BS 5385-2:2015

BSI Standards Publication

Wall and floor tiling –

Part 2: Design and installation of external ceramic, natural stone and mosaic wall tiling in normal conditions – Code of practice

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 38, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 5385 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 30 April 2015. It was prepared by Technical Committee B/539, *Ceramic tiles and other rigid tiling*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This part of BS 5385 supersedes BS 5385-2:2006, which is withdrawn.

Relationship with other publications

This part of BS 5385 is one of a series dealing with the installation of floor and wall tiling the other parts being:

- Part 1: *Design and installation of ceramic natural stone and mosaic wall tiling in normal internal conditions – Code of practice*
- Part 3: *Design and installation of internal and external ceramic and mosaic floor tiling in normal conditions – Code of practice*
- Part 4: *Design and installation of ceramic and mosaic tiling in special conditions – Code of practice*
- Part 5: *Design and installation of terrazzo, natural stone, agglomerated stone tile and slab flooring – Code of practice*

Information about this document

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

- includes recommendations on natural stone.
- expanded cement and sand mortar information.
- restrictions on mesh-backed mosaics above 3 m.
- includes repairs in existing buildings.

Use of this document

As a code of practice, this part of BS 5385 takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this part of BS 5385 is expected to be able to justify any course of action that deviates from its recommendations.

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.

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.

Particular attention is drawn to the following specific regulations:

- Building and Construction Regulations under the Factories Act [1]
- Lifting Operations and Lifting Equipment Regulations [2]
- Manual Handling Operations Regulations [3].

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1 Scope

This part of BS 5385 gives recommendations for the design and installation of external ceramic, natural stone and mosaic wall tiles in normal climatic conditions in the UK. It deals with the types of backgrounds and their suitability to receive tiling using the following fixing methods:

a) bedding in cementitious or reaction resin adhesives on an intermediate substrate or as a direct bedding method;

b) bedding mosaics in cement and sand mortar on rendering or as a direct bedding method on appropriate backgrounds.

NOTE Cement and sand mortar is seldom used as the bed for external wall tiling but, if needed, see BS 5385-1.

2 Normative references

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

BS 410-1, *Test sieves – Technical requirements and testing – Part 1: Test sieves of metal wire cloth*

BS 1210, *Specification for wood screws*

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

BS 4551, *Mortar – Methods of test for mortar – Chemical analysis and physical testing*

BS 5385-1, *Wall and floor tiling – Part 1: Design and installation of ceramic natural stone and mosaic wall tiling in normal internal conditions – Code of practice*

BS 5974, *Code of practice for the planning, design, setting up and use of temporary suspended access equipment*

BS 6100-6, *Building and civil engineering – Vocabulary – Part 6: Construction parts*

BS 6213, *Selection of construction sealants – Guide*

BS 8000-11, *Workmanship on building sites – Part 11: Internal and external wall and floor tiling – Ceramic and agglomerated stone tiles, natural stone and terrazzo tiles and slabs, and mosaics – Code of Practice*

BS EN 197-1, *Cement – Part 1: Composition, specifications and conformity criteria for common cements*

BS EN 12004:2001, *Adhesives for ceramic tiles – Requirements, evaluation of conformity, classification and designation –*

BS EN 12057, *Natural stone products – Modular tiles – Requirements*

BS EN 12371, *Natural stone test methods – Determination of frost resistance*

BS EN 13139:2002, *Aggregates for mortar*

BS EN 13888:2009, *Grouts for tiles – Requirements, evaluation of conformity, classification and designation*

BS EN 13914-1:2005, *Design, preparation and application of external rendering and internal plastering – Part 1: External rendering*

BS EN 14411:2012, *Ceramic tiles – Definitions, classification, characteristics, evaluation of conformity and marking*

BS EN 14647:2005, *Calcium aluminate cement – Composition, specifications and conformity criteria*

BS EN ISO 10545-12, *Ceramic tiles – Part 12: Determination of frost resistance*

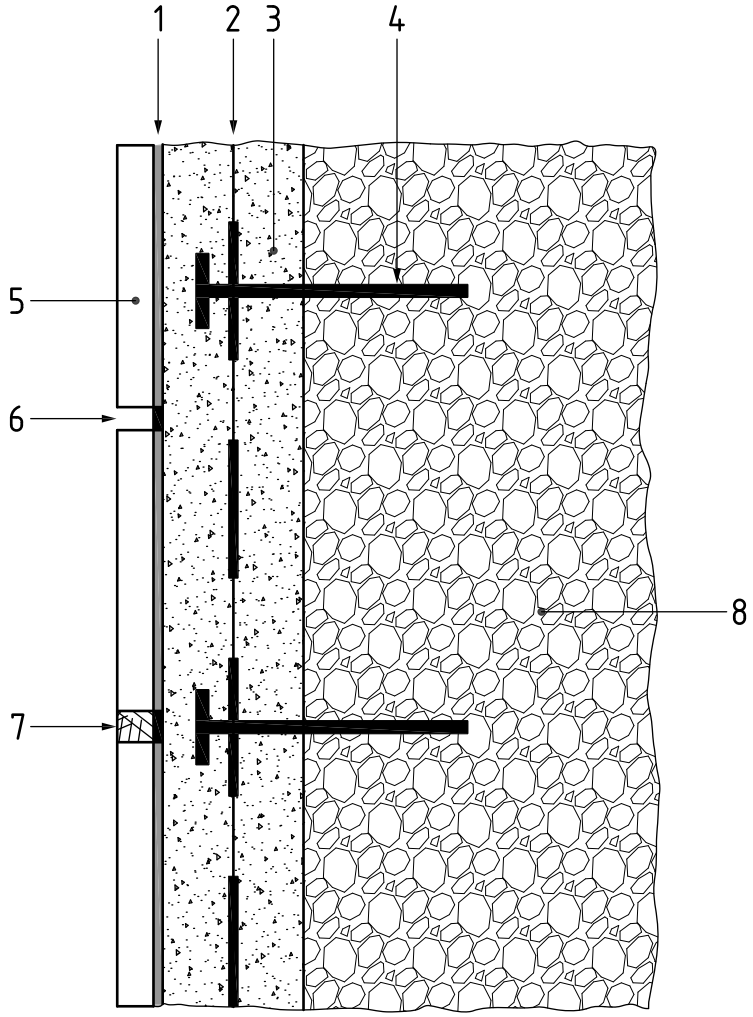
3 Terms and definitions

NOTE An illustration of some selected definitions is shown in Figure 1.

For the purposes of this part of BS 5385 the terms and definitions given in BS 6100-6, BS EN 14411 and the following apply.

3.1 bond breaker tape
self-adhesive tape, used to prevent sealant sticking to a substrate

Figure 1 **Illustration of selected definitions**



Key

1	Adhesive bed	5	Tile or tesserae
2	Reinforcement (optional)	6	Joint
3	Cement and sand rendering	7	Grout
4	Fixing	8	Structured wall

4 Exchange of information and time schedule

*NOTE Clause **4** deals with the exchange of information for the whole wall, including tiles, tile bed, background and intermediate substrate (if any).*

4.1 Exchange of information

The working drawings and specifications should be prepared in sufficient detail to afford proper guidance in the design and execution of the work. At the tendering stage the following information should be sought and documented:

a) Site. Location and means of access;

b) Building. Nature of building and particulars of corrosive or other potentially damaging conditions to which the installation might be subjected in service (e.g. mechanical cleaning);

c) Wall(s). Type and age of construction, location, height, type and accuracy of backgrounds and need for intermediate substrate or special mechanical fixing systems (see **6.5**);

NOTE Permissible deviations from horizontal and perpendicular lines in building construction are usually greater than appropriate for ceramic tiling or mosaic finishes.

d) Associated work. Elements embedded in or passing through the wall, skirtings and abutments, junctions with other adjacent finishes;

e) Finishes. Type(s) of tiles and/or mosaics, bedding and jointing requirements and required surface plane;

f) Contract. Details, if the work is to be completed in any specific order or in sections;

g) Health and safety. Information on articles and substances for use during the work that is liable to be a health risk;

h) Time schedule. A time schedule for the progress of the work (see **4.3**); and

i) Testing. Details of any installation compliance testing required.

4.2 Provision of utilities, facilities and materials

To prevent misunderstanding, particularly at the tendering stage, and to avoid possible situations detrimental to installation, it should be made clear whether or not the following is provided and by whom:

a) adequate clean, dry, lockable storage space protected from frost (if necessary) (see **5.1**);

b) clean water supply adjacent to working areas;

c) adequate artificial lighting (if necessary), e.g. for tiling within a protected enclosure;

d) safe means of access and places of work, to include, where necessary, suitable scaffolding and staging, which should conform to BS 5974;

NOTE 1 Attention is drawn to the requirements of the Building and Construction Regulations under the Factories Act [1].

e) unloading and hoisting facilities;

NOTE 2 The following references are valid: Lifting Operations and Lifting Equipment Regulations [2], Manual Handling Operations Regulations [3].

f) electric power supply adjacent to working areas;

g) protection of work during and after fixing (see **6.3**);

h) supplies of cement and sand in accordance with **9.2.1** and **9.2.2**; and

i) tiles, adhesives, grouts, primers and sealants.

A check should be made to ensure that all materials needed for the installation are available.

4.3 Time schedule

The time schedule for the whole building work should be planned in the initial stages before operations commence and, where possible, in consultation with those responsible for carrying out the work of each of the trades concerned.

In preparing the time schedule, each operation should be considered in relation to others. Due consideration should be given to the most economical use of general plant and scaffolding by all trades, also to ensure that the various trades do not interfere unduly with each other's work.

For economic and efficient application of external tiling and mosaics, work should begin at the highest point of the construction. In addition, in certain forms of a multi-storey construction, some deflection of the wall can occur at lower levels as the construction increases in height and the loading consequently increases. It is important, therefore, that application of tile or mosaic tiling should not commence until the construction has been erected to its full height.

At least six weeks should be allowed in the time schedule for the drying out and initial shrinkage of the structural or non-structural concrete. If an intermediate substrate e.g. rendering is subsequently applied, each coat should be cured, allowed to dry and harden in accordance with BS EN 13914-1 to permit drying shrinkage before the final coat is applied. The final coat should be cured and left to dry for at least a further two weeks. The drying times of all in situ backgrounds are the minimum required under optimum conditions and these drying times should be considerably extended under adverse drying conditions on site, e.g. low temperatures and wet conditions.

The schedule should allow sufficient time for the cutting of holes and chases and/or other work involving the use of percussion tools in or on the walls to receive a bedded finish, and adjacent walls, to be completed before a substrate is applied. All the time allowances mentioned are equally applicable where a substrate is to be omitted and the tile or mosaic finish bedded directly to the structural background.

