

Code of practice for

Design and installation of non-loadbearing precast concrete cladding

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/209, General Building Codes, to Subcommittee B/209/22, Concrete Cladding, upon which the following bodies were represented:

- Building Employers' Confederation
- Chartered Institute of Building
- Chartered Institution of Building Services Engineers
- Department of the Environment (Construction Directorate)
- Local Authority Organizations
- National Council of Building Material Producers
- National House-building Council
- Royal Institute of British Architects
- Royal Institution of Chartered Surveyors

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- Association of Consulting Engineers
- British Adhesives and Sealants Association
- British Non-ferrous Metals Federation
- British Precast Concrete Federation Ltd.
- Department of the Environment (Building Research Establishment)
- District Surveyors Association
- Federation of Civil Engineering Contractors
- Institute of Clerks of Works of Great Britain Inc.
- Institution of Civil Engineers
- Institution of Structural Engineers

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Foreword

This British Standard has been prepared under the direction of Technical Committee B/209, General Building Codes. It supersedes CP 297:1972 which is withdrawn.

With framed structures, where the loads are carried by the frame and not by the external walling, the materials or combinations of materials used to cover the structural framework are referred to as the cladding.

Cladding, in the form described in this standard, requires care to ensure secure fixing and to prevent or control the ingress of water. Adequate precautions have also to be taken to provide for permanent and temporary movements of the structure due to shrinkage and elastic deformation under load. Movement due to temperature and other factors has also to be taken into account.

This standard describes the provisions necessary for the cladding to perform its function satisfactorily. It gives the minimum standards needed and the materials and methods most frequently used.

Assessed capability. Users of this British Standard are advised to consider the desirability of assessment and registration of a supplier's quality systems against the appropriate Part of BS 5750 by a third party certification body.

Enquiries as to the availability of third party certification schemes will be forwarded by BSI to the Association of Certification Bodies. If a third party certification scheme does not already exist, users should consider approaching an appropriate body from the list of Association members.

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 to iv, pages 1 to 46, 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.

Section 1. General

1.1 Scope

This British Standard gives recommendations for the design and installation of precast concrete cladding in the form of:

- a) units supported by and fixed to a structural frame or wall;
- b) units used as permanent formwork in part or in whole.

The cladding can be self-finished or may carry integral factory cast-in finishes, such as natural stone, bricks, tiles and mosaics.

The standard includes precast cladding using specially formulated and designed mixes to provide special finishes in terms of colour and texture. The finishes include reconstructed stone.

Loadbearing cladding and glass reinforced cement units are not covered by this standard.

1.2 References

1.2.1 Normative references

This British Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on page 44. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this British Standard only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

1.2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the page 46, but reference should be made to the latest editions.

1.3 Definitions

For the purposes of this British Standard the definitions given in BS 6100 apply, except as otherwise defined in this clause. Other terms which are particularly relevant are also defined.

1.3.1

back-up material

material inserted in a joint which limits the depth of the sealant applied and which determines the back profile of the sealant

1.3.2

baffle¹⁾

flexible preformed section designed to be fitted in grooves between the adjacent units to minimize direct entry of rain into an open joint

1.3.3

bimetallic corrosion

corrosion caused by contact between dissimilar metals in the presence of an electrolyte, such as water

1.3.4

cavity barrier

construction provided to close a concealed space against penetration of smoke or flame, or provided to restrict the movement of smoke or flame within such a space

1.3.5

cladding¹⁾

form of building covering that supports only its own weight and environmental forces that may act upon it

1.3.6

composite unit

cladding unit having a facing of materials other than concrete

1.3.7 Fixings

1.3.7.1

loadbearing fixing

fixing designed to support the dead weight of one or more cladding units and to transfer this load directly to the structure

1.3.7.2

location fixing¹⁾

temporary fixing whose sole purpose is to assist in the alignment of the cladding units

1.3.7.3

restraint fixing¹⁾

fixing designed to tie cladding units to their backing or to one another

1.3.8 Joints

1.3.8.1

compression joint¹⁾

joint designed specifically to accommodate partial closure resulting from vertical shortening of the structure relative to the cladding

¹⁾ Definition differs from that given in BS 6100.

1.3.8.2**filled joint**

joint that makes use of a jointing product to fill a gap between the adjacent components

1.3.8.3**movement joint²⁾**

joint that permits movement between adjacent parts

1.3.8.4**open joint²⁾**

completed joint taking the form of an intentional open gap between adjacent units or between a unit and the structure

NOTE A baffle strip may be located in vertical open joints.

