BRITISH STANDARD

BS 5080-2: 1986
Incorporating Amendment No. 1

Methods of test for

Structural fixings in concrete and masonry

—

Part 2: Method for determination of resistance to loading in shear

Confirmed October 2008

UDC 693.1/.5:691.88:620.176.24

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Civil Engineering and Building Structures Standards Committee (CSB/-) to Technical Committee CSB/31, upon which the following bodies were represented:

Association of Building Component Manufacturers Ltd.
Brick Development Association
British Precast Concrete Federation Ltd.
Cement and Concrete Association
Concrete Society
Construction Fixings Association
District Surveyors' Association
Federation of British Hand Tool Manufacturers
Greater London Council
Institution of Civil Engineers
Institution of Structural Engineers
National Association of Scaffolding Contractors
Stainless Steel Fabricators' Association of Great Britain
Suspended Access Equipment Manufacturers' Association
Suspended Ceilings Association

This British Standard, having been prepared under the direction of the Civil Engineering and Building Structures Standards Committee, was published under the authority of the Board of BSI and comes into effect on
31 December 1986

The following BSI references relate to the work on this standard:
Committee reference CSB/31
Draft for comment 84/11024 DC

ISBN 0 580 15130 1

Amendments issued since publication

Amd. No.	Date of issue	Comments
7602	July 1993	Indicated by a sideline in the margin

Contents

Foreword

This Part of BS 5080 has been prepared under the direction of the Civil Engineering and Building Structures Standards Committee and describes a method for conducting tests under shear forces on structural fixings installed in concrete or masonry materials used in building and civil engineering construction.

A structural fixing joins, supports or retains components, and may be defined as one that has been designed to resist some form of loading, since its failure will have structural significance.

This method of test applies to a fixing installed according to the supplier's recommended procedure in a solid base material. It is a test of the composite assembly comprising the fixing and the base material and not just of the fixing itself. Failure of a fixing assembly under a shear force may be due to failure of the material from which the fixing has been manufactured or failure of the base material in which it has been installed.

The test is not intended for fixings comprising small plugs of metal, plastics or fibrous composition which are used in conjunction with woodscrews, or for fixings that pass through the base material (such as those for use with thin rigid sheet materials for walls, roofs or partitions) or for cavity fixings for use with hollow clay or concrete block masonry. Displacement fixings, i.e. pins or studs inserted by a cartridge-operated tool, are not included as the method of test is not appropriate to their use. However, should a design demand structural considerations and testing, the procedures given in this standard should be followed as far as possible.

The standard relates to the method of test only; it is not a performance standard. It has to be stressed that any recommendations on the interpretation of the results of tests for the purposes of design, selection or use of fixing are outside the scope of the standard.

If the method in this standard is used for proof testing the applied load and/or relative movement limits should be specified by the user.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

1.1 General

This Part of BS 5080 describes a method for conducting tests under shear force on structural fixings installed in concrete or masonry used in building and civil engineering.

1.2 Type of test

The test consists of applying a shear force to a fixing installed in a solid base material.

1.3 Type of fixings

The test is intended for expanded and undercut anchors, bonded fixings, cast-in fixings and channel inserts.

1.4 Construction materials

The materials in which these fixings may be installed are as follows:

a) concrete;

b) natural stone;

c) cast stone;

d) brick or block masonry.

1.5 Application of test

There are two distinct situations in which the test can be applied. These are as follows.

a) For comparative or reference purposes, for which a standard specimen of base material is specified (see **5.1**).

b) For a specific application, for which the base material should be appropriate to the intended use of the fixing. In this situation the base material may be either a specimen manufactured for the purpose or a representative section of the base material in place (see **5.2**).

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 5080, the definitions given in BS 5080-1 apply together with the following.

2.1
expanded anchors

anchors held in drilled holes by friction or wedging action

2.2
bonded fixings

fixings held in drilled holes by grout or other bonding material

2.3
cast-in fixings

anchor bolts and sockets cast into the material during construction

2.4
channel inserts

slots and channels cast into the material during construction

2.5
undercut anchors

anchors held in drilled holes by interlocking in under-reamed shapes during drilling or setting (see Figure 5)

3 Principle

The principle of the test is the subjection of a composite assembly consisting of a structural fixing installed in solid base material to a shear force applied through the structural fixing until failure occurs. Measurement of the load applied is carried out to determine the strength of the assembly.

4 Apparatus

4.1 *Shear testing apparatus*, being a loading frame incorporating a means of applying load through a block of steel having a diameter equal to $5d$ and a thickness equal to $d + 0.8$ mm, where d is the outside diameter of the part of the fixing that projects from the surface of the base material (see Figure 1). There shall be a hole in the block, located in the centre, the diameter being such that the clearance for the stud or bolt of the fixing is in accordance with BS 4186, medium fit.

The block of steel shall comply with either:

a) grade 665 M17 of BS 970-1, case hardened 0.5 mm to 0.8 mm deep with hardness HV 700; or

b) grade 43A of BS 4360 and bushed with a hardened steel sleeve having the same specification as given in a). The bush shall have a minimum wall thickness of 3 mm.

