BS 8298-2:2010

BSI Standards Publication

Code of practice for the design and installation of natural stone cladding and lining –

Part 2: Traditional handset external cladding

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Publishing and copyright information

ISBN 978 0 580 55962 4

ICS 91.060.10

The following BSI references relate to the work on this standard:
Committee reference B/545
Draft for comment 07/30140555 DC

Publication history

First published December 2010

Amendments issued since publication

Date	Text affected

Contents

Summary of pages
This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 26, an inside back cover and a back cover.

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Foreword

Publishing information

This part of BS 8298 was published by BSI and came into effect on 31 December 2010. It was prepared by Technical Committee B/545, *Natural stone*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

Together with BS 8298-1, BS 8298-3, BS 8298-4 and BS 8298-5 [1)], this part of BS 8298 supersedes BS 8298:1994, which is withdrawn.

Relationship with other publications

BS 8298, *Code of practice for the design and installation of natural stone cladding and lining*, will be issued in five parts:

- *Part 1: General;*
- *Part 2: Traditional handset external cladding;*
- *Part 3: Stone-faced pre-cast concrete cladding systems;*
- *Part 4: Rainscreen and stone on metal frame cladding systems;*
- *Part 5: Internal linings.* [1)]

Information about this document

This is a full revision of the standard, and introduces the following principal changes:

- BS 8298 has been completely restructured by splitting it into five parts;
- the BS 8298 parts have been updated to reflect general changes in the fixings systems available to support natural stone cladding panels.

BS 8298-1 contains the terms and definitions for all the parts of BS 8298.

Assessed capability. Users of this British Standard are advised to consider the desirability of quality system assessment and registration against the appropriate standard in the BS EN ISO 9000 series by an accredited third-party certification body.

Use of this document

As a code of practice, this part of BS 8298 takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this part of BS 8298 is expected to be able to justify any course of action that deviates from its recommendations.

1) In preparation.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

[1] GREAT BRITAIN. Building Regulations 2000 (as amended). London: The Stationery Office.

[2] SCOTLAND. The Building (Scotland) Regulations 2004. Edinburgh: The Stationery Office.

1 Scope

This part of BS 8298 gives recommendations for the design, installation and maintenance of traditional handset external cladding of natural stone held directly to a structural background by metal fixings.

It covers:

a) the provisions necessary for the cladding to perform its function satisfactorily;

b) the materials and methods most frequently used for stonework; and

c) the use of thermal insulation behind external cladding.

Loadbearing cladding or cladding held only by adhesion is not included, nor is any type of cladding supported or held in position around the perimeter of stones or series of stones by metal framing.

NOTE The general principles for cladding also apply to soffits and sloping surfaces.

This part of BS 8298 is to be read in conjunction with BS 8298-1. Different cladding and lining methods are covered in the other parts of BS 8298 (see Foreword).

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 5606, *Guide to accuracy in building*

BS 6093, *Design of joints and jointing in building construction – Guide*

BS 8298-1:2010, *Code of practice for the design and installation of natural stone cladding and lining – Part 1: General*

BS EN 1991 (all parts), *Eurocode 1 – Actions on structures*

BS EN 1991-1-4, *Eurocode 1 – Actions on structures – Part 1: General actions – Wind actions*

BS EN 12372, *Natural stone test methods – Determination of flexural strength under concentrated load*

BS EN 13161, *Natural stone test methods – Determination of flexural strength under constant moment*

BS EN 13364, *Natural stone test methods – Determination of the breaking load at dowel hole*

BS EN ISO 3506-1, *Mechanical properties of corrosion-resistant stainless steel fasteners – Part 1: Bolts, screws and studs*

BS EN ISO 11600, *Building construction – Jointing products – Classification and requirements for sealants*

3 Terms and definitions

For the purposes of this part of BS 8298, the terms and definitions given in BS 8298-1 apply.

4 Thickness of stone

4.1 General

The thickness of stone (other than soffit stones) selected for use should be:

a) determined by structural calculation or performance testing to establish the properties of the stone (particularly the flexural strength and the breaking load at dowel); or

b) in accordance with Annex A, if it is agreed that a) is not appropriate.

NOTE 1 The required thickness depends on the properties of the stone (particularly flexural strength), the panel size, the imposed loads and the fixing system. It is also necessary to consider both the flexural strength of the panel between fixing points and the failure load at the fixing point. These are then compared to the expected lateral wind loads and vertical dead loads.

*NOTE 2 Given that there are a number of variables and that the designer can start with any of these, the process by which all of the parameters are determined is potentially very complex. In order to produce a simplified scheme, it is assumed that under normal circumstances two variables are likely to be known: the stone type (**4.2**) and the panel dimensions and thickness (**4.3**).*

4.2 Known stone type

It is essential that the recent technical data are obtained for the stone (results from samples collected from the same bed/quarry within the last two years are considered to be recent). In particular, the flexural strength and the resistance of the fixings to lateral loads should be documented. Additionally, information on the likely lateral loads should be either calculated using the methods and factors given in BS EN 1991-1-4 or defined using the classification in Table 1.

NOTE It can be beneficial to view past records to build up a picture of the stone's performance and to compare its potential performance on site with the test data provided by the product supplier.

Table 1 **Classification of wind load environments in the UK**

Class	**Load** $N \cdot m^{-2}$	**Brief description**
Low	1 500	A sheltered environment such as the lower floors of a building in a central urban area, e.g. Central Manchester
Medium	2 250	An exposed environment such as the higher floors of a tall building or a more exposed location, e.g. Canary Wharf, London
High	3 000	An exposed environment such as a coastal location

4.3 Known panel dimensions and thickness

4.3.1 General

Where the panel dimensions and thickness are known, Table 2, Table 3, Table 4 and Table 5 should be used to determine the minimum values for the flexural strength (see **4.3.2**) and the strength around the fixing (see **4.3.3**). These values can then be used in the specification for the stonework.

EXAMPLE

- *Panel dimensions: 900 mm × 600 mm*
- *Panel thickness: 50 mm*
- *Fixing system: dowels in the short sides*
- *Location: high wind load environment*
- *Minimum flexural strength: 4.37 MPa*
- *Minimum strength around the fixings: 3 600 N*

4.3.2 Flexural strength

The flexural strength (in MPa) should be determined in accordance with BS EN 12372 or BS EN 13161 and should be not less than that shown in Table 2, Table 3 or Table 4, as relevant to the greatest panel span and thickness. Wet testing should also be requested in accordance with BS EN 12372, BS EN 13161 or BS EN 13364, as appropriate with the samples soaked in potable water at 22° C ±2° C for 48 hours prior to strength testing.

NOTE 1 Flexural strength is the mean value for 10 or more specimens.

NOTE 2 The greatest panel span is the maximum distance between fixings measured parallel to the sides of the panel.

NOTE 3 A factor of safety of 6 has been included in the calculations. Where flexural strength testing is carried out dry, a higher factor of safety might be needed as the exact increase depends on whether the actual flexural strength is determined wet and dry.

Deviations in the nominal thickness of the stone should be in accordance with Clause **8**.

