
Code of practice for
Stone masonry

(Formerly CP 121.201 and CP 121.202)

Code de bonne pratique relatif à la maçonnerie en pierre

Richtlinien für Steinmauerwerk

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Amendment No. 1
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to BS 5390 : 1976
Code of practice for stone masonry

Revised text

AMD 4272
June 1983

Contents

At the beginning of the list of tables, insert the following, and renumber the existing tables 1 to 6 as 2 to 7.

'1. Materials for metal components in masonry'.

AMD 4272
June 1983

Clause 1. Scope

In the first paragraph, delete the final sentence and substitute the following:

'For recommendations for the structural use of masonry, see BS 5628. For guidance on cleaning and surface repair of masonry, see BS 6270 : Part 1.'

AMD 4272
June 1983

Clause 7.2 Cast stone lintels

In line 2, delete 'and BS 1239'.

AMD 4272
June 1983

Clause 7.3 Stone lintels

Delete the first sentence.

In sentence 2, delete 'The stone' and substitute 'Stone for lintels'.

AMD 4272
June 1983

New clause 7.4 Sills

After 7.3, insert the following new clause:

'7.4 Sills. Stone and cast stone sills should comply with the requirements of BS 5642 : Part 1.'

AMD 4272
June 1983

Clause 8.2 Cement

Delete paragraph 2.

AMD 4272
June 1983

Clause 9.1 Metal dowels and fixings

Delete the existing clause and substitute the following:

'9.1 Metal dowels and fixings. Anchor bolts, armatures, cramps, dovetail slots, dowels, wall ties and any other reinforcement should be of non-ferrous metals or of austenitic stainless steel. In no circumstances should other ferrous metals be used. Materials for metal components in masonry should comply with the appropriate requirements given in table 1.

A wrought or continuously cast product should be used in preference to a sand casting, as freedom from porosity cannot be guaranteed in the latter.

Care should be taken not to allow metals of different types or grades to come into contact, as this can lead to galvanic action and consequent corrosion.'



Table 1. Materials for metal components in masonry

Base material	Form	Grade and standard to be complied with	Protective measures carried out after fabrication
Copper		BS 6017	
Copper alloys		BS 2870 : 1980, grades listed in tables 8 and 12	Material other than phosphor bronze to be formed either: (a) by bending at dull red heat and allowing to cool in still air; <i>or</i> (b) by cold forming and subsequently stress relief annealing at 250 °C to 300 °C for 30 min to 1 h. Effectiveness of stress relieving of cold formed components to be tested by the supplier using the mercurous nitrate test described in clause 11 of BS 2874 : 1969.
		BS 2873 : 1969, grades listed in tables 4 and 6	
		BS 2874 : 1969, grades listed in tables 6, 8 and 9 except CA 106	
Austenitic stainless steel, minimum 18/8 composition and excluding free machining specifications	Plate	BS 1449 : Part 2 : 1975, grades 304S15, 316S16, 321S12, 347S17 or high-proof stress versions of these steels	
	Strip	BS 1449 : Part 2 : 1975, grades 302S17, 304S16, 316S16, 321S12, 347S17	
	Bar	BS 970 : Part 4 : 1970, grades 302S25, 303S21, 304S15, 316S16, 321S12, 347S17 or the high-proof stress version of 316S16	
	Tube	BS 3014	
	Wire	BS 1554 BS 3111 : Part 2	

AMD 4272
June 1983

Clause 9.2 Metal wall ties

After the second sentence insert 'See BS 5628 : Part 1'.

AMD 4272
June 1983

Clause 11.2 Ducts

In line 3, delete 'and BS 540' and substitute 'or BS 5911'.

AMD 4272
June 1983

Clause 12. Flashings and weatherings

In item (a), after 'code no. 4' insert ', complying with BS 1178'.

In item (b), line 2, after 'polluted areas', insert ', complying with BS 849'.

In item (c), line 2, after '20 SWG', insert ', complying with BS 1470'.

In item (d), after '0.4 mm', insert ', complying with BS 1449 : Part 2'.

AMD 4272
June 1983

Clause 14. Sealants, mastics and other materials for expansion joints

Delete the final paragraph and substitute the following:

'For guidance on the selection of sealants, see BS 6213'.

