BS 5385-4:2015

BSI Standards Publication

Wall and floor tiling –

Part 4: Design and installation of ceramic and mosaic tiling in specific 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 ii, pages 1 to 38, 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 31 October 2015. 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This part of BS 5385 supersedes BS 5385-4:2009, which is withdrawn.

Information about this document

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

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

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

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

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.

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 specific functional, e.g. sterile conditions, or environmental requirements, e.g. wet areas, and conditions that are potentially detrimental, e.g. chemical attack, to either or both the installation or the background. 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 and 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 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 5385-2:2014, *Wall and floor tiling – Part 2: Design and installation of external ceramic and mosaic wall tiling in normal conditions – Code of practice*

BS 5385-3:2014, *Wall and floor tiling – Part 3: Design and installation of internal and external ceramic and mosaic floor tiling – 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 – Part 1: Code of practice for general criteria*

BS 8204-1, *Screeds, bases and in-situ floorings – Part 1: Concrete bases and cementitious levelling screeds to receive floorings – Code of practice*

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

BS EN 12002:2008, *Adhesives for tiles –Determination of transverse deformation for cementitious adhesives and grouts*

BS EN 12004:2007+A1:2012, *Adhesives for tiles – Requirements, evaluation of conformity, classification and designation*

BS EN 12620, *Aggregates for concrete*

BS EN 13888:2009, *Grouts for tiles – Requirements, evaluation of conformity, classification and designation*

BS EN 14411:2012, *Ceramic tiles – Definitions, classification, characteristics, evaluation of conformity and marking*

NA to BS EN 1992-3, *UK National Annex to Eurocode 2: Design of concrete structures – Part 3: Liquid retaining and containment structures*

3 Terms and definitions

For the purposes of this part of BS 5385, the terms and definitions given in BS 5385-1, BS 5385-2, BS 5385-3, 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

NOTE For example, 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

4 General

*COMMENTARY ON CLAUSE **4***

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.

*NOTE 1 Guidance on these subjects is given in Clause **15** and Annex A.*

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.

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

NOTE 3 Suitability of bedding methods for use in specific conditions are given in Table 3 for walls and in Table 4 for floors.

Recommendations given in Table 1, Table 2, Table 3 and Table 4 regarding suitability should be read only in conjunction with the specified clauses.

NOTE 4 Resistance of tile bed, grout and sealant materials to various liquids are given in Table 5.

As some adhesives and jointing materials emit odours during curing that might adversely affect foodstuffs and other materials and/or cause discomfort to occupants, the manufacturer's instructions should be closely followed.

Table 1 **Suitability of ceramic tiles for internal wall tiling in specific conditions**

Specific conditions		Product group as classified in BS EN 14411:2012, Table 1					Clause reference
		AI_a BI_a <0.5%	AI_b BI_b 0.5% to 3%	AII_a BII_a 3% to 6%	AII_b BII_b 6% to 10%	AIII BIII >10%	
Impact		S	S	S	C	C	6.3
Wet and damp conditions	installations subject to occasional wetting	S	S	S	S	S	7.2.3
	installations continuously immersed	S	S	S	U	U	7.3
	installations subject to frequent wetting	S	S	S	C	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	S	S	C	S	11
Thermal effects (climatic and environmental)		S	S	S	C	C	9
Thermal insulation		S	S	S	S	S	12
Sound insulation		S	S	S	S	S	13
Radioactivity		C	C	C	U	U	10

S - Suitable

U - Unsuitable

C - Confirm tiles' suitability with the manufacturer

Table 2 **Suitability of ceramic tiles for internal floor tiling in specific conditions**

Specific conditions		Product group as classified in BS EN 14411:2012, Table 1					Clause reference
		AI_a BI_a <0.5%	AI_b BI_b 0.5% to 3%	AII_a BII_a 3% to 6%	AII_b BII_b 6% to 10%	AIII BIII >10%	
Impact	light to moderate loads and impact	S	S	S	S	U	6.1
	heavy loads and impact	C	C	C	C	U	6.1
Wet and damp conditions	installations subject to occasional wetting	S	S	S	S	C	7.2.3
	installations continuously immersed	S	S	C	U	U	7.3
	installations subject to frequent wetting	S	S	C	C	U	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	S	C	C	C	11
Thermal effects (climatic and environmental)		S	C	C	C	C	9
Thermal insulation		S	S	S	C	C	12
Sound insulation		S	C	C	U	U	13
Radioactivity		S	C	U	U	U	10

S - Suitable

U - Unsuitable

C - Confirm tiles suitability with the manufacturer

Table 3 **Suitability of bedding methods for wall tiling in specific conditions**

Specific conditions		Bedding methods			Clause reference
		Cementitious adhesives	Reaction resin adhesives	Dispersion adhesives	
Impact		S	S	C	**6.3**
Wet and damp conditions	installations subject to high humidity and occasional wetting	S	S	C	**7.2.2 and 7.2.3**
	installations continuously immersed	C	C	U	**7.3**
	installations subject to frequent wetting	S	S	C	**7.2.4**
Chemical attack	mildly corrosive conditions	C	C	C	**8.4.2**
	highly corrosive conditions	U	C	U	**8.4.3**
Sterile conditions		S	S	C	**11**
Thermal effects (climatic and environmental)		C	C	C	**9**
Thermal insulation		S	C	S	**12**
Sound insulation		S	C	S	**13**
Radioactivity		S	S	S	**10**

S - Suitable

U - Unsuitable

C - Confirm tiles' suitability with the manufacturer

Table 4 **Suitability of bedding methods for floor tiling in specific conditions**

Specific conditions		Bedding methods		Clause reference
		Cementitious adhesives	Reaction resin adhesives	
Traffic and load conditions	light to moderate loads and impact	S	S	**6**
	heavy loads and impact	S [A)]	S	**6**
Wet and damp conditions	installations subject to high humidity and occasional wetting	S	S	**7.2.2 and 7.2.3**
	installations continuously immersed	S	C	**7.3**
	installations subject to frequent wetting	S	S	**7.2.4**
Chemical attack	mildly corrosive conditions	S	C	**8.4.2**
	highly corrosive conditions	U	C	**8.4.3**
Sterile conditions		S	S	**11**
Thermal effects (climatic and environmental)		C	C	**9**
Thermal insulation		S	S	**12**
Sound insulation by methods in **13.2** a) and b)		C	C	**13.2**
On thick screed over a sound-absorbent layer		S	S	**13.2**
Electrostatic conditions		S	S	**14**
Radioactivity		S	S	**10**

S - Suitable

U - Unsuitable

C - Confirm tiles' suitability with the manufacturer

[A)] Cementitious adhesives modified with resilient fillers 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.

NOTE The times given might require considerable extension depending on the site conditions, thickness and mass of the structure.

Longer drying times should be given for concrete pools and tanks (see **7.3.2**).

5.3 Moisture movement

*COMMENTARY ON **5.3***

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 drying.

Movement joints should be provided where necessary in accordance with **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

NOTE Moisture movement is unlikely to be a factor in mature sub-floors of concrete or screeded concrete construction.

As timber sub-floors are prone to distortion as a consequence of moisture absorption, they should be avoided where their use is detrimental to the installation (see BS 5385-3).

5.4 Moisture movement (long-term expansion)

NOTE In common with most porous ceramic materials, tiles with water absorptions more 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 less than 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 in accordance with BS EN 12002:2008, should be used to fix the tiles.

NOTE 1 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.

The area subject to vibration should be isolated from adjacent static areas.

NOTE 2 S2 classified adhesives and unbonded screeds 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 specific 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 and sand screed.

Where tiles are to be bedded on a cement and sand screed, the screed should be suitable for the anticipated load and be tested for soundness in accordance with 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 3 mm.

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

*COMMENTARY ON **6.2.2***

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. An adequate safety margin for ceramic flooring is advised.

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.

