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BSI Standards Publication

Ceramic tiles — Guidelines for installation

Part 2: Installation of thin ceramic wall and floor tiles and panels

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National foreword

This Published Document is the UK implementation of ISO/TR 17870-2:2015.

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A list of organizations represented on this committee can be obtained on request to its secretary.

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

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Part 2: Installation of thin ceramic wall and floor tiles and panels

Carreaux et dalles céramiques — Lignes directrices pour l'installation —

Partie 2: Installation des carreaux et dalles céramiques minces au sol et aux murs

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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 189, *Ceramic tile*.

ISO/TR 17870 consists of the following parts, under the general title *Ceramic tiles — Guidelines for installation*:

— *Part 1: Installation of ceramic wall and floor tiles*

— *Part 2: Installation of thin ceramic wall and floor tiles and panels*

Introduction

There are currently International Standards available for

— ceramic tiles, and

— adhesives and grouts for tiles.

NOTE ISO test methods for thin ceramic tiles and panels, as well as ISO 13007-5 dealing with liquid-applied waterproofing membranes for use beneath ceramic tiling bonded with adhesives, are under preparation.

For these products to give satisfactory service, they need to be selected and installed competently, and they have to receive appropriate initial treatment, protection, and maintenance.

Some countries have published standards and/or guides that specify the design and installation of ceramic tiling. The purpose of ISO/TR 17870 is to foster good installation practices for thin ceramic wall and floor tiles and panels, internationally.

TECHNICAL REPORT **ISO/TR 17870-2:2015(E)**

Ceramic tiles — Guidelines for installation —

Part 2: Installation of thin ceramic wall and floor tiles and panels

1 Scope

This part of ISO/TR 17870 defines the quality of thin ceramic tiling and provides guidance for materials selection, installation, and use, to achieve required levels of quality and performance.

It considers aspects related to the specification and installation of the tiling project, in terms of:

— manufacture and distribution of the materials (thin ceramic tiles and panels, adhesives, grouts, etc.),

— specification of the thin tiling, and

— installation of the tiling (thin tile fixing operations).

It is applicable to internal and external thin ceramic floor and wall tiling, installed by adhesive methods.

NOTE The quality of thin ceramic tiling depends on the following general characteristics:

— regularity;

— durability;

— safety.

The durability of the thin tiling can depend on its use and management.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13006, *Ceramic tiles — Definitions, classification, characteristics and marking*

ISO 13007-1, *Ceramic tiles — Grouts and adhesives — Part 1: Terms, definitions and specifications for adhesives*

ISO 13007-3, *Ceramic tiles — Grouts and adhesives — Part 3: Terms, definitions and specifications for grouts*

ISO 13007-5[1)], *Ceramic tiles — Grouts and adhesives — Part 5: Liquid applied waterproofing membranes for use beneath ceramic tiling bonded with adhesives — Requirements, test methods, evaluation of conformity, classification and designation*

3 Terms and definitions

For the purposes of this document, the terms and definitions given ISO 13006, ISO 13007-1, ISO 13007-3, ISO 13007-5, and the following apply.

1) To be published.

3.1 General

3.1.1
thin ceramic tile
ceramic tile with thickness ≤5,5 mm, surface area ≤3 600 cm^2, and no tile edge > 600 mm or a ceramic tile declared as a thin ceramic tile by its manufacturer or having properties meeting an international or national standard for thin ceramic tiles

3.1.2
thin ceramic large format tile
ceramic tile with thickness ≤5,5 mm, surface area >3 600 cm^2, and no tile edge >1 200 mm or a ceramic tile declared as a thin ceramic large format tile by its manufacturer or having properties meeting an international or national standard for thin ceramic large format tiles

3.1.3
thin ceramic panel
ceramic panel with thickness ≤5,5 mm, surface area >1 m^2, and any tile edge > 1 200 mm or a ceramic tile declared as a thin ceramic panel by its manufacturer or having properties meeting an international or national standard for thin ceramic panels

3.1.4
thin ceramic tiling
thin ceramic tiles and panels installed, together with its associated bedding and jointing

3.1.5
design (of thin ceramic tiling)
specification (of thin ceramic tiling)
selection of thin ceramic tiles and panels, backgrounds, fixing methods, and fixing and jointing materials as appropriate for the structure and intended use

3.1.6
installation (of thin ceramic tiling)
thin tile fixing
application of thin ceramic tiling in accordance with the specification

3.2 Components of thin ceramic tiling

3.2.1
background
any material system used as a base over which the thin ceramic tile or panel is to be fixed

3.2.2
filling out layer
separate application of material to achieve the required vertical flatness (walls)

EXAMPLE Plaster, render, proprietary tile backer boards.

3.2.3
fixing surface
plane rigid surface upon which the thin tile or panel is fixed

3.2.4
insulating layer
layer included to obtain sound or thermal insulation

3.2.5
intermediate joint
movement joint to divide large areas of tiling into smaller, approximately square areas

3.2.6
levelling layer
layer applied to compensate for unevenness and differences in height of the base or to accommodate services (floors)

3.2.7
movement joint
joint in thin tiles or panels, backgrounds or substrates, designed to accommodate movement

Note 1 to entry: Types of movement joints: structural joint, perimeter joint, intermediate joint.

