

BRITISH STANDARD

Wall and floor tiling –

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

ICS 91.060.10; 91.060.30

Publishing and copyright information

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 75 and a back cover.

Foreword

Publishing information

This part of BS 5385 was published by BSI and came into effect on 31 August 2007. 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This part of BS 5385 supersedes BS 5385-3:1989, which is withdrawn.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 tiles and slabs – Code of practice.*

Information about this document

The start and finish of text introduced or altered by Corrigendum No. 1 is indicated in the text by tags **[C1]** **[C1]**.

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

- a) updated references to take account of the new harmonized European product standards (BS EN 12004 (Adhesives), BS EN 13888 (Grouts), BS EN 14411 (Tiles) and their supporting suites of test methods;
- b) recommendations on using proprietary adhesives and grouts precede recommendations on using cement:sand mortar bedding and grouting methods;
- c) the exclusion in the text of recommendations on using cement:sand mortar (not semi-dry mix) over a separating layer;
- d) the exclusion of recommendations on using pavers and brick slips;
- e) the specifications for cements have been updated. In particular European Standard specifications for cements now include a number of cement types and standard strength classes;
- f) the use of higher slag content cements (> 35%) and the equivalent combinations have been excluded from levelling screeds due to limited experience of their use;
- g) the specifications for sands (aggregates) have been updated. Specifications for sands are now provided by European Standards for the specification of aggregates. Throughout this standard,

“sand”, the term commonly used in the UK building and tiling industry, is interchangeable with the term “aggregate” that is used in the European specifications.

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

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]

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.

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:sand screeds, timber, asphalt and existing hard floor finishes in normal conditions. For special conditions see BS 5385-4.

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

Individual floor tiles with a maximum facial surface area greater than 0.72 m² and with length to width ratio exceeding 2:1, might require special bedding procedures in accordance with advice from tile or adhesive manufacturers.

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.

Recommendations for the design and laying of levelling screeds are given in Annex C. 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 D contains a recommended method for assessing levels and surface regularity and Annex E is an informative annex providing guidance on the reduction of slip hazards.

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.

☐₁ Text deleted ☐₁

BS 3892-1, *Pulverized-fuel ash – Part 1: Specification for pulverized-fuel ash for use with Portland cement*

BS 4027, *Specification for sulfate-resisting Portland cement*

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 6100-1.3.3, *Glossary of building and civil engineering terms – Part 1: General and miscellaneous – Section 3: Parts of construction works – Subsection 3: Floors and ceilings*

BS 6213, *Selection of construction sealants – Guide*

BS 6399-1, *Loading for buildings – Part 1: Code of practice for dead and imposed loads*

BS 6699, *Specification for ground granulated blastfurnace slag for use with Portland cement*

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

BS 8000-11.1:1989, *Workmanship on building sites – Part 11: Code of practice for wall and floor tiling – Section 11.1: Ceramic tiles, terrazzo tiles and mosaics*

BS 8204-1:2003, *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 8218, *Code of practice for mastic asphalt roofing*

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

BS EN 934-2, *Admixtures for concrete, mortar and grout – Part 2: Concrete admixtures – Definitions, requirements, conformity, marking and labelling*

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 14411:2003, *Ceramic tiles – Definitions, classification, characteristics 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*

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 6100-1.3.3 and BS EN 14411 and the following apply.