NOTE 1 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.

NOTE 2 A longer drying period might be necessary in poor drying conditions.

NOTE 3 Sub floors constructed using insulation boards 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 cause more damage 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 heavy usage, where, for example, operations involve heavy trucking or the dropping of heavy loads, equipment and tools.

Compressive forces are exerted where impact occurs; therefore all precautions in **13.2** should 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 should be used e.g. walls of concrete or clay brick construction. If the walls have to be treated by the application of a levelling layer cement and sand mortar rendering should be used. Plaster is not suitable and should not be used.

Where severe impacts might occur the tiles should be fixed in a solid tile bed and additional protection can be provided by the use of thicker tiles. Tiles should have plane (non-relief) surfaces and there should be no projecting edges.

NOTE Minor chipping by point impacts cannot be avoided by these precautions.

The choice of tile bed can be complicated by other factors, e.g. movement or vibration, but, if possible, a rigid material should be used and for most installations a cementitious adhesive is preferred.

6.4 Abrasion

6.4.1 General

NOTE 1 For resistance to abrasion, physical toughness of the tile surface and a floor finish free from irregularities are basic provisions.

NOTE 2 High density pedestrian traffic, the movement of heavy objects on unprotected floor surfaces and the frequent use of abrasive cleaners can lead to wear. The effect is most marked at concentrated traffic areas, for example at doorways and cashpoints.

At external entrances, floors should be protected against the ingress of water and abrasive dirt by providing footwear cleaning devices, e.g. barrier mats; these mats might be required for a distance not greater than 6 m from the entrance depending on the position and traffic conditions.

NOTE 3 Recommendations for cleaning and maintenance routines are given in BS 5385-3.

6.4.2 Floor tiles

For very severe conditions of wear, unglazed tiles conforming to BS EN 14411:2012, AI_a, AI_b, BI_a, BI_b should be used.

6.5 Floor tile joints

As a general rule, the width of joints in ceramic tiling should not exceed the tile thickness. The width should be not less than 3 mm.

Wherever practicable, it should be ensured that the depth of the joints is at least 6 mm.

NOTE Wider joints, e.g. 10 mm wide, might be required to accommodate dimensional irregularities in the tiles, to maintain modular discipline or to provide a decorative effect.

For joints wider than 10 mm, consideration should be given to the use of proprietary grouts specially formulated to have low shrinkage with enhanced resistance to impact and abrasion.

6.6 Movement joints

Some movement joints are not designed to take trafficking or support loads; where subject to transient loading, movement joints should be kept to the minimum width necessary to accommodate the anticipated movement and should be sufficiently narrow to allow trafficking by heavy loads without the edges of the tiles being damaged. As far as possible, movement joints should be positioned to avoid the most obvious locations of impact and loading.

However, it is still likely that some joints will have to be sited in vulnerable positions and consideration should then be given to the use of proprietary pre-formed sections incorporating metal or rigid plastic angles, to protect the tile edges in accordance with BS 5385-3. Care should be taken to avoid projections above the level of the tiling.

Sealants are designed to be flexible to accommodate movement and thus do not readily withstand trafficking or support loads; where joints are subject to abrasion, only the harder sealants should be used.

NOTE Epoxide polysulfide and flexibilized epoxide sealants have the best resistance to impact and abrasion but only accommodate small amounts of movement. The harder (high modulus) polysulfide, silicone and polyurethane sealants possess good levels of elasticity and tend to recover well after deformation. They also tend to repel small particles but can be penetrated by sharp objects or lose adhesion under severe loading.

Most sealants, gun-applied, pourable or pre-formed, possess good slip resistant properties in dry conditions; in wet areas, epoxide polysulfide, flexibilized epoxides and silicones in particular can be slippery and joint widths in such areas should be kept to a minimum to reduce the possibility of accidents occurring.

The choice of sealant depends on factors such as movement accommodation, joint design, traffic loading, resistance to chemical attack, location in relation to wear, penetration of grit and other forms of contamination and resistance to the likely cleaning processes; in each case the manufacturers' advice should be sought.

7 Wet and damp conditions

7.1 General

The nature of any liquid involved should be known before the specification for the installation is determined.

NOTE Liquids include potable water, salt water, water treated with additives, contaminated water and liquids other than water; some might be aggressive.

7.2 Wet and damp conditions (not continuously immersed)

7.2.1 General

The effect of damp and wet conditions on tiled installations depends upon the degree of contact with, and the nature of, the liquids involved; when these conditions are accompanied by environmental influences, other factors should be considered such as condensation, humidity and temperature.

Tile and mosaic installations subject to damp and wet conditions should be divided into three groups as follows:

a) installations in high humidity areas (see **7.2.2**);

b) installations not immersed but subject to occasional wetting (see **7.2.3**);

c) installations not immersed but subject to frequent wetting (see **7.2.4**).

NOTE 1 Soluble sulfates are present in some backgrounds such as brickwork. If these backgrounds become wet, soluble sulfates can migrate in sufficient quantities into cement-based mortars and cause damage from sulfate attack. This type of damage is likely to affect the adhesion of cement and sand renders/beds and cement-based adhesives.

Gypsum plaster (calcium sulfate) based materials should not be used as backings for ceramic tiling in wet or damp conditions due to the deleterious effect of soluble sulfate on cement and sand renders/beds and cement-based adhesives.

NOTE 2 Excessive quantities of certain soluble salts, e.g. carbonates and sulfates of sodium and potassium, produce irreversible expansion of porous ceramic tiles, sufficient to promote crazing, cracking or adhesion failures. This is not a common problem, but might be encountered occasionally in damp or wet installations such as in floors with a defective damp-proof course, retaining walls and underpasses.

Where joints between tiles in sterile areas (e.g. yeast fermentation rooms) need to be impervious and bacteriologically-sterile, particular care should be taken when selecting the grout (see **11.1**).

Tile fixing should be carried out by one of the suitable methods given in Table 3 and Table 4.

Movement joints might be required and should be determined at the design stage. The installation should not be put into use for at least two weeks after completion of tile fixing, grouting and movement joints to allow proper curing of all material involved.

7.2.2 Installations in high humidity areas

In areas with a constant high humidity, e.g. saunas and steam rooms, **7.2.1** and the following apply.

a) The background should preferably be cement and sand rendering or dense concrete. Tiles should be solidly bedded in a water-resistant adhesive.

b) The joints between the tiles should be water-resistant; additional protection can be obtained by using an impervious grout.

c) Most sealants should perform satisfactorily under wide variations of humidity in service and require dry surfaces at the time of application. Some one-part sealants, in particular one-part polysulfide sealants, are slow curing under conditions of low humidity.

7.2.3 Installations not immersed but subject to occasional wetting

In installations where contact with water is only intermittent, and the installation has an opportunity to dry out between periods of use, e.g. domestic (not power) showers, **7.2.1** and the following should apply.

a) The background should preferably be cement and sand rendering or dense concrete. Sheet and boards should not be used unless they are dimensionally stable in changing moisture conditions. Tiles should be solidly bedded in a water-resistant adhesive.

b) The joints between the tiles should be water-resistant but additional protection can be obtained by using an impervious grout.

c) The gaps between wall and shower tray/bath should be sealed, particularly where the installation is located on a suspended floor.

NOTE 1 For water sensitive backgrounds e.g. gypsum plaster, additional protection in the form of a waterproofing tanking system may be considered.

NOTE 2 The use of impervious grouts and adhesives is no substitute for a tanked installation.