The edge of the hole in the block or the bush shall be radiused at each end, 0.4 mm radius.

After each series of tests the block and bush shall be visually inspected and shall be replaced if any wear or deformation is observed.

An example of a suitable form of apparatus is shown in Figure 2.

4.2 *Measuring equipment*, to measure the relative movement between the fixing and the base material to an accuracy of 0.02 mm.

4.3 *Load measuring device*, being a pressure gauge, proving ring, load cell or other suitable device, capable of measuring to an accuracy of 5 %.

4.4 *Structural fixings*, as appropriate.

4.5 *Drill bits*, or other devices used to install the structural fixings.

4.6 *Mould*, if required to cast standard specimen of base material (see **5.1**).

5 Base materials

5.1 Standard specimen of base material

NOTE The dimensional criteria given in **5.1** are intended to ensure that the behaviour under test of any one fixing does not affect that of adjacent fixings. The dimensions given here are not to be taken in any sense as guidance for field installation.

5.1.1 *General*. The standard specimen of base material shall be manufactured from concrete complying with the dimensional and casting requirements of **5.1.2** and **5.1.3**.

5.1.2 *Concrete*. The concrete from which the standard specimen is prepared shall have the following mix proportions, compaction and curing treatments.

a) Ordinary Portland cement (complying with BS 12):100 kg.

b) Total aggregate (complying with BS 882):510 kg (dry weight) composed as follows.

1) Coarse aggregate: flint gravel graded 20 mm to 5 mm.

2) Fine aggregate: natural sand as a proportion of the total aggregate content of one of the following:

i) Type C: 40 %; or

ii) Type M: 35 %; or

iii) Type F: 30 %.

c) Water content: the water content of each batch shall be adjusted to give a concrete of medium workability, equivalent to a slump of 25 mm to 75 mm when determined in accordance with BS 1881-102.

d) Compaction: mechanical vibration (applied externally or internally) shall be used to compact the concrete.

e) Curing: the specimen(s) shall be stored in moist air of at least 90 % r.h. and 20 °C for the first 2 days after casting.

NOTE 1 The quantities and proportions of materials given will produce approximately 0.28 m^3 of fully compacted concrete. The batch weights should be calculated to suit the size of the mixer and the actual quantity of concrete required.

NOTE 2 This concrete mix complies with the C25P ordinary prescribed mix of BS 5328.

Any reinforcement in the standard specimen shall be so positioned as to offer no additional strength in the zone of interaction between the concrete and the fixings.

The density and compressive strength of the concrete from each batch shall be determined at the time of testing in accordance with BS 1881-114 and BS 1881-116 respectively.

5.1.3 *Specimen size*. It shall be acceptable for a single specimen to be used for the installation and testing of any number of fixings, provided that it complies with the dimensional conditions specified in 1) to 3), which are based on characteristic dimension *A* of the fixing, defined as follows.

a) *expanding and undercut anchors* [see Figure 4(a)]: *A* = the hole diameter or one-quarter of the embedded depth, whichever is greater.

b) *bonded fixings* [see Figure 4(b)]: *A* = the maximum diameter of the fixing or one-quarter of the embedded depth, whichever is the greater.

c) *cast-in fixings* [see Figure 4(c)]: *A* = the maximum dimension perpendicular to the axis or one-quarter of the maximum embedded depth, whichever is the greater.

d) *channel inserts* [see Figure 4(d)]: the dimensions of the specimen shall, as far as possible, comply with the criteria for other fixings and allowance shall be made for projecting ties or lugs.

NOTE It is not practicable to define a characteristic dimension *A* for channel inserts.

The dimensions of the specimen shall comply with the following.

1) There shall be a minimum of 4*A* below the embedded depth of the fixing, *D*.

2) There shall be a minimum of 8*A* between the centre of any fixing and a free edge.

3) There shall be a minimum of 4*A* between the centres of any two fixings when the applied direction of shear force is at right angles to a line between the fixings. Where the direction of applied shear force is parallel to the line the minimum spacing shall be 8*A* (see Figure 3). Where fixings of two different sizes are considered their distances shall be taken as the sum of 2*A* (right angle loading direction) and 4*A* (parallel loading direction) for each fixing.

5.2 Other base materials

Where the test is to be carried out on a base material other than the standard specimen, a description of the base material shall be included in the test report.

NOTE The size of base material specimens including any reinforcement or bonding details of wall panels should be agreed before commencement of tests.

Other base materials shall be one of the following:

a) concrete;

b) natural stone;

c) cast stone;

d) brick or block masonry.

The compression strength of concrete base materials shall be determined in accordance with BS 1881-116 for cast specimens from the same batch of concrete as that in which the fixing is installed, or BS 1881-120 for cores cut from the concrete.

NOTE Other means of determining the compression strength may be agreed.