Table 2 **Low wind load environment: minimum flexural strength**

Panel span between fixings mm	**Minimum flexural strength based on panel thickness (t)** MPa					
	t = 20 mm	**t = 30 mm**	**t = 40 mm**	**t = 50 mm**	**t = 60 mm**	**t = 70 mm**
300	1.52	0.68	0.38	0.24	0.17	0.12
450	3.42	1.52	0.85	0.55	0.38	0.28
600	6.08	2.70	1.52	0.97	0.68	0.50
750	9.49	4.22	2.37	1.52	1.05	0.77
900	13.67	6.08	3.42	2.19	1.52	1.12

Table 3 **Medium wind load environment: minimum flexural strength**

Panel span between fixings mm	**Minimum flexural strength based on panel thickness (t)** MPa					
	t = 20 mm	**t = 30 mm**	**t = 40 mm**	**t = 50 mm**	**t = 60 mm**	**t = 70 mm**
300	2.28	1.01	0.57	0.36	0.25	0.19
450	5.13	2.28	1.28	0.82	0.57	0.42
600	9.11	4.05	2.28	1.46	1.01	0.74
750	14.24	6.33	3.56	2.28	1.58	1.16
900	20.20	9.11	5.13	3.28	2.28	1.67

Table 4 **High wind load environment: minimum flexural strength**

Panel span between fixings mm	**Minimum flexural strength based on panel thickness (t)** MPa					
	t = 20 mm	**t = 30 mm**	**t = 40 mm**	**t = 50 mm**	**t = 60 mm**	**t = 70 mm**
300	3.04	1.35	0.76	0.49	0.34	0.25
450	6.83	3.04	1.71	1.09	0.76	0.56
600	12.15	5.40	3.04	1.94	1.35	0.99
750	18.98	8.44	4.75	3.04	2.11	1.55
900	27.34	12.15	6.83	4.37	3.04	2.23

4.3.3 Breaking load at the fixings

The breaking load at the fixings and the resistance to lateral loads should be determined in accordance with BS EN 13364 and should be not less than that shown in Table 5.

NOTE 1 The load varies with the panel area and the lateral loading.

The breaking load at the fixings should be taken as the mean value for 10 or more specimens when tested wet (see **4.3.2**).

As the result is based on the thickness of the test specimens, this should be based on the thickness indicated by Table 2, Table 3 and Table 4.

NOTE 2 Available data indicate that the strength around the fixing might be the more critical value and might affect the thickness.

NOTE 3 The panel area is taken as the maximum height in metres multiplied by the maximum width in metres.

NOTE 4 A factor of safety of eight has been included in the breaking load calculations in Table 5. Where flexural strength testing was carried out in dry conditions, a higher factor of safety might be needed, e.g. 9 rather than 8.

Deviations in the nominal thickness of the stone should be in accordance with Clause **8** and BS 8298-1:2010, **7.2.2**.

Table 5 **Minimum breaking load at the fixing**

Panel area m^2	Minimum breaking load based on location N		
	Low wind load environment	**Medium wind load environment**	**High wind load environment**
0.4	1 200	1 800	2 400
0.5	1 500	2 250	3 000
0.6	1 800	2 700	3 600
0.7	2 100	3 150	4 200
0.8	2 400	3 600	4 800
0.9	2 700	4 050	5 400

4.4 Impact resistance

The risk of impact on the surface of the cladding system should be considered at the design stage and the recommendations of BS 8298-1:2010, **6.14** should be followed.

4.5 Cramp mortices and sunken dressed margins

The minimum thickness of stone in front or behind a slot or mortice should be suitable for its intended application. In the absence of any specific testing or calculation, the minimum thickness should be 12 mm for stones of 15 MPa mean flexural strength or greater, and 25 mm for all stones below 15 MPa. The location and type of different fixings should also be assessed using performance testing and/or calculation. Where stone might be vulnerable to impact damage, such as at plinth (ground) level, additional measures, e.g. using thicker stones in the affected area, or sealing the backs of the stones before fixing and then filling the cavity with a lightweight fine concrete mix after fixing, should be used.

Rebates can extend the full length of the stone (particularly where the stone is seated on a continuous angle). The quantity of stone left in front of the rebate is dictated by the type of stone: the performance under lateral load should then be determined by testing. In the absence of any specific testing or calculation, the minimum thickness should be 12 mm for stones of 15 MPa mean flexural strength or greater, and 25 mm for all stones below 15 MPa.

Where the design of the cladding incorporates a sunken dressed margin to provide a recessed joint (rustications) where it coincides with any fixings, its size should not compromise the performance of the stone.

Where fixings are located in the same joint as the rustication, the overall thickness of the stone should be increased or specifically tested in accordance with BS EN 13364.

4.6 Soffit stones

Soffit stones should not exceed 900 mm × 600 mm. If stones of a greater size are required, they should be justified by calculation.

In the absence of any specific calculation, the minimum thickness should be 40 mm for stones of 15 MPa mean flexural strength or greater, and

75 mm for all stones below 15 MPa. In all cases, the thickness of stone behind the fixing should be 50% of the total thickness of the stone.

5 Methods of attachment and support

5.1 General

NOTE 1 Typical loadbearing, restraint, face and soffit fixings are shown in Figure 1, Figure 2 and Figure 3 respectively.

Allowance should be made for articulation of cladding components, to take account of differential thermal movements.

NOTE 2 The methods of attachment of units to the structure vary widely, depending upon the type of stone, the size of the units and the structure of the building. Fixing devices fall into five groups:

*a) loadbearing fixings (see **5.5**);*

*b) restraint fixings (see **5.6**);*

*c) combined loadbearing and restraint fixings (see **5.7**);*

*d) face fixings (see **5.8**);*

*e) soffit fixings (see **5.9**).*

It is not normally possible to ascertain the conditions of fixings or to undertake maintenance once the cladding has been completed; therefore, the metals described in BS 8298-1:2010, **5.2**, should be used, as they offer high resistance to corrosion and do not require maintenance.

5.2 Design

Fixings should be able to withstand imposed loads; these could be dead load from the cladding together with lateral loads from wind pressure and suction, which are equal to the basic wind pressure appropriate to the degree of exposure and the height above ground level of individual units.

NOTE Guidance on determining wind loads can be found in Table 1 and BS EN 1991.

The design of the fixings should:

a) allow for three-way adjustment to enable proper fit within holes or mortices in the stone and to the substrate;

b) take into account the difference between the specified tolerances for the finished cladding and the likely structural tolerances as set out in BS 5606.

Where fixings are being set in a concrete-block backing wall, the location of bed joints in the blockwork in relation to the position of the fixings should be determined. Cast-in channels in structural concrete should be aligned.

Fixings should be such that claddings are not subject to undesirable stresses which might arise, for example, from the attachment to the structure being too rigid (see BS 8298-1:2010, **6.13**).

As fixings can be subject to a combination of direct bending, shear and torsional stresses, these stresses should be addressed in the design. Fixings should be designed using the appropriate stresses (see **4.3)** and should conform to BS 8298-1:2010, **5.2**.

The number, type and position of fixings should be calculated based on:

1) the stone to be used;
2) the thickness and face area of the units;
3) the nature of the substrate, e.g. in-situ concrete, brickwork, blockwork; and
4) the load applied to each fixing, i.e. dead load, cyclic load or a combination of both.

Wherever anchor slots, inserts or preset fixings of any kind are cast into structural concrete, it is essential that these are accurately positioned. Where, for any reason, the anchor slots, inserts or fixings are not accurately positioned, a new fixing should be provided which is securely post-fixed into the structural concrete.

Fixings into the back faces of stones which cannot be adjusted after the stone has been placed in position (i.e. blind fixing) should be avoided.