7.2.4 Installations not immersed but subject to frequent wetting

In the case of those installations not subject to continuous immersion but where there is frequent wetting with water, e.g. wet rooms, domestic power showers, communal showers and pool halls, **7.2.1** and the following should apply.

a) The basic structure behind the tiles should be watertight. Since there is likely to be relatively little opportunity for the installation to dry out between periods of use, it should be tanked (see **8.2.1**).

b) Water-resistant materials should be used throughout, i.e. cement mortar screed or rendering, bedding material and grouting should be capable of withstanding continuous contact with water without deterioration. Plaster and plasterboard, for instance, would be unsuitable in frequently wetted areas.

c) The tiles should be solidly bedded so that voids behind them are eliminated as far as possible.

d) When the installation is tanked and water-resistant materials are used throughout, it is not essential to use an impervious grouting material. Cementitious grouting compositions could then be specified instead.

e) Special attention should be paid to sealing the gaps between wall and base, particularly if the installation is on a suspended floor.

f) Where movement joints are subject to water immersion, water spray or splash, the joints should be sealed with curing sealants such as the epoxide polysulfides, flexibilized epoxide, two-part polysulfides, silicones or polyurethanes.

7.3 Wet conditions (continuously immersed)

7.3.1 General

The basic structure behind the tiling should be watertight. Additionally, screed or rendering, bedding material and grouts should withstand continuous contact with the immersion liquid without deterioration.

NOTE Cementitious grouting compositions are usually porous, and although integral waterproofers can be incorporated, they do not make the joints impervious.

The most common installations subject to continuous immersion are those in various kinds of pools, baths, tanks and reservoirs; in these situations there are many different service requirements and related factors such as the background structure, its subsequent treatment, the choice of tiled finish and its application, intervals between operations, the nature of the liquid concerned, temperatures and potential movement should be established.

7.3.2 Internal swimming pools of concrete construction (excluding salt water pools)

7.3.2.1 General

Ideally the sulfate concentration (SO_3) of water in swimming pools should not exceed 300 mg/L. Where greater concentrations of sulfates cannot be avoided, impermeable adhesives and grouting materials that are not affected by sulfates should be used. High levels of sulfate would otherwise react with and erode materials containing Portland cement (CEM 1).

The structural shell of indoor swimming pools containing mains (potable) water should be designed and constructed of reinforced or prestressed concrete or gunite (pneumatically applied cement and sand mortar or concrete). The design, specification, and construction should be in accordance with NA to BS EN 1992-3. If possible there should be no structural movement joints. The following recommendations apply in addition to those given in **7.3.1**.

a) Any cracks in the concrete, including those which conform to the limit stated in the design principles set out in NA to BS EN 1992-3 and cracks arising from thermal contraction in the early life of the concrete, should be effectively repaired prior to the application of any screed or rendering or other coatings to the floor and walls.

b) The mortar or concrete should be batched by mass and should consist of cement and fine and coarse aggregate conforming to BS EN 12620.

c) The free water:cement ratio for concrete and mortar used for the structural shell should be not greater than 0.5.

The surface of the concrete/gunite of the pool shell to receive rendering or screed, tiling or mosaic, should be prepared in such a way that maximum adhesion is acheived.

NOTE Methods for the preparatory work for walls and floors are described in BS 5385-2 and BS 5385-3 respectively.

A water tightness test should be undertaken over a seven day period. During the seven day test period the total permissible drop in water level after allowing for evaporation should not exceed 1/500 of the average water depth of the full tank, 10 mm or another specified amount such as The Swimming Pool and Allied Trades Association (SPATA) standard of 12 mm.

Before application of render, screed or tile finishes is carried out, the shell of the pool should be tested and proved to be watertight. The advice of the manufacturer should be obtained for all ceramic materials and components in swimming pools, including overflow channels, pool ladders, steps, etc. Some internal pools might on occasion be subjected to freezing conditions and, where this is likely, frost-resistant materials should be used.

Adhesives for use in the pool shell should conform to the requirements for a type C cementitious adhesive or type R reaction resin adhesive in accordance with BS EN 12004:2007+A1:2012 and should be suitable for continuous immersion.

Some concrete swimming pools have been constructed so precisely, that direct fixing with adhesives, is feasible. However, these are exceptional, and, of necessity, the costs of obtaining such precision casting are usually high. In most cases, therefore, the walls should be rendered and a screed provided on the floor to ensure a true and even surface.

The minimum time intervals that should be allowed to elapse between the successive stages are:

a) between curing of the pool shell and rendering or screeding: six weeks;

b) between completion of rendering or screeding and the commencement of tile fixing: three weeks;

c) between completion of tile fixing and the commencement of grouting: three days;

d) between completion of the grouting, movement joints and the filling of the pool: three weeks.

Under no circumstances should these time intervals be reduced. In wet weather or poor drying conditions a longer period should be allowed.

7.3.2.2 Pool surrounds

To minimize ponding, pool surrounds should be constructed with adequate gradients and should drain to appropriately sited outlets or channels. Nominally level floors do not drain satisfactorily and pool surrounds should have a gradient, but it should be not steeper than 1:35 nor shallower than 1:80.

NOTE 1 Small changes in gradient on wet floors can cause problems for pedestrians. The slip potential of pool surrounds is affected by contaminated water (chemicals), contamination of the floor by body fats, contaminated feet (contaminated water and body fats) and the gradient.

Tiles of appropriate slip resistance should be used (see **15.2** and Annex A).

NOTE 2 Further guidance can be found in Slip resistance of Hard Flooring *[1].*

7.3.2.3 Pool walls (rendering)

The walls of the pool shell should be rendered in accordance with BS 5385-2.

The rendering should be completed at least 21 days before tiling begins in order for the prepared surface to be dry to receive the tiles. When a bonding agent is used to achieve improved adhesion of the rendering to its background, the agent should be of a water-resistant type.

Bonding agents based on polyvinyl acetate do not have good water resistance and should not be specified for use in swimming pools.

7.3.2.4 Pool floors (screeds)

As the normal method of laying floor screeds in swimming pools is by separate construction, i.e. the screed is laid after the concrete of the pool shell has hardened (see **7.3.2.1**) the screed should be well bonded to the surface of the concrete. Immediately before laying the screed, the prepared surface of the concrete should be brushed with cementitious slurry or a bonding agent specifically recommended for use in swimming pools.

NOTE 1 Such a bonding agent can either be used neat or mixed with cement according to the recommendations of the manufacturer.

The concrete base should be accurately installed to allow a bonded screed thickness of between 25 mm to 50 mm to be maintained over the whole floor area.

The mix proportions of cement and sand for the screed should be between 1:3 and 1:4.5, by mass. The water:cement ratio should be kept as low as possible, compatible with sufficient workability to ensure full compaction; in practice this is likely to mean a water:cement ratio of approximately 0.5.

Careful curing of the screed is of great importance. Curing should start immediately once the screed is compacted and finished; to ensure this, each completed area should be covered without delay using polyethylene sheets well lapped and weighted down around the edges to prevent wind blowing underneath. Curing should continue for 7 days in good conditions and a further drying-out period of 14 days should be allowed before the application of tiling begins. The screed should be left with a wood float finish.

NOTE 2 For further information on the laying of floor screeds refer to BS 5385-3.

7.3.2.5 Fixing tiles to the pool shell (floor and walls)

For the installation of tiles with shallow key backs, bedding in cementitious adhesives or organic adhesives is considered the most suitable. Adhesives should be water resistant.

The tiles should be solidly bedded so that voids behind them are eliminated as far as possible.

NOTE 1 Suitable methods of bedding wall and floor tiles are given in Table 3 and Table 4 respectively.

NOTE 2 A semi-dry mix mortar bed is suitable only when a slurry bonding layer is also applied between the semi-dry mortar and the base.

Some adhesives are not suitable for the fixing of tiles with backs incorporating deep keys or frogs; for these, an appropriate adhesive or cement and sand mortar should be used.

7.3.2.6 Fixing floor tiles to the pool surround and adjacent areas

The tiles should be solidly bedded so that voids are eliminated beneath them as far as possible.

NOTE Suitable bedding methods are given in Table 4.

