TECHNICAL NOTE

AEFAC
Australian Engineered Fasteners and Anchors Council

AEFAC - TN05

SITE TESTING GUIDELINES

VOL 1: GENERAL

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Preface

This Technical Note is Volume 1 of a suite of AEFAC Technical Notes dedicated to providing best practice recommendations for site testing of post-installed fasteners. The recommendations are intended to assist design engineers formulate appropriate site testing procedures and to assist field testers conducting on site testing. It is assumed that the tester is suitably experienced and competent at testing fasteners.

The full series of the "Site Testing Guidelines" Technical Notes is as follows:

- Volume 1: General
- Volume 2: Proof tests
- Volume 3: Ultimate tests
- Volume 4: Testing in masonry

It is a requirement that Volume 1 be used in conjunction with the other volumes as necessary.

These guidelines have been based on recommendations made in BS 8539:2012 [1] and by the Construction Fixings Association [2].

Note: *Site testing only show the short-term performance of fasteners for the temperature and environmental conditions present during the tests. The performance and suitability of the product shall be reviewed and checked from the issued ETA for the exposure conditions such as temperature and environmental effects to the fastener during its lifetime.*

1. Scope

The test methods outlined in these Technical Notes relate to quasi-static loading procedures for product-specific evaluation performed on site. These Technical Notes apply for post-installed fasteners only. The advice provided in this document is of a general nature and is consistent with international guidelines ([1], [2]). This guidance document should not be considered a substitute for manufacturer's installation instructions or technical advice from the fastener manufacturer/supplier.

Incorrect or incomplete site testing practice may result in a failure to diagnose deficient installation or the correct performance of a fastener, leading to catastrophic outcomes.

These Technical Notes do not cover the tests in shear direction, as they are limited by material strength of base material and fastener, and less sensitive to installation. In addition, compressive actions are normally transferred from the fixture into the substrate with little or no effect on the fastener. Thus, the compressive actions are excluded in the Technical Notes. This document provides advice primarily on the tensile resistance of fasteners for applying Proof or Ultimate Loads in tensile direction

This document provides technical advice on site testing techniques to verify the performance of fasteners and does not address all safety-precautions needing to be followed during site testing of fasteners to concrete and masonry. Advice should be sought from the relevant safety authority such as WorkCover Authority and the site manager for advice on the use of Personal Protective Equipment (PPE) during testing.

Note: *As a minimum PPE for the tester should include a helmet, eye protection, gloves (if handling chemical fasteners), dust mask (if exposed to dust in a confined space), hearing protection, and equipment to restrain the test setup during testing (if necessary).*

2. Notation

f_y	=	Characteristic yield strength of steel (fastener)
FOS	=	Factor of Safety
A_s	=	Cross sectional area of steel (fastener) in tension
h_{ef}	=	effective embedment depth of fastener
$\kappa_{P,test}$	=	proof load test factor depending on the percentage of fasteners tested in a discrete area
k_s	=	statistical sampling factor
N_p	=	load applied to fixing for a proof load test
$N_{p,\,max}$	=	maximum allowable load applied to fixing for a proof load test without damaging fastening
N_{test}	=	maximum load applied to fixture during testing to determine allowable resistance based on the simplified method
N_{Rd}	=	design resistance of the fastening
N_{Rk}	=	characteristic resistance of a fastening
$N_{R,all}$	=	allowable resistance of the fastening
$N_{Rk,ETA}$	=	characteristic resistance of the fastening published in the approval document (ETA)
N_{Rk1}	=	characteristic ultimate load determined from tests on prequalified products

N_{Rk2}	=	characteristic ultimate load determined from simplified tests in the masonry
N_{Sk}	=	Characteristic action applied to fastener
N_u	=	ultimate strength of a fastening
$N_{u,ave}$	=	average ultimate strength of a sample of fastenings
$N_{u,low}$	=	lowest ultimate strength from a sample population of fastenings
N_{1mm}	=	load at 1 mm displacement for a single fastener
$N_{1mm,ave}$	=	average load at 1 mm displacement for a sample population of fasteners
S^*	=	design load
s	=	standard deviation of the ultimate strength of a sample population of fasteners
v	=	coefficient of variation of the ultimate loads determined from testing
β	=	product specific influencing factor provided in the approval document (ETA) based on performance measures determined from testing and evaluation in a given substrate
γ_F	=	partial safety factor for action, typically 1.4 for general case
γ_M	=	partial safety factor for material published in the approval document (ETA)
κ_{ave}	=	factor used to determine the allowable strength of a fixture based on average ultimate loads determined from testing
κ_{low}	=	factor used to determine the allowable strength of a fixture based on the lowest ultimate load determined from testing
κ_{test}	=	factor used to establish the test load for the simplified approach for determining the allowable resistance
φ	=	capacity reduction factor
φ_M	=	capacity reduction factor for material resistance, inversely related to the partial safety factor for material strength (γ_M) published in the approval document (ETA)

3. Terminology

The following terminology and definitions are adopted in this document. Additional terminology and definitions may be found in the AEFAC Fastener Dictionary [3].

