

BS 5385-3:2014



BSI Standards Publication

Wall and floor tiling –

Part 3: Design and installation of internal and external ceramic and mosaic floor tiling in normal conditions – Code of practice

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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 November 2014. 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This part of BS 5385 supersedes BS 5385-3:2007, which is withdrawn.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 2: *Design and installation of external ceramic and mosaic wall 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 and 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:

- details on thin tiles and panels;
- the inclusion of underfloor heating;
- the use of calcium sulfate-based screeds;
- updated recommendations on slip resistance.

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

Use of this document

As a code of practice, this part of BS 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.

Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

Presentational conventions

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

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

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

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

Contractual and legal considerations

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

Attention is drawn to the following statutory regulations:

- Building and Construction Regulations under the Factories Act 1961 [1]
- Lifting Operations and Lifting Equipment Regulations (LOLER) 1998 [2]
- Manual Handling Operations Regulations 1992 [3]

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

1 Scope

This part of BS 5385 gives recommendations for the design, installation and maintenance of floor tiling using ceramic tiles and mosaics bedded on concrete, cement and sand and calcium sulfate-based screeds, timber, flooring grade asphalt and existing hard floor finishes in normal conditions. For special conditions see BS 5385-4.

Tile fittings for use as skirting, step treads and channels are given in Annex A.

NOTE Where the floor tiling installation needs to meet specific functional or environmental requirements, or to assist in counteracting potentially detrimental effects on the installation and/or the structure, see BS 5385-4.

The special conditions described in BS 5385-4, for example, swimming pools, shower areas, etc., are given in Annex B.

Annex C gives recommendations for tiling onto underfloor heated bases and Annex D contains information on pumped calcium sulfate-based screeds.

Recommendations for the design and laying of levelling screeds are given in Annex E. Reference is made to tiles bedded directly to a concrete base, but for the design and construction of concrete bases see BS 8204-1.

Annex F contains a recommended method for assessing levels and surface regularity and Annex G has guidance on cement and sand bedding. Annex H is an informative annex providing guidance on the reduction of slip hazards.

The following flooring materials are not covered in this British Standard: natural stone (granite, slate, marble, etc.) tiles and slabs of terrazzo, and composition blocks (see BS 5385-5).

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

BS 5385-4, *Wall and floor tiling – Part 4: Design and installation of ceramic and mosaic tiling in special conditions – Code of practice*

BS 5385-5, *Wall and floor tiling – Part 5: Design and installation of terrazzo, natural stone and agglomerated stone tiles and slabs – Code of practice*

BS 6213, *Selection of construction sealants – Guide*

BS 6925:1988, *Specification for mastic asphalt for building and civil engineering (limestone aggregate)*

BS 8000-11:2011, *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 8203:2001+A1:2009, *Code of practice for installation of resilient floor coverings*

BS 8204-1:2003+A1:2009, *Screeds, bases and in situ floorings – Part 1: Concrete bases and cement sand levelling screeds to receive floorings – Code of practice*

BS 8204-5, *Screeds, bases and in situ floorings – Part 5: Mastic asphalt underlays and wearing surfaces – Code of practice*

- BS 8204-7:2003, *Screeds, bases and in-situ floorings – Part 7: Pumpable self-smoothing screeds – Code of practice*
- BS 8218, *Code of practice for mastic asphalt roofing*
- BS EN 197-1, *Cement – Part 1: Composition, specifications and conformity criteria for common cements*
- BS EN 314-2:1993, *Plywood – Part 2: Bonding quality requirements*
- BS EN 450-1, *Fly ash for concrete: Definition, specifications and conformity criteria*
- BS EN 636:2012, *Plywood – Specifications*
- BS EN 934-2, *Admixtures for concrete, mortar and grout – Part 2: Concrete admixtures – Definitions, requirements, conformity, marking and labelling*
- BS EN 1264 (all parts), *Water based surface embedded heating and cooling systems*
- BS EN 1991-1-1, *Eurocode 1: Actions on structures - Part 1-1: General actions – Densities, self-weight, imposed loads for buildings*
- BS EN 12004:2007+A1:2012, *Adhesives for tiles – Requirements, evaluation of conformity, classification and designation*
- BS EN 12620, *Aggregates for concrete*
- BS EN 13139:2002, *Aggregates for mortar*
- BS EN 13813, *Screed material and floor screeds – Screed material – Properties and requirements*
- BS EN 13888, *Grouts for tiles – Definitions and specifications*
- BS EN 13986:2004, *Wood based panels for use in construction – Characteristics, evaluation of conformity and marking*
- BS EN 14411:2012, *Ceramic tiles – Definitions, classification, characteristics and marking*
- BS EN 14647:2005, *Calcium aluminate cement – Composition, specifications and conformity criteria*
- BS EN 15167-1, *Ground granulated blast furnace slag for use in concrete, mortar and grout – Definitions, specifications and conformity criteria*
- BS EN ISO 10545-12, *Ceramic tiles – Part 12: Determination of frost resistance*
- PD 6682-1, *Aggregates – Part 1: Aggregates for concrete – Guidance on the use of BS EN 12620*
- PD 6682-3, *Aggregates – Part 3: Aggregates for mortar – Guidance on the use of BS EN 13139*

3 Terms and definitions

For the purposes of this part of BS 5385, the terms and definitions given in BS 6100-0 and BS EN 14411 and the following apply.

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

3.1 base/sub-floor

supporting structure beneath the tiles

3.2 bond breaker tape

self-adhesive tape, usually polyethylene or polytetrafluoroethylene (PTFE) used to prevent sealant sticking to a substrate

3.3 ceramic tile

ceramic tile with a surface area $\leq 3\,600\text{ cm}^2$, no tile edge $> 600\text{ mm}$

3.4 large ceramic format tile

ceramic tile with a surface area $> 3\,600\text{ cm}^2$, no tile edge $> 1\,200\text{ mm}$

3.5 ceramic panel

ceramic tile with a surface area $> 1\text{ m}^2$, any tile edge $> 1\,200\text{ mm}$

3.6 thin tile

ceramic tile with a panel thickness $\leq 5.5\text{ mm}$

3.7 levelling screed

screed suitably finished to obtain a defined level, surface regularity and to receive the final flooring

3.8 smoothing compound

material applied to a base or screed to provide a smooth, even surface suitable for the installation of a ceramic floor

3.9 solid bedding

adhesive under the tile which, as far as is practicable, is free of voids so that the tiles are solidly supported

NOTE Devices designed to eliminate lipping of the tiles during the fixing procedure inevitably reduces the solidity of the tile bed.

