

Wall and floor tiling —

Part 3: Code of practice for the design and installation of ceramic floor tiles and mosaics

(Formerly part of CP 202)

ICS 91.060.10; 91.060.30

Committees responsible for this British Standard

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- Brick Development Association
- British Adhesives and Sealants Association
- British Ceramic Research Limited
- British Ceramic Tile Council
- Building Employers Confederation
- Chartered Institute of Building
- Concrete Society
- Consumer Policy Committee of BSI
- Contract Flooring Association
- Department of the Environment (Building Research Establishment)
- Federation of Master Builders
- Health and Safety Executive
- Institute of Clerks of Works of Great Britain Inc.
- Mortar Producers Association Limited
- National Federation of Clay Industries Limited
- National Federation of Terrazzo and Mosaic Specialists
- National Master Tile Fixers' Association
- National Tile, Faience and Mosaic Fixers' Society
- Natural Slate Quarries Association
- Royal Institute of British Architects
- Stone Federation
- Terra Cotta Association 1937

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Contents

	Page
Committees responsible	Inside front cover
Foreword	iv
Section 1. General	
1 Scope	1
2 Definitions	1
3 Exchange of information and time schedules	1
3.1 Exchange of information	1
3.2 Provision of utilities, facilities and materials	2
3.3 Time schedules	2
Section 2. Materials	
4 Transport and storage	3
5 Ceramic tiles and pavers	3
5.1 Ceramic tiles	3
5.2 Pavers and brick slips	3
6 Mosaics	3
7 Materials for tile beds and screeds	4
7.1 Cement	4
7.2 Aggregates	4
7.3 Water	4
7.4 Reinforcement	4
7.5 Bonding agents	4
7.6 Adhesives	5
7.7 Admixtures to cement: sand mortars and screeds	5
8 Separating layers	5
8.1 Polyethylene film	5
8.2 Building paper	5
8.3 Bituminous felt	5
9 Grouts and joint materials	5
9.1 General	5
9.2 Sand for grouts	5
9.3 Pigments	6
10 Sealants and back-up materials for movement joints	6
11 Chemically-resistant materials	6
Section 3. Design	
12 General	7
12.1 General	7
12.2 Finished floor level	7
12.3 Alignment of wall and floor joints	7
13 Load considerations	7
14 Bases	7
14.1 General	7
14.2 Concrete	8
14.3 Screeds	8
14.4 Timber bases	8
14.5 Asphalt	9
14.6 Other bases	11
15 Durability and performance	11
15.1 General	11

	Page
15.2 Traffic and load conditions	11
15.3 Resistance to mechanical failure	11
15.4 Frost resistance	12
15.5 Slipperiness	12
15.6 Resistance to staining	12
15.7 Grouts, joints and sealant materials	12
16 Passage of liquids through floors	12
16.1 General	12
16.2 Passage from below	13
16.3 Passage from above	13
17 Variations in moisture content and temperature	13
18 Isolation of tile bed from the base	13
18.1 Separating layer	13
18.2 Semi-dry cement: sand bed	13
19 Movement joints	14
19.1 General	14
19.2 Sealants	14
19.3 Back-up materials	16
19.4 Pre-formed strips	17
20 Modular installations	17
21 Skirtings	17
22 Selection of bedding methods, grouts and joint materials	17
Section 4. Application of tiles and pavers: methods and materials	
23 General	23
23.1 Work on site	23
23.2 Preparation of bases to receive tile beds	23
23.3 Setting out	24
23.4 Tolerances on finished floor level	24
23.5 Joints	24
23.6 Movement joints	24
24 Bedding methods	25
24.1 Bedding in cement: sand mortar bonded to a base	25
24.2 Bedding in cement: sand semi-dry mix	26
24.3 Bedding in cement: sand mortar (not semi-dry mix) over a separating layer	27
24.4 Bedding in adhesives	27
25 Grouting	29
25.1 General	29
25.2 Grout materials	29
25.3 Grouting procedure: tiles	30
25.4 Grouting procedure: pavers	31
Section 5. Application of mosaics: methods and materials	
26 General	33
27 Workmanship	33
28 Mosaic beds	33
29 Setting out	33
30 Tolerances on finished floor level	33
31 Movement joints	33

