CONSTRUCTION FIXINGS association

CI/Sfb
Xt6
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CFA Guidance note:
Procedure for Site Testing Construction Fixings

1 INTRODUCTION
This procedure is not intended to be used in place of BS 5080 Pt 1 [1] but is intended to provide additional guidance for the testing of fixings away from laboratory conditions such that the users of the results can be confident that the fixing's performance has been properly assessed. Its general adoption by all manufacturers, suppliers and testers will ensure a uniformity of approach.

Members of the Construction Fixings Association may carry out tests free of charge when they are intended to prove the suitablity of a fixing for an intended purpose and where there is no existing data on which the suitability could be reasonably assessed. When the purpose of the test is to validate the quality of installation of fixings members may make a charge.

2 SCOPE
This procedure covers the requirements for applying Proof or Ultimate Loads in the tensile direction. Tests in the shear direction are rarely needed as shear performance is generally limited by the material strength of either the structure or the anchor. Refer to the fixing manufacturer for advice on assessing the suitability of fixings in shear.

This procedure covers both Proof and Ultimate Load Tests and may be applied to virtually any type of fixing in any type of base material.

3 PURPOSE
The purpose of site tests may be either:

a) To establish the suitability of a fixing and/or admissible loads in a particular base material.

To establish the *suitability* of a fixing in a particular base material then ULTIMATE LOAD tests should be carried out and the results compared with the required Design Load, and the Manufacturer's Recommended (Safe Working) Tensile Load.

To determine admissible loads then ULTIMATE LOAD tests should be carried out and Admissible Loads determined according to the Manufacturer's technical policy. See Section 11 Calculation of Admissible Loads.

or b) To validate installation

To validate the adequacy of the installation of fixings then PROOF LOAD tests should be carried out.

The level of Proof Load required should be decided by the engineer responsible for the fixing specification. The CFA recommends Proof Loads of between 1.25 and 1.5 times the Design Load. Proof Loads should not exceed twice the Manufacturer's Recommended Load or permanent damage may effect the fixing or the structure.

"Manufacturer's Recommended Load" means the Load Recommended by the Manufacturer for that type and size of fixing in the base material concerned at the same strength, if known, and taking account of any spacing and / or edge distance reduction factors. "Design Load" means the Load to be applied in the application, it should not exceed the Manufacturer's Recommended Load.

4 POSITION OF FIXINGS
The position of fixings for Ultimate Tests should be chosen carefully. The base material and any edge distances should be representative of the application concerned but tests should be positioned where damage to the structure will not be detrimental to its strength and can be made good. The position of fixings for Proof Loads will already be set. In both cases the dimensional requirements of the test apparatus must be taken into account.

If fixings are positioned closer to an edge or to each

other than is recommended by the manufacturer or called for in the design this should be noted in the test report.

Fixings into masonry should ideally be positioned away from mortar joints. If close to joints this should be recorded.

5 MOVEMENT

Fixings which are tightened down through the fixture against the base material will generally show no significant movement until loaded well beyond the Manufacturer's Recommended Load (See notes on Arrangement of Test Apparatus below). During Proof Load Tests no movement should be experienced therefore it is generally adequate that a visual check is made of movement and more accurate measurements recorded only if significant movement occurs. A movement of .1 mm is generally regarded as a suitable serviceability limit, this may be checked using a feeler gauge. The junction between the pulling plate and the base material is a convenient reference point for the visual check of movement or checks made using a feeler gauge.

In Ultimate Load Tests some movement may occur only after the clamping force induced by tightening has been overcome and before failure. As this movement is expected it may not be vital that it be recorded. Some authorities consider excessive tensile movement, in the order of 5mm, to constitute failure, it may be reasonable to halt tests at this point. (When fixings are not tightened down for the purpose of the test, e.g. resin anchors or internally threaded hammer set anchors, then significant movement may be experienced from the initial load application depending on the type of fixing.) The engineer responsible for the application should decide whether or not movement is to be recorded. The recording of movement inevitably slows testing considerably and may increase the cost of the test programme.