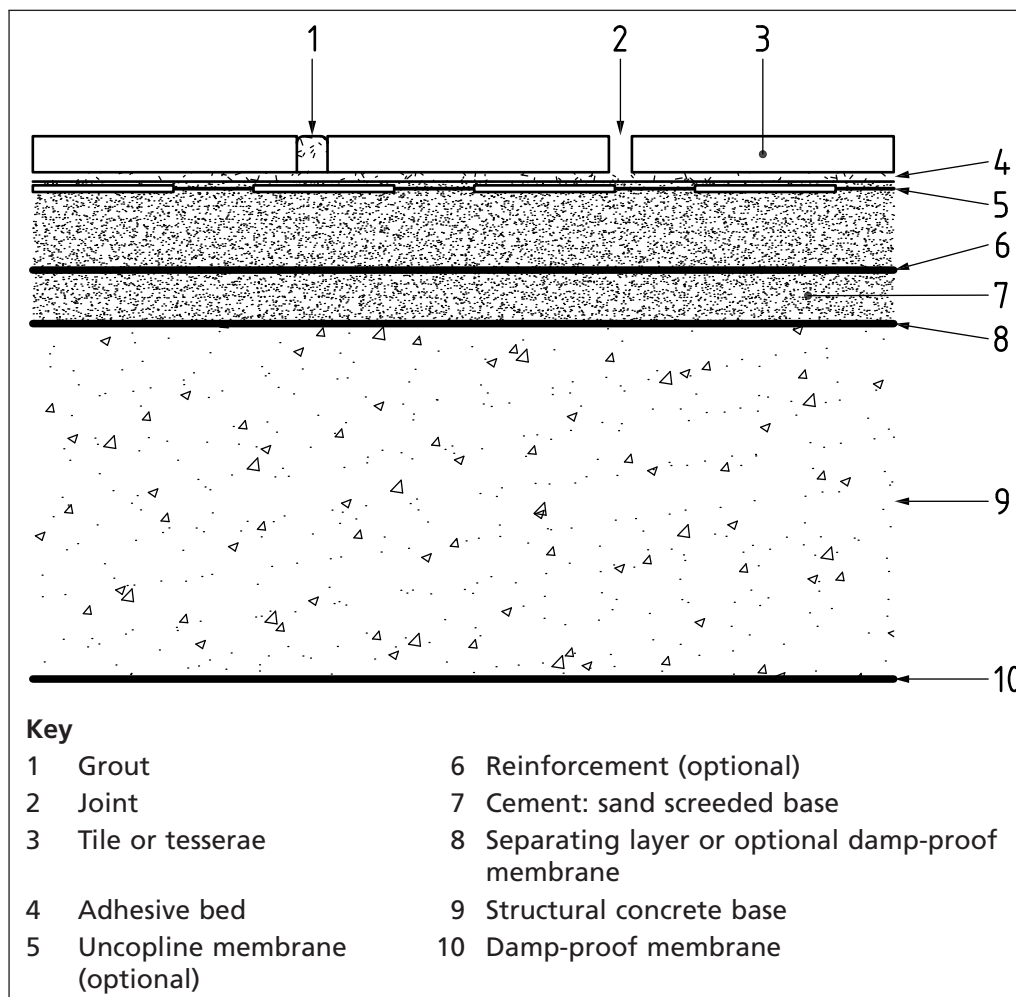
3.10 suction coat

layer of cement and sand mortar without admixture, placed monolithically with the wet base

3.11 floating floor

background that tiles are installed onto which is not bonded or mechanically attached to the base

Figure 1 Illustration of selected definitions



4 Exchange of information and time schedule

COMMENTARY ON CLAUSE 4

Clause 4 deals with the exchange of information for the whole floor, including the tiles, bed, base and levelling screed (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 the execution of the work. At the tendering stage, the following information should be sought and documented:

- site*; location and means of access;
- building*; nature of building, assessment of type and density of traffic, particulars of corrosive or other potentially damaging conditions to which the installation might be subjected in service (e.g. mechanical cleaning);
- floor*; structure of floor, type of damp-proof membrane and its location within the floor construction, details of levelling screed (including its surface regularity and the category of in situ crushing resistance required), curing and drying times, particulars of any floor warming installation, separating layer, finished floor levels and falls with permissible deviations;
- associated work*; services embedded in or passing through the floor, skirting and abutments, junctions with other adjacent flooring;

- e) *finishes*; types 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 are liable to be a health risk;
- h) *time schedule*; a time schedule for the progress of the work (see 4.3);
- i) *testing*; details of any compliance testing required (see E.3.2).

4.2 Provision of utilities, facilities and materials

4.2.1 General

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 (see 5.4.3);
- c) adequate artificial lighting if required (see 4.2.2);
- d) safe means of access and places of work;

NOTE 1 Attention is drawn to the requirements of the Building and Construction Regulations made under the Factories Act 1961 [1].

- e) unloading and hoisting facilities;

NOTE 2 The following references are valid:

- i) *Lifting Operations and Lifting Equipment Regulations [2];*
- ii) *Manual Handling Operations Regulations [3].*
- f) electric power supply adjacent to working areas;
- g) protection of work during and after fixing;
- h) supplies of sand and cement in accordance with 5.4.1 and 5.4.2;
- i) tiles, adhesives, grouts, primers and sealants.

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

4.2.2 Lighting on site

Lighting on site should be of similar type, direction and intensity as envisaged for the completed installation.

NOTE If this condition is not met then the appearance of the finished floor might be different from that originally intended.

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 by all trades, also to ensure that the various trades do not interfere unduly with each other's work.

At least six weeks should be allowed under good drying conditions for the concrete structural floor to undergo initial drying shrinkage. If a levelling screed is subsequently to be applied, the levelling screed should be left for at least a further three weeks. These drying times should be considerably extended under slow drying conditions, and depending upon the mass of the construction.

NOTE Where tiling is on a separating layer directly over the structural floor, the period of six weeks is not critical.

The schedule should also allow time for the cutting of holes and chases and/or other work involving the use of percussion tools in or on the floor that is to receive the tile bed.

The schedule should provide for the completion of all necessary subsidiary work including the commissioning of underfloor heating systems 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 the time schedule to allow for suspension of operations due to unfavourable weather or other conditions that jeopardize 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.

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 and damage.

5.2 Ceramic tiles

NOTE Requirements for ceramic tiles are specified in BS EN 14411.

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

Advice should be sought from the tile or adhesive manufacturers for large format floor tiles or panels requiring special bedding procedures.