Problems might arise where the floor areas have to be tanked to prevent penetration of water to underlying corridors, electrical equipment and other services; in these circumstances, safeguards necessary to prevent water penetration should be incorporated in the design of the structure and drainage system. It should not be assumed that the degree of protection against water penetration given by the tiling is adequate.

7.3.2.7 Grouting in swimming pools

Proprietary grouts should be specified, selected for their suitability to meet the service conditions anticipated and should be used in accordance with the grout manufacturer's instructions.

Epoxide resin grouts should be used to ensure long term durability: where the pool water is soft, i.e. with low levels of calcium (temporary hardness), where acidic cleaning agents are used and especially for heavily used free-form pools with simulated beaches, wave machines and similar machines that cause rapid water movement (see **7.3.2.9**).

Where the pool water is hard or can be maintained at a calcium level over 250 mg/L, expressed as calcium carbonate, grouts for use in the pool shell should conform to a CG2 improved cementitious grout in accordance with BS EN 13888:2009. Where the pool water is soft (low calcium level) and classed as aggressive or where intensive cleaning and high levels of abrasion take place, either reaction resin RG (usually epoxide), or some specially modified CG2 grouts in accordance with BS EN 13888:2009 should be used.

7.3.2.8 Movement joints in swimming pools

Most pools do not have movement joints in the structural concrete shell; older pools could have movement joints, which might be sources of water leakage and should be carried through to the face of the tiling.

NOTE 1 See the movement joint clauses in BS 5385-2 and BS 5385-3.

Movement joints should be incorporated in pool lining around the perimeter at the junction of the bottom and sides, at vertical corners and at any change of plane in the bottom; it is advisable to insert additional movement joints down the pool sides and across the bottom in a continuous loop at approximately 6 m intervals.

Movement joints should be inserted to coincide with the structural junction of the pool shell and the surround slab and where pool surround tiling abuts walls, drainage channels and other features. Intermediate movement joints should be inserted at intervals of 6 m or less, except for mosaics where they are not required.

Movement joints should be filled completely with a suitable sealant.

NOTE 2 Alternatively, the joints can be part-filled with compressible filler such as polyethylene foam strip and completed with the sealing compound. It is important to prepare the joints correctly, and whichever sealant is chosen it is advisable to consult the manufacturer concerning choice and method of application.

The sealant should not only accommodate the movement in the tiling but also resist the chemical attack due to chlorine and other additives used in the water and in cleaning agents.

NOTE 3 The joints are also vulnerable to physical damage.

NOTE 4 In general the polysulfide or silicone sealants are preferred. Silicone sealants require dry conditions at the time of application and careful preparation and priming of the joints, otherwise they are susceptible to adhesion loss and the sealant can easily be removed.

7.3.2.9 Pool water conditions

NOTE The durability of the grouting depends on the nature of the pool water supply and the chemicals used in the treatment of the water and the cleaning of the tiling.

Cementitious grouts should only be used where the pool water has adequate calcium hardness and alkalinity so that balanced water conditions can be consistently maintained at the recommended pH level.

Most pool chemicals should be dissolved and added to pool water as a solution. With the exception of some proprietary materials in tablet form, no chemicals should be left undissolved on top of the pool floor tiling since the localized concentrated solution might be sufficiently aggressive to erode cementitious grouts and even erode the tile glaze.

The use of sulfate containing chemicals, e.g. sodium bisulfate (dry acid), should be discouraged due to the need to keep sulfate levels as low as practicable and to prevent sulfate attack on cement grouts, tile beds, screeds, rendering and concrete.

7.3.2.10 Filling and emptying of pools

Pools should not be filled for at least three weeks after completion of the grouting and movement joints, this interval being important to the success of the installation (see **7.3.2.1**). Pools should be filled and emptied slowly in order to minimize the stresses due to loading and thermal changes. the maximum rate of filling or emptying pools should be controlled so that the water level rises or falls about 750 mm every 24 h.

7.3.2.11 Heating pool water

The pool water should be heated at a rate of 0.25 °C/h in order to minimize the effect of thermal movement which takes place during the heating process.

7.3.3 External swimming pools of concrete construction (excluding salt water pools)

The methods used should be similar to those described in **7.3.2** for internal pools of concrete construction. In addition, the usual precautions against inclement weather during and after the tiling operation should be taken, and notice taken of possible climatic/thermal effects in accordance with Clause **9**. In areas where frost can occur the tiles selected should be of class AI_a, AI_b, BI_a or BI_b as classified in BS EN 14411:2012. In all cases, reference should be made to the manufacturer to confirm the suitability of the tiles.

7.3.4 Salt water pools, tanks and reservoirs of concrete construction

7.3.4.1 General

Seawater and saline waters are particularly aggressive to ferrous metals and therefore care should be exercized to ensure that all ferrous metals are adequately protected.

For the recommendations of concrete in contact with seawater, reference should be made to BS 6349-1.

The recommendations in **7.3.2.1** regarding sealing of cracks and joints in the pool shell should be followed.

For pools containing water with a higher concentration of dissolved salts than in seawater, specialist advice should be obtained on the type of cement and mix proportions for all concrete and mortar. A full chemical analysis of the pool water should therefore be obtained and used as a basis for the decision on what special precautions, if any, are needed.

7.3.4.2 Screed, rendering, bedding and jointing in pools

Sulfate-resisting Portland cement (CEM II) conforming to BS EN 197-1 should be used for the rendering and screed and the tiles should be fixed with a sulfate-resisting adhesive, e.g. epoxide resin. Advice from the manufacturer of the adhesive should be sought and the enquirer should make known to the manufacturer full details of the chemical analysis of the pool water.

NOTE Walkways around the edges of pools are particularly vulnerable, due to the fact that they are subjected to alternate wetting and drying. This creates a build-up of salts in the grout and bed materials, unless they are impermeable to water.

Tiles should be solidly bedded in accordance with **7.3.2.5**. The jointing procedures in **7.3.2.7** and **7.3.2.8** should be followed.

Tiling should be carried out in accordance with **7.3**.

7.3.5 Pools, tanks and reservoirs of metal construction

The structure should be watertight. Rigidity is also a major factor and, if necessary, stiffening members should be incorporated behind the surface plates.

Surfaces should be thoroughly cleaned to ensure they are free from rust and contaminating substances and then treated with a rust-inhibiting primer in accordance with BS 5493. The tiles should be applied direct to the treated surface using a deformable adhesive or an epoxide adhesive compatible with the priming treatment.

NOTE The tiling could be subjected to adverse stresses arising from flexure transmitted from the structure, for example, that caused through inadequate restraint of the plates and/or temperature changes, the risk being proportionate to the areas of the surfaces.

7.3.6 Tanks for aggressive liquids

There are a number of chemical compounds used in industry that are aggressive to the structural shell of a tank and/or any lining applied to it; any liquid other than potable water or seawater from temperate zones should be analyzed and the results used to determine the specification for the tank shell and its lining. Specialist advice should be obtained, and reference should be made to Clause **8**.

Tiles should be solidly bedded in accordance with **7.3.2.5**. The jointing procedures in **7.3.2.7** and **7.3.2.8** should be followed.

7.3.7 Tanks for liquids at elevated temperatures

NOTE 1 NA to BS EN 1992-3 gives recommendations for the design of concrete structures to hold aqueous liquids at ambient temperature.

The design of the tank and its lining should take into account the fact that where the temperature is elevated, it results in a significant temperature gradient through the walls and floor of the structure and the structure itself has to withstand a wide temperature range and rapid changes of temperature.

NOTE 2 For example, a tank that holds a liquid at 90 °C could have been designed for a temperature range from 90 °C to 0 °C or even lower. The reason for this is that the tank might have to be put out of use during a period of very cold weather.

Tiles should be solidly bedded in accordance with **7.3.2.5**. Jointing procedures in **7.3.2.7** and **7.3.2.8** should be followed.