3.2.8
perimeter joint
movement joint to isolate the thin ceramic tiling from adjacent building elements

3.2.9
primer
fluid material, used separately or mixed with binder to form a slurry, applied as a thin layer to improve adhesion of the bedding to the background, or to isolate the bedding material from the background surface

3.2.10
separating layer
material which separates layers within the thin tiling system (floors)

3.2.11
structural joint
movement joint in thin ceramic tiling to correspond with structural movement joint in the background

3.2.12
tile bed
bedding
layer of specified materials in which the thin tile or panel is set and which bonds the thin tiles or panels to the background

3.2.13
tile joint
space between adjacent thin tiles or panels

3.2.14
waterproofing membrane
continuous layer of impervious material to resist the passage of water

3.3 Thin tiling techniques and operations

3.3.1
bonded method
floor tiling laid with a system where the bedding is bonded to the background

3.3.2
buttering method
adhesive applied to the back of the thin tile or panel, just before the tile or panel is placed

3.3.3
contact area
proportion of the thin tile or panel back and/or background support that is in contact with the bedding after the thin tile or panel has been fixed into position

3.3.4
direct bedding
thin tile or panel fixing directly onto a structural background

3.3.5
floating method
adhesive applied to the fixing surface, just before the thin tile or panel is placed

3.3.6
floating and buttering method
adhesive applied to the fixing surface and to the back of the thin tile or panel, just before the thin tile or panel is placed

3.3.7
grouting
operation of filling the joint space between thin tiles or panels other than at movement joints

3.3.8
maintenance (of thin ceramic tiling)
all aspects of the cleaning, treatment, and periodic repair of damage to the thin ceramic tiling

3.3.9
plastering
application of a gypsum plaster to a vertical background

3.3.10
rendering
application of a cement mortar to a vertical background

3.3.11
screeding
application of a screed on a floor background

3.3.12
tanking
application of an impermeable layer beneath thin tiling and bedding to prevent water penetration into the background

3.3.13
unbonded method
any method of laying floors which provides separation of the thin tiling system from the background

3.4 Characteristics/aspects of thin ceramic tiling

3.4.1
durability
quality of thin tiling which maintains its characteristics over time

3.4.2
flatness
conformity of the surface of the thin tiling to a theoretical plane within an allowable tolerance

3.4.3
levelness
conformity of the surface of thin floor tiling to a fixed horizontal level within an allowable tolerance

3.4.4
lipping
deviation between thin tile surfaces either side of a joint (including movement joints)

3.4.5
plumbness
conformity of the surface of thin wall tiling, designed to be vertical, to a fixed plane within an allowable tolerance

3.4.6
slip resistance
ability of a thin floor tile to provide sufficient friction to resist slipping by pedestrians

4 Exchange of information

In order for the correct floor/wall covering to be installed in appropriate conditions, at the right time, etc., it is essential that all parties have a clear understanding of the requirements of the project. To ensure that this is achieved, it is essential that there is wide consultation between all the parties involved in the project, including client, sub-contractors, and materials suppliers.

As each project will be unique, it is impossible to give a definitive list of the information to be exchanged, but the following are common examples.

a) Specification: the information required (see Clause 6).

b) Special attendances: access, unloading, hoisting and storage facilities, heat, light and power, and any additional items considered necessary to expedite the work.

c) Materials: technical specification and instructions for transport, storage, use.

d) Backgrounds: type and age of construction; location within the building; type, characteristics (mechanical strength, deformation, etc.), and regularity of background (see Clause 6); and any need for an intermediate substrate or for movement joints.

e) Associated work: services embedded in or passing through the backgrounds and junctions with other adjacent finishes

f) Finishes: type, size, and colour of thin tiles or panels and layout requirements.

g) Installation: type and technique (see Clause 7).

h) Programme: a time schedule for the progress of the work taking into consideration drying and curing periods of backgrounds and thin tiling until completion

5 Materials

5.1 General

This clause identifies and lists the materials that can be involved in a thin ceramic tiling installation using thin ceramic tiles or thin ceramic panels, and defines the main information and rules that apply to these materials.

The identification and selection of materials suitable for any given application are aspects of the specification. The relative criteria are therefore set out in 6.3.

5.2 Basic materials

The basic materials for “thin” tiling can be the following:

— finishing layer:

  — thin ceramic tiles or thin ceramic panels;

  — cementitious grouts;

  — reaction resin grouts;

- pre-prepared or proprietary grouts;

— bedding:

- adhesives;
- admixtures;
- water;

— movement joints:

- sealants;
- primers;
- back-up material;
- special components (profile, etc.).

Additional intermediate layers can be the following:

— primers;

— separating layer;

— filling out layer;

— levelling layer;

— anti-fracture/de-coupling membranes;

— waterproofing membrane;

— insulating layers (sound, thermal);

— reinforced screed, etc.