Ceramic tiles that are to be fixed in locations liable to frost should pass the frost resistance test as described in BS EN ISO 10545-12 (BI_a and AI_a).

5.3 Mosaics

Ceramic tesserae should conform to the relevant physical properties (as given in BS EN 14411) for their class according to water absorption and shaping, as indicated in BS EN 14411:2012, Table 1.

For a mosaic that has been assembled with a backing material, the following should be ensured.

- a) The backing material and its adhesive should not occupy more than 25% of the area of each tesserae (the critical factor is the spread of the adhesive over the backs of the tesserae).
- b) The backing material and its adhesive should not deteriorate in service and should be compatible with the mortar or adhesive bed in accordance with the manufacturers' instructions.

- c) For wet and external areas the backing material and the mesh glue should be water-resistant and the mesh glue should show no loss of adhesion with prolonged immersion.

5.4 Tile beds and levelling screeds

5.4.1 Cement

5.4.1.1 General

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Cement of all types should 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 and within expiry date. Cement that contains air set lumps should not be used.

5.4.1.2 Cement for cementitious levelling screeds

The cement for cementitious levelling screeds should be one of the following:

- a) Portland cement (CEM I) conforming to BS EN 197-1;
- b) Portland slag cement (CEM II/A-S & CEM II/B-S) conforming to BS EN 197-1;
- c) CEM I cement manufactured in the cement mixer from Portland cement and ground granulated blast furnace slag (GGBS) conforming to BS EN 15167-1 with a mass fraction of 6% to 34% of combination of GGBS;
- d) combinations produced in the concrete mixer from Portland cement (CEM I) conforming to BS EN 197-1 and pulverized-fuel ash conforming to BS EN 450-1, where the proportions and properties conform to CEM II/A-V or CEM II/B-V of BS EN 197-1:2000, with the exception of Clause 9 of that standard;
- e) calcium aluminate cement (high alumina cement) conforming to BS EN 14647;
- f) proprietary cements, designed to provide rapid drying and hardening properties, for which no British Standard exists. Reference should be made to the manufacturers for guidance on their use.

NOTE 1 Cements and combinations in a) to d) of strength class 42.5 have a compressive strength equivalent to that of ordinary Portland cement conforming to BS EN 197-1.

NOTE 2 Limited experience is available with the use of other types and grades of cement for cement and sand levelling screeds. For example, a cement of strength class 32.5 would probably require an increase in cement content of approximately 10%.

There are no British Standards for other additions and their suitability should be ascertained from experience of their use in similar mixes.

5.4.1.3 Cement for cement and sand mortar beds

The cement for cement and sand mortar beds 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.

5.4.2 Aggregates

5.4.2.1 General

Aggregates should not contain any deleterious material in sufficient quantity to adversely affect the surface of a cementitious levelling screed.

NOTE For example, lignite, coal and iron pyrites in the aggregate can cause "pop outs".

Some aggregates exhibit higher than average drying shrinkage and should not be used, as they can give rise to a greater risk of cracking (see BRE Digest 357 [4] and BS EN 1367-4).

5.4.2.2 Aggregates for concrete levelling screeds

Aggregates for fine concrete levelling screeds should be composed of 4/10 material conforming to BS EN 12620 and the recommendations of PD 6682-1 and sand should be in accordance with G.2.

5.4.3 Water

Water should be clean and free of materials deleterious to levelling screeds and mortar beds in their fresh and hardened states (see BS EN 1008); drinking water is suitable. Containers for storing or carrying water should be clean.

5.4.4 Reinforcement

Where light reinforcement is required in a levelling screed of the type described in Annex E, a welded steel fabric of 2.5 mm diameter wire spaced at approximately 50 mm × 50 mm centres should be used.

NOTE Heavier reinforcement conforming to BS 4483 might be necessary for use in levelling screeds constructed for structural purposes.

5.4.5 Bonding agents

COMMENTARY ON 5.4.5

Bonding agents are available to improve the adhesion of levelling screeds and/or tile beds to the base or structural slab.

Their use in conjunction with levelling screeds depends on the type of levelling screed required and the conditions the floor is expected to withstand in service. Details of levelling screed type along with recommended mix design and thickness of application are given in Annex E and further information is also available in BS 8204-1. Similarly for cement and sand mortar tile beds, bonding agents can be used with the appropriate bedding methods detailed in 7.2.

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

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

5.4.6 Adhesives

5.4.6.1 Cement-based adhesives [cementitious adhesives/hydraulically-hardening mortars]

Cementitious and dispersion/cement adhesives (Type C) should conform to BS EN 12004.

5.4.6.2 Reaction resin adhesives

Reaction resin adhesives (Type R) should conform to BS EN 12004.

WARNING: These products contain resins and hardeners that can cause skin irritation and contact dermatitis. Follow the manufacturer's instructions so that, where appropriate, the necessary personal protective equipment is used during mixing and application.

5.4.6.3 Admixtures to adhesives

An aqueous polymer dispersion admixture can be incorporated into cementitious adhesives to obtain greater adhesion, improved resilience or some degree of water resistance. Such admixtures should be used only with adhesives approved by the manufacturer.

NOTE Alternatively the use of admixtures can be eliminated by use of adhesives with additional characteristics such as those given in BS EN 12004:2007+A1:2012 under Type C Class 2 and Type R Class 2.

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

5.4.7 Calcium sulfate-based levelling screeds

NOTE 1 See Annex D for more details on calcium sulfate-based levelling screeds.

NOTE 2 Calcium sulfate-based levelling screeds contain calcium sulfate as the binder.

The binder should be either anhydrous calcium sulfate (known as anhydrite) or as α -hemihydrate, the most common being calcium sulfate α -hemihydrate.

Whichever form of anhydrite or α -hemihydrate is used as the screed binder, it should, when mixed with water, crystallise to form gypsum. All hardened calcium sulfate screeds should be of similar gypsum materials.

To form the screed, the calcium sulfate binder should be pre-mixed with either a well graded sharp sand aggregate and/or an inorganic filler.

NOTE 3 Dependent upon the screed manufacturer, additives and admixtures may also be included.

5.5 Separating layers

Polyethylene or suitable sheet membrane should be used in preference to building paper or bituminous felt. A minimum thickness of 0.125 mm should be used for most conditions, the purpose of the separating layer being to ensure that the applied screed or concrete does not adhere to the base.

