

BS 5385-4:2009

Incorporating Corrigendum No. 1



BSI Standards Publication

Wall and floor tiling –

Part 4: Design and installation of ceramic
and mosaic tiling in special conditions –
Code of practice

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Foreword

Publishing information

This part of BS 5385 was published by BSI and came into effect on 1 January 2009. 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This part of BS 5385 supersedes BS 5385-4:1992, which is withdrawn.

Information about this document

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

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

- updated references to take account of the new harmonized European product standards and their supporting suites of test methods.

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

- Wall and floor tiling – Part 1: *Design and installation of internal ceramic, natural stone and mosaic wall tiling in normal conditions – Code of practice*
- Wall and floor tiling – Part 2: *Design and installation of external ceramic and mosaic wall tiling in normal conditions – Code of practice*
- Wall and floor tiling – Part 3: *Design and installation of internal and external ceramic and mosaic floor tiling in normal conditions – Code of practice*
- Wall and floor tiling – Part 5: *Design and installation of terrazzo, natural stone, agglomerated stone tile and slab flooring – Code of practice*

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 BS 5385 is expected to be able to justify any course of action that deviates from its recommendations.

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.

Contractual and legal considerations

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

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

1 Scope

This part of BS 5385 gives recommendations for the design considerations and installation of ceramic wall and floor tiling and mosaics in situations where there are special functional or environmental requirements and/or conditions that are potentially detrimental to either the installation or the background or both. Recommendations are given for the choice of materials, application practices and, where appropriate, for the design of backgrounds and structural bases.

This part of BS 5385 augments the recommendations given in BS 5385-1, BS 5385-2 and BS 5385-3.

NOTE BS 5385-1, BS 5385-2 and BS 5385-3 give recommendations for internal and external, wall and floor tiling and mosaics for; exchanging information, time schedules, suitable materials, tile backgrounds and bases and their preparation, cement:sand rendering, movement joints, bedding methods for tiles and mosaics, grouting, protection, cleaning and maintenance.

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 4027, *Specification for Sulfate-resisting Portland cement*

BS 4247-1, *Surface materials for use in radioactive areas – Methods of measuring and evaluating the decontamination factor*

BS 4247-2, *Surface materials for use in radioactive areas – Guide to the selection of materials*

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

BS 5385-2, *Wall and floor tiling – Part 2: Design and installation of external ceramic and mosaic wall tiling in normal conditions – Code of practice*

BS 5385-3, *Wall and floor tiling – Part 3: Design and installation of internal and external ceramic and mosaic floor tiling – Code of practice*

BS 5385-5, *Wall and floor tiling – Part 5: Design and installation of natural and agglomerated stone and terrazzo tile and slab flooring in normal conditions – Code of practice*

BS 5493, *Code of practice for protective coating of iron and steel structures against corrosion*

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

BS 6349-1, *Maritime structures – Code of practice for general criteria*

BS 7976-2, *Pendulum testers – Method of operation*

BS 8007, *Code of practice for design of concrete structures for retaining aqueous liquids*

BS 8204-1, *Screeds, bases and in-situ floorings. Concrete bases and cement sand levelling screeds to receive floorings – Code of practice*

BS 8204-7, *Screeds, bases and in situ floorings – Part 7: Pumpable self-smoothing screeds – Code of practice*

BS EN 1264-4:2001, *Floor heating – Systems and components – Part 4: Installation*

BS EN 12002, *Adhesives for tiles – Determination of transverse deformation for cementitious adhesives and grouts*

BS EN 12004:2007, *Adhesives for tiles – Requirements, evaluation of conformity, classification and designation*

BS EN 12620, *Aggregates for concrete*

BS EN 13888:2002, *Grouts for tiles – Definitions and specifications*

BS EN 14411:2006, *Ceramic Tiles – Definitions, classification, characteristics and marking*

BS EN 14891, *Liquid applied water impermeable products for use beneath ceramic tiling bonded with adhesives – Requirements, test methods, evaluation of conformity, classification and designation*

