

BS 8297:2017



BSI Standards Publication

**Design, manufacture and installation
of architectural precast concrete —
Code of practice**

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 October 2017. It was prepared by Technical Committee B/524, *Precast concrete products*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 8297:2000, which is withdrawn.

Information about this document

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

- clarification of scope;
- updated terms and definitions;
- dimensions for certain components;
- describes the provisions necessary for the cladding to perform its function satisfactorily; and
- gives the minimum standards required of materials and methods to be employed.

Presentational conventions

The provisions of 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.

The word “should” is used to express recommendations of this standard. The word “may” is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word “can” is used to express possibility, e.g. a consequence of an action or an event.

Notes and commentaries are provided throughout the text of this standard. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

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.

Introduction

This British Standard has been developed to give recommendations and good practice for specifiers and manufacturers during the design, manufacture, transport and installation of architectural precast concrete units.

Framed structures are often enclosed by precast concrete panels. These in turn frequently serve an architectural role in providing the external appearance of the building. In such instances, the panels are generically referred to as cladding. As well as providing the external envelope of a building, similar precast concrete units might also be used for other purposes, such as decorative columns, either loadbearing or not, balconies, and other substantial elements. Where units provide the weathertight external envelope of a building, water and airtightness is ensured by appropriate design and treatment of the joints between the units.

Units are required to carry their own weight and also any directly or indirectly imposed loadings. Units are also required to resist wind loading, provide weather protection, acoustic and thermal performance. They might also need to provide fire resistance and be resistant to accidental damage, e.g. vehicle impact and internal or external explosion. Their construction needs to allow for the dimensional tolerances of construction and movement of the building structure during its designed lifetime. Where units are loadbearing, they need to be able to transmit loads as part of the structure. Strength, durability and versatility are the inherent characteristics of precast concrete. This type of precast concrete is almost inevitably bespoke, by virtue of its shape and size, colour and texture, finishes or facings, to achieve the specified aesthetic requirements of individual building projects. The manufacturing process is non-repetitive and might not lend itself to automation. The weight and size of units can also be critical. Involving the manufacturer at the design stage can therefore often lead to more efficient production and optimization of the fixing system.

1 Scope

This British Standard gives recommendations and guidance for the design, manufacture, transport and installation of architectural precast concrete units in the form of:

- a) units supported by and fixed to a structural frame or wall to perform a cladding role;
NOTE These might be part of the external envelope or separate elements, such as columns and balconies.
- b) units which may neither be associated with, or form part of, a building;
- c) units used as permanent formwork in part or in whole, but limited to architectural elements; and
- d) the architectural function of a sandwich panel (see [3.7.3](#)).

It includes recommendations on the measures which are to be taken to provide for permanent and temporary movements and tolerances of the structure, to enable the cladding to perform its function satisfactorily. It gives the minimum standards needed and the materials and methods of fixings most frequently used. It applies to new buildings but many provisions might be applicable to alterations or refurbishment of existing buildings.

Guidance is given on the quality of the finished product and verification of performance. The design recommendations given in this British Standard are based on limit state design principles.

This British Standard is intended to be used in conjunction with BS EN 13369:2013 and BS EN 13670, but provides comprehensive guidance specifically in relation to architectural precast concrete cladding and therefore takes precedence in the items addressed.

This British Standard does not provide recommendations relevant to units incorporating glass fibre reinforced concrete (GFRC/GRC), semi-dry or small wet-cast masonry units instead of larger architectural wall cladding panels (see BS 1217), nor the design of the supporting structure to which the units might be attached.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions 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.