1.3.9**sealant²⁾**

material which, applied in an unformed state to a joint, seals it by adhering to appropriate surfaces within the joint

1.3.10**gasket²⁾**

flexible, generally elastic, preformed material that constitutes a seal when compressed, and that resists the passage of water and air

1.4 Exchange of information and time schedules

1.4.1 General

Before tenders are invited a cladding specialist should be consulted to discuss practical time scales, availability and suitability of materials, etc. This is especially important for contracts with large quantities of special aggregates or finishes.

The information needed in order to schedule the work satisfactorily, obtain an accurate price, minimize supply and production difficulties, and ensure safe and practical site fixing, is given in 1.4.2, 1.4.3 and 1.4.4.

1.4.2 Initial feasibility planning

The information needed at the feasibility planning stage includes:

- a) total areas to be clad and their locations on the buildings;
- b) aesthetic and/or visual effect required, in terms of colour; jointing pattern, surface finish and durability;
- c) limitations on the use of the materials;
- d) functions of the cladding, and the type of structure to which it is to be fixed;

e) variations in colour, tone and markings that can occur in the selected materials;

f) approximate time between placing the order and commencing on site;

g) approximate duration of the cladding work on site, taking account of the work of other trades.

1.4.3 At tender stage**1.4.3.1 Design and performance specification**

Cladding specialists invited to tender should be provided with the following information:

a) conditions regarding the building site and site access, and any particular restrictions on the site of units or of deliveries, the time of deliveries or on storage, handling, or distributing facilities, including maximum crane capacities at different radii;

b) programme and/or bar chart defining sequence and duration of site fixing, or an invitation to present recommendations;

c) sufficiently explicit drawings to show the basic construction requirements, including the relationship between the structural frame and the frame of the cladding units, unit thicknesses, jointing (including movement joints) and any special cladding or labours;

d) building tolerance(s) allowed in the structure;

e) type(s) of materials and finishes, and any demands on matching or selection, or limits on variations in appearance;

f) type of pointing, where applicable;

g) type of sealant;

h) method of fixing to be used, or an invitation to present a suitable method;

i) any requirements for the routine, or special, testing of components, before or after erection, or for sample areas or mock-up panels and whether tested units should be retained or placed on the building;

j) criteria for the acceptance or rejection of individual units and fixings.

1.4.3.2 Facilities and materials required on site

To prevent misunderstanding, particularly when tenders are being called, it should be made clear whether or not the following will be provided and by whom:

- a) tower, or mobile crane, for offloading, distributing and raising cladding to fixing positions at each level, and elevation;

²⁾ Definition differs from that given in BS 6100.

- b) hard and level access road on to site and to hoisting positions all suitable for passage and working of delivery vehicles and mobile cranes;
- c) safe storage areas, with firm level access, for use when cladding cannot be directly offloaded and fixed to buildings;
- d) scaffolding, if required;
- e) cradles, if required;
- f) pushpull props or other items for temporary restraint or supports during fixing operations;
- g) supply of materials for bedding and grouting;
- h) datum lines and levels at each level and on each elevation;
- i) accurate and properly prepared fixing positions, marking out, forming, drilling all holes, mortices, pockets or bolts, dowels;
- j) water and electrical (110 V) supply to within 30 m of working areas to each level;
- k) provision of compressed air for hand tools, if required;
- l) provision of adequate task lighting to enable work to be continued;
- m) space for the provision of site accommodation/lock up store and installation of 240 V supply;
- n) provision of messing, toilet, medical and other welfare facilities;
- o) protection of fixed units from any likely physical damage or staining;
- p) removal of debris from agreed collecting areas;
- q) watching and protection of work, goods and materials fixed and unfixed.

1.4.4 Order documentation

If not previously notified, the following should be clearly stated and agreed as part of the order documentation and should be agreed before awarding any subcontract:

- a) fixing programme, and sequence, by elevation and levels;
- b) availability of a full set of latest architect's and/or structural engineer's design drawings giving all data relevant to the cladding;
- c) availability for taking site dimensions, if these are necessary;
- d) time for the preparation of production drawings (in fixing sequence when many involved);
- e) time for the architect to check and return production drawings, either approved or for amendment, incorporating all the design team comments;
- f) time between approval of production drawings and delivery of units to site;
- g) minimum notice for any changes to the fixing programme and opportunity to assess cost or extension implications.

Section 2. Materials and components

NOTE Materials other than those listed in 1.4 to 2.5 may be used if their suitability can be demonstrated to the satisfaction of the design engineer, and they conform to relevant British Standards if appropriate.