Allowable resistance: maximum working load derived from tests performed on site when the proposed fastener is to be used in a base material approved by the manufacturer but for which there is no recommended resistance.

Characteristic resistance: resistance derived as the 5% fractile (95% of fasteners exceed the characteristic resistance with 90% confidence level) of mean ultimate resistance. This is determined from tests or empirical calculations based on modes of failure.

Confined test: a test performed on an installed fastener such that the positioning of reaction points of the test rig inhibits the formation of concrete-related modes of failure.

Design resistance: resistance derived from the characteristic resistance by the application of capacity reduction factor

Fastener: a type of device that is post-installed into hardened concrete or cast into concrete.

Fastening: an assembly comprising fastener(s) to secure a fixture to the concrete base material.

Fixture: the element that is being secured to the base material via fasteners.

Manufacturer's recommended load: maximum working load recommended by a manufacturer, typically the characteristic resistance divided by partial safety factor for material and action [$N_{Rk} / (\gamma_M \times \gamma_F)$]

Preliminary test: test carried out on site to determine the allowable resistance in the case where no characteristic resistance or recommended resistance is available.

Proof tests: a test performed on a completely installed fastener and is intended to validate correct installation.

Responsible engineer: the person responsible for overseeing the test regime for the fasteners and to ensure that the site testing of fasteners provides the information required for the project.

Safe Working Load: See "Working Load Limit"

Tester: the person with the responsibility to conduct the on-site fastener testing to an agreed regime and to report information collected during testing.

Unconfined test: a test performed on an installed fastener such that the positioning of reaction points of the test rig does not inhibit the formation of any modes of failure.

Ultimate load test: A test performed on a fastener whose installation is complete and is intended to aid in establishing the suitability of the fastener in a particular base material.

Working Load Limit (WLL): the maximum load that can be applied without the strength and stability requirements being exceeded. Also known as safe working load, allowable working load, maximum rated load, and permissible working load.

4. General

Site testing may be performed for one of two reasons:

(i) Validate correct installation (proof tests), or
(ii) Identify the characteristic strength of a fastener in a given substrate (ultimate tests).

The performance of fasteners in concrete is typically known, thus ultimate tests generally are not warranted in concrete substrates. However, given the complexity of masonry substrates, technical data is generally limited such that site testing is frequently employed to determine the ultimate strength of a fixing for use in masonry substrates.

Site testing for proof tests and ultimate tests requires that the fasteners being tested are installed in accordance with the manufacturer's installation instructions, as well as any supplementary requirements stipulated by the responsible engineer.

Note*: It is the responsibility of the tester to prepare a report of results from the tests undertaken. Interpretation of the test results from site testing is undertaken by the responsible engineer, including identifying causes of any failures, any modifications to the test regime and the modification to the specification of fasteners (if required).*

This Guidance Note provides advice primarily on the tensile resistance of fasteners since the shear strength is less sensitive to installation and is generally governed by material strength if sufficient edge distance is present. Shear strength may therefore be readily determined by calculating the shear capacity of the fastener component or substrate. However, when the required edge distance is less than the manufacturer's published edge distance, technical assistance from the manufacturer should be sought to determine an appropriate shear test program. Shear testing may also be required to determine the performance of a fastener in low strength masonry. Tensile testing is necessary since the tensile performance of fasteners is dependent on the suitability of the fastener in the substrate, proper design and correct installation.

Fastener products having a European Technical Approval/Assessment (ETA) publish their performance for a given substrate type, together with other parameters defining their performance [4, 10]. This information may then be used with design provisions such as those in AS 5216 [5] to calculate the expected strength. When a product does have an ETA, the design engineer may request site tests to be performed to verify that the product has been installed correctly.

Note*: If site shear tests are deemed necessary, technical advice should be sought from the supplier of the fastener product to develop a suitable test procedure.*

5. Type of test: proof test vs ultimate test

The engineer responsible for requesting the site tests determines the nature of the tests which may fall into one of two categories outlined below. Therefore, while the tester performs the test in a prescribed manner, the tester's role does not include identification of suitable test loads, interpretation of results or calculating allowable loads based on the outcomes of testing [7]. These responsibilities belong to the engineer specifying the test.

5.1. Proof tests

5.1.1. General

The objective of proof tests is to validate installation on a sample population of fasteners by loading the installed fasteners to a prescribed test load (proof load) that is a fraction of the fastener's capacity. The magnitude of the test load depends on the fastener application and material. Proof tests should be conducted on a sample of the fasteners installed for the project. A proof load does not result in the fixture experiencing failure and is not used to determine the allowable strength of the fastener in a given substrate.

Proof tests are generally short term in nature and are therefore not suitable for investigating creep behaviour. While the nature of the proof tests provides a modest safety margin, they are not appropriate for investigating the suitability of a fastener in a given substrate.

Proof tests may only be carried out after the manufacturer's recommended curing time for the chemical fasteners.