	Page
32 Preparation of mosaics	34
33 Laying mosaics	34
33.1 Bedding in thin-bed cement-based adhesives and organic-based adhesives	34
33.2 Bedding in cement: sand mortar	34
34 Grouting	35
35 Marble and other natural stone mosaics	35
Section 6. Protection	
36 General	37
Section 7. Cleaning and maintenance	
37 General	39
38 Efflorescence	39
39 Residual cement film	39
40 Surface sealing materials	40
41 Cleaning agents	40
Appendix A Tile fittings	41
Appendix B Specific conditions included in BS 5385-4	49
Appendix C Screeds	50
Appendix D Recommended method for the assessment of levels and surface regularity of screeds	58
Figure 1 — Illustration of definitions	1
Figure 2 — Some typical movement joints	18
Figure 3 — Round edge floor tiles and typical round edge skirting system	41
Figure 4 — Square and round top cove systems: dust pressed tiles	42
Figure 5 — Typical cove and angle bead systems: dust pressed tiles	43
Figure 6 — Square and round top cove systems: extruded tiles	44
Figure 7 — Typical step tread systems: dust pressed tiles	45
Figure 8 — Typical step treads: extruded tiles	46
Figure 9 — Typical floor channels: dust pressed tiles	47
Figure 10 — Typical floor channels: extruded tiles	48
Figure 11 — Slip gauges for checking surface regularity	58
Table 1 — Classification of ceramic tiles	4
Table 2 — Sands for grouts for joints less than 6 mm wide	6
Table 3 — Suitability of tile beds for different bases	10
Table 4 — Final tile bed thicknesses	10
Table 5 — Grouts and joint materials: resistance to intermittent contact with various liquids and flexibility	15
Table 6 — Flexible sealants: summary of properties	16
Table 7 — Choice of soundness category for screeds	51
Table 8 — Classification of surface regularity (SR) of direct finished base slab or screed	52
Table 9 — Acceptance limits for soundness test	57
Publications referred to	59

Foreword

This part of BS 5385 has been prepared under the direction of the Elements and Components (of Diverse Materials) for Buildings Standards Policy Committee. It is a revision of those sections of CP 202 that deal with ceramic floor tiles, pavers and brick slips (up to 38 mm thick).

In addition to those subjects formerly included in CP 202, recommendations for mosaic floors have been added to the code, the section on design has been enlarged and now includes recommendations for laying tiles on timber and asphalt bases, the recommendations about screeds are now given in full in Appendix C and the tile beds and tile laying techniques have been revised.

Throughout the code, references to tiles and tiling are intended to apply equally to mosaics and mosaic work except where the recommendations for mosaics are different, as in Section 5.

The revision of the remaining sections of CP 202 dealing with terrazzo tiles and slabs, natural stone and composition block flooring will be published as Part 5 of this standard, when CP 202 will be withdrawn.

The other parts of BS 5385 are as follows:

- *Part 1: Code of practice for internal ceramic wall tiling and mosaics in normal conditions;*
- *Part 2: Code of practice for external ceramic wall tiling and mosaics;*
- *Part 4: Code of practice for ceramic tiling and mosaics in specific conditions;*
- *Part 5: Code of practice for the design and installation of terrazzo tile and slab, natural stone and composition block floorings.*

Assessed capability. Users of this British Standard are advised to consider the desirability of assessment and registration of a supplier's quality systems against the appropriate part of BS 5750 by a third party certification body.

Enquiries as to the availability of third party certification schemes will be forwarded by BSI to the Association of Certification Bodies. If a third party certification scheme does not already exist, users should consider approaching an appropriate body from the list of Association members.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 60, an inside back cover and a back cover.

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Section 1. General

1 Scope

This part of BS 5385 gives recommendations for the design, installation and maintenance of floor tiling using ceramic tiles, mosaics, pavers and brick slips 38 mm or less in thickness, bedded on concrete, cement and sand screeds, timber, asphalt and existing hard floor finishes.

NOTE 1 For information on laying clay and calcium silicate pavers in the flexible form of construction and the design of such flexible pavements, reference should be made to BS 6677-2.

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

Tile fittings for use as skirtings, step treads and channels are given in Appendix A.