For Safety Critical applications, in either Proof or Ultimate Load Tests, movement should be monitored to ensure that a serviceability limit (e.g. .1mm) is not exceeded defore the Design Load is reached.

6 ARRANGEMENT OF TEST APPARATUS

Figure 1 shows two suitable arrangements. 1a is a Loading Frame with Hydraulic Ram for large fixings/ high loads. The loading frame may be a beam or tripod arrangement.

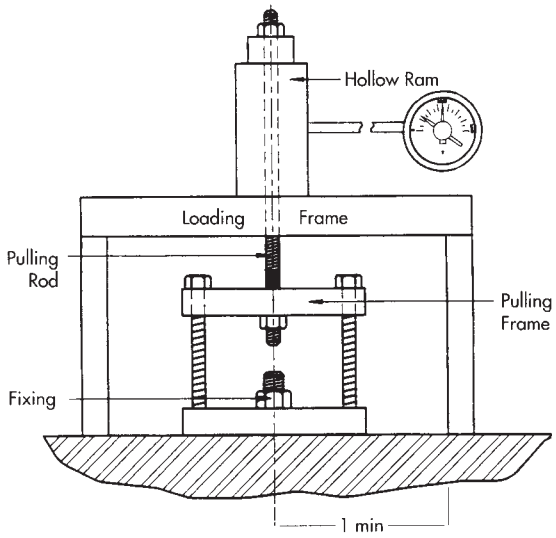

Fig. 1a

1b shows a test meter mounted on a bridge for small fixings/lower loads. Other adaptations are available for special situations e.g. wall ties and eye bolts

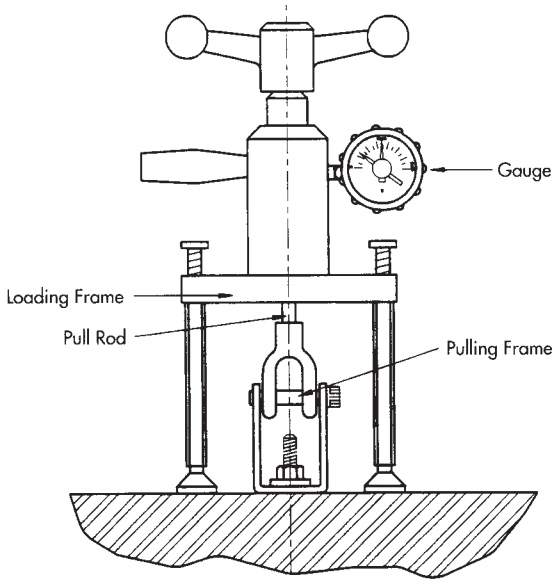

Fig. 1b

Adjustment of the feet or legs is helpful in ensuring loads are applied axially to the fixing.

The minimum spacing of the nearest support from the fixing centre, '1' depends on the purpose of the test:

PROOF LOADS up to 1.5 x Manufacturer's Recommended Load : 1 = $.75h_{ef}$
PROOF LOADS up to 2 x Manufacturer's Recommended Load : 1 = h_{ef}

ULTIMATE LOADS 1 = $2h_{ef}$
Where h_{ef} is the effective embedment depth of the fixing, (See Figure 2) i.e. the deepest point where the load is transferred into the base material, not the deepest point reached by the fixing nor the depth of the hole.

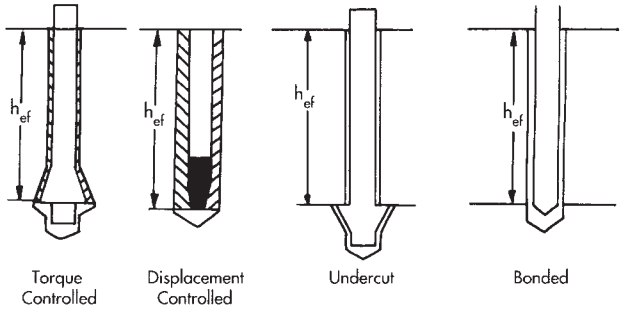

Fig. 2

Structural constraints on site may mean that requirements for '1' cannot be met, especially with large fixings, if so this must be noted on the test report.

