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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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 88, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 5385 is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 30 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This part of BS 5385 supersedes BS 5385-3:2007, which is withdrawn.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 cm^2, no tile edge >600 mm

3.4 large ceramic format tile
ceramic tile with a surface area >3 600 cm^2, no tile edge >1 200 mm

3.5 ceramic panel
ceramic tile with a surface area >1 m^2, any tile edge >1 200 mm

3.6 thin tile
ceramic tile with a panel thickness $\leq$5.5 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

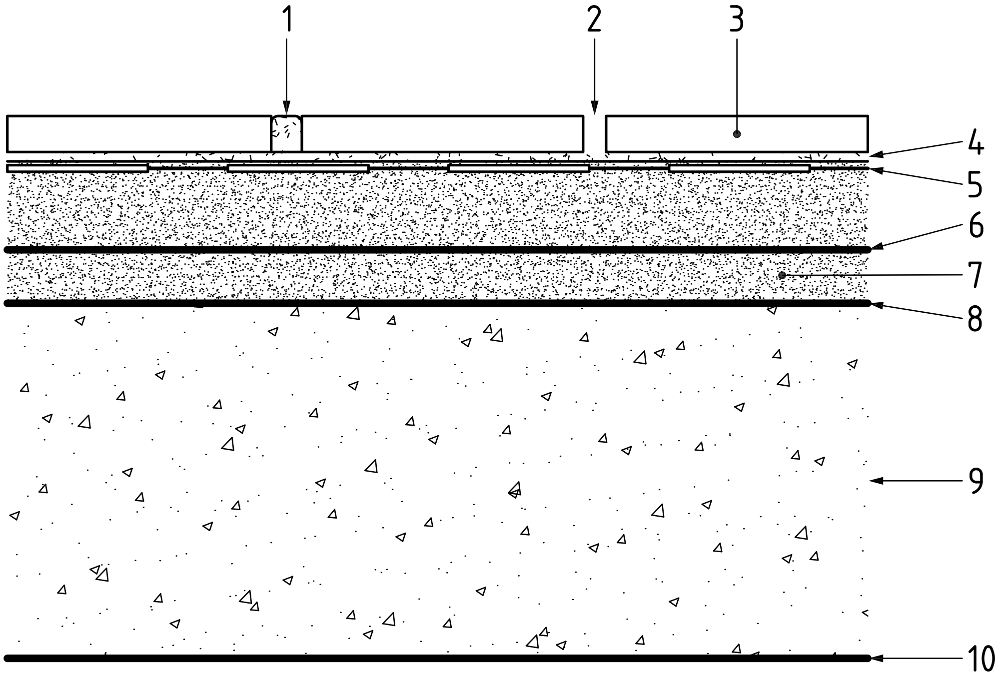
3.9 solid bedding
adhesive under the tile which, as far as is practicable, is free of voids so that the tiles are solidly supported

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**



Key

1	Grout	6	Reinforcement (optional)
2	Joint	7	Cement: sand screeded base
3	Tile or tesserae	8	Separating layer or optional damp-proof membrane
4	Adhesive bed	9	Structural concrete base
5	Uncopline membrane (optional)	10	Damp-proof membrane

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:

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 **4.3**);

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 **4.1**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) 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 exection 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 base 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 regularoty (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/m^2, 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 ≤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 **6.4.3.2**c)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 AI_a or BI_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 contaminantion (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.

6.8.1.2 Edge protection and transition profiles

*COMMENTARY ON **6.8.1.2***

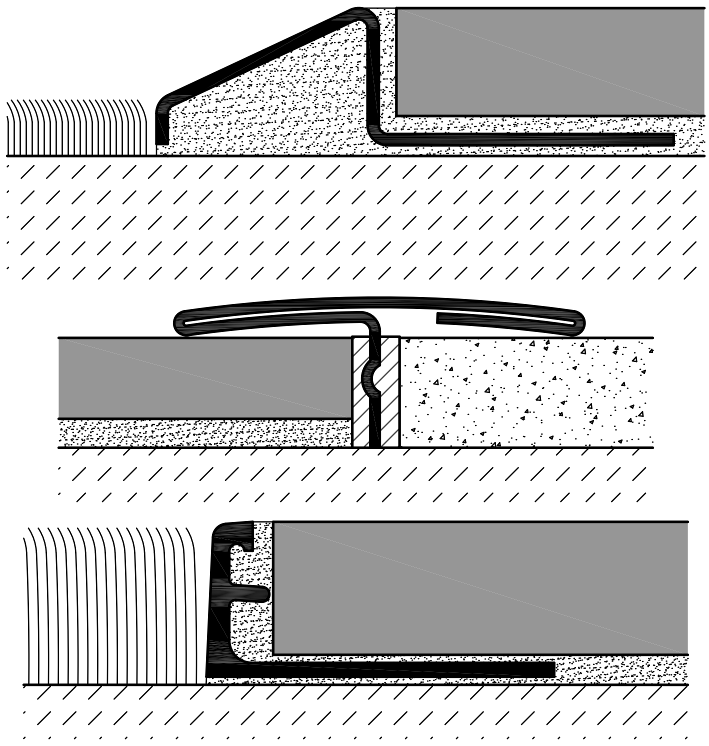
The development and proliferation of trim profiles has echoed two major shifts in the ceramic tile industry, including the transition from mortar bed installation to adhesive fixing and the change in ceramic tile production techniques. Trim profiles are valuable tools with the benefits ranging from simply improving the aesthetics and design options to providing durability of tile assemblies.

Tiles are a popular choice for their hygienic and easy maintenance properties, however exposed tile edges might need to be protected.

The profiles can be generally grouped into two categories: transitions between same height surfaces and transitions between different height surfaces.

Selection of the appropriate transition profile will be determined on individual applications, taking account of the environment and traffic conditions, etc. Figure 2 shows typical edge protection and transition profiles.

Figure 2 **Typical edge protection and transition profiles**



NOTE 1 The base flange of profiles require appertures of adequate size to allow the tile adhesive to support the tile edge through the profile.

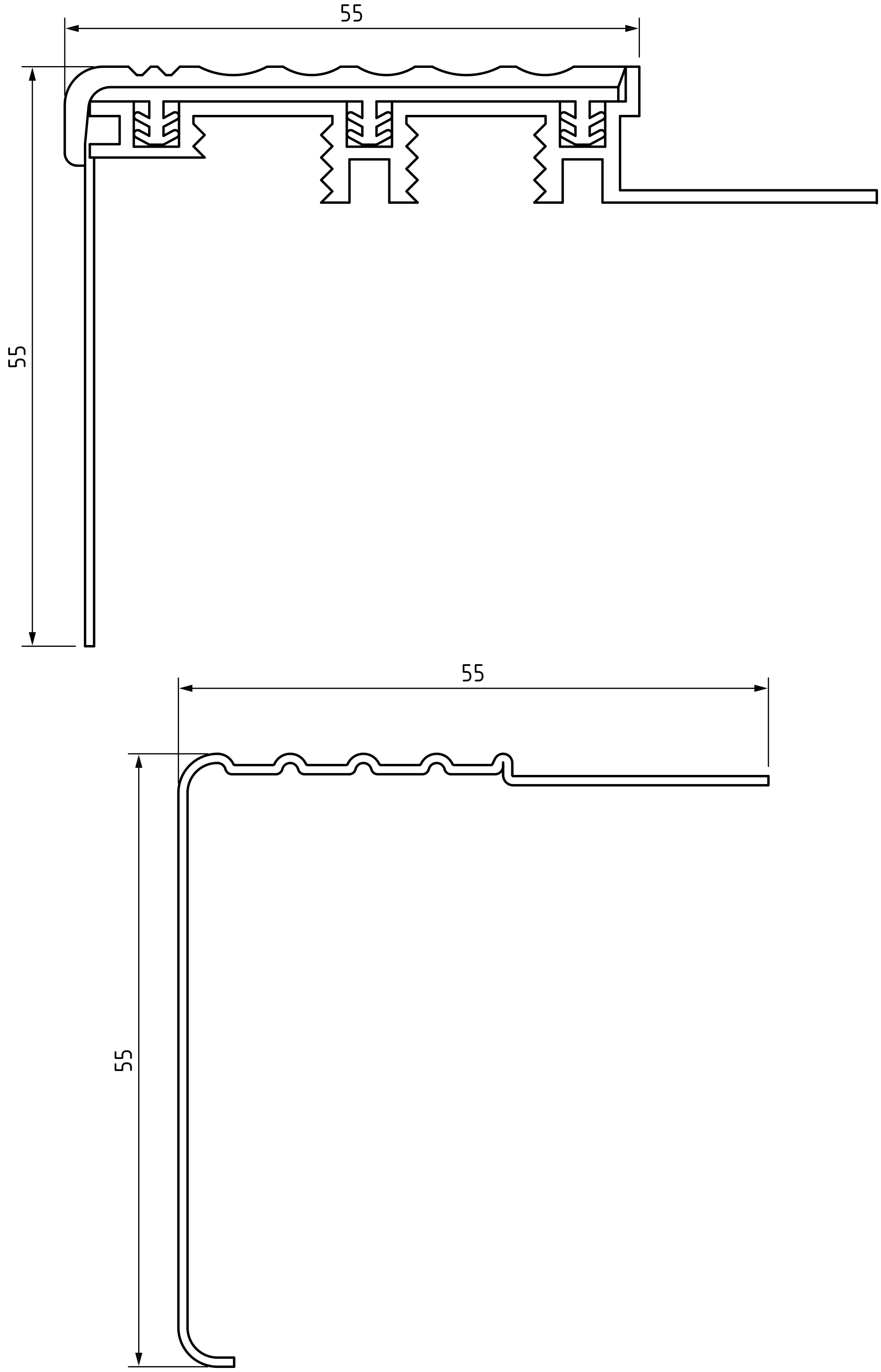
NOTE 2 Further information is given in TTA document Technical Guidance Note 10 on Tile Trim Profiles [7].

6.8.1.3 Stair nosing profiles

*COMMENTARY ON **6.8.1.3***

Various options are available to suit internal and external locations in all tiled applications including residential, commercial and industrial environments. Where compliance to current building regulations is required, e.g. DDA (The Disability Discrimination Act 1995) [8] or the Equality Act [9], then profiles are available to meet these needs. The advice provided within Approved Document M – Access to and use of buildings [10] states "all nosings are made apparent by means of a permanently contrasting material 55 mm wide on both the tread and riser". Figure 3 shows typical stair nosing profiles.

Figure 3 **Typical stair nosing profiles**



NOTE 1 The base flange of profiles require appertures of adequate size to allow the tile adhesive to support the tile edge through the profile.

NOTE 2 Further information is given in TTA document Technical Guidance Note 10 on Tile Trim Profiles [7].

6.8.1.4 Balconies and roof terraces

NOTE 1 Balcony and terrace assemblies are frequently exposed to a variety of weather conditions. Periods of frost, precipitation and movement stresses are caused mainly by temperature and moisture fluctuations. This can make balcony assemblies susceptible to material breakdown and subsequently lead to instability and eventual failure.

Balconies and terraces should be checked for anticipated static/dynamic loading demands. All materials selected for use in balcony and terrace construction should be checked for suitability prior to their installation. The tile selected for installation should be sufficiently slip resistant and be suitable for the anticipated traffic. Consideration to the environmental surroundings of the balcony or terrace should be given and only suitable materials selected for construction based on the impact posed by the location i.e. marine environments.

NOTE 2 The formation of soluble salts can occur when water becomes trapped for prolonged periods of time within cement based products.

It is important that balconies and terraces should therefore be designed and constructed as to allow water to drain free and effectively.

NOTE 3 Moisture becoming trapped at lower levels within construction materials can expand in freezing temperatures resulting in void formation over time. The correct surface gradients are typically found to be between 1/35 and 1/80.

The gradient should be incorporated within the base materials and below a suitable primary waterproofing layer. This should be formed from only rigid construction grade materials.

Any slope should encourage water away from the building and into suitable drainage outlets thus preventing moisture accumulation (or ponding) on the surface. Guidance on the slip resistance of the tile to be installed should be sought from the manufacturer. Any drainage system used should be capable of accepting the typical water volumes associated with external areas.

Care should be taken at junctions where balconies/terrace meets the building. Proprietary drainage channels are often considered at these points as a secondary drainage measure to compliment a well-designed gradient. Drains should be cleaned and maintained periodically to prevent blockages and back filing. A secondary drainage layer within the assembly should be considered in exposed areas.

NOTE 4 Some sub-surface drainage systems can provide additional functions which often help with the types of excessive movement experienced in external applications i.e. uncoupling.

NOTE 5 The use of edge profiles can help to divert water run-off away from the face of the balcony or terrace, and into an appropriate guttering system.

Penetration of the waterproofing layer with balustrades or fixings should be avoided wherever possible with anchoring points positioned either below or on the side of the balcony.

External tile installations are regularly exposed to greater fluctuations of thermal and moisture movement. Intermediate movement joints should be incorporated within the tile assembly at intervals not exceeding 3 m. Distances between joints might have to be reduced further dependent upon the anticipated movement in the background, the size and format of the tile and the width of the tile joints. Movement joints should also be incorporated where there are supporting beams and where the tile assembly abuts restraining surfaces i.e. parapet walls. Movement joints should be continuous throughout the entire assembly.

Resin based agglomerated stone tiles should not be used externally.

6.8.1.5 Structural movement joints

Structural movement joints in the bed and tiling should be sited immediately over and be continuous with structural movement joints in the base. This procedure might not be acceptable if the base joints are not straight and parallel, or if their layout does not coincide with that of the floor tiles; in these circumstances, guidance should be sought from the building designer or engineer.

6.8.1.6 Other movement joints

Flexible joints (see Figure 4a or Figure 4c) should be inserted over supporting walls and beams at intermediate positions to accommodate deflection of the base and movements in the flooring.

Flexible joints (see Figure 4a, Figure 4c, or Figure 4e) should be used at floor perimeters and to divide the floor into bays at the intervals recommended in **7.1.6.4**. Wherever possible they should coincide with structural features, e.g. columns and door openings, or they can be planned to provide a decorative panelled effect.

Where high temperatures are expected, for instance around boilers, over heating installations or from strong sunlight, an assessment of the likely temperature range and corresponding linear changes in the flooring should be made to determine whether and where any additional allowance for movement is necessary.

In floors that have to withstand hard-rimmed wheel traffic or the dragging of heavy loads, the position of movement joints should, where possible, be planned so that they do not occur in the traffic area. Where this is not practicable, pre-formed strip joints should be used with their edges reinforced with metal or rigid plastics sections (see Figure 4a, Figure 4b and Figure 4d).

Joints other than those protected by metal or rigid plastics edging, subject to traffic heavier than light pedestrian, should not be wider than 10 mm. Information on the permissible maximum and minimum joint widths should be obtained from the manufacturer of the particular joint filling selected.

NOTE The illustrations in Figures 4a to 4e indicate the basic principles of the types of joints referred to above. Prefabricated types of Figure 4a and Figure 4b are available that embody the principles shown, but they can differ in detail.

6.8.2 Sealants installation

*COMMENTARY ON **6.8.2***

Choice of sealant depends upon many factors including joint movement accommodation (MAF), resistance to chemical attack, wear, durability, penetration of grit and contamination, resistance to damage from cleaning processes, and ease of application (see BS 6213).

Sealants for movement joints are now classified by performance, at seven levels within type F of BS EN ISO 11600:2003+A1:2011. Class criteria include movement accommodation, degree of elasticity and modulus, substrate suitability and the need for priming. The classification is independent of chemical type.

Classified elastic sealants are normally suitable for a minimum service temperature range of 20 °C to 70 °C.

A particular chemical type of classified sealant might be selected preferentially in certain circumstances e.g. to ensure, resistance to particular chemicals, compatibility with adjacent materials, avoidance of substrate staining or severe service temperature conditions.

Sealants formulated for high abrasion and chemical resistance rather than movement accommodation might have some properties not fully classifiable by BS EN ISO 11600.

Bitumen and tar extended pavement sealants are classified to BS EN 14188 parts 1 to 3 for hot and cold application and curing. Sealants meeting the latter generally have higher movement accommodation (MAF) and a wider service temperature range. Hot poured elastic sealants can also accommodate higher movement. Certain BS EN 14188 grades are suitable for fuels contact.

Butyl mastics and other tacky forms of material are not suitable materials.

The chemical curing system for elastic sealants might be moisture initiated (single pack), or chemically initiated (multi-component). The latter require mixing prior to use.

The cure rate depends to a lesser or greater degree on the prevailing temperatures and in the case of moisture curing types, additionally, the surrounding humidity and depth of seal. Chemically initiated curing is normally faster and more uniform throughout the sealant bulk.

Walk on times vary according to conditions as well as the individual product properties.

Manufacturer's advice should be followed when installing sealants.

6.8.3 Back-up material installation

The sealant should be applied and tooled to ensure proper adhesion and surface finish.

Where sealants with a large movement capability are used, they should not stick to the back-up material as the ability of the sealant to accommodate movement can be reduced by any restriction of its under face. To prevent this, a bond breaker tape should be applied between the back-up material and the sealant. The filler should be placed so that it provides adequate support for the sealant and allows the application of an adequate depth of sealant into the joint to perform satisfactorily. The minimum depth of the sealant should be 6 mm or the thickness of the tile (whichever is smallest).

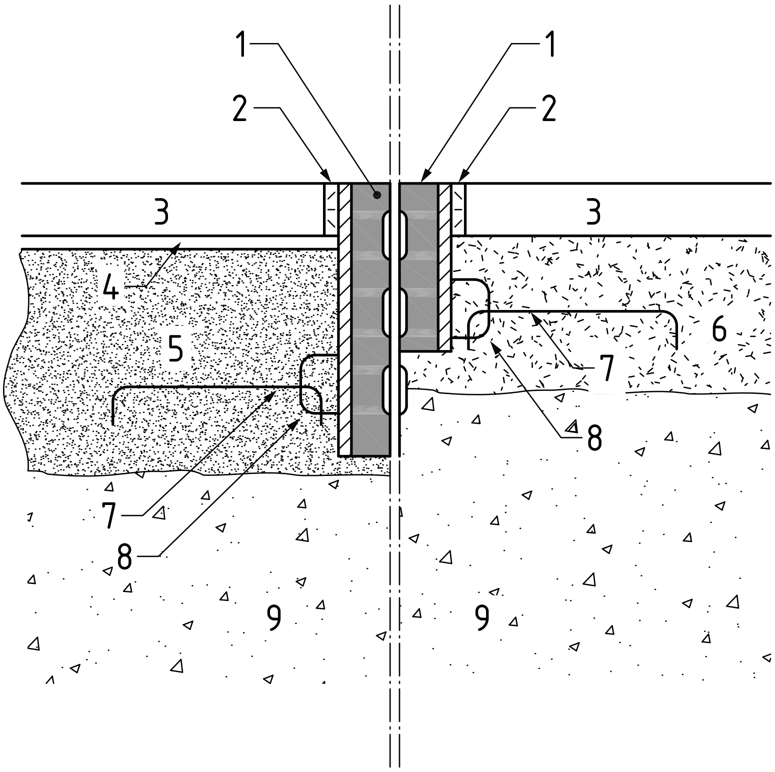
NOTE Further information on back-up material is given in ***5.7.3****.*

6.8.4 Pre-formed movement joints

NOTE Pre-formed movement joints are suitable for use in intermediate or perimeter joints. Cork and cork/rubber compound strips are suitable for use in light traffic areas. Synthetic rubber strips with metal edge supports and PVC are suitable for use in more heavily trafficked areas.

Movement joints should be inserted between tiles as they are laid. They should be fitted to the combined depth of the tiles and bed and keyed into the bed by the shape of the anchoring leg. Base levelling screeds to which tiles are bedded should be saw-cut to form a joint in the levelling screed directly below the pre-formed strip.