AMD 4272
June 1983

Clause 20.1 Exposure

In paragraph 2, line 1, delete 'Table 1' and substitute 'Table 2'.

AMD 4272
June 1983

Table 1. Types of wall suitable in given exposures

Renumber as table 2.

AMD 4272
June 1983

Clause 20.3 Protection against rain penetration

In paragraph 3, delete sentence 2 and substitute the following:

'Care should be taken to select the appropriate type and class of water repellent for treating a particular material.

For guidance see BS 3826.'

AMD 4272
June 1983

Clause 22.1 Thermal transmittance

In the first paragraph, final line, delete '1.0' and substitute '0.6'.

AMD 4272
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Clause 27. Structural considerations

Delete the first paragraph and substitute the following:

'Structural stone masonry should be designed following the recommendations of BS 5628, with particular reference to 23.1.8, 23.1.9 and clause 34 of BS 5628 : Part 1 : 1978.

The end bearing for lintels should normally be not less than 150 mm. Provision should be made for spreading concentrated loads over the wall area, e.g. by the use of padstones.'

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Clause 29. Fixing of metal and stone

In paragraph 1, delete lines 1 and 2 and substitute 'This clause deals with exposed ironwork'.

AMD 4272
June 1983

Clause 29.4 Summary

In line 2, delete 'table 2' and substitute 'table 3'.

AMD 4272
June 1983

Table 2. Methods of fixing ironwork, and their advantages

Renumber as table 3.

AMD 4272
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Clause 33. Scaffolding

In the final paragraph, delete the final sentence and substitute the following:
'Cantilevered scaffolds may also be provided,'.

After the final paragraph, insert a new paragraph as follows:

'All scaffolds and suspended access equipment should be in accordance with BS 5973, BS 5974 or BS 6037, as appropriate.'

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Clause 44. Cleaning

In paragraph 5, line 7, delete 'BRE Digest No. 113 Cleaning external surfaces of buildings' and substitute 'BS 6270 : Part 1'.

AMD 4272
June 1983

Clause 45. Repairs

After paragraph 2, insert a new paragraph, as follows:

'For detailed recommendations for surface repairs,
see BS 6270 : Part 1.'

AMD 4272
June 1983

Clause 46. Preservation of stone

In paragraph 1, insert a new final sentence as follows:

'For further information see appendix D of
BS 6270 : Part 1 : 1982'.

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Appendix A. Computation of thermal transmittance

In paragraph 4, item (b), line 3, delete 'table 4' and substitute 'table 5'.

In paragraph 2 of A.1, line 1, delete 'table 4' and substitute 'table 5'.

In paragraph 5 of A.1, line 7, delete 'table 5' and substitute 'table 6'.

Re-number tables 3, 4 and 5 as tables 4, 5 and 6 respectively.

In paragraph 7 of A.1, line 1, delete 'Table 6' and substitute 'Table 7', in line 3, delete 'table 5' and substitute 'table 6' and in line 5, delete 'table 6' and substitute 'table 7'.

Re-number table 6 as table 7.

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Appendix C. Geological age of some building stones

Delete asterisked footnote and substitute the following:

'* Availability should be checked. See 'Natural Stone Directory' available from Ealing Publications,
73A High Street, Maidenhead, Berks. SL6 1JX.'

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Standards publications referred to

Delete 'BS 65 & 540 Clay drain and sewer pipes including surface water pipes and fittings'.

Delete 'BS 1239-40 Lintels (cast concrete and natural stone)'.

In the reference to BS 1449, delete 'Part 4' and substitute 'Part 2'.

Delete 'BS . . . * The structural use of masonry Part 1 unreinforced masonry
(revision of CP 111)'.

Delete 'CP 97 Metal scaffolding'.

Insert the following in the correct numerical order.