Note: *The requirement for proof tests to verify correct installation of safety-critical fasteners may not be required if the fastener has been prequalified according to the relevant EAD/ETAG, and the installer is under supervision and is appropriately trained either via the AEFAC Installer Certification Program and/or training provided by the product supplier. The requirement for proof testing is determined by the responsible engineer.*

5.1.2. Proof test sequence

The requirement of a proof test is to load each fastener to the proof load identified by the design engineer to demonstrate that the fastener has been installed correctly. Upon achieving the proof load, the test may be terminated. Further guidance may be found in Volume 2.

5.2. Ultimate tests

5.2.1. General

The objective of ultimate tests is to determine the allowable strength of the fastening. If ultimate tests are required, they should be performed prior to completion of the fastener selection process to ensure that all project requirements are met.

Scenarios where ultimate testing may be performed are as follows:

(i) Manufacturer has a provisional approval for the product to be used in the substrate but performance data is not available.

(ii) Fastener has an approval (e.g. ETA) for use in masonry but the type, strength or dimensions of the masonry are outside the scope of the ETA.

(iii) Fastener has an approval (e.g. ETA) but the application is outside the scope of the ETA, for example edge distance is outside the scope of the ETA.

The test procedure for applications involving products without an ETA is closely based on recommendations from BS 8539 [1] and the Construction Fixings Association's guidance note, "Procedure for Site Testing Construction Fixings" [2].

Ultimate tests are carried out on a sample population of sacrificial fastenings that are considered to be representative of the intended application. This requires a representative substrate, the same type of fasteners that will be used in the project and installation by the same work crew. It may be necessary following testing to make good any substrate damage incurred by the test population.

Ultimate tests are not required for fasteners in concrete provided the product is prequalified in accordance with Appendix A of AS 5216 and the application falls within the scope of the product's approval. In this case the design data is published in the prequalification. If the fastener is being installed in masonry that is the same category for which it has been awarded a prequalification, ultimate tests may still be required if either the strength of the masonry or the dimensions of the masonry are less than the minimum requirement of the prequalification. In the case of masonry, the category of substrate relates to the type or material and type of brick unit (e.g. solid, perforated, hollow).

If the intended application is beyond the scope of its prequalification (approval), ultimate tests may be performed to establish the allowable strength provided the fastener manufacturer approves the fastening for use in this specific application. Further guidance is available on the limitations of fasteners installed in concrete applications in [3] and for chemical fasteners installed in masonry in [6].

Note*: Fasteners for ultimate tests are considered sacrificial and should not be used in the project.*

5.2.2. *Ultimate test sequence*

There are two types of ultimate test that may be performed depending on the requirements of the project:

- *Simplified regime*: Each fastener in the sample population is loaded to a test load (N_{test}) determined by the designer prior to the test taking place. Once the desired load is achieved the load is removed to reduce the likelihood of damaging the substrate. The allowable strength of the fastener ($N_{R,all}$) is calculated by considering the maximum test load, average ultimate strength and the lowest ultimate strength recorded from tests on the sample population.
- *Statistical regime*: This regime is destructive and requires each specimen within the sample population to be tested to failure. The allowable strength of the fastener ($N_{R,all}$) is calculated using a statistical method based on the ultimate strength of the sample population.

Further details of these two regimes are provided in Volume 3.

6. Test Setup

6.1. Test equipment

Test equipment should be inspected prior to commencement of testing to ensure good working condition. Additional requirements for the test apparatus include:

- The Working Load Limit of all components of the test apparatus (support frame, tension rods, couplers, etc.) should not be less than the test loads. The Working Load Limit should include a suitable safety margin to ensure the equipment is not damaged during testing.
- The specified stroke of hydraulic test equipment should not be exceeded at any stage during the test.
- The accuracy of the load gauge should be +/- 5% of the load readings. The equipment should be calibrated at least annually, as well if the equipment is dropped or repaired. If a calibration requires a conversion from gauge readings to actual load, the conversion should be provided in the test report. The load gauge

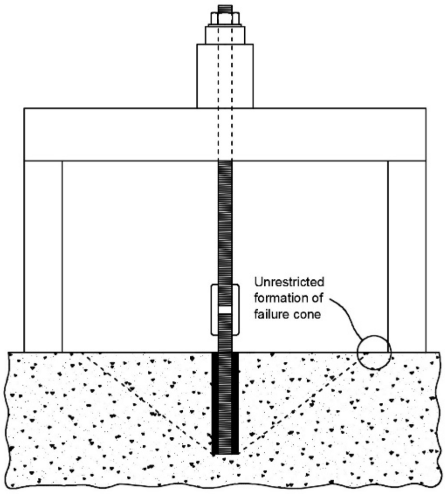
should be capable of indicating the maximum load achieved during the test that may be referred to upon completion of the test.
- Calibration should occur in a precision test machine such as one that has NATA certification.
- The accuracy of displacement measurement should be to within +/- 0.02 mm.