NOTE Cutting holes in natural stone might need to be carried out at the factory. If undertaken on site, use only equipment that will not result in damage to the stone. For some types of natural stone, e.g. granite such work can only be carried out with correct dust control.

The schedule should provide for the completion of all necessary subsidiary work before the fixing of tiles or mosaics begins. The schedule should include times for commencement and completion of tiling or mosaic work to the different parts of the construction, allowing sufficient time intervals between the operation of the bedding, grouting and final cleaning down.

Provision should be made for adjustment to allow for suspension of operations due to frost or other unfavourable weather or other conditions that jeopardize the safety of workers and/or the success of the installation.

Alternatively, consideration should be given to the possibility of providing a protective enclosure, e.g. cocooning, to enable work to continue during unfavourable conditions. In addition, heating might be necessary.

5 Materials

5.1 Transport and storage

The delivery of materials should be arranged to minimize handling. Adequate precautions should be taken to guard against the possibility of damage.

Materials should be stored in clean, dry, frost-free (if necessary), lockable storage to avoid excessive handling, theft or damage.

5.2 Ceramic tiles

Ceramic tiles for external use up to 3 m should have water absorption of not more than 3% and should either be extruded tiles type AI_a or AI_b or dust-pressed tiles types BI_a and BI_b (see Table 1 and **6.3**).

Ceramic tiles for external use above 3 m should be Class AI_a or BI_a and the tile surface should not be larger in facial surface area than 0.1 m^2 unless secured by mechanical means (see **6.5**).

Before selecting a particular type of tile, advice about its suitability should be obtained from the supplier.

Table 1 **Classification of ceramic tiles with respect to water absorption (E) and shaping**

Shaping (see Note)	**A Extruded**	**B Dry pressed**
Group I	Group AI_a	Group BI_a
$E \leq 3\%$	$E \leq 0.5\%$	$E \leq 0.5\%$
	Group AI_b	Group BI_b
	$0.5\% < E \leq 3\%$	$0.5\% < E \leq 3\%$

NOTE See BS EN 14411:2012, Table 1 for water absorption limits for Groups II and III tiles which are of higher water absorption and therefore unsuitable for external use.

5.3 Mosaics

NOTE Annex A contains information about mosaics.

Mosaics with any form of mesh backing should not be used.

Ceramic tesserae should conform to the relevant physical and chemical properties given in BS EN 14411.

For mosaics that are to be fixed in locations liable to frost, ceramic tesserae should pass the frost resistance test as described in BS EN ISO 10545-12.

Before selecting a particular type of mosaic, advice about its suitability should be obtained from the supplier.

5.4 Natural stone

Stone should conform to BS EN 12057 and declared to be appropriate for external use.

NOTE 1 Descriptions of natural stone can be found in Annex B.

NOTE 2 Natural stone tiles as described in BS EN 12057 can be calibrated or not calibrated. Natural stone tiles are flat pieces of natural stone square or rectangular in standard sizes, obtained by cutting or splitting at a nominal thickness of ≤ 12 mm. There are no limitations on the length or width.

The stone used to produce the tiles for external use should be tested to the freeze thaw test in BS EN 12371. Stone tiles which are resin mesh backed should not be used.

Natural stone for external use at above 3 m should not be larger in facial surface area than 0.1 m^2 unless secured by mechanical means (see **6.5**).

5.5 Adhesives

5.5.1 General

Cementitious adhesives (C) and reaction resin adhesives (R) should conform to BS EN 12004.

Adhesives conforming with BS EN 12004 are designed for use with ceramic tiles. The performance characteristics set out in this standard do not apply to all types of natural stone. For external conditions, the adhesive used should achieve the required performance according to BS EN 12004.

5.5.2 Admixtures to adhesives

An aqueous polymer dispersion can be incorporated in cement based adhesives to obtain greater adhesion, improved resilience or some reduction in water permeability. Such admixtures should be used only with adhesives approved by the manufacturer. The use of admixtures is not necessary when adhesives with additional characteristics such as those given in BS EN 12004:2001, under Type C Class are used.

Admixtures should be used strictly in accordance with the manufacturer's instructions and should not be added to an adhesive unless approved by the manufacturer of the adhesive.

5.6 Bonding agents

NOTE Bonding agents are available to improve the adhesion of renderings and/or tile beds to backgrounds.

Bonding agents are usually mixed with cement and sand, or more commonly with neat cement, and should be applied as a wet slurry or stipple immediately prior to the application of the mortar. For optimum results the bonding agent should also be used as an admixture in the mortar. This gives improved compressive and tensile strength, allowing mortars to be applied in thinner sections, thus reducing the weight of the construction.

Bonding agents based on polyvinyl acetate or any other polymer affected by moisture should not be used in external applications.

The manufacturer's recommendations for the particular type of bonding agent to be used and its method of application should always be strictly followed.

5.7 Sealants and back-up materials for movement joints

5.7.1 General

Materials for movement joints should be non-rigid; they should combine the properties of resilience and/or plasticity within the maximum temperature ranges likely to be encountered and should be resistant to mould growth.

5.7.2 Sealants

Joint sealants should be selected and applied in accordance with the guidance given in BS 6213.

Sealant manufacturers' advice should be taken into account as the properties of individual sealants can vary. Generally, a sealant should be capable of accommodating the anticipated amount of movement without loss of adhesion to the sides of the joints and be able to withstand the normal service conditions affecting the installation, e.g. resistant to water, ultraviolet light.

Where movement is large and frequent, Class 25 sealants should be used. For joints undergoing smaller and less frequent, movement Class 20 or Class 12.5 can be considered however where the class number is less than 20 the sealant might not be suitable over structural movement joints. For a given extent of movement, the narrower the joint, the higher the sealant class needed to accommodate the movement.

*NOTE Information on sealant installation is given in **10.4**.*

5.7.3 Back-up materials

The compressible back-up material should be a material to which the sealant does not adhere, or one which can be covered with a bond breaker tape to prevent adhesion.

The back-up material in the lower part of the joint should be compatible with the sealant used, should recover after compression and should support the sealant. It should not exude bituminous or oily products and should not absorb excessive amounts of moisture. In particular, its compressibility should be such that when the joint closes the sealant is not forced out. Suitable materials include closed cell cellular rubber and plastics, such as cellular polyethylene, some fibre building boards, cork boards and mineral or synthetic ceramic cords or blankets. Back-up materials are available in sheet strip and cord form in a range of sizes.

*NOTE Information on back-up material installation is given in **10.5**.*

5.8 Grouts

5.8.1 General

Grouts should have good working characteristics, low shrinkage and good adhesion to the sides of the tiles, whilst being capable of being cleaned off the face of the tiles without undue difficulty. When selecting a grout the specifier should establish that it is suitable for exposure to external conditions.

5.8.2 Types of grout

5.8.2.1 Proprietary grouts

Proprietary grouts should conform to BS EN 13888:2009, Type CG or RG and should be one of the following types:

a) mixes based on cement and mineral fillers but modified by the inclusion of various additives, including pigments and organic additives, that only require to be mixed with clean water to the recommended consistency (CG);

b) mixes based on cement and mineral fillers and additives to be mixed with aqueous synthetic polymer dispersions to the recommended consistency (CG); or

c) mixes based on epoxide resin consisting of separate pre-gauged components to be mixed together immediately before use (RG)

NOTE 1 Some types of grout might cause "picture frame" staining of natural stone.

NOTE 2 Epoxide resin grouts might take longer to apply and clean off than cement based grouts.

NOTE 3 Epoxide grout might not suitable for use with natural stone.

5.8.2.2 Cement and sand mortar grouts

Cement and sand mortar grouts are sometimes used for grouting joints over 3 mm in width. In order to promote good adhesion and strength development there should be dampness in the joint cavities.

Mixes of this type are more suited for mosaics in cement and sand mortar beds that are thick enough to retain sufficient dampness when re-wetted.

NOTE The physical properties of cement and sand mortar grouts are generally inferior to those of proprietary grouts, which provide performance and properties that are more consistent.

Neat cement mixed with water should not be used as a grout for external tiling except for pre-grouting paper-faced mosaics with narrow joints.

5.8.3 Admixtures to grouts

NOTE Admixtures, normally in the form of aqueous dispersions, can be incorporated in grout mortars based on cement and sand to enhance adhesion in the tile joints, whilst improving the resilience and reducing the water permeability of the hardened grout mortar. Proprietary aqueous admixtures are available for incorporation in proprietary grouts to provide improved characteristics.

Admixtures should be used strictly in accordance with the manufacturer's instructions and they should not be added to a proprietary grout unless approved by the grout manufacturer.

5.9 Reinforcement and metal lath for cement and sand rendering

Metal reinforcement should be of austenitic stainless steel wire conforming to BS 4483. The wire should be 2.5 mm diameter welded into a mesh size of approximately 50 mm × 50 mm. Fixings should be of austenitic stainless steel. The type of fixing depends upon the background.

Galvanized reinforcement as recommended in BS 5385-1 should not be used in external rendering, except where it might be suitable for small areas in sheltered locations.

6 Design

6.1 Initial considerations

In the early stages of designing external wall tiling, consideration should be given to the following:

a) type, size and colour of tile;

b) type and width of the joints;

c) type, height and age of backgrounds (see Clause **7**);

d) method and materials to be used for bedding or mechanically fixing the tiles (see Clause **6.5**, Clause **12** and Clause **17**); and

e) position and requirements for movement joints (see Clause **10**).

6.2 Appearance and effect

NOTE Many types of tiles and mosaics are available but, as with most other building materials, some variations in colour and size might occur. In selecting tiling for architectural effect, some limitation to choice might be imposed by the technical ability of the tile or mosaic to fulfil the durability requirements for any specific application.

The designer should consider the merits of the various finishes available in tiles and select finishes that give the best balance of attributes. For example, a tile with a highly glazed finish reflects light differently from an unglazed tile and is more self-cleaning.

The effect created by the joints is an integral feature of tiling and should be taken into consideration at the design stage. This is particularly so in some forms of mosaic and decorative tiling where the directions of the joints form an integral part of the design. Joint widths should be as uniform as possible throughout the installation (see **6.3.3**).

As it is usual for the colour of joints to contrast with the colour of the tiles to some degree the natural colour of the grout is normally satisfactory. However, it should be noted that if the colour of the grout and that of the tile is too contrasting it could lead to very small differences in joint width becoming noticeable.

Tinted grouts should be used with caution as variation in colour can occur and fading or deposits of atmospheric dirt can, over a period of time, nullify the intended effect. Where joints are strongly defined and/or form an important part of the design, consideration should be given as to whether the sizes of walls, openings and margins should be planned to accommodate whole tiles.

6.3 Exposure conditions and protection

6.3.1 General

Exposure to thermal effects, water penetration, pollution and frost should be considered in relation to the choice of tile, tile bed or mechanical fixing system, the design of joints and the detailing of architectural features. For exposed locations generally and at above first floor level, class BI_a tiles should be selected. For sheltered locations at low level, which are protected by prominent features of the construction, such as canopies or in underpasses, class BI_a, BI_b and AI tiles should be suitable.