Standards publications

BS 1881-208, *Testing concrete — Recommendations for the determination of the initial surface absorption of concrete*

BS 4449, *Steel for the reinforcement of concrete — Weldable reinforcing steel — Bar, coil and decoiled product — Specification*

BS 4482, *Steel wire for the reinforcement of concrete products — Specification*

BS 4483, *Steel fabric for the reinforcement of concrete — Specification*

BS 5606, *Guide to accuracy in building*

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

BS 6100-9, *Building and civil engineering — Vocabulary — Work with concrete and plaster*

BS 6180, *Barriers in and about buildings — Code of practice*

- BS 6213, *Selection of constructional sealants — Guide*
- BS 6744, *Stainless steel bars — Reinforcement of concrete — Requirements and test methods*
- BS 7979, *Specification for limestone fines for use with Portland cement*
- BS 8221-1, *Code of practice for cleaning and surface repair of buildings – Part 1: Cleaning of natural stone, brick, terracotta and concrete*
- BS 8298-3:2010, *Code of practice for the design and installation of natural stone cladding and lining — Stone-faced pre-cast concrete cladding systems*
- BS 8500-2:2015+A1:2016, *Concrete — Complementary British Standard to BS EN 206 — Specification for constituent materials and concrete*
- BS 8539, *Code of practice for the selection and installation of post-installed anchors in concrete and masonry*
- BS EN 197-1:2011, *Cement — Composition, specifications and conformity criteria for common cements*
- BS EN 206, *Concrete — Specification, performance, production and conformity*
- BS EN 450-1:2012, *Fly ash for concrete — Definition, specifications and conformity criteria*
- BS EN 480-1, *Admixtures for concrete, mortar and grout — Test methods — Part 1: Reference concrete and reference mortar for testing*
- BS EN 934-2, *Admixtures for concrete, mortar and grout — Part 2: Concrete admixtures — Definitions, requirements, conformity, marking and labelling*
- BS EN 1008, *Mixing water for concrete — Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete*
- BS EN 1011-1, *Welding — Recommendations for welding of metallic materials — General guidance for arc welding*
- BS EN 1011-3, *Welding — Recommendations for welding of metallic materials — Arc welding of stainless steels*
- BS EN 1015-12, *Methods of test for mortar for masonry — Determination of adhesive strength of hardened rendering and plastering mortars on substrates*
- BS EN 1090 (all parts), *Execution of steel structures and aluminium structures*
- BS EN 1991-1-1, *Eurocode 1 — Actions on structures — General actions — Densities, self-weight, imposed loads for buildings*
- BS EN 1991-1-7:2006+A1:2014, *Eurocode 1 — Actions on structures — General actions — Accidental actions*
- BS EN 1992-1-1:2004+A1:2014, *Eurocode 2 — Design of concrete structures — General rules and rules for buildings*
- BS EN 1992-1-2:2004, *Eurocode 2 — Design of concrete structures — General rules — Structural fire design*
- BS EN 1993-1-1, *Eurocode 3 — Design of steel structures — General rules and rules for buildings*
- BS EN 1993-1-4, *Eurocode 3 — Design of steel structures — General rules — Supplementary rules for stainless steels*
- BS EN 1996-2, *Eurocode 6 — Design of masonry structures — Design considerations, selection of materials and execution of masonry*

- BS EN 10080, *Steel for the reinforcement of concrete — Weldable reinforcing steel — General*
- BS EN 10088-2, *Stainless steels – Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes*
- BS EN 10088-3, *Stainless steels – Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes*
- BS EN 12155, *Curtain walling — Watertightness — Laboratory test under static pressure*
- BS EN 12179, *Curtain walling — Resistance to wind load — Test method*
- BS EN 12878:2014, *Pigments for the colouring of building materials based on cement and/or lime — Specifications and methods of test*
- BS EN 13050, *Curtain walling — Watertightness — Laboratory test under dynamic condition of air pressure and water spray*
- BS EN 13055, *Lightweight aggregates*
- BS EN 14019, *Curtain walling — Impact resistance — Performance requirements*
- BS EN 15651-1, *Sealants for non-structural use in joints in buildings and pedestrian walkways — Part 1: Sealants for façade elements*
- BS EN 15167-1, *Ground granulated blast furnace slag for use in concrete, mortar and grout — Part 1: Definitions, specifications and conformity criteria*
- BS EN ISO 3506-1, *Mechanical properties of corrosion-resistant stainless steel fasteners – Part 1: Bolts, screws and studs*
- BS EN ISO 3506-2, *Mechanical properties of corrosion-resistant stainless steel fasteners – Part 2: Nuts*
- BS EN ISO 6946, *Building components and building elements — Thermal resistance and thermal transmittance — Calculation method*
- BS EN ISO 11600:2003+A1:2011, *Building construction – Jointing products — Classification and requirements for sealants*
- BS EN ISO 13788, *Hygrothermal performance of building components and building elements — Internal surface temperature to avoid critical surface humidity and interstitial condensation — Calculation methods*
- BS ISO 15510:2014, *Stainless steels — Chemical composition*
- DD CEN/TS 772-22, *Methods of test for masonry units – Determination of freeze/thaw resistance of clay masonry units*
- PD CEN/TR 15739: 2008, *Precast concrete products – Concrete finishes – Identification*
- NA to BS EN 1990:2002+A1: 2005, *UK National Annex for Eurocode – Basis of structural design*