Note*: If it is necessary to install fasteners for the purpose of testing the manufacturer's installation instructions should be consulted for a list of equipment necessary for correct fastener installation.*

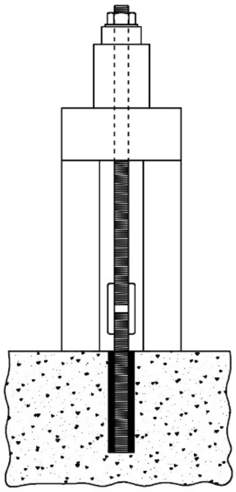
6.2. Configuration of test rig

There are a variety of different sized test setups available for applying loads to fixings, including those suitable for larger fixings (see Figure 2) and those suitable for smaller fixings (see Figure 3). The suitability of the test rig should be accounted for when considering the project requirements.

Selection of an appropriate test rig should consider the nature of the test (proof test vs. ultimate test) and the type of fastener (e.g. mechanical vs. chemical) since this affects the potential mode(s) of failure that may be observed. An ultimate test performed for mechanical or chemical fasteners or a proof test of mechanical fasteners generally requires an unconfined test setup (refer to Figure 1 (a)) to demonstrate the decisive mode of failure. A confined test setup (refer to Figure 1(b)) may be utilised for proof test of chemical fasteners to verify the correct bond has been achieved between the chemical and steel element or the chemical and substrate. However, it should be noted that a confined test may not detect gross errors related to incorrect embedment depth of fasteners installed. An unconfined test setup would be more appropriate for checking potential gross errors in embedment depth during installation.



(a) Unconfined test setup.



(b) Confined test setup.

Figure 1: Different types of test setup that may be required on site.

6.2.1. Position of legs of test rig

Regardless of the size of the rig, the legs should be adjustable to ensure that direct tension is applied to the fixing and that shear loads and bending moments are avoided. Proper adjustment of the legs will ensure correct alignment of the application of load and proper support of the legs of the test rig.

The proximity of the test apparatus's legs to the fastener is important and may influence the results when too close to the fastener by suppressing a mode of failure (such as concrete cone failure). The recommended *minimum* spacing between the test rig leg and the fixing for an unconfined test (refer to Figure 2 and Figure 3) depends on the type of test as summarised in Table 1.

Table 1: Minimum required distance between fastener and support legs of test rig.

Type of test	Magnitude of maximum load	Minimum distance between fastener and support legs of apparatus
Proof*	≤ 1.5 x manufacturer's recommended load and 0.7 × steel yield strength	$0.75h_{ef}$
Ultimate	Determined from test	$2.0h_{ef}$

** Note that for proof tests on chemical fasteners to assess the performance of the interface between the fastener and concrete, the support legs may be very close to the fastener to simulate a confined test.*

The effective depth (h_{ef}) refers to the greatest depth to which load is resisted by the fixing (fastener engages with the concrete), not the total depth of the fixing or depth of hole.

If the minimum spacing between the fastener and test rig support leg outlined in Table 1 cannot be achieved due to restricted access, the engineer requesting the tests should be notified in the test report.

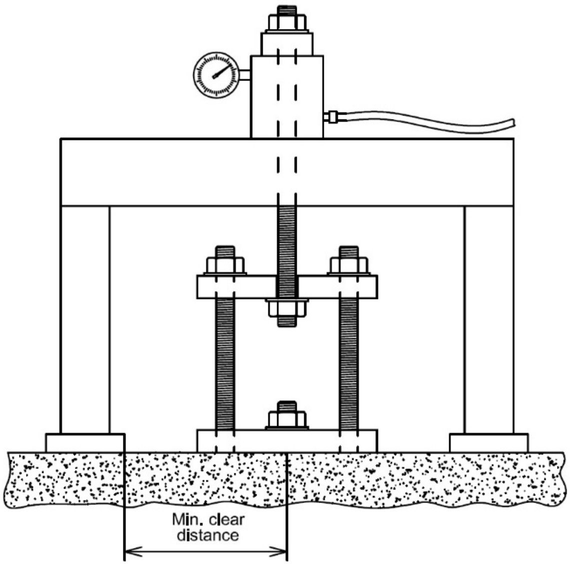


Figure 2: Hydraulic ram setup for large fixings with high load.

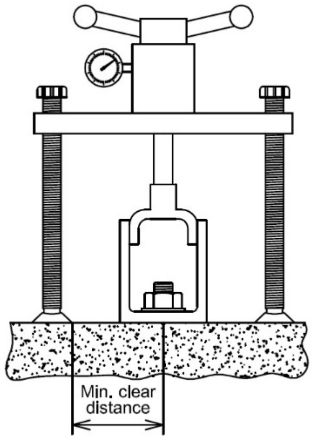


Figure 3: Hand operated test rig for small fixings with lower test loads.