- BS 65 Specification for vitrified clay pipes, fittings and joints
- BS 849 Plain sheet zinc roofing
- BS 1178 Milled lead sheet and strip for building purposes
- BS 1470 Wrought aluminium and aluminium alloys for general engineering purposes — plate, sheet and strip
- BS 1554 Specification for stainless and heat-resisting steel round wire
- BS 2870 Specification for rolled copper and copper alloys: sheet, strip and foil
- BS 2873 Copper and copper alloys. Wire
- BS 2874 Copper and copper alloys. Rods and sections (other than forging stock)
- BS 3014 'As welded' and cold drawn welded austenitic stainless steel tubes for mechanical, structural and general engineering purposes
- BS 3111 Specification for steel wire for cold forged fasteners and similar components
Part 2 Stainless steel
- BS 5628 Code of practice for the structural use of masonry
Part 1 Unreinforced masonry
Part 2* Reinforced and prestressed masonry
- BS 5642 Sills and copings
Part 1 Specification for window sills of precast concrete, cast stone, clayware, slate and natural stone
- BS 5911 Precast concrete pipes and fittings for drainage and sewerage
- BS 5973 Code of practice for access and working scaffolds and special scaffold structures in steel
- BS 5974 Code of practice for temporarily installed suspended scaffolds and access equipment
- BS 6017 Specification for copper refinery shapes
- BS 6037 Code of practice for permanently installed suspended access equipment
- BS 6213 Guide to the selection of constructional sealants
- BS 6270 Code of practice for cleaning and surface repair of buildings
Part 1 Natural stone, cast stone and clay and calcium silicate brick masonry'

Foreword

This British Standard code of practice is published as a revision of, and to supersede, CP 121.201 'Masonry walls ashlared with natural stone or with cast stone' and CP 121.202, 'Masonry—Rubble walls'. The content of these two codes has undergone complete technical revision to bring it in line with current practices.

The main areas of change include the introduction of more detailed information on lifting devices, scaffolding and repairs, and, in the clause on testing, a discussion of the principal measurements that could be made for the assessment of durability and quality control. The subject of cleaning is dealt with more fully and appendix B lists the

various methods now in use, their advantages and disadvantages, and gives guidance on the use of new products marketed as 'stone preservatives' and 'water repellents' in dealing with the preservation of stone. The approach to computation of thermal transmittance in appendix A differs from that given in other publications because it takes into consideration the effect of changes in moisture content and porosity of the stone.

Appendix C has been added to give information on the geological age of some building stones.

The standard units of measurement adopted throughout are in accordance with BS 3763 and PD 5686.

British Standard Code of practice for Stone masonry

Section one. General

1. Scope

This code deals with the design and construction of, and the selection of materials for, walls ashlar (i.e. faced) with stone or cast stone, and rubble or rubble-faced walls using stone or cast stone. For stone used as a cladding to structural masonry or to any structural steelwork or concrete frame see also CP 298. For structural requirements of all masonry (including stone or cast stone) see BS : Part 1 (in course of preparation).

In the case of rubble walling, methods of construction, style and appearance will vary in different districts according to the nature of the stone locally available and to local traditions, but the general principles laid down in this code should be adhered to.

2. References

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

3. Definitions

For the purposes of this British Standard code the definitions contained in BS 2847, BS 3589 and BS 4049 apply, with the following additions and exceptions.

General terms:

3.1 ashlar (aisler)

- (a) A square-hewn stone.
- (b) Masonry consisting of blocks of stone, finely squared to given dimensions and laid in courses with thin joints.

3.2 edge-bedded. A stone laid with the natural bed vertically, and at right angles, to the face of the wall.

NOTE. Edge-bedding is used in the cutting of voussoirs with a view to distributing stress around the arch and so helping to avoid breaking and exfoliation when the stone is submitted to the action of time and atmosphere. It is also used for cornices and projecting string courses.

3.3 face-bedded. A stone laid with the natural bed running vertically, and parallel, to the face of the wall.

3.4 natural bed (quarry bed). The plane of stratification in a sedimentary rock.

3.5 bond

- (a) An interlocking arrangement of stones within a wall to ensure stability.
- (b) Adhesion between mortar and stone composing a wall.

3.6 cast stone. Any product manufactured from aggregate and cement and intended to resemble in appearance and be used in a similar way to stone.

3.7 cornice. A projection that crowns a wall or an architectural feature, associated with the classical style.

3.8 course. A continuous layer of stones of uniform height in a wall, including the bed mortar.

3.9 fixings. A general term for the various types of cramp, dowel or metal corbel used to fix stone permanently to a backing.

3.10 freestone. Any fine grained sandstone or limestone that can be sawn easily.