3 Terms and definitions

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

3.1 salt water

all types of saline water such as medicinal spa water, used in swimming and hydrotherapy pools, and seawater

3.2 chemical attack

that which occurs when certain materials in tile installations are affected by chemical reaction, e.g. when cementitious bedding and joint filling materials are attacked in acidic conditions

3.3 mildly corrosive situations

situations in which the corrosive substance is of low concentration, or is only mildly aggressive by nature, or is promptly removed after spillage

3.4 highly corrosive situations

situations in which the corrosive substance is highly aggressive, especially if it is likely to remain in contact with the tiling for long periods

3.5 underfloor heating

heating within a screed or base below the tile installation

3.6 undertile heating

heating installed during the tiling process

4 General

The conditions covered in this part of BS 5385 fall into two groups:

- a) conditions to be resisted (see Clause 5 to Clause 10):
 - movement (see Clause 5);
 - traffic and load conditions (see Clause 6);
 - wet and damp conditions (see Clause 7);
 - chemical attack (see Clause 8);
 - thermal effects (climatic and environmental) (see Clause 9);
 - contamination from radioactivity (see Clause 10).
- b) conditions to be achieved (see Clause 11 to Clause 14):
 - sterile conditions (see Clause 11);
 - thermal insulation (see Clause 12);
 - sound insulation (see Clause 13);
 - anti-static conditions (see Clause 14).

For situations where several conditions are present the design specification should be directed towards achieving the most important function required of the system. In some cases a compromise solution might be found for meeting conflicting needs, but this should not be undertaken if its adoption is likely to place the durability of the installation at risk.

Design specifications should meet the most exacting conditions that could be imposed on the installation, even though these might not be sustained and might occur infrequently.

Slip resistance and cleaning should be considered at the design stage. Guidance on these subjects is given in Clause 15 and Annex B.

If an installation is subjected to change of use, introducing conditions different from those originally foreseen, a careful check of the installation should be made to assess its degree of suitability.

Classes of tiles suitable for use in special conditions are given in Table 1 for wall tiling and Table 2 for floor tiling.

Suitability of bedding methods for use in special conditions is given in Table 3 for walls and in Table 4 for floors.

Resistance of tile bed, grout and sealant materials to various liquids is given in Table 5.

NOTE Some adhesives and jointing materials emit odours during curing that might adversely affect foodstuffs and other materials and/or cause discomfort to occupants. It is important that the manufacturer's instructions are closely followed.

Table 1 Suitability of ceramic tiles for wall tiling in special conditions

Special conditions	Product group as classified in Table 1 of BS EN 14411 ^{A)}						Clause reference
		AI	AI _a	BI _a	BI	BIII	
Impact		S	C	S	S	C	6.3
Wet and damp conditions	Installations subject to infrequent contact with water	S	S	S	S	S	7.2.3
	Installations continuously immersed	S	U	S	S	U	7.3
	Installations subject to frequent contact with water	S	C	S	S	C	7.2.4
Chemical attack	Mildly corrosive conditions	C	C	C	C	C	8.4.2
	Highly corrosive conditions	C	C	C	C	C	8.4.3
Sterile conditions		S	C	S	S	S	11
Thermal effects (climatic and environmental)		S	C	S	S	S	9
Thermal insulation		S	S	S	S	S	12
Sound insulation		S	S	S	S	S	13
Radioactivity		C	U	C	C	U	10

S Suitable

U Unsuitable

C Confirm tiles suitability with the manufacturer

^{A)} For product groups not shown in the table, determine their suitability with the tile manufacturer