Figure 1 **Illustration of typical loadbearing fixings**

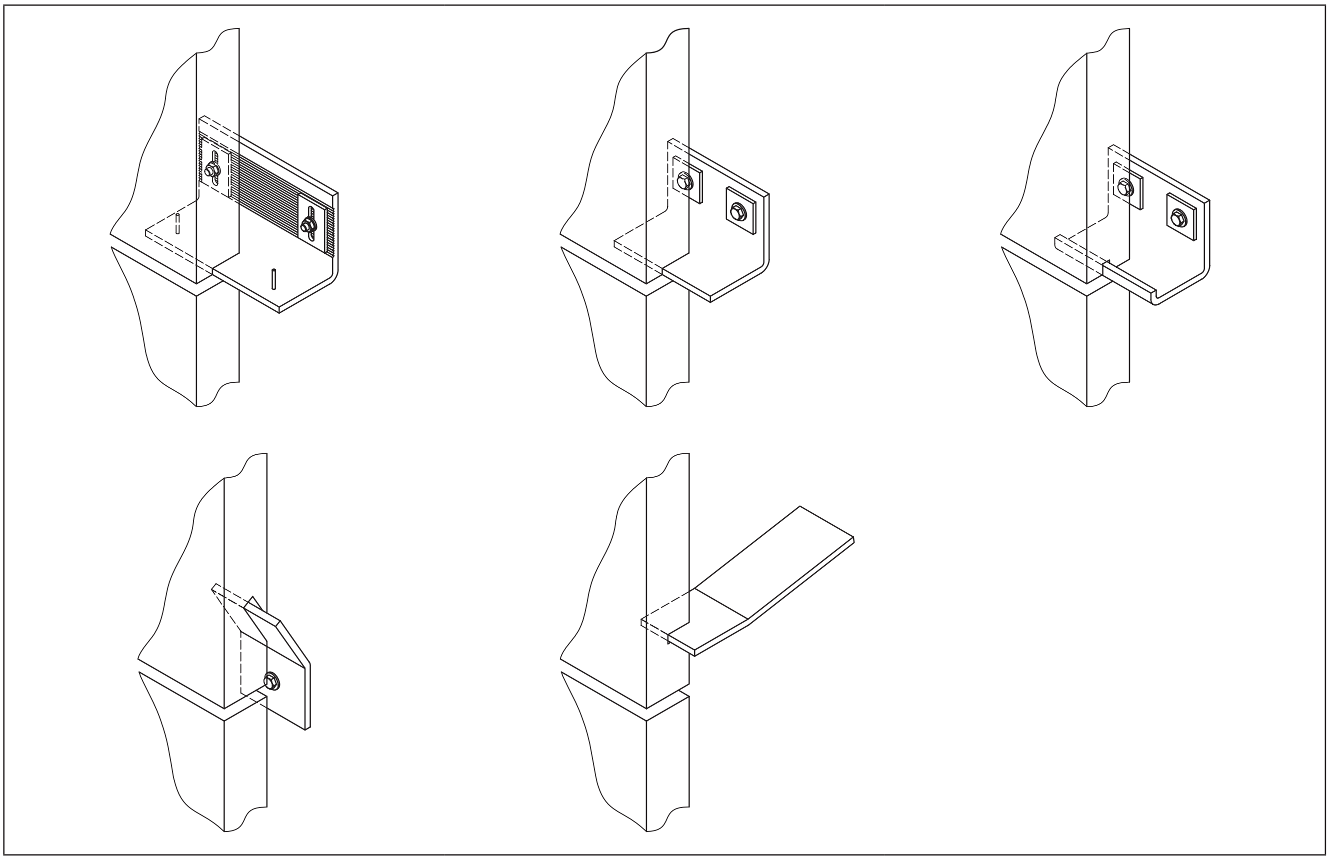
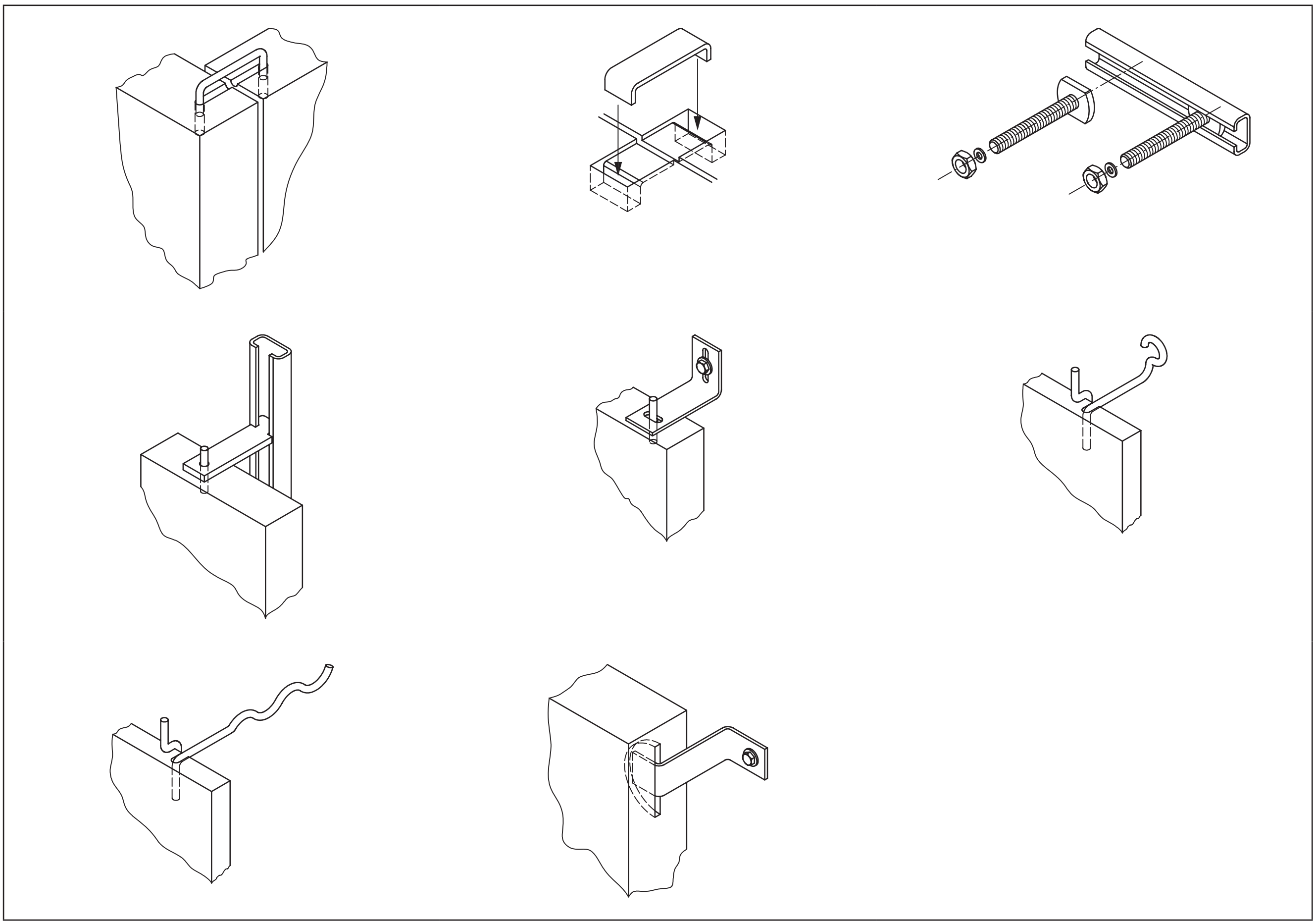


Figure 2 **Illustration of typical restraint fixings**



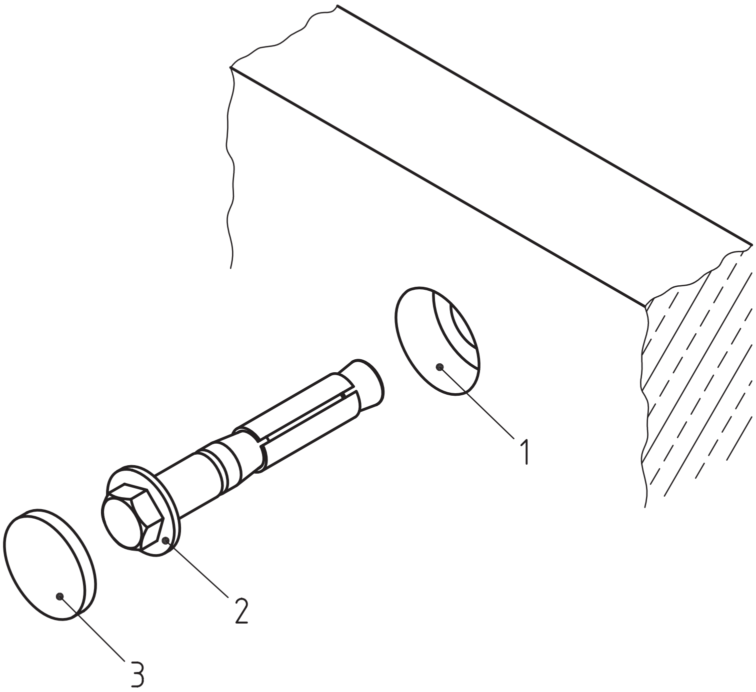
5.3 Cement/resins

The mortar used for holding the fixings in place in the cladding or in the concrete structure, should consist of one part ordinary or rapid-hardening cement to one part sand.