3.11 plastic stone. A mix of mortar consistency containing a stone dust or sand aggregate, used to fill small cavities in chipped or decayed stonework.

3.12 pointing. The finishing of joints in mortar as the work proceeds or the filling with mortar of the joints in a wall from which the bedding or jointing mortar has been raked out.

3.13 profile. A temporary gauge-lath used in setting-out to define the position and levels of foundations, walls or other parts of a structure. The sectional outline of a moulding or other feature from which the templet is made.

3.14 scaffolding. A temporary erection of timber or metal framing with boarded platforms at levels suitable for building a wall.

3.15 seasoning. The process of storing the stone after quarrying to reduce its moisture content and bring it to the proper condition for use.

NOTE. Some stone can be very soft on its removal from the quarry and hardens considerably at this stage.

3.16 storey rod. A batten of exact storey height on which vertical dimensions are marked.

3.17 tingle. A small flat strip of lead or copper fixed below one piece of the same and long enough to project below the upper piece and be turned over free edge to prevent it lifting. Generally used for flashings or in tiling repair.

3.18 tooling. Having a surface obtained by using a batting tool in parallel strokes each traversing the full depth of the stone face. The strokes may be vertical or oblique. The result is a pattern of fluted cuts in the stone face. The number of bats (strokes) desired may be specified per 25 mm (see figure 11).

3.19 weathering

- (a) Working the top face of a stone to an inclined plane for the purpose of throwing off rainwater.
- (b) The effect of the action of time and weather on the surface of masonry which may change its appearance.

Terms peculiar to Scotland:

3.20 blaes. Blaze, poorly bituminous sandstone, shale or fireclay in coal measures.

- 3.21 bottle-nosing.** Rounded nosing.
- 3.22 bottoming.** Hard core.
- 3.23 cant.** Edge-bedded stone.
- 3.24 coddling.** Padstone or template.
- 3.25 gorge.** Throating.
- 3.26 hewing.** Hand working of stone.
- 3.27 intake.** Plinth or offset to a wall.
- 3.28 lime-shells.** Quicklime in lumps, unground, kiln burnt limestone.
- 3.29 lineal stones.** Stones sold by the linear measurement.
- 3.30 long-stone-swings.** Stone lintels.
- 3.31 munion.** Mullion.
- 3.32 oncome.** Corbel at springers of opening as at gathering of flue.
- 3.33 rest.** Wall hold, bearing of a structural member on a wall; template or padstone.
- 3.34 rubbed jointing.** Masonry joints rubbed with leather or india rubber to remove marks and ensure close fit to irregular stones.
- 3.35 shivers.** Chippings, spalls, broken or crushed stone.
- 3.36 shiver bottoming.** Hard core filling.
- 3.37 snecked harling.** Rough cast showing the faces of occasional walling stones built proud.
- 3.38 snecked pointing.** Flushing up the joints in walling leaving the faces of larger stones clear.
- 3.39 spalls.** Small pieces of broken stone.
- 3.40 super stones.** Stones sold by superficial measure.
- 3.41 tusks.** Tooothing.

Section two. Materials

4. General

The choice of building stone is influenced by the design of the building and its situation and may involve aesthetic as well as technical considerations.

5. Types of natural stone

The primary classification of building stones falls into three major groups:

- (a) igneous;
- (b) sedimentary;
- (c) metamorphic.

5.1 Igneous rocks. Igneous rocks are formed from molten magma, and the different types derive from the position of emplacement in the earth's crust of the magma and from its chemical composition. The principal igneous building stones are:

- granite
- basalt
- diorite
- serpentine

5.2 Sedimentary rocks. Sedimentary rocks derive from the disintegration of pre-existing rocks by weathering and erosion, the resultant sand, mud and grit being redeposited in water or by the wind in layers which eventually harden to form rocks and clays. The principal sedimentary building stones are:

- limestone
- sandstone

These have many subdivisions, and many varieties are found within the spectrum, e.g. shaly arenaceous and magnesian limestones, calcareous sandstones, and breccia or conglomerate where large fragments of much older stone have been naturally cemented together.

5.3 Metamorphic rocks. Metamorphic rocks are so called because they are produced from pre-existing rocks which have undergone change caused either by pressure or by heat, or both. The principal metamorphic building stones are:

- slate
- marble

So-called 'stone slates' from Collyweston, the Cotswolds, Yorkshire etc., are not true slates, but are from sedimentary rocks which split naturally along the bedding planes.