*NOTE Relevant information is given in **5.2, 5.3, 6.3.2, 6.3.3, 6.3.4** and Clause **11**.*

6.3.2 Thermal effects

Where it is suspected that thermal movement of the tiling and background threatens the stability of the installation, special precautions or provisions of additional movement joints should be considered. Adhesives conforming to BS EN 12004 should be used.

NOTE Tiles which are dark coloured absorb and lose heat more readily than light coloured ones.

6.3.3 Design of joints

The optimum width for joints between ceramic tiles is influenced by the variations in tile size and the depth of joint required. With extruded tiles the joint width should usually be 5 mm to 10 mm, whilst joints between dust pressed tiles can be less, depending on size tolerance, but should be at least 3 mm. The nominal joint width selected should allow for some adjustments during setting out so that variations in joint width, necessary to accommodate the tile size tolerances, are not too evident in the finished tiling.

For natural stone, the width of the joint between calibrated tiles should be at least 3 mm wide and non-calibrated tiles should be at least 5 mm wide. Natural stone tiles can be cut to suit variations in the setting out.

Joints should be sufficiently wide to enable the grout to be inserted, without undue difficulty, to the full depth of the joints and thus achieve solid joints as far as practicable without voids or cavities where water could collect.

Cement and sand and proprietary mortar grouts are resistant to wet and freeze/thaw conditions but should not be treated as impervious. Modified cementitious mortars can inhibit water penetration; however, if a totally impervious joint is required, an epoxide resin grout should be used, but it should be appreciated that even when impervious tiles are grouted with an impervious epoxide resin grout, the tiling system as a whole cannot be considered to be an impervious finish.

6.3.4 Waterproofing details and external features

6.3.4.1 General

External features should be designed to protect the tiling at positions where it might be vulnerable to water penetration or discoloration from the deposition of waterborne dirt. This protection should prevent the ingress of water to the back of the tiling.

Flashing and edge trims covering the top edges of tiling should be designed to prevent driven rain seeping into the structure over the top edge of the tiling. Gutters and water heads should be of adequate capacity for the volume and flow rate of water they handle.

6.3.4.2 Parapet walls

The walls and top edge of tiling should be suitably capped with preformed units designed to provide weather-tight protection. Water should be prevented from penetrating through to the tiling from behind. In the case of cavity walls and walls of permeable construction, where height allows, provision should be made for ventilation under the capping and drainage at the base.

Where natural stone is used, a minimum slope of 4.5° should be used.

6.3.4.3 Sills

Preformed units designed to provide weatherproof protection to the structure should be specified for sills. These should be suitably bedded to form an adequate seal over the top of the tiling below. Where there is less risk of water penetration, sills can be tiled to provide a self-draining sloping surface with nosings overhanging the tiling below and with all joints completely filled.

NOTE Improved protection can be provided by the use of epoxide resin grout.

Where natural stone is used, a minimum slope of 4.5° should be used.

The practice of continuing mosaic tiling over sill ledges is not recommended.

6.3.4.4 External corners

In conditions that might introduce a substantial risk of damage, for example from mobile plant, suitable robust corner pieces should protect the tiling or be substituted for it.

6.3.4.5 Treatment at base

A space sufficient to accommodate comfortably any potential movement of the paving should be left between the bottom edge of tiling and paving to avoid possible disruption by any movement in the latter. At this position, and at other positions where the tiling is similarly interrupted horizontally, a drip should be formed to divert rainwater away from the gap.

Some types of limestone are not suitable for use as the base course. Disfigurement of plinths can be caused by rising damp and rain splashing from pavements and earth. This can be minimised by the use of suitable and possibly dark stones.

Tiling should not be carried across the exposed edges of horizontal damp-proof courses without a break, since it can transmit moisture past the damp-proof course and make it ineffective; furthermore, movement of the building on the damp-proof course can cause damage to the cladding. The top edge of tiling immediately beneath a damp-proof course should be protected by the latter, which should be designed to project through the tiling to serve as a flashing. Suitable provision should be made to discharge water from damp-proof courses through the tiling (see **7.2**).

6.3.4.6 Horizontal surfaces

The inclusion of horizontal surfaces should be avoided, but if this is not possible, sufficient slope should be provided to inhibit the retention of water, especially where this is likely to contain potentially aggressive substances.

6.4 Suitability of tiles or mosaics

*NOTE 1 Guidance and recommendations on the selection of suitable materials are given in **5.2, 5.3** and **6.3**.*

*NOTE 2 The effects of solar heat when dark coloured tiles are used are referred to in the Note in **6.3.2**.*

*NOTE 3 Ceramic tiles as described in **5.2** and mosaics as described in **5.3** when used as tiling can contribute to the fire resistance of a wall.*

6.5 Ceramic rain screen cladding

Class AI_a or BI_a ceramic tiles and slabs are produced in a variety of colours and in sizes ranging from small to very large units of 3 m^2 format. The high mechanical strength characteristics needed of these materials in order to conform to BS EN 14411 are such that some of these products can be suitable for use as cladding for ventilated rain screen systems. The manufacturer's advice should be sought.

The ceramic tiles or slabs should be mechanically fixed to a supporting metal framework structure by means of special clips or expanding anchors which are fitted into undercut slots or holes formed in the back of the ceramic tiles or slabs. Various types of proprietary support and mechanical fixing systems are manufactured for this purpose.

NOTE For natural stone rain screen cladding, BS 8298-4 provides detailed information.

7 Backgrounds

7.1 General

Backgrounds should have sufficient strength to support the weight of the whole tiling system.

NOTE 1 Properties of background materials that determine their suitability for the installation of tiling or mosaic work include integral strength, freedom from contamination, trueness of construction, physical key, porosity, suction, moisture movement, thermal movement, drying shrinkage and creep.

The drying shrinkage movement expected of concrete and concrete products varies according to the type of aggregate used and/or the free water:cement ratio.

Dense backgrounds should be left to dry out sufficiently to allow initial drying shrinkage to take place. In warm, dry, well-ventilated conditions the time required for the initial drying out is not less than six weeks. In conditions, which are cold, damp, poorly ventilated, etc., drying shrinkage can take longer than six months before preparation commences to receive rendering or tiling. Porous backgrounds should be protected from rain. Before starting work, it should be ensured that the temperature of the background is at the least 5 °C, irrespective of the ambient temperature.

NOTE 2 Table 2 and Table 3 summarize the properties of backgrounds, their preparation and the suitability of fixing materials.

7.2 Soluble salts in backgrounds

Some types of clay bricks and blocks contain substantial amounts of soluble sulfates and should not be used as backgrounds for tiling.

Brickwork and other backgrounds containing soluble sulphate should be prepared by the installation of a mesh reinforced cement and sand render adequately secured to the background.

Preparatory treatments should be in accordance with Clause **8**.

NOTE 1 Where backgrounds are likely to become damp and remain so for prolonged periods, soluble salts can migrate and result in adhesion failure or disruption of the rendering. It can also result in staining appearing on the surface of natural stone.

NOTE 2 Soluble salts in the background might also cause surface efflorescence and lime bloom on the surface of the finished tiling.

Table 2 **Backgrounds: direct fixing**

Background	Details	Material for direct fixing of tiles and mosaics			Drying shrinkage movement (see 7.1)	Surface character/ Suction	Preparation of background	
		Cementitious adhesives	Reaction resin adhesives	Cement and sand mortar (see Note 2)			Fixing with adhesive	For rendering or cement and sand mortar bedding
Clay: bricks, blocks and tiles	Tiles and glazed bricks	C	S	U	Negligible. Might expand slightly	Very low	See **8.3.4**	See **8.2.2.4**
Cement and sand rendering	New	S	S	S	Moderate	Moderate	See Clause **9**	See **14.4**
Other surfaces	Existing render	S	S	S	Negligible	Moderate to high	See **8.3.2**	Unsuitable
	Fibre cement board	C	C	U	Moderate to high	True and smooth	See **8.3.1** and **8.3.3**	See **8.2.5.3**
	Metal surfaces	U	C	U	Nil	Low and poor key	See **8.3.1** and **8.3.5**	See **8.2.5.3**

NOTE 1 Properties of backgrounds indicate only relative characteristics of the materials.

NOTE 2 Cement and sand mortar is seldom used for fixing tiles externally and has been included in this Table as an alternative method of fixing mosaics or for historic restoration work. For fixing tiles in cement and sand mortar see BS 5385-1.

NOTE 3 S denotes "suitable", U denotes "unsuitable" and C denotes "confirm adhesive's suitability with manufacturer".

NOTE 4 Use of fibre cement board is subject to confirmation of suitability by the board manufacturer.

Table 3 **Backgrounds: requiring rendering**

Background	Details	Drying shrinkage movement (see 7.1)	Surface character/ Suction	Preparation of background	
				Fixing with adhesive	For rendering or cement and sand mortar bedding
Concrete: in situ or precast	Dense aggregate	Can vary from low to moderate	Low to moderate	See **8.3.1** and **8.3.2**	See **8.2.2.2**
	Lightweight aggregate: open surface	Moderate to high	Moderate to high		See **8.2.4.2**
	Lightweight aggregate: closed surface	Moderate to high	Moderate		
	Autoclaved aerated	Moderate to high	Moderate to high		
Concrete: blocks and bricks	Dense aggregate [A)]	Moderate to high	Low to moderate	See **8.3.1**	See **8.2.2.2**
	Lightweight aggregate autoclaved open surface [A)]	Moderate to high	Moderate to high		See **8.2.4.2**
	Autoclave, closed surface [A)]	Moderate to high	Moderate		
Clay: bricks, blocks and tiles	High-density bricks and blocks	Negligible. Might expand slightly	Low		See **8.2.2.1**
	Normal bricks and blocks	Negligible. Might expand slightly	Moderate or high		See **8.2.3.1**
	Dense aggregate	Can vary from low to moderate	Low to moderate	See **8.3.1** and **8.3.2**	See **8.2.2.2**
Other surfaces	Wood-based panel products	Moderate to high	True and smooth	See **8.3.1** and **8.3.3**	See **8.2.5.3**
	Paintwork	N/A	N/A	Unsuitable	See **8.2.5.2**

[A)]Confirm with the block manufacturer that the treatment recommended is appropriate to the product.

NOTE 1 Properties of backgrounds indicate only relative characteristics of the materials.

NOTE 2 Cement and sand mortar is seldom used for fixing tiles externally and has been included in this Table as an alternative method of fixing mosaics or for historic restoration work. For fixing tiles in cement and sand mortar see BS 5385-1.

NOTE 3 S denotes "suitable", U denotes "unsuitable" and C denotes "confirm adhesive's suitability with manufacturer".