Other publications

- [N1] EAD 330232-00-0601, *Mechanical fasteners for use in concrete*
- [N2] ETAG 0034, *Guidelines for European Technical Approval of kits for external wall claddings*
- [N3] CWCT Standard for systemised building envelopes (all parts)
- [N4] CWCT Technical Note 75, *Impact performance of building envelopes: guidance on specification*
- [N5] CWCT Technical Note 76, *Impact performance of building envelopes: method for impact testing cladding panels*

3 Terms and definitions

For the purposes of this British Standard the terms and definitions given in BS 6100-9 and the following apply.

3.1 bimetallic corrosion

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

3.2 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

3.3 cladding

form of building covering that supports its own weight and resists any other forces that may act upon it

3.4 cladding designer

person responsible for the design and detailing of the cladding using information provided by the principal designer(s)

3.5 fire stopping

construction provided to prevent the spread of fire and smoke between building compartments

3.6 principal designer(s)

person(s) responsible for the overall design of the building to include structure and envelope

3.7 Types of unit

3.7.1 monolithic (solid) unit

unit comprising single skin with the same mix throughout

3.7.2 faced unit

single skin comprising a cast-in facing of a different material (e.g. stone, brick, tiles) or a different concrete facing mix

3.7.3 sandwich panel

panel consisting of an inner and outer concrete skin, either of which can be structural and/or decorative, mechanically connected and with a thermal insulation core in between

3.8 Types of fixings

3.8.1 fixing

device or assembly used to connect, support or restrain one or more cladding units to the main structure

NOTE This may comprise of several components including a bolt, threaded stud, anchor, bracket, etc.

3.8.2 loadbearing fixing

device or assembly used to support the dead weight of one or more cladding units and to transfer this load to the structure

NOTE This may also be used to restrain the unit.

3.8.3 location fixing

device or assembly, temporary or permanent, whose sole purpose is to assist in the alignment of the cladding units

3.8.4 restraint fixing

device or assembly designed to connect cladding units to the structure, or to one another, to resist applied forces

3.8.5 temporary fixing

device or assembly whose sole purpose is to assist in the installation of the cladding units

3.9 Joints

3.9.1 movement joint

purpose-designed joint that accommodates multi-directional movement between adjacent units and takes account of manufacturing and construction tolerances

NOTE Also commonly known as an "expansion joint".

3.9.2 compression joint

purpose-designed joint that commonly acts under load and only accommodates one direction of movement between adjacent units.

3.9.3 open joint

unfilled gap between adjacent units or between a unit and the structure

3.9.4 sealed joint

purpose-designed joint to perform, in addition to [3.9.1](#) and [3.9.2](#), further specific functions

NOTE Examples of specific functions are airtightness, watertightness, fire resistance, acoustic performance, aesthetics.

3.10 Joint materials

3.10.1 sealant

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

3.10.2 backing rod

material inserted in a joint which controls the depth and prevents three-sided adhesion of the sealant

3.10.3 baffle

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

3.10.4 impregnated foam sealing strip

impregnated foam weatherproofing strip flexible, generally elastic, preformed material that constitutes a linear seal when compressed

4 Materials and components

4.1 Customer requirements

4.1.1 General

The specifier should provide the cladding designer with the following information, where applicable:

- a) scope of works, basic building information and finishes in accordance with [Annex A](#);
- b) performance and/or prescriptive specifications;
- c) design interfaces to be considered; and
- d) sustainability requirements.