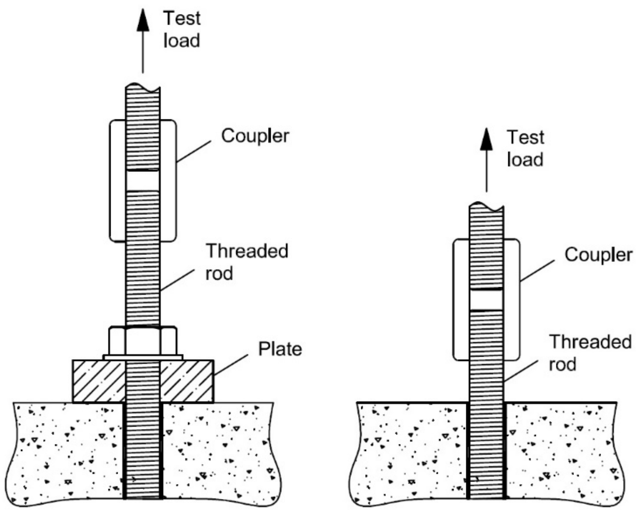
6.2.2. Stability of test rig

The stability of the test rig should not be compromised at any time during the test or as a result of a failure of the fixture being tested. In the case of overhead tests (such as on the soffit of a concrete slab) the test rig should be secured so as the test rig and its parts/components will not fall in the event of failure of the fixing.

6.2.3. Connection of fastener to test equipment

The fastener should be installed in accordance with the manufacturer's installation instructions. In the event that the fastener is to be torqued during installation, the fastener should be installed through an appropriately sized bush and plate assembly with an appropriate hole clearance and thickness as per the engineer's specification. A torque may only be applied to chemical fasteners once manufacturer's recommended curing time is complete.

The choice of connection between the fixing and the test rig will depend on the objective of the test. A simple threaded coupler may be used where a projected thread is available, with or without a plate clamped with a nut to simulate clamping (refer to Figure 5(a) and Figure 5(b), respectively). All necessary precautions should be taken to ensure the test rig is aligned with the orientation of the fastener so as not to induce bending during testing that may lead to invalid results.



(a) Torque required to clamp plate.

(b) Torque not required for fixture installation.

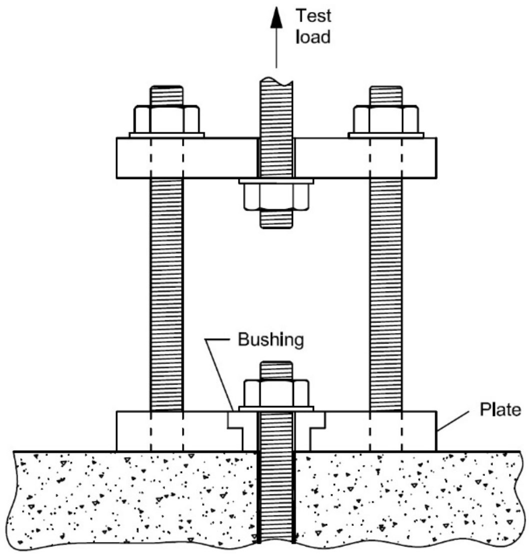


Figure 4: Pulling frame for clamping effect.

Figure 5: Couplers attached to pulling rod.

For ultimate load testing the coupler should cover a length of thread equal to at least 1.5 times the diameter of the rod being tested. The choice between the two methods (with or without a clamped plate) will depend on whether a torque is applied to the fixture during installation. Displacement-controlled fasteners, some undercut fasteners and most bonded fasteners do not require an installation torque to operate correctly. Conversely, installation torque for torque-controlled expansion fasteners is imperative for their correct operation.

Figure 5 depicts an alternate setup that may be adopted when the clamping effect is to be monitored during the test. In this setup the plate simulates the fixture and accurate displacement measurements may be made on the top of the fastener. Spherical washers may be used to eliminate negative effects of bending.

6.2.4. Displacement measurement

Characteristics important for displacement measurement including the following:

i) The accuracy of the displacement measurement should not exceed 10% of the actual reading.

ii) The precision of measurement should be no greater than 5% of the maximum displacement for the test.

Recording of deformation is at the discretion of the engineer requesting the test and will generally depend on the type of test (proof or ultimate). The three typical deformation measurement profiles adopted during site testing are as follows:

i) None: measurement of deformation is typically not warranted for proof tests where very little (if any) visible deformation occurs. A fastener exhibiting visible movement up to the proof load will often be deemed a failure. For applications where serviceability function is critical for the fastener, displacement measurements should be taken.

ii) First visual: if *visible deformation* is observed, a suitable method of measurement such as a dial gauge should be adopted to quantify the relative deformation between the fastener head and the surface of the substrate.

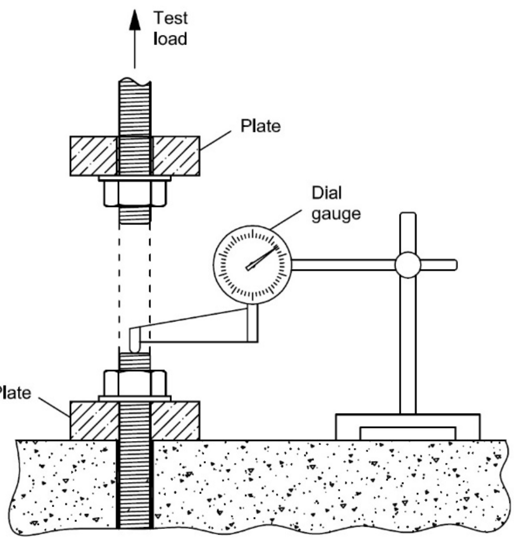
iii) Detailed: where the intent of the site test is to reproduce the load-deflection characteristics of the fastener's performance, it is recommended that displacement measurements occur at load intervals equal to one-tenth of the ultimate load expected or at shorter intervals.