2.1 Materials for precast concrete

2.1.1 Cement

Cement should conform to the following British Standards:

Ordinary and rapid-hardening Portland cement	BS 12
Sulfate-resisting cement	BS 4027

Other cements conforming to the following standards may be used, but as concrete made with these cements may have different properties they should only be used after their suitability has been demonstrated (see also 6.1.2 of BS 8110-1:1985).

Portland blastfurnace cement	BS 146
Portland pulverized-fuel ash (PFA) cement	BS 6588

Combinations manufactured in the concrete mixer from Portland cement and ground granulated blastfurnace slag (GGBS) or PFA should conform to the following British Standards.

Ordinary Portland cement with GGBS conforming to BS 6699	BS 146 BS 4246
Ordinary Portland cement with PFA conforming to BS 3892-1	BS 6588
Portland limestone cement	BS 7583

2.1.2 Aggregates

Aggregates should conform to the following British Standards:

Aggregates from natural sources	BS 882
Lightweight aggregates	BS 3797

2.1.3 Additions

If the following materials are used, they should conform to the relevant British Standards:

Ground granulated blastfurnace slag	BS 6699
Pulverized-fuel ash	BS 3892-1

2.1.4 Admixtures

Admixtures should conform to the following British Standards:

Accelerating admixtures	BS 5075-1
Retarding admixtures	BS 5075-1
Water reducing admixtures	BS 5075-1
Air entraining admixtures	BS 5075-2
Superplasticizing admixtures	BS 5075-3

Other admixtures may be used if their suitability can be demonstrated.

2.1.5 Pigments

Pigments should conform to BS 1014.

2.1.6 Water

Water should be clean and free from materials deleterious to concrete (see Appendix A of BS 3148:1980).

2.1.7 Reinforcement

Steel reinforcement should conform to BS 4449, BS 4482 and BS 4483, as appropriate. Stainless steel reinforcement should conform to BS 6744.

2.1.8 Facing materials

Where composite construction is envisaged, care should be taken to ensure the materials are compatible particularly in service (see 3.9).

2.1.9 Water resisting admixtures

Aluminium stearate waterproofers may be incorporated into concrete to reduce the permeability depending on mix design.

Stearate waterproofers are also available as admixtures for mortars and the manufacturer's instructions for use should be followed.

2.2 Fixings

NOTE This standard refers to alloys readily available in the UK. This does not preclude the use of other alloys if their suitability can be demonstrated.

2.2.1 Stainless steel

2.2.1.1 Stainless steel fixings

NOTE See also *Design of stainless steel fixings and ancillary components* [1].

The grades of stainless steel used for the manufacture of restraint and loadbearing fixings should be as specified in the following British Standards:

- for fixings made from sheet strip and plate, BS 1449-2;
- for fixings made from rod and bar, BS 970-1.

The recommended grades and their uses are as follows:

- 304 S15 and 304 S16. These are the most common grades used for the manufacture of fixings.
- 304 S11. The reduction in carbon makes this grade suitable for hot working or welding, as subsequent heat treatment may be unnecessary.
- 316 S31. The additional molybdenum enhances the resistance to pitting corrosion of this grade, which makes it more appropriate in aggressive environments, e.g. by the coast.
- 316 S11. The reduction in carbon content makes this grade more suitable for hot working or welding, as subsequent heat treatment may be unnecessary.
- 321 S31. This grade contains titanium which acts as a stabilizer and may permit the elimination of subsequent heat treatment.
- 303 S31. This grade contains phosphorus and sulfur and is used when significant machining is involved. It is not suitable for welding or working on site.

Other austenitic stainless steels, especially those with a carbon content greater than 0.06 %, should only be used if it has been clearly demonstrated that the fixings have not been sensitized to intergranular corrosion. This can be demonstrated by tests carried out in accordance with BS 5903 on specimens tested without further sensitization heat treatment.

Welding should only be permitted where the necessary facilities, expert knowledge and skill are available.

Any testing required should be agreed.

Welding, hot working and heat treatment operations lead to scale formation and discoloration. In order to maintain the intrinsic corrosion resistance of the material, it is necessary to remove the scaling and discoloration by suitable cleaning methods. Such cleaning may not be essential for all fixings but if scale is not removed, then premature rust and staining of the surface is likely to occur. Corrosion attack may commence more readily and a shorter serviceable life may result.