The density of the concrete at the time of testing shall be determined in accordance with BS 1881-114.

6 Installation of fixing

6.1 Location of fixing

6.1.1 *Standard specimen of base material*. When installed in a standard specimen of base material a fixing shall be located in the soffit as cast.

6.1.2 *Other base materials*. In base materials other than a standard specimen of base material, where individual units are bonded with mortar joints, the fixing shall be located in the material, in the mortar joint (bed or perpend) or at the interface between them.

NOTE The location should be agreed before commencement of tests.

6.2 Expanding and undercut anchors

For expanding and undercut anchors, the hole shall be drilled and the anchor installed in accordance with the supplier's recommended procedure.

NOTE Where the recommended procedure is incomplete, a specified procedure should be agreed before commencement of tests.

The hole shall be normal to the base material surface. The diameter of the drill bit and any other special feature used shall be as specified by the supplier of the fixing.

6.3 Bonded fixings

For bonded fixings, the hole shall be drilled and proprietary systems installed in accordance with the supplier's recommended procedure. Non-proprietary systems, whether using resin adhesive or cement grout, shall be installed in accordance with the user's specification. The diameter of the drill bit used shall be as specified either by the supplier of the fixing for proprietary systems or by the user for non-proprietary systems. The hole shall be normal to the base material surface. The fixing shall be secured so that the axis of the threaded portion remains normal to the surface of the base material during the placing and hardening of the bonding material. As curing times for resin adhesives are dependent on the formulation of the constituents and the surrounding temperature, the test described in **7.2** and **7.3** shall not be carried out until the adhesive has fully cured in accordance with the supplier's recommendations.

6.4 Cast-in fixings

For cast-in fixings, the fixing shall be installed in accordance with the supplier's recommended procedure or with the user's specification. The fixing shall be secured so that the axis of the threaded portion remains normal to the surface of the base material while it hardens.

6.5 Channel inserts

For channel inserts, the insert shall be installed in accordance with the supplier's recommended procedure. The fixing shall be secured so that it remains parallel to the surface of the base material while it hardens.

7 Procedure

7.1 Arrangement of test apparatus

Locate the steel block over the fixing and directly on the surface of the base material without any interfacing. Before tightening the nut or bolt, position the steel block so that the clearance of the projecting part of the anchor in the bush allows movement of the plate when the load is applied.

Align the loading frame to ensure that the shear force is applied parallel with the surface of the base material by a suitable rod or bar. A sheet of low friction material such as polytetrafluoroethylene (PTFE) shall be inserted between the base material and the rig; however, this shall not exceed 2 mm in thickness. The reaction to the load shall be located at a distance of at least 8A either side of the fixing, measured at right angles to the direction of loading (see Figure 2).

NOTE Where tests are carried out for a specific application it may not be possible to comply with these dimensional requirements. In such situations every effort should be made to prevent the reaction forces from influencing the load-carrying performance of the fixing assembly. For example, the base material should not be restrained in such a way that a normal failure mode is prevented.

Measure the relative movement between the fixing and the base material. Support the measuring instrument on one or more reference points independent of the loading frame and fixed to the base material at a distance of at least 6*A* from the axis of the fixing. Arrange the measuring instrument to read the movement of the steel block parallel to the direction of the applied force.

7.2 Load application

7.2.1 *General*. Only hand-tighten the nut or bolt head initially, and apply a force sufficient to take up any slack in the apparatus and attachment, ensuring that this force does not exceed approximately 1 % of the anticipated ultimate force. While the force is maintained, tighten the nut or bolt head to the manufacturer's recommended torque, after which the initial force shall be released.

NOTE 1 For standard applications, the load is applied in a direction opposite to the nearest edge of the base material to the fixing.

NOTE 2 Personnel and measuring instruments may require protection from impact in the event of sudden fixing or base material failure.

NOTE 3 For channel inserts the shear force may be applied parallel to, at right angles to or at any intermediate angle relative to the longitudinal axis of the channel. The direction of loading should be agreed before the commencement of tests.

7.2.2 *Continuous loading*. Use a rate of load application such that the stress on the core diameter area increases at a rate of between 9 newtons per square millimetre per second and 11 newtons per square millimetre per second. Make a simultaneously recorded graph of applied force and relative movement.

Continue loading until failure of the fixing device or base material, or until the block has displaced a distance equivalent to *d* (see Figure 1), at which stage the test shall be terminated.

7.2.3 *Incremental loading*. Increase loading by substantially equal increments, recording the applied force and relative movement at each increment. Take sufficient readings to enable a graph of applied force and relative movement to be drawn. Continue loading until failure of the fixing device or base material, or until the block has displaced a distance equivalent to *d* (see Figure 1), at which stage the test shall be terminated.

NOTE 1 At higher loads, when displacement may occur with little corresponding increase in applied force, readings should be taken at increments of movement rather than load. Relaxation of load may also occur; the load level and the resulting movement need to stabilize before readings are taken and before the next increment is applied.