Mortar should be mixed to a fairly dry consistency, well-tamped into the hole around the fixing and left to mature for 48 h before being subjected to stress.

Where the fixings are to be secured into the stone panels using resin, the resin type selected should be compatible with the metal fixings and specifically formulated for use with the stone. All resins should be supported with the appropriate fire-rating certificate.

Figure 3 **Illustration of typical face and soffit fixings**



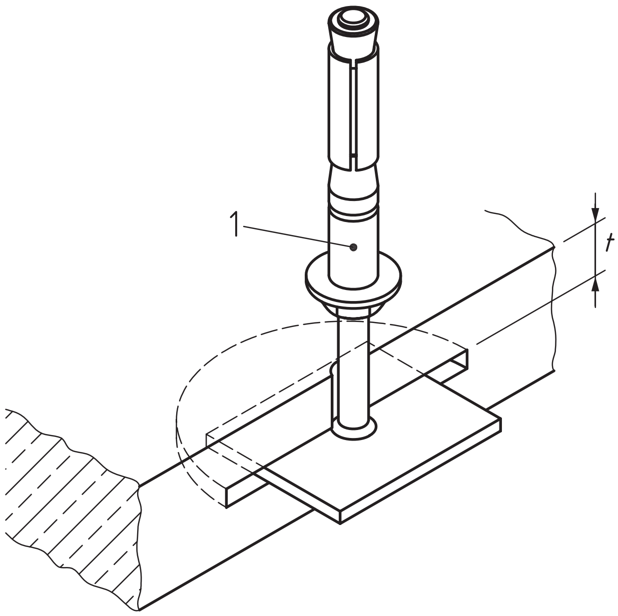
Key

1 Countersunk hole

2 Oversize washer

3 Disguising pellet

a) Face fixing



Key

1 Expanding bolt

b) Soffit hanger

NOTE "t" is the minimum thickness of stone behind the soffit hanger.

5.4 Stress for fixings

5.4.1 Working stresses for stainless steel fixings

The recommended working stress values to be used when designing fixings manufactured from stainless steel should be in accordance with Table 6.

Table 6 **Permissible stresses for austenitic stainless steel**

Application	Permissible tensile stress N/mm^2	Permissible shear stress N/mm^2
Brackets made from sheet, plate or strip	129	77
Bolts, nuts and studs made from rod or bar	116	70

For simple fixings, the design should be based on 59% of the 0.2% proof stress to calculate the permissible stress; this design approach minimizes the possibility of permanent deformation. Due to the variations in the mechanical properties of the different grades of austenitic stainless steel, the lowest values from Table 7 and Table 8 (these are the specified minima) should be used.

Table 7 **Minimum mechanical properties of austenitic stainless steel sheet, plate and strip given in BS EN 10088-2**

Grade	0.2% proof stress N/mm^2	Ultimate tensile strength N/mm^2
1.4301	210	520
1.4305	190	500
1.4307	200	500
1.4401	220	520
1.4404	220	520
1.4541	200	520

Table 8 **Minimum mechanical properties of austenitic stainless steel rod and bar given in BS EN 10088-3**

Grade	0.2% proof stress N/mm^2	Ultimate tensile strength N/mm^2
1.4301	190	500
1.4305	170	475
1.4307	180	460
1.4401	200	500
1.4404	200	500
1.4541	190	500

5.4.2 Specified properties and working stresses for stainless steel bolts and nuts

The mechanical properties of the stainless steel fasteners should be in accordance with BS EN ISO 3506-1.

5.5 Loadbearing fixing

NOTE See Figure 4.

Wherever possible, loadbearing fixings should be at the lower edge of the panel. The effective length of the mortice should not exceed ⅙ the length of the stone in which they are located. Corbel supports should penetrate to not less than 3 mm of the full depth.

Where a continuous rebate is formed in the bottom edge of the stone to accept continuous support, the size selected should not compromise the performance of the stone. In the absence of any specific testing or calculation, the minimum thickness should be 12 mm for stones of 15 MPa mean flexural strength or greater, and 25 mm for all stones below 15 MPa. The location and type of different fixings should also be assessed using performance testing and/or calculation.

Loadbearing support members such as corbel plates and angles should support the applied loads to be carried. A single support carrying two stones should not be less than 100 mm in width. At vertical movement joints, stones should be carried on two separate supports, one each side of the movement joint and each support should be not less than 50 mm in width. Restraint fixing should be provided at, or adjacent to, the level of the loadbearing supports.

Corbel plates should be built into pockets formed in the supporting structure or, where embedment cannot be achieved, an alternative method of support should be used. The embedment of such corbels into the structure should be equal to twice the projection of the corbel from the actual face of the structure.

Corbel plates should be set horizontal or inclined slightly upwards towards the outer face. Loadbearing fixings can incorporate a restraint function (see **5.7**).

5.6 Restraint fixing

Restraint fixings should resist positive and negative wind pressure and any imposed loads from window cleaning equipment and so on. The recess in the stone for such fixings should be a hole, mortice or enclosed rebate. To achieve structural efficiency and reduce the likelihood of damage, the recess should be located at approximately ⅕ points for stack bonded stones and ¼ points for ½ bonded stones (see Figure 2). If this cannot be achieved, the fixing should be at least 75 mm from the corner.

Unless proved by structural calculation or performance testing, the peripheral distance between restraint fixings should not exceed 1 200 mm. There should be a maximum of four restraint fixing points per stone. Generally, these should be located in pairs in the top and bottom joints, but this will be dictated by the stone layout and sequence of erection. The bottom of the stones may be restrained by the use of combined loadbearing/restraint fixings (see **5.7**), though site installation practice should be carefully controlled. It is essential that restraint fixings do not cross any movement joints.

The type of fixing selected is largely dependent on the thickness of stone and, in all cases, the embedment in the stone should be not less than 20 mm.

For grouted fixings the depth of embedment in the structure should be not less than 75 mm.

Units nominally 30 mm thick and under should be restrained using cramps, with the dowels being not less than 3 mm in diameter (see Figure 5).

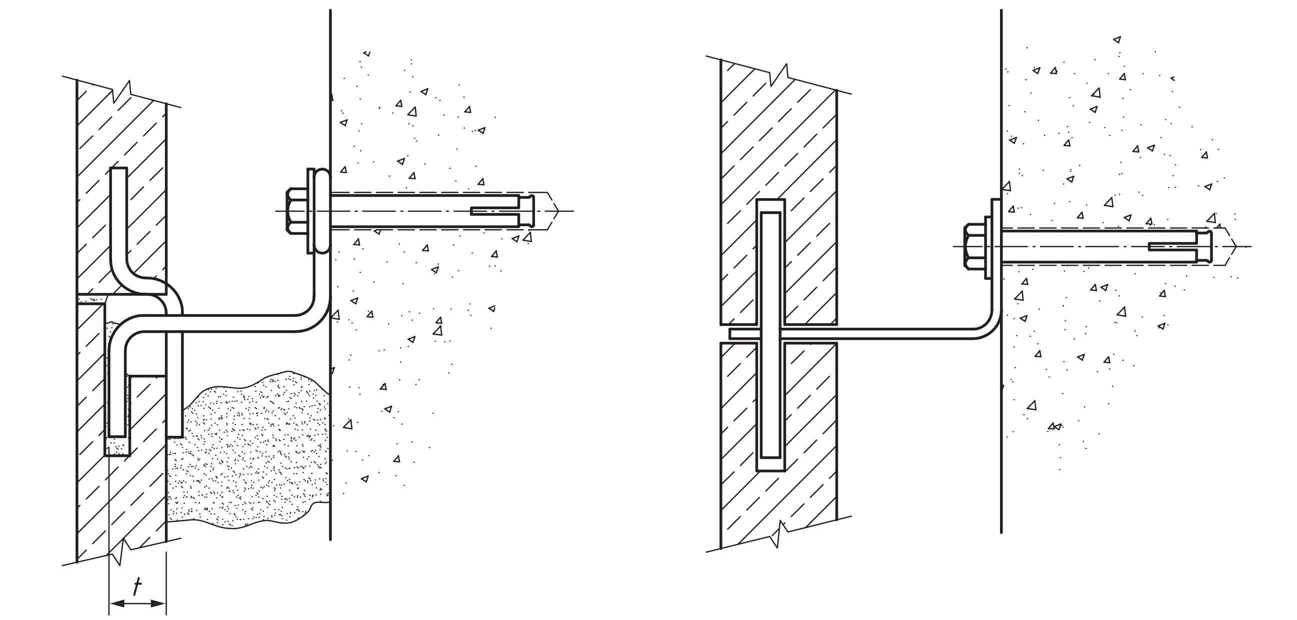
Units nominally 40 mm thick should be restrained using cramps, with the dowels being not less than 5 mm in diameter (see Figure 5).