NOTE Uncoupling membrane systems provide an intermediate substrate between the tile covering and load bearing substrate. They can be used over a variety of substrates, which include timber, concrete, cementitious screeds and gypsum based screeds, etc. They are designed to neutralize lateral stresses that occur between the substrate and tile covering; they are not designed to accommodate differential vertical movement. The membrane works by preventing stresses from the substrate being transferred into the tile covering; this prevents cracking and possibly delamination of the covering material. They are designed to work with tile adhesives where the bedding does not generally exceed 10 mm.

5.6 Grouts for tile joints

5.6.1 General

Grout mortars should have good working characteristics, low shrinkage and good adhesion to the sides of the tiles, whilst being cleaned off the face of the tiles without undue difficulty as well as fulfilling the aesthetic requirements of the installation. When selecting a grout the specifier should establish that it is suitable for exposure to external conditions.

5.6.2 Proprietary grouts

Proprietary grouting materials should conform to the requirements of BS EN 13888.

NOTE 1 BS EN 13888 specifies performance criteria for properties such as abrasion resistance, compressive and flexural strength, shrinkage and water absorption.

NOTE 2 Additional properties can assume special importance, for example, resistance to water absorption and abrasion resistance, heat and cleaning agents, resistance to mould growth and bacteria, resilience and compressibility.

Proprietary materials should be stored and used in accordance with the manufacturer's instructions.

5.6.3 Admixtures to grouts

COMMENTARY ON 5.6.3

Admixtures, normally in the form of aqueous polymer 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.

5.7 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.

NOTE The selection of the most suitable materials depends upon design considerations and service conditions (see 5.7.2 and 6.8.2).

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 might 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. Sealants with a movement accommodation factor (MAF) (see BS 6213) of at least 15% should be used over structural movement joints.

NOTE 1 Guidance on joint design is given in BS 6093 and guidance on the selection of sealants in BS 6213.

NOTE 2 For further information on the installation of sealants see 6.8.2.

5.7.3 Back-up materials

Back-up materials should be compressible materials that do not force out the sealant when the joint closes.

NOTE 1 Suitable materials include cellular rubber and plastics such as closed cell polyethylene, some fibre building boards, cork boards and caulking cotton. These materials are available in strip form.

The back-up material in the lower part of the joint should be compatible with the sealant being used (see 5.7.2); it should be compressible, should support the sealant and should not give up bituminous or oily products. In particular, it should assist the seal in carrying traffic loads and its compressibility should be such that when the joint closes the sealant is not forced out. Suitable materials include cellular rubber and plastics, such as cellular polyethylene.

NOTE 2 For further information on the installation of back-up materials see 6.8.3.

5.8 Chemical-resistance

Most chemically-resistant materials are proprietary and should be stored and used in accordance with the manufacturer's instructions.

5.9 Impregnating sealers, surface sealers and waxes

5.9.1 General

Various maintenance and aftercare materials are available for the surface treatment of unglazed floor tiles to improve the surface characteristics, such products should only be used after the initial clean procedure has been carried out (see 11.1).

All surface treatment materials should be handled and applied in accordance with the manufacturer's recommendations. Information from the tile manufacturer should be sought to ensure compatibility with the tile surface being treated.

The three main types of products available are impregnating sealers (see 5.9.2), surface sealers (see 5.9.3) and waxes (see 5.9.4). These products can affect the physical properties (e.g. slip resistance) of the finished installation. The extent of any adverse effects should be determined and risk of accident assessed before proceeding with their use.

5.9.2 Impregnating sealers

NOTE Impregnating sealers act as a penetrating sealer to reduce the water absorption of the tile surface and hence improve the staining resistance properties of the floor finish. Such products can also change the surface colour without noticeably changing the tiles' inherent surface glossiness.

5.9.3 Surface sealers

NOTE Surface sealers are also described as sealcoats and polishes. Surface sealers provide a protective coating to the tile surface. Such coatings are normally of metal cross-linked acrylic polymer composition that enrich the appearance of the tile and improve the stain resistance properties of the tile.

5.9.4 Waxes

NOTE Unglazed ceramic floor tiles with a high water absorption, e.g. terracotta, might need specialist treatment with a wax-based product. Such products reduce the porosity of the surface and in most cases change the surface appearance and colour of the tile surface.

6 Design

6.1 General

The relative importance of the following factors should be assessed at the design stage so that due allowance is made for their possible effect on the finished floor (solid and suspended floor floorings):

- a) the load it has to support;
- b) the type of tile used;
- c) the resistance it provides to the passage of liquid water or water vapour either from below or from above (see 6.5.2 and 6.5.3);
- d) size changes produced by variations in moisture content and temperature within the floor and the attack of various corrosive agents, e.g. in chemical plant and industrial premises.

When possible, selection of the tiles or mosaics and bedding method should be made at the structural design stage so that the appropriate depth can be allowed between the base and the finished floor surface.

6.1.1 Finished floor level

Floor surfaces are usually required to be level or laid to a given fall, some variations in surface level can be allowed without detriment to the satisfactory use of the floor, and this should be specified.

There should be no appreciable difference in level across joints, especially in areas where heavy loads are likely to be moved.

NOTE 1 For floor level and across joints tolerances see 7.1.4.

NOTE 2 Guidance on tolerances is given in BS 5606.

6.1.1.1 Falls and drainage

NOTE 1 For further information on slip resistance on sloping floors see Annex H.

Adequate falls should be provided where necessary for drainage of water. Gradients should be between 1:80 and 1:35, the precise fall being varied to cope with conditions in different areas.

NOTE 2 The choice of gradient depends on the character of the surface and the amount of water that has to be drained.

Gradients of 1:80 should be the minimum; gradients steeper than 1:35 might be inconvenient and even dangerous.

The direction of falls should be planned so they are appropriate to the traffic flow, so that traffic moves across, rather than up and down, the slope.

Drainage outlets should be adequate to cope with the anticipated volume of water.

6.1.2 Alignment of wall and floor joints

Alignment of joints between wall tiles and floor tiles is sometimes possible if appropriately sized co-ordinating tiles are specified, however, the practical difficulties involved in achieving alignment should not be underestimated. Careful consideration should be given to the greater accuracy, which is required in the setting out and the construction of the walls to suit the tile module and all the walls should be precisely at right angles or parallel to each other. Allowance should be made for the greater costs which are likely to be incurred.

6.2 Load considerations

When a sub-floor is designed, due allowance should be made for the ultimate weight it might have to support, including the flooring installation, and reference should be made to BS EN 1991-1-1. Where an existing sub-floor is to be covered by the tiles and beds given in this code, a check should be made that the floor is sufficiently strong and rigid to accept the added load, particularly if the sub-floor is of timber construction.