NOTE 2 In order to produce a graph it will be necessary to obtain about 10 readings of applied force and relative movement.

7.3 Base material strength at time of test

A sufficient number of cubes shall be made in order that the strength gain can be monitored. The tests in the standard specimen of base material shall be carried out when the concrete has attained a compressive strength of 30 ± 5 N/mm^2, based on the average of at least three cubes, tested in accordance with BS 1881-116.

NOTE For tests in other base materials, the required compressive strength of the material before the tests are carried out should be agreed in advance.

7.4 Number of tests

For tests in the standard specimen of base material, test five samples of each type and size of fixing device.

NOTE For other applications, the number of tests should be agreed in advance, but preferably at least five of each type and size should be tested. If a statistically significant characteristic value is required then a larger number of tests is necessary.

8 Presentation of results and calculation

Each test shall be reported individually by plotting a graph of the force applied to the fixing against relative movement.

NOTE It is recommended that the same unit length on the scales should represent 5 kN applied force and 1 mm relative movement.

The graph shall be annotated with the characteristics that describe fully the behaviour of the fixing throughout the test, which shall include the following as appropriate:

a) movement of the steel block in overcoming the initial friction in taking up the clearance and subsequent displacement relative to the base material;

b) onset of cracking in the base material;

c) rupture of base material;

d) shear fracture of the fixing device;

e) deformation of the component parts of the fixing device;

f) failure of bars or lugs attached to cast-in fixings or channel inserts.

For each series of tests with a given type and size of fixing, the mean and standard deviation shall be calculated at the ultimate force, the standard deviation S being given by the following equation:

$$S = \sqrt{\left(\frac{\Sigma(x - \bar{x})^2}{n - 1}\right)}$$

where

x is the individual test result;

$\bar{x}$ is the arithmetic mean of the results;

n is the number of tests.

The fixing and the base material shall be examined wherever possible after completion of the test and all significant features noted, including mode of failure.

9 Test report

The following information shall be included in the report for each type and size of fixing.

a) Confirmation that the test has been carried out in accordance with this Part of BS 5080. If tests are carried out on site then any deviation from the requirements of this standard shall be detailed.

b) The name and location of the testing authority and the date the test was carried out.

c) The specification and description of the base material as follows:

1) standard concrete specimens (see **5.1.3**):

i) the dimensions of the specimen;

ii) the location in the specimen of the fixing(s) being tested;

iii) the specification of the concrete mix;

iv) a description of the aggregates used in the concrete mix in accordance with the method given in BS 812-102;

v) the quantity of water added to the concrete mix, expressed as a water/cement ratio based on aggregates in the saturated surface dry condition;

vi) the slump achieved in the concrete mix;

vii) a description of the compaction method used on the concrete mix;

viii) a description of the curing method used on the concrete mix;

ix) the concrete age, compressive strength and density at the time of testing;

2) concrete (see **5.2**):

i) mix proportions, including the type of cement and aggregate;

ii) the location and type of any reinforcement;

iii) the shape and dimensions of the cast unit;

iv) the concrete age, compressive strength and density at the time of testing;

3) natural stone:

i) rock name, in accordance with BS 6100-5.2 or BS 812-102;

ii) its compressive strength, including the manner in which this was measured;

iii) the shape and dimensions of the block;

iv) the angle of the fixing relative to any natural bedding plane;

4) cast stone: a description as given for concrete in c(2) of clause **9** but with the compressive strength measured in accordance with BS 1217 and, where the cast stone consists partly of a facing material and partly of a structural concrete, a description of both parts:

5) brick or block masonry:

i) type of unit, as defined in BS 187, BS 6073 or BS 3921;

ii) size and compressive strength measured in accordance with the relevant British Standard;

iii) the thickness and bonding of the wall;

iv) mix proportions and strength, in accordance with BS 4551, of the mortar.

d) The description of the installation of the fixing as follows.

1) expanding and undercut anchors [see Figure 4(a)]:

i) the supplier's name and reference number for the fixing, including the nominal hole diameter for which the fixing is intended and the nominal diameter and thread type of the threaded portion;

ii) the specification of the material from which the fixing is made and its finish;

iii) the actual diameter of the bit used to drill the hole, measured to the nearest 0.1 mm before starting and after completion, and the type of drill employed, i.e. rotary, rotary-percussive or hammer;

iv) the embedded length and, where relevant for impact-expanded anchors, the hole depth, both to the nearest millimetre;

v) the location of the fixing in the sample or specimen of base material;

vi) a copy of the supplier's recommended installation procedure with any additional observations on this procedure, including the tightening torque where relevant;