Figures 3 and 4 show suitable means for applying the load to the fixing. Figure 3 is a pulling frame, it could be a cup, whose base replaces the fixture which is thus clamped down by tightening the fixing. This arrangement is necessary if the clamping force induced by tightening is to be monitored or recorded.

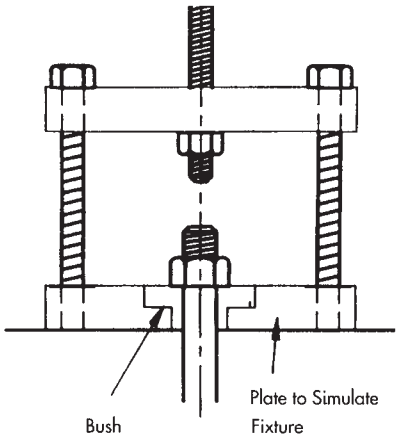

Fig. 3

Figure 4 shows two ways in which threaded couplers may be used for testing fixings with projecting threaded studs. Figure 4a shows the only way a fixing may be proof tested with the fastened component in place. 4b shows an anchor without a fixture in place and without a nut to generate a clamping force. This method is suitable only for fixings which do not require a torque to be applied for their correct installation, e.g. bonded anchors, displacement controlled anchors and some undercut anchors.

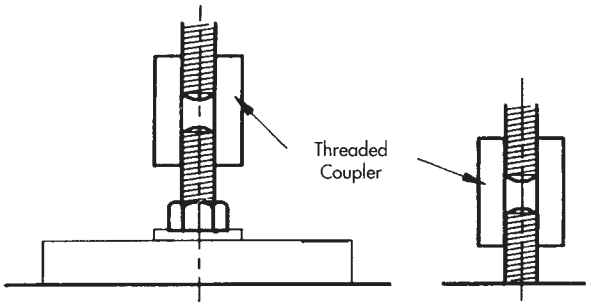

Fig. 4a Fig. 4b

In both cases the thread engagement between fixing and coupler should be adequate to take the applied load and for Ultimate Load Testing should be at least 1.5 x d, where d = nominal diameter of the thread under test.

7 EQUIPMENT

All equipment, especially pulling rods and nuts, should be strong enough to sustain the loads involved safely.

Any hydraulic ram or meter used to apply the test load should have a stroke exceeding the expected movement of the fixing under test.

The load measuring gauge should be accurate to within 5% of the readings. This equipment should be recalibrated at least annually, by a laboratory with load measuring equipment whose calibration is traceable to national standards such as a NAMAS accredited calibration laboratory. Calibration should always be carried out immediately if gauges are dropped or repaired following damage sustained on site. If load measuring gauges are not calibrated directly in units of load or if the calibration shows a significant difference between actual load and gauge readings then corrected readings should be recorded in the final test report.

Movement should be measured to at least .02mm.

A full list of the equipment necessary is shown in Appendix 1, Equipment check list.

8 INSTALLING FIXINGS & TEST APPARATUS

SAFETY. All installation and testing operations must be carried out with due regard for the safety of the installer and others.

Fixings should be installed strictly in accordance with the manufacturer's Installation Instructions or Method Statement.

When using a pulling frame, or cup, the fixing should be installed through an appropriately sized bush and tightened to the manufacturer's recommended tightening torque. When testing in a weak base material a reduced tightening torque may be necessary to prevent over stressing of the anchorage before testing. Refer to the manufacturer for advice. In the case of Bonded Anchors, Proof Tests may only be carried out after at least the recommended curing time has elapsed. In the case of Ultimate Load Tests additional curing time should be allowed; in the absence of other guidance, 3 times the recommended curing time should enable over 90% of full strength to be developed.