Rust staining of the surface can occur as a result of surface contamination. This can arise from particles of non-stainless steel tools used in manufacture, from storage and surface impact. Although such rusting is unsightly it is generally non-progressive and has no long-term detrimental effects on the performance of the fixing.

2.2.1.2 Stainless steel bolts and nuts

Bolts and nuts should be manufactured from austenitic stainless steel as specified in BS 6105. The bolts and nuts will be identified as:

- A1 which generally equates to 303;
- A2 which generally equates to 304;
- A3 which generally equates to 316.

2.2.2 Copper and copper-based alloy fixings

The grades of copper and copper alloy used for restraint and loadbearing fixings should be as follows.

Aluminium bronze and silicon aluminium bronze.

BS 2872	CA 104 and CA 107
BS 2874	CA 103 and CA 104

Phosphor bronze

BS 1400	PBI
BS 2870	PB 101 and PB 102
BS 2873	PB 102 and PB 105
BS 2874	PB 102
BS 2875	PB 102

Copper

BS 2870	C101, C104 and C106
BS 2873	C101 and C106
BS 2874	C101 and C102

NOTE Fixings produced from copper are not suitable for carrying permanent loads.

Welding and brazing should only be permitted where the necessary facilities, expert knowledge and skill are available.

2.3 Jointing and pointing materials

2.3.1 Mortars

Materials for mortars and their storage should be in accordance with the requirements of BS 5628-3. The types of mortar for different claddings are described in section 3.

2.3.2 Sealants

Sealants should be one of the following types and, where relevant, should conform to the appropriate British Standard.

One-part polysulfide-based	BS 5215
Two-part polysulfide-based	BS 4254
One-part silicone-based (type A)	BS 5889
One part polyurethane	
Two part polysulfide (high modulus)	
Two part polyurethane	

The expected service life of the sealants listed above may be limited to 20 years, but will depend upon environmental conditions and quality of application (see BS 6093 and BS 6213).

2.3.3 Back-up materials

Back-up material should be made of polyethylene closed cell foam, polyurethane closed cell foam or butyl rubber closed cell foam. They can be obtained as sheet material which is cut to the required width or as square, rectangular or circular section strips. All are intended to be installed in the joint under a degree of compression and the section selected will be governed by the joint sizes. Back-up materials should be compatible with the selected sealant.

2.3.4 Gaskets

Non-cellular gaskets should be made of chloroprene, butyl, chlorobutyl or ethylene propylene rubbers. Cellular gaskets should be made of natural chloroprene, butyl, ethylene propylene, styrene-butadiene or isoprene rubbers (see BS 6093 and BS 4255).

Gaskets may be of various sections, but tubular, fir cone and cellular gaskets are the most satisfactory. Gaskets should be durable and take up movements and tolerances. See also 3.11.

2.3.5 Baffles

Baffles should be preformed sections made of polychloroprene or similar material.

2.4 Flashings, weatherings and cavity trays

Flashings, weatherings and cavity trays should conform to the relevant British Standard and the recommendations given in Table 1.

In general only durable materials which do not stain light coloured materials should be used in positions where run-off can occur so bitumen-based materials may not be suitable. Similarly, copper and copper alloys should not be used for flashings and weatherings. The initial white carbonate run-off from lead flashings, which may stain adjacent units, can be avoided by a smear coat of patination oil after fixing.

2.5 Coating agents

Water repellents are not recommended for impervious surfaces or for surfaces consisting mainly of impervious materials such as those commonly used in exposed aggregate concrete.

Where water repellents are to be used they should be applied to completed surfaces rather than to components, to avoid inadvertent treatment of bedding surfaces which could affect mortar bonding; this ensures that the faces of mortar joints are treated.

Silane treatments can be used on permeable concrete subject to suppliers' recommendations.

Table 1 — Flashings, weatherings and cavity trays

Material	Standard and grade	Minimum thickness mm	Other recommendations
Aluminium alloy	BS 1470 Grade 3103	0.6	Prefabricated items should be of H2 or H4 temper. Items worked on site should be "0" condition
Aluminium and aluminium alloys	BS 1470 Grades 1050 A 1080 A and 1200	0.6	Protect from mortar contact by bituminous compound
Lead	BS 1178	1.8 Code No. 4	Lengths should not exceed 1.5 m. Protect from contact with mortar and concrete by a coating of bituminous paint
Polyethylene	BS 6515	0.46	May need bedding in mastic
Bitumen polymer and pitch polymer		1.10	May need bedding in mastic
Polypropylene		2.0	
Stainless steel	BS 1449-2	0.7	See BS 8200 but min. thickness of 0.25 mm deemed inadequate for BS 8297
PVC-U		2.0	
Bitumen	BS 6398	As classified in BS 6398	Should be fully supported