Units nominally 50 mm thick should be restrained using cramps, with the dowels being not less than 6 mm in diameter (see Figure 5).

5.7 Combined loadbearing and restraint fixing

Combined loadbearing and restraint fixings should resist the positive and negative pressures and the dead load of the stone. They should be positioned as close to the bottom of the stone as possible.

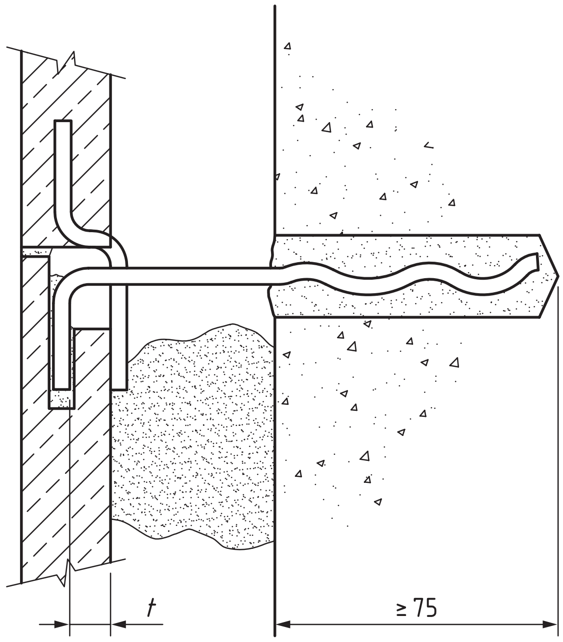
Figure 4 **Details of typical loadbearing fixings**



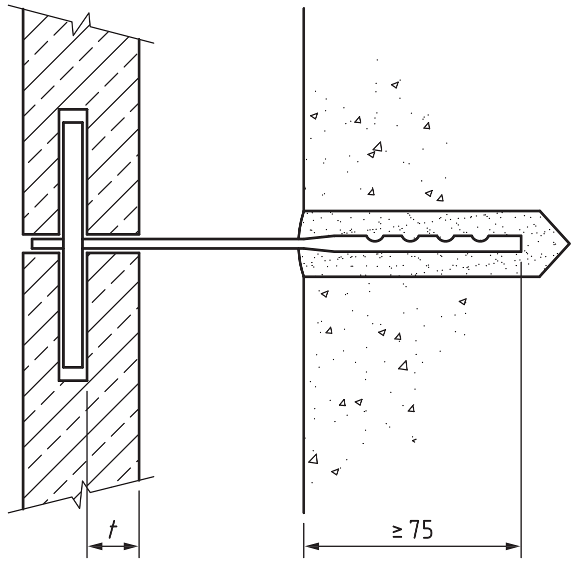
a) Bolted wire ties

b) Bolted cramp and dowel

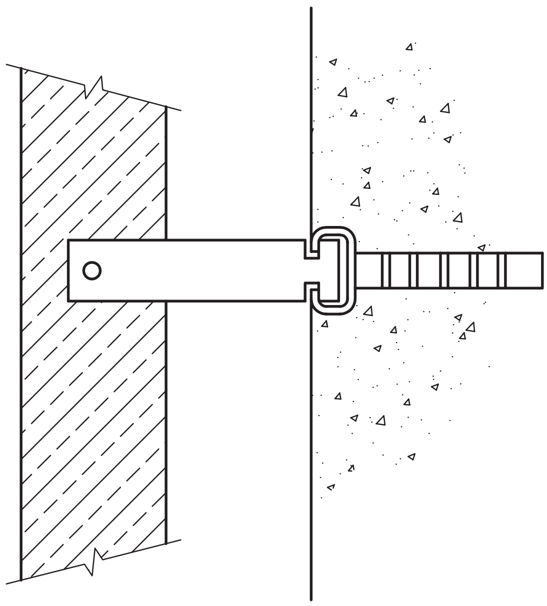
Figure 4 **Details of typical loadbearing fixings** *(continued)*



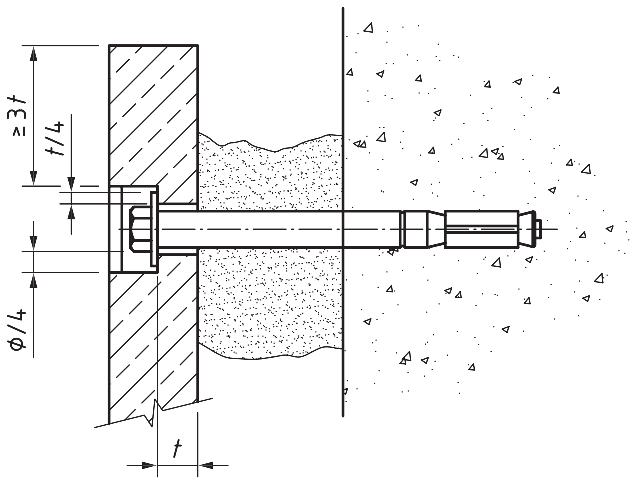
c) Grouted wire ties



d) Grouted cramp and dowel

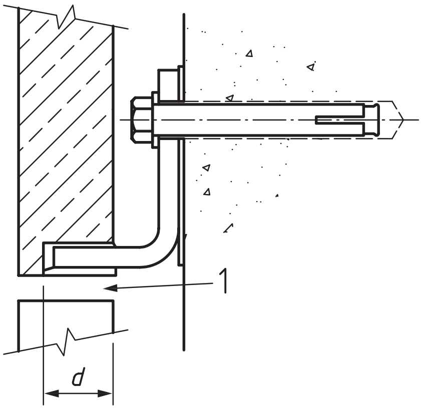


e) Cast-in channel and cramp



f) Face fixing

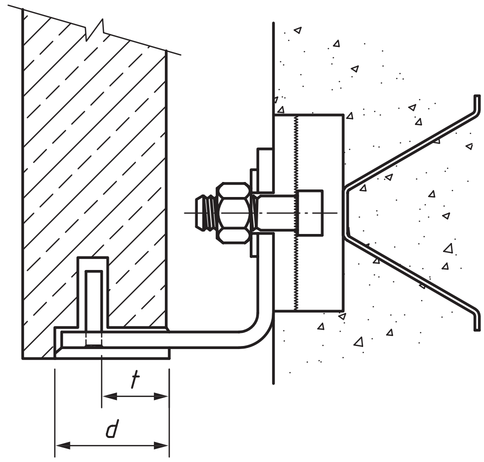
Figure 5 **Details of typical restraint fixings**