Many British 'marbles' are not true marbles but limestones formed with a very dense matrix and small fossil shells, e.g. Purbeck, Ashburton, Frosterley and Wealden marbles. In the British Isles true marble is found only in Ireland (Connemara) and north-west Scotland.

6. Cast stone

Cast stone is a building material manufactured from cement and natural aggregate for use in a manner similar to, and for the same purpose as, building stone. It is also described as artificial stone (a term that is deprecated), reconstructed stone or reconstituted stone. It should comply with the requirements of BS 1217. Reconstructed stone contains crushed stone, but cast stone need not.

7. Components

7.1 Cast stone blocks. Cast stone blocks in standard sizes can be obtained in many areas with textured faces to simulate rubble. Some of these are in single stones and others composed of several to form a walling unit carefully designed to create a sound bond.

7.2 Cast stone lintels. Cast stone lintels should comply with the requirements of BS 1217 and BS 1239.

7.3 Stone lintels. Stone lintels should comply with the requirements of BS 1240. The stone should be carefully selected, free from vents and similar sources of weakness, and of proven durability and weather resistance.

NOTE. For typical details of sills, lintels and copings see figures 15 to 17.

8. Mortar

Mortar may consist of:

- (a) lime and fine aggregate;
- (b) cement, lime and fine aggregate;
- (c) cement and fine aggregate;
- (d) cement and fine aggregate with suitable air entraining agents, as required.

8.1 Lime. Lime should comply with the requirements of BS 890, which also specifies requirements for hydrated lime powder, quicklime and lime putty for use in building.

There are four types of hydrated lime and of lime putty:

- (a) high calcium lime (white lime);
- (b) high calcium by-product lime;
- (c) semi-hydraulic lime (grey lime);
- (d) magnesian lime;

and of these (a), (c) and (d) can be quicklime.

Eminently hydraulic lime may be used, but is not covered by any existing standard.



Documents

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8.2 Cement. Cement should comply with the requirements of one of the following British Standards:

BS 12, BS 146, BS 4027, BS 4248.

High alumina cement (HAC) may be used for special purposes, for example, resistance to chemical attack, resistance to elevated temperatures in chimneys, or where early high strength is required. However, because of conversion HAC mortars may suffer in time a reduction of strength and no guidance is given in this code on its use. Consequently, a designer wishing to use high alumina cement has to rely entirely on his own judgement.

8.3 Masonry cement. Masonry cement is a prepared product based on Portland cement and contains no lime; it should comply with the requirements of BS 5224. The easy-working quality is obtained from the addition during manufacture of a finely ground mineral filler and an air entraining agent, and is mixed with sand and water to produce mortar. It should only be used for mortar or rendering.

8.4 Sand and other fine aggregate. Sand and other fine aggregate should comply with the requirements of BS 1200 which covers naturally occurring sands, crushed stone sands and crushed gravel sands. They should be hard, durable, clean and free from adherent coatings, such as clay, and from any appreciable amount of clay in pellet form. They should not contain iron pyrites or soluble salts or other harmful materials that would disfigure or weaken the mortar, or any organic impurities.

Crushed stone and stone dust of the same type as the stone used in the construction is often substituted wholly, or in part, for sand, to match the walling.

Demolition rubble should not generally be used, but in some cases crushed, hard, durable brick or tile may be used, as may any other fine aggregate provided that it is free from harmful materials.

8.5 Water. Water should be clean and should not contain any material, either in solution or in suspension, in quantities sufficient to have a harmful effect on the mortar or on metals or to impair the durability of the units of constructions.

8.6 Pigments. Pigments should comply with the requirements of BS 1014, if they are used.

9. Metal dowels, fixings, and wall ties

9.1 Metal dowels and fixings. Metal dowels and fixings should be non-corrodible, preferably of non-ferrous metal or stainless steel. Galvanizing or coating with bitumen affords only a temporary protection against the corrosion of iron or mild steel and could cause staining in a sensitive stone. Iron cramps set back 175 mm from the face of buildings have been known to cause spalling and even with this or a greater depth of cover the use of iron is dangerous.