6.3 Bases

6.3.1 General

Concrete (see 6.3.2) and cement and sand levelling screeds are the most common bases over which ceramic floor tiles and mosaics are laid but other bases might be encountered, namely, calcium sulfate-based screeds (see Annex D), timber (see 6.3.4), asphalt (see 6.3.5) and metal.

NOTE 1 In refurbishing work, it might sometimes be necessary to apply new finishes over old floors such as ceramic tiles, terrazzo, wearing screeds, stone, etc.

Before the tile bed is applied:

- a) the correct falls should have been incorporated in the base, where required;
- b) the base should be free from contamination, loose areas of weak or friable material and cracks liable to subsequent movement;
- c) the base should be true to the specified plane (see also 7.1.2).

NOTE 2 Bases suitable to receive floor tiling in each case are summarized in Table 1.

In new work, the plane of the base in relation to that of the finished floor surface should be specified; usually this is possible only if the floor tiles are selected at the design stage. The level of the base in relation to the finished floor surface should be such that the bed can be of the recommended thickness uniformly throughout the installation.

In refurbishing work, as the new floor surface might be higher than the original, any effect on existing features such as channels, outlets, skirtings, doorways, etc. should be determined.

Where a separating layer is to be interposed between the base and the tile bed, the separating layer should be accurately formed and should have a true and smooth surface to enable the tile bed to slide freely over the base in the event of differential movement.

NOTE 3 For details on separating layers and uncoupling membranes see 5.5.

NOTE 4 Ceramic tiling is rarely adhered to a concrete base without a levelling screed since it is not normally possible to achieve the required surface regularity (see Annex E).

6.3.2 Concrete

When tiling is bedded directly to a concrete base without a levelling screed, the finish of concrete should be struck-off level with a straightedge and the surface texture closed. When a bonded bed is required, laitance should be removed by the use of appropriate mechanized surface preparation equipment.

6.3.2.1 Tolerances on levels and surface regularity

The recommendations given in E.1.7 for tolerance on levels and surface regularity for levelling screeds should be followed.

6.3.2.2 Elimination of construction moisture

Structural concrete should have been cured and then subjected to continuous air for at least six weeks before either a bonded levelling screed or direct bedding of the flooring material is applied. The same allowance should be made for concrete with a monolithic levelling screed surface.

NOTE A longer drying period might be necessary under adverse site conditions.

6.3.3 Levelling screeds

NOTE 1 A levelling screed is often used as an intermediate layer between the structural base and tile bed to provide a true and even surface on which to apply tiling. Recommendations for the design and laying of levelling screeds are given in Annex E.

NOTE 2 A method for the assessment of levels and surface regularity is given in Annex F.

6.3.4 Timber bases

NOTE 1 See 6.4 for load considerations.

NOTE 2 Additional guidance can be found in The Tile Association guidance note Tiling to timber substrates and alternative products [5].

NOTE 3 Fibreboards, whether wet pressed (MDF) or dry pressed (Hardboard), are not suitable flooring substrates to receive ceramic tiling.

NOTE 4 Timber base sub-floors are unsuitable for exterior locations.

6.3.4.1 General

Timber sub-floors are not the ideal bases for floor tiling, especially where heavy static/dynamic loading is likely in service. If a timber sub-floor has to be used as a base for floor tiling, it should be rigid and stable with respect to humidity and moisture changes.

NOTE 1 Timber is not a suitable base for floor tiling in wet, frequently damp, or high humidity areas, unless appropriate precautions are taken (see BS 5385-4).

When it is necessary to install wood based sheets and boards such as plywood, the moisture content of the wood based sheets and boards should be close to the equilibrium moisture content that prevails under the service conditions. In heated domestic buildings, where the temperature is above 21 °C, to be in equilibrium the moisture content of any wood based fabricated underlay plywood should be between 6% and 10%. For installations in conservatories, on heated timber sub-floors and areas with higher temperatures or lower humidity levels the equilibrium moisture content might need to be at the lower moisture content value, or even lower, since the average temperatures is higher than those normally experienced in rooms in domestic buildings.

Plywood of an appropriate quality should be used and it should be correctly stored and, if required, conditioned to the appropriate moisture content before installation.

Glue bond class 3 exterior, in accordance with BS EN 314, should be used

NOTE 2 CE2+ marking does not necessarily designate adequate quality.

NOTE 3 Noggings might be required between joists in order to achieve the required rigidity. The limit of deflection normally permitted for domestic timber floors (see BS 5268-2) might be too great to avoid damage to tiling systems.

It should also be established that ventilation is adequate and that effective damp-proof courses are correctly located.

The design should take into account the initial drying shrinkage of the timber and subsequent movement due to seasonal moisture changes, bearing in mind the type of heating.

NOTE 4 Failure to observe this can lead to subsequent warping and distortion of the boards with consequential cracking and delamination of the tiling.

Where the rigidity is satisfactory but the moisture stability of the floor cannot be assured, consideration should be given to the use of an appropriate intermediate water resistant substrate system designed for use with tiling on timber floors.

Screw fixings should be of adequate strength. The length of screw fixings should be at least 2.5 times the thickness of the plywood material (for example, use a minimum 45 mm length screw for 18 mm plywood) to ensure adequate penetration into the timber sub-floor or joist/strut supports, bearing in mind that there might be underfloor services that could be damaged by oversized screws.

6.3.4.2 New timber bases

New timber bases should be constructed with strutting between the joists. Plywood of at least 15 mm thickness should be screwed to both joists and strutting at 300 mm maximum intervals. The lower face and edges of the plywood should be sealed using preferably non-aqueous sealers, e.g. polyurethane varnish or styrene butadiene rubber. All junctions between boards should be supported by struts or joists. If it is considered necessary to further reduce or eliminate the risk of movement, an additional layer of sheets of minimum thickness of at least 10 mm, resistant to moisture and thermal movement, should be screwed over the plywood at 300 mm centres ensuring that the joints in both layers of sheets do not coincide.

In general, the top sheet to receive the tile finish should be laid broken-bond in both directions. Where the sheet or board has a rough and smooth side, the latter should be used for tiling. The surface to receive the tiles should be clean and free from dust and contamination.

6.3.4.3 Existing timber bases

Existing timber bases to be covered by tiles should be checked to ensure that they are sufficiently strong and rigid. They should be examined to determine whether they can carry the additional dead load of up to 0.8 kN/m², and the probable dynamic loading, without excessive deflection. Where possible, existing boards should be removed and the floor stiffened with noggings and joist support sleeper walls before following the recommendations for new timber bases.