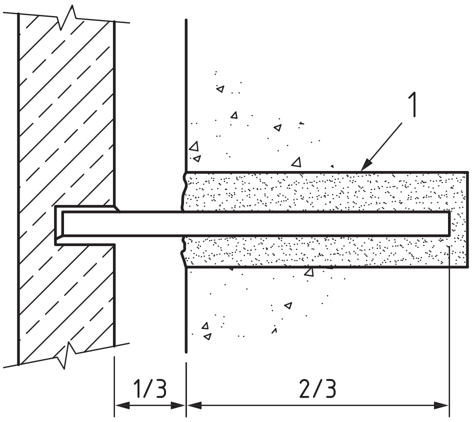
Key

1 Compression joint below loadbearing fixing

a) Bottom edge support



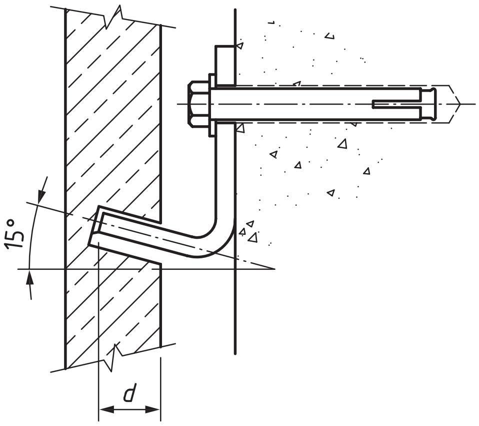
b) Bottom edge support with restraint



Key

1 Preformed pocket

c) Support by a corbel plate in a slot



d) Support by a corbel plate in a slot with restraint

5.8 Face fixing

NOTE 1 Face fixings are normally used where a concealed fixing cannot be installed [see Figure 4f)]. They have the advantage that they can be visually inspected after erection.

Face fixings can function as both loadbearing and restraint fixings and should have adequate spacing from the edge of the stone while still maintaining a secure fixing.

Four fixings should be used, located at a clear distance measured from any edge equal to three times the minimum thickness of stone behind a cramp mortice but not less than 75 mm. A greater distance in from the edge should be used for stones reduced in strength, e.g. rebated or damaged.

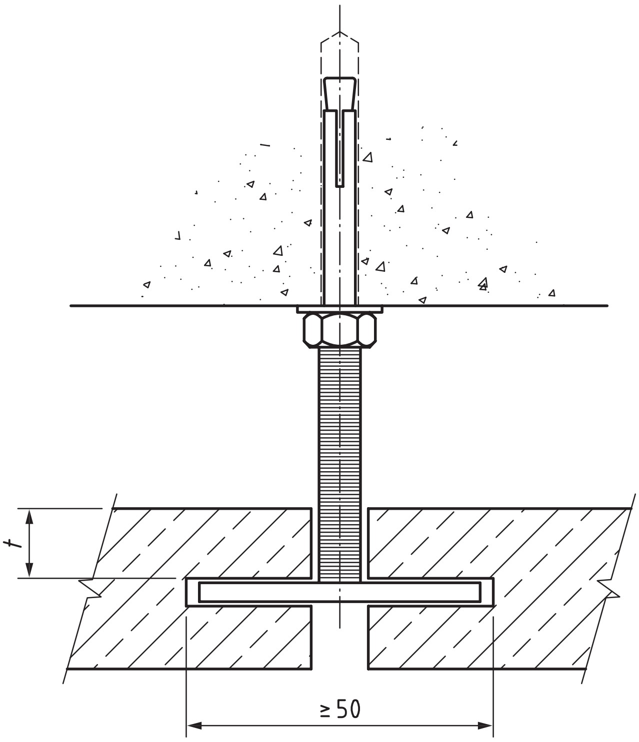
NOTE 2 For small stones, fewer than four bolts might be sufficient.

Any hole which has to be re-drilled because a fixing cannot be achieved should be positioned away from any other holes at a clear distance equal to at least three times the minimum thickness of stone behind a cramp mortice.

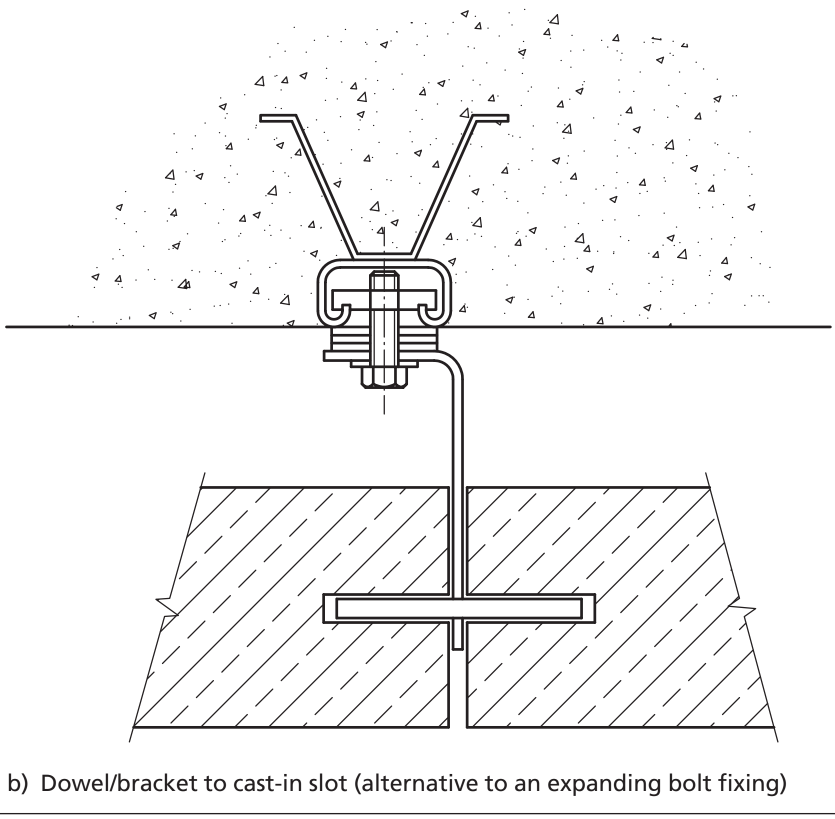
The type of expanding bolt or resin bonded anchor and any sheathing used should not apply a force which might impose undue stress on the stone. Where expanding anchors are used, the whole assembly should be made from stainless steel.

Figure 6 **Details of typical soffit fixings**

Dimensions in millimetres



a) Bolted hanger plate



b) Dowel/bracket to cast-in slot (alternative to an expanding bolt fixing)

5.9 Soffit fixing

The attachment of cladding to soffit or sloping surfaces (72° maximum) where permanent load is imposed on the fixing presents special problems.

Soffit units are suspended from bolts or hangers which are connected to anchorages cast into the structure; where expanding bolts or resin bonded anchors are used (see Figure 6), their performance should be justified by testing.

NOTE Soffit stones can also be face fixed as shown in Figure 6.

5.10 Block liners

On most types of stone, the use of block liners should be avoided; they can, however, be used as reinforcement to naturally unsound types of stone, such as brecciated marbles. At corbel supports, block liners should not be used to transmit the weight of the stone. Corbel plates should penetrate the un-reinforced panels to the minimum depth, *d*, equal to half the thickness of the stone or 20 mm, whichever is the greater.

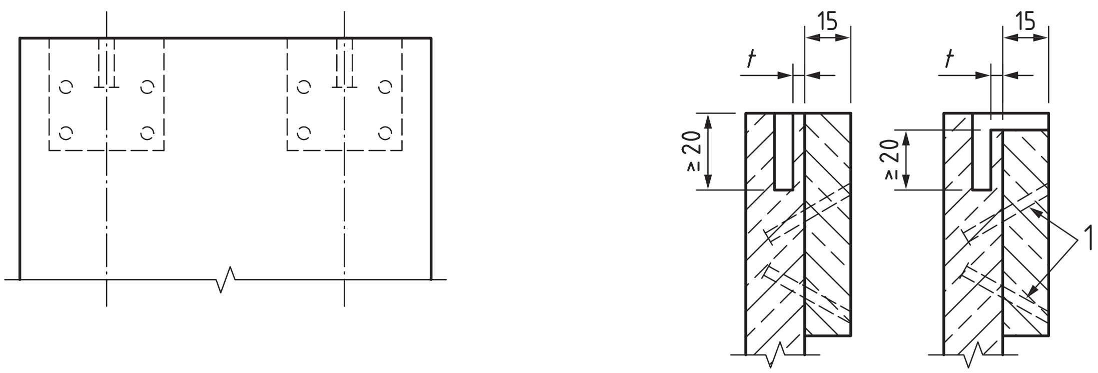
Block liners should be attached under factory conditions and be not less than 75 mm × 75 mm × 15 mm, cross pinned and glued with a two-part polymeric adhesive or similar.