2) bonded fixings [see Figure 4(b)]:

i) the supplier's name and reference number of the system or other full description where appropriate, including the nominal hole diameter for which the fixing is intended and the nominal diameter of the threaded portion;

ii) the specification of the material from which the fixing is made and its finish;

iii) the actual diameter of the bit used to drill the hole, measured to the nearest 0.1 mm before starting and after completion, and the type of drill employed, i.e. rotary, rotary-percussive or hammer;

iv) the embedded length and the hole depth to the nearest millimetre;

v) the location of the fixing in the sample or specimen of base material;

vi) for resin systems, the type, source and adhesive used;

vii) for cement grouts, the proportions of the material used, including, if required by the user, its strength at the time of test, determined in accordance with BS 4551;

viii) a copy of the supplier's recommended installation procedure with any additional observations on this procedure or the user's specification;

3) cast-in fixings [see Figure 4(c)]:

i) the supplier's name and reference number for the fixing or other full description where appropriate;

ii) the size and shape of the fixing, including a diagram where possible;

iii) the specification of the material from which the fixing is made and its finish;

iv) the embedded length of the fixing to the nearest millimetre and details of any attachment of the fixing to reinforcement in the base material;

v) the location of the fixing in the sample or specimen of base material;

vi) the specifications of the bolts used in socket type fixings;

4) channel inserts [see Figure 4(d)]:

i) the supplier's name and reference number for the insert, including details and location of any lugs attached to it;

ii) the specification of the material from which the insert is made and its finish;

iii) the length of the insert to the nearest millimetre;

iv) the embedded depth to the nearest millimetre;

v) the location of the fixing in the sample or specimen of base material;

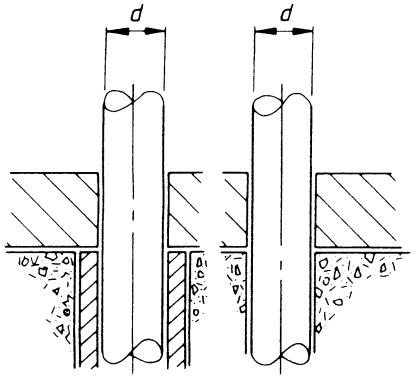
vi) the direction of the test load relative to the longitudinal axis of the channel.

e) Where the dimensional requirements of **7.1** cannot be complied with, e.g. in field tests as indicated in the note to **7.1**, a description of the test layout with the actual dimensions adopted shall be reported.

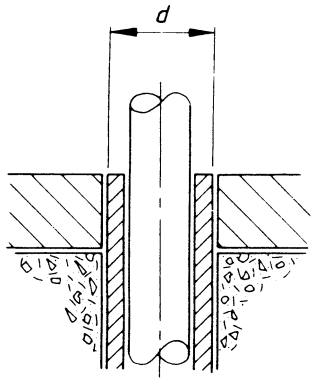
f) The method of loading, either continuous or incremental, as described in **7.2**.

g) The graphical presentation of results.

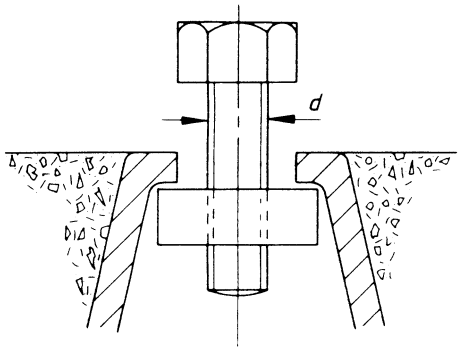
h) The mean and standard deviations of the ultimate force applied.