Alternatively, for floors of small area (e.g. a single sheet/board, or where board joints are unlikely to cause problems) the required rigidity might be achieved by fixing exterior grade plywood of at least 15 mm thickness over existing boards. The underside and the edges of the plywood should be sealed, using preferably non-aqueous sealers, e.g. polyurethane varnish, or styrene butadiene rubber, on the lower faces and edges to prevent distortion by changes in atmospheric humidity and screwed to joists and existing boards at 300 mm intervals.

NOTE Timber floors have often behaved satisfactorily for a period of years as a result of surface evaporation of moisture. If this is hindered by the laying of a nearly impervious covering, the moisture content can rise to a level sufficient to promote fungal attack, e.g. dry rot.

The plywood sheets should be laid broken-bonded with the long edges running at right angles to the joints between the existing boards.

6.3.4.4 Floating floor

NOTE 1 There are many different types of floating floors including floating cement and sand and calcium sulfate-based screeds to other sheet- and board-based systems.

Before fixing ceramic tiles, there are some basic essential requirements which should be checked.

These should include:

- a) Where applicable, the suitability of proprietary floating floor systems should be checked with the manufacturer as to its suitability to receive a rigid tiled finish.
- b) Any resilient insulating layer should be able to provide sufficient support.
- c) The existing structural substrate, i.e. concrete, should be flat, level and smooth with no localised raised areas.
- d) The floor should have minimal vertical deflection under load, typically for ceramic tiles, the floor should not deflect any more than 1/360 of the span of the structure or for natural stone tiles this is typically 1/720 of the span in the case of most natural stone.
- e) To avoid shrinkage defects, the moisture content of the various floor elements should match that expected of the finished installation.
- f) Tiles should be solidly bedded in accordance with 7.2.1.

The floating floor to receive a tiled finish should be rigid, stable and capable of taking both the dynamic and static loads imposed upon it without excessive movement or vertical deflection. Vertical deflection and moisture movements should be kept to a minimum otherwise there might be a risk of tiles cracking, grout disruption or even loss of adhesion.

NOTE 2 Direct fixing of ceramic tiles to a wood based floating floor entails a high element of risk and where practicable, this should be avoided. However where the floor is deemed to be suitable, the use of a proprietary intermediate substrate (e.g. uncoupling membrane or tile backing board) may be considered.

NOTE 3 Use of uncoupling membranes could also be considered.

NOTE 4 For details on separating layers and uncoupling membranes see 5.5.

NOTE 5 In the draft of the National Annex to BS EN 1990, Table NA1 for vertical deflections has a value of $\leq 1/500$ for rigid flooring such as ceramic tiles.

6.3.4.5 Adhesives

Proprietary deformable tile adhesives and grouts and water resistant membrane systems specially formulated for fixing tiles onto timber bases (installed as described in this clause) have been used successfully and these products should be used strictly in accordance with the manufacturer's instructions.

6.3.5 Asphalt

Flooring grade asphalt should be laid on a rigid base, e.g. concrete or levelling screed, in accordance with BS 8204-5 for internal floors and in accordance with BS 8218 for external locations. Before tile fixing commences the asphalt sub-floor should be carefully examined to ensure that it is in a suitable condition to receive ceramic tiles.

In internal locations the grades of asphalt used should be Type F 1076 conforming to BS 6925:1988 and should be suitable for the anticipated loads and conditions.

NOTE 1 The ceramic floor tiles can be solidly bedded in cementitious adhesives, in accordance with 7.2.1, such that the bed thickness does not exceed 6 mm.

In dry locations if the surface of the asphalt has a natural float finish the surface should be clean and primed in accordance with the adhesive manufacturer's recommendations.

NOTE 2 It might not be necessary to prime the clean asphalt surface if the asphalt surface has a sand-rubbed finish.

NOTE 3 In internal locations the ceramic tiles can also be bedded in a cement and sand semi-dry mortar bed over a separating layer if appropriate for the type of tile being fixed and the required floor finish levels.

In external locations the asphalt should be laid to falls in accordance with BS 8218 as either a paving or roofing grade. The falls should not be less than 1 in 80, but where rapid or effective drainage of water is essential the falls should not be less than 1 in 60 nor greater than 1 in 35. The ceramic floor tiles should be frost resistant (see 5.2) and suitable for bedding in a cement and sand semi-dry mortar bed over a separating layer in accordance with G.8.

Sheets of the separating layer material should be overlapped and brought up vertically at the perimeter of the semi-dry bed where it abuts upstands and walls.

NOTE 4 In most cases a movement joint is required at the perimeter. This can be formed with a compressible back up filler inserted between the upstands and mortar bed, with the movement joint between the perimeter tiles and upstands being finished with a suitable sealant (see 5.7 and 6.8).

The asphalt and the semi-dry mortar bed at the lower end of the fall should be free draining into a suitable gully or drainage outlet.

Table 1 Suitability of tile beds for different bases

Bases	Cement based adhesives (see 7.2.1)	Cement and sand mortar	Semi-dry cement and sand mix		Reaction resin adhesives ^{A)}	Clause reference
		Bonded (see G.10)	Bonded (see G.6)	Unbonded (see G.7)		
New concrete (with less than six weeks drying) or levelling screed (less than three weeks old)	U C	U	U	S	U	6.3.1, 6.3.2 and 6.3.3
Mature concrete or levelling screed	S	S	S	S	S	6.3.1, 6.3.2 and 6.3.3
Levelling screed over suspended precast floor or underfloor heating	S	S	S	S	S	6.3.1 and 6.3.3
Wood	C	U	U	U	C	6.3.1 and 6.3.4
Internal asphalt	S	S	S	S	C	6.3.1 and 6.3.5
External asphalt	U	S	S	S	U	
Metal	C	U	U	C	C	6.3.1 and 6.3.6
Existing hard floor finishes after preparation						6.3.1 and 6.3.6
Terrazzo	S	S	S	S	S	6.3.1 and 6.3.6

Table 1 Suitability of tile beds for different bases

Bases	Cement based adhesives (see 7.2.1)	Cement and sand mortar	Semi-dry cement and sand mix		Reaction resin adhesives ^{A)}	Clause reference
		Bonded (see G.10)	Bonded (see G.6)	Unbonded (see G.7)		
New concrete (with less than six weeks drying) or levelling screed (less than three weeks old)	U C	U	U	S	U	6.3.1, 6.3.2 and 6.3.3
Unglazed ceramic tile	S	S	S	S	S	6.3.1 and 6.3.6
Glazed ceramic tile	S	S	S	S	S	6.3.1 and 6.3.6
Wearing screed (e.g. granolithic)	S	S	S	S	S	6.3.1 and 6.3.6
Natural stone	S	S	S	S	S	6.3.1 and 6.3.6

Key

S Suitable (confirm classification/system with the manufacturer)

U Unsuitable

C Confirm suitable with manufacturer and specialist contractor

*NOTE 1 The tile bed chosen also depends on the traffic conditions (see 6.4.2).**NOTE 2 See Table G.1 for bed thicknesses (Annex G).*^{A)} See 6.3.6.**6.3.6 Other bases****6.3.6.1 General**

NOTE 1 Existing floor finishes such as ceramic tiles, terrazzo, natural stone and similar hard surfaces are suitable as bases provided they are clean and firmly adhered to their base. However, the choice of tile and type of bed might be influenced by the change in level available from existing to new.