4.1.2 Performance specification

The principal designer should provide the cladding designer with the following information:

- a) design life and service life;
- b) structural movement, deflection and construction tolerances;
- c) environmental performance criteria;
- d) fire performance;
- e) applied loading criteria;
- f) thermal performance;
- g) acoustic performance;
- h) cladding manufacturing and installation tolerances (see [11.3.1](#), [11.5](#) and [Table 6](#));
- i) testing criteria (e.g water or airtightness); and
- j) accidental damage (see [5.5.4](#)).

4.1.3 Prescriptive specification

Alternatively, the principal designer or cladding designer should provide the manufacturer with all relevant details of the cladding, including, but not limited to, the following:

- a) geometry profiles and shapes with dimensions of units;
- b) joint details;
- c) concrete mix specifications;
- d) reinforcement details, cover requirements and schedules;
- e) surface finish requirements;
- f) insulation details;
- g) fixing details;
- h) tolerances;
- i) details of any "cast-in" components and/or formed openings; and
- j) transport and handling limitations.

4.2 Specifications for materials and components

4.2.1 General

For materials and components not covered, proof of satisfactory performance and suitability for use in particular conditions should be obtained and carefully assessed.

4.2.2 Materials for precast concrete

4.2.2.1 Cement

Cement should conform to the relevant standards as follows.

- a) Common cement to BS EN 197-1:2011.
- b) Sulfate-resisting cement to BS EN 197-1:2011, SR0 or BS EN 197-1:2011, SR3.

Combinations of CEM I as given in BS 8500-2:2015+A1, Annex A and BS EN 197-1:2011 with either:

- 1) fly ash conforming to BS EN 450-1:2012, Category A or B;
- 2) ground granulated blast furnace slag (GGBS) conforming to BS EN 15167-1; or
- 3) limestone fines conforming to BS 7979 or BS 8500-2:2015+A1.

Combinations manufactured in the concrete mixer from Portland cement and GGBS or PFA should conform to the relevant standards.

4.2.2.2 Aggregates

Aggregates general suitability should conform to the following.

- a) Normal-weight and heavyweight to BS EN 12620 and the requirements specified in BS 8500-2:2015+A1.
- b) Coarse crushed concrete aggregate (CCA) to BS EN 12620 and the requirements specified in BS 8500-2:2015+A1.
- c) Granulated, including pelletized, blastfurnace slag and air-cooled blastfurnace slag to BS EN 12620 and the requirements specified in BS 8500-2:2015+A1.
- d) Lightweight aggregates to BS EN 13055 and the requirements specified in BS 8500-2:2015+A1.
- e) Reclaimed aggregate to BS EN 206.

4.2.2.3 Admixtures

Admixtures should conform to BS EN 480-1 and BS EN 934-2.

4.2.2.4 Pigments

Where a specified coloured concrete requires a pigment, the pigment should conform to BS EN 12878:2014. For reinforced concrete, the pigment should conform to BS EN 12878:2014, Category B.

4.2.2.5 Water

Mixing water should conform to BS EN 1008.

4.2.2.6 Facing materials

Where facing materials are to be used, these should be correctly specified and care should be taken to ensure that these are compatible in service.

The facing material should be incorporated by a proven mechanical fixing or bonding method.

4.2.2.7 Water resisting admixtures

Water resisting admixtures may be incorporated into concrete to reduce the permeability depending on mix design.

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

4.3 Steel

4.3.1 Carbon steel reinforcement

Steel reinforcement for concrete should conform to BS 4449, BS 4482 and BS 4483, as appropriate.

4.3.2 Stainless steel reinforcement

Stainless steel reinforcement for concrete should conform to BS 6744.

4.3.3 Stainless steel fixings

4.3.3.1 General

Austenitic and duplex (austenitic/ferritic) stainless steel should conform to the following standards:

- a) stainless steel sheet strip and plate to BS EN 10088-2; and
- b) stainless steel rod and bar to BS EN 10088-3.