5.3 Basic information

For each material, the following basic information should be provided.

a) Classification

With reference to ISO 13006, ISO 13007-1, ISO 13007-3, ISO 13007-5.

b) Safety requirements

The specification should define the safety requirements.

NOTE Safety requirements can be defined in national regulations.

c) Materials transport, storage use

d) Technical information

The technical information for a given material is usually in the form of a document, supplied by the manufacturer, containing a list of the technical characteristics as specified in the standards (where available, see Section 2 and Bibliography) and the results of the respective measurements, carried out according to the standardized test methods.

The information document is a basic requirement for the correct and knowledgeable selection, application, and use of materials for thin tiling.

- All materials
  - The delivery of materials should be so arranged as to minimize handling.
  - Adequate precautions should be taken to prevent damage. Products should be stored in clean, dry, frost free (if necessary) secure storage to avoid theft and damage.
  - The materials should be transported, stored, prepared, and used strictly in accordance with the manufacturer's instructions (when applicable).
  - Thin ceramic panels can require specially designed equipment and more than one person for handling them during and after removal from the manufacturer's original packaging, as well as for the actual installation of the panels (see Figure 1). This is because very large thin ceramic panels can deform and fracture if lifted or moved incorrectly.
- Cement and cement-based materials
  - Cement should be stored under dry conditions, and used in order of delivery.
  - Cement that contains air set lumps should not be used.
- Grout
  - In order to avoid colour differences, the same batches of sand and cement should be used for mixing the grout.
- Sand and aggregates
  - Sand and aggregates should be protected from contamination.
  - Any contaminated sand or aggregates should not be used.
- Water
  - Water should be clean. Seawater is not suitable.
  - All containers used for storing or carrying water should be clean.

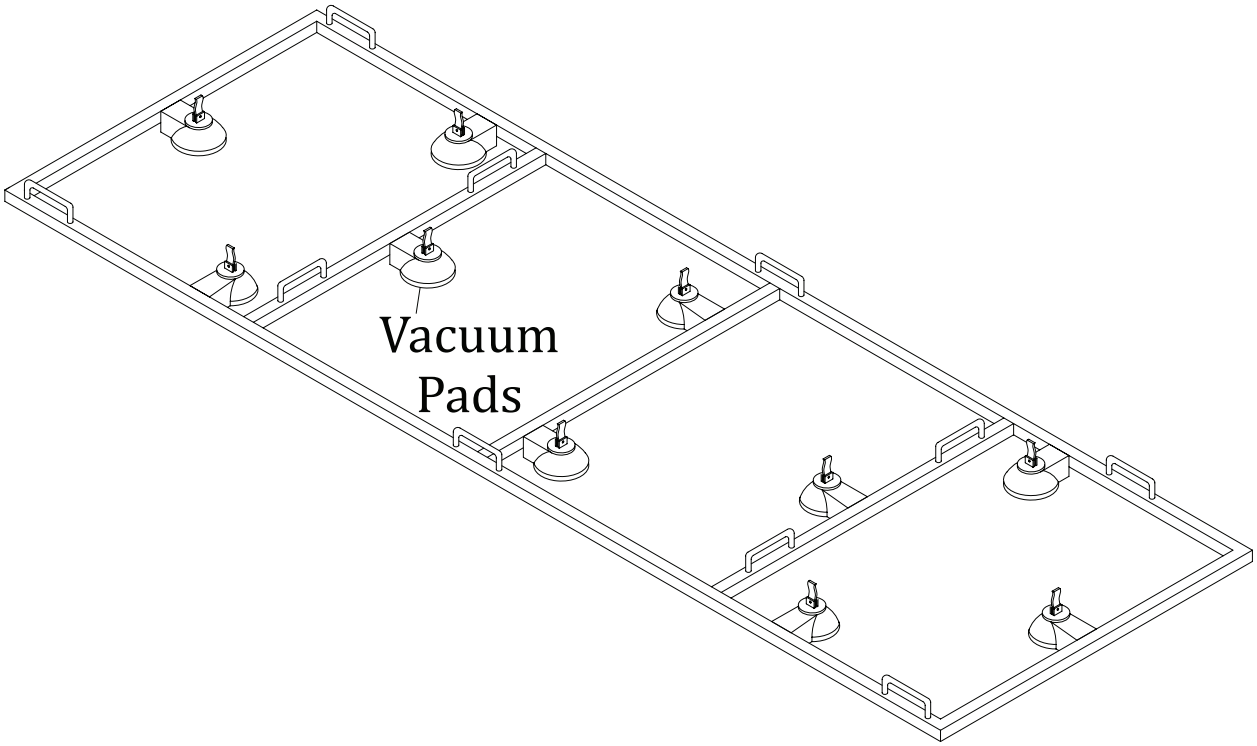


Figure 1 — Light alloy frame with vacuum pads

6 Specification

6.1 General

The specification of tiling using thin ceramic tiles or thin ceramic panels aims to identify and define, in any specific situation, one or more correct fixing method, suitable to achieve an acceptable finish complying with the general requirements of regularity, durability and safety (see Clause 8).