NOTE Typical details of block liners are shown in Figure 7.

Stones that are naturally unsound and normally require stopping, cramping or reinforcing should only be used for low-level and internal work.

Figure 7 **Block liners**

Dimensions in mm



a) Elevation b) Sections

Key

1 Dowel pins in resin

NOTE "t" is the minimum thickness of stone behind cramp mortices.

5.11 Bolts

5.11.1 General

Bolts should be located carefully, especially in reinforced concrete structures where drilling holes could expose the steel.

NOTE The location of steel reinforcement can be determined by the use of a "cover meter".

The bolt manufacturer's recommendations on the location of anchor bolts should be followed for spacing and edge distances.

5.11.2 Expanding bolts

Where expanding bolts are used, the effective penetration of these bolts into the structure should be considered in relation to the magnitude of the forces to be resisted and the suitability of the substrate. Guidance should be sought from the bolt manufacturer or a specialist designer.

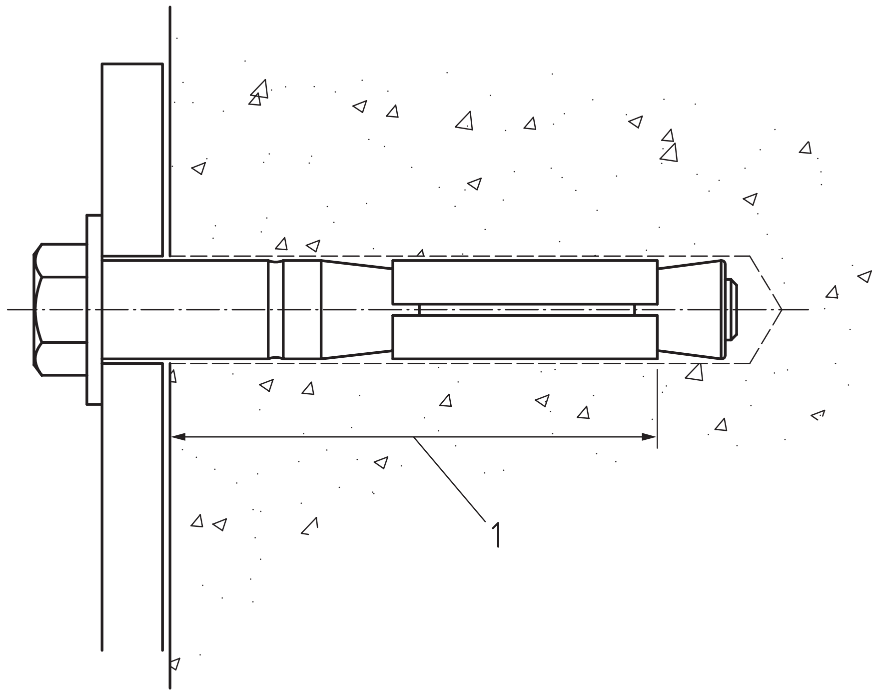
NOTE When the anchor bolts offered are not supported with ETA or CE marking, attention is drawn to the requirements of Part A1 and Part A2 of the Building Regulations [1–2] and justification by testing.

Where expansion anchors are used, the minimum effective penetration depth should be in accordance with Table 9 and Figure 8.

Table 9 **Minimum effective penetration requirements for expanding bolts**

Type of fixing	**Minimum effective penetration**	
	Concrete	**Brick**
	mm	mm
Loadbearing	75	100
Soffit	75	100
Restraint	50	75

Figure 8 **Effective penetration of a typical expanding bolt**



Key

1 Effective penetration

5.11.3 Bolt tightening

All bolt fixings should be tightened in accordance with the manufacturer's recommended torque figures. Due to the nature of the material, once installed and tightened to the correct torque, anchor bolts should not be retightened as relaxation naturally takes place.

NOTE The manufacturers' declared working loads (for bolts carrying ETA or CE marks) take into account this relaxation.

5.12 Resin bonded fixings

NOTE Attention is drawn to resin bonded fixings being supplied/supported with the appropriate ETA performance certificate or CE marking.

*COMMENTARY ON **5.12***
In some situations, resin bonded fixings can be used. Their effectiveness depends upon:

a) the shelf life of the resin;

b) the standard of workmanship;

c) the type of structure;

d) the occurrence of voids in the structure.

Where these matters can be satisfactorily resolved and their structural adequacy proved by project specific testing, there are occasions when such anchors can be used to transmit loads in shear.

A resin bonded fixing, with an appropriate expected design life, should selected.

5.13 Load-bearing masonry supports

*COMMENTARY ON **5.13***
In addition to the metal fixing methods, support can be provided by:

a) bonder or corbel courses forming part of the background, the background and cladding being built simultaneously;

b) beams, floor slabs or units projecting from the face of the background.

The positional accuracy of the structural supports is critical to proper setting of the units, and these should be constructed with a permissible deviation not exceeding ±10 mm. In the case of structural corbel courses, etc. that provide direct support for the units, between half and two-thirds of the unit thickness should receive direct bearing upon the support. Stainless steel load-bearing fixings should be used because of the degree of accuracy required when using a continuous corbel.

Where the cladding is to be restrained to a solid or cavity wall (whether on a masonry structure or on a concrete-framed structure with brick or block infill panels) sufficient time should be left to allow the mortar bedding to cure before fixings are installed.

NOTE See BS 8298-1 for construction tolerances.

5.14 Glued and pinned returns

Where two pieces of stone are fabricated to provide a stone with a return piece to form at the external corner, the size of the return and method of gluing and pinning should be carefully considered. Whether a butt joint or birds' mouth joint, the corner should use dowel pins and block liners located at not more than 300 mm centres with dog cramps located in the top and bottom bed of each stone.

All types of stone can be glued and pinned; the length of the return, particularly if unsupported, should not exceed values in Table 10.

Table 10 **Length of return**

Stone thickness mm	**Overall length of return**
20	5 × thickness
30	5 × thickness
40	4 × thickness
50	4 × thickness
75	3 × thickness

NOTE All gluing and pinning needs to be carried out under controlled conditions at the manufacturing works.

Where longer returns are needed, consideration should be given to the methods of transportation, handling, installation and external loadings, e.g. wind loads and live loads.

5.15 Fascia, pilaster and stall-riser stones

Where the fascia, pilaster or stall-riser stones are fixed to a framework, the framework should consist of suitable members having adequate strength and stiffness, securely fixed to the building. If timber is used, it should be preserved in accordance with BS EN ISO 11600.

6 Jointing and pointing

6.1 General

A joint might need to be both loadbearing, or to accommodate movements of the cladding and any movement of the superstructure that can be transmitted to the cladding; in all cases, joints should be weathertight. The joint should always take account of the respective manufacturing, setting out and assembly deviations of the materials used in accordance with BS 5606 and BS 6093.

When selecting the type of joint to be used, the following points should be taken into account.

a) The joint should be simple (square cut edge) so that reasonable manufacturing tolerances can be allowed and the erection procedure is straightforward.

b) Allowance should be made for movements of the building and dimensional changes in the joints between units.

NOTE The type of jointing or pointing depends upon the type, size, thickness and surface finish of the cladding units and also its location on the building, environmental condition, aesthetic requirements and designed life.

6.2 Unfilled joints

Butt joints should not be used.

NOTE With butt joints, any movement of the units cannot be absorbed and would, therefore, be transmitted between the units, and these might become damaged as a result. This movement could occur during fabrication or in service. In addition, any slight out-of-squareness of the units or irregular abutting would cause point loading which, in turn, would lead to damage at these points.

Open joints are sometimes used as a design feature but, if external, should only be used where the effect of water penetration to the cavity has been fully assessed and allowed for (see **4.3**).