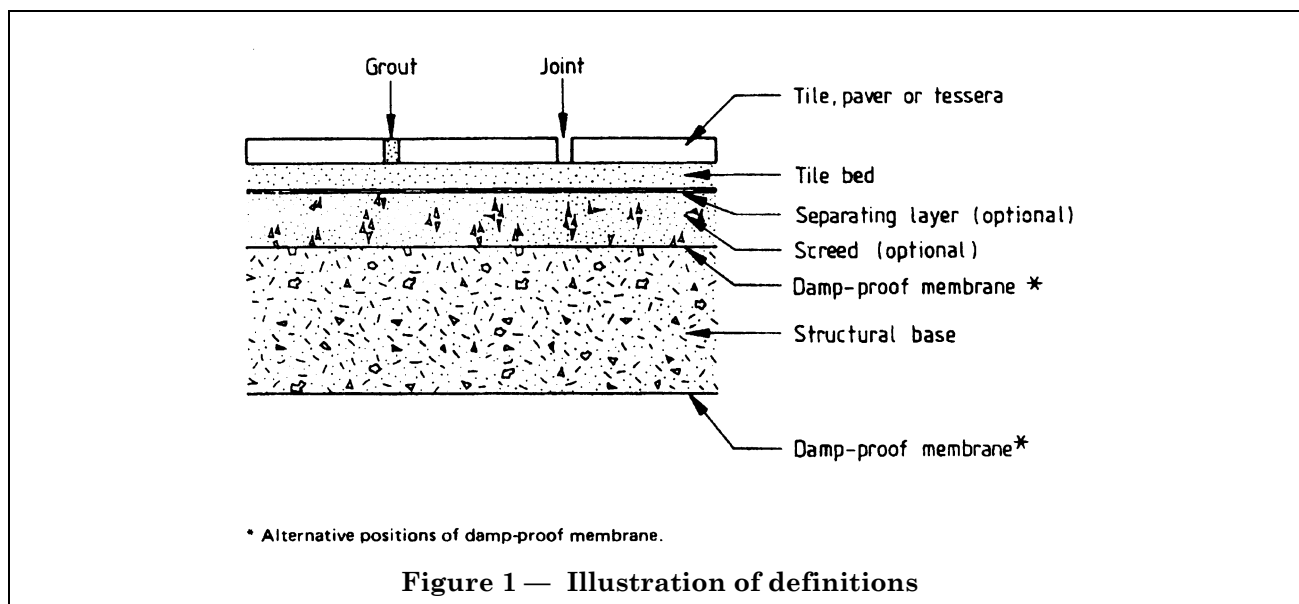
Where the floor tiling installation needs to meet specific functional or environmental requirements, or to assist in counteracting potentially detrimental effects on the installation and/or the structure, reference should be made to BS 5385-4. The specific conditions dealt with in BS 5385-4, for example, swimming pools, shower areas etc., are given in Appendix B.

Recommendations for the design and laying of screeds are given in Appendix C. Reference is made to tiles bedded directly to a concrete base, but for the design and construction of concrete bases reference should be made to BS 8204-1.

NOTE 2 The titles of the publications referred to in this part of BS 5385 are listed on page 57.

2 Definitions

For the purposes of this part of BS 5385 the definitions given in BS 6100 and BS 6431-1 apply. An illustration of some definitions is shown in Figure 1.



3 Exchange of information and time schedule

NOTE This clause deals with the exchange of information for the whole floor, including the tiles, bed, base and screed (if any).

3.1 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 provided.

- 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 may be subjected in service.

- c) *Floor*. Structure of floor, type of damp-proof membrane and its location within the floor construction, details of screed (including its surface regularity and the category of soundness 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, skirtings 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 3.3).
- i) *Testing*. Details of any compliance testing required.

3.2 Provision of utilities, facilities and materials

3.2.1 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 will be provided and by whom:

- a) adequate, clean, dry, lockable storage space protected from frost (if necessary);
- b) clean water supply adjacent to working areas;
- c) adequate artificial lighting if required (see 3.2.2);
- d) unloading and hoisting facilities;
- e) electric power supply adjacent to working areas;
- f) protection of work during and after fixing;
- g) supplies of sand and cement in accordance with 7.1 and 7.2.

3.2.2 Lighting on site

Lighting on site should be of the same type, direction and intensity as envisaged for the completed installation. If this condition is not met then the appearance of the finished floor might be different from that originally intended. This is a matter that should be appreciated by the specifier at the design stage.

3.3 Time schedule

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

At least six weeks should be allowed for the structural floor to undergo initial drying shrinkage. If a screed is subsequently to be applied the screed should be left for at least a further three weeks. These times may require extension depending on the conditions on site and mass of the structure. Where tiling is on a separating layer directly over the structural floor the period of six weeks may be reduced.

The schedule should also allow time for the cutting of holes and chases in the floor that is to receive the tile bed.

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.

Section 2. Materials

4 Transport and storage

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

Products should be stored in a clean, dry, frost free (if necessary) lockable storage to avoid excessive handling, theft and damage.

5 Ceramic tiles and pavers

5.1 Ceramic tiles

Ceramic tiles are classified in BS 6431-1 and fall into two main classes according to their method of manufacture.

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

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

Tiles are further sub-divided according to their water absorption: low (group I), medium [groups II(a) and II(b)] and high (group III); see Table 1.

Tiles may be unglazed, engobed, partly glazed or glazed. Glazed floor tiles are not suitable for heavy duty situations but they may be used in other locations with comparatively light traffic (see 15.2).

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

Properties and characteristics to which products should conform are laid down in the standards of individual products, BS 6431-2 to BS 6431-9, and the relevant standard(s) should be quoted in the specification.

5.2 Pavers and brick slips

Pavers and brick slips suitable for use in flooring are available in a very wide range of plan dimensions, worksize thicknesses, porosities (densities) and surface textures, all of which may influence the method of laying.

6 Mosaics

Mosaics are available in a variety of shapes and sizes, in glazed and unglazed ceramic, glass and marble. To facilitate ease of handling, mosaics are assembled as sheets, the individual tessera being glued either face side down to paper (paper-faced mosaics) or bed side down to synthetic strips, mesh, latticed paper or other material.