Specification is considered to be a duty of the designer or specifier in consultation with the project owner and with the specification approved by the project owner.

6.2 The project data

The project information constitutes the basis of the thin tiling specification.

6.2.1 Installation location and working conditions

The following criteria should be considered at the design stage as a basis for the specification of the materials and the thin tiling system.

Information on the location of the installation:

— the position of the thin tiling: horizontal (floors), vertical (walls), other (for example, inclined, vault, ceiling, etc.);

— the location of the thin tiling: outdoor/external or indoor/internal;

— the nature of the location: private/residential or public;

— the destined use of the location: domestic or commercial, private or public, etc.;

— the specific activities which will be carried out in the thin tiled area.

Information on working conditions:

— climate (for external thin tiling);

— location (for example, urban, industrial, etc.) for external thin tiling;

— expected traffic type (for example, pedestrian, wheels, etc.) and intensity (for floors);

— expected static and dynamic loads on thin floor tiling;

— presence of water or other fluids on the thin tiled surface;

— presence of chemicals on the thin tiled surface.

The information above should be used to anticipate:

— the expected level of mechanical, abrasive, chemical wetting, and thermal loads acting on the thin tiling and the suitability for purpose of the thin tile or panel selected, and

— general (not individual) requirements regarding safety (for example, slip resistance, hygiene, etc.) or other additional requirements.

6.2.2 Backgrounds

The nature of the background is a prime consideration in deciding the fixing method (specification of materials — in particular, adhesives — and of the thin tiling system, as well as of any intermediate substrate or other preparatory treatment that may be necessary before tiling). The characteristics of the background that influence the choice of fixing method are summarized in Table 1.

The characteristics listed in Table 1 can be used as a framework in order to evaluate backgrounds at the thin tiling design stage, as well as providing indications for the specification of the thin tiling system (see 6.4).

The mechanical properties of the background are very important factors to be considered when specifying thin ceramic tiling.

The following general rules should be adopted.

— Backgrounds for thin tiling should be dry, dimensionally stable, rigid, sound, and free from contamination.

— Cementitious-based backgrounds are subject to long-term drying shrinkage. The associated risks can be reduced by selecting a suitable time schedule and procedures to allow the background materials to cure sufficiently where the majority of the shrinkage will have occurred prior to the installation of thin ceramic tiles or panels, while recognizing that some shrinkage will also occur afterwards. The size of thin ceramic tile or panel specified is also an important factor in this respect, e.g. the effect of long-term background shrinkage on thin ceramic panels can be more severe than for smaller thin ceramic tiles.

— Levelling and/or filling out layers, e.g. suitable levelling compounds, etc., should be used when desired by project owner to improve the background flatness/finish, or to compensate for floors out of level and walls out of plumb.

NOTE The flatness of backgrounds intended to receive thin ceramic tiles should be appropriate when there is no gap wider than 3 mm between the background and a 2 m straightedge. Better surface regularity of the background can be required for large format thin ceramic tiles or panels.

— Special intermediate substrates can be used for waterproofing, or for sound /thermal insulation if approved by the manufacturer of the thin ceramic tile or thin ceramic panel.

— In the case of deformable backgrounds, the application of a suitable strengthening layer (e.g. dimensionally stable backer board or a reinforced screed) should be considered.

— Existing mature floor and wall coverings with the above recommended mechanical, integrity, regularity and surface characteristics can be suitable backgrounds for thin ceramic tiling.

Table 1 — Background characteristics

Characteristics			Description
Mechanical	Mechanical strength	— Compressive strength — Bending strength — Pull off strength	— Resistance to rupture or damage under working loads — Ability to support the permanent load of the tiling (tiles, mortar bed, etc.)
	Deformation under load	— Compression — Deflection — Creep	— Tendency of the support to deform under static and dynamic load
	Deformation without load	— Shrinkage — Plastic deformation — Chemical shrinkage — Thermal and Damp Conditions	— Movements due to non-load factors
	Surface soundness		— Ability to support the weight (walls) of the tiling system
Regularity	Flatness		— Departure from planarity (depressions, protuberances, bumps)
	Surface finish		— Texture of surface
Chemical/Physical	Water absorption		— The amount and rate at which the background absorbs water from the tile bedding
	Water resistance		— The behaviour of the background exposed to contact with water (both during tile installation and in use
	Chemical		— Compatibility between the background surface and the material or layers laid on it

6.3 Selection and specification of the materials

The selection of the materials (thin ceramic tiles, thin ceramic panels, adhesives or grouts) is a basic step in the specification of “thin” ceramic tiling, since it can significantly influence the achievement of satisfactory compliance with the general requirements of regularity, durability, and safety, which define the quality of thin ceramic tiling (see Clause 8).

A very wide range of products are available on the market: products with different appearance (for example, tiles having different thickness, format, colours, surface texture, decorations, etc.), different technical characteristics, and associated different expected performance levels (for example, in terms of resistance to mechanical loads, or to frost and other extreme conditions of temperature or humidity). The technical characteristics of thin ceramic tiles and panels, adhesives and grouts will be documented in the manufacturer’s technical specifications, which therefore, represent basic documents for the selection of materials. Three general criteria for the selection of the materials should be adopted, see 6.3.1 to 6.3.3.