Figure 4 **Some typical movement joints**



(a) Slightly flexible joint: preformed strip with reinforced edges

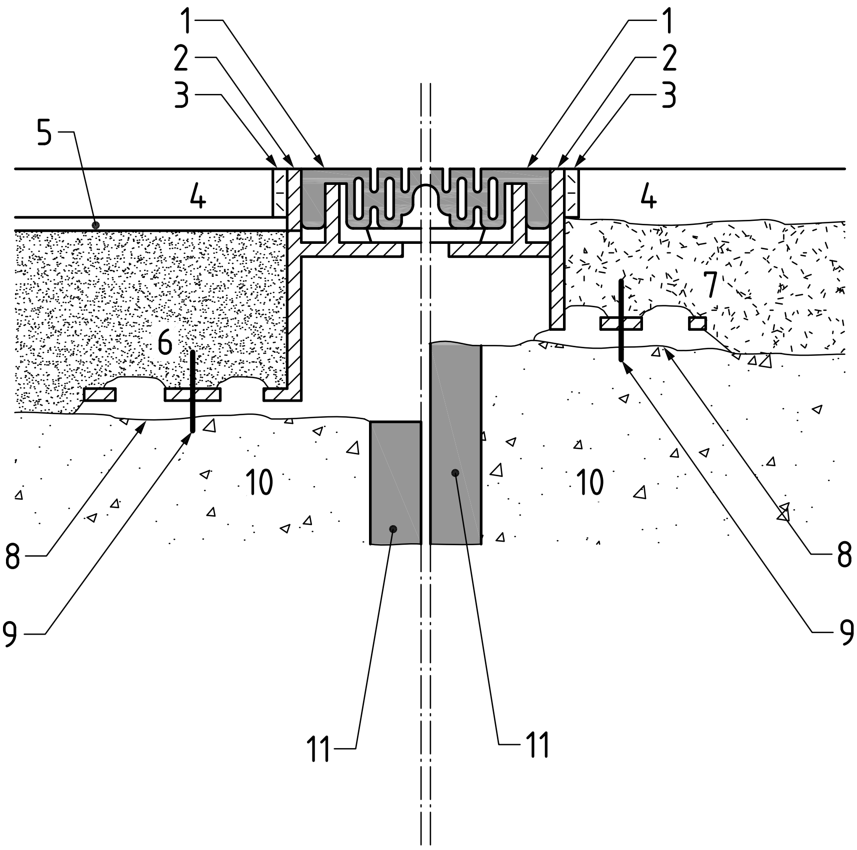
Key

1	Neoprene bonded to non-ferrous metal or rigid plastic strips	6	Cement and sand mortar bed
2	Grout	7	Tie wire
3	Tile	8	Locating lug attached to preformed strip
4	Adhesive bed	9	Concrete base
5	Screed		

NOTE 1 All drawings in Figure 4 illustrate principles only.

NOTE 2 Semi-dry mix beds have movement joints similar to those shown for levelling screeds.

Figure 4 – Some typical movement joints



(b) Prefabricated joint with reinforced edges and capping over structural movement joint

Key

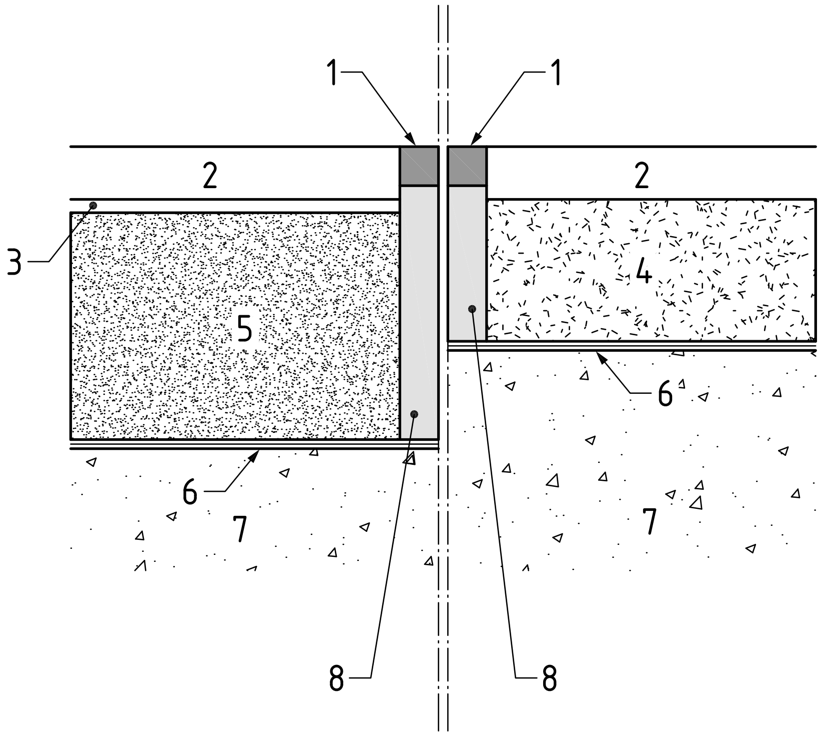
1	Flexible insert	6	Screed
2	Metal profile	7	Cement and sand mortar bed
3	Grout	8	Levelling bed
4	Tile	9	Mechanical fixing as necessary
5	Adhesive bed	10	Concrete base
		11	Structural movement joint

NOTE 1 All drawings in Figure 4 illustrate principles only.

NOTE 2 Semi-dry mix beds have movement joints similar to those shown for levelling screeds.

NOTE 3 The base flange of profiles require appertures of adequate size to allow the tile adhesive to support the tile edge through the profile.

Figure 4 – Some typical movement joints



(c) Flexible joint in bed, with or without separating layer

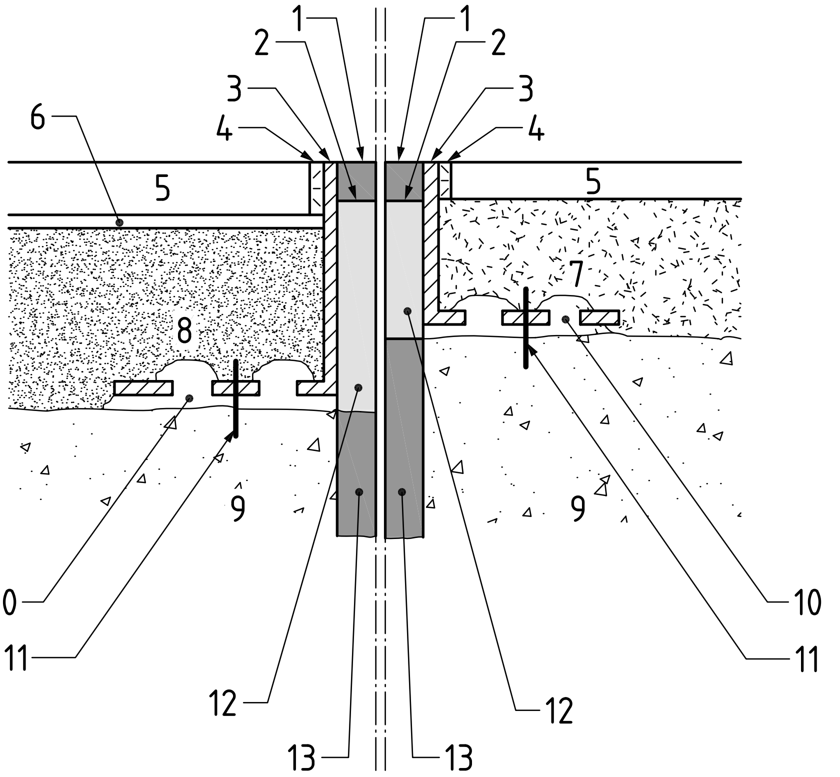
Key

1	Sealant	5	Screed
2	Tile	6	Seperating layer (optional)
3	Adhesive bed	7	Concrete base
4	Cement and sand mortar bed	8	Back-up material

NOTE 1 All drawings in Figure 4 illustrate principles only.

NOTE 2 Semi-dry mix beds have movement joints similar to those shown for levelling screeds.

Figure 4 – Some typical movement joints



(d) Joint aligned to structural movement joint

Key

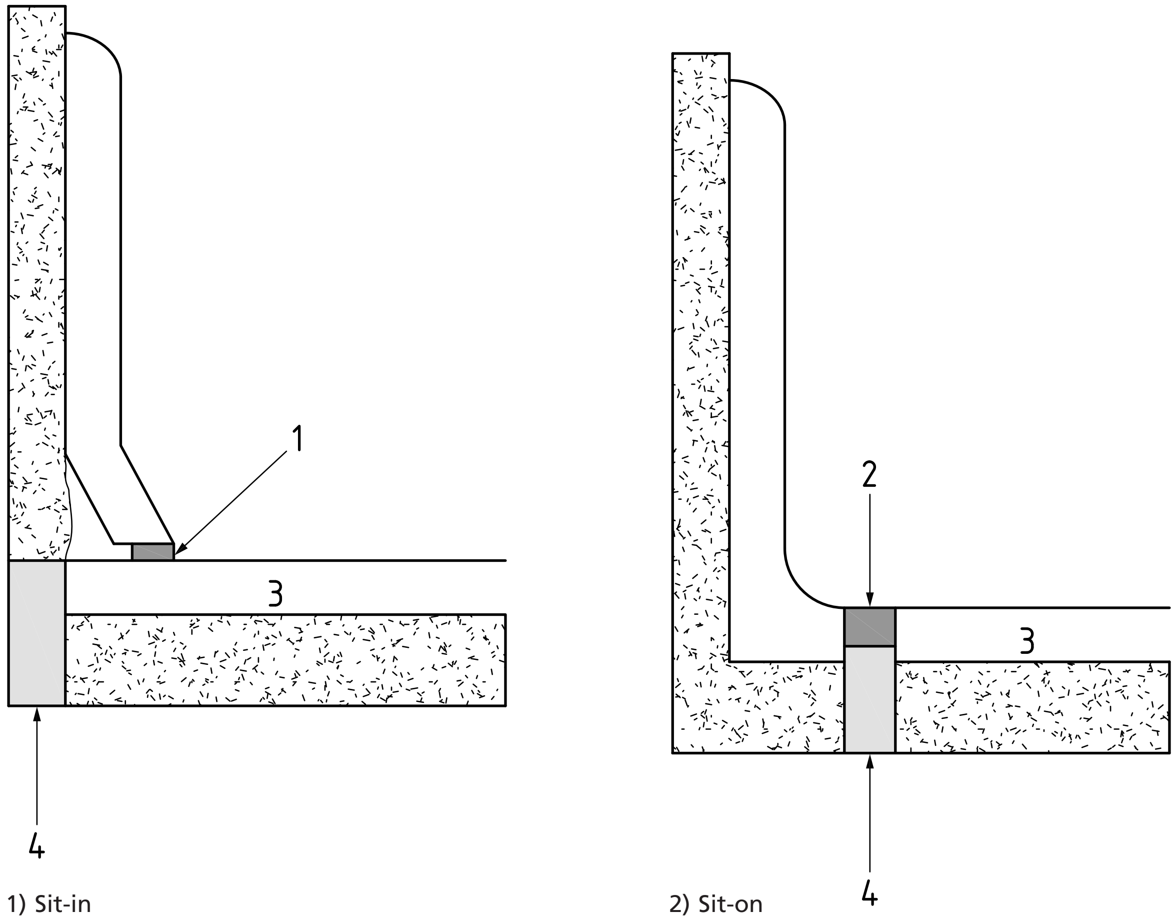
1	Sealant	8	Screed
2	Bond breaker tape	9	Concrete base
3	Metal angle	10	Levelling bed
4	Grout	11	Mechanical fixing as necessary
5	Tile	12	Back-up material
6	Adhesive bed	13	Structural movement joint
7	Cement and sand mortar bed		

NOTE 1 All drawings in Figure 4 illustrate principles only.

NOTE 2 Semi-dry mix beds have movement joints similar to those shown for levelling screeds.

NOTE 3 The base flange of profiles require appertures of adequate size to allow the tile adhesive to support the tile edge through the profile.

Figure 4 – Some typical movement joints



1) Sit-in

2) Sit-on

(e) Alternative perimeter joints (with skirtings)

Key

1 Sealant (optional)

2 Sealant

3 Tile

4 Back-up material

NOTE 1 All drawings in Figure 4 illustrate principles only.

NOTE 2 Semi-dry mix beds have movement joints similar to those shown for levelling screeds.

6.9 Modular installations

NOTE Some floor finish tiles are made in sizes that allow their installation in modular grid systems.

Factors concerning setting out and joint widths should be appreciated and resolved at the design stage. For example, the introduction of movement joints (see **6.8**), if they are to be wider than the general joints between tiles in the installation, a decision should be made as to the way in which the interruption to the modular grid pattern is to be corrected.

An important consideration is the effect of variations in joint widths as a result of manufacturing deviations; reference should be made to BS EN 14411 in order that the work sizes and permissible manufacturing deviations can be ascertained. Usually, these deviations cannot be determined in advance of manufacture and it should be accepted that joint widths specified prior to manufacture might not be achievable at the time of installation.

The desirable minimum joint widths are stated in **7.1.5** and, if the widths are appreciably greater, the suitability of the joints should be considered in relation to the expected traffic conditions.

6.10 Skirtings

NOTE 1 Skirtings (Figure 4e) can be employed for aesthetic reasons, for protecting the base of wall surfaces, for ease of cleaning or to assist in forming a liquid-tight system at the junction of floors and walls. The most common types of tile fittings used for skirtings are given in Annex A.

Where it is important that the installation is resistant to the passage of water or other liquid, and especially where "tanking" is necessary (see **6.5** and **D.2**), a flushfit coved base skirting should be used. This allows a perimeter joint to be positioned between the foot of the coved base and the adjacent floor tile to accommodate movement and which, when filled with an impervious sealant, contributes to a smooth uninterrupted resistant surface from horizontal to vertical.

NOTE 2 In other circumstances, a coved base skirting known as a "sit-on" cove or, alternatively, a tile with a square or rounded top edge, can be adapted. These skirtings are fixed to the wall. Movement is accommodated by compressible back-up material between the wall and the adjacent floor tiles. The joint between skirting and floor tiles is filled with a sealant.

6.11 Selection of bedding methods, grouts and joint materials

*NOTE 1 All the bedding methods given in **7.2** and Annex G are suitable for the flooring products described in Clause **5**. Guidance on which tile beds are suitable for different bases is given in Table 1. See also Table G.1 for tile bed thicknesses and **6.4.2** for traffic and load conditions.*

For installations that require particular properties to meet specific functional requirements and/or conditions that are potentially detrimental to the installation and/or the base, e.g. tiling designed to be in prolonged contact with liquids, reference should be made to BS 5385-4.

NOTE 2 For the suitability of grouts and joint materials likely to be in intermittent contact with liquids see Table 2.

7 Application of tiles – methods and materials

7.1 General

7.1.1 Work on site

During the application of floor tiling, skilled operatives working safely with the appropriate protective clothing and equipment in accordance with BS 8000-11 should be employed. There should be sufficient supervision.

7.1.2 Preparation of sub-floors to receive tile beds

7.1.2.1 General

The sub-floor should meet the surface regularity requirements for the specified tile bedding method.

NOTE 1 The sub-floor might not have been installed to the required surface regularity and require further preparation before the installation of the ceramic floor tiling is carried out.

Where tiles are to be fixed with adhesives the surface regularity of the sub-floor should be SR1 (see Annex E) and this should apply regardless of the adhesive bed thickness.

NOTE 2 Where tiles are bedded in cement and sand mortar beds a greater variation in the surface regularity can be accommodated (see BS 8000-11:2011, ***3.5.3****).*

If the surface regularity of the sub-floor is inadequate it should be corrected before the tiling trade commences work on site, e.g. by the use of a smoothing compound.

7.1.2.2 Preparation

Where a bonded tile bed is specified, the sub-floor should be correctly prepared and the recommended bonding treatment carried out to ensure good adhesion of the tile bed. Concrete surfaces should be suitably prepared to ensure that adhesion is not impaired by any surface contamination. In most cases, the concrete surface has laitance and lime bloom present that can be removed by light mechanical means.

NOTE If the concrete has been treated with a curing agent, or has had a film of laitance and fines worked up to its surface during finishing, the preparation to remove these barriers to adhesion by equipment such as contained shot blasting is usually necessary.

Where cement-based or reactive resin adhesives are used to bed the floor tiles the sub-floor should be inspected prior to tiling to ensure that it is free of any contamination, loosely adhered materials and other surface defects.

Where a bonded cement and sand bedding system is used the sub-floor should be roughened using appropriate mechanized equipment designed specifically for this purpose and a suitable bonding treatment used. If the concrete sub-floor is of suspended construction, e.g. a precast concrete plank, care should be taken to ensure that any roughening by mechanized equipment, e.g. by scabbling, does not cause damage to the concrete. In such cases contained shot blasting with coarse shot should be considered.

Where there is a risk of subsequent contamination, the surface preparation should be delayed until shortly before the tile bed is laid.

7.1.2.3 Bonding

Before the cement and sand mortar bed is laid the concrete base should be dampened down and excess water brushed off before the application of a bonding grout or slurry is applied to the concrete. The bonding grout or slurry should consist of cement mixed with an aqueous synthetic polymer dispersion, so that a creamy consistency is obtained that can be brushed out or trowelled as a thin coat on the prepared concrete sub-floor or a 1:1 cement:screed sand aggregate (mixed by weight). The cement and sand bedding mortar should be placed on the bonding grout or slurry whilst the slurry is still wet and workable.

The aqueous synthetic polymer dispersions and other proprietary bonding agents should be fit for use in bonding cement and sand mortar beds to concrete and applied in accordance with the manufacturer's instructions but roughening of the concrete sub-floor should still be carried out.

NOTE 1 Proprietary bonding agents may be used mixed with cement to form a bonding slurry or applied direct to the base as an alternative to cement slurry.

NOTE 2 See BS 8204-1:2003+A1:2009, ***6.4.2*** *for more information.*

7.1.2.4 Unbonded beds

Where an unbonded cement and sand bed is to be laid over a separating membrane, either on a new sub-floor or on an old one being renovated, the base should be sufficiently clean and smooth to receive any separating material specified.

7.1.3 Setting out

7.1.3.1 General

When setting out the correct datum level for the floor should be established. The level of the finished work should be controlled by a series of "spot levels". A gauge rod should be set up indicating the overall measurement of a given number of tiles with specified joint widths; with this the tiling contractor determines the best method of setting out to avoid unsightly cut tiles. Whole tiles should be used to the greatest possible extent. If cutting is necessary, then cut tiles should be fixed as unobtrusively as possible and should achieve symmetry with regard to cut tiles in the total area.

NOTE 1 For modular installations see ***6.9****.*

NOTE 2 Setting out might have to be related to the siting of movement joints that are usually detailed on working drawings but it is sometimes necessary for their positioning to be left to the discretion of the tiling contractor. The principles to be observed for siting movement joints are given in ***6.8*** *and* ***7.1.6****.*

7.1.3.2 Straightness of joints

The joints between tiles are an important feature of any tiling installation, particularly when small tiles, wide joints, or contrasting coloured grouts are specified. The width of the joints between tiles should be even and of regular dimension (subject to the manufacturing tolerance for the type of tile specified).

Generally, tile joints should be straight in alignment unless the tiles are, by design, irregular in shape. Special attention should be paid to large areas of floor tiling where the joint can be sighted.

The straightness of tile jointing can be checked using a taut lightweight nylon builder's line. The nylon line should be in alignment with the tile joint at all points along the nylon line at any point within the width of the joint, i.e. the normal permissible tolerance being the width of the tile joint.

Any sections of tile jointing not within this tolerance should not necessarily be considered to be a defect unless clearly visible by normal eyesight from both ends of the taut string line used for the test and viewed from a standing position.

7.1.4 Tolerances on finished floor level

NOTE 1 Floor surfaces are usually specified to be level or to be laid to a given fall. Some variations in surface level are permitted.

The central areas of a large floor might be higher or lower than the edges without causing serious inconvenience; a departure from datum of ±15 mm should be deemed acceptable depending on the area and use of the floor.

NOTE 2 Greater accuracy is needed at partitions, door openings and where plant is to be installed directly onto the floor.

Local variations in level for a nominally flat floor should be such that, when checked with a 2 m straightedge with 3 mm thick feet at each end, the straightedge should not be obstructed by the tiles and no gap should be greater than 6 mm.

The maximum deviation between tile surfaces either side of a joint, including movement joints, should be as follows:

a) joints less than 6 mm wide, 1 mm;

b) joints 6 mm or more wide, 2 mm.

Where the tiling is bedded in an adhesive, the tolerance of the base should conform to that required for the finished floor.

NOTE 3 There are permissible manufacturing tolerances for ceramic tiles as defined in BS EN 14411.

Certain types of tiles, e.g. extruded or large format, might have permissible surface flatness irregularities that cannot be satisfactorily accommodated within the surface flatness tolerance permitted to the tile installer and this should be taken into account when evaluating the achievable flatness of a floor tiling installation.

Where tiles are bedded in adhesives, the sub-floor should conform to SR1 (see Annex E).

7.1.5 Joints

As a general rule, the width of joints in ceramic tiling should not exceed the tile thickness. The width should not be less than 3 mm. Wider joints, for example 10 mm wide, might be required to accommodate dimensional irregularities in the tiles, to maintain modular discipline or to provide a decorative effect.

