendix

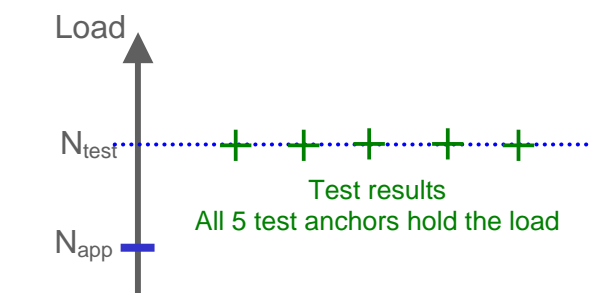
**Nylon anchors require higher factors due to the issue of creep.

Procedure Test 5 fixings to a load of $N_{test} = N_{app} \times \gamma_{test}$

Where N_{app} is the actual load intended to be applied.

Test anchors must be anchors which will not be used on the job and installed away from the position of anchors that will be used but set in the base material typical of the job.

If all 5 anchors hold the test load then the Applied Load may be used in this base material.



If any anchor fails to reach the test load then the situation must be reviewed with the client. If the number of fixings being used can be increased then the following approach may be applied using the same fixing type. This should only be contemplated if the failure is close to the required test load (e.g. $> 0.8 \times N_{test}$).

If the number of fixings cannot readily be increased then the fixing specification should be changed – options include increasing the diameter and/or embedment depth of the fixing or changing to a different type of fixing. In this case the Preliminary tests must be repeated with the new fixing.

Procedure following one failure before reaching N_{test} - if the number of anchors to be used on the job may be increased & failure is close to the required test load:

Load all five test anchors carefully to failure, if an anchor moves during loading the tests should be halted at approximately 1mm movement to avoid damaging the structure. The load at this point should be taken as the failure load for that test.

The new Allowable Load is then calculated* as the lowest of

Average failure load, $N_{u,ave} \div \gamma_{ave}$

or

Lowest load, $N_{u,low} \div \gamma_{low}$.

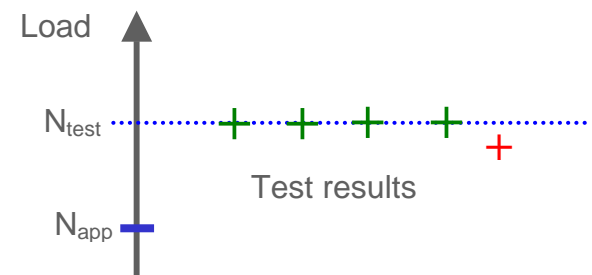
Where the factors γ_{ave} and γ_{low} are shown in the table:

Application	Anchor material	Factors to determine new allowable load*	
		γ_{ave}	γ_{low}
General Purpose anchor testing (long term loading)	Nylon	7	5
	All Other	4	3
Steeplejacks & Scaffolders Guidance Notes (short term loading)	Nylon	5	3
	All other	3	2

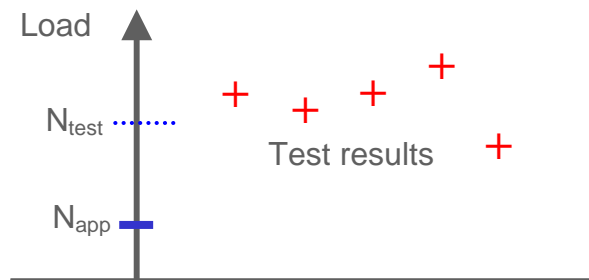
*Alternatively the statistical approach outlined in the Guidance Note may be used.

Illustration of tests taken to failure to determine Allowable Load.:

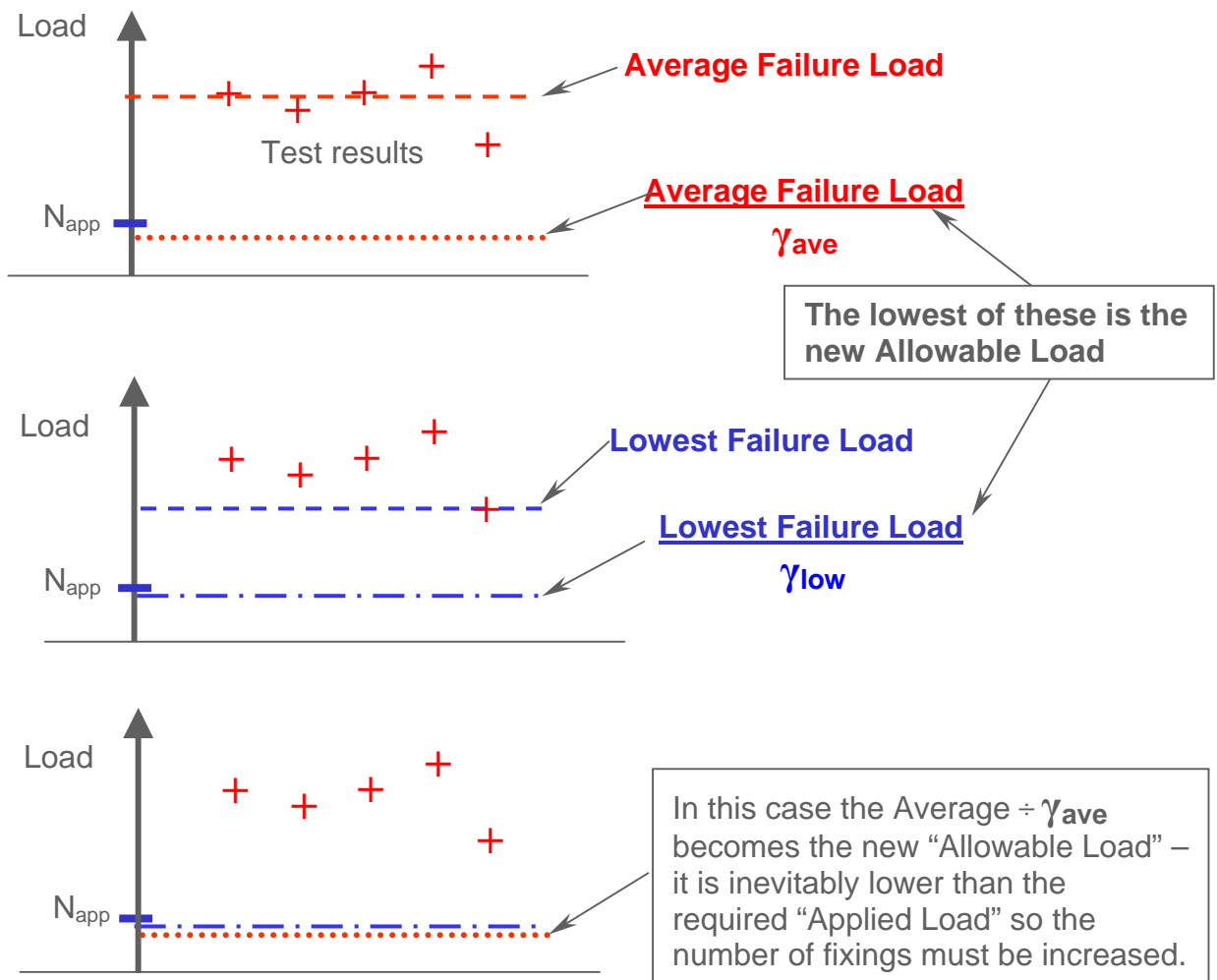
On initial test four anchors hold the required load satisfactorily but one fails at a slightly lower load:



The first four anchors are then carefully loaded to failure



Determining the Allowable Load from the test results:



If the number of fixings may be increased pro rata by, for instance, simply reducing spacings between anchors then the new number of fixings required on the job comes from:

Revised number of fixings required $N_2 = N_1 \times \frac{N_{app}}{N_{all}}$

Where N_1 = number of fixings originally required
and N_2 = number of fixings required with the Allowable Load

For more information:

Refer to CFA Guidance note "Procedure for site testing Construction Fixings".

Appendix Loads – Terminology and Notation

The terminology and notation listed here is that used in CFA procedures for testing fixings and in particular for determining Allowable Loads, it is not all common to other aspects of fixings usage.

Applied Load, N_{app} = The actual load intended, by the designer, to be applied to the fixing (Sometimes referred to as Design Load, in CFA Guidance Note for Scaffold Anchors as “Working Load”) – NOT to be confused with “Design Action”.

Safe Working Load = Load which may be applied to the fixing in the base material specified - not a term used by fixings manufacturers – see “Recommended Load”.

Recommended Load, N_{rec} = SWL as quoted by the manufacturer – usually for concrete only. (Not to be confused with “Design Resistance”)

Allowable Load, N_{all} = SWL of the fixing into the base material concerned as determined from site tests - usually only required when no manufacturer’s Recommended Load is available.

Test load, N_{test} = Load to be applied during Preliminary Tests

Proof Load, N_p = Load to be applied during Proof Tests, $N_p = N_{app} \times 1.5$

Ultimate load, N_u = maximum or failure load recorded during tests

In the above definitions “N” is used to refer to Tensile loads. For shear loads “V” is used.

Note: The following factors are those used in the CFA procedure “Preliminary Tests” used to determine Allowable Loads. They are not used anywhere else in fixings practice.

γ_{test} = factor used to determine the test load, N_{test}

$$N_{test} = N_{app} \times \gamma_{test}$$

γ_{ave} = factor used to determine Allowable Load from Average failure load, $N_{u,ave}$

$$N_{all} = N_{u,ave} \div \gamma_{ave}$$

γ_{low} = factor used to determine Allowable Load from Lowest failure load, $N_{u,low}$

$$N_{all} = N_{u,low} \div \gamma_{low}$$