Arrange the test apparatus over the fixing so that the support spacing distance requirements of Section 6 above are met, if they cannot be met this should be recorded. On vertical surfaces or under soffits all apparatus must be fixed so as to be secure, taking account of failure of the fixing under test. Attach the fixing or pulling frame to the loading apparatus ensuring that the load will be applied axially to the fixing.

MONITORING MOVEMENT

a) Where full load/movement characteristics are to be monitored:-

Mount the dial gauge on the base material at a point remote from the fixing under test, this point should be as far from the fixing as is required for the load frame supports, 1. See figure 5. The dial gauge probe may locate on the bolt head or on a suitable area provided this accurately shows the movement of the fixing. In the case of tests to Ultimate Load a sudden release of the load may damage the dial gauge. This may be avoided by arranging for the movement 'arm' to move away from the gauge as in figure 6. In most cases sudden load release only occurs when the failure is caused by failure of the bolt material.

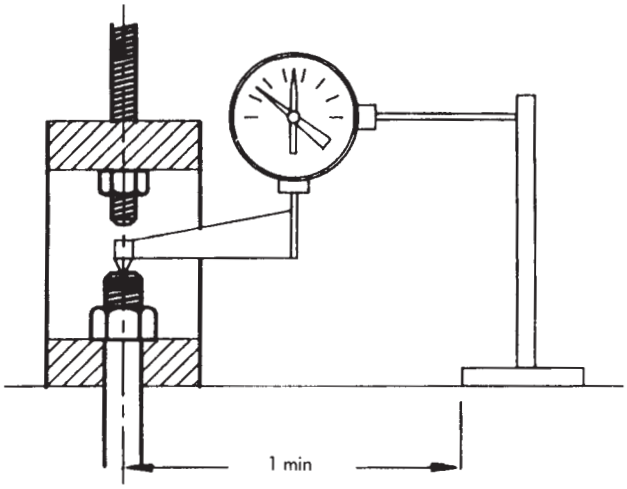

Fig. 5

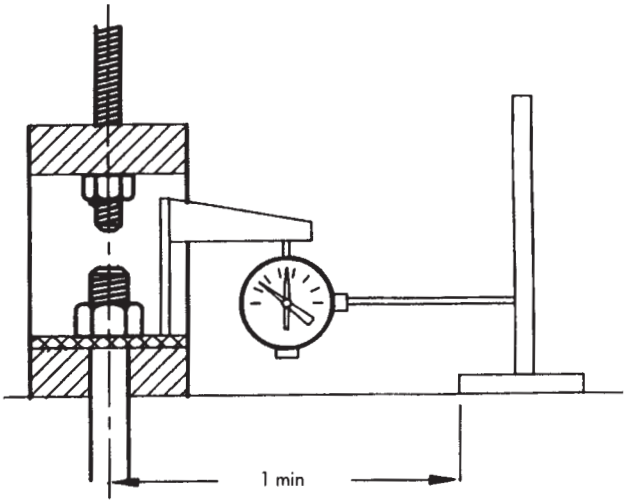

Fig. 6

b) Where a serviceability limit is to be recorded:-

A feeler gauge may be used to determine this point. This is feasible only where load application is via something simulating the fixture such as a

pulling plate, the gauge should be used where movement of the bolt will reliably be indicated.

c) Where first movement is to be noted in relation to the Manufacturer's Recommended Load:-

In this case a simple visual check can be arranged to show up the first movement e.g. a gap opening up below the "Fixture".

9 LOAD APPLICATION

SAFETY. It is the responsibility of all parties involved to take particular care to ensure the safety of all bystanders during the application of loads especially when testing to failure. When using pulling rods in tension ensure no one stands in line with the rod.