Wherever practicable, the depth of the joints should be at least 6 mm.

Recommendations for joint filling materials and procedures are given in **7.3**.

7.1.6 Movement joints

7.1.6.1 General

*NOTE Types of movement joints and stress-relieving joints are given in **6.8** and illustrated in Figure 4. The siting of these joints is given in **7.1.6.2**, **7.1.6.3** and **7.1.6.4**.*

Care should be taken to ensure that levelling screeds or tile beds adjacent to movement joints are fully compacted.

Movement joint cavities should extend through the tiling, tile bed and levelling screed and should be completely filled and sealed after the grouting of the normal joints. Where separating layers are incorporated, however, the movement joint should extend to this layer but should not penetrate it. Prior to the filling and sealing operation, the joints should be thoroughly cleaned of all extraneous matter, excess grout, dust, etc.

7.1.6.2 Structural movement joints

Movement joints as illustrated in Figure 4b and Figure 4d should be inserted in the bed and tiles over movement joints and/or contraction joints in the base. They should be continuous with the base joints and should be of sufficient width to permit the joint filling to accommodate the expected movement. In the event of the base joints not being true, e.g. not straight and parallel, or their layout not coinciding with that of the tiles, the siting of the movement joints in the finish as stated might not be acceptable and a decision as to any alternative procedure should be obtained from the building designer or engineer or their agent.

7.1.6.3 Perimeter joints

Movement joints should be inserted where the tiling abuts restraining surfaces such as perimeter walls, columns, curbs, steps and plant fixed to the base. In floors with dimensions of 2 m or less between restraining surfaces, perimeter joints are not necessary unless the conditions that can generate stresses are likely to be extreme, for example, violent temperature changes or prolonged immersion in liquid.

7.1.6.4 Intermediate joints

In larger floor joints as illustrated in Figure 4a, Figure 4d, or Figure 4e joints between perimeter joints should be employed to divide the area into bays of size not greater than 10 m × 10 m for internal floors without underfloor heating. For external floors, the spacing of intermediate movement joints should be less than 10 m × 10 m.

NOTE 1 The need for intermediate joints between perimeter joints depends on the dimensions of the floor; for example, with the exception of those on suspended construction, in floors with less than 10 m between perimeter joints no intermediate joints are necessary.

NOTE 2 For information on underfloor heating see Annex C.

On suspended floors, stress-relieving joints (see Figure 4a, Figure 4c or Figure 4e) should be inserted where flexing is likely to occur, e.g. over supporting walls or beams.

NOTE 3 Suspended floors are not resting on a solid base but are supported by other forms of construction.

For internal floors, which might be subjected to significant thermal changes, i.e. direct sunlight in atria, or underfloor heating, etc., the floor area should be divided up by intermediate movement joints into bays of size not greater than 40 m^2 with an edge length not greater than 8 m.

7.2 Bedding methods

7.2.1 Bedding in adhesives

7.2.1.1 General

Only adhesives given in **5.4.6** and manufactured specifically for fixing ceramic floor tiles and mosaics should be used. Cementitious adhesives (Type C) are usually proprietary compositions in dry powder form containing cement as the basic ingredient, and generally require mixing on site with water or an aqueous polymer dispersion. Reaction resin adhesives (Type R) are usually proprietary products.

Where adhesives are to be used to bed the tiles the accuracy of the sub-floor should be such that any gap under a 2 m straightedge does not exceed 3 mm, i.e. SR1.

NOTE 1 The overall surface of tiling laid using adhesives necessarily follows the surface of the sub-floor since the application techniques normally used do not allow the level of the sub-floor to be adjusted whilst the tiles are being bedded.

Where base surfaces are not sufficiently flat and true to permit adhesive fixing the sub-floor should be pre-levelled as recommended in **7.1.2.1**. In some cases the adhesive can be used to pre-smooth the sub-floor either as a levelling layer or to fill small isolated depressions. When used as a pre-levelling layer the thickness of the application should not exceed the maximum recommended by the adhesive manufacturer.

NOTE 2 With some adhesives a thicker pre-smoothing application might be possible in small isolated depressions in the sub-floor, subject to the manufacturer's recommendations.

It should be appreciated that the larger the tile being fixed the greater the accuracy of the sub-floor has to be to enable the floor tiles to be solidly bedded and laid without lipping at the tile joints.

The tiles should be thoroughly bedded in the adhesive so that as far as possible no voids remain beneath the tiles, i.e. solid bed fixed.

NOTE 2 Any voids under the tiles are vulnerable to damage under loads and impacts, whilst in exterior situations, water can accumulate in voids so that damage can occur on freezing.

Joints between tiles should be not less than 3 mm wide (see also **7.1.5**).

The sub-floor should be clean, dry, of adequate strength and prepared to suit the adhesive being used. The surface being adhered to should not be dampened before applying the adhesive.

The precise recommendations of the adhesive manufacturer should be followed concerning the mixing procedure, the method of use, the maximum thickness of bed, the working time before and after spreading and the suitability of the base. Cementitious adhesives should be mixed with clean water, carefully following any specific instructions, to obtain the required consistency, usually a fairly thick creamy slump-free mix. Cementitious adhesives should never be mixed with more water or admixture than the maximum amount that is recommended by the adhesive manufacturer otherwise the performance of the adhesive will be impaired. Cementitious adhesives are also available that can be mixed to a pourable consistency to facilitate the solid bedding of large format floor tiles and such adhesives should be mixed and applied strictly in accordance with the adhesive manufacturer's instructions.

7.2.1.2 Bedding in cementitious adhesives

7.2.1.2.1 Notched trowelling and buttering method

When floor tiles are fixed using normal cementitious adhesives the adhesive should be applied to the sub-floor as well as to the back of the tile to ensure solid bed fixing. The mixed adhesive should be applied to the sub-floor using a trowel as a floated coat, pressing the adhesive into the surface before combing through with a notched trowel as a spreading gauge to provide a uniform ribbed adhesive bed. The backs of the dry tiles should be buttered with the adhesive to coat the surface and to fill flush any back profile or key to form a contact layer before placing the tile on the ribbed adhesive bed. Each tile should then be pressed or tapped down with a rubber mallet firmly into position. The adhesive should preferably be trowelled out as straight ribs and tiles should be pressed into the ribbed adhesive bed whilst the ribs are still wet and workable, i.e. within the "open time" of the spread adhesive.

NOTE 1 If pourable floor tile adhesives are used it is possible to fix the tiles in a solid bed of adhesive without having to butter the backs of the tiles. If the floor tile has a deep back profile then solid bedding might not be achieved unless the back of the tile is buttered.

A freshly fixed tile should be lifted to check that the size of notched trowel and the bedding technique used results in no voids being left beneath the tile. When bedding is found to be incomplete either increase the angle between the trowel and sub-floor when combing out the adhesive ribs or use a trowel with larger notches. This check should be carried out occasionally during the fixing of the floor tiles to ensure solid bedding is consistently maintained.

The advice of the adhesive manufacturer on the size and type of notched trowel should be followed.

NOTE 2 Too large an amount of adhesive under the tiles can result in excess adhesive grinning up through the joints and the tiles "swimming" on the adhesive, whilst too small an amount of adhesive prevents solid bedding.

7.2.1.2.2 Buttering method

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

7.2.1.3 Bedding in reaction resin adhesives

Because of their nature, the manufacturer's instructions should be closely followed when using reaction resin adhesives (**5.4.6.2**).

These adhesives are usually supplied as two components; a resin and hardener should be mixed together to produce an adhesive for bedding tiles. Care should be taken to ensure that the two components are thoroughly mixed together immediately prior to use. The mixed adhesive should be applied by methods similar to those described for cementitious adhesive installation in **7.2.1.1** and **7.2.1.2**.

When mixed these adhesives set and harden by reaction between the two components and the mixed adhesive should not be left in the container but should be spread out on a suitable surface so that self-heating does not curtail the working time. The "open time" of the spread adhesive is normally as long as its working time so that backs of the tiles should be buttered with the adhesive before bedding in the ribbed adhesive bed within the working time of the mixed adhesive. Checking the solidity of bedding should be carried out as described in **7.2.1.2.1** as fixing proceeds.

7.2.1.4 Movement joints

Movement joints should be sited in accordance with **7.1.6**.

7.3 Grouting

7.3.1 General

Some bedding methods require that grout is applied during, or within a prescribed interval after, the tile-laying operation (see **7.2.1.4** and **7.3.3**). With these exceptions, grouting should be carried out not sooner than 12 h nor later than 48 h after the completion of the laying of the tiles. Sufficient time should be allowed to elapse to ensure adequate setting of the bed to preclude disturbance of the tiles during the grouting operation. On non-absorbent backgrounds, it might be necessary to wait up to three days before the tile adhesive is firm enough to permit grouting. When fixing tiles in adhesive, e.g. rapid setting products, these timings might not be accurate and the adhesive manufacturer's instructions should be followed. The grouting should not be unduly delayed as open joints can collect general building dust and debris.

In most tiling situations a cement and sand mortar or a proprietary cement-based grout should be used.

7.3.2 Grout materials

7.3.2.1 Proprietary grouts

NOTE 1 Proprietary grouts offer the advantages of controlled formulation and consistency and are available in the following categories:

a) mixes based on cement but modified by the inclusion of various admixtures. They require only the addition of clean water to obtain the desired consistency;

b) mixes based on epoxide resin, generally supplied in pre-gauged components for mixing on site;

c) mixes based on other resins and materials, for specialist uses.

Proprietary grouts should be selected so as to meet the conditions of exposure. Reference should also be made to Table 2, which gives the grades of resistance of grouts to various liquids.

NOTE 2 Grouts in Note 1, categories b) and c) are likely to be more expensive, slower to use and more difficult to clean off, than cementitious grouts.

Many proprietary grouts are pigmented and, provided that surplus coloured grout is cleaned off promptly in accordance with the manufacturer's instructions, no problems should arise. However, coloured grouts and grouts containing fine-grained pigments are likely to prove more troublesome in this respect than those containing coarser-grained pigments. In such cases, the potential risk of staining should be checked by applying the grout to a few tiles before fixing is carried out.

NOTE 3 In any doubtful case, this enables an alternative grouting procedure to be adopted; alternatively, the use of a proprietary tile sealer can be considered.

Proprietary tile sealers should be used strictly in accordance with the manufacturer's instructions and should be applied before grouting is carried out to provide a protective coating which can readily be removed after completion of grouting.

7.3.3 Grouting procedure – tiles

7.3.3.1 General

Before grouting commences joints should be cleared of dust, debris and weak friable material. The depth of joints should be at least 6 mm except where tiles thinner than 6 mm are being used.

Grouting should start not sooner than 12 h nor later than 48 h after completion of tile laying, unless the tiles have been bedded with a beating machine on a semi-dry bed, when grouting should be completed within four hours.

NOTE 1 On non-absorbent backgrounds it might be necessary to wait up to three days before the tile adhesive is firm enough to permit grouting.

When fixing tiles in adhesive, e.g. rapid setting products, the above timings might not be accurate and the adhesive manufacturer's site work instructions should be followed.

NOTE 2 The application of grout mortar in tile joints does not provide completely flush joints since the application and cleaning off techniques result in some removal of grout mortar from the surface of the joints.

7.3.3.2 Grouting with proprietary grouts

The recommendations of the manufacturers of these materials should be followed for their mixing and application, removal of surplus grout and for cleaning off the floor surface.

The procedure when using cementitious material [in **7.3.2.1,** category a)] is as described in this British Standard, except that the joints are not wetted.

Different procedures should be applied when using materials in **7.3.2.1,** categories b) and c), as follows:

a) as a rule it is not necessary to wet the joints, but this point should be checked by reference to the manufacturer's instructions;

b) the application of chemically-resistant grouts in situations where the floors are subject to attack from highly aggressive substances should be as described in BS 5385-4.

7.4 Thin ceramic tiles and panels (non-mesh backed)

7.4.1 Quality of thin ceramic tiling – characteristics and requirements

NOTE Some thin ceramic tiles and thin ceramic panels are not suitable for floors.

Some thin ceramic tiles and thin ceramic panels might be suitable for light domestic/light commercial floorings in areas where the sub-floor is mature and rigid, e.g. existing ceramic or terrazzo, but they should be fit for purpose. The thin ceramic tile/panel manufacturer's recommendations should always be followed.

7.4.2 Technical information

NOTE 1 Thin ceramic panels might require specially designed equipment and more than one person for handling them during and after removal from the manufacturer's original packaging, as well as for the actual installation of the panels (see Figure 5).

NOTE 2 Very large thin ceramic panels can deform and fracture if lifted or moved incorrectly.

7.4.3 Thin tile joints

Thin tiles and panels should be positioned with regular straight joints, the width of which should be specified taking into account the thickness, size and dimensional tolerances of the thin tiles or panels, the characteristics of the background, the installation method and the expected end use of the thin tiling and anticipated loads likely to be imposed. There should be sufficient joint space between the thin ceramic tiles or panels for grout to penetrate to the full depth of the joint. Thin ceramic tiles and panels should not be butt jointed. Joints between thin ceramic panels should be at least 3 mm wide and increase in width pro-rata to panel size (e.g. for 3 m long thin ceramic panels the recommended minimum joint width between 3 m panels is 5 mm).

When solidly bedding thin tiles and panels into the adhesive bedding, much of the shallow joint between the thin tiles/panels becomes partially filled with residual adhesive which should, as far as is practicable, be removed from the joints in order to provide adequate joint depth and volume to receive the specified tile grout.

NOTE 1 Failure to do this can result in unsightly grout and reduced performance.

The grout should be specified taking into account both the need of protecting thin tile edges, and the destination environment. Grout should be well compacted into the tile/panel joints and finished as flush as is practicable with the surface of the thin tiles/panels.

NOTE 2 The joints between thin ceramic tiles and panels are usually the most vulnerable points of a thin tiling installation; thin tile edges might be less resistant to static, dynamic and impact loads, than the edges of thicker tiles.

7.4.4 Movement joints

*COMMENTARY ON **7.4.4***

Thin ceramic tiles and thin ceramic panels (porcelain) have similar coefficient of thermal expansion characteristics to porcelain as defined in BS EN 14411.

The effect of thermal expansion/contraction on smaller format thin tiles (e.g. 200 × 200 mm) is relatively insignificant across a temperature range which could be reasonably anticipated (depending upon area of usage, see ***6.2.1****). This is because the minimal expansion/contraction of the thin tile is, to some degree, "cushioned" by the grout joints between each tile because the compressive strength of a proprietary cement based tile grout e.g. CG2 (see BS ISO 13007-3) is lower than the compressive strength of porcelain.*

For larger format thin tiles and panels, any thermal expansion/contraction is cumulative across the area of the thin tile or panel so that, for a ceramic panel of 3 m long for example, the expansion of the panel across a temperature range of 30°C equates to approximately 0.65 mm which, as a percentage of a 5 mm wide joint between adjacent panels, equates to an approximately 12.5% compaction/expansion requirement of the joint grouting mortar, as well as a significant lateral deformation capacity of the panel bedding adhesive; depending upon any corresponding temperature change within the background structure onto which the panels are installed.

Usually in normal environments, the temperature of the tiling layer and its background (internal tiling) might not vary from each other to such extremes, but where thin tiles and panels, particularly dark coloured ones are installed externally or in areas subject to intense direct sunlight e.g. sun rooms, conservatories, atria etc, the thin tiling layer can heat up and cool very quickly whilst the background may not.

Conversely, any significant drying shrinkage of the background which continues after thin tiles or panels have been installed directly onto it might result in the build-up of lateral stresses within the tiling system. The larger the size of thin tile or panels, the greater the degree of "stress" that develops. Failure in the form of fracturing of the thin tiles/panels, or debonding of the tiles/panels from the background can result.

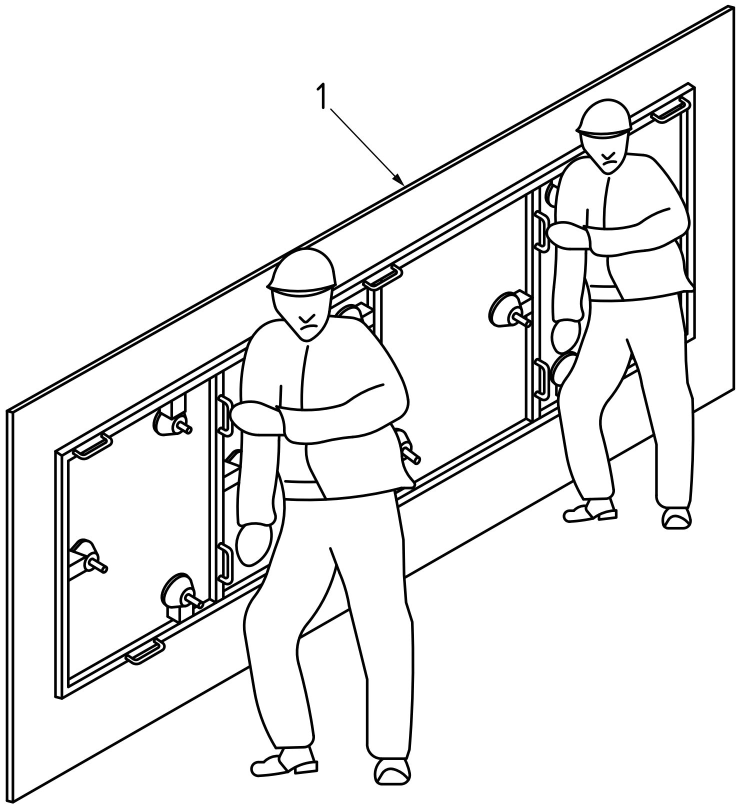
Consideration should be given at the design stage to the provision of movement joints (structural joints, perimeter joints, intermediate joints). The specification for the movement joint should include information on type, materials, construction, dimensions (width and depth) and position.

7.4.5 Storage and control of the materials

NOTE 1 Thin ceramic panels might require specially designed equipment for supporting them in order to prevent possible fracture during and after removal from the manufacturer's original packaging, as well as for the actual installation of the panels (see Figure 5).

NOTE 2 Very large ceramic thin panels can deform and fracture if lifted or moved incorrectly.

Figure 5 **Light alloy frame with vacuum pads**



Key

1 Thin ceramic panel

7.4.6 Control and preparation of the background, preparation of the bedding material, application of bedding thin tiles and panels

Some thin ceramic panels currently being produced are larger than 3 m^2, therefore, depending upon the size of the panel and the characteristics of the specified bedding adhesive, enough bedding adhesive should be spread to install one panel at a time in order to avoid possible "skinning" of the adhesive which could have a detrimental effect upon the performance of the adhesive/tiling.

In order to achieve solid bedding of large format thin ceramic tiles and thin ceramic panels, the floating and buttering technique should be used.

To achieve solid bedding of large format thin tiles and panels, the thin tiles or panels should be adequately pressed into the bedding adhesive using an appropriate tool designed for the purpose in order to ensure that, as far as it is practicable, there are no voids or trapped air behind the thin tiles or panels.

Backgrounds should be checked as having the regularity characteristics considered in the specification, for example the larger the thin tile/panel the greater the importance of the accuracy in planarity of the background. Any discrepancy from the specification should be communicated to the appropriate parties.

Particular attention should be paid to the application of adhesive to the backs of thin ceramic tiles and panels, to ensure that the edges and corners are properly covered with adhesive (see **6.3.4.5**).

8 Application of mosaics – methods and materials

8.1 General

*NOTE The description of mosaics and suitable locations for their use is given in Clause **6**. The recommendations for the application of tiles given in Clause **7** are of equal importance to the success of mosaic installations, but some modification is necessary concerning setting out, preparation of mosaic, placing in position and grouting.*

After sheets have been firmly pressed down any facing papers should be removed by soaking and sponging so that the joints are exposed. Before the bed begins to set, any necessary adjustment to the joints should be completed. Any adjustments should be made within 10 min of laying.

It should be appreciated that the colour of grout and bed materials, when seen through translucent tesserae, affects the shade of the finished work.

If in the absence of experience, there is doubt as to the suitability of a bedding method for a particular kind of mosaic, advice should be sought from the mosaic supplier or fixing specialists.

8.2 Workmanship

NOTE The application of mosaics requires efficient supervision and the employment of skilled operatives working safely and using protective clothing and equipment where appropriate. Many of the requirements for basic workmanship for floor tiling also apply to laying mosaics.

In the finished work the outlines of the sheets of mosaic should not be apparent, the joints between them being the same as those between the tesserae. Joints within the mosaic sheets are formed during assembly and are usually less than 3 mm wide.