8 Chemical attack

8.1 General

NOTE 1 Cementitious bedding and joint filling materials can be attacked in acidic conditions and discolouration and surface attack of tiles can occur from chemical reaction with strong alkalis, including some detergents (ph > 9).

Although ceramic products are resistant to attack in most acidic and alkaline situations they should not be used where they are in contact with fluoride chemicals, especially hydrofluoric acid.

NOTE 2 It is advisable to consult the manufacturers of tiles, jointing and bedding materials as to the suitability of their products to withstand attack from the chemicals envisaged.

NOTE 3 It is important to note that certain cleaning agents, particularly those containing acids, can also attack cementitious bedding and joint filling materials. Both wall and floor tile installations can be affected in this way but floors are more at risk than walls.

NOTE 4 The effect of chemical reaction on ceramic tiles is to corrode the surface, but with suitable tiles this will be at such a slow rate that it will not significantly affect the life of the installation.

NOTE 5 Discolouration of tiles can occur from chemical reaction with strong alkalis.

If penetration of corrosive chemicals occurs beyond the tiled layer of an installation, chemical reaction could cause rapid deterioration or removal of the base or structural wall; for this reason the tiles and grouting material chosen for chemical resistant installations should be of low permeability.

The design of physical features should be considered as a further means of reducing the risk of chemical attack; this applies especially where corrosive substances remain in contact with the tiles for long periods.

8.2 Design considerations

8.2.1 Tanking

Floor installations should preferably be tanked, i.e. a chemically resistant and impervious layer should be incorporated between the base and the floor finish, and carried up the sides to an appropriate height. If any corrosive liquid succeeds in penetrating the tiles and joints, effective tanking should avert any serious structural damage. It should not be assumed that the protection against liquid penetration given by the tiling is adequate and drainage from the impervious layer should be provided.

8.2.2 Falls

Adequate falls should be provided in floors. Gradients between 1:80 and 1:35 should be used, the precise fall being varied to cope with conditions in different areas. The choice of gradient depends on the character of the surface and the amount of spillage anticipated; smooth surfaces call for less slope than rougher types, while large spillages should be taken away more readily than smaller amounts. Falls should be not less than 1:80; gradients steeper than 1:35 might be inconvenient and even dangerous.

The direction of falls should be planned with traffic flow in mind, so that traffic moves across, rather than up and down, the slope.

8.2.3 Drainage

The position of drainage channels and gullies should be considered to ensure rapid removal of corrosive liquids and also their relationship to the direction of wheeled traffic, e.g. trolleys and trucks, likely to be encountered in service.

8.2.4 Movement joints

The design and disposition of movement joints should follow the recommendations given in BS 5385-1 and BS 5385-3 but, where possible, joints should be placed away from areas where corrosive liquids might collect and remain for long periods.

8.3 Materials

8.3.1 General

To ensure that suitable materials having adequate chemical resistance are selected, the potential service conditions should be defined precisely. The type of corrosive chemical involved should be known, as should its concentration and also its temperature at the time it makes contact with the tiling; the attack of acids, for instance, is more marked at high temperatures.

NOTE Specifiers are advised to draw upon the experience of specialists to determine the most suitable combination of materials in respect of performance, cost and appearance.

There might be occasions when the attack is more severe than that originally envisaged, perhaps by accident; this possibility should be considered at the outset by choosing a system that will provide a greater degree of resistance than would normally be required.

If the installation is subjected to a change of use involving corrosive substances other than those for which provision was made, a careful assessment of the system should be made to check that it offers adequate resistance in the new conditions.

8.3.2 Bedding and joint filling

Chemically resistant materials chosen to resist the particular corrosive environment should be used for joint fillings; in addition, tiles should be bedded in suitably resistant materials where corrosion is likely to be severe.

NOTE The chemical resistance to various liquids of the more commonly used materials for tile beds, grouts and movement joints is given in Table 5.

Proprietary materials should be selected and used strictly in accordance with the manufacturers' recommendations.

8.3.3 Tiles

8.3.3.1 General

In choosing the type of tile for an application where exposure to hazardous chemicals is likely, not only chemical resistance but also other properties should be considered, such as resistance to impact (see **6.3**), abrasion (see **6.4**), ease of cleaning (see **15.1**), slip resistance (see **15.2**) and appearance. Classes of tiles suitable to resist chemical attack are given in Table 1 and Table 2 but manufacturers should be asked to confirm that their tiles have properties suited to particular situations.

Ceramic and glass mosaics have properties similar to those of other ceramic products but should not be used for applications where exposure to hazardous chemicals is likely because chemically resistant beds and grouts do not lend themselves to the methods of mosaic application.

NOTE Grout cannot be inserted successfully into the narrow joints which are a feature of mosaic in sheet form.

8.3.3.2 Floor tiles

NOTE 1 Ceramic floor tiles and pavers have a high resistance to chemical attack but strength and thickness are also important. Strength is necessary to provide resistance to impact and heavy traffic and to withstand thermal movement associated with steam cleaning or hot liquids coming into contact with the floor surface. The breaking strength of a tile depends upon the body composition, the density (related to the porosity or water absorption) and the thickness of the tile. The thickness is also important where there is a need to provide sufficient depth of filling material in the joints to prevent corrosive liquids reaching the tile bed and base.

NOTE 2 Concentrated mineral acids other than hydrofluoric, (e.g. sulfuric, nitric or hydrochloric), concentrated alkalis, e.g. potassium and sodium hydroxide, attack ceramic floor products extremely slowly.

In general, organic chemicals have no effect, the only exceptions being some containing fluorine; ceramic products in applications which involve contact with chemicals likely to contain or give rise to significant concentrations of hydrofluoric acid should not be used.

8.3.3.3 Wall tiles

In severe conditions the denser types (Groups AI_a, $AI_{b,}$ BI_a and BI_b) should be specified in combination with chemically resistant bedding and joint filling.

Glazes are attacked more readily than tile bodies and colouring stains in glazes might be affected; on the latter point, the selection of tiles should be supported by advice from the manufacturer.

8.3.4 Adhesives and grouts

For mildly corrosive environments, the adhesives used should conform to type C cementitious or type R reaction resin adhesive in accordance with BS EN 12004:2007+A1:2012 and in most cases will be an epoxide adhesive. For highly corrosive areas, the grouts used should conform to type RG in accordance with BS EN 13888:2009. These should be used in situations where chemical resistance, high adhesion strength and an impervious bed are required on floors and walls and they are normally supplied as pre-gauged components to be mixed together immediately prior to use.

NOTE 1 The open time and pot life of the adhesive are identical; however, if the adhesive is not solvent-free, or is an epoxide-modified mortar, the open time is considerably shorter than the pot life.

For mildly aggressive chemical environments, cementitious, reaction resin or resin modified cementitious based adhesives conforming to BS EN 12004:2007+A1:2012 should be selected.

NOTE 2 In most cases the reaction resin or resin modified cementitious adhesive is based upon an epoxide resin.

For highly corrosive areas, a reaction resin adhesive only should be used.

For mildly aggressive chemical environments the grout should conform to BS EN 13888:2009, type RG reaction resin grout or alternatively a manufacturer recommended modified cementitious based grout conforming to BS EN 13888:2009, type CG. For highly corrosive environments the grout used should conform to to BS EN 13888:2009, type RG reaction resin grout.

Reaction resin adhesives and grouts should be used in situations where chemical resistance, high adhesion strength and an impervious bed are required on floors and walls and they are normally supplied as pre-gauged components to be mixed together immediately prior to use.

The chemical resistance of the adhesive or grout should always be checked with the manufacturer before work commences.

The chemical resistance of any adhesive and grout mortar should be checked to ensure that it provides adequate resistance to the chemicals likely to come into contact with the installed tiling, bearing in mind the degree of exposure and the frequency of removal of any chemical spillage. The reaction resin adhesive and grout mortars should be mixed and applied in accordance with the manufacturers' instructions.