Stainless steel plate for restraint and loadbearing fixings should conform to the grades and uses given in [Table 1](#).

Table 1 — *Recommended grades of austenitic or Duplex (Austenitic/ferritic) stainless steel used for fixings*

Grade ^{A)}	Formerly known as	Application
1.4301	304	For general fixings
1.4305	303	If significant machining is required (i.e. for cast-in sockets and some bolts). It is not suitable for welding or working on site.
1.4307	304L	For hot working or welding.
1.4401	316	For enhanced resistance to pitting corrosion (e.g. for use on coastal sites).
1.4404	316L	For hot working or welding for use on coastal sites
1.4462	-	Extreme coastal conditions (Duplex)

^{A)} The designation system used in BS EN 10088 (all parts) for stainless steel is defined in BS EN 10027.

Guidance on the design of stainless steel fixings is given in [7.3](#).

NOTE Further guidance is given in BS EN 1993.

If visually exposed, or specified to a higher grade, plate and strip grade 1.4401 (316) to BS EN 10088 or Grade 1.4404 (316L) should be used if plate is thicker than 16 mm. For steel rod and bar 1.4401(316) should be used to prevent tarnishing of the surface.

4.3.3.2 Cast-in fixings

Cast-in fixings should conform to the grades of austenitic stainless steel cast into the panel and their uses given in [Table 1](#).

As cast-in fixings perform a critical role in the securing of the cladding to the structure, the quality control process should include a 100% visual inspection of the fixing type, size and secure positioning in accordance with the intended design detail.

The specified mechanical properties of the material used in the manufacture of cast-in sockets should take account of the performance classification of the proposed fastener from BS EN ISO 3506-1. The minimum thread engagement of the fastener into the socket should be specified.

4.3.3.3 Fasteners

Bolts and nuts should be of austenitic or Duplex (Austenitic/ferritic) stainless steel conforming to BS EN ISO 3506-1. The grades of fasteners should be as given in [Table 2](#).

Table 2 — Recommended grades of fasteners

Grade	Application	BS ISO 15510:2014 steel number for suggested corresponding plate specifications
A1	General machining. Lower resistance to corrosion than corresponding stainless steels	4305-303-00-I
A2	Most frequently used. Not suitable for non-oxidizing acids, chlorides or marine environments.	4301-304-00; 4307-304-00-I
A3	As A2 up to temperatures of 300 °C	4541-321-00-I; 4550-347-00-I
A4	Often referred to as "Acid proof steels" with higher resistance to most forms of corrosion	4401-316-00-I; 4404-316-03-I; 4436-316-00-I
A5	As A4 upto temperatures of 300 °C	4571-316-35-I
A8	Resistant to all forms of corrosion (including pitting). Suitable for marine and chloride environments	4529-089-26-I; 4547-312-54-I
D2/D4 ^{A)}	Comparable to A2 and A4 in relation to corrosion, respectively	4362-323-04-I (D2); 4162-321-01-E (D4)
D6/D8 ^{A)}	Comparable to A5 and A8 in relation to corrosion, respectively	4462-318-03-I (D6); 4501-327-60-I (D8)

^{A)} Typically for internal environments A2 or D2 should be specified as a minimum. If externally exposed the fixings should be A4, D4 or D6 and if externally exposed in chloride bearing environments and of aesthetic interest should be A8 or D8.

NOTE Where duplex (austenitic-ferritic) plate is not readily available it is acceptable to use austenitic stainless steel plate with duplex fasteners ensuring that the minimum relative corrosion resistant properties are maintained, e.g. D2 with A2, D4 and D6 with A4 and D8 with A8, etc.

4.3.3.4 Welding

Welding of austenitic stainless steel components should conform to the requirements of BS EN 1011-1 and BS EN 1011-3, and should only be undertaken where the necessary facilities, expert knowledge and skills are available.

Procedures for testing welds should be agreed at the design and specification stage.

If the fixing provides structural stability, the components should conform to BS EN 1090 (all parts).

4.4 Materials for jointing and pointing

4.4.1 Mortars

Mortar should be specified to fulfil the necessary performance requirements.