8.3 Mosaic beds

*COMMENTARY ON **8.3***

Suitable beds for mosaics are:

*a) cementitious adhesives (see **7.2.1.1** and **7.2.1.2**);*

*b) reaction resin adhesives (see **7.2.1.3**);*

c) cement and sand mortar (see Annex G).

If the tesserae are not of uniform thickness and/or if the background surface to receive the bed and mosaics is not sufficiently even, the use of thin-bed fixing methods can be precluded.

8.4 Setting out

When setting out, the correct datum level for the floor should be established. The level of the finished work should be controlled by a series of "spot levels".

When setting out, sheets of mosaic should be used, although part sheets are necessary to fill out lengths and to cover areas not coinciding with full sheet sizes.

A gauge rod should be made, indicating the overall measurement of a given number of sheets including the predetermined joint widths. This can then be used to determine the best method of setting out to avoid cut tesserae.

NOTE Any attempt to minimize cutting of the mosaics by adjusting joint widths after the bed has partly set could break the bond between the tesserae and the bed. This condition could arise if a long interval has elapsed between fixing and the removal of any paper facing.

Joint widths between tesserae, established when the mosaics were assembled, should be maintained between sheets, otherwise the outline of the sheets is defined and the overall effect of consistency of spacing of the tesserae is marred.

Setting out might have to be related to the siting of movement joints. Movement joints should be detailed on working drawings but it is sometimes necessary for the exact positioning of non-structural movement joints (**6.8.1.3**) to be determined during the mosaic installation.

Surplus adhesive remaining on the face of the mosaics or in the joints should be removed before it sets. Grouting should be carried out in accordance with **8.9**.

8.5 Tolerances on finished floor level

*NOTE The recommendations given in **7.1.4** are applicable.*

8.6 Movement joints

The principles to be observed for siting movement joints should follow those given in **6.8** and **7.1.6**.

8.7 Preparation of mosaics

Mosaics should be inspected prior to fixing and any noticeably damaged tesserae replaced. With paper-faced mosaics the paper should be clear of the edges to assist with joint alignment whilst the sheets are being fixed.

8.8 Laying mosaics

8.8.1 Bedding in adhesives

8.8.1.1 Application of adhesive

*NOTE The information given in **7.2.1.2** and **7.2.1.3** is relevant.*

When adhesives are used the precise recommendations of the manufacturer should be followed concerning the suitability and preparation of the base, the mixing procedure, the method of use, the thickness of adhesive and the open time after spreading. In most cases a 3 mm square toothed and notched trowel should be adequate to provide the required straight ribbed bed of adhesive.

The sheets of mosaic should be placed in position as accurately as possible and tapped down with a laying-on trowel or wooden beater so that the adhesive ribs are flattened and full contact with the adhesive bed is achieved.

With paper-faced mosaic, joints between sheets should be filled with grout as work proceeds.

A straightedge should be used to ensure that the surface of the mosaic is true, as defined in **7.1.4**.

8.8.1.2 Application of mosaics

The adhesive should be applied to the base and evenly spread using a notched trowel suitable for mosaics. Extra care should be taken in order to minimize, as far as is practicable, any excessive thickening of the adhesive bedding which can subsequently be compacted up into the joints between tesserae during the beating-in process.

Sheets of mosaic should be placed in position as accurately as possible and tapped down with a laying-on trowel or wooden beater so that full contact with the adhesive is achieved.

8.8.2 Bedding in cement and sand mortar

8.8.2.1 Application of cement and sand mortar bed

The bed should be applied to the prepared sub-floor using a technique described in **G.8** or **G.10** and finished with a woodfloat. The bed should be allowed to stiffen slightly before any mosaic is applied, but it should not be left more than two hours before laying commences.

8.8.2.2 Application of mosaics

A slurry of neat cement or one consisting of one part cement to one part clean sand should immediately be spread and trowelled over the bed in an even layer about 2 mm thick.

The sheets should then be placed in position as accurately as possible and tapped down with a laying-on trowel or wooden beater so that full contact with the bed is achieved.

Immediately before bedding paper-faced sheets into the cement and sand mortar, the bed side should be pre-grouted with a neat cement grout. Where joints are wider than 2 mm, or the mosaic thickness is greater than 4 mm, it is advisable to mix sand with cement to avoid cracking as the grout dries out, a suitable mix being one part cement to one part sand by volume.

With paper-faced mosaic, joints between sheets should be filled with grout as work proceeds.

A straightedge should be used to ensure that the surface of the mosaic is true, as defined in **7.1.4**.

8.8.3 Inspection

The completed tiling should be inspected after completion in accordance with BS 8000-11:2011, **4.9.1.10** and with Clause **9** of this British Standard.

8.9 Grouting

NOTE Recommendations on grouting are given in ***7.3****.*

Paper-faced mosaics should be grouted using material similar in type and colour to that used for any pre-grouting.

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

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

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

9 Inspection

The floor tiling should be inspected on completion as follows:

a) the finished tile surface should meet the requirements given in **7.1.4**;

b) the straightness of the joints between the tiles should be checked in accordance with **7.1.3.2**.

NOTE See BS 8000-11:2011, ***4.9.1.10****.*

10 Protection

Finished and partly finished flooring should be protected from damage or contamination from following trades.

During the laying operation, the areas should be accessible to no-one but the tiling operatives. Completed floor tiling should not be subject to traffic until the bed has hardened and sufficient bond has developed between the bed and tiles.

Light pedestrian traffic should be allowed on floors bedded in non-rapid-setting adhesive and in cement and sand mortars four days after completion of laying and grouting, but heavier traffic should not be permitted to use the floor for 14 days after completion.

Where tiles are laid in a rapid-setting adhesive the floor can take traffic earlier than four days after completion. However, unless a rapid hardening grout is used the four-day period should not be reduced. The precise times at which a floor can safely put into service vary for different rapid-setting products, and the manufacturer's recommendations should be followed.

At all times the floor tiling should be kept clean and free from cement and plaster droppings, and all materials likely to cause stains. The flooring should be covered during work carried out on or over the floor involving substances that could cause permanent staining, e.g. oils, grease, paint. Appropriate types of sheets or boards should be laid loosely over the finished floor to protect it. Sawdust should not be used for this purpose any earlier than three days after grouting is completed.

If plant likely to cause damage has to be used, any parts in contact with the floor surface should be padded; sliding of plant over the surface should not be allowed. When heavy equipment has to be moved over the floor surface, special precautions should be taken, probably involving the use of timber planking, to ensure that the equipment, moving tackle and the protection itself are not allowed to damage the tiled surface by abrasion.

Stair finishings, especially nosings, are vulnerable to damage from following trades and should be protected by temporary casings.

The recommended drying times of all in situ floor bases are the minimum required under optimum conditions and these drying times should be considerably extended under adverse drying conditions on site, e.g. low temperatures and/or wet conditions.

For external applications, work should also be protected both during and after completion from frost or other unfavourable weather conditions.

11 Cleaning and maintenance

11.1 General

Where floor tiling is installed, an initial clean should be carried out to remove residual cement film and other materials from the surface. Damage can occur to a floor finish by misuse or incorrect maintenance because of inadequate initial instructions. Personnel responsible for maintenance should be given full information concerning any particular risks of misuse likely to occur, including recommendations for cleaning.

NOTE 1 Further information is given in the document The cleaning of ceramic tiles, The Tile Association [8].

NOTE 2 Generally, ceramic floor finishes require little maintenance and are easily kept clean by regular sweeping, then washing with warm water to which a soapless detergent has been added and finally rinsing with clean water.

Matt unglazed finishes are not damaged by the occasional use of scouring powder, or household cleaners to remove particularly stubborn blemishes. However, it should be noted that cleaning machines with abrasive pads, or the use of coarse cleaning agents can damage the surfaces of polished unglazed and shiny glazed tiles.

Care should be taken to ensure that cleaning agents are not allowed to come into contact with adjacent fixtures and wall surfaces.

NOTE 3 Apart from normal usage or obvious misuse, surface contamination can arise from:

*a) residual cement film (see **11.2**);*

*b) efflorescence (see **11.3**);*

*c) surface sealing materials (see **11.4**);*

*d) the reaction of cleaning agents with hard water (see **11.6**);*

e) unsuitable cleaning agents;

*f) frequent use of unsuitable cleaning agents, including highly alkaline detergents and chemicals (see **11.6**).*

11.2 Residual cement film

The surface of the grouted floor tiles can have cementitious residues that are not removed by washing with water. These residues can be removed by the use of proprietary acidic cleaners but the cementitious joints should be wetted immediately and surplus water removed before cleaning so that the acidic cleaners does not penetrate into and attack the grout mortar. Phosphoric acid-based cleaners produce reaction products that offer temporary protection to the joint surface but the grout should still be wetted before treatment.

This treatment should be immediately followed with rinsing down with fresh water so that any acidic cleaner is removed from the floor tiling.

NOTE If the tiles have been grouted with epoxide-based grout mortars, any set and hardened residues on the floor tiling is difficult to remove unless special chemicals are used. These chemicals contain solvents that can soften set and hardened epoxide mortar residues but care needs to be taken and any necessary health and safety precautions taken.

11.3 Efflorescence

*NOTE Efflorescence is aggravated by excessively damp conditions following installation or prolonged delay in drying out and can be persistent if it is due to rising moisture where damp resisting construction (see **6.5.2**) is inadequate. The deposit is very likely to disappear with washing but can reappear after drying; it is very likely to diminish with progressive washing and the most effective treatment is to increase the frequency of washing until the deposit ceases.*

Persistent deposits can be treated with appropriate proprietary cleaners, but in such cases the floor should be wetted and the free water removed before the application of the cleaning agent. This treatment should be immediately followed by thorough rinsing with clean water and drying.

11.4 Temporary tile sealers

NOTE Temporary tile sealers can be used to facilitate cleaning-off after laying and grouting; these proprietary compositions can be readily removed after completion of the grouting operation by using normally alkaline detergents and rinsing.

Where temporary sealers are employed they should be used strictly in accordance with the manufacturer's instructions.

11.5 Cleaning and slip resistance

Cleaning and cleanliness of flooring is an important factor that should be considered in conjunction with slip resistance (see **6.4.5**). The frequency and timing of cleaning should be determined by the number of pedestrians who use the floor. Where cleaning is carried out effectively, it can make the difference between a floor being an unacceptably high slip risk or an acceptably low slip risk. Slip accidents can be serious and costly; simple inexpensive measures can be effective and should be employed. In the work environment the work processes should also be considered when cleaning regimes and schedules are developed. Flooring with a surface texture (roughness) should use an appropriate method and materials to maintain a clean condition; a build up of dirt on a textured floor negates the benefit of that texture.

The correct cleaning procedures should be followed in accordance with the instructions which flooring (and surface treatment) manufacturers provide.

NOTE 1 Flooring manufacturers are required to provide information on the cleaning regime that is to be used to make their floor safe in the intended environment. Floor treatment manufacturers similarly specify how to avoid risks through the proper use of their products.

Safe cleaning procedures to minimize risks from wet cleaning should include the following:

a) leaving smooth floors to dry after cleaning;

b) containing local spills;

c) using dry methods for cleaning wherever possible;

d) spot cleaning and cleaning of spillage between scheduled whole-floor cleaning; it is equally important to thoroughly dry spot cleans;

e) cleaning in sections so that there is always a dry path through the area;

f) excluding people from wet cleaning areas;

g) cleaning during periods of minimum use;

h) using warning signs to identify contaminated floors or floors wet as a result of cleaning;

i) thoroughly rinsing wet cleaning areas with fresh, clean water.

Warning signs only remain effective if they are properly used and they should not be visible on areas while they are clearly not being cleaned as they can quickly lose their impact and effectiveness.

Personnel should be trained so that they can correctly use any cleaning equipment provided. Equipment should be properly serviced and maintained. Records should be kept to demonstrate that schedules for both cleaning and the maintenance of equipment are being met.

Properly maintained matting systems can be an effective way of reducing the incidence of contamination on floors. Matting systems should be considered for use at entrances and within buildings; for example, next to stills and vending machines.

NOTE 2 Matting systems have the added benefit of prolonging the lifetime of a given floor.

The entrance matting surface should remain effective under the anticipated traffic and contamination. At entrances, if wet footprints can be seen beyond the entrance matting, the entrance matting is compromised and additional temporary matting should be used. Care should be taken in selection and maintenance of matting systems so that they do not present a tripping risk.

NOTE 3 Further information is available in Annex G, and in the following references:

- *HSE information sheet – Slips and trips: The importance of floor cleaning [16];*
- *The Cleaning of Ceramic Tiles, The Tile Association [11];*
- *Slip Resistance of Hard Floorings, The Tile Association [12].*

11.6 Cleaning agents

Effective cleaning can usually be achieved by normal washing or scrubbing with warm water and a neutral sulfate-free detergent. Greasy deposits can be removed by detergents incorporating an organic solvent or a highly alkaline detergent (pH >9), but these should be used for only occasional cleaning.

NOTE 1 Greasy deposits require sufficient contact time with the detergent to be effective.

A detergent used on a regular basis should be of a type recommended for cleaning ceramic floors. The occasional use of abrasive cleaners can be beneficial but should be restricted to matt unglazed floor finishes.

The cleaning agent should be completely removed by a final rinsing with fresh, clean water.

NOTE 2 Household soaps are not recommended as they tend to leave a slippery scum, particularly in hard water areas.

Annex A (normative) Tile fittings

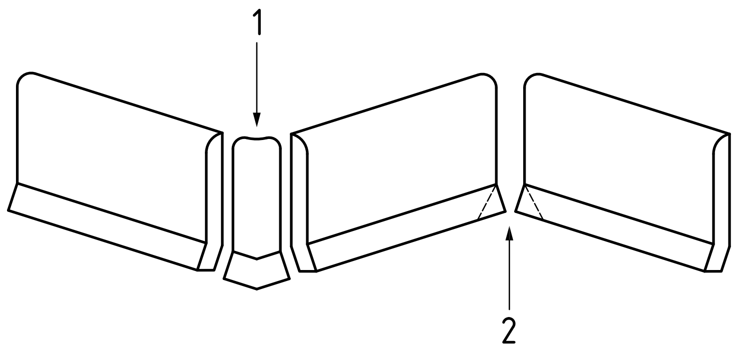
Tile fittings to form skirtings, step treads, channels, etc., should be manufactured to the requirements of BS EN 14411. The most common types available are shown in Figures A.1 to A.7.

The tile fittings illustrated indicate only their appearance; individual manufacturers should be consulted about the range of sizes they produce and the availability of any particular size.

NOTE 1 Non-regular sizes and shapes can be difficult to standardize.

*NOTE 2 Modular tile size includes its share of the adjacent joint(s), joint widths conforming to **7.1.5**. Non-modular sizes are the nominal manufacturing sizes.*

Figure A.1 **Sit-on cove systems – dry pressed tiles**

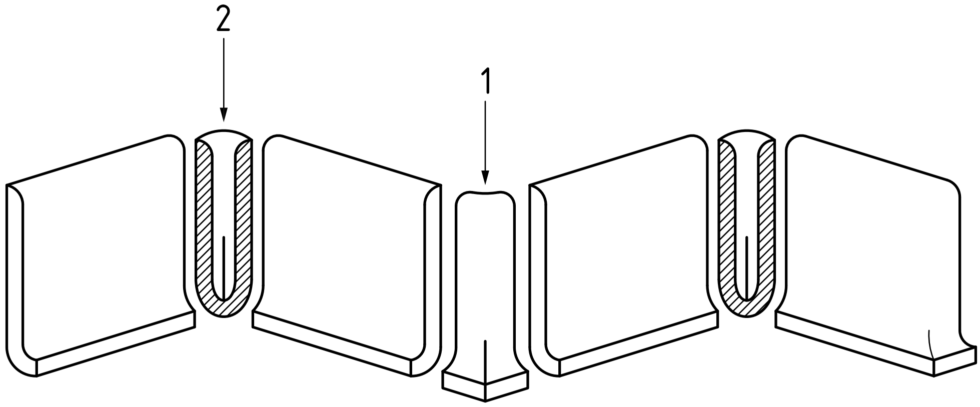


Key

1 External angles

2 Mitre cut for internal angles

Figure A.2 **Flushfit cove systems – dry pressed tiles**

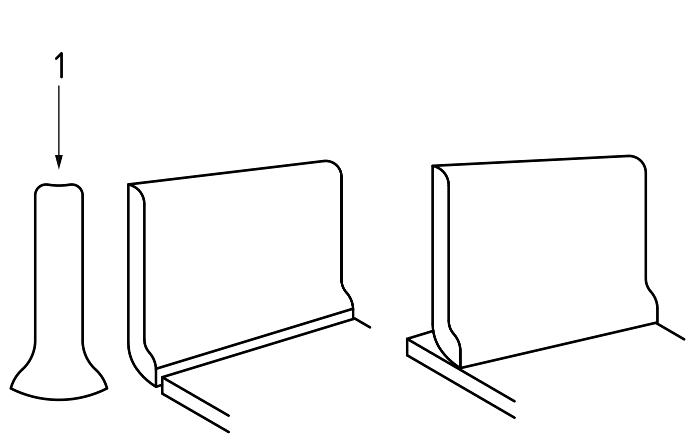


Key

1 External angles

2 Internal angle

Figure A.3 **Flushfit cove systems – dry pressed tiles**



Key

1 External angles

2 Internal angle

Figure A.4 **Typical floor channels – extruded tiles**

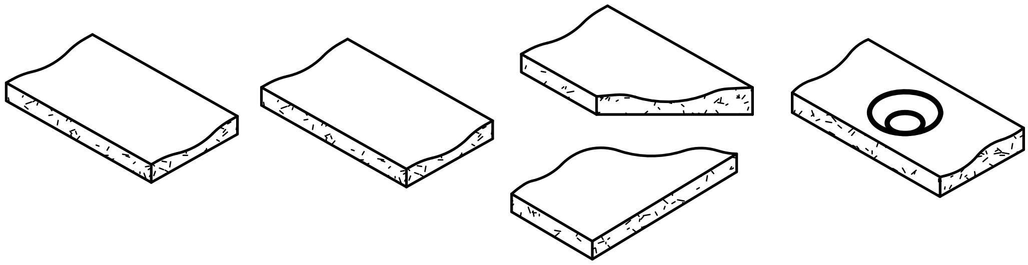


Figure A.5 **Typical floor channels – dry pressed tiles**

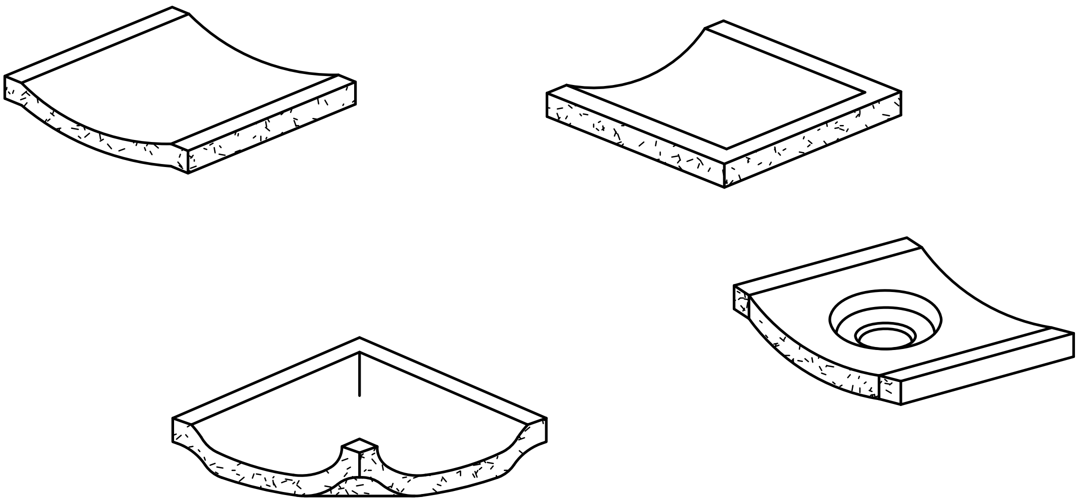
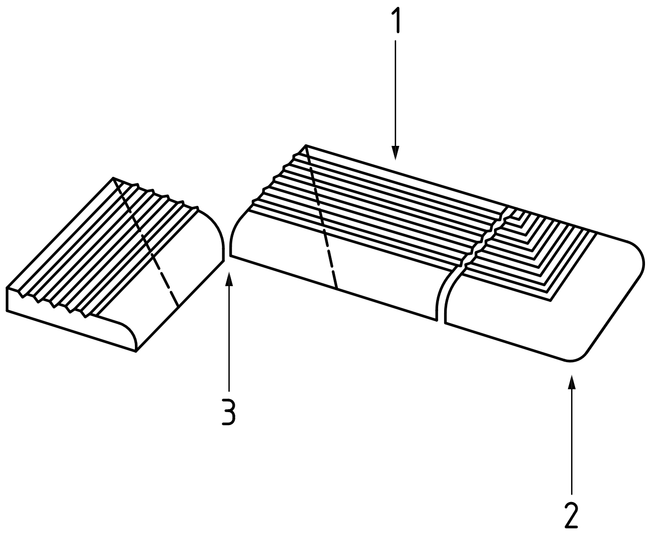


Figure A.6 **Typical step treads – dry pressed tiles**



Key

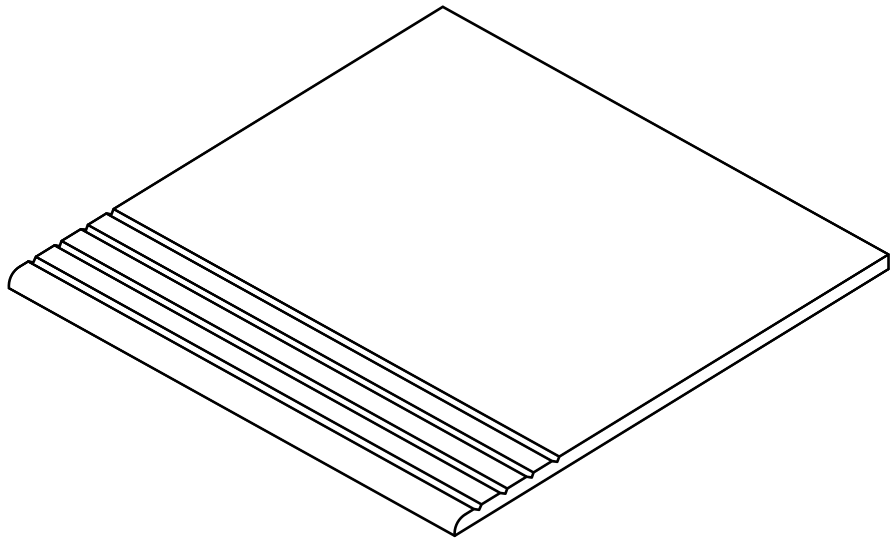
1 Stepnosing tile (2402)

2 Stepnosing external angle file (2402X)

3 Mitre cut for internal angle

NOTE For further information, see Approved Document M – Access to and use of buildings [10].