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

3.1 levelling screed

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

3.2 smoothing compound

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

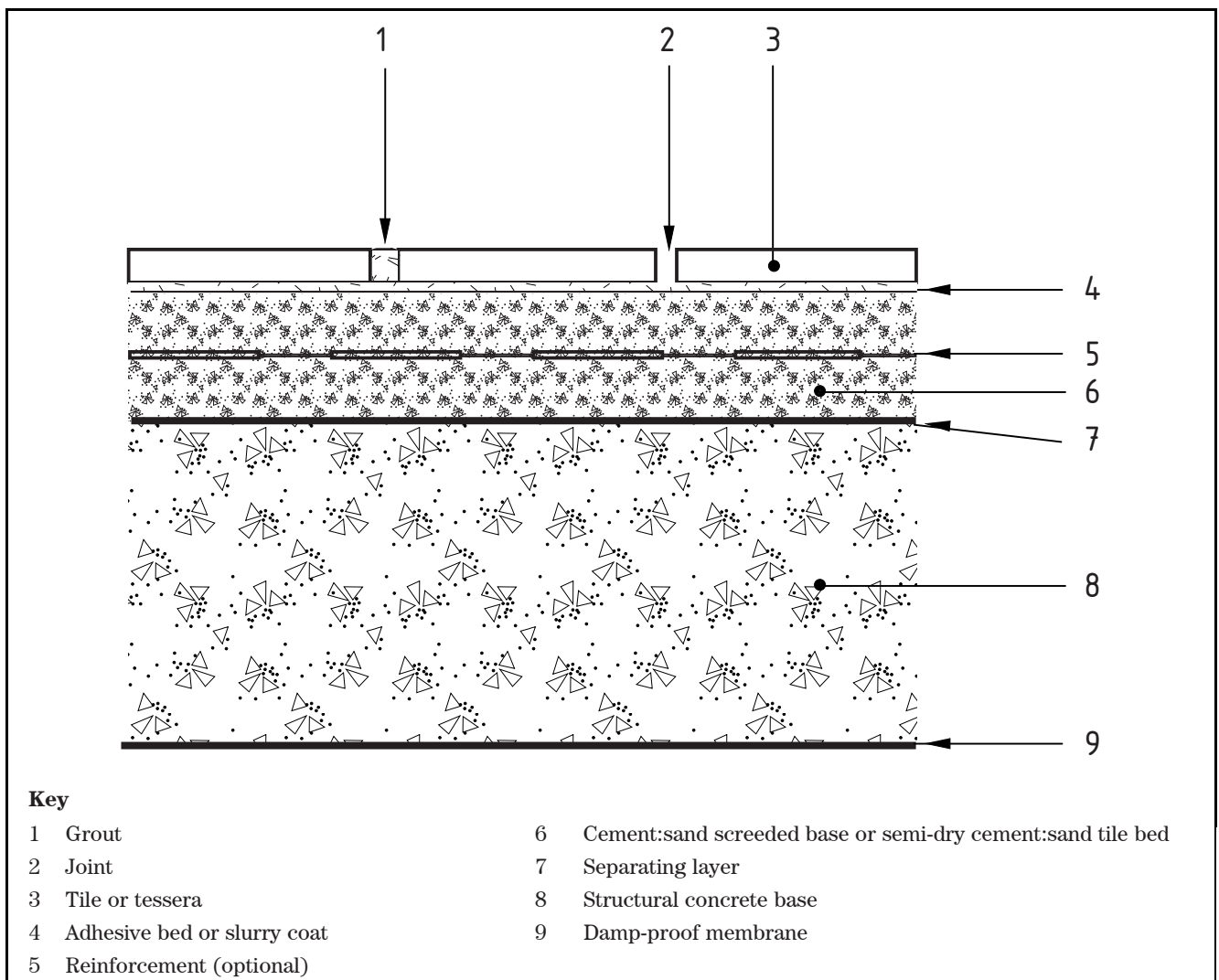
3.3 suction coat

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

3.4 bond breaker tape

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

Figure 1 Illustration of selected definitions



4 Exchange of information and time schedule

NOTE 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

It is essential that the working drawings and specifications are 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.

- a) *Site*. Location and means of access.
- b) *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).
- c) *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.
- d) *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 4.2).
- i) *Testing*. Details of any compliance testing required.

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. If this condition is not met then the appearance of the finished floor might be different from that originally intended. This is a matter that should be appreciated by the specifier at the design stage.

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 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 require considerable extension under slow drying conditions, and depending upon the mass of the construction. 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 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.

Individual floor tiles with a maximum facial surface area greater than 0.72 m² and with length to width ratio exceeding 2:1, might require special bedding procedures in accordance with advice from tile or adhesive manufacturers

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.

5.3 Mosaics

Ceramic tesserae should conform to the relevant physical properties given in BS EN 14411, for their class according to water absorption and shaping, as indicated in BS EN 14411:2003, Table 1.

For a mosaic that has been assembled with a backing material, it is essential that:

- a) the backing material and its adhesive does not occupy more than 25% of the area of each tessera; the critical factor is the spread of the adhesive over the backs of the tesserae;
- b) the backing material and its adhesive does not deteriorate in service and that they are compatible with the mortar or adhesive bed in accordance with manufacturers' instructions.

For wet and external areas the backing material and its adhesive should be water-resistant and the adhesive should show no loss of adhesion with prolonged immersion. For external areas, the backing material and its adhesive should not be subject to atmospheric attack.

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 4.1 g) 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) Sulfate-resisting Portland cement conforming to BS 4027;
- c) Portland slag cement (CEM II/A-S & CEM II/B-S) conforming to BS EN 197-1;
- d) CEM I cement manufactured in the cement mixer from Portland cement and ground granulated blast furnace slag (GGBS) conforming to BS 6699 with a mass fraction of 6% to 34% of combination of GGBS;
- e) Combinations produced in the concrete mixer from Portland cement (CEM I) conforming to BS EN 197-1 and pulverized-fuel ash conforming to BS 3892-1, where the proportions and properties conform to CEM II/A-V or CEM II/B-V of BS EN 197-1:2000, except Clause 9 of that standard.
- f) Calcium aluminate cement (high alumina cement) conforming to BS EN 14647;
- g) 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 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.