Epoxide adhesives and grouts might produce an allergic reaction from skin contact and the manufacturer's recommendations regarding the safe handling of the product should be strictly observed.

Table 5 **Resistance of tile bed, grout and sealant materials to various liquids**

Substance		Tile bed and grout materials		Sealants				
		Epoxide resin	Cement based	Polysulfide rubber	Epoxide/ polysulfide	Silicone rubber	Polyurethane	Bitumen compounds
Acids	Oxidizing (concentrated)	F	P	P	F	P	P	P
	Oxidizing (dilute)	G	P	P	F	G	P	F
	Other (concentrated)	F/G	P	P	G	P	F	F
	Other (dilute)	G	P/F	F	G	G	F	G
	Fatty acids	F/G	F	F	G	G	G	P
Alkalis	Concentrated	F/G	F/G	P/G	G	F/G	P	P
	Dilute	G	G	F/G	G	G	P	F
Sulfates		G	P	G	F	G	P	G
Solvents	Chlorinated	F	G	P	G	P/F	G	P
	Other	G	G	F/G	G	P/F	F	P
Oils and greases	Animal/vegetable	G	F	F	G	G	G	P
	Mineral	G	G	G	G	G	G	P
Milk		G	P	F/G	G	G	G	P
Water		G	G	G	G	G	G	G
Chlorinated water		G	G	P/F	G	G	G	G
Seawater		G	G	G	G	G	G	G
Sugar solutions		G	F/G	F/G	G	G	G	G
Common salt		G	G	G	G	G	G	G

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

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.

8.4 Bedding methods

8.4.1 General

The suitability of bedding methods in areas subject to chemical attack is given in Table 3 and Table 4 but the precise recommendations of manufacturers of proprietary materials should be followed concerning, for example, the mixing procedure, the working time after spreading, the suitability of the background and the type of trowel.

Care should be taken to seal junctions where floor tiling abuts walls, fixed machines and drainage channels, to ensure that penetration of corrosive liquids cannot occur at these positions.

8.4.2 Mildly corrosive situations

For mildly corrosive situations, any of the bedding methods in Table 3 and Table 4 should be used provided the grout is appropriate for the chemical(s) to be resisted.

8.4.3 Highly corrosive situations

Apart from the effect on the tiles and grout, the risk of highly corrosive liquids penetrating to the tile bed and through to the base should be anticipated. Chemically resistant adhesives should be used and the following procedures should be adopted.

a) The tiles selected should provide the necessary chemical resistance as well as the required strength and resistance to the anticipated loads and impacts.

b) The tiling should be laid on bases with adequate free draining falls. Concrete should be allowed to dry for at least six weeks and screeds should be allowed to dry for at least four weeks (see **5.2**).

c) Either a chemical resistant coating/tanking should be applied, aggregate blinded if required, or a continuous coat of a chemically resistant mortar should be trowelled on the prepared base and up any walls behind the skirting as recommended by the adhesive manufacturer. Where recommended the backs of the tiles should also be buttered with the adhesive immediately prior to bedding.

d) The tiles should be bedded into the adhesive ensuring that no voids remain beneath the tiles and the bed thickness is as recommended by the adhesive manufacturer.

e) When thicker, slump-free chemically resistant adhesive mortars are used to bed the tiles, the backs and two adjacent edges should be buttered with adhesive mortar and pressed into the adhesive bed on the base and against adjacent tiles and tapped firmly into position.

f) Once the adhesive mortar has set and hardened the joints between the tiles should be grouted with the same adhesive mortar or an appropriate grout, as recommended by the manufacturer.

It should not be assumed that the tiles and bedding provide adequate protection against the penetration of corrosive liquids in highly corrosive situations on suspended floors or where high temperatures occur. A chemically resistant coating or sheet membrane should be incorporated between the base and bedding adhesive, bonded to the base, forming a tanking, rising up walls and upstands to an adequate height. Where a sheet membrane is used, it should be bonded to the base with a compatible adhesive and any overlap joints suitably sealed or welded to provide a liquid tight seal.

Irrespective of the laying system employed, in corrosive situations it is important that, as far as possible, there should be no voids either in or between the bedding adhesive and the joint filling.

9 Thermal effects (climatic and environmental)

*COMMENTARY ON CLAUSE **9***

Tiling can be affected by thermal influences, existing at the time of installation or developing subsequently under severe service conditions. Such influences could be the natural effects of climatic conditions (frost or solar heat) or the result of environmental refrigerating or heating processes.

9.1 Natural thermal effects

9.1.1 Climatic extremes during tile installation

Tiling should preferably be avoided during periods of extremely high or low temperatures. If such conditions occur after tiling has commenced, the operation should be suspended until the situation eases or suitable precautions have been taken.

NOTE 1 Although the prevailing humidity and degree of air movement might be modifying factors, the approximate temperature range within which the installation can be satisfactorily carried out with normal methods and materials is 5 °C to 25 °C.

The temperature should not fall below 5 °C while the bedding and grout sets and hardens. When the prevailing temperature is outside this range, precautions should be taken to enable work to proceed.

NOTE 2 In the case of external work, such precautions might consist of cocooning against cold or shielding against direct sunlight; for internal areas the provision of mechanical heating or ventilation might be necessary.

NOTE 3 Background structures can act as heat or cold sinks and might not therefore reach suitable working temperatures for some time after corrective steps have been taken. In addition, where hot conditions prevail, it might be necessary to modify bedding techniques to avoid the drying or skinning over of bedding material in the interval between application of the bed and the positioning of the tiles.

9.1.2 Climatic effects on tiling in service

Where there are climatic effects on tiling in service, the exposure conditions and protection recommendations in BS 5385-2:2014, **6.3** should be followed.

9.2 Environmental thermal effects

9.2.1 General

Conditions of extreme heat or cold occur in many tiled areas in commercial, industrial and domestic installations; designers and installers should take this into account when specifying tiled areas.

9.2.2 High temperature during tile installation

NOTE 1 The temperature of a hot background is changed by the application of a tile finish according to the source of heat. If the heat is generated from within or behind the background, the temperature of the background surface rises but if the heat is radiated or conducted on to the background surface, the additional layer of tiling reduces the temperature of the background surface.

At the time of bedding tiles to a background, the temperature of the latter should preferably be within the temperature range 5 °C to 25 °C (**9.1.1**). For backgrounds with a surface temperature over 25 °C, an adhesive with an extended open time should be used.

NOTE 2 Generally, tiling cannot be undertaken satisfactorily on backgrounds having temperatures in excess of 40 °C, with subsequent effects of temperature variation on these tile installations, e.g. practical application of the bedding, reduced open and setting time, shrinkage and expansion.

9.2.3 Low temperatures during tile installation

Precautions necessary during tile installation under cold climatic conditions should be made in accordance with **9.1.1**. In instances where the temperature of the area to be tiled is reduced by other environmental influences, similar considerations apply; the procedure in such cases should be either to remove the cooling influence (e.g. by switching off refrigeration) or to apply insulation between the cooling influence and the area to be tiled. Time should be allowed for the backgrounds and the atmosphere to rise to a minimum temperature of 5 °C before tiling. The temperature should not be allowed to fall below 5 °C while the bedding and grout sets and hardens.

9.2.4 High temperature effects on tiling in service

*COMMENTARY ON **9.2.4***

Tiling can be subjected to heat transmitted by:

a) conduction of heat to the background from heat sources in or near to it, e.g. heaters, ovens, under-floor heating;

b) radiation from a heat source, e.g. domestic fire, industrial furnace or boiler, sunlight, tiling in atria, conservatories, cookers, etc.;

c) contact with hot gases, vapours or liquids on the surface, e.g. from steam, open fires, industrial processes.