Care should be taken when measuring deformation, particularly regarding the chosen reference point. Deformation measurements on test apparatus are typically global in nature and include stretching or deformation of various components of the test rig that are difficult to compensate for. Consequently, it is strongly recommended that the point of reference is beyond the zone where a concrete cone may form and that is independent to any part of the test device. Further, measurement should not be made from any point on the test rig since this will experience deformation during testing.

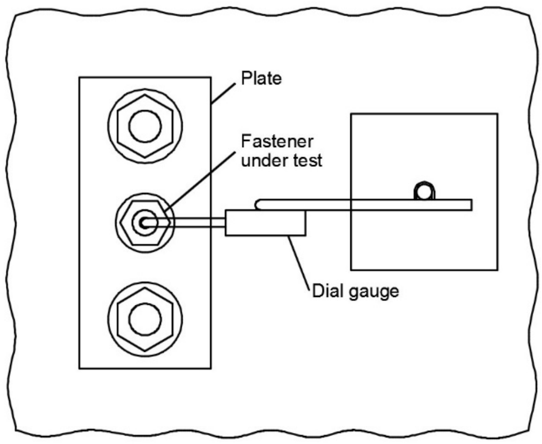
Where 'first movement' requires detection, a simple visual assessment may be made of a gap opening in the fixture. If the serviceability limit is to be assessed at the manufacturer's recommended load, feeler gauges may be used to assess the gap in the fixture, taking care to ensure the gap measured is representative of fastener displacement. For safety-critical applications, in either Proof or Ultimate Load Tests, movement should be monitored to ensure that a serviceability limit is not exceeded before the Design Load is reached.

In the event that detailed recordings are required a dial gauge or a more sophisticated electronic data acquisition system should be adopted. When detailed recordings and a pulling plate assembly are required, direct measurements of the head of the fastener may be made (refer to Figure 6). Direct measurement provides the most accurate recording of displacement; however, the measuring equipment may be damaged if the fastener fails. To avoid the possibility of damaging the measuring equipment, an eccentric attachment may be introduced to facilitate measurement of the head of the fastener as illustrated in Figure 6. If an eccentric displacement measurement is performed (e.g. on one side of the plate), errors are possible since the fastener may experience rotation during loading, resulting in an apparent increase or decrease in the displacement measurement. Care should be taken as this error may go unnoticed during testing since the tester may not be able to detect bending visually.

The application of a torque during installation of a fastener results in a preload that will delay displacement until the preload has been overcome by the applied load. The permissible deformation of the fastening may be governed by serviceability limits specific to the project that will determine when the test should terminate. The serviceability limit for deformation should not be reached before achieving the design load. The expected displacement will also depend on the type of fastener, with an example being displacement-controlled expansion fasteners which are likely to experience relatively less displacement prior to failure compared to torque-controlled expansion fasteners which have a follow-up expansion capability.



(a) Elevation.



(b) Plan view.

Figure 6: Example test rig set for detailed displacement measurement (section view).

In the event that detailed deformation measurements are required, the following procedure should be adopted for the application of load:

1. Recordings of displacement are made at predetermined intervals, such as 1/10th ultimate load or proof load, depending on the type of test being conducted. Sufficient resolution should be available in the results to identify the load-displacement curve of the fastener. It is recommended that the loading regime include measurements when the displacement equals 0.1mm, as well

as when the design load or manufacturer's recommended applied load is achieved. If the fastener is not tightened during installation, the load reading at 0.1 mm displacement may not be relevant.

2. It is recommended that a very small 'bedding-in' load (< 100 N or no greater than 5% of the estimated strength of the fastening) be applied at the beginning of the test to help correct for any offset present in the displacement measuring equipment and a recording made of the load and displacement.
3. Upon reaching the end of a load interval, record the load and displacement readings.
4. Resume loading until the proof load or ultimate load is achieved.
5. Record the maximum load achieved, failure mode observed and any damage sustained by the structure.
6. Deduct the displacement recorded from the 'bedding-in' load from all displacement measurements and plot the resultant load-displacement relationship.

6.3. Summary of test equipment

The test equipment typically required will include:

- Loading frame
- Hydraulic cylinder
- Load gauge
- Displacement transducer with suitable mount (if required)
- Coupler or suitable connection to fastener
- Pulling rod
- Spherical washer (optional)

7. Test regime

7.1. Application of load

In all cases the load should be applied progressively, without abrupt changes or a sharp stepped behaviour if the application of load is via a hand operated pump. Sudden changes in load may lead to erroneous results and premature failure due to a sudden spike in load.

The nature of loading will be influenced by the chosen displacement measurement profile. Load relaxation may occur due to many factors such as pressure release in test equipment, slip between fastener components, slip between the fastener and wall of the hole, formation of micro-cracks within the substrate, elastic deformation within the fastener system, as well as other factors. Consequently, corresponding load and displacement measurements should be recorded as close together as possible to avoid the effects of load relaxation on the results.