(a) Stud or bolt only projecting from surface of concrete



(b) Stud or bolt with sleeve projecting from surface of concrete



(c) Bolt projecting from channel insert

Figure 1 — Outside diameter of fixing

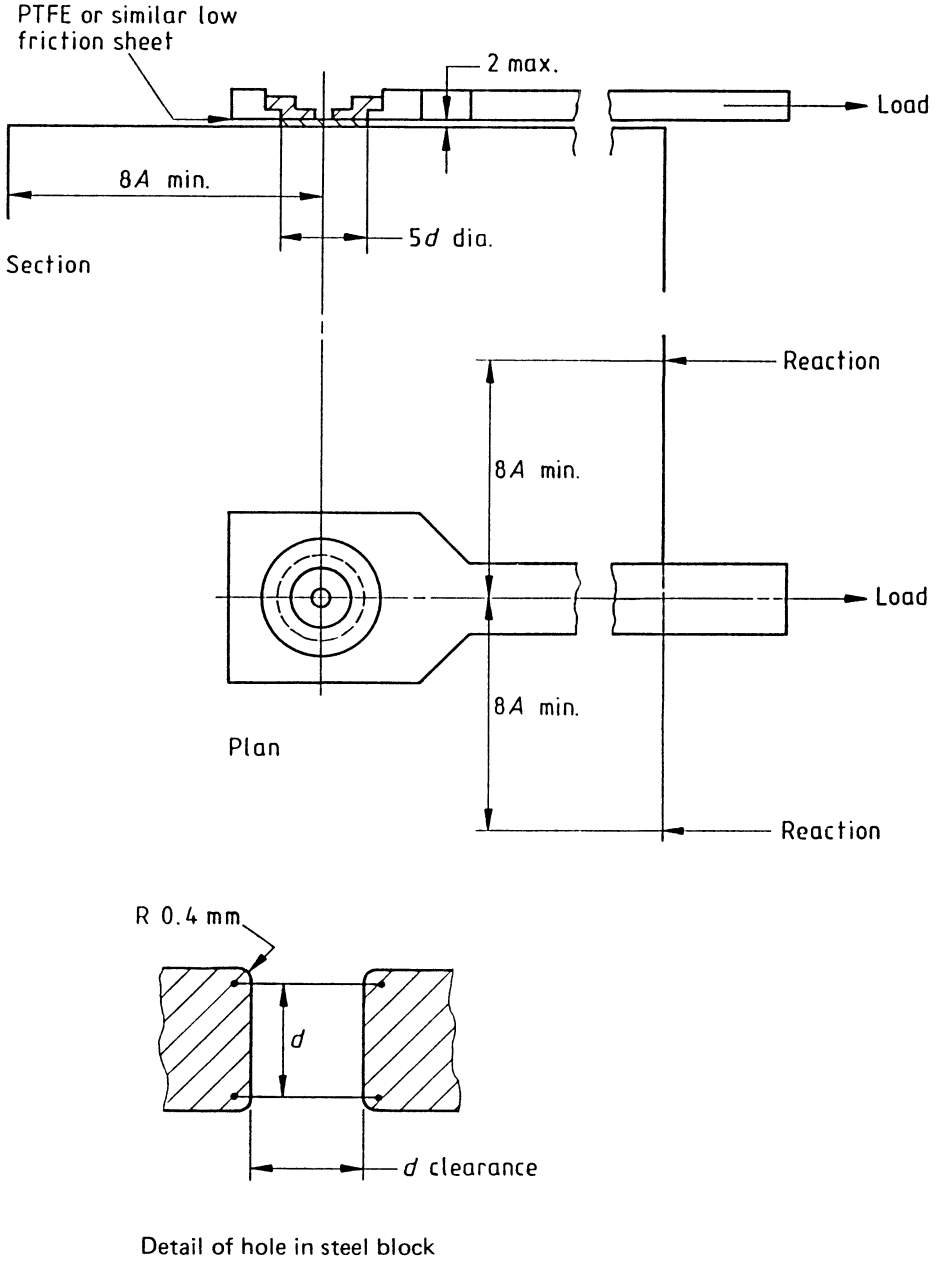


Figure 2 — Suitable form of loading apparatus

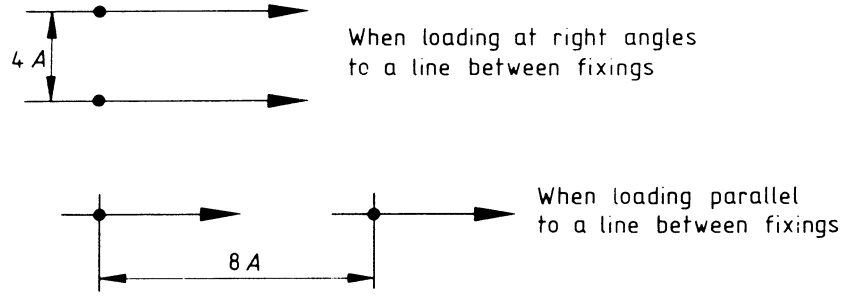
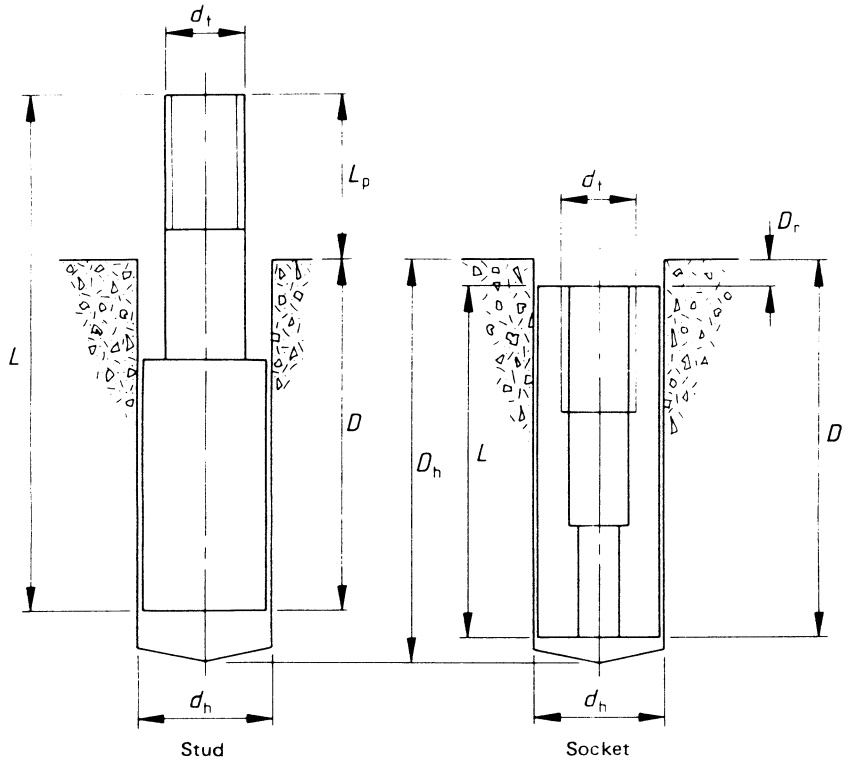