Paper-faced mosaic allow full contact to be achieved with the bed, i.e. mortar or adhesive. When sheets are assembled by means of backing material it should be made of synthetic fabric, not of cotton or paper as this becomes embedded in the mortar or adhesive.

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

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

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

The use of mosaic is not recommended where it will be subject to heavy traffic. Paper-faced mosaic is suitable in light and moderate traffic conditions but mosaic backed with synthetic strips or net should be confined to areas with light traffic conditions (see 15.2).

The physical and chemical properties of ceramic tesserae should be in accordance with the relevant requirements given in BS 6431-6.

Before selecting a particular system the advice of the mosaic supplier or mosaic fixing specialist should be obtained as to the suitability of a particular type of mosaic for a particular environment. Mosaics should not be used in corrosive situations.

7 Materials for tile beds and screeds

7.1 Cement

Unless otherwise stated the recommendations in this part of BS 5385 refer to cement complying with the requirements of BS 12 or BS 4027.

High alumina cement complying with BS 915 may be used for particular purposes but it should not be mixed with other types of cement.

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

Table 1 — Classification of ceramic tiles

	Group I	Group IIa	Group IIb	Group III
Water absorption (<i>E</i>)	$E \leq 3\%$	$3\% < E \leq 6\%$	$6\% < E \leq 10\%$	$E > 10\%$
<i>Tile shaping</i>				
A Extruded	AI	AIa	AIb	AIII
B Dust-pressed	BI	BIa	BIb	BIII

7.2 Aggregates

7.2.1 General

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

7.2.2 Aggregates

Aggregates for fine concrete screeds should comply with BS 882 using coarse aggregates of 10 mm single size to Table 4 of BS 882:1983 and fine aggregates conforming with 7.2.3

7.2.3 Sands

Sands for cement: sand screeds and mortar beds should comply with grading C or M in Table 5 of BS 882:1983. (See 9.2 for sand for grouts.)

7.3 Water

Water should be fresh and clean. Sea water is not suitable. All containers used for storing or carrying water or for soaking tiles should be clean.

7.4 Reinforcement

Where light reinforcement is required in a screed it should consist of steel fabric complying with BS 4483, reference D49 or D98.

Heavier reinforcement may be necessary for use in screeds constructed for structural purposes.

7.5 Bonding agents

Bonding agents to improve the adhesion of screeds and/or tile beds to bases should be used in accordance with the manufacturer's instructions. Manufacturers recommend particular grades and methods of application depending on the materials involved and service conditions, e.g. flooring in heavy duty areas, external applications.

7.6 Adhesives

7.6.1 Cement-based adhesives (*hydraulically-hardening mortars*)

Cement-based adhesives should conform to type 1 in BS 5980.

7.6.2 Organic-based adhesives (*dispersion, dispersion/cement, dissolved resin and reaction resin adhesives*)

Organic-based adhesives should conform to types 2, 3, 4 and 5 in BS 5980.

7.6.3 Admixtures to adhesives

A polymer additive or some other liquid or powdered product may be incorporated in adhesives to obtain greater adhesion, improved resilience or some degree of water repellence.

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.

7.7 Admixtures to cement: sand mortars and screeds

Admixtures to cement: sand mortars and screeds should comply with the appropriate part of BS 5075 (see C.1.10).

8 Separating layers

8.1 Polyethylene film

Polyethylene film should comply with BS 3012. A 500 gauge (0.125 mm) film is recommended for most conditions.

8.2 Building paper

Building paper should be selected from those specified in BS 1521.

8.3 Bituminous felt

Bituminous felt should be selected from those specified in BS 747.

9 Grouts and joint materials

9.1 General

Grouts and joint materials should have good working characteristics, low shrinkage and good adhesion to the sides of the joints. Additional properties may assume special importance, for example, impermeability; resistance to water, heat, cleaning agents and chemical attack; resistance to mould growth and bacteria; resilience and compressibility. Proprietary materials should be stored and used in accordance with the particular manufacturer's instructions.

9.2 Sand for grouts

For joints of nominal widths 6 mm and above, sand for grouts should comply with the grading limits of type B of Table 1 of BS 1199:1976.

For joints less than 6 mm wide, sands for grouts should comply with the grading limits given in Table 2. Sands complying with type G of Table 1 of BS 1200:1976 may be suitable provided the fraction greater than 2.36 mm is screened off.

Table 2 — Sands for grouts for joints less than 6 mm wide

BS 410 sieve	Percentage by mass passing BS sieves
mm	
2.36	100
1.18	95 to 100
µm	
600	80 to 100
300	30 to 100
150	0 to 60
75	not greater than 7

9.3 Pigments

Pigments should be inorganic and compatible with the grouting materials.

Pigments for cement: sand or cement-based grouts should conform to BS 1014.

10. Sealants and back-up materials for movement joints

The selection of the most suitable materials will depend upon design considerations (see clause 19), and the manufacturer's advice should be taken into account. Guidance on the selection of sealants is given in BS 6213.