Section 3. Design considerations

3.1 General

Many materials used as non-loadbearing external vertical enclosures of buildings have functional requirements similar to external concrete cladding and reference should be made to BS 8200 which provides a systematic framework for the design of non-loadbearing external walls. The subjects covered in BS 8200 are listed in Annex A

In the case of projects involving the extensive use of cladding and fixings, it is recommended that a structural engineer sets down the functional requirements governing the principles of its design, its means of support and restraint and the maximum movement of the cladding for which allowance is to be made, together with the anticipated movement characteristics of the building frame, including calculations of the anticipated shortening and how this is to be accommodated in the cladding.

On such projects it is further recommended that a technical specification dealing with all aspects of the supply and/or fixing of the cladding should be prepared in consultation with a structural engineer and that this should include definitions of the nature of any special tests required to be carried out on the cladding in advance of the work.

Maximum economy will be achieved when the number of panel types is minimized. A "type" of unit should be identical in all respects on front, back and edges.

Allowance should be made in the design of the cladding for the expected deviations of the supporting construction [see 1.4.3.1 d)].

3.2 Cladding units

3.2.1 General

Consideration should be given to the following:

- a) structural design;
- b) sizes of the units including their thicknesses;
- c) position and detail of joints;
- d) method of support and fixing;
- e) handling, transport and erection facilities;
- f) manufacture of the units, including their surface finishes.

3.2.2 Structural design

3.2.2.1 General

The structural design should be based on the recommendations of BS 8110-1.

3.2.2.2 Loadings

The characteristic dead load of the units, their facings, if any, and any attached components should be calculated from the unit weights given in BS 648.

The characteristic wind loads should be calculated in accordance with the recommendations for class A structures of CP 3:Chapter V-2:1972 using the pressure coefficients in Table 7 of that standard.

There will usually be no imposed loads on cladding units, but upward facing units forming surfaces with a slope of less than 60° with the horizontal should be designed for snow loading and imposed loading in accordance with BS 6399-3.

For units acting as permanent formwork, the pressure of the wet concrete should generally be assumed to be the hydrostatic pressure of a liquid with density of 2 400 kg/m³.

When the attachment of the units to the frame is by means of nibs or corbels, cast monolithic with the units, or by means of metal brackets, rigidly connected to the units, the support reactions should be assumed to act at a distance from the edge of the bearing area on the frame, equal to the depth of that bearing area, unless special provisions are made which will ensure that edge bearing will not occur, in which case the distance may be assumed to be two-thirds of the depth of the bearing (see Figure 1).

Stresses during lifting from the moulds and subsequent handling should be checked to ensure cracking does not occur, which although it may not be noticed at the time may result in lack of durability later.

This calculation should be based on the unfactored tensile strength of concrete at the time of lifting. When demoulding, a factor of 2 should be applied to the weight of the unit. During subsequent handling a factor of only 1.5 need be applied to the weight of the unit to allow for the dynamic effect of crane snatch.

3.2.2.3 Cover to reinforcement for durability

The thickness of panels and the dimensions of ribs, corbels, etc. may be governed by the thickness of cover, necessary to ensure durability.

NOTE The use of aggregate with a maximum size greater than the thickness of cover may result in undesirable patterns appearing on the surface.

The thickness of dense concrete cover to all carbon steel reinforcement should be in accordance with the requirements of BS 8110-1. The principal cover thicknesses relevant to cladding units are summarized in Table 2. For units made from lightweight aggregate concrete, the cover thicknesses given in Table 2 should be increased by 10 mm.

The reinforcement nearest to any face that is to be treated to provide a surface finish to the concrete, e.g. exposed aggregates should be positioned so that the thickness of cover remains effective after the treatment. If units are to have exposed aggregate with stones 75 mm or larger, the clear distance from the back of such stones to the nearest reinforcement should be at least 20 mm. For units faced with permeable bricks or brick slips, that are placed in the mould (as opposed to being applied after de-moulding) cover thickness should be provided from the back of the bricks and should be not less than 30 mm.

Special consideration should be given to the thickness of cover where the unit is made of or faced with a mix that is permeable.

For reinforcement made of stainless steel, the thickness of cover can be reduced to 20 mm for external units and 15 mm for internal units, subject to the cover requirement for fire resistance.