The heat transmitted by any of these processes might be:

1) uniformly distributed, producing an even temperature in the system;

2) non-uniformly distributed, creating temperature gradients both within individual tiles and between tiles and backgrounds;

3) of a continuous nature, causing a steady temperature distribution once equilibrium has been established;

4) of a discontinuous nature, causing a cyclical rise and fall of temperatures and thermal gradient within the tiling.

Where service temperatures in excess of 80 °C occur, all the factors referred to should be taken into consideration in selecting tiles and fixing materials. The adhesive manufacturer and the tile manufacturer should be consulted to ensure that the tiles and adhesives are compatible and that the combination is suitable for the service requirements.

NOTE Although ceramic tiles are non-combustible they can fracture when subjected to a large temperature gradient or thermal shock; colour could be affected and glazed tiles might become crazed. Tiles of small surface area are more resistant to high temperature gradients and thermal shock than tiles of large surface area. Porcelain or vitrified tiles have greater resistance to thermal shock or gradient than glazed porous bodied tiles.

In general, organic adhesives are unsuitable for continuous service temperatures in excess of 80 °C; cementitious materials are capable of withstanding somewhat higher temperatures but should not be used in service conditions where the temperature is likely to exceed 100 °C for prolonged periods.

Proprietary heat-resistant adhesives are available but these generally have less convenient working properties than normal tile adhesives and might also place a greater stress on the tiles; their use should be restricted to situations where the prevailing temperature is too high to allow normal tile bedding materials to be used. Some proprietary heat-resistant adhesives are based on alkaline silicate compounds and can have a low moisture resistance; their use, therefore, should be restricted to installations, which dry out completely and remain dry.

9.2.5 Moderate temperature effects on tiling in service

9.2.5.1 General

Finished tiling that has fully matured and dried is unlikely to be directly affected by heat where the maximum service temperature throughout the system remains below 90 °C but it might be necessary to accommodate other factors present either independently of, or as a result of, the heat; in all such cases the tiling system should be designed with these associated, secondary factors in mind.

NOTE For example, if the heat arises from steam or water vapour there is an associated factor of moisture to be considered, or if the heat causes movement due to thermal expansion, there is an associated condition of movement to be accommodated.

9.2.5.2 Heated floors

*COMMENTARY ON **9.2.5.2***

Floor heating systems are covered in BS 5385-3 and BS EN 1264-4. Natural stone tiles are outside the scope of this standard, and guidance is given in BS 5385-5 for their installation on heated floors.

9.2.5.3 Heated seating

For heated seating formed in reinforced concrete, and where it is intended that tiles are to be fixed to them, it is advisable to restrict the length of the seats to 2.5 m.

Tiles should be solidly bedded and grouted in suitable adhesives and grouts in accordance with the manufacturers' instructions.

9.2.6 Low temperature effects on tiling in service

Tiled walls and floors inside refrigerated storage rooms might be subjected to temperatures as low as, for example, –30 °C; tiles or mosaics for both floors and walls should be selected to withstand extreme frost conditions and also the rise and fall of temperature which occurs during maintenance. Tiles should be AI_a or BI_a (water absorption not exceeding 0.5%) and of size and thickness suitable for the conditions of impact and/or loading. The selection of wall and floor tiles and mosaics should be made in consultation with the manufacturer of the tiles as to their suitability for the conditions.

Surfaces to be tiled should be rendered or screeded with a cement and sand mortar. A water-resistant bedding material should be used for fixing and, if frequent freeze/thaw cycling is a probable condition of service, a suitable adhesive should be used to accommodate the resulting thermal movement. After tiling, sufficient time should be allowed to ensure the removal of any volatile material before refrigeration takes place. If necessary, forced ventilation should be applied to achieve a dry and/or vapour free condition.

9.3 Movement joints

Where high temperatures or changes in temperature are expected, additional movement joints should be provided.

NOTE 1 The heat-resistance of sealants varies considerably. Standard polysulfide sealants recommended for use with tiles are satisfactory for extended exposure up to temperatures of 80 °C and for short exposures of temperatures up to approximately 100 °C.

NOTE 2 Silicone sealants are usually able to withstand higher temperatures; this can be confirmed with the sealant manufacturer.

10 Exposure to radioactivity

10.1 General

NOTE Examples of areas where radioactivity can occur are nuclear power stations, hospitals and plants where radioactive chemicals are processed or used.

To facilitate decontamination, tiles should have a smooth surface, be AI_a or BI_a, large format tiles or panels, with minimal joints filled with suitable reaction resin grout. Mosaics should not be used.

10.2 Movement joints

NOTE Most sealant and polymeric materials are subject to degradation by high energy radiation.

The resistance of materials can be improved by special compounding techniques; the sealant manufacturers' advice should be obtained in all cases.

11 Sterile conditions

11.1 General

Wall and floor tile surfaces should be maintained in a bacteriologically-sterile condition. Glazed wall tiles and porcelain or vitrified floor tiles meet this need; however, particular care and attention should be paid to the joints. Mosaics should not be used.

*NOTE Bacteriological tests carried out on conventional cementitious grouting materials show that they do not harbour harmful germs and that they can be maintained in a bacteriologically-sterile condition by regular, disinfectant procedures, e.g. wiping with diluted bleach. Materials based on epoxide resins are also suitable and provide a more easily cleaned surface, but grouting with resin based products is more time consuming (see **8.3.4**).*

Wall and floor tile surfaces should be easily disinfected and should not support the growth of micro-organisms.

11.2 Bedding and jointing

The tiles should be solidly bedded so that voids behind them are eliminated as far as possible.

NOTE 1 Cementitious products offer good resistance to micro-organisms because of their alkalinity. With organic adhesives, protection against biodeterioration is achieved by incorporating suitable biocides and fungicides during manufacture.

Epoxide-resin-based grouts should be used, strictly in accordance with the manufacturers' instructions.

NOTE 2 Epoxide-resin-based materials have a smoother surface texture and are impermeable so that that the degree of contamination is reduced and can be more effectively cleaned.

11.3 Movement joints

Any sealants used should have an adequate degree of abrasion resistance to permit washing and vigorous scrubbing; the most suitable are the epoxidized polysulfides, flexibilized epoxides, the harder two-part polysulfide sealants, harder polyurethane sealants and silicone sealants.

12 Thermal insulation

12.1 General

NOTE 1 The thermal insulation of walls and floors is expressed in terms of its thermal transmittance (U-value).

NOTE 2 All the individual layers of materials in walls and floors contribute to the total thermal insulation but the proportion provided by the tiling is small. The principal functions of tiling are to protect underlying or background layers and to provide the surface finish.

In general the methods and materials for fixing should be carried out in accordance with BS 5385-1 and BS 5385-3 subject to several important reservations as given in **12.2**, **12.3** and **12.4**.

12.2 Wall tiling

Wall tiles fixed in accordance with BS 5385-1 should not be fixed directly to insulation material of low cohesive strength (e.g. <0.5 N/mm^2).

NOTE 1 Direct fixing with an adhesive to insulating materials having low impact resistance is suitable only where the impacts are of low energy.

The adhesive should be a type known to be compatible with the insulating material and advice should be obtained from the manufacturer of the adhesive.

NOTE 2 Adhesives containing solvents might not be suitable on organic materials such as expanded polystyrene.

Care should be taken to ensure that the load on the insulating layer does not exceed the cohesive strength of the material or the adhesion strength at its surface. Accessories such as soap dishes and toilet roll holders should be fastened through the insulating material and secured to a stronger part of the wall construction.

NOTE 3 If the insulating material is faced with an applied layer of gypsum plaster or cement and sand rendering, the fixed methods and materials appropriate to these surfaces are those recommended in BS 5385-1.

12.3 Floor tiling

For floor tiling over porous insulating materials, a membrane separating layer should be used, covered by a screed. The thickness of the 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 thickness of not less than 65 mm should be used. The screed should be reinforced and preferably of fine concrete. Tiles should then be fixed with an adhesive.