Figure A.7 **Typical step tread – dry pressed tiles [large format]**



NOTE For further information, see Approved Document M – Access to and use of buildings [10].

Annex B (informative) Special conditions included in BS 5385-4

Special conditions included in BS 5385-4 are as follows:

a) chemical attack;

b) electrostatic conditions;

c) movement;

   1) drying shrinkage movement;

   2) moisture movement (wetting and drying);

   3) moisture movement (long-term expansion);

   4) thermal movement;

   5) movement associated with soluble salts;

   6) movement joints;

d) radioactivity;

e) sound and thermal influences;

f) sterile conditions;

g) thermal effects (climatic and environmental);

h) traffic and load conditions;

   1) compression;

   2) impact;

   3) abrasion;

   4) slipperiness;

   5) ramps, steps and tactile surfaces;

i) wet and damp conditions;

   1) not immersed but subject to frequent contact;

   2) not immersed but subject to occasional wetting;

   3) high humidity areas;

   4) external patios, walkways, balconies;

j) wet conditions (continuous immersion);

   1) internal swimming pools of concrete construction (excluding salt-water pools);

   2) "beach" areas and wave machines;

   3) external swimming pools of concrete construction (excluding salt-water pools);

   4) salt water pools, tanks and reservoirs of concrete construction;

      i) concrete tanks and service reservoirs;

      ii) pools, tanks and reservoirs of metal construction;

      iii) tanks for aggressive liquids;

      iv) tanks for liquids at elevated temperatures.

Annex C (normative) Tiling onto underfloor heated bases

C.1 Types of heating system

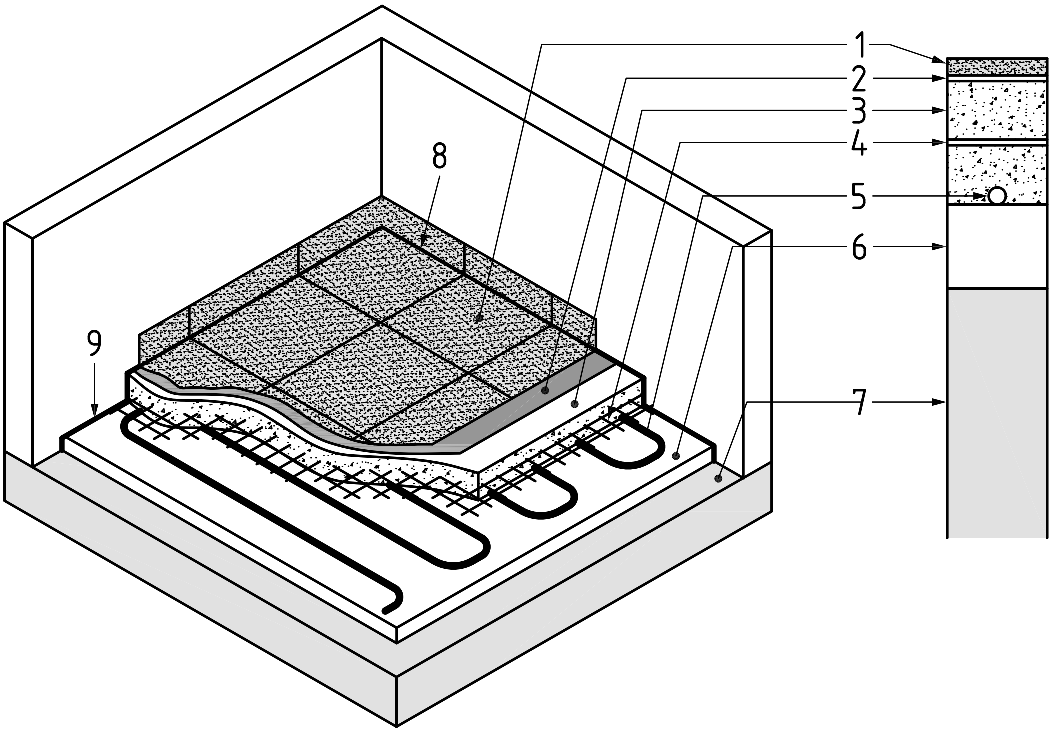
C.1.1 Type A

Fully floating concrete floor screeds (see BS EN 1264) should be 65 mm to 75 mm thick, containing metal wire mesh reinforcement (see BS 8204-1:2003+A1:2009, **5.7**, **6.4.4**, and **6.9**) resting on a layer of suitable thermal insulation, with heating pipes or cables laid above the insulation/screed interface, all supported by the structural slab.

Fully floating floor screeds should be reinforced with metal mesh reinforcement (see BS 8204-1:2003+A1:2009, **5.7**, **6.4.4**, and **6.9**) resting on a layer of thermal insulation, and containing heating pipes or cables, either resting on, or just above the interface between the screed and insulation.

NOTE Figure C.1 shows a Type A heating system.

Figure C.1 **Type A heating system**



Key

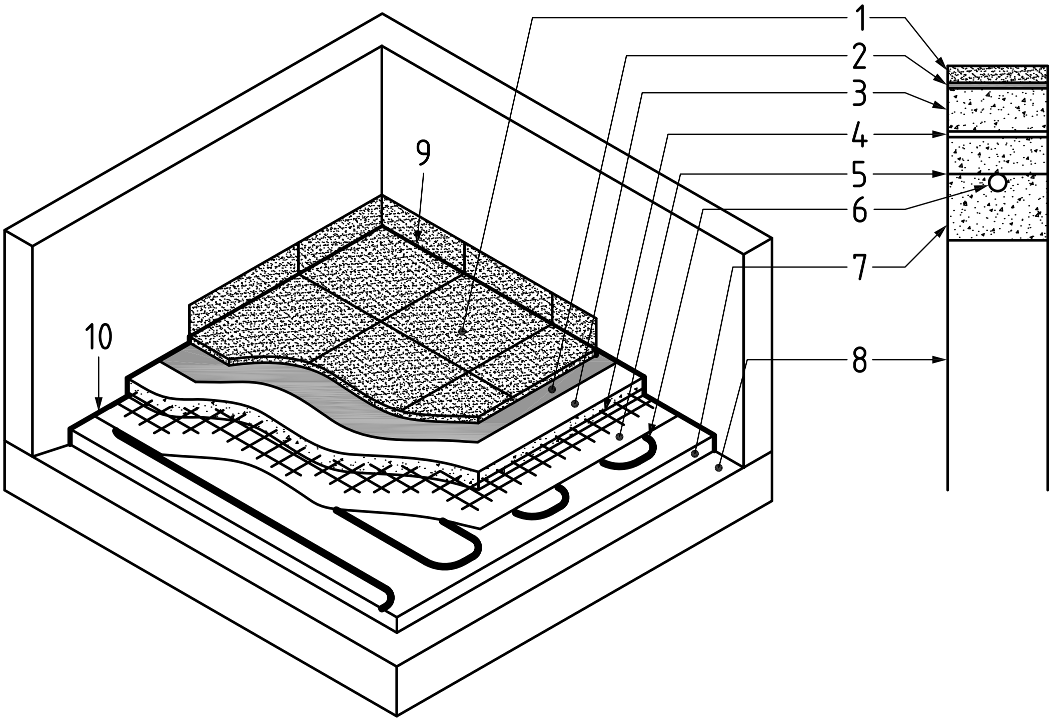
1	Tile	6	Suitable loadbearing insulation
2	Adhesive	7	Structural base
3	Levelling screed	8	Perimeter movement joint
4	Steel mesh	9	Perimeter movement joint
5	Heating pipes		

C.1.2 Type B

Fully floating floor screed (see BS EN 1264) should be at least 35 mm calcium sulfate or modified cement, consisting of proprietary systems where pipes or cables are recessed into grooves within the insulation layer and should be installed strictly in accordance with the system manufacturer's recommendations.

NOTE Figure C.2 shows a Type B heating system.

Figure C.2 **Type B heating system**



Key

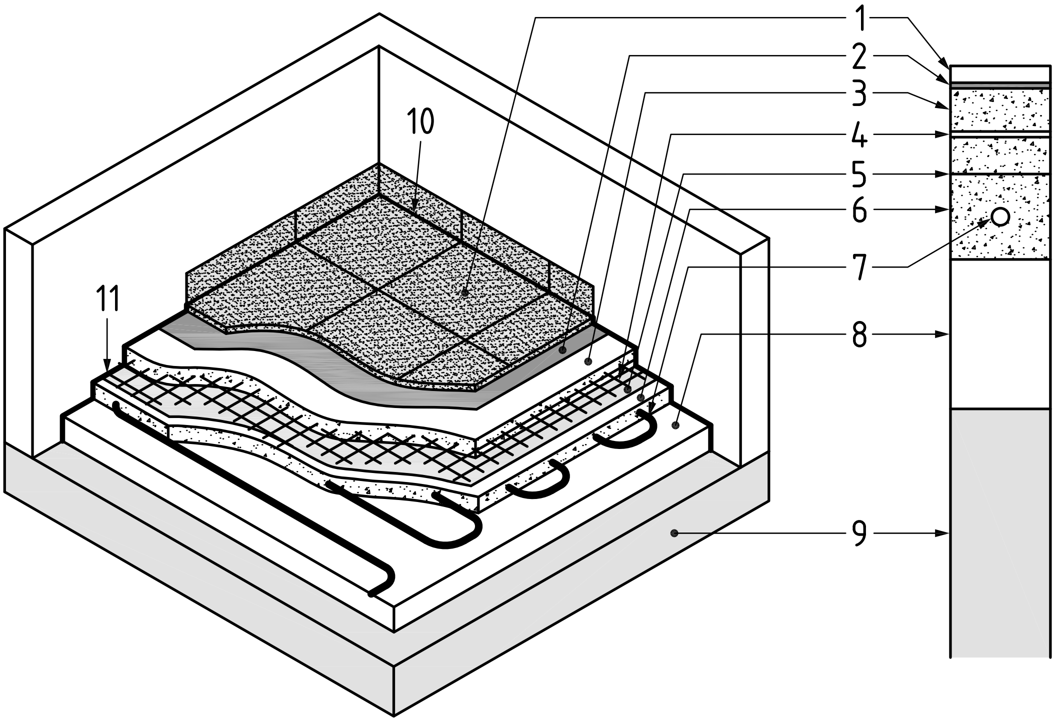
1	Tile	6	Heating pipes
2	Adhesive	7	Suitable loadbearing insulation
3	Levelling screed	8	Structural base
4	Steel mesh reinforcement	9	Perimeter movement joint
5	Slip membrane	10	Perimeter movement joint

C.1.3 Type C

Fully floating floor screeds (see BS EN1264) should be to a specified average thickness, laid level or laid to falls, with metal wire mesh reinforcement (a welded steel fabric of 2.5 mm diameter wire spaced at approximately 50 mm × 50 mm centres) laid upon a slip membrane, over a sub-screed, not less than 45 mm thick, containing heating pipes or cables, all of which rest upon or set into recessed grooves within a suitable thermal insulation layer in accordance with the relevant Building Regulations by typically 90 mm to 100 mm thick, supported by the structural slab.

NOTE Figure C.3 shows a Type C heating system.

Figure C.3 **Type C heating system**



Key

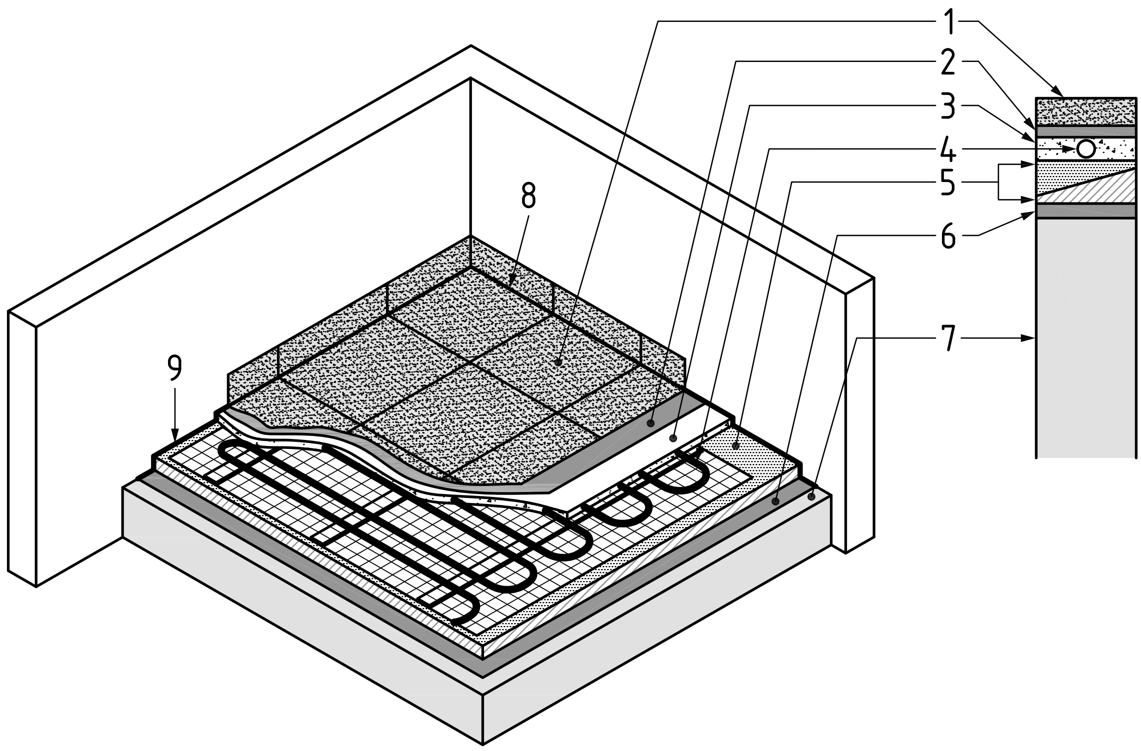
1	Tile	7	Heating pipes
2	Adhesive	8	Suitable loadbearing insulation
3	Levelling screed	9	Structural base
4	Steel mesh reinforcement	10	Perimeter movement joint
5	Slip membrane	11	Perimeter movement joint
6	Levelling screed		

C.1.4 Installed during tiling process (Undertile)

These should consist of proprietary manufactured heating systems that are installed immediately beneath a tiled floor, usually using electrically heated wires.

NOTE These are available in a number of forms as shown in Figure C.4 and Figure C.5.

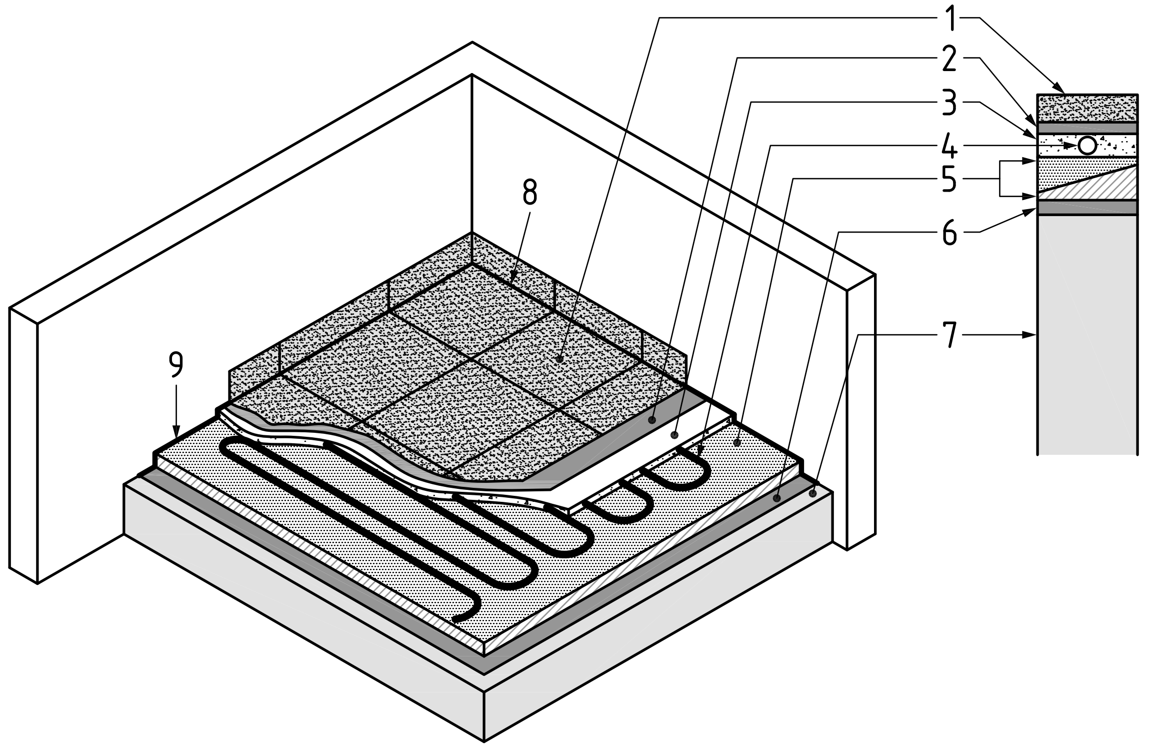
Figure C.4 **Type D heating system**



Key

1	Tile	6	Adhesive
2	Adhesive	7	Structural base (SRI)
3	Levelling screed (encapsulating layer)	8	Perimeter movement joint
4	Cable mat	9	Perimeter movement joint
5	Suitable loadbearing insulation or backerboard		

Figure C.5 **Type E heating system**



Key

1	Tile	6	Adhesive
2	Adhesive	7	Structural base (SRI)
3	Levelling screed (encapsulating layer)	8	Perimeter movement joint
4	Loose cables	9	Perimeter movement joint
5	Suitable loadbearing insulation or backerboard		

C.2 Design considerations

NOTE Strand fibre reinforcements are not a suitable substitute for metal mesh reinforcement when used in screed which will take underfloor heating.

C.2.1 Movement joints

Movement joints are traditionally installed over structural movement joints as in such locations movement is to be expected over the life of the building. Joints in floor screeds and tiled finishes should therefore include expansion joints immediately over such unrestrained structural joints to eliminate risks of cracking.

Since ceramics and natural stone are rigid finishes that do not deform laterally when they are bonded directly to the heated screed with adhesives, the requirements for intermediate movement joints should be strictly followed.