Zinc coating (galvanizing) or resin coating of reinforcement should not be used as a means of reducing the thickness of the concrete cover for the following reasons.

a) Zinc coating (galvanizing) may provide some initial extra protection to carbon steel reinforcement. Fresh zinc coating will however react with the alkali in wet concrete and produce hydrogen bubbles. These will remain as porosities in the cover concrete and may facilitate the access of air and moisture to the metal surface and thus negate the extra protection given by the zinc. Hot dip galvanizing can cause embrittlement of cold worked high yield reinforcement.

b) Epoxy-resin and similar resin powder coatings on reinforcement may provide extra durability. When they are used special care should be taken during bending, handling and concreting to avoid damage to the coating. This is because any spots where the coating is damaged is likely to be the origin of pitting corrosion with accompanying volume expansion, leading to cracking and spalling of the concrete.

If reinforcement bars are coated prior to cutting and bending, the cut ends and any damage to the coating caused during the bending process, should be coated with a compatible, durable, rust-inhibiting compound prior to concreting.

3.2.2.4 Concrete mixes and strengths

3.2.2.4.1 General

In order to provide adequate durability, any concrete that provides cover to reinforcement should conform to Table 2.

Where different mixes are to be used for facing and backing, the mix or mixes providing the structural strength of the unit should satisfy the requirements of Table 2 and should be specified in accordance with BS 5328.

3.2.2.4.2 Surface absorption

Initial surface absorption tests, if required, should be carried out on units produced in the same way as those for the production run.

The samples should then be subject to the initial surface absorption test in accordance with clause 6 of BS 1881-5:1970.

The initial absorption for each sample should be not more than the following:

- 10 min test: $0.50 \text{ ml/m}^2 \text{ s}$;
- 1 h test: $0.20 \text{ ml/m}^2 \text{ s}$.

3.2.2.5 Fire separating wall units

If units have to form fire-resisting walls (compartment walls) their thicknesses should be not less than those shown in Table 3.

3.2.2.6 Support conditions and bending movements

Account should be taken of the support conditions, provided by the fixings, when calculating forces and bending moments in units.

Where support and/or tie-back fixing is by means of discrete corbels, brackets or shims, point supports should be assumed and the units should be designed against wind loads as flat-slabs (see 3.7.6 of BS 8110-1:1985).

Effective bearings should be provided as recommended in 5.2.3 of BS 8110-1:1985.

For concrete corbels, the local bending moments produced by the eccentricity of the own weight reactions being transmitted to individual corbels or brackets may be assumed to be distributed over an effective width equal to the width of the corbel plus twice the effective structural thickness. For bolted-on metal brackets, the effective width should be taken as twice the effective thickness plus the width between centres of bolts, attaching one bracket, if two or more bolts spaced horizontally are used.

If units are top hung, the reinforcement should be designed to resist the tensile force from their own weight as well as the bending moments. Account should be taken of the concentration of such tensile forces at discrete corbels.

Account should be taken of the support conditions during lifting and handling, where these differ from those applying in the final position (e.g. lifting at discrete points while final support will be on a continuous nib).

3.2.2.7 Corbel and nib details

Individual corbels should be reinforced with horizontal loops of bars which should envelop any dowels providing horizontal restraint; the ends of the bars forming the loops should be anchored near the face remote from the corbels. The bars forming the loops should be designed to resist the moment in the corbel due to the weight of the unit. The reaction should be assumed to act at a distance from the edge of the slab equal to the depth of the bearing on the slab (see Figure 1 and Figure 2).

Table 2 — Thickness of cover for mixes and strengths of concrete

Nominal cover for conditions of exposure			Max. free water/cement ratio	Min. cement content ^a kg/mm ³	Min. characteristic strength N/mm ²
1 mm	2 mm	3 mm			
35			0.60	300	35
30	40	50 ^b	0.55	325	40
25	30	40 ^b	0.50	350	45
20	25	30	0.45	400	50

1 Dry internal exposure
2 Ordinary external exposure
3 Exposure to wind-driven salt water spray

NOTE The cover thicknesses above apply to 20 mm maximum aggregate size.