Figure 3 — Minimum spacing of anchors



(a) Expanding and undercut anchors

Notation

The following notation is used in Figure 4(a), Figure 4(b), Figure 4(c) and Figure 4(d):

D is the embedded depth;
D_h is the depth of hole;
D_r is the recess depth of socket below surface of base material;
d_h is the hole diameter;
d_t is the thread diameter;
L is the overall length of stud or socket;
L_c is the length of channel insert;
L_p is the length of stud projecting above surface of base material.

For studs:

$D = L - L_p$

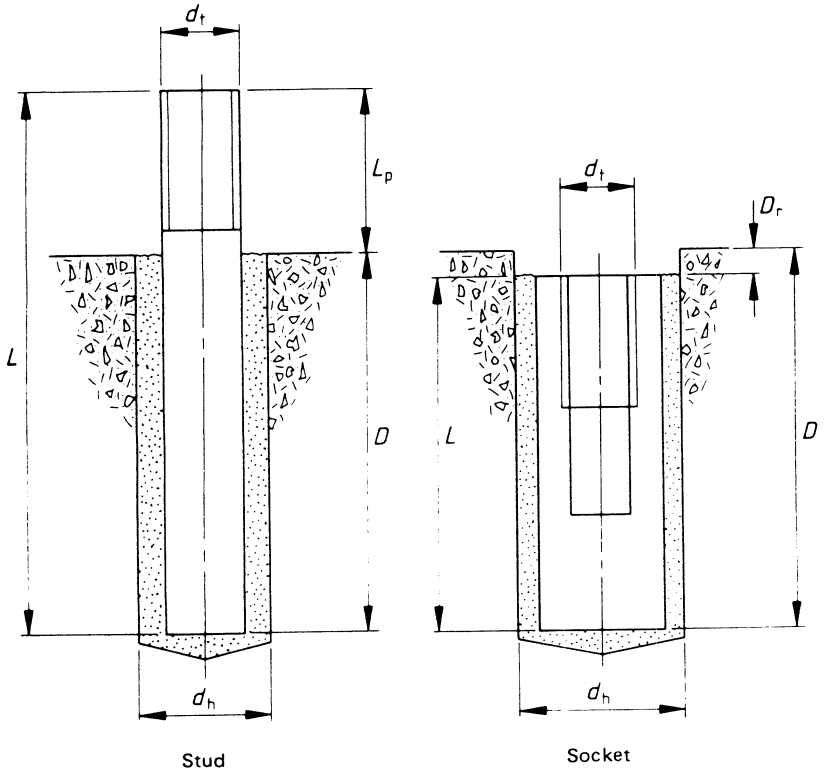
For sockets:

$D = L + D_r$

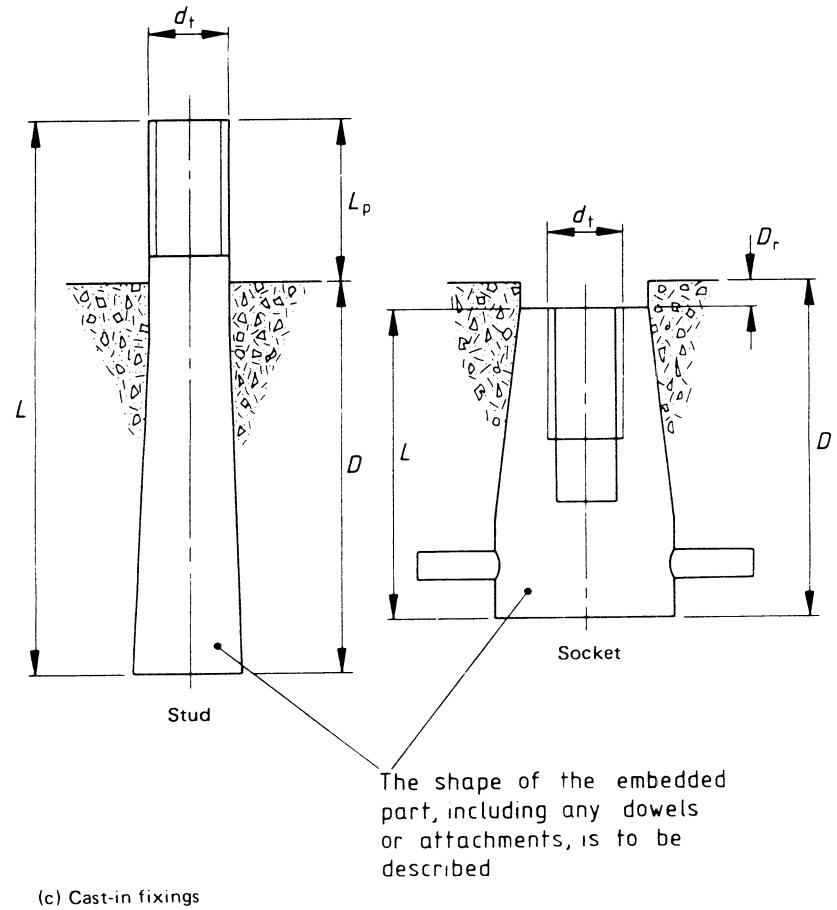
NOTE 1 D_r may be zero.