WITNESSES. It is strongly recommended that all tests are witnessed by a representative of the client or engineer requesting the tests.

Proof Load Tests with no recording of movement:-

Apply the load slowly and progressively until the required Proof Load is reached watching for significant movement. Record the load achieved and whether or not significant visible movement has occurred. If significant movement does occur reference should be made to the client as to the desirability of testing with detailed recording of movement, see below.

Ultimate Load Tests recording first movement or serviceability limit:-

Apply the load slowly and progressively until the Design Load or Manufacturer's Recommended Load is reached; note whether or not any movement has occurred.

Continue loading until first movement is visible, note applied load. (Where a serviceability limit is to be recorded continue loading slowly and progressively until the appropriate feeler gauge can be inserted at the measuring point, record the load). Continue loading progressively until maximum load is achieved. Once no further load increase is possible the test may be discontinued to avoid damaging the structure. Note the maximum load achieved, mode of failure and any damage to the structure or the fixing.

Ultimate or Proof Load Tests with detailed recording of movement:-

Note the reading of the dial gauge.

Apply the load slowly and progressively in pre-determined increments (typically 1/10th of the expected Ultimate Load or 1/5th of the Proof Load).

Record the dial gauge readings at each increment. Movement is given by the difference in reading from the initial reading. Include the Design Load or Manufacturer's Recommended Load as one increment and the load at .1mm movement as another. (May be inappropriate for fixings which are not tightened down for test purposes. See 5 Movement).

Continue loading progressively until the required Proof Load or Maximum Load is achieved. Once no further load increase is possible the test may be discontinued to avoid damaging the structure. Note the Maximum Load achieved, mode of failure and any damage to the structure or the fixing (if applicable), and for Proof Loads the displacement at the Proof Load.

Load/movement curves may then be plotted.

Load Relaxation:-

When loading is halted relaxation takes place in the anchorage as stresses are distributed in the base material, and continues at a reducing rate throughout the life of the anchorage. This results in reduction of the indicated load and is to be expected. Readings of movement and load should therefore be taken simultaneously as far as possible and after the indicated load has substantially stabilised.

Note : Ensure the stroke of test equipment is not exceeded.

10 NUMBER OF TESTS

The number of tests required should be decided by the engineer requesting the tests, however, the following guide-lines may be used.

For Proof Load Tests : test a minimum of 2.5% of the total number of fixings or at least 3.

For Ultimate Tests to establish suitability of the fixing in a particular base material at least 3 tests should be carried out.

If Safe Loads are to be determined from the tests at least 5 should be carried out.

11 CALCULATION OF ADMISSIBLE LOADS

Admissible Loads may be calculated according to the Technical Policy of the Manufacturer of the Fixings under test or to the requirements of the engineer requesting the tests.

In the absence of other guidance the following guide-lines may be adopted for the determination of Admissible Loads.

The Admissible Load should not exceed any of the following three loads :

a) Characteristic Load ÷ Safety Factor.
Where Characteristic Load = 5% Fractile Load and is determined from the formula:-

Characteristic Load = $N_{u,m} - k.s$

Where $N_{u,m}$ = mean ultimate load in a series of tests.

k is a factor relating to the confidence level required and the number of tests carried out.

No. of tests	5	6	7	8	9	10
k factor*	3.40	3.09	2.89	2.75	2.65	2.57

*These values of k are relevant for a confidence level of 90%

Note : Values for other sample sizes and confidence levels are tabulated in relevant statistical tables.

s = Standard deviation and is given by :

$$s = \sqrt{\frac{\Sigma(N_u - N_{u,m})^2}{n - 1}}$$

Where N_u = ultimate load in individual test.
n = number of tests.

The applicable Safety Factor is at the option of the Engineer requesting the tests, however, for general purposes a suitable Safety Factor, for static load applications = 3.

b) Mean Load at .1 mm movement from the test series.

c) Load limited by stress limit of the anchor bolt material ÷ Safety Factor.