8 Preparation of backgrounds

8.1 General

NOTE The suitability of a background to receive tiling depends on the quality of its surface relative to the various methods and materials that can be used to fix the tiles. It might be necessary to introduce some intermediate treatment of which the following are examples:

a) hacking back and making good the background prior to application of any intermediate substrate;

b) application of a bonding agent to improve the adhesion;

c) keying of the surface;

d) welded stainless steel mesh reinforcement anchored to the background;

e) utilizing an intermediate substrate to provide the necessary measure of suction and/or accuracy.

All backgrounds should be inspected for contamination and any potentially deleterious material should be removed.

Backgrounds not built accurately to a true plane, or having surfaces that are uneven, might have deviations too great to be accommodated within the recommended render thickness. In such cases, the background should be cut back and/or made good as a separate operation. Where backgrounds are bricks, blocks or concrete, it is recommended that a rendering should be applied to provide a true surface.

Tile beds of thicknesses greater than those recommended in Clause **11** should not be used to accommodate inaccuracies in a background surface, especially if the bed thickness is not consistent throughout the installation. This can give rise to variable stresses and possible loss of adhesion or cracking.

Separately from the need to correct irregularities, rendering is still recommended. The benefits derived from the use of thin-bed adhesives as a bed for tiling are realized only when the adhesives can be spread to a consistent thickness in accordance with the manufacturer's recommendations; thus the accurate surface that can be provided by a rendering makes an important contribution to the cladding tiling system as a whole.

8.2 Preparation to receive cement and sand render

8.2.1 General

Before applying cement and sand render it should be ensured that the substrate has dried out (see **4.3**), especially where the background consists of materials such as lightweight concrete blocks, calcium silicate bricks, concrete bricks and concrete blocks, which can have an appreciable drying shrinkage related to their composition and degree of saturation (see Table 2).

Any laitance on the surface, contamination by oil, grease or any other substances that inhibit adhesion of the rendering should be cleaned or removed. All loose material on the surface should be brushed off.

It is essential that the surface to be rendered provides a good key, a good bond being dependent upon a mechanical key and adequate suction and/or the use of a suitable bonding agent. A suitable treatment can be one or more of the following:

a) Mechanical preparation. The surface should be removed to expose the aggregate using suitable mechanical equipment;

b) Indented keys. These are formed in concrete by rubber or composition formers fixed to the shuttering at sufficiently close centres to support the tiling system;

c) Spatterdash. A mix of cement and sand, or a proprietary admixture applied over the surface in the form of closely spaced globules;

d) Retarders. These are painted on shuttering to enable a good key to be formed on the surface of concrete. After removal of the shuttering considerable care should be taken to ensure that all traces of retarder, unset cement and loose particles are removed and that the aggregate is exposed uniformly: this can be done by wire brushing and thorough washing using clean water with a suitable detergent, followed by a final washing down with clean water. Retarders and detergents containing coloured dyes are recommended so that their removal can be seen to be complete when no traces of the dyes remain;

e) Metal laths and reinforcement. These are appropriate for constructing backgrounds for tiling onto sheltered ground floors. The laths and mesh should be austenitic stainless steel secured with austenitic stainless steel fixings at intervals such that the applied rendering is rigid. Laths and mesh made of other non-corrosive materials should be suitably secured to ensure the rigidity of the render and to support its weight and that of the tiling. Where laths or mesh are fixed onto a ventilated timber framework, a vapour-control membrane, e.g. polyethylene, should be fixed between the mesh and the timber. Provision should be made for movement joints in the rendering and tiling at all perimeters of the laths or mesh areas [see **10.3c)**];

f) Bonding agents. Of the several different chemical types of bonding agent available, those based on styrene butadiene rubber are the most widely used in external applications. However, before deciding on a proprietary product the advice of the manufacturer should be sought regarding its suitability, method of application and the necessary properties of the surface of the background to which it is to be applied. The bonding agent should be water and frost resistant after application and its performance should not deteriorate with time under these conditions. Bonding agents can be applied by one of the following methods:

   1) as a coating without additives before rendering;

   2) as a slurry formed by mixing with neat cement or cement and sand, applied as a wet tack coat before rendering;

   3) as an admixture to the rendering mix, partially or completely replacing the gauging water; or

   4) by combining 1) or 2) with 3) in one rendering operation.

NOTE 1 When bonding agents are applied using method 3) as complete replacement of the gauging water, the plasticizing action of the bonding agent can limit the thickness of rendering which can be applied, without slumping occurring.

NOTE 2 Backgrounds on which bonding agents can be used are included in Table 2 and Table 3.

Porosity and suction affects the adhesion of cement and sand rendering. The amount of wetting, if necessary, to reduce suction and to ensure uniformity of suction depends upon the nature of the background, type of mix, method of application and weather conditions. Wetting should be carefully controlled and only the necessary amount of water applied.

8.2.2 Dense, strong and smooth materials

8.2.2.1 High-density clay brickwork and clay blocks

Where the joints of brickwork have not been raked back during construction, this should be done prior to tiling, to a depth of 13 mm if the mortar in the joints is soft enough. If the mortar is too hard for raking back or if the bricks or blocks are very hard and smooth, methods described in **8.2.1** should be used to form a good key. Walls constructed of keyed bricks should not be raked back.

8.2.2.2 Dense concrete (precast or in-situ)

Ridges and fins left on concrete by shuttering imperfections should be removed before cleaning down. Methods of providing a good key are given in **8.2.1**.

8.2.2.3 Hard natural stone masonry

Dense or smooth stone masonry should, if necessary, be treated to form a key [see **8.2.1e)**].

8.2.2.4 Tiles and glazed bricks

Tiles and glazed bricks should, if necessary, be treated to form a key [see **8.2.1e)**].

8.2.3 Moderately strong and porous materials

8.2.3.1 Clay bricks and blocks

Treatment for clay bricks and blocks should be as described in **8.2.2.1**.

8.2.3.2 Calcium silicate bricks and concrete bricks and blocks

Joints in calcium silicate bricks and concrete bricks and blocks should be raked back (see **8.2.2.1**). With some types of extremely smooth calcium silicate bricks, spatterdash coat, laths or mesh might be necessary (see **8.2.1**).

Unusually smooth blocks should be treated as described for brickwork (see **8.2.2.1**).

8.2.4 Moderately weak and porous materials

8.2.4.1 General

NOTE Moderately weak and porous materials are only suitable at ground floor height.

8.2.4.2 Lightweight concrete blocks and panels, concrete containing lightweight aggregates and autoclaved aerated concrete

Rendering to lightweight concrete blocks and panels, concrete containing lightweight aggregates and autoclaved aerated concrete should be applied through anchored reinforcement as described in **9.4**.

8.2.4.3 Soft natural stone masonry and soft calcium silicate bricks

Rendering to soft natural stone masonry and soft calcium silicate bricks should be applied through anchored reinforcement as described in **9.4**.

8.2.5 Other backgrounds

8.2.5.1 No-fines concrete

No-fines concrete should be suitable for low level work and normally needs no preparation other than cleaning (see **8.2.1**).

8.2.5.2 Painted surfaces

Where existing painted surfaces need to be rendered, either the paint should be removed and the surface mechanically prepared to receive a cement and sand rendering, or the rendering should be supported by reinforcement mechanically fixed to the background (see **9.4**).

If expertise in this area is lacking on site, then specialist advice should be sought from the manufacturers of paint removal equipment or chemicals.

8.2.5.3 Other substrates

Other substrates should be inspected and a decision taken as to whether or not cement and sand rendering is compatible and whether or not they have sufficient integral strength to support both rendering and subsequent applied tiling.

8.3 Preparation of backgrounds to receive tiles by direct bedding

8.3.1 General

Tiles can be fixed directly to a background using BS EN 12004:2001, Type C or Type R adhesives. Methods of application and suitability of backgrounds to accept these methods should be in accordance with Clause **11** and Table 2.

The trueness of the background surface should be such that, when checked with a 2 m straightedge, any gap under the straightedge, between points of contact, does not exceed 3 mm. Where the gap exceeds 3 mm, local correction of the background is necessary; this also applies to backgrounds not built accurately to a specified plane, i.e. not upright. Isolated depressions up to 6 mm should be pre-filled using adhesive.

8.3.2 Existing rendering

Existing renderings should be inspected to ensure that they are well adhered to the background and free from efflorescence and any other contamination. Any laitance on the surface, contamination by oil, grease or any other substances that inhibit adhesion of the adhesive should be cleaned or removed. All loose material should be brushed off.

8.3.3 Sheets and boards

Plasterboard, fibre building board, plywood and wood chipboard should not be used as backgrounds for tiling and mosaics in external situations. Some proprietary sheets and boards that are dimensionally stable in changing moisture conditions are suitable for use on walls as a backing for external wall tiling. Confirmation should be obtained from the manufacturer on the suitability for the height of the installation, as well as the weight of tiling and degree of exposure to the weather.

Such proprietary sheets and boards should be fixed in accordance with the manufacturer's instructions to provide a rigidly supported surface suitable to receive ceramic tiling. Movement joints should be incorporated into the tiling where the boards abut other background materials (see Clause **10**).

8.3.4 Existing glazed tile, unglazed tile and glazed brick surfaces

If existing glazed tile, unglazed tile and glazed brick surfaces are sound and stable they are suitable for tiling with adhesives but the surfaces should be thoroughly cleaned and/or abraded to completely remove all traces of grime, grease and other contaminants that could impair adhesion. Existing tiles should be sufficiently well adhered to support the new tile bed and withstand any stresses between the new tile bed and backing from thermal effects. Advice should be sought from adhesive manufacturers for suitable adhesives.

If any of the existing tiling is found to be loose, a thorough check should be carried out to ascertain the adhesion of the remaining tiling and a decision should be made, either to repair loose areas and proceed as previously described, or to remove the existing tiling and fix to the exposed, sound backing.

8.3.5 Other backgrounds

NOTE A number of other backgrounds exist that are suitable for tiling with adhesives e.g. dense concrete blockwork.

All backgrounds should be durable, of adequate dimensional stability and compatible with the tile adhesive being used. Some of these backgrounds can present problems and a decision should be taken, either to use an intermediate background such as a reinforced rendering, or to consult an adhesive manufacturer for advice on a suitable adhesive after giving full information on the application and service conditions.

9 Cement and sand rendering

9.1 General

It is essential that the rendering is compatible with the background to which it is applied as well as with the tile bedding technique. Recommendations for achieving the best compatibility between the materials used with respect to their strength and shrinkage movement are given in Table 2.

The rendering should be true, free of hollow-sounding areas and firmly bonded to the background. The rendering should be protected to prevent rapid drying-out for at least the first three days after application and should be completed at least two weeks before fixing tiles begins. This period should be extended under adverse weather, humidity and site conditions (see BS 5385-4).