6.3.1 Criterion of performance

This criterion is based on the comparison of

— the expected loads and needs associated with the intended end-use and expected working conditions of the thin tiling (see 6.2.1), as well as to the characteristics of the background (see 6.2.2), with

— the technical characteristics and performance level of the thin tiles or panels, adhesive etc., as documented in their respective technical specification (see Clause 5).

The criterion of performance is the following:

"The performance level of the material selected should not be lower than the expected demands of the end-use environment as communicated by the project owner."

6.3.2 Criterion of compatibility

The criterion of compatibility is the following: "the materials selected should be reciprocally compatible."

The information on compatibility or possible incompatibilities is usually found in the technical specification or informative documentation supplied by the manufacturer. (For example, some thin tiles and panels are only suitable for walls and some adhesives are designed for particular types of background materials.)

6.3.3 Criterion of safety

The criterion of safety is the following:

"The materials selected should be selected considering their safe use and meet local building code regulations for safety, understanding that individual use and owner maintenance also affect individual safety."

EXAMPLE In external walls, the use of thin tiles of a suitable type and size can be specified taking into account the fixing system, which for large format thin tiles and panels might need to be mechanical.

6.3.4 Adhesives

The specification of the adhesives should be considered according to the above criteria, taking into account the relevant project data (see 6.2): installation location and working conditions, backgrounds and, finally, the specified thin tile or panels.

The following indications are reported as an example of guidelines for the specification of the adhesives for thin tiles and panels installation. Always seek the advice of the tile and adhesive manufacturers before selecting a suitable tile adhesive.

Typically, for cementitious backgrounds, e.g. mature cement:sand render or cement:sand screed and existing stable backgrounds, i.e. natural stone, agglomerated stone, ceramics, etc., C2S1 adhesive (see ISO 13007-1) is suitable for the installation of thin ceramic tiles, or, for walls, C2ES2 and C2FES2 adhesives are suitable for large format thin ceramic tiles or thin ceramic panels.

These adhesives may also be suitable for installing thin ceramic tiles and panels onto dry and stable gypsum based backgrounds, i.e. gypsum plaster or calcium sulfate screeds subject to appropriate preparation of the backgrounds and the application of a suitable primer.

R2 adhesive (see ISO 13007-1) may also be appropriate for use on these and other suitable backgrounds.

The choice of a notched trowel which is suitable for the application of adhesive beds depends on the type of installation, the tolerance in the background, the size of the tile, and the type of adhesive. The objective being to achieve solid bedding.

For all internal wall tiling with large format thin ceramic tiles and thin ceramic panels and for thin ceramic tiles which are expected to be exposed to thermal or damp conditions, the adoption of the floating and buttering method is advisable. For external wall tiling with large format thin tiles and thin panels, mechanical fixing should be considered.

Where large format thin porcelain tiles or panels are installed onto impervious backgrounds, e.g. existing porcelain or glazed tiling or plastic decoupling systems, etc., some cement based adhesive bedding materials may remain wet, underneath the thin porcelain tiles or panels for a considerable period of time, possibly weeks because any "free water" in the adhesive is not able to be absorbed into either the impervious background or through the impervious porcelain large format tiles or panels.

Usually, this should not significantly affect the adhesion or the hardening characteristics of most proprietary manufactured rapid drying cementitious adhesive bedding systems, but some slow drying cement based adhesives which cannot dry out properly may also remain "soft", which will adversely affect the adhesion properties of the adhesive and the stability/durability of the tiling.

6.4 Specification of the thin tiling

6.4.1 Thin tiling system

Thin tiling systems can be classified essentially according to:

— the type of thin ceramic tile or thin ceramic panel,

— the type of adhesive,

— the need of specified layer(s) under the thin tile bed,

— the mechanical fixing,

  examples of additional layers: screed, reinforced screed; levelling out layer; levelling layer; separating layer; etc.(see 3.2),

— the method of application of the bedding (see 3.3):

  — floating method;

  — buttering method;

  — floating and buttering method;

  — unbonded method – floors (de-coupling systems).

The choice of the thin tiling system should take into consideration the performance characteristics of the thin ceramic tiles or thin ceramic panels, the characteristics of the background, and the expected end-use environment as communicated by the project owner.

6.4.2 Thin tile joints

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

Inevitably, when solidly bedding thin tiles and panels into the adhesive bedding, much of the shallow joint between the thin tiles/panels will become partially filled with residual adhesive which should, as

far as is practicable, be removed from the joints in order to provide adequate joint depth and volume to receive the specified tile grout. Failure to do this can result in unsightly grout and reduced performance.

The joints between thin ceramic tiles and panels are usually the most vulnerable points of a thin tiling installation — thin tile edges may be less resistant to static, dynamic and impact loads, than the edges of thicker tiles. Therefore, the grout can be specified taking into account both the need of protecting thin tile edges and the destination environment as communicated by the project owner. Grout should be well compacted into the tile/panel joints and finished as flush as is practicable with the surface of the thin tiles/panels.