This is given by Load = $(A_s \times f_u) \div$ Safety Factor

Where A_s = stressed area of the bolt
f_u = nominal strength of the bolt material

The applicable Safety Factor is at the option of the Engineer requesting the tests, however, for general purposes a suitable Safety Factor is 1.66.

12 INFORMATION TO BE RECORDED

Administration details :
- Date of test.
- Unique report reference number.
- Clients company name, address, contact name and position.
- Site location, contact name and position.
- Name of tester with job title or appropriate qualifications.
- Name and companies of witnesses.
- Name of installer of fixings.

Fixing / application details :
- Fixing : manufacturer, type, size and finish.
- Proposed application of fixing.
- Design load and Manufacturer's Recommended Load in the base material concerned.

Procedure for Site Testing Construction Fixings

Test objectives :
- Proof or Ultimate Load.
- Required test load.

Test Location :
- Detail sufficient to identify each anchor.
- Edge, spacing and structural thickness details if appropriate.

Base material :
- Type and strength at time of test if known.
- Whether solid or hollow.

Installation details if known :
- Hole diameter.
- Hole depth.
- Effective embedment depth.
- Tightening torque applied.
- For bonded anchors ambient temperature when installed and curing time.

Test equipment details :
- Make, type and load capacity of hydraulic ram/ gauge or tester.
- Date of last calibration, calibrating authority.
- Make & type of movement recorder, dial gauge etc.
- Loading frame: dimension 1, between fixing and closest support.
- Make & type of torque meter.

Test results, depending on purpose :

For each fixing tested* :
- Movement - at different load increments and maximum load.
- Load - maximum load applied.
  - load at first movement, 0.1mm if required.

Mode of failure where appropriate :
- Base material failure by cone failure, spalling or cracking. (Cone failure after Significant Movement should be recorded as Significant Movement followed by Cone Failure).
- Bolt breakage.
- Failure of resin or bonding material i.e. Bond Shear (may be combined with Cone Failure).
- Pull through / excessive movement.

*Unless a simple proof load is required and all fixings achieve the requirement in which case a simple statement to that effect could suffice.

Statement to the effect that the test complied with this procedure and any exceptions.

Statement as to whether or not fixing(s) met the test objective.

Reference :

[1] British Standard 5080: Structural Fixings in concrete and masonry. Part 1: 1993. Method of test for tensile loading.

Appendix 1. Equipment check list.

Equipment to install fixings

- Fixings
- Drilling Machine
- Transformer
- Extension Cable
- Drill bit
- Hole cleaning equipment :
  - Blow out bulb for small fixings i.e. hole diameter up to 10mm, or large volume pump for larger fixings
  - Brush
- Setting equipment appropriate to fixing
- Torque wrench
- Socket (Deep reach in the case of projecting studs)

Test Equipment

- Loading frame or bridge
- Hydraulic pump, ram & gauge combination or Test meter
- Pulling frame
- Bushes to suit fixing diameter
- Pulling rod, washers and nuts
- Threaded coupler

If movement is to be monitored :

- Dial gauge or feeler gauge
- Stand with remote mounting arm
- Fixing plate or bracket, fixings to attach to base material.

Safety Equipment

- Helmet
- Eye protection to BS 2092 Grade 1 (if drilling or if installing anchors overhead)
- Fixings, drill bit etc. to secure loading frame and ram to base material in the case of testing under a soffit or against a vertical surface.

Administration

- Report forms
- Calibration chart / curve for load gauge or test meter.

This Guidance Note is one of a series published by the **ASSOCIATION** covering different product types and applications.

Details of the aims and objectives of the **CONSTRUCTION FIXINGS ASSOCIATION**, together with a list of members and the products they supply are included in **CONSTRUCTION FIXINGS ASSOCIATION - An Introduction**.

For copies of these publications or more information contact :

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