Back-up materials should be compressible materials that will not force out the sealant when the joint closes. Suitable materials include cellular rubber and plastics such as cellular polyethylene, some fibre building boards, cork boards and caulking cotton. These materials are available in strip form.

11. Chemically-resistant materials

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

Section 3. Design

12 General

12.1 General

In solid and suspended floor constructions the stability and durability of the floor is dependent on a number of factors, including the load it has to support, the resistance it offers to the passage of liquid water or water vapour either from above or from below, 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. These factors should therefore be assessed at the design stage so that due allowance may be made for their possible effect on the finished floor.

Where specific conditions need to be considered reference should be made to BS 5385-4, the list of contents of which is given in Appendix B

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. The variety of thicknesses in and between tiles, pavers, mosaics and tile beds is considerable (see 14.1).

12.2 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.

NOTE 1 Insistence on very close limits may result in higher costs.

NOTE 2 Where the flooring is applied using a thin-bed adhesive, no correction of any variations in the base can be made; consequently, the tolerance required of the surface has to be applied to the base.

It is important that there should be no appreciable difference in level across joints, especially in areas where heavy loads are likely to be moved.

For floor level and across joints tolerances, see 23.4.

12.3 Alignment of wall and floor joints

Alignment of joints between wall tiles and floor tiles is sometimes possible if appropriately sized co-ordinating modular 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 must be precisely at right angles or parallel to each other. Allowance should be made for the greater costs which are likely to be incurred.

13 Load considerations

When a floor is designed, due allowance should be made for the ultimate weight it may have to bear including the flooring installation, and reference should be made to BS 6399-1. Where an existing floor is to be covered by the tiles and beds given in this code, a check should be made that the floor is sufficiently strong and rigid to accept the added load, particularly if the floor is of timber construction.

14 Bases

14.1 General

Concrete and cement: sand screeds are the most common bases over which ceramic floor tiles and mosaics will be laid but other bases may be encountered, namely timber, asphalt and metal. In refurbishing work, it may sometimes be necessary to apply new finishes over old floors such as ceramic tiles, terrazzo, granolithic, stone, etc.

Before the tile bed is applied it is essential that:

- a) the correct falls have been incorporated in the base, where required;
- b) the base is free from contamination, loose areas and significant cracks;
- c) the base is true to the specified plane (see also 23.2).

Bases suitable to receive tiling and the tile beds suitable in each case are summarized in Table 3.

In new work it is necessary to specify the plane of the base in relation to that of the finished floor surface; usually this is possible only if the floor tiles and the appropriate beds are selected at the design stage. The level of the base surface in relation to the finished floor surface should be such that the bed can be of the recommended thickness uniformly throughout the installation. An exception can be made when a semi-dry mix bed is to be used as this can be applied in varying thicknesses, subject to the minimum stated in **24.2.1**, to overcome irregularities and to form falls. The recommended maximum and minimum final tile bed thicknesses are given in Table 4.

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

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

14.2 Concrete

14.2.1 *Surface finish*

When tiling is bedded directly to a concrete base without a screed, the finish of concrete should be struck-off level with a straightedge and the surface texture closed. When a bonded bed is required, laitance should be removed by mechanical means. To receive a cement: sand bonded bed, the prepared concrete surface should be wetted down for 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.

14.2.2 *Tolerances on levels and surface regularity*

The same tolerances on levels and surface regularity given for screeds in **C.1.7** apply to concrete bases.

14.2.3 *Elimination of construction moisture*

Structural concrete should have been subjected to continuous air drying after the end of curing for at least six weeks before either a screed or directly-bedded finishing product is applied. The same allowance should be made for concrete with an integral screed surface. A longer period may be necessary in wet weather.

14.3 Screeds

A 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 screeds are given in Appendix C. A method for the assessment of levels and surface regularity is given in Appendix D

14.4 Timber bases

Timber sub-floors should be avoided if at all possible as a base for floor tiling. If a timber sub-floor has to be used as a base for floor tiling it should be rigid and be stable with respect to humidity and moisture changes. Timber is not considered to be a suitable base for floor tiling in wet or frequently damp or high humidity areas unless appropriate precautions are taken, see the recommendations in clause 6 of BS 5385-4:1992.

When a floor is designed, due allowance should be made for the ultimate weight it may have to bear, including the floor installation. Noggings may 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) may be too great to avoid damage to tiling systems

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

The design should take into account the initial drying shrinkage of the timber and subsequent movement due to seasonal moisture changes, bearing in mind the type of heating. Failure to observe this can lead to subsequent warping and distortion of the boards with consequent cracking and delamination of the tiling. Where the rigidity is satisfactory but the moisture stability of the floor cannot be assured, then consideration should be given to the use of a proprietary intermediate substrate system designed for use on timber floors

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

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

To further reduce or eliminate the risk of movement, an additional layer of sheets of minimum thickness 10 mm, resistant to moisture and thermal movement, should be screwed over the plywood at 300 mm centres ensuring that the joints in both layers of sheets do not coincide.