NOTE In the specification of the grouts, the relevant information/instruction of the manufacturer can be considered. Grouts classified as CG2 (see ISO 13007-3) or reaction resin based may be considered.

6.4.3 Movement joints

NOTE Thin ceramic tiles and thin ceramic panels (porcelain) have similar coefficient of thermal expansion characteristics to porcelain as defined in ISO 13006.

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

For larger format thin tiles and panels, any thermal expansion/contraction is cumulative across the area of the thin tile or panel so that, for a ceramic panel, e.g. 3 m long, the expansion of the panel across a temperature range of 30 °C equates to approximately 0,65 mm which, as a percentage of a 5-mm-wide joint between adjacent panels, equates to an approximately 12,5 % compaction/expansion requirement of the joint grouting mortar, as well as a significant lateral deformation capacity of the panel bedding adhesive; depending upon any corresponding temperature change within the background structure onto which the panels are installed.

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

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

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

- Type, materials, and construction
  - back-up and sealing material, metal angles, etc.; or pre-formed movement joints.
- Dimensions
  - Width:
    - perimeter joints: minimum width (for example, 6 mm);
    - intermediate joints: minimum width (for example, 6 mm);

  - structural joints: width should be greater than or equal to the joint in the background.
- Depth:
  - perimeter joints: depth to penetrate to the full depth of the screed or render;
  - intermediate joints: depth to penetrate to the full depth of the screed or render;
  - structural joints: depth to be continuous from the joint in the background.
- Position:
  - perimeter joints: where the thin tiling abuts a restraining surface
  - intermediate joints: minimum area between joints and/or the distance between joints should be specified. Different limits or reference values should be established according to the size of the thin tiles or panels, end-use environment as communicated by the project owner (for example, for internal or external applications and areas of thin tiling that incorporate underfloor heating). Areas between intermediate movement joints should be approximately square where applicable.
  - structural joints: immediately over and continuous with structural movement joints in the background.

7 Installation

7.1 General

The installation of thin ceramic tiles and thin ceramic panels may include the following:

- analysis of the specification and planning of the work,
- control of environmental conditions,
- possible storage and control of the materials, depending on when transfer to the owner or others occurs,
- control and preparation of the background (fixing surface),
- preparation of the bedding material (adhesive),
- application of the bedding and application of thin tiles or thin panels,
- preparation and application of the grout,
- installation of movement joints, and
- cleaning and protection depending on when transfer to the owner or others occurs and provisions by owner for protection of the finish work.

7.2 Analysis of the specification and planning of the work

7.2.1 On the basis of the specification [materials (thin ceramic tiles or panels, adhesives and grouts), see 6.3; thin tiling system, see 6.4.1; thin tile joints (width), see 6.4.2; movement joints, see 6.4.3], taking into account the characteristics of the background and the environmental conditions on the work site, a schedule of the work should be prepared. This scheduled work plan should reflect the time requirements for the different operations, as well as the time required by some materials (for example, the type of bedding adhesives) or layers (for example, a levelling layer) to reach suitable levels of mechanical strength.

7.2.2 A preliminary setting out of the thin tiling is advisable, in order to avoid, as far as possible, small or unequal cut courses, as well as to optimize the lay-out.

7.3 Control of environmental conditions

7.3.1 Environmental temperature, humidity, exposure to sunny, windy, or rainy conditions can influence the application behaviour and ageing of some materials (mortars, adhesives, grouts). Therefore, acceptable parameters for environmental conditions should be agreed by all parties, taking into account the materials and the thin tiling system adopted.

For example:

— installation of thin ceramic tiles or thin ceramic panels should not be undertaken when the temperature of the air, backgrounds, or materials is less than 5 °C. (Higher minimum temperatures can be required by different materials. The relevant information by the manufacturer can be considered);

— external tiling should not be undertaken under adverse climatic conditions (rain, snow, wind).

7.3.2 Lighting conditions on the work site can influence the standard of workmanship that can be achieved (regularity requirements, see 8.2.2). Therefore, acceptable lighting conditions should be specified at the design stage.

For example:

— where work is carried out in artificial light, the direction and intensity of the temporary lighting should be similar to the intended final lighting.

7.4 Storage and control of the materials

7.4.1 Materials should be stored and controlled according to the specification considered (see 5.3 c).

7.4.2 Technical information supplied by the manufacturers of the materials used (thin tiles or panels, adhesives, grouts, etc.) should be carefully reviewed. All the relevant storage, control, transportation, preparation, and application conditions should be carried out strictly in accordance with the manufacturer's instructions.

Thin ceramic panels can require specially designed equipment for supporting them in order to prevent possible fracture during and after removal from the manufacturer's original packaging, as well as for the actual installation of the panels (see Figure 2). This is because very large ceramic thin panels can deform and fracture if lifted or moved incorrectly.