The increase in load should occur at a rate such that the peak load is experienced between one to three minutes from the commencement of the test.

It is highly recommended that the test be witnessed by a representative from the client or engineer requesting the tests.

Note: *Testing fasteners may be dangerous, particularly when testing to ultimate load or failure. When pulling rods in tension no person should stand in line with the rod. Before commencing the tests, all necessary precautions such as the wearing of personal protective equipment should be taken to mitigate the risk of injury to the tester, witnesses and any bystanders present during testing.*

The number of required tests should be assessed on a case-by-case basis by the engineer requesting the tests. The minimum number of tests is recommended in the respective Volumes 2 to 4 of this series.

8. Additional requirements for tests

8.1. General

If the fastener manufacturer does not approve their use in the general category of the substrate, site testing should not be considered a suitable method of demonstrating satisfactory performance. Some fasteners are not compatible with certain types of substrate (e.g. expansion fasteners in hollow masonry). Manufacturer's literature should always be consulted to determine suitability of a product.

Where the properties of the substrate are known or may be readily identified, design data is available for the substrate properties, and installation is performed by a competent individual under appropriate supervision, site testing is generally not required.

There may be certain special applications whereby industry-specific requirements may be published for which the fastener manufacturer should be able to provide guidance.

9. Report of results

A list of the information to be included in the test report is provided in Appendix A.

10. Summary

This Technical Note provides general recommendations for the site testing of safety-critical fasteners for the purpose of proof testing and to evaluate ultimate strength. Recommendations have been provided for proper test setup, including test rig positioning, connection to the fastener, displacement measurement and application of load. Provided the substrate properties are known, the fastener has a suitable prequalification such as an ETA for the substrate, and the fastener is installed as per manufacturer's installation instructions by a suitably qualified installer, site testing is generally not required. However, the responsible engineer may elect to specify site testing for added confidence in the installation. While proof tests are performed to verify correct installation, the purpose of ultimate tests is to determine ultimate strength of the fastening. Appendix B provides a summary of test regimes.

The advice provided is not exhaustive and should be used together with advice provided in the other volumes of this series as appropriate to the type of testing being conducted.

11. References

[1] British Standard 8539, "Code of practice for the selection and installation of post-installed anchors in concrete and masonry", BSI Standards Limited 2012

[2] Construction Fixings Association, "Procedure for Site Testing Construction Fixings", Guidance Note, www.fixingscfa.co.uk

[3] AEFAC Technical Note 07, "AEFAC Fastener Dictionary", www.aefac.org.au

[4] EAD 330232, "Mechanical fasteners for use in concrete", EOTA, 2016

[5] AS 5216:2018, "Design of post-installed and cast-in fastenings in concrete", Standards Australia

[6] EOTA TR053" Recommendations for job-site tests of metal injection anchors for use in masonry", www.eota.eu, 2016

[7] Construction Fixings Association, "How to test anchors on site in accordance with BS 8539:2012", Guidance Note, www.fixingscfa.co.uk

[8] AEFAC Technical Note 01, "Design Concepts for Post-Installed and Cast-In Fasteners", www.aefac.org.au

[9] AEFAC Technical Note 02, "Prequalification of Post-Installed and Cast-In Fasteners", www.aefac.org.au

[10] EAD 330499, "Bonded fasteners for use in concrete", EOTA, 2017

APPENDIX A
TEST REPORT

The following provides a list of minimum information that should be recorded and reported to the design engineer/specifier. Additional information may be warranted subject to site-specific considerations.

The purpose of the test report is to identify if all objectives of the test(s) have been met, as well as any deviations.

A.1 Administration details

- Date of test
- Reason for test
- Name of person requesting test
- Report reference number
- Client's company name, address, contact name and position
- Site location, contact name and position
- Name and company of tester with job title and/or appropriate qualifications
- Name and companies of witnesses
- Name and company of installer of fasteners

A.2 Anchor/application details

- Name of manufacturer
- Anchor type, size and finish
- Proposed application of fastener
- Design resistance and manufacturer's recommended resistance in the base material concerned (for proof tests)

A.3 Test objectives

- Proof tests or ultimate tests
- Required load for proof tests (if applicable)

A.4 Test location

- Detail of the location of each test within the structure with sketch where appropriate
- Edge distance, centre spacing and structural thickness, if appropriate

A.5 Base material

- Type and strength at time of test, if known
- Whether solid, hollow or perforated units (masonry)

A.6 Installation details

If the installation is carried out by the tester, the following information should be reported:

- Nominal hole diameter
- Drill bit cutting diameter, recorded to 0.1 mm
- Drilling method/tools
- Hole depth
- Effective embedment depth
- Hole cleaning method in detail
- Prescribed installation torque and tightening torque applied
- For bonded fasteners (if applicable):
  - Ambient temperature when installed
  - Manufacturer's recommended curing time
  - Actual curing time allowed

A.7 Test equipment details

- Make, type and load capacity of hydraulic ram/gauge or tester
- Date of last calibration, calibrating authority
- Make and type of movement recorder, dial gauge, etc.
- Loading frame: distance between fastener and closest support
- Make and range of torque wrench

A.8 Test results

The information reported is dependent on the nature of the test undertaken.