NOTE 2 Tiles can also be bedded directly to rigid metal (see Table 1).

6.3.6.2 Calcium sulfate-based levelling screeds

Calcium sulfate-based levelling screeds, i.e. anhydrite or hemihydrate levelling screeds, should not be used for directly overlaying with ceramic tiles or mosaics in cementitious adhesives unless adequately dried, abraded to remove laitance and then completely sealed with an appropriate primer so as to prevent the adhesive from coming into direct contact with the levelling screed.

NOTE See Annex D for further information on calcium sulfate-based screeds.

Calcium sulfate bases should not be laid to falls and are not suitable for an installation which is frequently wetted, e.g. commercial kitchens, hotel bathrooms, etc.

6.3.6.3 Raised access floors

NOTE See the TTA document Tiling to raised flooring systems [6], for further information.

6.4 Durability and performance

6.4.1 General

NOTE Correctly installed and maintained ceramic floor tiling provides a durable floor finish.

6.4.2 Traffic and load conditions

NOTE For the purpose of this code, traffic loads are categorized as light or heavy.

Floor loading should be considered as heavy if heavy cleaning equipment, hard-wheeled trolleys, etc., are to be used.

Light loading should be considered as normal low density pedestrian traffic, e.g. domestic and office locations.

Heavy loading areas should be considered as where high density pedestrian traffic, and/or heavy loads, static, moving, dropped or dragged, are likely to occur, e.g. in supermarkets, shopping malls, engineering premises and garages for heavy vehicles.

6.4.3 Resistance to mechanical failure

6.4.3.1 Resistance of tile bedding

NOTE 1 Where heavy loading is likely, and particularly where the moving of heavy loads is contemplated, adhesion to the base is crucial.

The tiles should be solidly bedded so that, as far as possible, they are free from voids to ensure good adhesion to the base.

NOTE 2 Greater resistance to loading can be achieved by the use of thicker flooring tiles with increased impact resistance, bearing in mind also that the joints between the tiles are usually the most vulnerable part of the flooring [see 6.4.3.2c)3)].

6.4.3.2 Resistance of tiling

Abrasion, compression and impact can operate singly, but they are often to be found in various combinations; the relevant mechanical properties of flooring should be considered and are as follows:

- a) *for resistance to abrasion*: physical toughness of the flooring itself and a surface free from irregularity in level;
- b) *for resistance to compression*: strength and thickness of tile, solidity and strength of bed and compressive strength of sub-floor;
- c) *for resistance to impact*: in addition to the properties given in a) and b), the following factors are also important:
 - 1) Within the normal tolerances of the flooring tiles used, the individual tiles should be laid to a true plane. Therefore, a true base to SR1 is a necessary pre-requisite.
 - 2) The flooring tiles should be solidly bedded so that, as far as possible, there are no voids beneath the tiles.
 - 3) Joints between ceramic tiles should be as narrow as possible, but not less than 3 mm, appropriate with the tiles and grout being used.
 - 4) The maximum joint width should not exceed 10 mm. Proprietary grouts specially formulated with enhanced resistance to impact and abrasion and low shrinkage should be used.

6.4.3.3 Mesh backed

With large tiles and slabs any reinforcing mesh should be well adhered to the underside, and the mesh and adhesive should be suitable for the location and type of installation and should not obscure more than 25% of the underside of the tile or slab unless they are mechanically fixed.

The manufacturer or supplier of the mesh-backed tile should ensure that they can be effectively installed using tile adhesives that conform to BS EN 12004.

6.4.4 Frost resistance

Suitable assurances about frost (freeze-thaw) resistance should be sought from suppliers of both tiles and bed materials. The tiles selected should be of class Al_a or Bl_a (see BS EN 14411).

The flooring tiles should be solidly bedded so that, as far as is possible, there are no voids.

6.4.5 Slipperiness

NOTE 1 A tiled ceramic floor is not slippery when clean and dry. The slip resistance of a floor in service is dependent upon the nature of its surface. It is important to recognize that this can change over time and often merely during the process of installation and finishing. Floor surface contamination (such as water, oil, dust) is often the cause of slip accidents.

NOTE 2 Measurement of slip resistance values in the wet, by means of the pendulum test method given in BS 7976, provides useful information for assessing the likely slip resistance of flooring materials in water wet conditions in service, though results are more difficult to interpret for barefoot applications and for heavily textured surfaces.

When it is known that slippery conditions might arise in service and present a significant hazard, tiles with slip resistant finishes suitable for the conditions and location should be used.

Special attention should be paid to correct cleaning procedures as described in 11.5, both to remove contamination and to ensure that cleaning agents that could otherwise attack the surface are rinsed away.

NOTE 3 Further advice on the reduction of slip hazards is given in Annex G.

6.4.6 Resistance to staining

NOTE Glazed floor tiles are generally resistant to staining and are usually more easily cleaned than unglazed tiles. The degree of resistance to staining of unglazed tiles depends mainly on the porosity of the tile, i.e. the greater the degree of vitrification, the greater the degree of resistance.

6.4.7 Grouts, joints and sealant materials

NOTE 1 The resistance of grouts and jointing materials to various liquids that might be in contact with them for a short time is shown in Table 2, which also gives an indication of their characteristics.

Spillages should be cleaned off as soon as possible.

Where coloured grouts are used, they should not always be expected to retain their appearance after wear. Light coloured grouts should be avoided.

NOTE 2 By following the recommended drying times for concrete bases and cement and sand levelling screeds and by mixing and cleaning off cementitious grouts as directed by the manufacturer, the appearance of efflorescence (white salt deposit) in the grouted joints can usually be prevented.

NOTE 3 Sealants, under favourable conditions, have an expected service life of up to 10 years for the bitumen and bitumen/rubber types, and can be in excess of 20 years for the more elastic sealants.

NOTE 4 See 6.8.2 for sealants installation.