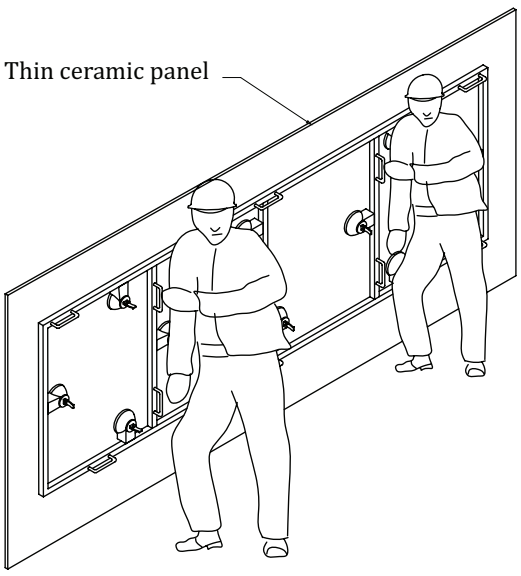


Figure 2 — Light alloy frame with vacuum pads

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

7.5.1 These operations may involve taking into account the behaviour or characteristics of materials, which may bring about detrimental effects, if unsuitably managed. The associated risks should be prevented through advisable procedures.

For example:

— tiles should be provided from the same dye lot/production run. If not some thin tiles should be mixed before fixing to the extent reasonably practical and confirmed with the project owner [the effects of any shade variations — acceptable according to the relevant Standards (see Bibliography) — become less visible after this procedure];

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

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

NOTE The profile of the notched floating trowel is an important factor to achieve the correct thickness and spread of bedding adhesive onto the background. The angle of the floating trowel used in relation to the background is also important in this respect.

Floating trowels with appropriately sized and spaced notches are used to spread the bedding adhesive over the background. Floating trowels with "angled" notches may assist in achieving improved distribution of the bedding adhesive when it is compressed between the background and the thin tiles or panels for solid bedding (see Figure 3). The trowel used for spreading adhesive over the backs of the thin tiles or thin panels can have smaller, more closely spaced notches, as the objective is to create an even, well adhered 100 % contact layer of bedding adhesive over the backs of the thin tiles or thin panels.

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

For floor tiling, the use of a suitable lower viscosity bedding adhesive can be advantageous in achieving this.

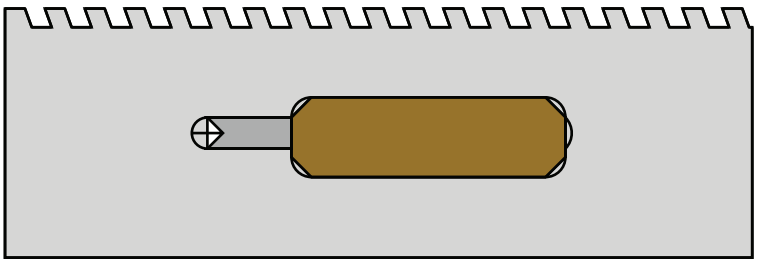


Figure 3 — Floating trowel with angled notches

7.5.2 All these tiling operations should be carried out taking into account the specific characteristics of the materials used (and the manufacturer's instructions, which should be strictly followed, as stated above), and being aware that the regularity and durability requisites of the tiling (8.2.2 and 8.2.3) can be complied with, provided the following conditions are reached:

— the thin tile or panel bed is reasonably uniform in thickness where relevant (reference: the specified thickness).

— the thin tile or panel bed meets criteria established by the mortar manufacturer and the tile manufacturer.

These factors are more critical and important, the higher the level of expected exposure of the thin tiling to impact, loading, and thermal or damp conditions (see 6.2.1.) Also, the type of tile, its size, and thickness are important too from this point of view. Therefore, the recourse to special techniques can be specified in particular situations.

For example:

— backgrounds should be checked as having the regularity characteristics considered in the specification, e.g. the larger the thin tile/panel the greater the importance of the accuracy in planarity of the background. Any discrepancy from the specification should be communicated to the appropriate parties;

— particular attention should be paid to the application of adhesive to the backs of thin ceramic tiles and panels, so that the edges and corners are properly covered with adhesive (see 6.4.2).

7.6 Installation of movement joints

At the positions specified by the designer, open joints through the thin ceramic tiling and thin tile/panel bedding should be provided, leaving them clean and clear of debris, for filling with the specified sealant.

Alternatively, build into the thin tile/panel and bed for the full thickness, preformed deformable movement joint strips as specified.

7.7 Cleaning and protection

The thin tiling work should be cleaned, and, where necessary, protected against premature loading and adverse climatic conditions (9.2 and 9.3) as per an understanding with the project owner on when transfer takes place and who is responsible prior to that time.

8 Quality of thin ceramic tiling: characteristics and requirements

8.1 General characteristics of thin ceramic tiling

The quality of thin ceramic tiling depends on the following general characteristics:

— regularity, which includes characteristics such as flatness, lipping, levelness, and plumbness;

— durability, which includes the resistance of the thin ceramic tiling to abrasion, loads, and conditions associated with the intended end-use of the tiling (see Note);

— safety, which includes thin tiling characteristics such as slip resistance and certain limited aspects of fire resistance.