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

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

Alternatively, for floors of small area, the required rigidity may be achieved by fixing WBP exterior grade plywood of 15 mm minimum thickness over existing boards. The plywood should be sealed using preferably non-aqueous sealers, e.g. polyurethane varnish, 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 may rise to a level, sufficient to create conditions favourable to fungal attack, e.g. dry rot.

The joints between the plywood sheets should be laid broken-bonded and running in the opposite direction to the joints between the existing boards

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

14.5 Asphalt

The asphalt base should be laid in accordance with Section four of CP 204-2:1970 or CP 144-4. Before tile fixing commences the asphalt base should be examined to ensure that it is in a suitable condition to receive tiles; in particular, it should have adequate cohesive strength and should be laid on a rigid base, e.g. concrete.

The three preferred methods which can be adopted for laying floor tiles on an asphalt base are as follows.

a) *Bedding in cement-based adhesives.* The use of cement-based adhesives is described in 24.4, particularly 24.4.2 and 24.4.3. Cement-based adhesives may be used for bedding direct to asphalt in both interior and exterior situations provided that the following conditions are met.

- 1) The asphalt has adequate cohesive strength.
- 2) The asphalt base is sufficiently true to the specified plane to permit fixing with an adhesive at a bed thickness not exceeding 6 mm (see 23.4).
- 3) As the adhesive sets it should confer a relatively low degree of stress on the system. When tested as described in Appendix C of BS 5980:1980, the adhesive should not cause a tensile strain development of more than 250 microstrain. Where tensile strains in excess of this limit are encountered there is the possibility that some tearing of the asphalt may occur as the adhesive shrinks and sets so that the waterproofing character of the asphalt may be damaged. Adhesives producing tensile strains greater than 250 microstrain should not be used to fix the tiles direct to an asphalt base.
- 4) It is essential that in all external installations the asphalt should have been laid to finished falls of not less than 1 in 60. Factors such as wind loading and climatic conditions should be taken into consideration and the bedding should be of sufficient depth to be stable in these external conditions.

b) *Bedding in cement: sand mortar over a separating layer.* This method is described in **24.3** and is suitable for interior installations only.

c) *Bedding in cement: sand semi-dry mix.* This method is described in **24.2**. Where this method is used it is recommended that a separating membrane be interposed between the asphalt and the bed. In exterior situations the asphalt should be laid to adequate free draining falls.

Table 3 — Suitability of tile beds^a for different bases

Bases	Cement: sand mortar		Semi-dry cement: sand mix		Adhesives (see 24.4)	Chemically-resistant resins and mortars ^b	Clause reference ^b
	Bonded (see 24.1)	Unbonded (see 24.3)	Bonded (see 24.2)	Unbonded (see 24.2)			
New concrete (less than 6 weeks old) or screed (less than 3 weeks old)	U	S	U	S	U	U	14.1, 14.2 and 14.3
Mature concrete or screed	S	S	S	S	S	S	14.1, 14.2 and 14.3
Screed over suspended floor or underfloor heating	U	S	U	S	C	C	14.1 and 14.3
Timber	U	U	U	U	C	C	14.1 and 14.4
Asphalt	U	S	U	S	C	C	14.1 and 14.5
<i>Existing hard floor finishes after preparation</i>							14.1 and 14.6
Terrazzo	S	S	U	S	C	C	
Unglazed ceramic tile	S	S	S	S	S	U	
Glazed ceramic tile	S	S	U	S	C	U	
Granolithic topping	S	S	S	S	S	C	
Natural stone	S	S	S	S	S	U	
Metal	U	U	U	U	C	S	^b

NOTE Key

S Suitable

U Unsuitable

C Confirm suitable with manufacturer

^a The tile bed chosen will also depend on the traffic conditions (see **15.2**).

^b For special situations, including corrosive situations, reference should be made to BS 5385-4.

Table 4 — Final tile bed thicknesses

Tile bed	Thickness	
	Minimum mm	Maximum mm
Cement: sand mortar (see 24.1)	15(10 ^a)	20(15 ^a)
Cement: sand semi-dry mix (see 24.2)	40	70
Cement: sand over a separating layer (see 24.3)	20	30
Adhesive: thin-bed (see 24.4.1 , 24.4.2 and 24.4.4)	1	3
Adhesive: thick-bed (see 24.4.1 , 24.4.3 and 24.4.4)	> 3	6 ^b

^a When tiles are not greater than 10 mm thick.

^b Some may be applied up to 12 mm thick for filling small isolated depressions in the base.

14.6 Other bases

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 may be influenced by the change in level available from existing to new.

Tiles may also be bedded directly to rigid metal (see BS 5385-4).

15 Durability and performance

15.1 General

Floor tiling may deteriorate because of defects in the design of the structure, mechanical failure of the materials, the action of frost and the use of unsuitable cleaning agents (see clause 41). Tiled floors may also be unsatisfactory because they become slippery, are stained or the grout and/or sealants deteriorate.