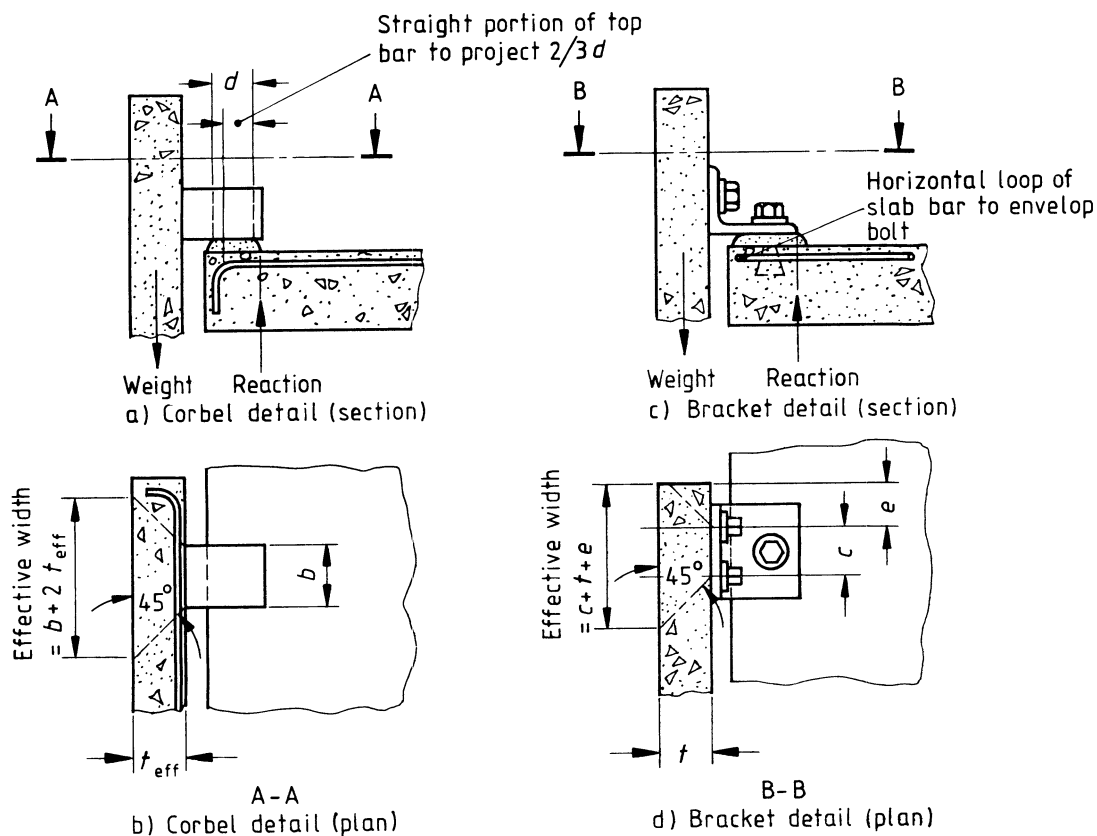
^a Minimum cement content refers to Portland cement BS 12 class 42.5 or greater. For other or coloured cements and for Portland cement/blastfurnace slag mixtures, the cement content may have to be adjusted to compensate for the different alkalinities of such cements and mixtures.

^b Where units will be subject to freezing, whilst wet, air-entrainment should be used (see 3.3.4.2 of BS 8110-1:1985).