Rendering should not have a total thickness in excess of 20 mm as this can result in unduly high shrinkage stresses and consequent cracking. Each coat of rendering should be not less than 8 mm thick, nor greater than 16 mm thick.

NOTE Fine shrinkage cracks not accompanied by debonding are generally acceptable.

Care should be taken to ensure that surfaces wetted down to control suction (see **8.2.1**) do not dry before the rendering is applied. The rendering should keep pace with the wetting or the surfaces should be rewetted as necessary before any bonding treatment is applied.

Rendering through anchored reinforcement is recommended for work above first floor and in any situation where differential movement is expected or the background material is considered too weak or friable to support rendering and/or tiling without such treatment, for example concrete and concrete blocks containing lightweight aggregate (see **9.4**).

9.2 Materials

9.2.1 Cement

The cement for cement and sand mortar beds to be used for bedding mosaics and key-backed extruded tiles should be one of the following:

a) Portland cement (CEM I) conforming to BS EN 197-1;

b) Calcium aluminate cement (high alumina cement) conforming to BS EN 14647:2005.

WARNING. Cement of all types to be used with care, because of the possible risk of adverse skin effects. Suppliers' material safety data sheets obtained at the exchange of information stage described in **4.1g)** should be used as a basis for assessing and managing the risk associated with its use in a particular application.

Cement should be stored under dry conditions and used in order of delivery. Cement that contains air set lumps should not be used.

9.2.2 Sand

9.2.2.1 General

All stocks of sand should be protected from rain, frost and any form of contamination.

9.2.2.2 Sand for cement and sand rendering and mortar beds for mosaics

NOTE For guidance see the first entry under "Plastering or rendering" in PD 6682-3:2003, Table A.1.

Sand conforming to BS EN 13139:2002 recommended European designation 0/2 (CP or MP), Category 2 fines, is recommended for cement and sand rendering and mortar beds for mosaics.

9.3 Application and trueness of rendering

If two coats of rendering are necessary, the first coat should be combed before it hardens to provide a key for the following coat. The comb, which usually has metal teeth 20 mm apart, should be used to create wavy horizontal furrows approximately 5 mm deep. The first coat should be allowed to harden and dry out to permit shrinkage before a second coat is applied. The second coat should not have a richer mix than the first coat and should be less thick.

If the tile bed is to be cement and sand mortar the final coat should be lightly combed; but if an adhesive is to be used the surface should have a wood float finish.

Where the tile bed is an adhesive, the trueness of the rendering surface should be such that, when checked with a 2 m straightedge, any gap under the straightedge, between points of contact, does not exceed 3 mm. Where the gap exceeds 3 mm, local correction of the rendering surface is necessary.

NOTE Adhesion is not essential with anchored reinforced renderings.

It is essential that sufficient thickness of render be specified to allow for the deviations in the trueness of the background to be accommodated. Excessive thicknesses of both unreinforced and reinforced render should be avoided (see **9.4**).

9.4 Rendering through anchored reinforcement

Wire mesh should be firmly secured to the background. The rendering should be applied so that the mesh is completely embedded to ensure that, in the event of adhesion failure between the rendering and the background, the rendering and the applied cladding tiling remain intact and fully supported.

Austenitic stainless steel welded-fabric reinforcing mesh conforming to BS 4483 consisting of 50 mm × 50 mm squares, having wires not less than 2.5 mm in diameter, should be fixed to the background. It is essential that the fixings into the structural wall be made to a depth of at least 40 mm, depending on the strength of the background, passing through any dubbing or first coat of rendering, as described in this Clause.

The reinforcement should be applied with the horizontal wires outwards and should be fixed by means of 50 mm × 10 mm austenitic stainless steel anchors, or by drilling holes for plastics anchors to receive stainless steel screws with countersunk heads. Tapered, not parallel-sided, screws should be used of at least 38 mm × 10 mm gauge, conforming to BS 1210. Plastics anchors should be approximately 50 mm in length although 40 mm can be used in dense strong background materials. Fixings should be set at approximately 450 mm centres in both directions, staggered, and located so that the horizontal wires rest on the screws, thus providing direct support for the mesh. Vertical wires of the mesh should be spaced approximately 4 mm from the background by stainless steel or plastic washers placed as the screws are inserted.

Sheets of mesh should overlap by approximately 100 mm at all junctions including external angles. They should either be secured to the fixings by austenitic stainless steel binding wire at 1.22 mm diameter, twisted tightly with its ends turned inwards, or the mesh should be cramped back by placing stainless steel washers on the inner and outer faces under the heads of the fixing screws or bolts thus holding the mesh firmly against the spacers.

A slurry coat of neat cement should be brushed on the background and the mesh; whilst this is still wet, the rendering should be applied, working around and through the wires and ensuring that the rendering is in full contact with the background and that the mesh is covered by a thickness of approximately 7 mm.

Spatterdash can be used instead of slurry and should be a mix of 1:2 cement and sand by volume, thrown by mechanical means or by a dashing scoop over the background to an average thickness of approximately 3 mm, then allowed to dry slowly in order to cure before the rendering is applied.

Where, in order to bring the background to the desired plane, it is necessary to apply dubbing or a first coat of rendering in thicknesses in excess of 20 mm, a slurry coat or spatterdash should be applied; this should be followed by the dubbing or rendering in single coats each 8 mm to 13 mm in thickness, combed and then cured as described in **9.3** before the reinforcing mesh is fixed. It is not advisable to exceed a total thickness of 25 mm of dubbing or rendering before the mesh is fixed and further rendering is applied.

9.5 Mix for rendering to various backgrounds

9.5.1 General

*NOTE 1 The relationship between the background, rendering, adhesive or mortar bed and the tiles is important in respect of two properties of the components: their strength and drying shrinkage movements. Attention has been drawn in **8.2.1** to the variation in strength and drying shrinkage movement of the common backgrounds.*

Masonry cement and sand mixes can be used as an alternative to the cement and sand mixes described in **9.5.2**. These mixes, providing equivalent strength to the cement and sand mixes described in **9.5.2** and **9.5.3**, should be used in accordance with the instructions of the manufacturers of any proprietary materials employed.

Weight batching should be adopted whenever practicable as this helps to ensure uniformity of mix proportions and thus the uniformity of the quality of the material.

Where weight batching is impracticable, mortar batches should be based on multiples of a whole bag of cement (50 kg, approximately 35 l). In such cases the sand and water should be measured by volume using correctly made gauge boxes or other suitable containers of fixed, measurable volume. This method allows water addition to be checked and thus permits appropriate mix proportions to be established and maintained.

Batching by the shovelful is not recommended as it eliminates the possibility of establishing and controlling mix proportions.

Wherever it is practicable, mixing of mortars should be by machine and preferably of the forced-action type. Quantitative measurements of consistency, in accordance with BS 4551, should preferably supplement subjective estimations when establishing or controlling mix proportions. It is recognized, however, that it is not always practicable to adopt these recommendations particularly in the cases of small tiling operations and work in restricted surroundings.

NOTE 2 BS 4551 warns that, where samples of the cement and sand used are not available, the analysis of the mortar can lead to inaccurate assessment of the mix proportions and that the use of assumed data can give results which could be at variance with the true mix proportions.

Where mixing by machine is not possible, mortars can be mixed on a clean non-absorbent surface using clean hand tools. Whatever method of mixing is used, the materials should be thoroughly blended in the dry state before water is added. Mixing should be continued until the batch has a uniform consistency.

No water should be added once mixing is complete. Any mortar unused within 2 h of adding the mixing water should be discarded.

Any admixtures such as plasticizers and water-proofers should not adversely influence the adhesion strength, contraction or expansion of the mortar and should be used in accordance with the manufacturer's instructions.

9.5.2 Dense, strong and smooth or moderately strong and porous backgrounds

On backgrounds such as high-density clay bricks or blocks, dense concrete (either precast or in situ) and stone, the rendering should consist of one part of cement to between three and four parts of sand by volume (1:3.5 to 4.5 by weight) when based on dry sand. Sand is usually delivered and used in the damp state and if no allowance is made for this, the mix (particularly if volume batched) might be richer than is desirable. Therefore, based on damp sand with the maximum effect of bulking, the mix should consist of one part of cement to 4 to 5.5 parts of sand by volume. If a mix is too strong the drying shrinkage is increased and if a mix is too lean it might be too weak to support the tiling.

9.5.3 Moderately weak and porous backgrounds

For backgrounds such as certain types of lightweight aggregate concrete, autoclaved aerated concrete, and bricks of relatively low strength, the rendering mix should be one part cement to four parts sand by volume (1:4.5 by weight) when based on dry sand. For damp sand (based on damp sand with the maximum effect of bulking), one part cement to 5.5 parts of damp sand (see **9.5.2**).

9.5.4 Mixed backgrounds

Where tiling is continuous across backgrounds of varying types, their differential movements can induce cracking. This risk should, if necessary, be avoided by incorporating a movement joint in such locations (see Clause **10**).

9.5.5 Reinforced renderings

Mixes for reinforced renderings should be as described in **9.5.2**.

10 Movement joints

10.1 General

Consideration should be given at the design stage to the provision of movement joints. The type and location of movement joints are influenced by considerations of construction, materials, bedding systems, anticipated temperature and humidity conditions, areas involved and the setting out of the tiling.

Sealants and back-up materials for movement joints should be in accordance with **5.7**.

NOTE Stresses occur in the tiled installation as a result of movement due to such factors as drying shrinkage and moisture, thermal changes and creep. These stresses can cause loss of adhesion, bulging or cracking of the tiling but they can be localized by incorporating movement joints.

10.2 Location

Movement joints should be located in the tiled installation to coincide and be continuous with all existing structural movement joints, although they are isolated by suitable thicknesses of back-up material.

Where tiles are fixed to an intermediate substrate, the movement joint should extend through the intermediate substrate.

Where backgrounds are mature and stable, the movement joints in the tiling, which are not to be confused with structural movement joints, should extend only through the tiling and its bed, and should be a minimum of 6 mm wide.

10.3 Disposition and forming

When detailing the disposition of movement joints, the designer should consider the following locations in relation to their effect on the setting out of the tiling:

a) over existing and/or structural movement joints;

b) where tiling abuts other materials;

c) junctions between different background materials, where tiling is continuous across them;

d) storey heights horizontally and approximately 3 m to 4.5 m apart vertically; ideally, they should be located over movement joints in the structural background and at structural material changes; for example, horizontal joint at top and bottom of floor slab, vertical joint at internal corners and at junctions with columns;

e) external building corners, vertically between 0.25 m and 1 m from the corner and symmetrically wherever possible;

f) at internal corners.

Where movement joints in tiling occur over movement joints in the background, they should coincide and be continuous with these joints and should be of a suitable width to permit the sealant to accommodate the expected movement.