Table 2 Grouts and joint materials: resistance to intermittent contact with various liquids and characteristics

Liquid	Cementitious grout	Polymer modified cementitious grout	Epoxide resin
Lemon juice	Poor	Poor	Good
Vinegar	Poor	Fair/Good ^{A)}	Good
Acidic soft drink	Poor	Poor/Fair	Good
Alcoholic drinks	Fair/Good	Fair/Good ^{A)}	Good
Tea and coffee	Good	Good	Good
Sugar solution	Fair	Fair	Good
Milk	Poor/F	Fair	Good
Olive oil	Good	Good	Good
Disinfectant (phenolic)	Fair	Fair	Good
Disinfectant (hypochlorite)	Fair/Good	Fair/Good	Good
Acidic cleaners	Poor	Poor/Fair	Good
Detergent (neutral)	Good	Good	Good
Ammonia (10% solution)	Fair	Fair	Good
Paraffin oil	Good	Good	Good
Acetone	Good	Good	Good
Butyl acetate	Good	Good	Good
Carbon tetrachloride	Good	Good	Good
Urine	Fair/Good	Fair/Good ^{A)}	Good
Sea water	Fair	Good	Good
Characteristics	Rigid	Slightly resilient	Rigid and tough

NOTE This Table is a general guide to the properties of the materials listed. Submit precise details of corrosive conditions to specialists.

^{A)} For prolonged contact see BS 5385-4.

6.5 Passage of liquids through floors

6.5.1 General

NOTE The floorings dealt with in this British Standard are not normally completely impervious to liquids nor do they normally offer substantial resistance to the passage of water vapour.

In many situations, continuous transmission of moisture is tolerable but account should be taken of effects that make it desirable to use damp-resisting construction (see BS 8102 and CP 102).

6.5.2 Passage from below

COMMENTARY ON 6.5.2

Ground moisture and the water used in construction can be transmitted through solid floors by capillarity and by evaporation to the air above and thus leave the floor surface apparently dry.

Evaporation is impeded by additional floor coverings less permeable than those discussed or by fittings or stored goods in direct contact with the floor. Local dampness might consequently be so severe as to encourage moulds and to rot or corrode materials in contact with it.

Moisture rising through a solid floor is likely to contain soluble salts from the sub-soil, the hard fill and the concrete of the floor itself. These tend to accumulate in increasing concentration at or near the floor surface as long as they can be replenished from below. In the worst possible case, i.e. where the sub-soil or the fill is contaminated with acids or high concentrations of soluble sulfates which attack cement, the safety of the whole floor might well depend on adequate damp-proofing below the base (see BS 8102 and CP 102).

In less aggressive situations, damp-proofing which serves only as a capillary barrier should still be used as a precaution against persistent efflorescence at the floor surface and possible attack on the concrete by small concentrations of sulfates.

6.5.3 Passage from above

COMMENTARY ON 6.5.3

Tiles and bedded finishes, even when the joints are filled with impervious grout, cannot be guaranteed to eliminate entirely the passage of liquids downwards. Minor defects in workmanship and movement in the structure can cause fissures through which liquids pass readily.

In ground floor situations aggressive chemicals, i.e. some cleaning agents, passing through the floor can attack concrete bases leading to severe disruption.

NOTE 1 *In the case of suspended floors as well as attack on the structure by chemicals, water passing downwards can cause dampness on walls and ceilings below and in the worst cases lead to flooding.*

If more than occasional spillage of liquids is expected, then the tiled surface should be laid to falls and drains provided to collect the run-off.

The most satisfactory method of preventing the downward movement of liquids is by providing a membrane between the base and the tiling. The membrane should usually be covered by a levelling screed. The base should be constructed with falls so that any liquid reaching the membrane flows down to a drain. The membrane material should be impervious and chemically resistant to the liquids that come into contact with it and be sufficiently flexible and strong to resist movement in the structure and loads without rupturing. The membrane should be continuous around upstands and at points where services pass through the floor.

NOTE 2 *The most commonly used membrane materials are asphalt, bituminous felt, polyethylene film, composite pitch polymer sheets and synthetic rubber sheets.*

6.6 Variations in moisture content and temperature

COMMENTARY ON 6.6

In solid and suspended floor constructions, the base and the floor tiling usually have different dimensional responses to changes in moisture content and temperature. Probably the most extreme relative moisture movements occur when new concrete floors or screeds are covered before most of the drying shrinkage has taken place. The shrinkage of the base and/or screed can persist for some years after the tiling has reached equilibrium with the result that compression forces can ultimately crack the tiles or break down the adhesion between the tiles and the bed in the long term. Vibration, impact and thermal shock can produce early failure while the floor tiling is in the stressed condition, as can further contraction of the base in very cold weather. Wood based sub-floor constructions exhibit dimensional changes with changes in the atmospheric humidity levels and temperature (see 6.3.4.1). Such movement can be significant in new constructions where lower temperatures and higher atmospheric humidity levels prevail on site during installation of the sub-floor and the floor tiling.

6.7 Isolation of tile bed from the base

Failure arising from variable stresses (see 6.6) should be avoided by isolating the tile bed from the base by a separating layer or intermediate substrate that prevents the two elements from adhering to each other and thus allows each to move independently.

NOTE 1 Such a layer might consist of building paper, bituminous felt, polyethylene film or similar material, on which the tiles are bedded in semi-dry cement and sand mortar.

The base should be prepared and installed to the manufacturer's instructions.

NOTE 2 Intermediate substrate (e.g. tile backing boards) can consist of foam cored with reinforced surfaces on both faces and cementitious boards that provide a stable and rigid base for the specified floor tiling.

NOTE 3 For details on separating layers and uncoupling membranes see 5.5.

6.8 Movement joints

NOTE For the positioning and location of movement joints see 7.1.6.

6.8.1 Types of movement joints

6.8.1.1 General

Stresses can result from factors such as drying shrinkage, deflection and moisture movements in the base and thermal and moisture changes affecting the flooring. These stresses can sometimes cause loss of adhesion and bulging or cracking of the flooring. To counteract this, movement joints extending through the tiling and its bed should be incorporated in the installation.

The building designer should assess the magnitude of any stresses and decide where movement joints should be located, having regard to all the relevant factors including the type of flooring and bed.

NOTE Movement joints for the floor tiling are as follows:

- a) flexible joints aligned to structural movement joints (see Figure 4b and Figure 4d);*
- b) flexible joints to accommodate smaller movements than structural joints (see Figure 4a, Figure 4c and Figure 4e).*

For movement joints in special conditions refer to BS 5385-4.