NOTE 2 The type of thread, e.g. ISO metric, should be stated.

Figure 4 — Types of fixing to show the dimensions required for reporting their description *(continued)*

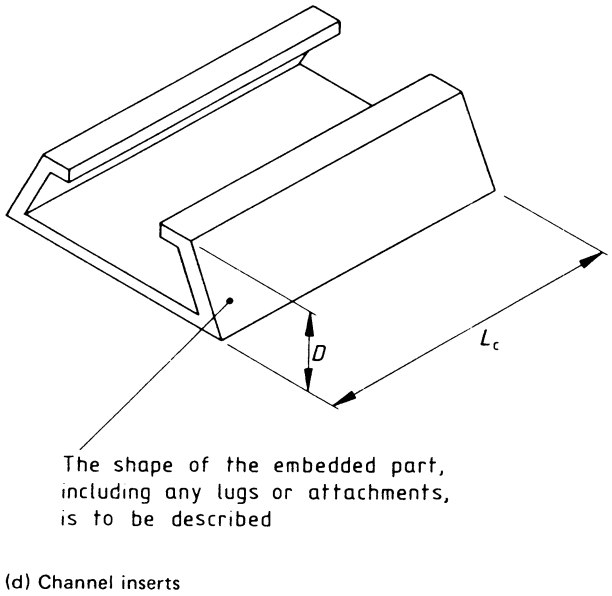


(b) Bonded fixings



(c) Cast-in fixings

Figure 4 — Types of fixing to show the dimensions required for reporting their description *(continued)*



(d) Channel inserts

Figure 4 — Types of fixing to show the dimensions required for reporting their description *(concluded)*

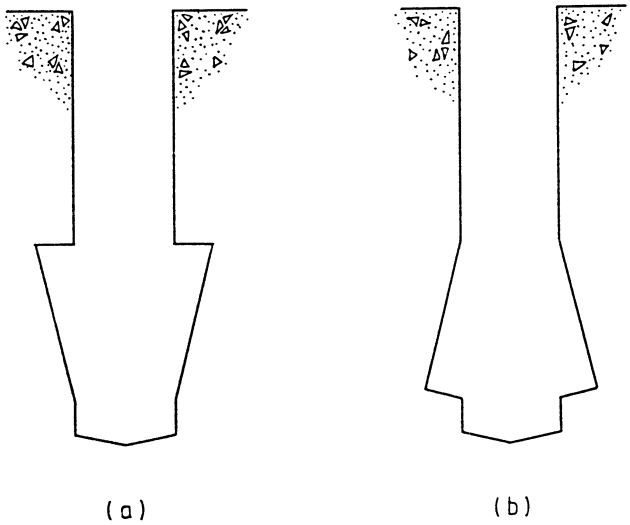


Figure 5 — Undercut anchors — alternative profiles of undercuts in the base material

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Publications referred to

BS 12, *Specification for ordinary and rapid-hardening Portland cement.*

BS 187, *Specification for calcium silicate (sandlime and flintlime) bricks.*

BS 812, *Testing aggregates.*

BS 812-102, *Methods for sampling.*

BS 882, *Specification for aggregates from natural sources for concrete.*

BS 970, *Specification for wrought steels for mechanical and allied engineering purposes.*

BS 970-1, *General inspection and testing procedures and specific requirements for carbon, carbon manganese and stainless steels.*

BS 1217, *Cast stone.*

BS 1881, *Methods of testing concrete.*

BS 1881-102, *Method for determination of slump.*

BS 1881-114, *Methods for determination of density of hardened concrete.*

BS 1881-116, *Method for determination of compressive strength of concrete cubes.*

BS 1881-120, *Method for determination of the compressive strength of concrete cores.*

BS 3921, *Clay bricks and blocks.*

BS 4186, *Specification for clearance holes for metric bolts and screws.*

BS 4360, *Specification for weldable structural steels.*

BS 4551, *Methods of testing mortars, screeds and plasters.*

BS 5080, *Methods of test for structural fixings in concrete and masonry.*

BS 5080-1, *Tensile loading.*

BS 5328, *Methods for specifying concrete, including ready-mixed concrete.*

BS 6073, *Precast concrete masonry units.*

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BS 6100-5, *Masonry.*

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