15.2 Traffic and load conditions

For the purposes of this code, traffic loads are categorized as light or heavy. Floor loading should be considered as heavy if heavy cleaning equipment, hard-wheeled trolleys, etc. are to be used.

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

Heavy loading areas are those where high density pedestrian traffic, and/or heavy loads, static, moving, dropped or dragged, are likely to occur, e.g. in industrial and engineering premises and garages for heavy vehicles. For resistance to mechanical failure see 15.3.

Where heavy loading is likely, the tile bed should be well compacted and, as far as possible, should be free from voids since adhesion to the base is crucial, particularly where the moving of heavy loads is contemplated. Greater resistance to loading will be achieved by the use of thicker tiles with increased impact resistance, bearing in mind also that the joints between the tiles are usually the most vulnerable part of the tiling [see 15.3 c)3)].

The tile bed selected will depend on the base conditions but a cement: sand mortar on a separating layer should not be used.

If, because the base is a suspended floor, or for some other reason, a separating layer is needed, a reinforced semi-dry mix bed with intermediate movement joints should be used over the layer (see 24.2.2 and 24.2.6). For a heavily loaded, suspended floor subject to wetting, see also clause 16.

15.3 Resistance to mechanical failure

The basic agencies, abrasion, compression and impact, may operate singly, but they are often to be found in various combinations. The relevant mechanical properties of flooring 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 base.
- 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 units used, the individual units should be laid to a true plane. Therefore, a true base is a necessary prerequisite.
 - 2) The flooring units should be solidly bedded so that, as far as possible, there are no voids.
 - 3) Joints between ceramic tiles should be as narrow as possible, compatible with a minimum of 3 mm, and the manufacturing tolerances of the type of tiles used.

Care should be taken to ensure that joints are at least 6 mm deep unless tiles thinner than 6 mm are used.

The maximum width should not exceed 10 mm when conventional cement: sand grouts are used because such joints possess lower impact and abrasion resistance than the tiles. For joints wider than 10 mm consideration should be given to the use of proprietary grouts specially formulated with enhanced resistance to impact and abrasion and low shrinkage (see 25.2).

15.4 Frost resistance

Suitable assurances about frost resistance should be sought from suppliers of both tiles and bed materials. In areas where frost can occur the tiles selected should be of class A1 or B1 as classified in BS 6431-1.

Purpose-made clay pavers may be expected to be frost resistant. Where, however, clay bricks or brick slips are to be used in external paving, they should be stated to be of category F as indicated in 5.1 of BS 3921:1985.

15.5 Slipperiness

Unglazed floor tiles are not slippery when clean and dry but, as with every flooring material, if water, dust, oil, grease or wax is present on the surface, potentially slippery conditions will be created.

Glazed tiles should not be used in areas likely to become wet unless designed to be slip resistant.

Floor surfaces may become slippery in time through the polishing action of traffic.

When it is known that in service slippery conditions may arise and present a significant hazard, especially on steps and where floors are laid to steep falls, tiles or inserts with slip-resisting finishes should be used.

At external entrances to public building or other high density pedestrian traffic areas, floors should be protected against the ingress of water and other slippery contaminants by providing footwear cleaning devices e.g. effective barrier mats. These mats should extend for an adequate distance from the entrance depending on the location, environment and traffic conditions.

Special attention should be paid to correct cleaning procedures as described in Section 7, both to remove contamination and to ensure that cleaning agents, that could otherwise attack the surface, are rinsed away.

15.6 Resistance to staining

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. a fully vitrified tile will have a high degree of resistance, whereas a porous tile will stain more easily. The classes of ceramic tiles with low, medium and high water absorption are given in 5.1.

15.7 Grouts, joints and sealant materials

The resistance of grouts and jointing materials to various liquids that may be in contact with them for a short time is shown in Table 5, which also indicates their flexibility. Spillages should be cleaned off as soon as possible.

Where coloured grouts are used, they cannot always be expected to retain their colour and appearance after wear.

Sealants, under favourable conditions, have an expected service life of up to 15 years for the acrylic types and 20 years for the others. A summary of properties of flexible sealants is given in Table 6

16 Passage of liquids through floors

16.1 General

Floors consisting of a concrete base or floors of suspended construction (other than those of metal, with an asphalt covering, or with tile joints sealed by an impervious grout) and the bedded floorings dealt with in this code are not completely impervious to liquids, nor do they 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 some form of damp-resisting construction (see CP 102).

The use of integral admixtures containing water-repellent ingredients, such as metallic soaps in the base concrete, will make the hardened surface difficult to wet and will result in poor adhesion of conventional cement and sand bedding. Where cement: sand bedding is to be used and firm adhesion is required between base and bedding, it will be necessary to provide a "suction coat". This should be a layer of cement: sand mortar without admixture, placed monolithically with the wet base. For some adhesives the suction coat can be omitted.