Table 2 Suitability of ceramic tiles for floor tiling in special conditions

Special conditions	Product group as classified in Table 1 of BS EN 14411 ^{A)}						Clause reference
		AI	AI _a	BI _a	BI	BIII	
Impact	Light to moderate loads and impact	S	S	S	S	C	6.1
	Heavy loads and impact	S	S	S	S	U	6.1
Wet and damp conditions	Installations subject to infrequent contact with water	S	S	S	S	S	7.2.3
	Installations continuously immersed	S	C	S	S	C	7.3
	Installations subject to frequent contact with water	C	C	C	C	C	8.4.2
Chemical attack	Mildly corrosive conditions	C	C	C	C	C	8.4.2
	Highly corrosive conditions	S	C	S	S	S	8.4.3
Sterile conditions		S	C	S	S	C	11
Thermal effects (climatic and environmental)		S	S	S	S	S	9
Thermal insulation		S	S	S	S	S	12
Sound insulation		C	U	C	C	U	13
Radioactivity		C	U	C	C	U	10

S Suitable

U Unsuitable

C Confirm tiles suitability with the manufacturer

^{A)} For product groups not shown in the table, determine their suitability with the tile manufacturer

Table 3 Suitability of bedding methods for wall tiling in special conditions

Special conditions		Bedding methods				Clause reference
		Cementitious adhesives	Reaction resin adhesives	Dispersion adhesives	Cement:sand mortar	
Impact		S	S	C	S	6.3
Wet and damp conditions	Installations subject to high humidity and occasional wetting	S	S	C	S	7.2.2 and 7.2.3
	Installations subject to frequent contact with water	S	S	C	S	7.2.4
	Installations continually immersed	C	S	U	S	7.3
Chemical attack	Mildly corrosive conditions	C	C	C	U	8.4.2
	Highly corrosive conditions	U	C	U	U	8.4.3
Sterile conditions		S	S	C	S	11
Thermal effects (climatic and environmental)		S	C	C	S	9
Thermal insulation		S	S	S	S	12
Sound insulation		S	C	S	U	13
Radioactivity		S	S	S	S	10

S Suitable

U Unsuitable

C Confirm adhesives suitability with the manufacturer

Table 4 Suitability of bedding methods for floor tiling in special conditions

Special conditions		Bedding methods				Clause reference
		Cementitious adhesives	Reaction resin adhesives	Cement:sand mortar (including semi-dry mix)	Cement:sand mortar over separating layer	
Traffic and load conditions	Light to moderate loads and impact	S	S	S	S	6
	Heavy loads and impact	S ^{B)}	C	S ^{A)}	U	6
Wet and damp conditions	Installations subject to high humidity and occasional wetting	S	S	S	S	7.2.2 and 7.2.3
	Installations subject to frequent contact with water	S	S	S ^{A)}	U	7.2.4
	Installations continually immersed	S	C	S ^{A)}	U	7.3
Chemical attack	Mildly corrosive conditions	S	S	S	S	8.4.2
	Highly corrosive conditions	U	C	U	U	8.4.3
Sterile conditions		S	S	S	S	11
Thermal effects (climatic and environmental)		S	S	S	S	9
Thermal insulation		S	S	S	S	12
Sound insulation by methods a) and b)		C	C	U	U	13
On thick screed over a sound-absorbent layer		S	S	S	S	13.1
Electrostatic conditions		S	S	S	S	14
Radioactivity		S	S	S	S	10

S Suitable

U Unsuitable

C Confirm adhesives suitability with the manufacturer

A) Bonded to the base

B) Cementitious adhesives modified with rubber might have reduced impact resistance

5 Movement

5.1 General

NOTE Stresses could be created in the tiling system as a result of movement due to factors such as drying shrinkage (see 5.2) and moisture movement (see 5.3) in the background and thermal and moisture changes in the tiling. These stresses, if not properly controlled, can sometimes be sufficient to promote loss of adhesion and bulging or cracking of the tiling. There are also sources of movement external to the tiling system that might affect the tiles themselves, e.g. settlement and subsidence of buildings, vibration and lift shafts and machinery. Settlement, subsidence and vibration are uncommon sources of trouble, but where the stresses they promote are considerable, wall and floor tiling are likely to be affected.

No precautions can be taken at the time of tiling to eliminate the effects of settlement and subsidence but the use of a deformable adhesive can be beneficial in reducing the effects of vibration and specialist advice should be sought. With other sources of movement, there are positive steps that should be taken to reduce the risk of tiles being damaged during their service life.