A.8.1 Load

- Maximum load
- Condition of fastener and surrounding base material before and after test
- Load at first visible movement

A.8.2 Movement

If required, the load should be reported at different load increments specified by the engineer requesting the tests, as well as the maximum load.

A.8.3 Mode of failure

Single or multiple modes of failure observed including the following possible modes:

- Base material: cone failure, spalling, splitting, cracking, blow-out failure, bond failure (chemical fasteners), combined cone-bond failure (chemical fasteners)
- Steel failure: fracture
- Pull-out/excessive movement

A.8.4 Method statement

A.8.5 Gauge calibration certificate

A.8.6 Test summary

- Statement of whether the test procedure was followed including a summary of any deviations
- Statement regarding whether or not the test objectives where met

APPENDIX B:

SUMMARY OF TEST REGIMES

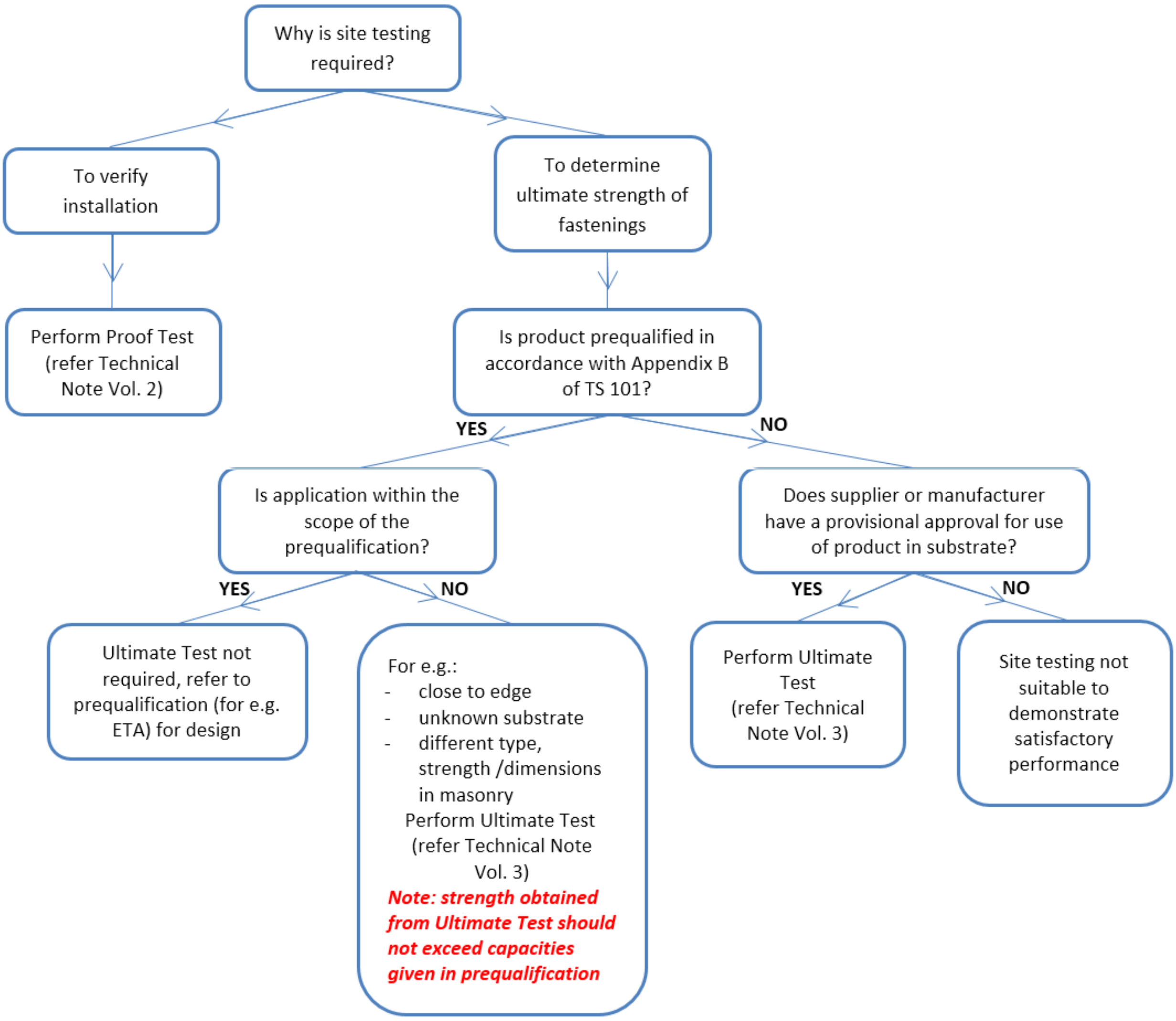


Figure B1: Flowchart of test regimes

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