Limited experience is available with the use of other types and grades of cement for cement: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:sand mortar beds

The cement for cement:sand mortar beds should be one of the following:

- a) Portland cement (CEM I) conforming to BS EN 197-1;
- b) Sulfate-resisting cement conforming to BS 4027;
- c) 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 affect adversely the surface of a cementitious levelling screed. 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 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 in accordance with **5.4.2.3**.

5.4.2.3 Sand for cement:sand levelling screeds and cement sand mortar beds

Sand for cement:sand levelling screeds and cement:sand beds should conform to BS EN 13139:2002, 0/4 category 1 and the recommendations of PD 6682-3. Other sand can be used provided there are satisfactory data on the properties of similar levelling screeds or mortar beds made with them.

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 soaking tiles (see **7.2.2.2**), 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 C, a welded steel fabric of 2.5 mm diameter wire spaced at approximately 50 mm × 50 mm centres is suitable.

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 C and further information is also available in BS 8204-1. Similarly for cement: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 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.

5.4.6 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 should be used during mixing and application.

5.4.6.3 Admixtures to adhesives

A polymer admixture, or other liquid or powdered product, can be incorporated in to 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 12004:2001 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 Admixtures to cement:sand mortars and levelling screeds

Admixtures to cement:sand mortars and levelling screeds can be used and these should conform to BS EN 934-2.

NOTE Details are given in Annex C (see C.1.10) and further information is also given in BS 8204-1.

5.5 Separating layers

Polyethylene film should be used in preference to building paper or bituminous felt [C1] Text deleted [C1]. A [C1] minimum [C1] film thickness of 0.125 mm is recommended for most conditions, the purpose of the film being to ensure that the applied mortar does not adhere to the base.

5.6 Grouts for tile joints

5.6.1 General

Grouts 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 This standard specifies performance criteria for properties such as abrasion resistance, compressive and flexural strength, shrinkage and water absorption.

Additional properties can assume special importance, for example, impermeability; resistance to water, 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.

Sand for grouts should comply with the grading limits given in Table 1 of BS EN 13139:2002, 0/1 mm Category 2.

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 Clause 6).

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 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. 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 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

COMMENTARY ON 5.9.2

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

COMMENTARY ON 5.9.3

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

COMMENTARY ON 5.9.4

Unglazed ceramic floor tiles with a high water absorption, e.g. natural 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

Solid and suspended floor floorings could be affected by the following factors, and the relative importance of these factors should therefore be assessed at the design stage so that due allowance is made for their possible effect on the finished floor:

- a) the load it has to support;
- b) type of tile used;
- c) the resistance it offers to the passage of liquid water or water vapour either from above or from below (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 is allowed without detriment to the satisfactory use of the floor, and this should be specified.

It is important that 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.

6.1.2 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 floor is designed, due allowance should be made for the ultimate weight it might have to bear, including the flooring installation, and reference should be made to BS 6399-1. Where an existing 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 floor is of timber construction.

6.3 Bases

6.3.1 General

Concrete (see 6.3.2) and cement:sand levelling screeds are the most common bases over which ceramic floor tiles and mosaics are laid but other bases might be encountered, namely timber (see 6.3.4), asphalt (see 6.3.5) and metal. 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 it is essential that:

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

NOTE 1 Bases suitable to receive tiling and the tile beds suitable in each case are summarized in Table 1.

In new work, it is necessary to specify the plane of the base in relation to that of the finished floor surface; usually this is possible only if the floor tiles and the appropriate beds 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.

NOTE 2 An exception can be made when a bonded semi-dry mix bed is to be used as this can be applied in varying thicknesses, subject to the minimum stated in 7.2.3.1, to overcome irregularities and to form falls. The recommended maximum and minimum final tile bed thicknesses are given in Table 3.

In refurbishing work, the new floor surface might be higher than the original. Any the 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 bed it is important that the base is accurately formed and has a true and smooth surface to enable the tile bed to slide freely over the base in the event of differential movement.

6.3.2 Concrete

6.3.2.1 Surface finish

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 mechanical means. To receive a cement:sand bonded bed, the prepared concrete surface should be wetted down several hours prior to the application of the bed. When a separating layer is to be interposed between the bed and a concrete base, the surface of the latter should be free of ridges or steps that would impair the sliding action between the two elements.

6.3.2.2 Tolerances on levels and surface regularity

The recommendations for tolerance on levels and surface regularity for levelling screeds should be followed (see C.1.7).

6.3.2.3 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

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 C.