All joints should be rectangular in section, with firm, straight, smooth edges, free from cavities and irregularities. The width:depth ratios and dimensions of the sealant profile in a joint should accord with the recommendations of the sealant manufacturer. When forming the joints it is useful to insert a suitable filler strip or batten to ensure smooth clean faces to the joints, and remove it only when the tiling is sufficiently firm. Care should be taken to avoid grout or other materials becoming trapped in the joint cavity, as these prevent the proper application of the back-up and sealant.

Typical movement joint details are shown in Figure 2 and an example of their positions in Figure 3.

10.4 Sealant installation

NOTE 1 Guidance for good practice in sealant installation is given in BS 8000-16.

In most cases, the sealant should not be applied until the joint spaces are thoroughly clean and dry, but special sealants are available which can be applied in wet conditions. Preferably, joints awaiting sealing should be protected from the ingress of foreign matter by being covered, e.g. by an adhesive tape or batten, but when moisture or solvents are present in the bed or the background, the joints should be left exposed until all moisture has dried out and any solvents have dissipated. Joint spaces left open and uncovered might collect deleterious matter and should be thoroughly cleaned before sealing.

If the sealing of the joints is to be carried out by a specialist, the tiling contractor should be made aware of any requirements in the instructions for applying the sealant that affect his operations. Particular care might be necessary to avoid contamination of the joint.

Any provision of drainage through the movement joint, for example by means of plastics tubes, should not impair the integrity of the seal.

*NOTE 2 Information on sealant material is given in **5.7.2***

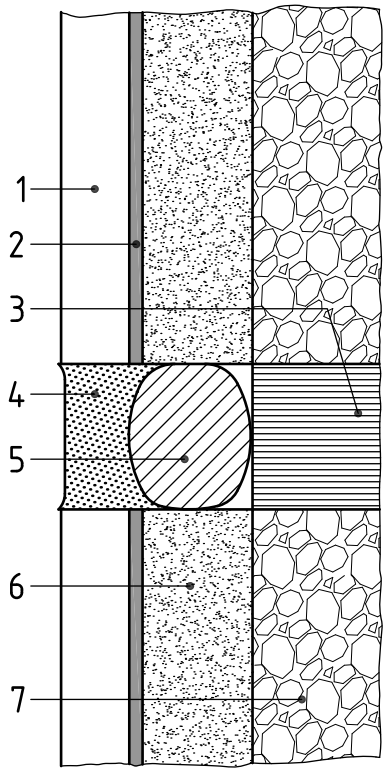
10.5 Back-up material installation

From both functional and economic standpoints a compressible back-up material should be incorporated in the joint to achieve the required depth of sealant. The sealant should be applied and tooled to ensure proper adhesion and surface finish.

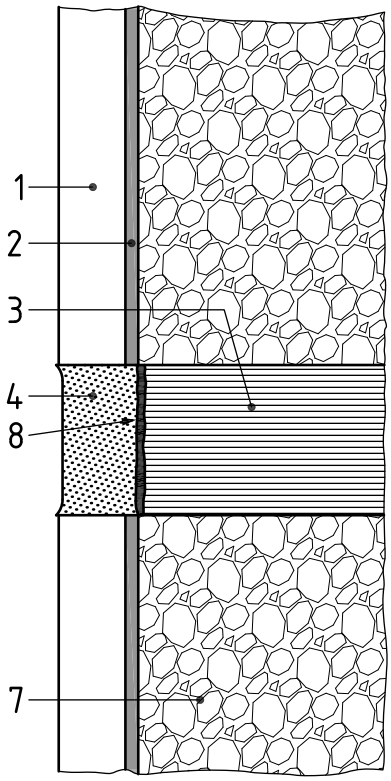
Sealants should be bonded only to the opposing faces of the joint, allowing the sealant to stretch or compress freely when subjected to movement. If the sealant is bonded to a third surface at the back of the joint it inhibits movement accommodation and increases the stress on the joint and the likelihood of sealant failure.

Where there is insufficient depth in the joint to accommodate a compressible back-up material, a bond breaker tape at the bottom of the joint improves performance.

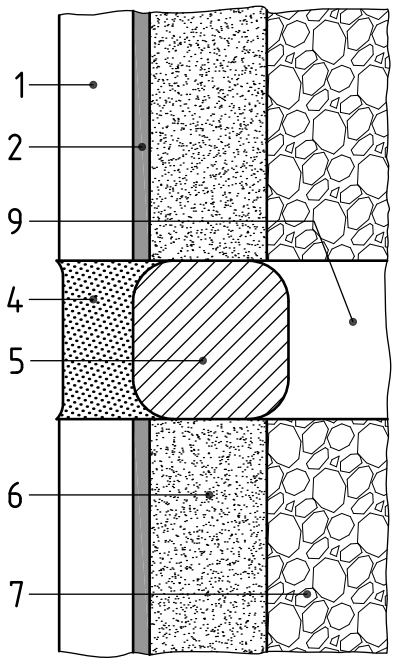
Figure 2 **Typical movement joint details in external wall tiling**



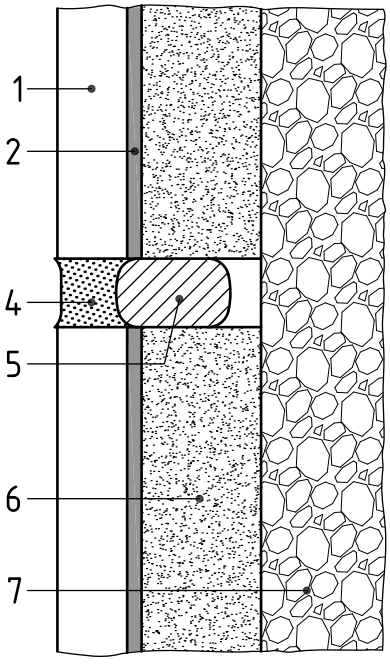
a) Aligned to structural movement joint (on rendering)



b) Aligned to structural movement joint (direct fixing)



c) Plan of open structural joint



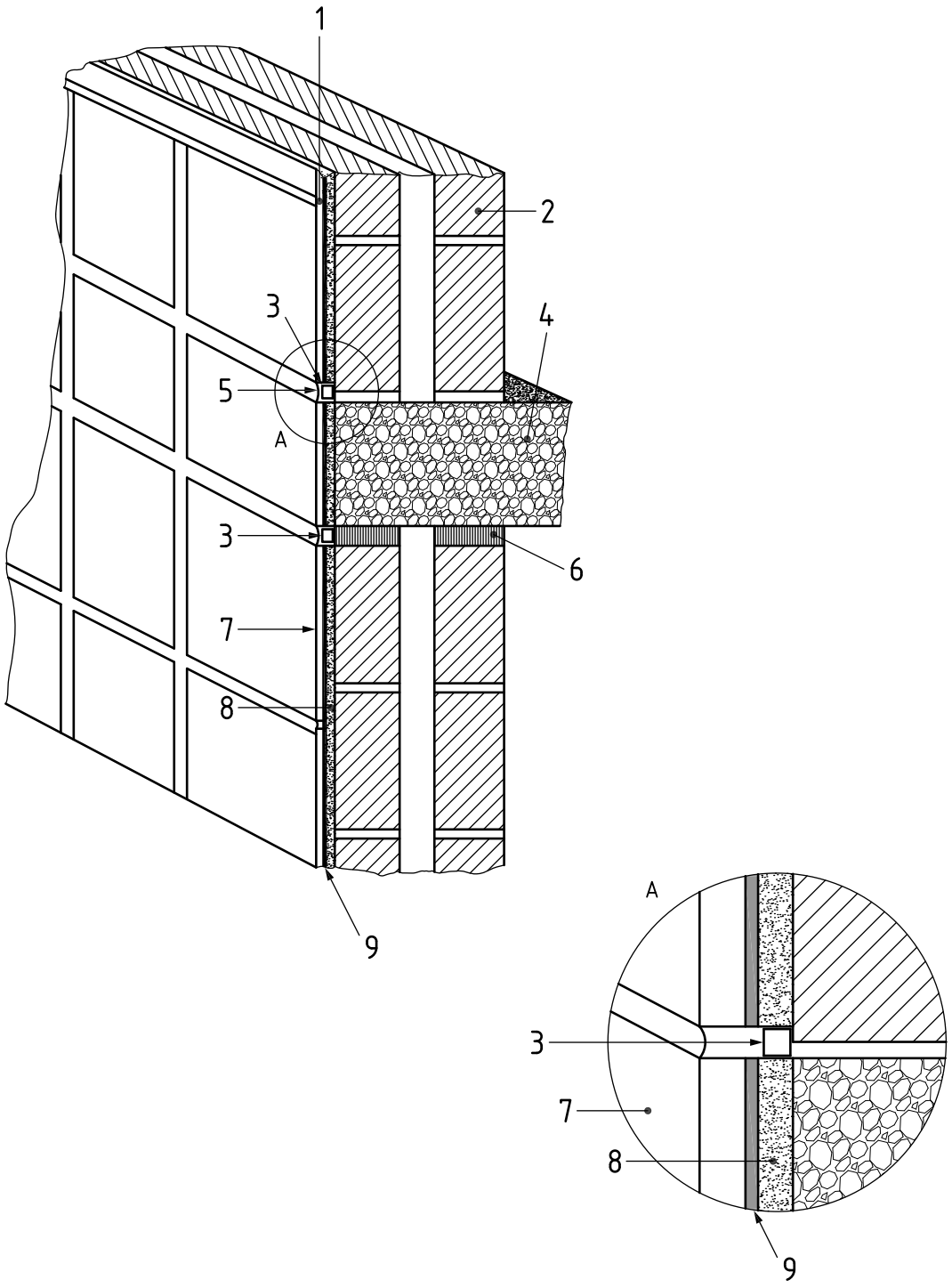
d) Non-structural movement joint

Key

1	Tile	4	Sealant	7	Structural wall
2	Adhesive	5	Back-up strip	8	Bond-breaker wall
3	Joint filler board	6	Rendering	9	Void

NOTE Construction details irrelevant to tiling are not shown.

Figure 3 **Position of movement joints in concrete frame construction at abutment of brick/block infill**



Key

1	Grout	5	Sealant	9	Adhesive bed
2	Bricks or concrete block	6	Joint filler board		
3	Back-up strip	7	Tile		
4	Concrete slab or edge-beam	8	Rendering		

The filler should be placed so that it allows the application of an adequate depth of sealant into the joint to perform satisfactorily; the minimum depth should be 6 mm.

*NOTE Information on back-up material is given in **5.7.3**.*

11 Application of tiles – methods and materials

*NOTE In the context of Clause **11** the term "background" refers to the surface intended to receive the tile bed. This might be the surface of a wall or the surface of an applied cement and sand render as described in Clause **19**.*

11.1 Workmanship

Tiles should be applied using experienced technical supervision and the employment of skilled operatives working safely using protective clothing and equipment where appropriate in accordance with BS 8000-11.