6.3 Filled joints other than compression and movement joints

*COMMENTARY ON **6.3***
Joints in external cladding, particularly sandstone and limestone, are usually filled with cement and sand or cement, lime and sand mortars. Lime mortars using naturally hydraulic lime and sand or stone dust can also be used. Increasingly for granite, slate and marble, an approved sealant is used.

Where mortar is used, the cladding should be bedded and pointed with the same mortar as one operation, even if it is a special colour, as all mortar is then homogeneous.

NOTE If it is necessary to introduce colours as a separate operation, the joints can be raked out to a minimum depth of 13 mm as the work proceeds.

7 Width of joints and type of filling

7.1 General

The maximum width of mortar-filled joints should be 13 mm, but sealant-filled joints can be up to 30 mm wide subject to the manufacturer's advice. The minimum width of joints should be in accordance with Table 13, which allows for cutting tolerances.

NOTE Where specially required, the minimum width can be reduced but this can demand extra precision in production of the stones.

Where narrower joint widths are required, face dimensions tighter than those shown in BS 8298-1:2010, **7.2.2**, might be necessary; where tighter cutting tolerances are required, these should be agreed between the specifier and supplier prior to tender.

If the joint width is less than that given in Table 11, the implications for jointing material should be considered at the tender stage.

Table 11 **Minimum width of joints**

Stone	**Minimum width of joint**	
	Mortar	**Sealant**
	mm	mm
Granite, marble and slate	3	6
Slate with riven finish	7	7
Limestone and sandstone	5	6

7.2 Compression and movement joints

7.2.1 General

Compression and movement joints should be in accordance with **7.2.2** and **7.2.3** but account should also be taken of the time between construction of the frame and erection of the cladding. The shorter the period between these operations, the bigger the joints should be. No grout, mortar or other material should be allowed to accumulate in the joint. Before application of a flexible sealant, all joints should be cleaned and inspected.

7.2.2 Compression joints

*COMMENTARY ON **7.2.2***
The compression joint is designed to accept primarily the vertical shortening of a frame, in order to prevent a build up of compressive forces being transferred to the cladding.

Compression joints are horizontal and should be provided at each floor level immediately under the support for the cladding, although a greater spacing can be achieved if the fixings between the cladding and the structure are correctly detailed to allow relative movement between the two.

The width of the joint should be calculated to allow for maximum column or wall shortening from all causes. The calculation should also allow for compressibility [movement accommodation factor (MAF)] of the jointing or joint caulking and sealing material which, when fully compressed, might transmit pressure. The width of the joint should not be less than 15 mm, unless the calculation indicates that this value can be varied.

The material for the compression joint should be readily compressible and can consist solely of a sealant or a backing material with a pointing of sealant. The compression joint should be watertight. The time at which the compression joints needs to be sealed depends upon the detail design of the units and upon the materials used for making the compression joint; the joint should be left open for as long as practicable.

NOTE Compression of the joint results in the sealant protruding beyond the face of the cladding. The protrusion can be reduced if the sealant is tooled concave at the time of application, or eliminated by the use of a recessed joint.

7.2.3 Movement joints

The units and the structure to which they are fixed are both liable to dimensional changes. These dimensional changes should be accommodated by the provision of movement joints so that the cladding is not disrupted.

Compression joints (see **7.2.2**) should normally accommodate any movements in the height of the building, but movements along the length of the building should be accommodated by vertical movement joints.

In many buildings, a structural movement joint (commonly known as an expansion joint) might already be incorporated in the design to accommodate the movements of the building; where this is the case, the joint should be taken through the cladding. The amount of movement to be accommodated at these points can be appreciable and the sealant for pointing the joints should be selected accordingly.

A movement joint should be placed between 1.5 m and 3 m from any corner and the distance between the joints should not exceed 6 m.

NOTE The width of the movement joint depends on a number of factors: the distance between the movement joints, the expected amount of movement and the maximum strain that can be accommodated by the sealant (MAF). Movement has two main components, thermal and moisture, and the magnitude of the movement can be estimated by the method outlined in BS 8298-1:2010, ***6.13****. The movement calculated is not the width of the joint, but the strain that the sealant has to accommodate (MAF). For example, if the estimated movement over a given distance is 1 mm and the sealant can accommodate strains of up to 10%, the movement joint has to be at least 10 mm wide.*

The allowance for joint width should be not less than 10 mm per 6 m length of cladding. Adequate movement joints should be provided in the cladding to parapets and to copings, since parapets are generally more affected than other parts of the building, being open to the weather on two sides.

8 Permissible deviations

The design should allow for deviations in the erection of the structure and in the cladding and joints.

NOTE 1 Deviations of cladding units are given in BS 8298-1, but (when erected) joint widths normally vary to take up these deviations.

If evenness of joint width is required, the use of purpose-made end units should be used if desirable, since slight variations in the dimensions of an occasional unit are likely to be less noticeable than wide variations in joint width between units. Reference should also be made to BS 5606 and BS 6093.

Construction tolerances for cladding should be agreed at the tender stage to avoid problems during construction.

NOTE 2 Suggested construction tolerances based on BS 5606 are given in Table 12.

Table 12 **Stonework erection tolerances**

Walls	**Cladding construction tolerance**
	mm
Overall height (up to 3 m)	±10
Verticality [A)] (up to 3 m)	±6
Verticality [A)] (up to 7 m)	±10
Straightness (in 5 m horizontal)	±6
Bed joint level (in 5 m)	±6
Length along wall (in 6 m)	±10

A) The tolerance on verticality is measured in relation to the true vertical from the base of the wall and is not cumulative.

Annex A (normative) Alternative guidance for the assessment of panel thickness

NOTE 1 This annex provides recommendations, based on satisfactory past experience, for smaller projects where testing is not economically viable.

Recent stone test data from the supplier in accordance with relevant European Standards should be obtained and used. Particular attention should be paid to the test condition (dry/wet) of flexural strength results.

While still using the test results for the stone, if it has been agreed that structural calculations and/or performance testing (flexural strength/modulus of rupture) are not appropriate, the thickness of stone should be in accordance with Table A.1, Table A.2 or Table A.3, as relevant.

NOTE 2 These tables are based on the flexural strength of stone determined from the results of tests according to BS EN 12372 and BS EN 13161.

NOTE 3 BS EN 13161 describes the four point bending moment, rather than the single point bending moment in BS EN 12372, and BS EN 13161 is therefore more likely to detect weakness.

Table A.1 **Panel thickness for high wind load environments**

Greatest span between fixings mm	**Panel thickness based on mean flexural strength** mm			
	1.00 MPa to 2.99 MPa	**3.00 MPa to 8.99 MPa**	**9.00 MPa to 14.99 MPa**	**>15.00 MPa**
>300	50	40	30	30
300 to 450	70	50	30	30
451 to 600	80	60	40	30
601 to 750	—	70	40	40
751 to 900	—	80	50	40

Table A.2 **Panel thickness for medium wind load environments**

Greatest span between fixings mm	**Panel thickness based on mean flexural strength** mm			
	1.00 MPa to 2.99 MPa	**3.00 MPa to 8.99 MPa**	**9.00 MPa to 14.99 MPa**	**>15.00 MPa**
>300	50	30	30	30
300 to 450	60	40	30	30
451 to 600	70	50	40	30
601 to 750	80	60	40	30
751 to 900	—	70	50	40

Table A.3 **Panel thickness for low wind load environments**

Greatest span between fixings mm	**Panel thickness based on mean flexural strength** mm			
	1.00 MPa to 2.99 MPa	**3.00 MPa to 8.99 MPa**	**9.00 MPa to 14.99 MPa**	**>15.00 MPa**
>300	40	30	30	30
300 to 450	50	40	30	30
451 to 600	60	40	30	30
601 to 750	80	50	40	30
751 to 900	—	60	40	30

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[2] SCOTLAND. The Building (Scotland) Regulations 2004. Edinburgh: The Stationery Office.

2) In foreword only.

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