A method for the assessment of levels and surface regularity is given in Annex D.

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 [4].

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. 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, it is important to ensure that the moisture content of the wood based sheets and boards are 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 8% and 12%. 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. It is important that good quality plywood is used and it is correctly stored and, if required, conditioned to the appropriate moisture content before installation.

NOTE 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. 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.

The length and strength of screw fixings should be appropriate to ensure adequate penetration into timber sub-floor or joist/nogging supports, bearing in mind that there might be underfloor services that might be damaged by oversized screws.

6.3.4.2 New timber bases

New timber bases should be constructed with noggings between the joists. Water and boil proof (WBP) exterior grade plywood of 15 mm minimum thickness should be screwed to both joists and noggings at 300 mm maximum intervals. The lower face and edges of plywood should be sealed against the ingress of moisture using preferably non-aqueous sealers, e.g. polyurethane varnish, or styrene butadiene rubber, to prevent distortion by changes in atmospheric humidity before being screwed down. All junctions between boards should be supported by noggings or joists.

If it is considered necessary to further reduce or eliminate the risk of movement, an additional layer of sheets of minimum thickness 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 WBP exterior grade plywood of 15 mm minimum thickness over existing boards. 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 Adhesives

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

6.3.5 Asphalt

Asphalt should be laid on a rigid base, e.g. concrete or levelling screed, in accordance with BS 8204-5 for internal floors and to 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 suitable for the anticipated loads and conditions. 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 1 It might not be necessary to prime the clean asphalt surface if the asphalt surface has a sand-rubbed finish.

NOTE 2 In internal locations the ceramic tiles can also be bedded in a cement: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 and suitable for bedding in a cement:sand semi-dry mortar bed over a separating layer in accordance with **7.2.3.3**.

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. 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 ^{A)} for different bases

Bases	Adhesives (see 7.2.1)	Cement:sand mortar	Semi-dry cement:sand mix		Reaction resin adhesives ^{B)}	Clause reference
		Bonded (see 7.2.2)	Bonded (see 7.2.3)	Unbonded (see 7.2.3)		
New concrete (with less than six weeks drying) or levelling screed (less than three weeks old)	U	U	U	S	U	6.3.1, 6.3.2 and 6.3.3
Mature concrete or levelling screed	C	U	U	S	C	6.3.1, 6.3.2 and 6.3.3
Levelling screed over suspended precast floor or underfloor heating	C	U	U	U	C	6.3.1 and 6.3.3
Timber	C	U	U	S	C	6.3.1 and 6.3.4
Asphalt	C	C	C	S	C	6.3.1 and 6.3.5
Metal	C	U	U	U	C	6.3.1 and 6.3.6
<i>Existing hard floor finishes after preparation</i>						6.3.1 and 6.3.6
Terrazzo	C	U	U	S	U	6.3.1 and 6.3.6
Unglazed ceramic tile	S	C	C	S	C	6.3.1 and 6.3.6
Glazed ceramic tile	C	C	C	S	C	6.3.1 and 6.3.6
Wearing screed (formally granolithic)	C	U	U	U	C	6.3.1 and 6.3.6
Natural stone	S	C	C	S	C	6.3.1 and 6.3.6

Key

S Suitable

U Unsuitable

C Confirm suitable with manufacturer and specialist contractor

NOTE See Table 3 for bed thicknesses (7.2.3.1)^{A)} The tile bed chosen also depends on the traffic conditions (see 6.4.2)^{B)} See 6.3.6**6.3.6 Other bases****6.3.6.1 General**

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 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 dried to less than 0.5% moisture content, 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.

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

NOTE Full technical information and advice is contained in a code of practice on the subject, Tiling to calcium sulfate based levelling screeds, available from The Tile Association [5].

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 is normal low density pedestrian traffic with possibly lightweight soft-wheeled trolleys, e.g. domestic and office locations. All types of flooring are suitable but the bed chosen also depends on the base conditions.

Heavy loading areas are those 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. For resistance to mechanical failure, see 6.4.3.

6.4.3 Resistance to mechanical failure

6.4.3.1 Resistance of tile bedding

Where heavy loading is likely, and particularly where the moving of heavy loads is contemplated, adhesion to the base is crucial. The flooring bed should be well compacted and, as far as possible, free from voids to ensure good adhesion to the base. 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 6.4.3.2 c) item 3)].

NOTE The flooring bed selected depends on the base conditions.

If, because the base is a suspended floor or for some other reason, a separating layer is needed, a reinforced semi-dry mix bed with intermediate movement joints should be used over the layer (see 7.2.3.2 and 7.2.3.3).

NOTE For a heavily loaded, suspended floor subject to wetting, see also 6.5.