NOTE Attention is drawn to the requirements of:

- *Manual Handling Operations Regulations [3]*
- *Management of Health and Safety at Work Regulations [4]*
- *Control of Substances Hazardous to Health Regulations [5]*
- *Noise at Work Regulations [6]*
- *Personal Protective Equipment at Work Regulations [7].*

11.2 Bedding methods for tiles

Cement and sand adhesives should be used for fixing tiles externally. Tiles with a facial surface area greater than 0.1 m^2 should not be used above 3 m unless secured by mechanical means.

11.3 Compatibility of backgrounds and tile beds

The preparation of backgrounds to receive rendering and tiling should be in accordance with Clause **8**.

Preparatory work in the formation of backgrounds to meet the recommendations of this standard should be completed before tiling commences. Sufficient additional time should be allowed for curing, commensurate with the extent of making good.

Care should be taken to ensure that the background temperature is above 5 °C and remains above this temperature while the adhesive hardens.

11.4 Setting out

It is important to the appearance of the finished tiling that unsightly cut tiles should be avoided and that joints should have as uniform a width as is practicable. Allowance should be made for an adequate specified width of joint, which in external tiling is often a feature of the installation.

Cut courses, both vertical and horizontal, should be:

a) kept to a minimum;

b) determined in advance;

c) as large as possible;

d) arranged in the least prominent of alternative locations.

Where wall surfaces are interrupted by features such as windows, pilasters or movement joints, guidance on how the tiles are set out should be sought from the designer.

The positioning of horizontal joints and cut courses depends on several factors, of which the following are examples.

1) Tiled areas that adjoin or are adjacent should be set out so that horizontal joints are aligned.

2) The lower extremities of a wall might not be level, requiring a course or courses to be cut with a raking edge. Wherever possible, the horizontal joints should be positioned so that the whole of the rake can be taken up within the height of the tile in the cut course.

3) If it is thought desirable to align a joint with a feature, this might initiate the need for, and frequently dictate the location of, cut courses.

To ensure that rows of tiles are truly horizontal, a level line should be established to position the starting course.

11.5 Preparation of tiles

For most bedding methods the tiles should be dry. All tiles should be inspected and any damaged tiles should be removed and replaced.

11.6 Tolerances for finished tile surfaces

The surface should be true such that, when checked with a 2 m straightedge, with 3 mm thick feet at each end, the straightedge should not be obstructed by the tiles and no gap should be greater than 6 mm, i.e. a tolerance of ± 3 mm.

NOTE Where adhesives are used, this degree of accuracy can be achieved only when the background surface is equally true.

11.7 Tile joint treatment

To ensure a high standard of finish, careful attention should be given to the selection of the methods and materials to be adopted in filling and finishing the joints (see Clause **13**). The selection depends upon the joint widths and the functional and aesthetic specifications of the installation.

11.8 Movement joints

Provision should be made to incorporate movement joints in appropriate positions when setting out the tiling (see Clause **10**). Movement joints should extend through the tile, bed and rendering where applied.

11.9 Mixing of tile bed materials

When a proprietary adhesive is used as the tile bed, strict attention should be paid to the manufacturer's instructions.

12 Bedding in adhesives

12.1 General

The method to be adopted for fixing tiles should achieve solid bedding. It is important to follow the precise recommendations of the adhesive manufacturers concerning, for example, the type of trowel, the mixing procedure, the working time after spreading and the suitability of the background.

Whichever adhesive is selected for fixing, it should conform to **5.5**.

12.2 Backgrounds

Surfaces for which adhesives are suitable are given in Table 2. The backgrounds should be dry and the surface should not be dampened before applying the adhesive.

The trueness of the background surface needed for adhesive beds should be in accordance with **11.6**. Where the gap exceeds 3 mm, local correction of the background by dubbing out up to 6 mm thick can sometimes be conducted using the same adhesive, but advice on this should be sought from the manufacturer of the adhesive.

The preparation of various backgrounds to receive adhesives and the precautions that should be adopted in each instance are described in **8.3**.

12.3 Inspection

Before fixing commences, any significant shade or colour variations between tiles, particularly if not intended, should be confirmed as acceptable by the designer. Variegated tiles should be thoroughly mixed by selecting from a number of boxes as fixing proceeds.

12.4 Application of adhesive and tiles

12.4.1 Notched trowelling and buttering method

Adhesives should be applied to the background with a trowel as a floated coat, pressing the adhesive into the surface and then it should be combed through with a notched trowel of the type recommended by the adhesive manufacturer for external tiling. Whatever type of trowel is used, it should apply the adhesive in a manner such that the finished bed thickness is no greater than that recommended by the manufacturer and that maximum contact between tile and adhesive is assured.

A thin coating of adhesive should be buttered over the backs of the tiles as a contact layer and to fill the keys before placing the tiles on the combed adhesive bed. Each tile should then be pressed or tapped firmly into position.

The period of time during which tiles can be adequately bedded after spreading the adhesive is approximately 20 min but this varies according to the prevailing atmospheric conditions. It is important that more adhesive should not be spread on the wall than can be covered with tiles within the open time.

As fixing proceeds a tile should be removed occasionally to check that the maximum possible contact is being maintained with the adhesive.

NOTE This bedding method aims to achieve a solid bed but in practice it is inevitable that there will be a number of small voids.

12.4.2 Buttering method

The buttering method might be necessary for occasional awkward tiling positions, e.g. around openings and restricted areas where the notched trowel and buttering method as described in **12.4.1** cannot be used. Where this technique has to be adopted the adhesive should be spread evenly over the whole of the back of each dry tile with a trowel. The bed thickness should be slightly greater than the final thickness required so that when each tile is pressed or tapped firmly into position the correct thickness is achieved. The thickness should not be greater than the maximum recommended by the manufacturer of the adhesive. Care should be taken to ensure that as far as possible no voids are left behind the tiles.

13 Tile joint treatment

13.1 General

Grouting should commence as soon as possible after fixing is complete and after the adhesive bed has hardened sufficiently.

*NOTE A wide range of grouts is available for filling the joints between tiles. The methods to be employed in using these products are described in **13.2**, **13.3** and **13.4**.*

When using proprietary grouts, usually the joint cavities are not wetted, however when grouting with cement and sand there should be dampness in the joint cavity.

13.2 Grouting procedure for joints of 3 mm wide

Grouting joints of 3 mm wide can be carried out at any time to suit the convenience of the work, although it is essential that sufficient time should elapse to ensure adequate setting of the bed to prevent disturbance of the finish during the grouting operation. Grouting should be delayed, if necessary. However, grouting should not be delayed unduly as the open joints can collect general building dust and deleterious material.

Proprietary grouts should be mixed and applied strictly in accordance with the manufacturer's instructions.

The usual procedure is to apply the grout to as large an area as can be worked before hardening commences, this being dependent on climatic conditions. The grout should be applied with a rubber squeegee or grouting trowel, working back and forth over the area until the joints are completely filled. Surplus grout should be removed from the tiles with the aid of a rubber squeegee or grouting trowel and a damp, not wet, cloth ensuring that the joints are well filled. For cushion-edged tiles, once the grout has stiffened it should be tooled back to a consistent line and face using a rounded wooden peg or similar tool. It should be then finally cleaned down using a clean cloth to an even consistent appearance. After the grout has fully dried, the tile surface should be given a final polish using a clean, dry cloth.

13.3 Wide joint filling

Proprietary jointing mortars are recommended for wide joint filling and should be prepared and applied strictly in accordance with manufacturer's instructions.

Where site mixed sand:cement mortar is used for wide joint filling, it should be a stiff, slump-free mix consisting of one part cement and two parts sand mixed with the minimum of water necessary to achieve workability.

*NOTE Admixtures can also be incorporated (see **5.8.3**).*

The consistency of jointing mortar should be such that no slumping of the mortar occurs during setting. The wider the joints, the greater should be the stiffness of the mix.

Joints should be well filled and their surfaces should be even.

Using a rubber float or similar tool, the mortar should be applied over the surface of the finished work to as large an area as can be worked before the mortar starts to stiffen.

Surplus mortars should be cleaned off the face of the work with a rubber squeegee which also helps to ensure that all joints are filled. When joints are filled and the jointing mortar sufficiently firm, joints should be worked or tooled to an even, consistent line. Joints can be finished by either tooling or sponge finishing. On completion, the work should be carefully washed down and, when fully dry, polished with a clean, dry cloth.

Care should be taken when jointing glazed tiling to avoid damage to the surface.

13.4 Application of coloured grout for ceramic tiling

Where coloured grouts are required, it is advisable to check the potential risk of staining by applying the grout to a few tiles in a small trial area. In any doubtful case, an alternative grouting procedure should be adopted, or, alternatively, the use of a proprietary tile sealer should be considered. Proprietary tile sealers should be used strictly in accordance with the manufacturer's instructions and should be applied before grouting is carried out to provide a protective coating that can be removed after completion of grouting.

For colouring cement and sand grout, the pigment should be thoroughly mixed with the dry cement before this is added to the mix in order to obtain the best staining power and homogeneity; alternatively, coloured cement can be used, as supplied by the manufacturer. In the case of proprietary grout, pigments can be incorporated at source by the grout manufacturer, or subsequently by the user on site, in which case the instructions of the pigment manufacturer should be followed.

Mineral pigments can be incorporated in cementitious or epoxide resin proprietary grout compositions, usually in amounts of up to 5% by mass, depending on the shade required. Some organic pigments are suitable for incorporating in epoxide resin grouts. With most tiles no problems should arise provided surplus coloured grout is cleaned off promptly in accordance with the manufacturer's instructions. However, coloured grouts might prove more difficult to remove from matt glazed tiles, tiles with textured surfaces and some unglazed tiles and, in general, grouts containing finer-grained pigments are likely to prove more troublesome in this respect than those containing coarser-grained pigments.

Care should be taken to ensure that all areas of grouting are treated and finished in as an identical manner as possible, particularly when strong colours are used.

NOTE Slight differences in the method of working, or of the finish of the grout, can result in either true or apparent colour variation. Excessive working of the grout can result in the particles of pigment acting as fines in the mix, working to the surface and giving a richer colour; finishing grout unevenly can result in the more polished areas appearing richer and darker than the other areas.

14 Application of mosaics – methods and materials

14.1 Preliminary considerations

The recommendations for the application of tiles, including suitable backgrounds and movement joints, given in Clause **11**, are of equal importance to the success of mosaic installations but some modification is necessary concerning the setting out, preparation, placing in position and grouting of mosaics. It is recommended that if, in the absence of experience, there is doubt as to the suitability of a bedding method for a particular kind of mosaic, advice should be sought from the mosaic manufacturer or supplier.

14.2 Workmanship

Mosaics should be applied using experienced technical supervision and the employment of skilled operatives working safely using protective clothing and equipment where appropriate in accordance with BS 8000-11.