The following materials may be used for the stated purpose.

Tying back and together fixings: copper, phosphor bronze, austenitic stainless steels.

Loadbearing fixings: aluminium bronze, phosphor bronze, austenitic stainless steels. All these should comply with the requirements of the appropriate British Standards.

A wrought or continuously cast product should be used in preference to a sand casting as freedom from porosity

cannot be guaranteed in the latter. The types of austenitic stainless steels recommended for these fixings are as follows.

(a) Fixings made from sheet and strip (BS 1449 : Part 4) 302S17, 304S16, 316S16, 321S12, 347S17.

(b) Fixings made from plate (BS 1449 : Part 4) 304S15, 316S16, 321S12, 347S17 or the high-proof stress versions of these steels.

(c) Fixings made from bar (BS 970 : Part 4) 302S25, 303S21, 304S15, 316S16, 321S12, 347S17 or the high-proof stress version of 316S16.

9.2 Metal wall ties. Metal wall ties should be of copper, phosphor bronze, or stainless steel, and comply with the requirements of BS 1243 in which the three types (butterfly, double-triangle and vertical twist) are described. The type selected should be suitable for sound insulation and structural requirements. If other types of tie are used the manufacturer should submit evidence that the material is suitable for the intended purpose.

10. Damp-proof courses

Suitable materials are:

- (a) lead-cored bituminous sheet;
- (b) bituminous felts;
- (c) mastic asphalt;
- (d) black polyethylene (low density sheet not less than 0.46 mm thick);
- (e) slates (at least two courses set in cement/sand mortar 1:3).

These materials should comply with the requirements of BS 743, and the standards appropriate to each material. Copper is not recommended here because of staining, and impervious bricks, whilst efficient, could be aesthetically undesirable.

If other materials are proposed evidence should be available that they are suitable for the intended purpose and conditions of use.

The mortar in which the above materials are bedded is related to their efficiency and should not be weaker than 1:1/4:3 of cement, lime and sand.

11. Airbricks, gratings and ducts

11.1 Airbricks and gratings. Airbricks and gratings should comply with the requirements of BS 493, where the materials used are appropriate to that British Standard.

Other airbricks, for use in external walls, and gratings for internal use in conjunction with airbricks should be of durable materials, should provide an adequate wall-hold or anchorage and should, wherever possible, be of such a size as to course in with the units of the wall.

11.2 Ducts. Ducts, consisting of pipes, used to bridge and close the cavity of a cavity wall, should be in accordance with BS 65 and BS 540. Slates used to form ducts should comply with the requirements of BS 743. The passage of vermin and rubbish into the building through the ducts should be prevented by having a suitable form of grating on the outside of the wall with as large an area of free airway as possible provided that a 10 mm diameter ball cannot pass through, or by backing it with a durable mesh of similar fineness. The inner ends of ducts, where they are exposed in rooms or elsewhere inside buildings, also should be fitted with a suitable form of grating, complying with the requirements of BS 493.

12. Flashings and weatherings

Sheet metals used for flashings and weatherings should comply with the requirements of appropriate standards.

The metals suitable for this purpose are:

- (a) lead, cast or milled: not less than code no. 4;
- (b) zinc: 14 ZG for normal exposure including coastal; 20 ZG for industrial and heavily polluted areas;
- (c) aluminium: not less than 99 % purity, 22 or 20 SWG;
- (d) stainless steel: usual thickness 0.4 mm.

Copper is not recommended because of staining, and attention is necessary to avoid corrosion if different metals are used for flashings and for roofing.

13. Resin adhesives

These adhesives are being used more frequently in stone construction and repair. Several varieties are produced by each manufacturer and it is important that the correct one is selected. They should not be used for pointing porous stone as they are impermeable, and decay of the stone is likely to be accelerated. At present these adhesives are not covered by a British Standard, and caution is urged in their use. Advice may be obtained from the Building Research Establishment.

14. Sealants, mastics and other materials for expansion joints

These are covered by BS 3712 and BS 4254.

BS 3712 is general and defines building mastic as a sealing or caulking material applied by gun or trowel, or in strip form, or by pouring. It should maintain a weatherproof seal between the sides of a joint which is subject to some degree of movement. The materials in strip form are readily deformable on compression but do not revert to their original shape.