5.2 Drying shrinkage movement

Drying shrinkage movement of backgrounds is the most common source of movement in tile installations and it is important that new constructions should be allowed to dry out before tiles are fixed. Minimum drying times in accordance with BS 5385-1, BS 5385-2 and BS 5385-3 should be followed. The times given might require considerable extension depending on the site conditions, thickness and mass of the structure. Longer drying times are recommended for concrete pools and tanks (see 7.3.2).

5.3 Moisture movement

NOTE Porous materials can absorb moisture from the atmosphere and might expand as a result. Conversely, some porous materials contract when they dry out. When these changes are small they do not create problems; but if the size changes are appreciable and ceramic tiles are fixed to such backgrounds, the tiling will be subjected to stress and some loss of adhesion or cracking can result.

5.3.1 Walls

Backgrounds of porous materials having appreciable moisture movements should be thoroughly dry before fixing commences. If these backgrounds are rendered or plastered at least a further two weeks and four weeks respectively should be allowed for further drying.

It is essential that movement joints be provided where necessary according to the guidance given in 5.7 and 6.6.

The walls of premises that are closed for appreciable periods in winter and have no space heating might become damp and expand. In extreme conditions such premises are liable to frost damage and should have provision for automatic heating.

5.3.2 Floors

Moisture movement is unlikely to be a factor in floors of concrete or screeded concrete construction. It assumes greater importance where the base is of timber construction. Timber sub floors prone to distortion as a consequence of moisture absorption should be avoided where their use is detrimental to the installation (see BS 5385-3).

5.4 Moisture movement (long-term expansion)

In common with most porous ceramic materials, tiles with water absorptions greater than 3% could expand slightly as a result of the gradual uptake of moisture irrespective of the level of dampness in the installation. Where water absorption is below 3%, tiles have negligible expansion. The fixing methods and the provision of expansion joints recommended in this standard should be followed in order to accommodate long-term expansion.

5.5 Thermal movement

Where thermal movement in tiling occurs the recommendations in 12.4 should be followed.

5.6 Vibration

Where vibration, from machinery located on or adjacent to walls for example, is likely to subject wall tiling to small but constant movement, a deformable adhesive classified S1 or S2 according to BS EN 12002, should be used to fix the tiles.

Where vibration affects floor tiling an S1 or S2 classified adhesive laid onto an unbonded screed can be used or the semi dry mix method or the separating layer method, incorporating an adhesive slurry bonding coat, might be used.

NOTE S2 classified adhesives are not suitable in heavily trafficked floor areas.

5.7 Movement joints

Stresses in wall and floor tile installations should be controlled by incorporating adequate movement joints (see 6.6). Unless recommendations specific to tiling in special conditions are given in this part of BS 5385 for materials, design and location of the movement joints, reference should be made to one of the following:

- a) internal wall tiling, BS 5385-1;
- b) external wall tiling, BS 5385-2;
- c) floor tiling, BS 5385-3.

6 Traffic and load

6.1 General

For floor tiling subject to light traffic only, i.e. low density pedestrian and lightweight soft-wheeled vehicular traffic, the recommendations in BS 5385-3, including solid bedding, should be followed.

Pedestrian traffic of high density, heavy vehicular traffic and the dragging of heavy objects and loads can result in damage due to dynamic and static loading, impact and abrasion. This can be severe and further precautions should be taken. The additional resistance to damage should be achieved by solidly bedding sufficiently thick ceramic tiles directly to a structural concrete or sound cement:sand screed.

Where tiles are to be bedded on a cement:sand screed, the screed should be suitable for the anticipated load and be tested for soundness by the method given in BS 8204-1. In the area in which the screed is tested, 90% of all indentations should be category A, i.e. a maximum depth of three millimetres.

Materials and the method of application should be selected to resist the most arduous conditions likely to be imposed on the tiling, no matter how infrequently, during the life of the installation.