Table 3 — Minimum thickness of fire-resisting wall units

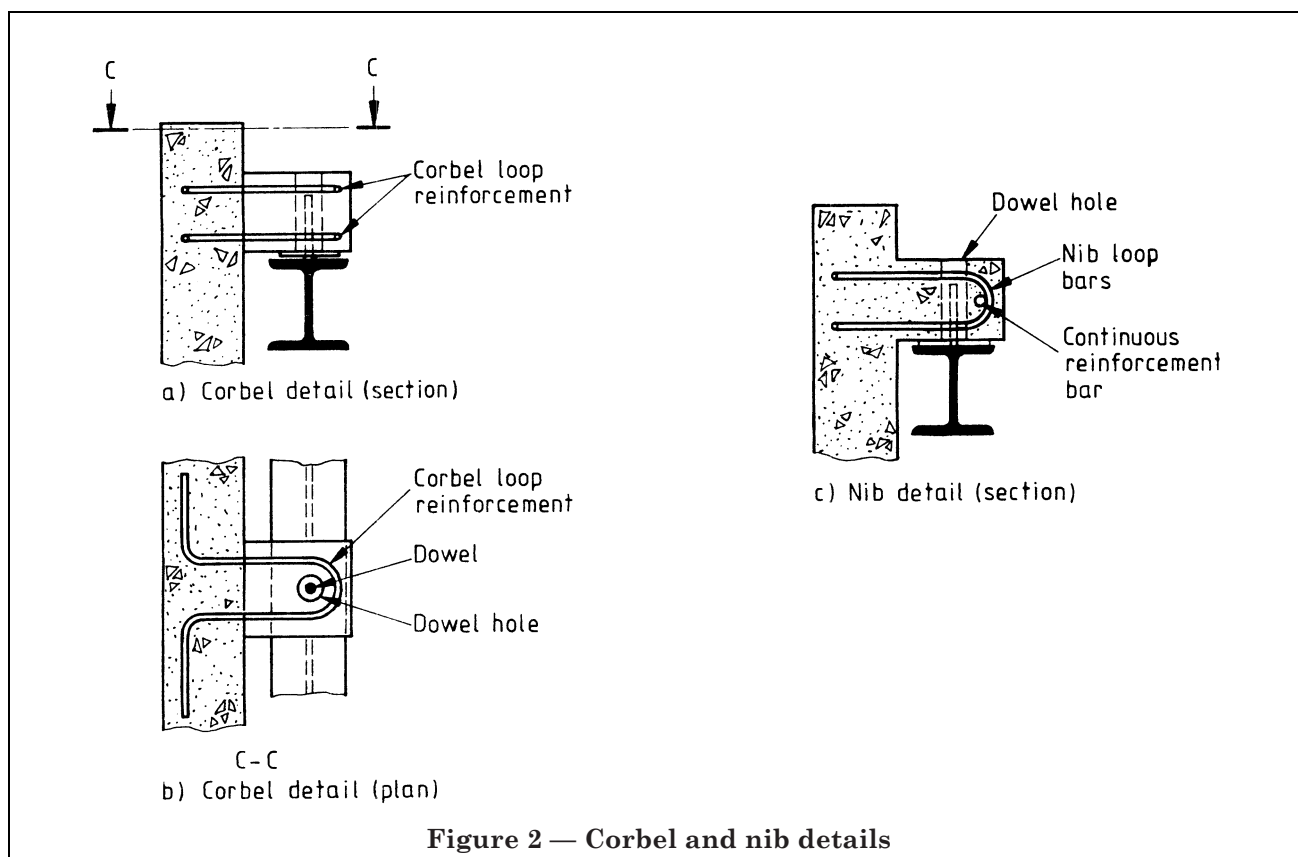
Dimensions in millimetres

Type of wall unit	Fire-resisting period				
	1 h	1.5 h	2 h	3 h	4 h
Units with less than 0.4 % reinforcement	150	175	—	—	—
Dense concrete units with 0.4 % to 1.0 % reinforcement	120	140	160	200	240
Lightweight aggregate concrete units with 0.5 % to 1.0 % reinforcement	100	115	130	160	190



NOTE. Reinforcement omitted in sectional views.

Figure 1 — Assumptions for design of units and corbels/brackets



Where temporary discrete bearing packs are used (by the erector) to support full load, the stresses in the supporting nib should be checked.

Continuous supporting nibs should have a continuous horizontal bar running between any dowels or dowel holes and the edge of the slab. This bar should be held by vertical loop reinforcement anchored near the front face of the unit. The loop reinforcement should be designed for the moment due to the own weight, assuming that the reaction acts at a distance from the edge of the slab equal to the bearing on the slab.

Alternatively, continuous nibs may be reinforced with horizontal loops which should envelop any dowels and dowel holes as for individual corbels.

When metal brackets are fixed to the units by bolts into cast-in sockets, reinforcement should be provided around the sockets to prevent a cone-failure around the fixings.

NOTE Substitution of cast-in-sockets by post-drilled bolts may not be suitable, due to the greater edge distances required for post-drilled bolts.

3.2.2.8 Supporting beams and slab edges

Beams or slab edges supporting cladding units should be designed assuming that the reactions from the weight of the cladding units act at the front face of the beam or slab edge.

Continuous horizontal bars should be provided between dowel holes or bolt sockets and the edge of the slab and should be tied back with loops into the slab. Alternatively, the edge of the slab may be reinforced with horizontal loops which should envelop any dowels and dowel holes.

3.2.3 Sizes of units including thickness

3.2.3.1 General

The sizes of units should be considered in relation to their weight and likely method of handling. Most concrete cladding units will require mechanical handling.

Consideration should be given to the maximum sizes permissible for transport and for manoeuvring units at the place of manufacture and for site installation.

Very large or composite units, particularly where lightweight aggregate concrete has been used, may shrink or warp making their accurate alignment and fixing difficult. This may require greater tolerances in fixings and joints.

Sharp arrises and thin projections should be avoided, particularly in large units as they are easily chipped in handling. Chamfered edges resist damage and mask irregularities of alignment.