BS 4254 defines the sealant as a two part compound consisting of one part containing a liquid polysulphide polymer and a second part containing a curing liquid. When mixed according to the manufacturer's instructions the sealant cures at ambient temperature to form a rubber-like solid. There are two grades, pouring grade and gun grade, and they have a known shelf life and application life.

In all but shallow joints a back-up material has to be used which may be cellular polyurethane, polyethylene, or types of rubber. The choice of sealant and back-up material depends on the conditions and result required, and different types of sealant require different back-up materials on which the manufacturers will make recommendations.

Appendix B in CP 121 : Part 1 : 1973 gives a summary of the properties of available sealing compounds.

Section three. Design and specification

15. General

Once it is decided that framing and cladding are not required but that solid stone should be used, it is likely to be clear, at an early stage in the design, whether the building is to have ashlar or rubble walling, the operative factors probably being the context of the building in its environment, and its function. The locality may influence the type of stone to be used.

15.1 Consultation and exchange of information. The previous codes of practice recommended consultation and exchange of information when the contract is signed. Supply of stone is now much more limited, and a great deal of design detailing is dependent on the limitations imposed by the material so that this stage should be brought forward almost to sketch design stage.

The designer should programme the precontract work to allow time for at least one quarry visit, combined with a visit to the workshops in order to obtain the necessary information. Indications are given in this section of the type of information to be collected.

Whilst the use of competitive tendering may mean that full consultation is impossible, the practice of using nominated subcontractors for specialist work such as stone masonry is normal practice, and a negotiated contract is used more frequently. These methods allow full coordination at the earlier stage, and this is particularly important in view of the very limited knowledge of the nature and uses of stone now prevalent. Although repair contracts are likely to involve smaller expenditure, the need for consultation is greater in view of the specialized knowledge of traditional craftsmanship involved in the repair of old and historic buildings.

The designer should supply adequate dimensional drawings from which, in the case of ashared walls particularly, the masonry contractor can prepare his working drawings and fixing schedules. Specification of depths of beds related to what the chosen quarry is able to supply, thickness of joints, minimum bonding overlap in vertical joints and suitable lengths of stone should be made in consultation with the masonry contractor.

Instructions as to the selection and approval of the stone, and to its finishes and fixings must be included in the specification and/or bills or quantities.

16. Choice of stone

16.1 Environmental suitability. The preponderance of sandstone in the north and of limestone in the south is a generalization of the circumstances that affect the choice of stone. Each area of the country is characterized by the local stone or, in areas without good building stone, by the most readily available stone from the surrounding regions. Regard should therefore be taken, in country areas particularly, to the local type of stone. In towns more flexibility can operate since stone from remote areas may have been and continue to be imported — hence the generalization of the opening sentence. The construction of a building in a stone totally alien to the area is likely to cause it to jar with its surroundings for its entire life.

The choice of the appropriate stone also affects the way in which the building weathers and matures. For instance, the local stone might no longer be obtainable, and a stone of the same colour from a totally different area and geological age (e.g. blue-grey Kentish ragstone and blue Clipsham) might be used instead. This might be visually acceptable for twenty years, but the method of weathering of the two stones is so different that their dissimilarity would increase with time.

The performance of the stone used in any area should be studied to gauge the effects of exposure and the methods of dressing and jointing. Stones that are suitable for use in inland areas may be totally inappropriate on the coast, being unable to withstand the salt-laden atmosphere and degree of exposure.

16.2 Availability. The supply of many varieties of local stone is very limited because of the closure or partial closure of many quarries, particularly as far as building stone is concerned. The designer should therefore ascertain at a very early stage in the design that the required stone is still available, and the sizes in which it is obtainable. If a large building is being considered then he should also ensure that the quarry will be able to supply the quantity of stone needed. 'Natural Stone Directory', published from time to time by Stone Industries, lists the quarries that are producing stone for building.

The sizes of stone blocks are determined by the depth of the natural bed and the occurrence of joints. Where blocks are required to the maximum depth of the bed they may be available, but not economically so, and this factor should be given careful consideration at the design stage.

At this early stage the designer should visit the quarry and consult the quarry manager so that he is aware of the limitations the material may impose before the design has progressed too far to accommodate them. If cast stone is to be used the manufacturer should also be consulted at an early stage in the design.