NOTE Attention is drawn to the requirements of:

- *Manual Handling Operations Regulations [3]*
- *Management of Health and Safety at Work Regulations [4]*
- *Control of Substances Hazardous to Health Regulations [5]*

- *Noise at Work Regulations [6]*
- *Personal Protective Equipment at Work Regulations [7].*

In the finished work, the outline of the sheets of mosaic should not be apparent, the joints between them being the same width as those between the tesserae. Joints within the mosaic sheets are defined in manufacture and these should be regular and in alignment unless irregular by design, and are usually less than 3 mm wide.

14.3 Tolerances for finished mosaic surfaces

Unless an uneven surface is specified or the tesserae are made with irregular or distorted faces, no significant change of plane should be visible between adjacent tesserae. Surface tolerances should conform to **11.6**.

14.4 Mosaic beds

Suitable mosaic beds are:

a) cementitious, dispersion/cement and reaction resin adhesives conforming to BS EN 12004:2001, Types C and R (see **5.5**) and;

b) cement and sand mortar.

NOTE If the background surface to receive the mosaic bed is not flat and true, the use of adhesive fixing methods might be precluded and traditional cement/sand mortar bedding techniques are necessary. This bedding technique requires tilers that have been trained to carry out such work.

Cement and sand mortar beds should only be used with paper-faced or silicone dot mounted mosaics as these beds require the mosaics to be pre-grouted (see Clause **19**).

15 Setting out

Drawings provided for designs and murals should be checked before any fixing commences.

The setting out of the finished work should be controlled from a given datum. To ensure the rows of tesserae are truly horizontal, a level line should be established to position the starting row of sheets.

A gauge rod should be made indicating the overall measurement of a given number of sheets of mosaic with the specified joint widths. Using this rod the best arrangement of sheets should be determined so that, as far as possible, uncut tesserae occur at external corners and prominent features and cut tesserae are located at internal corners where they are less noticeable.

No attempt should be made to minimize cutting of the tesserae by adjusting joint widths where the bedding has partly set since this could break the bond between the tesserae and the bedding. This condition can arise if a long interval is allowed to elapse between the fixing and the removal of any paper facing.

16 Preparation of mosaics

All mosaics should be inspected and any damaged tesserae should be removed and replaced. Designs and murals should be laid out for inspection prior to fixing.

The paper of paper-faced mosaics should be clear of the edges to assist with joint alignment whilst the sheets are being fixed.

17 Adhesive bedding methods for mosaics

Both cementitious (BS EN 12004:2001, Type C) and some reaction resin adhesives (BS EN 12004:2001, Type R) are suitable for adhering mosaics. The precise recommendations of the adhesive manufacturer should be followed concerning the suitability of the background, the mixing procedure, the method of use, the thickness of adhesive and the open time after spreading.

18 Application of mosaics

Sheets of mosaic should be fixed in horizontal lines. Each sheet should be hung in position as accurately as possible and tapped with a laying-on trowel, or wooden beater, so that full contact with the bed is achieved.

Horizontal and vertical alignment should be checked as the work proceeds.

The joint width between the tesserae established when the mosaics were assembled should be maintained between the sheets, otherwise the overall appearance of the mosaic is marred by the outline of the sheets.

Sheets of mosaic that have been pre-grouted should have the joints between them filled with grout as the work proceeds.

A straightedge should be used to ensure that the surface of the mosaic is true as defined in **14.3**.

After the sheets have been firmly tapped in place, any facing papers should be removed by soaking and sponging; then, before the bedding sets, any necessary adjustment of tesserae or joints should be carried out.

Any surplus cement or adhesive remaining on the face of the mosaic should be removed before it sets.

19 Grouting of mosaics

*NOTE The information given in **13.1** for the treatment of tile joints should be followed.*

With paper-faced mosaics the grout should be similar in type and colour to that used for any pre-grouting.

Where epoxy resin is to be used, sheets should be pre-grouted with specified grout before being fixed.

The grout should be rubbed over the surface to fill the joints, either as the work proceeds or when it is sufficiently firm, and the surface given a preliminary cleaning.

After the grout has hardened sufficiently, the surface of the mosaic should be washed over with water and left clean.

When a proprietary grouting material is used, the manufacturer's instructions for cleaning off should be followed.

20 Glass mosaics

Glass mosaics supplied paper-faced should always be pre-grouted with neat cement before being fixed.

When fixing glass mosaics on a thin-bed of adhesive the recommendations of the adhesive manufacturer should be sought before fixing commences.

If a cement and sand bed is used, the incorporation of a synthetic dispersion bonding agent is desirable in the pre-grouting mix to ensure good adhesion of the glass tesserae. The bonding agent used should have properties, after applications, which are not impaired by moist conditions.

NOTE The colour of grouting and bedding material, when seen through translucent tesserae, affects the shade of the finished work.

21 Cleaning and maintenance

21.1 Cleaning

21.1.1 General

Advice about suitable cleaning materials and methods should be sought from the appropriate supplier.

NOTE Further information is given in the document "The Cleaning of Ceramic Tiles" [8].

Care should be taken to ensure that the suggested cleaning materials have no deleterious effect on other building elements.

21.1.2 Glazed tiles

The method and frequency of cleaning glazed ceramic wall tiles and mosaics depends upon their location and the prevailing environmental conditions.

Some class BI_a tiles which are glazed or surface ground to a smooth mirror finish need little or no cleaning. However, provision should be made for access to external elevations for regular cleaning and maintenance.

Tiles in a sheltered and relatively clean environment need little maintenance. If necessary they can be washed using water with added soapless detergent and then rinsed with clean water. Tiles in a dirty environment require different procedures and specialist advice should be obtained.

21.1.3 Unglazed tiles

At the completion of the tiling work, unglazed tiles might retain a film which water does not easily remove. Under such circumstances tiles should be cleaned with a proprietary acidic cleaner, which should be strictly used in accordance with the manufacturer's instructions, then rinsed with clean water. It is essential to avoid damage to adjacent walls, fittings and paintwork when using such cleaners.

*NOTE Any efflorescence which appears on newly installed tile surfaces diminishes and eventually disappears with weathering or washing as part of the same routine cleaning used for glazed tiles (see **7.2** and **21.1.2**).*

21.2 Maintenance

Tiling should be regularly inspected for any defect in the tile surface or joints, which could occur as a result of background movement or climatic changes. Such defects should be rectified before they deteriorate and lead, for instance, to water penetration via cracks and possibly more serious problems for the installation.

Provision should be made for access to external elevations for regular cleaning, maintenance and close inspection of the tiling and the condition and movement of joint sealants.

Care should be exercised in the choice of suitable joint sealants to ensure that the stated manufacturer's expected effective life is adequate for the particular conditions.

Annex A (informative) Ceramic tiles and mosaics

A.1 Ceramic tiles

Ceramic tiles are classified in BS EN 14411 and fall into two main categories according to their method of manufacture:

a) Extruded tiles (shaping A), whose body is shaped in the plastic state in an extruder and the resulting column cut into tiles of predetermined thicknesses;

b) Dry-pressed tiles (shaping B), which are formed of powder or small grains, shaped in moulds under high pressure before firing. These tiles generally are made to finer dimensional tolerances than extruded tiles.

Ceramic tiles are further sub-divided according to their water absorption (see BS EN 14411).

Ceramic tiles can be glazed, partly glazed, unglazed, polished, textured or profiled.

The range of sizes, thicknesses and accessories varies with individual manufacturers. The range is predominantly of square or rectangular shapes but other geometrical and decorative shapes are available.

Various tile edge shaping and finishes are manufactured as standard, e.g. square, rounded, cushioned and bevelled.

Some large format unglazed class BI_a, BI_b and AI tiles are suitable for special edge profiling such as full round, half round or other decorative shaping, utilizing similar machinery and grinding equipment that is normally used for shaping natural stone tiles and slabs.

A.2 Mosaics

Mosaics can be glazed and unglazed ceramic, glass and natural stones. They are available in a variety of shapes and sizes.

To facilitate handling, mosaics are assembled as sheets, the individual tesserae being adhered either face side down to paper (paper-faced mosaics) or silicone dot mounted.

Paper-faced or dot mounted mosaics allow maximum contact with the bed, i.e. mortar or adhesive.

Annex B (informative) Natural stone descriptions

B.1 Granite

The term granite has been applied to almost any igneous stone that can retain a polish. True granites provide many of these stones but other types of igneous stone that might fall into this classification include syenites, gabbros, dolerites, and diorites. The metamorphic stones gneiss, schist and granulite are frequently also included in this “granite” classification.

B.2 Sandstone

The term sandstone is used to describe almost any stone of sedimentary origin with a granular texture. Some other types of stone that might fall under this classification include gritstones, siltstones, greywackes, conglomerates and marls. Aside from particle size variations, the dominant factor affecting sandstone performance is the grain cement that might be siliceous, calcareous, clay bearing or iron-rich.

B.3 Quartzites

Quartzites are typically the metamorphosed product of an original sedimentary rock, e.g. sandstone, composed almost entirely of quartz.

B.4 Slate

The term slate is often used to describe any rock that can be easily split into thin sheets, principally for roofing purposes. True slate is defined by the presence of a "slaty" cleavage; this allows the slate to be split at almost any point through the stone parallel to the cleavage plane. Most true slates are metamorphosed sediments, often formerly mudstones; however, some British "slates" are derived from volcanic ash sequences and are not true slates in the strict geological sense.

B.5 Limestone

Limestone is a sedimentary rock. Many of the commonly used varieties were formed by the accretion of the hard remains of former organisms such as corals and shells. These materials principally comprise calcium carbonate (calcite), as does the cement. Calcite is a relatively soft mineral and places many restrictions on the way limestone is to be used. Variations in the types and quantities of shell and other remains and the nature of the cement provide a huge range in the types of limestone available.

B.6 Marble

True marbles in the geological sense are metamorphosed limestone and are principally composed of recrystallised calcite formed into an interlocking granular structure. Some hard or partially metamorphosed limestones are incorrectly referred to as marble, even though they exhibit many of the characteristics of marble.

Marble is unlikely to be suitable for external use.

B.7 Travertine

Travertine is the name normally given to a type of precipitated calcite associated with the cooling of waters around hot springs or in caves. The performance of travertine greatly depends on the size and frequency of the voids, which, in most instances, are routinely resin surface filled before the finished stone is supplied.

Vein-cut travertine is most appropriate for external use.

B.8 Green marble or verde

Green marble or verde is considered separately to true marble because its origin is often the result of the metamorphism of rocks other than limestones. The green colour is typically derived from the presence of serpentine minerals. These minerals are relatively soft and the structure often weak, the stone commonly requiring reinforcement from matting glued to the underside. Green marble or verde might also be known as Serpentinite.

Green marble or verde is unlikely to be suitable for external use.

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