6.2 Dynamic and static loading

6.2.1 General

Compressive forces are exerted by dynamic and static loading and by some kinds of impact; to reduce the incidence of damage from these forces there should be no voids within the system.

6.2.2 Floor tiling

NOTE 1 Severe loading arises from high-density pedestrian and heavy vehicular traffic (dynamic) and from heavy standing loads and objects (static).

Vehicular traffic is essentially of two types, heavy vehicles with pneumatic tyres and trolleys and forklift trucks with small wheels generally with solid tyres.

The loads exerted by moving vehicular traffic at constant speed on level surfaces are the same as the static loads which the vehicles at rest exert. The highest loads under moving traffic occur from bouncing on uneven surfaces. The maximum load that can be exerted is twice the static load. An adequate safety margin for ceramic flooring subject to vehicular traffic is therefore provided by assuming a factor of two.

NOTE 2 The most severe stresses are exerted by small hard-rimmed wheels, and the harder the rim the smaller the area of contact and, therefore, the greater the static load.

Acceleration and deceleration of heavy vehicles with pneumatic tyres exert little additional load on floors because the speed is usually low.

In situations where heavy loads are involved, especially when carried by vehicles with hard-rimmed wheels, the strength of the floor is improved by the use of the denser and thicker types of tile. Damage can arise from the bouncing and gouging of hard wheels, especially metal-shod wheels; the smaller the wheels the greater the risk. Tiles should be chosen of different thicknesses each appropriate to the operations and traffic load in a given area.

In areas where only vehicles with pneumatic tyres are used it is possible to lay floor tiles with relief surfaces in order to provide improved slip-resistance. Generally, however, for vehicular traffic areas and always for areas carrying vehicles with hard-rimmed wheels, the

tiles should have plane or low-relief surfaces. Tile joints should be solidly filled with grout as far as practicable.

In situations of extremely high dynamic and static loading, methods incorporating cement:sand mortar or cementitious adhesives are generally suitable, with the exception of the separating layer method. However, the semi-dry mortar method, which is designed to provide a cleavage plane between the bedding and the base, should be modified for use in severe conditions so that cleavage is prevented. The mortar bed should be bonded to the base with a slurry of either neat cement or 1 part cement and 1 part clean, fine, sharp sand, brushed over the base just prior to the semi-dry mortar being spread. The mortar bed should be compacted thoroughly so that consistent strength is achieved throughout its thickness.

The suitability of classes of floor tiles and bedding methods for different conditions is given in Table 2 and Table 4 respectively.

In all cases the structural base should be dense concrete and it is important that this is strong, rigid and allowed to mature after curing for at least 6 weeks before a screed or tiling by direct bedding is applied. A longer drying period might be necessary in poor drying conditions. Sub floors constructed using insulation layers of low density such as expanded polystyrene are not suitable in situations of extremely high dynamic and static loading.

6.3 Impact

COMMENTARY ON 6.3

Damage from impacts can range from minor chips in the face of the tiles through to large cracks that extend into the underlying layers. Once damage has occurred it could be rapidly extended by subsequent impacts, for example, truck wheels meeting a hole in a surface not only tend to remove further material but might also bounce resulting in further impact a short distance away.

6.3.1 Floor tiling

It should be assumed that damage from impact is a potential hazard to flooring in any situation subject to rugged usage, where, for example, operations involve heavy trucking or the dropping of heavy loads, equipment and tools. Compressive forces are exerted where impact occurs.

It is recommended therefore that all the precautions in 13.1 be observed. Additionally, projecting edges in the tiling should be avoided in order to prevent multiple impacts from the bouncing of truck wheels.

6.3.2 Wall tiling

For installations in areas subject to direct impact, including those exposed to vandalism, strong dense backgrounds are preferred, e.g. walls of concrete or clay brick construction. If the walls have to be treated by the application of a levelling layer cement:sand mortar rendering should be used. Plaster is not suitable.

Where severe impacts might occur the tiles should be fixed in a solid tile bed. Additional protection can be provided by the use of thicker tiles. Tiles should have plane (non-relief) surfaces and there should