NOTE 1 This requirement applies to all types of rigid screeds including cementitious and calcium sulfate-based screeds.

At the design stage, provision should be made for the thermal expansion of the screed and the applied flooring. Taking into account the movement joint positions indicated in **6.8** and **7.1.6**, additional considerations should be observed.

Tiling should only commence when the heating is off and an appropriate screed and room temperature is reached, i.e. above 15 °C but not above 20 °C.

NOTE 2 Higher temperatures reduce the open time of the adhesive and might induce higher contraction stresses on cooling.

C.2.2 Perimeter movement joint strip

An isolating perimeter strip should be fitted prior to the screed installation. The compressible expansion strip should be placed around the perimeter of the floor and where tiling abuts columns, curbs, steps and plant fixed to the base.

The isolating perimeter strip should extend from the supporting base up to the surface of the finished floor and permit a screed movement of at least 6 mm. After the screed has been laid the peripheral insulating strip should be cut off after completion of the finished floor or cut off at the surface of the screed and a surface movement joint should be installed within the floor covering, e.g. a pre-formed profile or suitable sealant.

C.2.3 Intermediate joints

Intermediate joints should penetrate through the full depth of the tiling and screed. The width and spacing of intermediate movement joints should be sufficient to accommodate anticipated movement within the floor assembly so that the stresses between the flooring and heated screed remain within acceptable limits. The maximum area bounded by intermediate joints within the heated screed should not exceed panels of 40 m^2 in an area for ceramic and natural stone tiles and 25 m^2 in an area for resin agglomerated tiles. The panels formed should be square to rectangular with a length to width ratio of no more than 8 m × 5 m.

The provision and detailing of intermediate joints should be considered at the design stage and the thermal movements of the substrate assembly should be taken into account plus any other factors, e.g. exposure to strong sunlight. Where heating elements pass through the movement joints in the heated screed the heating elements should be sleeved so that the movement at the joint can be accommodated over a greater length of heating element.

To accommodate the differential movement that occurs either between zones of heated screed or concrete operated by separate control systems, or between zones of heated and unheated screed or concrete, these should be isolated by intermediate movement joints through the screed and tile bed.

On completion of the floor heating system, all necessary tests should be carried out including a hydraulic pressure test for wet systems, and cable resistance and continuity plus earth tests for electrical systems.

Shortly after completion (within 24 h to avoid risk of damage) the floor screed should be applied. Where a wet system is used, the water pressure should be maintained at operating pressure during the screeding process.

Following the curing and hardening period (21 days for cement screeds), the floor screed should be thermally conditioned to relieve stress and reveal defects (see BS EN 1264-4) for a period of approximately 1 week.

C.2.4 Heated cement and sand screeds

Any screed containing Portland cement, conforming to BS EN 197-1:2011, should be allowed to cure for at least 7 days by preventing the surface from drying and then allowed to dry out for a further 2 weeks. After this drying out period, the screed should be heated slowly at a maximum rate of 5 °C per day up to the maximum operating water temperature of 45 °C as recommended by the heating manufacturer and maintained at that level for a further 3 days before being allowed to cool to room temperature. The heating system should be turned off or in cold weather turned on so that the screed is held at approximately 15 °C before tile fixing commences.

Once the floor tiling is installed, the heating system should not be run for at least ten days in order to allow the tile bedding to cure/dry thoroughly.

C.3 Selection of hard flooring

C.3.1 General

The following factors should be considered when selecting hard floorings for use in conjunction with underfloor heating systems:

a) the end use of the installed floor after the underfloor heating is operational;

b) the strength, thickness and abrasion resistance of the flooring where the flooring is to be subject to heavy traffic and loads;

c) the use of adequately robust pre-formed movement joint (since heated sub-floors will have more movement joints than unheated sub-floors);

d) the correct provision of movement joints in the screed and tile bed when fixing large format tiles (edge length at least 600 mm).

Advice should be obtained from the supplier or manufacturer of the flooring with regard to the suitability of the hard flooring when installed on heated sub-floors under the anticipated traffic, loading and spillage of materials.

C.3.2 The coefficient of thermal expansion of the flooring in relation to that of the heated sub-floor

The coefficient of linear thermal expansion of the hard flooring should not be too dissimilar to that of the heated sub-floor otherwise excess stresses will be set up between the flooring and the sub-floor during heating and cooling cycles. This is because the Young's modulus of hard materials, such as ceramic and natural stone, are high so that a small amount of expansion or contraction exerts a high level of stress on any materials that are restraining the hard flooring.

NOTE The coefficient of thermal expansion values normally quoted for building materials are mm per mm × 10^{-6} °C^{-1}. This is the increase or decrease in length in millionths of a millimetre per millimetre length per degree Celsius temperature change. As an example, a large hard flooring unit, i.e. 1 000 mm long, at a temperature of 10 °C with a coefficient of thermal expansion of 7 × 10^{-6} °C^{-1}, at 30 °C the length of the tile would have increased by (1 000 × 7 × 10^{-6} × 20) mm = 0.14 mm for the 20 °C rise in temperature. If the hard flooring unit were 1 000 mm × 1 000 mm then the opposite edges would each move by 0.07 mm.

Particular care should be taken to use hard flooring units and heated sub-floors with similar coefficients of thermal expansion.

C.3.3 Size of the flooring units

*COMMENTARY ON **C.3.3***

For larger format tiles and panels any thermal expansion/contraction is cumulative across the area of the tile or panel so that, for example, for a ceramic panel 3 m long the expansion of the panel across a temperature range of 30 °C equates to approximately 0.65 mm which, as a percentage of a 5 mm wide joint between adjacent panels, equates to an approximately 12.5% compaction/expansion requirement of the joint grouting mortar, as well as a significant lateral deformation capacity of the panel bedding adhesive; depending upon any corresponding temperature change within the background structure onto which the panels are installed.

Usually in normal environments, the temperature of the tiling layer and its background (internal tiling) might not vary from each other to such extremes, but where tiles and panels, particularly dark coloured ones are installed externally or in areas subject to intense direct sunlight (e.g. sun rooms, conservatories, atria, etc.), the tiling layer can heat up and cool very quickly whilst the background might not.

Conversely, any significant drying shrinkage of the background which continues after tiles or panels have been installed directly onto it might result in the build-up of lateral stresses within the tiling system.

Thermal expansion/contraction should be considered when using very large ceramic tiles and panels, especially those with a coefficient of linear thermal expansion that differs greatly from that of the heated sub-floor.

When the value for the coefficient of thermal expansion of any hard flooring material is required this information should always be obtained from the technical data provided by the manufacturer or supplier.

C.4 Selection of adhesive and grout

C.4.1 Adhesive Selection

The selected adhesive should be capable of withstanding changes due to thermal effects, in particular conduction of heat through the background to the tiled finish and any associated movement due to thermal gradients. Therefore a suitable polymer modified cement based adhesive should be selected which conforms to BS EN 12004:2007+A1:2012, having a minimum C1S1 classification.

NOTE 1 The selection of a suitable adhesive conforming to BS EN 12004:2007+A1:2012 is also dependent on factors such as:

- *the type and size of tile selected;*
- *the nature of the type of heated substrate, e.g. heated screeds or timber*
- *boards with undertile heating;*
- *the service conditions to which the tiling is exposed.*

Suitable proprietary normal or fast setting to minimum cement based S1 adhesives should be used. On suspended timber a cement based S1 or S2 adhesive with deformable characteristics should be used.

NOTE 2 When fixing large format floor tiles (minimum edge length of 600 mm), the use of a pourable, i.e. lower viscosity adhesive, is advantageous in achieving a solid bed.

There should be no voids and all tiles, regardless of their size, should be fully supported and bonded to the heated screed by the adhesive. Further advice however should be sought from the manufacturer to confirm their suitability.

C.4.2 Grout Selection

Polymer modified cement based grouts should be selected. For cement grouts, they should conform to BS EN 13888:2009, class 2 (CG2).

C.4.3 Insulation

The insulation selected for use with the heating system should have a compressive strength compatible with the floor loadings.

NOTE Typically, for commercial applications the insulation will require a minimum compressive strength of 350 MPa.

Annex D (normative) Pumped calcium sulfate-based screeds

D.1 General

Pump applied screeds should be installed in accordance with BS 8204-7. They can be applied to provide flat and level sub-floors as bonded, unbonded and floating screeds, and the application thicknesses should be as given in Table D.1.

Table D.1 **Application thicknesses for levelling screed**

Type of levelling screed	Area of use	Minimum thickness mm
Bonded screed	Domestic and commercial	25
Unbonded screed	Domestic and commercial	30
Floating screed	Commercial	40
	Domestic	35

Any deviations in the levels and surface regularity of the base slab should be taken into consideration when determining the thickness of the pumpable self-smoothing screed to be laid, so as to ensure the minimum/maximum thickness can be achieved.

Pump applied calcium sulfate-based screeds can be installed as a base for ceramic floor tiling and mosaics however the designer should appreciate that such screeds should only be used in locations where the applied screed is neither exposed to moisture, nor subsequently become wet. The same restraints that apply to wall tiling on gypsum (calcium sulfate) plaster should be observed in this respect.

Where the ceramic floor tiling is likely to be exposed to intermittent wetting, the surface of the calcium sulfate-based screed should be protected by the application of an appropriate waterproof coating or tanking system prior to the installation of the floor tiling to prevent ingress of moisture into the calcium sulfate-based screed beneath the floor tiling. The design should also ensure that lateral ingress of moisture from adjacent screeds, walls and other abutting structures, as well as through any joints in the floor tiling, is prevented (see **6.5** for additional guidance on this point).

The applied calcium sulfate-based screed should be dry before the floor tiling is installed. If testing for dryness is required before the installation of ceramic floor tiling, this should be in accordance with the calcium sulfate screed manufacturer's recommendations.

NOTE 1 Further information on the drying of calcium sulfate-based screeds is given in the document Tiling to Calcium Sulfate Based Screeds prepared by The Tile Association [13].

Movement joints should be installed in the floor tiling and where necessary in the calcium sulfate-based screed as recommended in **6.8**.

The surface of the pump applied calcium sulfate-based screed should be checked and prepared so that any cohesively weak, friable and dusty surface residues are removed by the use of appropriate surface preparation techniques.

The prepared surface should be cleaned using vacuum cleaning equipment to remove any dust and similar residues. The clean prepared surface of the calcium sulfate-based screed should be primed with the primer recommended by the manufacturer of the tile adhesive being used to subsequently bed the floor tiles. The primer application should be in accordance with the primer and tile adhesive manufacturer's recommendations and the applied primer should be allowed to dry before the floor tiles are installed. The primer should effectively prevent undue wetting of the calcium sulfate-based screed surface and isolate the screed from the cement based tile adhesive so no adverse chemical reaction occurs.

The primer and tile adhesive used to solidly bed the ceramic floor tiling should be appropriate for use on a pumped calcium sulfate-based screed. Rapid drying tile adhesives that reduce the amount of water that remains beneath the installed tiling also minimizes any wetting of the pumped calcium sulfate screed.

Where the pumped calcium sulfate screeds are installed as heated floating screeds then the screed should be laid with a minimum 25 mm cover over the heating pipes or wires. The heated screed should have appropriate movement joints passing through the screed and tile bed so that provision is made for the thermal expansion and contraction of the screed and the applied ceramic floor tiling.

These movement joints should be as follows:

a) installed where the heated screed and tile bed abuts any walls or upstands;

b) across thresholds between rooms;

c) dividing the heated screed into approximately square areas not exceeding 40 m^2 with a length: width ratio not exceeding 8:5;

d) installed between areas of the pumped screed on different heating circuits.

NOTE 2 With a pumped calcium sulfate-based screed this requires appropriate design of the movement joints so they are compatible for use in conjunction with a fluid mortar.

D.2 Background information

Calcium sulfate screed should not be used in locations that are damp, frequently wet or have standing surface water. If there are cases where occasional spillages might occur, tanking should be used as a safeguard to prevent the calcium sulfate screed becoming wet. To ensure adequate protection, the tanking should be brought up the walls to a sufficient height.

D.3 Surface treatment

Where required, removal of loose or friable surface laitance/fines should be carried out at a suitable time after screeding, usually 2 to 6 days after application using appropriate surface preparation equipment.

NOTE This procedure exposes a cohesively strong surface and also assists the drying of the screed.

D.4 Drying

Screed drying time is approximately 1 mm per day up to 40 mm thickness in adequate temperatures and drying conditions. Sample drying times are given in Table D.2. This period should be increased for screeds thicker than 40 mm and in poor drying conditions.

Good drying conditions should be provided as soon as the screed is laid. The screed should be protected from very rapid drying or draughts on the first day, but thereafter atmospheric humidity should be low, i.e. not greater than 65 °RH, and the air temperature should be adequate (e.g. 20 °C) so that moisture can evaporate.

NOTE Good ventilation or the use of dehumidifiers can assist in reducing the atmospheric humidity.

Table D.2 **Sample drying times in ideal drying conditions**

Screed thickness mm	**Drying time** days
40	40
50	60
60	80

D.5 Residual moisture levels

Before ceramic floor finishes are laid, the moisture content of the screed should be checked to ensure that it is adequately dry. Three different tests for determining moisture levels are described below.

a) BS 8203:2001+A1:2009 method for measuring the moisture condition of a base to receive a floor covering is to use an insulated impermeable box on top of the screed and measure the equilibrium relative humidity of the trapped air inside the box using electronic probe, or hair hygrometer.

b) BS 8203:2001+A1:2009 recommends the CM (Carbide Method) of testing.

c) The moisture content of the screed may be determined by drying a sample of the screed in an oven. The sample is weighed before and after the oven drying to determine the weight loss as a percentage of the dry weight.

NOTE This assessment is the responsibility of the main contractor.

D.6 Product recognition

*COMMENTARY ON **D.6***

Calcium sulfate-based screeds are a mix of fine and coarse aggregates with either a hemi-hydrate, or anhydrous calcium sulfate binder, and therefore look similar to a cement sand screed. It is not always obvious that a screed is, or is not, a calcium sulfate-based screed. Often a light colour, almost white, indicates that the screed is likely to be calcium sulfate-based. However, calcium sulfate screeds are not always white and can be coloured by the calcium sulfate, sand and aggregate they contain. In addition, where refurbishment work is being undertaken, residues of any previous floor finishes, adhesives or smoothing compounds obscures the colour of the screed beneath.

A definitive determination of the nature of the screed requires a chemical analysis of a sample of the screed. A calcium sulfate screed is characterised by a high calcium and sulfate content.

The planarity of the screed should be accurate to meet the requirements of the specification for the floor tiles being installed.

NOTE BS 8204-7:2003, Table 4 defines three classes of Surface Regularity – SR1, SR2 and SR3. If SR1 is not achieved, further work, by the use of a suitable levelling compound, might be required before tiling installation is undertaken using appropriate cement based tile adhesives.

D.7 Joints in screed

Any movement joints, or other joints in the calcium sulfate screed likely to be subject to movement, should coincide with movement joints in the tile bed. Such movement joints should be designed to accommodate differential movement between the separate sections of screed, i.e. of sufficient width to accommodate the anticipated movement. Wherever possible movement joints in the screed should be formed as straight joints and should intersect with other movement joints at right angles to assist the setting out of the floor tiling. In addition to these locations, intermediate or stress relieving joints, spaced and formed as recommended in **6.8**, should be incorporated in the tile bed and where necessary in the calcium sulfate-based screed.

With heated calcium sulfate-based screeds the appropriate movement joints should be incorporated where the heated screed abuts walls and upstands, across thresholds as well as dividing the screed into approximately square areas not exceeding 40 m^2 in area. The heated calcium sulfate-based screed should be dried adequately; the underfloor heating should be commissioned after at least 7 days as recommended in BS EN 1264-4 and gradually brought up to operating temperature and maintained at this temperature for the recommended time period.

D.8 Priming and levelling

To ensure maximum adhesion, and to avoid an adverse chemical reaction (e.g. ettringite formation between the sulfate in the screed and cementitious adhesives or levelling compounds), the screed should be primed with a primer compatible with the tile adhesive, e.g. acrylic polymer, polyurethane or water dispersed epoxy primer. The primer application should provide complete coverage and should be adequately absorbed in the calcium sulfate surface in accordance with the instructions of the manufacturer of the adhesive or levelling compound. The applied primer should then be allowed to dry.

D.9 Adhesive selection

The most suitable adhesive for tiling over primed calcium sulfate screeds is a suitable polymer modified cementitious adhesive which should conform to BS EN 12004:2007+A1:2012, C1 or C2 classification. Both normal and rapid-setting types should be suitable but the adhesive manufacturer's advice should also be sought to confirm suitability.

With natural stone tiles or agglomerated stone tiles, the selection of the adhesive should follow the recommendations of BS 5385-5 as well as being compatible with the characteristics of the tiles being fixed.

D.10 Grout selection

For the majority of installations a cementitious grout, preferably polymer modified should be used, conforming to BS EN 13888, CG1 or CG2 classification, depending on the load and traffic conditions. Where additional protection is required from either temporary wetting of the floor surface, or spillage of aggressive liquids, then the use of a reaction resin grout, conforming to BS EN 13888:2009, RG classification, should be used.

Annex E (normative) Cement and sand levelling screeds conforming to BS 8204-1

COMMENTARY ON Annex E

Other types of screed may be used, such as polymer modified screeds conforming to BS 8204-3 and pumpable self-smoothing screeds conforming to BS 8204-7.

E.1 Design considerations

E.1.1 Methods of levelling screed construction

Levelling screeds laid in large areas can curl as they dry and shrink and subsequently crack when loaded if the bond to the base is insufficient (see **E.1.8**). To avoid this they should be constructed in one of the following ways.

a) A levelling screed should be bonded to a prepared concrete base. If a damp-proof membrane is required, it should be placed below the base slab.

b) An unbonded or floating levelling screed thick enough to provide sufficient rigidity and reduce the likelihood of curling should be used.

E.1.2 Cement and sand or fine concrete levelling screeds

*COMMENTARY ON **E.1.2***

As an alternative to direct bedding on a base concrete, a cement and sand or fine concrete levelling screed can be applied to a hardened base as a levelling layer on which to lay the tiles.

E.1.2.1 Bonding

The adequacy of the bond of the levelling screed to the base should be considered in relation to the floor tiling to be applied and its subsequent use.

Where maximum bond between the levelling screed and the base is required, the method for preparation of the base given in **E.2.2.2** should be followed. A base with only a tamped surface is unsuitable and a levelling screed laid over such a base should be considered as unbonded.

Levelling screeds should be considered as unbonded where the base:

a) has been contaminated, e.g. with oil;

b) contains admixtures to reduce permeability;

c) has a damp-proof membrane between it and the levelling screed.

Where an insulating quilt is between the levelling screed and the base the levelling screed should be considered as floating.

E.1.2.2 Thickness

The thickness of the levelling screeds should be as follows.

a) *Bonded levelling screed*: when laid on and bonded to a set and hardened base prepared as in **E.2.2.2**, the minimum thickness of the levelling screed at any isolated point should be 25 mm. The design thickness should be 40 mm. In some circumstances, the thickness of the levelling screed might have to be increased above 40 mm, but it should be noted that above this thickness there is an increasing risk of loss of adhesion with the base. If the degree of preparation described in **E.2.2.2** cannot be achieved then the levelling screed should be considered as unbonded.

b) *Unbonded levelling screed*: when laid on a damp-proof membrane, a separating layer or a base that incorporates an admixture that reduces permeability or has been contaminated, e.g. with oil, or a base that for any reason cannot be prepared for bond as in **E.2.2.2**, the levelling screed thickness at any point should be greater than 50 mm.

c) *Floating levelling screed*: when laid on a compressible layer, e.g. insulating quilts or boards, the thickness of the levelling screed at any point should be not less than 75 mm, except for domestic and similar applications where light loading is to be expected, for which a minimum thickness of 65 mm should be used. The levelling screed should preferably be of fine concrete.

NOTE It is emphasized that a high risk of the levelling screed curling exists with unbonded and floating levelling screeds, which can lead to steps at joints due to differential movement. These steps can be eliminated by the incorporation in the levelling screed of mesh reinforcement, which also passes through the levelling screed joints.

Where the risk of curling of an unbonded or floating levelling screed cannot be accepted, a concrete overslab 100 mm thick or more should be used. This should be designed as a new floor. Where possible, falls in the floor should be formed in the base concrete so that an applied levelling screed is of uniform thickness.

E.1.2.3 Pipes and trunking

The laying of conduits or pipes within the thickness of a levelling screed should be avoided if possible as cracks can occur over them. To minimize the effects of cracking where it is essential that conduits and pipes are incorporated, a minimum 25 mm thickness of levelling screed containing reinforcement in accordance with **5.4.4** should be placed over the conduit or pipe. The reinforcement should be placed centrally in the depth of the levelling screed over the conduit or pipe and extend for 250 mm on each side.