12.4 Movement joints

The need for additional movement joints should be considered at the design stage to accommodate the larger thermal gradients seen within tiling on insulated surfaces.

13 Sound insulation

13.1 Walls

NOTE Sound insulation is normally achieved by the density and thickness of the wall structure and by sound-absorbent surfaces. The addition of a ceramic tile or mosaic wall finish therefore adds only marginally to the total thickness and consequently to insulation through density.

One of the following methods should be used to improve sound insulation in walls:

a) bedding the tiles in an adhesive on a proprietary sound-absorbent material fixed on the background wall face. When this method is adopted, the principles in **6.2** should be observed or;

b) bedding the tiles in a sound-absorbent adhesive, e.g. rubber-filled. This method is suitable on surfaces of cement and sand rendering. The adhesive should be of a type that can be applied at the required thickness.

13.2 Floors

To reduce the transmission of airborne or impact sound through a floor structure one of the following methods should be used:

a) by laying the tiles in a bed of sound-absorbent adhesive directly on the sub-floor or;

b) by laying the tiles in an adhesive over a layer of high compressive strength proprietary sound-absorbent material installed to the sub-floor construction and similarly isolating the tiling from the surrounding walls.

Adhesives should be compatible with the proprietary sound-absorbent material.

NOTE 1 These methods can be employed over wooden joists and boards, concrete and screeds where there is no excessive loading, for instance, in domestic situations.

However, it should be recognized that there is a degree of flexibility inherent in these systems that renders the finished work susceptible to damage from heavy impact and compression. In order to distribute the load on such sub-floors, tiles having sides less than 100 mm in length should not be used.

To achieve consistent results, tiles should be laid as a "floating" floor isolated from the surrounding walls, over a concrete sub-floor on which are first placed layers of sound-absorbent material, such as expanded polystyrene or glass-fibre quilting covered by a reinforced cement and sand screed.

Direct fixing of ceramic tiles to a wood-based floating floor entails a high element of risk and where practicable, this should be avoided.

*NOTE 2 BS 5385-3:2014, **6.3.4.4** gives further advice on tiling to floating floors.*

NOTE 3 Guidance for construction of fixed timber bases, in respect of tiling considerations, is given in Tiling to Timber Sheets and Board, Timber Substrates and Alternative Products *[2].*

For floor tiling over porous insulating materials, a polyethylene separating layer is necessary, covered by a reinforced screed. The thickness of the 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 reinforced screed should preferably be of fine concrete. Tiles should then be fixed with an appropriate adhesive.

14 Anti-static conditions

Anti-static precautions should be used in interior situations where flammable or potentially explosive materials are in use or in other situations where the avoidance of possible electrical discharges is essential, e.g. the handling of flammable liquids, gases and fine powders in industrial processes, in clean rooms to prevent the attraction of particles to surfaces and for the protection of microelectronic equipment during use, manufacture, assembly or repair.

In order to prevent build-up of electrostatic charges in such cases, and to ensure safe discharge of static electricity from persons and equipment, floors in such areas should be conductive. However, the electrical resistance of the anti-static floor should not be too low or the risk of electric shock associated with equipment connected with mains electricity is increased.

Anti-static flooring is normally supplied as a proprietary system and manufacturer's advice should be followed regarding the selection and installation of such systems.

15 Cleaning and slip resistance

15.1 Cleaning

Cleaning and cleanliness of flooring is an important factor that should be considered in conjunction with slip resistance. The frequency of cleaning is determined by the numbers (normal and peak levels) and type (children, elderly, disabled, etc.) of pedestrian using the floor; in the work environment the work processes should also be considered when cleaning regimes and schedules are developed.

NOTE 1 Some floor tiles which have a surface texture or profile designed for the purpose of increasing slip resistance (coefficient of friction) might be appropriate for wet barefoot areas, i.e. showers and swimming pool surrounds, etc., but not for heavily soiled industrial flooring. Similarly, textured or profiled surfaces designed for industrial flooring are generally not appropriate for wet barefoot areas.

NOTE 2 The design of the floor tiles surface texture or profile is a crucial factor relative to the intended usage of the floor and to the ease of cleaning of the floor.

NOTE 3 Rough surface textures resulting from closely spaced peaks and crevices, for example, can have high coefficient of friction values when clean but can be extremely difficult to maintain in a clean condition because soil and/or emulsified dirt residue from washing is not easily extracted from crevices, whereas the same surface texture in a wet area can be more easily maintainable in a clean condition.

NOTE 4 Flooring with a surface texture (roughness) requires more effort to maintain in a clean condition. A build up of dirt on a textured floor negates the benefit of that texture.

NOTE 5 Correct cleaning procedures can be found in the instructions which flooring tile manufacturers or distributors provide.

Properly designed and maintained matting systems are an effective way of reducing the incidence of contamination on floors. Matting systems should be of a design which is suitable to meet the anticipated requirements of the installation and should be considered for use at entrances and within buildings. Matting systems have the added benefit of prolonging the lifetime of a given floor; care should be taken in selection and maintenance of matting systems so that they function satisfactorily and do not present a tripping risk.

NOTE 6 Further information is available in Annex A of this standard, and in the following references:

- *The cleaning of ceramic tiles [3];*
- *Slips and trips: Guidance for the food processing industry [4].*

15.2 Slip resistance

*COMMENTARY ON **15.2***

The interaction of feet, shod or bare, with flooring materials governs slipping. 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 significantly over time and often merely during the process of installation and finishing. Generally, dry floors are not slippery but the combination of very smooth floors and hard smooth heel or sole material can be slippery even when dry. Similarly, dry contaminants such as dust, fibres, lint and paper can make dry floors slippery.

Measurement of slip resistance values in the wet, by means of the pendulum test method according to BS 7976-2, 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.

Further advice is given in HSE 156 [4].

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

Special attention should be paid to correct cleaning procedures as discussed in **15.1** and BS 5385-3:2014, Clause **11**, both to remove contamination and to ensure that cleaning agents, that could otherwise attack the surface, are rinsed away.

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

Annex A (informative) Guidance on the reduction of slip hazards

COMMENTARY ON ANNEX A

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.

A.1 General

NOTE The following guidance adheres to the various relevant HSE documents 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 shoe material and the individual.

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 surface 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 1134-1). 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.

A.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).

A.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 [5] require the employer to make an assessment of the risks of slipping caused by conditions in the 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:

- make sure that the cleaning method is effective for the type of floor;
- do not introduce more slip or trip risks while cleaning is being done;
- leave smooth floors dry after cleaning or exclude pedestrians until the floor is dry;
- remove spillages promptly;
- have effective arrangements for both routine cleaning and dealing with spills;
- use the appropriate detergent mixed at the correct concentration. If a detergent is used, a rinse with fresh, clean water is especially important;
- clean in sections, so there is a dry path through the area;
- use warning signs. Consider using cones carefully as they do not act as a barrier and only warn of the hazard;
- 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.

A.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 and who is primarily responsible for removing them immediately and alerting others to the hazard.

Bibliography

Standards publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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 7976-2*, Pendulum testers – Part 2: Method of operation*

BS EN 1264-4, *Water based surface embedded heating and cooling systems – Part 4: Installation*

Other documents

[1] THE TILE ASSOCIATION. *Slip resistance of Hard Flooring*. Stone, Staffordshire: TTA.

[2] THE TILE ASSOCIATION. *Tiling to Timber Sheets and Board, Timber Substrates and Alternative Products.* Stone, Staffordshire: TTA.

[3] THE TILE ASSOCIATION. *The cleaning of ceramic tiles.* Stone, Staffordshire: TTA.

[4] HSE. *Slips and trips: Guidance for the food processing industry.* Sudbury: HSE 156, 1996.

[5] GREAT BRITAIN. The Management of Health and Safety at Work Regulations 1999. London: HMSO.

Further reading

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*

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