NOTE Guidance is given in BS EN 1996-2, BS EN 998-2 and BS 8000-0.

4.4.2 Sealants

Sealants should conform to BS EN ISO 11600:2003+A1, Type F requirements and should be selected using the guidance given in BS 6213 and BS 6093. Sealants should be tested for adhesion, staining (see [5.10.3](#)) and compatibility with materials that they are likely to come into contact with.

The design life of the sealant might not equal the design life of the cladding and therefore regular inspections should be carried out.

Materials used should conform to BS EN 15651-1.

4.4.3 Backing rods

Backing rods for use with wet sealants should be made of polyethylene closed cell foam or polyurethane closed cell foam.

NOTE These 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 is governed by the joint sizes.

Back-up materials should be compatible with the selected sealant.

4.4.4 Impregnated foam sealing strips

Impregnated foam sealing strips should be made of closed cell proprietary polymer sections relying on compression against adjacent substrates to provide a weather seal. They should be permanently flexible and where necessary should provide movement accommodation without loss of performance.

NOTE Guidance on impregnated foam sealing strips is given in BS 6093 and BS 4255-1.

4.4.5 Baffles

Baffles should be made of resilient polymer or rubber material.

4.5 Flashings, weatherings and cavity trays

Flashings, weatherings and cavity trays should be made of durable materials to meet the design specification.

They should be tested for staining and compatibility with materials that they are likely to come into contact with.

Copper and copper alloys should not be used for flashings and weatherings.

4.6 Coating agents

Coating agents are generally either water repellants or anti-graffiti products; the requirements for these should be identified by the client or designer as early as possible in the design process.

NOTE 1 For example they may be used to reduce environmental exposure conditions.

Where coating agents are used they should be applied to surfaces as late as possible to allow natural curing of the base concrete to occur. Wherever possible, they should not be applied to individual components in the factory to avoid inadvertent treatment of bedding surfaces to the base concrete which could affect mortar or sealant bonding.

In advance of selecting the coating agent, it should be tested with the manufacturer's products for compatibility and checked with the coating agent manufacturer's recommendations.

NOTE 2 See BA 85/04 [1] for further reference.

NOTE 3 Coating agents might vary the appearance of the concrete and might require future maintenance.

5 Design of cladding units

5.1 General

NOTE 1 The design of cladding units is largely determined by actions due to self-weight, handling, transport, wind and imposed loads. Design is also influenced by specific actions, methods used by the manufacturer, such as tilting tables, cradles etc and the method of support, either self-supporting or stacked.

The design of cladding units should be in accordance with NA to BS EN 1990:2002+A1. The basis of the structural design table in NA to BS EN 1990:2002+A1, Table NA.2.1, is the design working life of the precast cladding should be specified at 50 years (category 4) which aligns with the design values within BS 8500.

For loadbearing elements, the design of concrete and reinforcement should be in accordance with BS EN 1992-1-1:2004+A1, and for the design of steel elements should be in accordance with BS EN 1993-1-1.

For the design of stainless steel items such as supports and restraints, reference should be made to BS EN 1993-1-4.

NOTE 2 Users might also wish to refer to industry publications such as Design manual for structural stainless steel (Euro Inox and Steel Construction Institute) [2].

There should be close cooperation between the designer of the precast elements, and the designer of any supporting structure. In particular the designer of the structure should be made aware of the magnitude and location of the loads likely to be imposed onto the structure by the precast.

5.2 Structural design

5.2.1 General

Structural design should conform to the recommendations of BS EN 1992-1-1:2004+A1. The design should take into account other relevant factors including:

- a) self weight;
- b) stacking of panels;
- c) initial handling;
- d) balconies, canopies, balustrades; and
- e) attachments such as glazing, signage, lighting etc.

The use of characteristic self-weights, including any facings and attached components, should take into account the type of aggregate and the amount of reinforcement, which can have a considerable effect on the self-weight.

5.2.2 Initial handling

The most severe loading case is often the demoulding and initial handling. Load factors should be used that are appropriate to the method of lifting, type of mould, and subsequent handling. In addition to the self-weight of the element, allowance should be made for adherence to the mould.