16.2 Passage from below

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

Evaporation will be impeded by additional floor coverings less permeable than those discussed here 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 will 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 sulfur compounds which attack cement, the safety of the whole floor may well depend on adequate damp-proofing below the base (see CP 102). In less aggressive situations, damp-proofing which serves only as a capillary barrier is still justified as a precaution against persistent efflorescence at the floor surface and possible attack on the concrete by small concentrations of sulfates.

16.3 Passage from above

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 in solution passing through the floor may attack concrete bases leading to severe disruption.

In the case of suspended floors as well as attack on the structure by chemicals, water passing downwards may 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 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 will 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. The most commonly used membrane materials are: asphalt, bituminous felt, polyethylene film, composite pitch polymer sheets and synthetic rubber sheets.

NOTE Further discussion is beyond the scope of this code and advice should be sought from a specialist in this field.

17 Variations in moisture content and temperature

In solid and suspended floor constructions, the base and the floor tiling usually have different dimensional reactions 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 persists for some time after the tiling has reached equilibrium with the result that compression forces may ultimately crack the tiles or break down the adhesion between the tiles and the bed. 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.

18 Isolation of tile bed from the base

18.1 Separating layer

Failure arising from variable stresses (see clause 17) can be avoided by isolating the tile bed from the base by a separating layer that prevents the two elements from adhering to each other and thus allows each to move independently. Such a layer may consist of building paper, bituminous felt, polyethylene film or similar material, on which the tiles are bedded in mortar.

18.2 Semi-dry cement: sand bed

Another method of isolating the tile bed from the base is with a cement: sand semi-dry bed (see 24.2). The dryness of the mix results in weak adhesion between the bed and the base and any cleavage can occur at the interface in the event of differential movement.

19 Movement joints

19.1 General

19.1.1 *General*

Stresses may 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, flexible joints and contraction joints should be located, having regard to all the relevant factors including the type of flooring and bed.

Movement joints for the floor tiling are as follows:

- a) flexible joints aligned to structural movement joints (see Figure 2 types A and B);
- b) flexible joints to accommodate smaller movements than structural joints (see Figure 2 types C, D and E);
- c) contraction joints which are non-compressible to relieve tension (see Figure 2 type F).

19.1.2 *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 may 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.

19.1.3 *Other movement joints*

Flexible joints (types C, D or E) should be inserted over supporting walls and beams at intermediate positions to accommodate deflection of the base and movements in the flooring. Contraction joints (type F) may be used instead of flexible joints over supporting walls and beams.

Flexible joints (types C, D or E) or contraction joints (type F) should be used at floor perimeters and to divide the floor into bays at the intervals recommended in 23.6.4. 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 the joints should be of types having their edges reinforced with metal or rigid plastics sections (types A, B, D and E).

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 Figure 2 indicate the basic principles of the types of joints referred to above. Prefabricated types of B and E are available that embody the principles shown, but they may differ in detail.

19.2 Sealants

Choice of sealant will depend upon many factors including the extensibility, resistance to chemical attack, wear, the passage of time, penetration of grit and contamination, and resistance to damage from cleaning processes; ease of placing is also a factor. In each case the manufacturer's advice should be taken into account.

A summary of the more important properties of recommended sealants is given in Table 6. Butyl mastics and other forms of tacky mastics are not suitable.

Table 5 — Grouts and joint materials: resistance to intermittent^c contact with various liquids and flexibility

Grouts and joint materials	Lemon juice	Vinegar	Acidic soft drinks	Alcoholic drinks	Tea and coffee	Sugar solution	Milk	Olive oil	Disinfectant (phenolic)	Disinfectant (hypochlorite)	Acidic cleaners	Detergent (neutral)	Ammonia (10 % solution)	Paraffin oil	Acetone	Butyl acetate	Carbon tetrachloride	Urine	Sea water	Flexibility
Portland cement mortar	P	P	P	F/G	G	F	P	G	F	F/G	P	G	F	G	G	G	G	F/G	F	Rigid
High alumina cement mortar	P	F	F	F/G	G	F	F	G	F	F/G	P/F	G	F	G	G	G	G	F/G	G	Rigid
Polymer modified cement	P	F/G ^d	P/F	F/G ^d	G	F/G	F/G ^d	G	F	F/G	P/F	G	F	G	G	G	G	F/G ^d	G	Slightly resilient
Furane resin	P	P/F	F	G	G	G	G	G	G	G	P/F	G	G	G	G	G	G	G	G	Rigid and tough
Epoxide resin	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	Rigid and tough

NOTE 1 Key

P Poor
 P/F Poor/fair
 F Fair
 F/G Fair/good
 G Good

NOTE 2 This table should be regarded as a general guide to the properties of the materials listed. Precise details of corrosive conditions should be submitted to specialists.

^c For prolonged contact see BS 5385-4.

^d The higher resistance is obtained with certain synthetic rubbers.