Ducts or trunking more than 75 mm wide should not be used.

NOTE The significant increase in depth of a bonded levelling screed required to accommodate pipes and trunking within its thickness can lead to increased risk of hollowness.

E.1.3 Bay sizes

Levelling screeds should be laid in as large an area as possible in one operation, consistent with achieving the appropriate surface regularity (see **E.1.7.1**) and the levels required, to minimize the number of joints.

NOTE 1 These areas can be divided into strips 3 m to 4 m wide for convenience of laying.

NOTE 2 Levelling screeds in large areas can crack at random intervals as they dry and shrink. These shrinkage cracks are more easily dealt with than the more pronounced curling which can occur at vertical butt joints if levelling screeds are laid in small bays.

E.1.4 Joints

Formed daywork joints between strips of levelling screeds should be vertical butt joints.

E.1.5 Use of bonding agents

Proprietary bonding agents can be used as an alternative to cement grout. If bonding agents are used, the recommendations for roughening the base and bonding treatment given in BS 8204-1 should be followed.

E.1.6 In situ crushing resistance of levelling screeds

To withstand the imposed loads and traffic in service, the designer should select the category of in situ crushing resistance (ISCR) required for the levelling screed as given in Table E.1.

NOTE 1 Acceptance limits for the various categories of in situ crushing resistance are given in Table E.2.

In making the selection the designer should take into account the thickness of the tile and the method of laying.

NOTE 2 For any traffic conditions, tiles laid with thin-bed adhesives tend to require a higher in situ crushing resistance category than those laid by other methods.

Whilst bearing in mind the possible extra cost of a higher category screed, the designer should, at the same time, not lose sight of the consequences of a failure of the floor due to the breakdown of a lower category screed.

Table E.1 **Choice of in situ crushing resistance category for levelling screeds**

Factors to be considered in choosing a category		**In situ crushing resistance category [see Table E.2]**
Thickness of tile	**Loading**	
Thinner	Heavier	A
		B
		C
Thicker	Lighter	D

Category D should be selected only where an unbonded tile bed is to be used.

Table E.2 **Acceptance limits for in situ crushing resistance test**

Category	**Acceptance limits after dropping the weight four times max depth of indentation** mm
A	3
B	4
C	5
D	6

NOTE 1 Tests carried out on an area of levelling screed that has been laid with a rough texture or has been roughened by wear can result in some extra compaction of the surface layer on the first impact which might give rise to an increase in indentation of up to 1 mm.

NOTE 2 The method of test for in situ crushing resistance measures the strength and integrity of a levelling screed in depth. It does not measure the surface strength of the levelling screed. Very occasionally, levelling screeds might be encountered that pass the in situ crushing resistance test but, because they have a weak or dusty surface, are unsuitable to receive flooring.

E.1.7 Tolerances on levels and surface regularity of levelling screeds and concrete bases

*COMMENTARY ON **E.1.7***

Flatness or surface regularity is a measure of the deviations from a parallel plane over a large area of the floor, as well as over small local areas. Some variations in surface level can be allowed without detriment to the satisfactory application of the floor tiling, and the permissible limits associated with these variations depends on many factors.

E.1.7.1 Surface regularity

The designer should select the class of local surface regularity from those given in Table E.3, taking into account the method to be used to fix the tiles.

*NOTE 1 Methods based on fixing tiles with substantial thicknesses of mortar as described in **7.2.2** and **7.2.3** allow some adjustment of the surface regularity, whereas thinner adhesive beds allow no adjustment.*

The highest standard (SR1) should be used where floor tiles are to be applied using adhesives.

NOTE 2 Conversely, the lowest standard (SR3) can be selected where the thicker semi-dry bed is to be used to bed the tiles. Sub-floor smoothing and levelling compounds can be used to correct irregularities in the levelling screed prior to fixing ceramic tiles with adhesives.

The manufacturer's recommendations for their use and application should be closely observed. The materials used should be well adhered to the base (even when applied down to a feather edge), should be of adequate strength to support anticipated loads and should be compatible with the ceramic tile adhesive. Generally, these products should only be used where light to moderate traffic is expected.

Table E.3 **Classification of surface regularity [SR] of direct finished base slab or levelling screed**

Class	Maximum permissible departure from the underside of a 2 m straightedge resting in contact with the floor mm
SR1	3
SR2	5
SR3	10

E.1.7.2 Departure from datum

The designer should specify the maximum permissible departure of the level of the levelling screed or the base slab from datum, taking into account the area of floor and its use (see **7.1.4**).

NOTE Thin tile beds cannot be used to adjust the level of the final surface.

E.1.8 Susceptibility to cracking of levelling screeds

NOTE 1 The cracking of levelling screeds is mainly caused by restraint to drying shrinkage. Curling due to differential drying through the thickness can lead to cracking under load.

Where screeds are placed in very hot weather or without cover from the sun, the subsequent contractions on cooling increases the risk of cracking. To reduce this risk, screeds should be laid under an overhead covering, although care should be taken to avoid any funnelling effect that could produce rapid drying.

NOTE 2 If the levelling screed is not adequately bonded to the base slab, curling can occur which can subsequently lead to the levelling screed cracking under load. Joints in the base that might open should be carried through the levelling screed, otherwise reflected cracking can form at these positions.

Consideration should be given to the following factors, which also influence cracking.

a) *Water content*: increasing the water content of a mix increases the drying shrinkage of screeds, thus increasing the risk of cracking. The quantity of water used should be kept to the minimum necessary to ensure thorough compaction. Some admixtures reduce water content (see **E.1.10**).

b) *Reinforcement*: the provision of reinforcement does not prevent, but can control, shrinkage cracking. It is seldom used in screeds, but if used limits the width of cracks and so provide some advantage. Reinforcement does not prevent curling of levelling screeds, but where it passes through joints it can prevent steps.

c) *Curing*: shrinkage occurs as concrete dries. Screeds should therefore be kept continuously moist for at least seven days after laying, until they have attained sufficient strength to resist the stresses due to further shrinkage, which can continue for several months.

d) *Drying*: screeds should be allowed to dry out as slowly as practicable after curing to reduce the risk of curling (see **E.1.9**).

e) *Aggregates*: some aggregates have higher than average shrinkage properties and can cause a greater risk of cracking.

NOTE Further information is given in Building Research Establishment Digest 357 [4].

E.1.9 Eliminating construction moisture

*COMMENTARY ON **E.1.9***

Although ceramic tiles are unaffected by constructional water, concrete bases and screeds shrink as they dry out and can produce sufficient compression forces to break the adhesion between the tiles and bed.

A proportion of the drying shrinkage of the concrete base and/or levelling screed should be allowed to take place before fixing tiles.

Structural concrete should be subjected to continuous air drying after the end of curing for at least six weeks before either a levelling screed or a tile bed is applied to it.

NOTE 1 A longer period might be necessary in poor drying conditions.

Cement and sand and fine concrete levelling screeds should be cured for at least seven days and be subjected to continuous air drying after curing for at least two weeks before the tiling is applied.

NOTE 2 A longer period might be required in poor drying conditions and/or where the floor is to be heated.

*NOTE 3 Where the bed is laid over a separating layer, as described in **G.8**, the need to allow some shrinkage to take place before tiling is less important as movements in the base or levelling screed are not transmitted to the tile bed or tiles.*

E.1.10 Admixtures

The following admixtures should be used.

a) *Air entraining*: air entraining admixtures should conform to BS EN 934-2.

NOTE 1 Admixtures which entrain a small amount of fine air bubbles might help to reduce "bleeding" of free water and improve the finished surface of the concrete. An excessive amount of entrained air can reduce the strength and abrasion resistance of the concrete to unacceptable levels.

b) *Water reducing*: water reducing admixtures should conform to BS EN 934-2.

NOTE 2 These admixtures can be used to improve workability and reduce the water content otherwise required in the mix. They can also entrain a small quantity of air.

c) *Superplasticizing*: superplasticizing admixtures should conform to BS EN 934-2.

NOTE 3 These admixtures greatly increase workability at normal water contents for a short period to produce "flowing concrete" which needs little or no compaction. Alternatively, they can be used as water reducing admixtures.

d) *Accelerating*: accelerating admixtures should conform to with BS EN 934-2.

NOTE 4 These admixtures can be used to accelerate the rate of setting and hardening of concrete in cold water. Admixtures that contain calcium chloride should not be used in, or in materials adjacent to, reinforced concrete or concrete screed containing embedded metal.

e) *Retarding*: retarding admixtures should conform to BS EN 934-2.

NOTE 5 These admixtures decrease the initial rate of reaction between cement and water and thereby retard the setting of the concrete.

f) *Waterproofing*: waterproofing admixtures should be used with caution, as some contain water-repelling ingredients which can impair the adhesion of a levelling screed with the base or the tile bed with the levelling screed or base. Integral waterproofing admixtures should not be considered as alternatives to damp-proof membranes in accordance with CP 102.

E.2 Work on site

E.2.1 Protection against the weather

E.2.1.1 Cold weather

If mixing and laying screeds are to proceed during cold weather, measures should be taken to ensure that stored aggregates and cement are maintained at temperatures above freezing and that the surface temperature of the laid screed (not the air temperature) is maintained at or above 5 °C during construction, and for four or five days after laying.

NOTE 1 In this way the screed normally achieves sufficient strength to resist later damage by frost.

Freshly placed and finished screeds exposed to the weather should be covered with tarpaulins or sheeting, carefully lapped and supported clear of the surface on a temporary framework in such a manner that the wind cannot blow underneath.

NOTE 2 The time and amount of protection can be reduced by employing rapid-hardening cement, or admixtures to accelerate setting and hardening. Unless heated enclosures and/or heated material are used it might be preferable to delay operations until the advent of warmer weather.

E.2.1.2 Hot or drying weather

In hot or drying weather, care should be taken that the screed mixes do not stiffen or dry out to an extent that prevents thorough compaction. After compaction and finishing the surface should not be allowed to dry out quickly and this can be achieved by protection with plastics sheeting or other suitable means. In addition, where a screed is laid in the open, its surface should be protected from the effects of the sun, to reduce the risk of thermal cracking.

E.2.1.3 Wet weather

If no protection is provided by the structure, a freshly placed screed should be covered to prevent rain damage to the surface.

E.2.2 Preparation of the base

E.2.2.1 General

The surface of the base should be above freezing whilst the screed is being laid.

NOTE The bond between the screed and the concrete base depends to a great extent upon the conditions of the surface of the base at the time of laying the screed. Where the screed is laid on a set and hardened base, complete bond cannot be ensured.

E.2.2.2 High degree of bond

E.2.2.2.1 Roughening of base

In the case of in situ or precast concrete slabs, where a high degree of bond is required, the laitance on the base should be entirely removed by suitable mechanized equipment to expose cleanly the coarse aggregate. All loose debris and dirt should be removed, preferably by vacuum equipment.

Where the base is a concrete layer over precast concrete slabs it should be prepared in this way, the exception being if the layer is thin (less than 100 mm) and roughening by heavy mechanical scabbling is likely to damage it or the precast layer below, consideration should be given to the use of shot blasting or grit blasting equipment as an alternative. These operations should be delayed until shortly before the screed is laid to prevent contamination or accumulation of dirt.

E.2.2.2.2 Bonding treatment

The base concrete should be kept wet for several hours before the screed is to be laid, e.g. overnight, any excess water being brushed off before applying a slurry. Within a period of 30 min before the screed is to be laid (less in hot weather), a thin layer of neat cement slurry of creamy consistency should be brushed into the surface of the base concrete. The screed should be compacted onto the base while the slurry is still wet. A proprietary bonding agent can be used or a proprietary bonding admixture can be added to the slurry in accordance with the manufacturer's instructions. In these cases the appropriate procedure of **E.2.2.2.1** should be carried out.

E.2.2.2.3 Unbonded screeds

Where an unbonded screed is to be constructed either on a new floor or on an old one being renovated, the base should be sufficiently clean and smooth to receive any separating material specified. Before the screed is laid, the reasons for any cracking or hollowness of the existing base should be diagnosed and appropriate remedial treatment carried out. Cracks and loose or hollow portions should be cut out and made good.

E.2.2.3 Levelling screed mix

E.2.2.3.1 Mix proportions

All mix proportions should be based on the use of the following materials:

a) *Portland cement of strength class 42.5 N*;

   NOTE If cements of other types and/or classes are used (see ***5.4.1.2****), then the mix proportions might need to be adjusted in order to achieve mixes of similar strength characteristics to those recommended. Definitive guidance on their use in cement sand screeds is not available at the time of publication.*

b) *Dry aggregates*: due allowance should be made for the moisture content of any damp materials used.

For both bonded and unbonded levelling screeds the precise mix proportions should be determined by the contractor. A levelling screed with mix proportions of cement to sand within the range 1:3 to 1:4.5 by weight or fine concrete with proportions of cement to total aggregate within the range 1:4 to 1:5 by weight should normally be expected to meet the in situ crushing resistance criteria (see **E.1.6**). For floating screeds, the mix proportions for cement and sand and fine concrete should be within the range given above.

Where possible, dense aggregates and cement should be batched by weight. This might not be practicable on many sites and in these circumstances the screeds should be volume batched. The cement should be batched by the whole bag and the sand by means of a suitable container of known volume. Due allowance should be made for the bulking of damp sands.

Where the thickness of the levelling screed is 50 mm or greater it should preferably be of fine concrete.

E.2.2.4 Method of mixing

The materials should be thoroughly and efficiently mixed by means of forced action mechanical mixers, e.g. trough and pan paddle mixers and paddle mixers attached to screed pumps. The amount of water added should be the minimum necessary to give sufficient workability for laying and thorough compaction.

NOTE 1 Free fall drum mixers have been found to produce inconsistent mixing of low moisture cement material and their use is not recommended for such mixes.

NOTE 2 A common problem is the use of too dry, badly mixed, cement and sand mixes which cannot be properly compacted, with the result that the screed has a dense upper crust with the underlying screed very weak and friable. The consequence of this has been that point loads cause breakdowns in the screed.

E.2.2.5 Ready-mixed screeds

Ready-to-use screeding mortars should conform to BS EN 13813.

NOTE 1 Screeds based on calcium sulfate anhydrite are generally unsuitable as a base to receive tile beds described in this code.

NOTE 2 For further guidance on the additional precautions needed when using calcium sulfate anhydrite-based screeds, see the relevant TTA guidance paper "Tiling to calcium sulfate based screeds" [13].

E.2.3 Pumping the screed

The pumping system should deliver the material to the working area in a condition suitable for laying.

NOTE Experience has shown that most efficient pumping can be achieved when well-graded sand with not less than 15% passing a 300 μm sieve is used. It is often difficult to pump satisfactorily mixes richer than 1:4 at water contents suitable for levelling screeds.

E.2.4 Laying the levelling screed

Narrow strips of levelling screed material laid and compacted to finished level should be used to establish the level of the levelling screed. The levelling screed should be placed and compacted immediately after laying the strips. Where the edge of a strip forms a daywork joint it should be formed or cut to produce a vertical joint. Alternatively, levelling screed battens carefully levelled and trued should be fixed at the correct height for the required thickness of levelling screed. Battens should be removed before laying the adjacent bay of levelling screed. At daywork joints all bedding levelling screed beneath the battens should be cut away to form a vertical joint.

The mix should be spread on the prepared base with adequate surcharge, thoroughly compacted by heavy tamping or by mechanical means, and levelled with a levelling screed board.

In order to facilitate the compaction of thicker cement and sand levelling screeds, i.e. over 50 mm thickness, the levelling screeds can be laid in two layers. Both layers should be of approximately equal thickness and of the same mix and water content.

To ensure satisfactory adhesion, the surface of the compacted lower layer should be lightly roughened, e.g. by raking, before adding the second layer. The upper layer should be placed and compacted immediately after compaction of the lower layer.

Where a levelling screed is laid on a compressible insulation layer, extra attention should be given to ensure adequate compaction, e.g. by the use of a slightly wetter mix.

Where reinforcement is used, it should be placed in about the middle third of the thickness of the screed.

NOTE This can only be achieved if the thickness of the reinforcement is correctly chosen in relation to the thickness of the creed so that the total thickness of the steel fabric at the overlaps can fit into the middle third of the screed depth. This can be achieved by laying the levelling screed to about half its thickness, compacting it, lightly roughening the surface with a rake, laying the reinforcement on the compacted layer and then immediately placing and compacting the upper layer.

E.2.5 Finishing the levelling screed

Cement and sand or fine concrete levelling screeds should be finished with a wood-float.

E.2.6 Curing the levelling screed

The screed should be kept covered with waterproof sheeting for at least seven days after laying to prevent drying out.

NOTE 1 During this curing period strength is gained and drying shrinkage delayed; when the later drying takes place the material is better able to resist the shrinkage stresses.

NOTE 2 When using cements other than CEM I 42.5 N extended periods of curing might be necessary in accordance with BS 8204-1:2003+A1:2009, Annex E.

After the seven day curing period, levelling screeds should be subjected to continuous air drying for at least a further two weeks before tiling is started. A longer period might be necessary in wet weather and/or where the floor is to be heated.

E.2.7 Protection of the surface

Levelling screeds are not designed as wearing surfaces. Therefore their surfaces should be given adequate protection against damage or wear during subsequent building operations.

E.3 Inspection and testing of bases and screeds

E.3.1 Inspection

Before screeding work commences the base should be checked to ensure that the minimum thickness of screed can be applied.

The work should be inspected during progress and after completion, attention should be given to the following points:

a) materials;

b) preparation of the base, where the screed is to be bonded;

c) batching and mixing;

d) proper compaction;

e) correct finishing;

f) correct curing.

E.3.2 Testing of the completed work

After completion of the work, the following tests, in accordance with **4.1**i), should be carried out:

a) levels and surface regularity of screeds and concrete bases;

b) mix proportions (for floating screeds only see **E.3.4**);

c) adhesion of bonded screeds to the base;

d) curling and lipping of unbonded and floating screeds;

e) in situ crushing resistance of screeds.

E.3.3 Levels and surface regularity

When the base or screed is tested by the methods given in Annex F, the departure from datum should be within the limit specified by the designer and the surface regularity should be within the limit given in Table C.3 for the appropriate class chosen by the designer.

E.3.4 Determination of mix proportions of floating screeds

When it is necessary to determine the proportions of the mix constituents in a hardened screed, this should be done by the method given in BS 4551.

When it is necessary to determine the constituent material proportions of a hardened levelling screed this should be done by the method given in BS 4551.

NOTE Attention is drawn to the warnings given in BS 4551 that, where samples of the cement and aggregate used are not available, the analysis of the screed can lead to inaccurate assessment of the constituent material proportions and the use of assumed data can give results that could be at variance with the true constituent material proportions

E.3.5 Adhesion of bonded screeds to the base

The adhesion of the levelling screed to the base should be examined by tapping the surface with a rod or a hammer.

NOTE 1 A hollow sound indicates lack of adhesion.

Tests to check the adhesion of a levelling screed to its base should be made as late as possible in a construction programme, when the maximum effect of drying shrinkage has taken place.

NOTE 2 Tests undertaken in less than 4 weeks could be unreliable.

Account should be taken of the time necessary for any required replacement section of levelling screed to be laid within the construction programme.

NOTE 3 Good preparation of the base, together with good workmanship, minimizes loss of adhesion, however, it cannot be guaranteed that adhesion is always complete. It would be unrealistic to expect levelling screeds thicker than 40 mm always to be completely adhered even to a correctly prepared base.

NOTE 4 If any hollowness is found it is usually confined to the edges and corners of bays and on either side of any cracks that have developed in the levelling screed. Hollowness, indicating lack of adhesion, does not necessarily mean that the screed is unsatisfactory, unless it is accompanied by visible or measurable lifting of the edges of bays or at cracks, to the extent that the lifted areas of screed could break under anticipated loads.

NOTE 5 The type of flooring to be applied subsequently and the end use of the floor are also to be considered.

Areas of levelling screed that are considered to be unsatisfactory should be treated by one of the following methods:

a) making good the affected areas by filling or injecting the hollow areas with a low-viscosity synthetic resin to stabilize and improve the bond between the levelling screed and the base;

b) isolating the affected areas by sawing, making vertical cuts into adjacent sound screed, and taking care to minimize the effect of the cutting-out operation on the adhesion of the sound screed. The unsatisfactory areas of screed should then be removed and replaced by new material.