16.3 Durability. A factor to be considered here is the life expectancy of the building, in the case of a new structure, or the actual life of an existing one. Criteria are different and repairs of the large stone buildings may be the only ones possible in a hundred-year cycle. (See section seven.)

16.3.1 The selection of stone. The selection of stone is liable to be affected by variation in the bed. In some quarries the beds are sufficiently regular in character for selection to present no special difficulty, the relative durability of stone from such quarries being fairly well known, whereas in others the variations are such that each individual block has to be considered separately. In some beds blocks of good or inferior quality can be distinguished by inspection; in others the difference is not so apparent. Here again the quarry manager is a key adviser. Samples of selected stones should be taken and these should represent the range of variations that are acceptable.

16.3.2 The selection of cast stone. Cast stone is made from aggregate (sand, gravel or stone, whole or crushed, or a mixture of both) and cement. It may be homogeneous or may be made with a facing mix not less than 19 mm thick cast integrally with a different concrete mix. The colour may be varied by the addition of pigments, and the texture may be as required, with the stone cast against it. The designer or purchaser should satisfy himself that the cast stone is not liable to surface crazing. The manufacturer should ascertain that the aggregate will give a frost resistant stone, as some aggregates that could be used for this purpose are not resistant in their natural state. Walls that have been erected for more than five years may be inspected to investigate their weathering characteristics, but the manufacturer should certify, if requested, that the cast stone is in accordance with BS 1217.

16.4 Seasoning. The quarryman is knowledgeable about the length of time needed for a stone to become seasoned. This varies from quarry to quarry. Many stones can be worked by hand more easily immediately after quarrying, but because of the high water content some stone, when mined in winter, is not brought to the surface for working until the spring. Salts in the stone will tend to move towards the surface during seasoning and will thus be removed when the stone is dressed.

Cast stone must be properly cured before being brought to the site, otherwise damage can occur to arrises, and if it is laid too soon joints will open up, and there will be a great risk of crazing.

16.5 Soluble salts. Many stones are affected by the action of soluble salts which disfigure and finally decay them. Soluble salts may be:

- airborne, especially near the sea, but also from road salt;
- absorbed from the backing or jointing material;
- absorbed from the ground or stored materials;
- formed by reaction with sulphur gases in polluted air;
- introduced by some cleaning materials or processes.

Special care may need to be taken to avoid contamination by sea salts if stone has to be transported by sea.

To avoid the deleterious effects of sea salts on buildings in coastal areas guidance should be sought in selection by observing other stone buildings in the locality.

All backing materials for stone may contain salts, and clean sand is essential in the mortar, which should not contain an unnecessary proportion of cement. This could cause staining from impurities present in it. If bricks or blocks are used as backing, they should be stored off the ground before use to prevent absorption of soil salts, and if the stone is backed by structural concrete, the concrete should be painted with bitumen paint before any stone is fixed. The practice of painting the stone with bitumen paint is not recommended in most circumstances for the following reasons.

- (a) It could cause bitumen staining.
- (b) It restricts the ability of the stone to shed its natural moisture in any direction but the face, and this can cause staining.
- (c) It inhibits the natural bonding between stone and mortar.
- (d) It is an additional labour on the stone which experience suggests to be generally unnecessary.

See clause 45 for circumstances connected with old buildings.

Contamination by soil salts is a common cause of staining, particularly in buildings without a damp-proof course. The use of an impervious granite or similar stone set in cement mortar for plinths is an acceptable substitute for a damp-proof course, but not all granites are impervious.

16.6 Atmospheric pollution. Sulphur compounds in the air or in rainwater may react with stone or be deposited on its surface. This may lead to deterioration. Some stones are more resistant than others to this action. The type of stone used on other buildings in the locality should be a guide.

16.7 Frost action. Some stones are seriously affected by frost when wet, and care should be taken to ensure that these are not used in positions where they can become saturated, e.g. cornices, copings.

Care should be exercised in the selection of the stone and in the detailing of the structure so that the parts that protect the building are stooled and weathered. If there is doubt about the frost resistance of the stone all projecting mouldings should be protected by lead flashings or other impervious coverings. Copings and sills should be bedded on damp-proof courses to prevent water penetration into the walling below them.