NOTE 1 As an example, for complex profiles in a timber mould, this adherence can be significant and be considerably more than when using a steel mould, particularly if tilting moulds are used.

NOTE 2 Concrete strengths are likely to be relatively low at this stage.

Appropriate dynamic (snatch) factors should be included to take account of crane types and speed of lifting.

5.2.3 Design analysis

Design cases generally fall into two types, flexural design due to self-weight and wind, and shear design at supports. Flexural design should take account of features such as false joints and architectural recesses which reduce the effective depth of the section.

NOTE Where supports consist of integral concrete corbels, a strut and tie analysis is normally used.

The point of application of loads, which could be affected by shims etc., should be taken into account.

5.3 Thickness of concrete cover to reinforcement

5.3.1 General

Minimum concrete cover should be provided in order to ensure the safe transmission of bond forces, the protection of the steel against corrosion and adequate fire resistance. Nominal cover should allow for depths of any surface profiles or finishes.

NOTE 1 See BS EN 1992-1-1:2004+A1, 4.4.1.2 and BS 8500.

NOTE 2 Where plain CEM I cements are required for colour and consistency BS EN 13369:2013, Table A.2 may take precedence.

5.3.2 Environmental exposure

An additional 10 mm of cover to reinforcement should be provided in exposed non-vertical faces which might be subject to severe wetting/freezing, e.g. cornices, parapets, copings etc. Full cover should be maintained at false joints and architectural features, which could otherwise reduce the cover locally.

NOTE 1 See BS EN 13369:2013 for durability requirements.

NOTE 2 For the purposes of architectural concrete cladding, XS1 exposure conditions are defined as being less than 100 m horizontally from high tide.

NOTE 3 Where a precast concrete panel is faced with natural stone or similar materials having a thickness greater than 25 mm, cover may be reduced by 10 mm, providing the cover from the rear of the facing material is not less than 20 mm.

5.3.3 Fire exposure

If units have to form fire-resisting walls (compartment walls) their thicknesses should be not less than those recommended in BS EN 1992-1-2:2004 (see 5.4).

5.3.4 Concrete mixes and strengths

In order to provide adequate durability, any concrete that provides cover to reinforcement should conform to the requirements of BS EN 1992-1-1:2004+A1.

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 BS EN 1992-1-1:2004+A1.

NOTE Guidance on measures to minimize the risk of alkali-silica reaction in concrete are given in Concrete Society Report TR 30 [3].

5.3.5 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. Tests should conform to the requirements of BS 1881-208.

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

- a) 10 min test = $0.50 \text{ ml/m}^2\cdot\text{s}$;
- b) 1 h test = $0.20 \text{ ml/m}^2\cdot\text{s}$.

5.3.6 Avoidance of tension cracks

Reinforcement should be positioned to counter cracks in the concrete surface.

5.4 Fire-resisting wall units

When required by design, the panels and their fixings should provide the specified fire resistance for building requirements (see BS EN 1992-1-2:2004, 5.4).

5.5 Support conditions and bending moments

5.5.1 General

Account should be taken of the support conditions, provided by the loadbearing support, restrain fixings and tolerances designed within them, 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 in accordance with BS EN 1992-1-1:2004+A1.

Effective bearings should conform to recommendations given in BS EN 1992-1-1:2004+A1, 10.9.5.

NOTE 1 In both stacked and independently supported cladding panel design the position and specification of the bearing details are critical.

For concrete corbels, the local bending moments produced by the eccentricity of the vertical 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. See [Figure 1b](#)).

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). See [Figure 1d](#)).

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 from any eccentricity created by the bearing detail. Account should be taken of the concentration of such tensile forces at points of attachment to the structure.

Account should be taken of the support conditions during lifting and handling, where they differ from those applying when lifting into final position (e.g. lifting at discrete points; with final support on a continuous nib). When designing elements for use during lifting, dynamic load factors should be applied, appropriate to the type of crane.

NOTE 2 Orientation and re-orientation during handling and geometry of the panel are critical factors. These are in addition to load factors relating to static design, as per the recommendations given in PD CEN/TR 15728.