E.3.6 Curling and lipping of unbonded and floating screeds

Unbonded and floating screeds should be considered unsatisfactory if they have lifted by a visible or measurable amount that joints or cracks, to the extent that there is risk of fracture under superimposed loads.

NOTE Unbonded and floating screeds often sound hollow when tapped with a rod or hammer.

E.3.7 In situ crushing resistance of bonded and unbonded screeds

When the levelling screed is tested by the method given in this annex, the indentation produced after dropping the weight four times should not exceed that given in BS 8204-1:2003+A1:2009, Table 5 for the specified category (see **6.7**). However, up to 5% of indentations exceeding those in BS 8204-1:2003+A1:2009, Table 5 by not more than 1 mm are acceptable.

NOTE 1 These are in addition to any allowance for roughness referred to in Note 2 of BS 8204-1:2003+A1:2009, Table 5.

The screed should pass the in situ crushing resistance (ISCR) test 14 days after it has been laid.

NOTE 2 In cold weather, low curing temperatures can require this period to be extended.

NOTE 3 Conformity can be proved at an earlier age provided that the requirements of BS 8204-1:2003+A1:2009, Table 5 can be met.

E.3.8 In situ crushing resistance of floating screeds

The ISCR of this type of screed should be assessed by the method given in BS 8204-1:2003+A1:2009, Annex D.

When the floating screed contains pipes or heating elements, tests should be carried out at least 75 mm from their known position to avoid possible damage to them.

The levelling screed should meet the acceptance limits for the category chosen. If the levelling screed does not meet the appropriate acceptance limits for the category chosen, the screed should not necessarily be rejected as alternative methods, such as analysing the material for cement content and taking cores for strength determination, can be used to ascertain whether the screed is sound and fit for purpose.

Annex F (normative)

Recommended method for the assessment of levels and surface regularity of levelling screeds

Levels of datum should be checked using standard surveying methods.

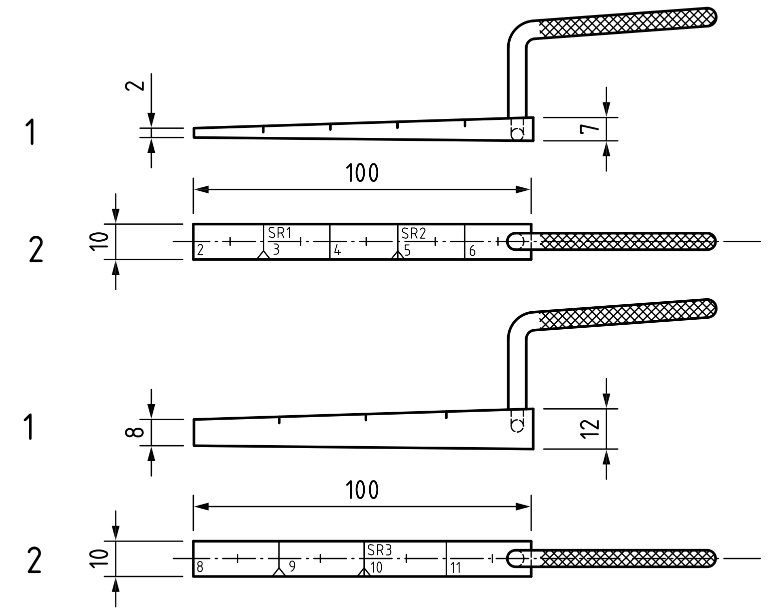
Surface regularity should be checked by using a straightedge between points of contact two metres long, laid in contact with the floor surface and resting under its own weight. The deviations of the floor surface should be measured from the underside of the straightedge, between the two points which are in contact with the floor surface, by means of a slip gauge or other suitable accurate measuring device.

NOTE A suitable form of slip gauge is shown in Figure F.1.

The number of measurements required to check levels and surface regularity should be agreed between the parties concerned bearing in mind the standard required and the likely time and costs involved.

Figure F.1 **Slip gauges for checking surface regularity**

Dimensions in millimetres



Key

1 Side elevation

2 Top plan

Annex G (normative)

Cement and sand bedding

COMMENTARY ON ANNEX G

This bedding method was historically, extensively used, but with the development of new thin bed adhesive installation materials and techniques, has largely been replaced.

G.1 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.

G.2 Sand for cement and sand mortar beds

Sand for cement and sand beds should conform to BS EN 13139:2002, 0/4 category 1 and the recommendations of PD 6682-3.

NOTE Other sand can be used provided there are satisfactory data on the properties of similar mortar beds made with them.

G.3 Admixtures to cement and sand mortars

Admixtures to cement and sand mortars should conform to BS EN 934-2.

G.4 Surface finish of the base

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.

To receive a cement and 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.

G.5 Semi-dry mix

The mix should consist of one part cement to 1:4 to 4.6 by weight. The sand should conform to **G.2**.

A trial mix should first be batched, by weight. In order that a water:cement ratio between 0.55 and 0.60 by weight (about 27.5 l of water:50 kg cement [two bags]) can be achieved, the proportion of water in the sand should be determined beforehand, but if this is not possible the correct water content in the mix should be established by means of both of the following tests.

a) When a sample of mortar is squeezed in the gloved hand, the sample should retain its shape and not crumble, the hand being left slightly moist. Gloves should be thin and non-absorbent.

NOTE Disposable plastics gloves are suitable.

b) When a sample is compacted on the base, no film of water should form on the surface.

G.6 Bedding in semi-dry cement and sand mix

NOTE The bedding of tiles in a semi-dry mix permits the laying to be carried out to a much greater thickness in a single operation than can be achieved using a standard sand and cement mortar. It also allows for floors to be either bonded or laid over an isolation membrane.

Where a floor is not to be isolated the base preparation advice given in **G.7** is particularly important and should be followed as the dryness of the mix described in **G.5** results in weak adhesion between the bed and an inadequately prepared base. Cleavage can occur at the interface in the event of differential movement to the detriment of the floor.

Where a uniformly thick bed can be applied to achieve the required level of the tile surface, it maximum thickness thickness should be 70 mm. Where falls have to be formed entirely in the bed, its maximum thickness should be 100 mm. In all cases, the minimum thickness should be 40 mm.

Forced action type mixers should be used because free fall drum mixers do not produce uniform mixes with semi-dry ingredients.

G.7 Application of semi-dry mix [bonded method]

Before the bed is laid, the base should be brushed clean and the finished floor level should be established by means of dots and rules. The sub-floor should be dampened and a bonding slurry, as described in this subclause, should be spread over and well brushed into the base.

When tile beds or tiles are laid on slurries containing proprietary materials recommended for this purpose, the manufacturer's instructions should be followed.

Laitance should be removed from the surface of the concrete base by appropriate mechanized equipment prior to the slurry being applied.

The semi-dry bedding mix should then be spread to a thickness of, roughly, 10% to 15% greater than that required for the actual bed, and thoroughly tamped and drawn off to the required level. No greater area of mix should be spread than can be tamped and topped with slurry and tiles in one continuous operation.

A slurry consisting of one part cement to one part sand, or of neat cement, after being mixed with water, should immediately be spread and trowelled over the bed in an even layer about 2 mm thick.

NOTE Alternatively, the backs of tiles can be totally coated with slurry to combine with the slurry on the semi-dry mix bed.

G.8 Separating layer [unbonded method]

A separating layer should be used over suspended floors subject to significant deflection, e.g. made from thin-section beams, planks or slabs or if the condition of the sub-floor prevents adhesion for any reason. In this method, a separating layer or membrane is interposed between the bed and the base. The base should be smooth and swept clean. A layer of polyethylene sheet should be laid over it and the joints lapped at least 100 mm. A semi-dry mix as described in **G.5** should be laid over this with a minimum bed thickness of 40 mm and reinforced with steel fabric incorporated within the middle third of the bed thickness, lapped 100 mm and wire tied (see **5.4.4**). Unbounded floors should have a consistent bed thickness.

G.9 Application of tiles

The tiles should be placed on the slurried bed, with care being taken to avoid depressing any of the corners; the tiles should be tapped firmly into position, a useful tool for this purpose being a rubber mallet. The tiles should preferably be dry but, to prevent excessive absorption of moisture from the bed, the porous tiles should be immersed in clean water, and surface water drained off before placing them (see **G.10.2**). Tiles that have uneven or deep back patterns, such as some extruded tiles, should have the depressions filled before laying, with a suitably stiffened mortar of one part cement to two parts sand. No tiles should be fixed with joints less than 3 mm in width.

Extruded tiles should be fixed with nominal joints 6 mm to 10 mm wide. Special care should be taken to ensure that when tapping tiles less than 10 mm thick into the semi-dry bed, excessive material is not forced up into the tile joint, as this restricts the thickness of grout which can be later applied resulting in a significant reduction in the capacity of the joint to withstand point loading. The joints to receive grout should be not less than 6 mm deep unless tiles thinner than 6 mm are used (see **7.1.5**).

The traditional "beating-in" of tiles involves thoroughly tapping the tiles with a flat faced wooden block which, dimensionally, is usually approximately 300 mm × 100 mm × 50 mm. Alternatively, some floor tiling contractors use vibrating machines for beating-in. During this operation the tile joints should be regulated and an occasional check made to establish that full contact is being achieved between tiles and the slurried bed by lifting a tile out at random; any slurry or mortar disturbed should be made good before the tile is replaced.

There should be no delay between spreading the slurry on the semi-dry mix bed, placing the tiles and tapping them in.

Where tiles have been bedded using a vibrating machine, grouting should be completed within four hours. Where proprietary manufactured grouts are to be used, the manufacturer's instructions should be followed.

NOTE Some large format tiles might not be suitable for the semi-dry bedding technique; being too large for beating in or to allow the bed to be compacted to the same degree as with a smaller tile.

G.10 Bedding in cement and sand mortar bonded to a base

G.10.1 General

The cement and sand ratio, using Portland cement and clean dry sand, should lie in the range 1:3.5 to 1:5 by weight.

The materials should be thoroughly and efficiently mixed by means of forced action mixers.

NOTE 1 Trough and pan paddle mixers are suitable for all types of mortar.

NOTE 2 Cement and sand bedding mortar can be mixed manually, provided it is done thoroughly.

The thickness of the bed should be 15 mm min and 20 mm max. Where, however, tiles of 10 mm thickness or less are used, the thickness of the bed should be 10 mm to 15 mm. The mix should be of a stiff but workable consistency and should contain the appropriate quantity of water so that when tamped and fully compacted into place free water does not bleed to the surface.

The mortar should be spread between wooden fillets and levelled with a draw-float drawn across the containing fillets, only sufficient area being laid for from two to three hours tiling work.

G.10.2 Preparation of porous tiles

To prevent rapid suction and subsequent failure to bond with the mortar bed, porous tiles should be soaked before fixing.

NOTE Tiles classified in BS EN 14411 in groups IIb and III require this saturation treatment. Soaking of tiles of groups Ia, Ib and IIa is unnecessary.

Tiles should be removed from their packaging and completely immersed in clean water for at least 30 min. After soaking they should be stacked tightly together, with the end tiles face outwards, on a clean surface and allowed to drain.

G.10.3 Application of tiles

Immediately before bedding tiles, any excess water on soaked tiles should be removed. The mortar bed should be dusted with dry cement sprinkled with a fine sieve and lightly trowelled level until the cement becomes damp. Alternatively, a slurry of neat cement and water or a normal setting cement-based adhesive should be applied to the backs of the tiles, covering them completely.

Bonding can be improved by incorporating in the slurry a suitable aqueous synthetic dispersion as a bonding agent. Tiles should be laid on the mortar bed with at least 3 mm wide joints between them and tapped level.

G.10.4 Movement joints

Siting of movement joints should be as given in **7.1.6**.

G.10.5 Tile bed thickness

Tile bed thickness should conform to Table G.1.

Table G.1 **Thickness of tile bedding**

Bedding method	Sub floor surface regularity	Bed thickness	Comments
Bonded cement and sand mortar bed (see **G.10**)	SR2	15 mm to 20 mm (tile thickness greater than 10 mm)	For tiles thinner than 10 mm a bed thickness of 10 mm to 15 mm is recommended
Unbonded semi-dry cement and sand mortar bed (see **G.8**)	SR3	40 mm to 70 mm	Steel fabric reinforcement might be required on the bed, e.g. on suspended floors
Bonded semi-dry cement and sand mortar bed (see **G.7**)	SR3	40 mm to 70 mm	Maximum thickness 100 mm where falls are formed within the bed

G.11 Cement and sand grout

Cement and sand grout should consist of Portland cement (CEM 1) and sand, mixed with the minimum amount of water necessary to achieve a paste consistency; too wet a mix can result in cracking in the joints as the grout dries out. For joints about 3 mm wide the grout mortar should be an equal weight mix of cement and sand. For joints between 3 mm and 6 mm wide the grout mortar should consist of one part cement to two parts sand by weight. For joints wider than 6 mm but not exceeding 10 mm in width the grout mortar should consist of one part cement to three parts sand by weight.

*NOTE 1 These cement and sand grouts require dampness in the joint cavities to promote good adhesion and are best suited to the cement and sand bedding methods given in **7.2.1** and **G.10** in which the tiles are dampened or soaked prior to laying and where the joints can be re-wetted, if necessary.*

*NOTE 2 These grout mortars are generally not suitable for use in joints between fully vitrified tiles unless a grout admixture (see **G.12**) is used to improve adhesion to the non-absorbent sides of the tiles.*

G.12 Admixtures

When admixtures are incorporated in cement and sand grout they should be used in accordance with the admixture manufacturer's instructions.

Only materials and admixtures approved by the manufacturer should be incorporated in their proprietary grouting products.

G.13 Grouting with cement and sand mortar

There should be dampness in the joint cavities and if, in the interval between the completion of tile-laying and the start of grouting, the cavities have dried out, they should be re-wetted.

The mortar, mixed as described in **G.11**, should be spread over the surface and worked into the joint cavities until they are filled solidly, using a rubber squeegee or similar tool; grouting machines are available for this purpose that can be used with advantage on large floors. For filling joints wider than 6 mm, the mortar mix should be stiffer than that for narrower joints and should not be spread but should be trowelled into the joint cavities.

The grout should be brought flush with the tile surface, as nearly as is practicable.

Surplus grout should be removed from the floor surface before the grout sets too firmly; on no account should sawdust be used for this purpose as there is a danger that sawdust entering moist grout can reduce its strength. Following removal of surplus grout and after the grout in the joints has hardened sufficiently, the surface of the work should be washed over with water and left clean. If any grout residue resists removal by water, it should be cleaned off in accordance with **11.2.**

Annex H (informative) Guidance on the reduction of slip hazard

COMMENTARY ON ANNEX H

The information given in this annex is aimed at raising the awareness of the problem of slips and falls and resultant injuries. However, in giving advice on how to help reduce some of the major contributors to such accidents, it can only provide guidance rather than an absolute guarantee.

H.1 General

NOTE The guidance below follows the various HSE documents [14], [15], [16], [17], and [18] and applies to all types of impervious floor coverings.

Ceramic floor tiles are not slippery when clean and dry. The slip resistance of a floor in service depends on the nature of its surface, and this can change over the lifetime of the floor. Flooring surfaces in common use generally have acceptable slip resistance provided they are clean, dry, free from oil, fat and other slippery substances and have received thorough cleaning after installation, and continue to receive appropriate maintenance in service. The likelihood of slipping on a floor is increased by the presence of contamination; the most common contaminant is water but others including oil, grease, soap, dust, lint and sand are also possible. The likelihood of slipping also varies with the type of footwear worn by pedestrians (see **H.3**).

Instruments that purport to measure slip resistance are actually measuring coefficient of friction in standard test conditions, which might vary considerably from those in service. For instance, it is important that tests in wet conditions are used to assess slip resistance on a wet floor, and that the thickness of the layer of water in the test is similar to that which is present under a sliding heel, as is the case with the Pendulum test.

Surface roughness can provide useful complementary information. Monitoring the change in the roughness (R_z) of a surface due to wear and other factors can be helpful in gauging the likely change in slip resistance, although it is not a substitute for proper measurement of slip resistance (see BS 1134). The required surface roughness depends on the contaminant, for example, dirty water is likely to require a higher surface roughness than clean water because the viscosity is higher.

Slipping incidents can occur in which the person is able to recover their stance, or if they fail, do not injure themselves to any great extent. Comprehensive records of all slip incidents, including those which do not result in serious injury, and thorough investigation to uncover the root causes of these events helps to identify problem areas and allow action to be taken before a serious accident does occur. Records also allow patterns to be identified, giving further clues to the action required to reduce the hazard.

H.2 Design

The measures that can be taken by designers, in consultation with their clients, to promote safe conditions in service include:

a) considering the likely contaminants that are likely to be present in service and specifying the floor surface and measures required to maintain it in a safe condition;

b) anticipating the cleaning and maintenance regime necessary and making the necessary provisions for it;

c) providing adequate entrance flooring systems at foyers and entrances to intercept water and dirt brought in by traffic. At entrances, if wet footprints can be seen beyond the entrance matting, the entrance matting is compromised and additional temporary matting is to be used. The entrance matting surface is to:

   1) remain effective;

   2) extend to the entrance threshold;

   3) not leave gaps (where supplementary mats are used);

   4) not present a trip hazard;

d) the proper cleaning, maintenance and replacement where necessary of entrance flooring systems, in order to maintain their effectiveness. Matting can be securely fixed so that it does not present a tripping hazard;

e) the use of canopies over entrances;

f) positioning entrances to reduce the effects of prevailing weather;

g) the use of ventilation systems to help reduce the impact of wet weather and/or cleaning;

h) people pulling or pushing loads generally require a surface with a higher slip resistance to operate safely.

Poor lighting, inside or outside, can significantly increase the risk faced by pedestrians. Limited lighting can also skew individuals' perceptions or expectations of the degree of slipperiness of a walking surface. Steps, stairs and ramps present an increased risk and need to be clearly identified and well lit.

Accidents generally occur when unexpected changes in floor conditions are encountered. It is often the difference between the dry and wet (contaminated) coefficient of friction that is important. Specifiers need to remember this and not simply choose a floor covering material with a high dry coefficient of friction value. It is also good practice to avoid significantly different flooring materials (in terms of their slip resistance) in adjacent areas.

If contamination is likely to be present, then flooring with enhanced slip resistance can be used. The use of such floorings is particularly important on slopes and in areas where tiling is laid to falls to drain water from foreseeably wet areas (expert advice might be required).

H.3 Service

The measures that can be taken by the owner or occupier of the building to promote safe conditions in service include identifying potentially wet areas and using an appropriate surface there, establishing an effective cleaning/maintenance procedure that uses appropriate cleaning materials, confirming that these procedures are conducted at the appropriate frequency and using normal measures of good housekeeping.

NOTE The Management of Health and Safety at Work Regulations 1999 [19] require the employer to make an assessment of the risks of slipping caused by conditions in his workplace and to take the necessary measures to minimize them.

Slip resistance can only be maintained by frequent effective cleaning with appropriate detergent and cleaning tools. The flooring product manufacturer might provide details of cleaning methods. When a wet cleaning process is used, a thorough final rinse with fresh, clean water is particularly important. It is particularly important to leave smooth floors dry after cleaning.

Areas of smooth floor coverings wet as a result of cleaning call for clear identification and small areas of local contamination are to be cordoned off. Freshly cleaned surfaces need to be completely dry before the floor is returned to use.

Good housekeeping practices are the first defence against slip and fall accidents. Good housekeeping is therefore a state to be maintained (rather than merely achieved) by the following measures:

a) make sure that your cleaning method is effective for the type of floor you have;

b) do not introduce more slip or trip risks while cleaning is being done;

c) leave smooth floors dry after cleaning or exclude pedestrians until the floor is dry;

d) remove spillages promptly;

e) have effective arrangements for both routine cleaning and dealing with spills;

f) use the appropriate detergent mixed at the correct concentration. If a detergent is used, a rinse with fresh, clean water is especially important;

g) clean in sections, so there is a dry path through the area;

h) use warning signs: consider using cones carefully as they do not act as a barrier and only warn of the hazard;

i) provide information on alternative routes.

In occupational settings it is often possible to select the footwear to be worn. An informed choice of footwear might offer some protection against the incidence of slipping accidents. Footwear needs to be properly cleaned and maintained to remain effective. In situations where no control over footwear is possible the condition of the floor is even more crucial in reducing the likelihood of slipping accidents.

H.4 Personal responsibility

Water and other liquids are arguably the substances that most often contaminate floors. Spills of tea, coffee, cleaning solution, rinse water and other liquids are too hazardous to leave until the cleaners arrive. Water or other spilt liquids on the floor are primarily the responsibility of the person who spilt them to remove them immediately and alert others to the hazard.

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