Further characteristics, such as impermeability, thermal or sound insulation, insulation from impact noise, are considered to be special performance characteristics for the tiling.

NOTE Some thin ceramic tiles and thin ceramic panels are not suitable for floors. Some thin ceramic tiles and thin ceramic panels can be suitable for light domestic/light commercial floorings in areas where the sub-floor is mature and rigid, e.g. existing ceramic or terrazzo, etc. Always follow the thin ceramic tile/panel manufacturer's recommendations.

8.2 Guidelines for the specification of the requirements and their recommended tolerances

8.2.1 General

This clause covers the general requirements related to the characteristics listed in 8.1. The relevant thin tiling properties, the measuring method, and the reference limit value (when available), as well as some general (qualitative) concepts.

Each reference limit value is understood as the minimum acceptable level of the respective characteristic or property.

NOTE National standards or guides can adopt tolerances that are equal to or more severe than the reference limit values reported in this document.

It is assumed that compliance with both the general and specific thin tiling tolerances presented in this part of ISO/TR 17870 depends on (i) the quality, characteristics and performance of the materials used (thin tiles, thin panels, adhesives, grouts, etc.), (ii) the suitability and correctness of the design, (iii) the suitability and correctness of the installation activities, and (iv) the suitability and correctness of the use of the tiling.

8.2.2 Regularity

8.2.2.1 General

Visual examination of thin tiling should be carried out from a distance of at least 1,5 m, without acute angled lighting.

8.2.2.2 Flatness of finished thin ceramic tiling

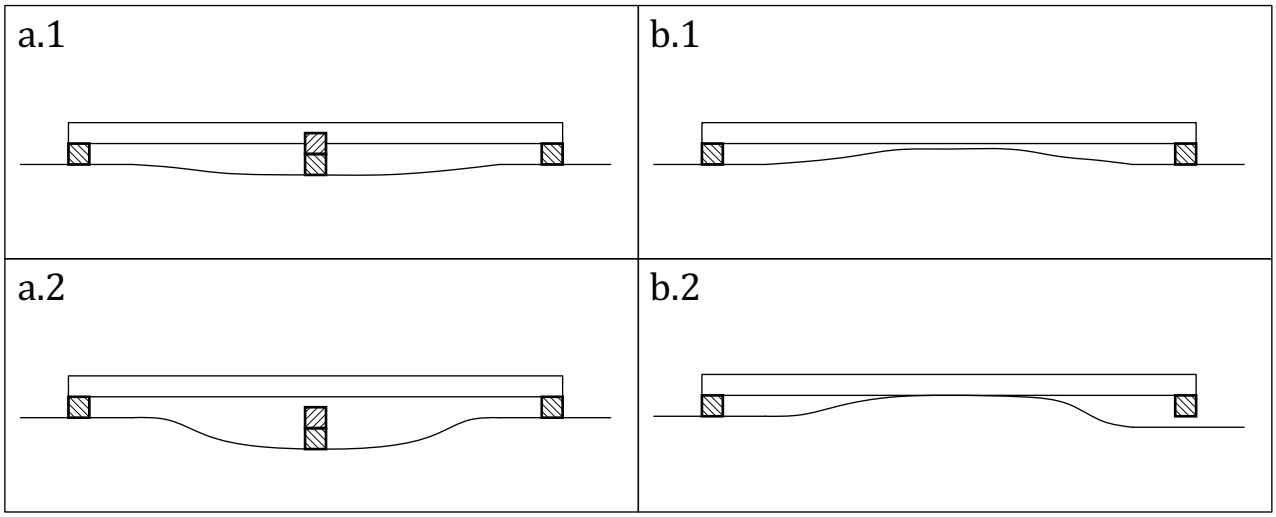
This is applicable to both floor and wall tiling.

Method: ISO 7976-1:1989, 7.3.1.

Reference limit*:* Tolerance = ±3 mm under a 2 m straightedge but no tighter than the actual background over which the tile is being installed unless provisions for a levelling layer have been made.

A 2 m straightedge with 3 mm “feet” at each end is placed on the thin tiling, both “feet” being in contact with the tiling. The max distance X between the tile surface and the straightedge is measured, using a rule or a measuring wedge. The straightness deviation is (X-3), and this is an indicator of flatness.

EXAMPLE Compliance with the above tolerance can be assessed as shown in Figure 4 using a fillet 6 mm thick.



Key

a.1 within the tolerance

a.2 out of tolerance

b.1 within the tolerance

b.2 out of tolerance

Figure 4 — Flatness measurement

Remarks: The finished thin tiling flatness will depend upon the flatness regularity of both the thin tiles and panels used and the flatness of the background.

8.2.2.3 Lipping

This is applicable to both floor and wall thin tiling.

Method: Straightedge across joints.

A suitable length straightedge is placed on the lipped edge, with the straightedge held flat to the thin tile. Any gap between the overhanging straightedge and the adjacent thin tile is measured by calibrated wedge (see Figure 5) or other thickness gauge.

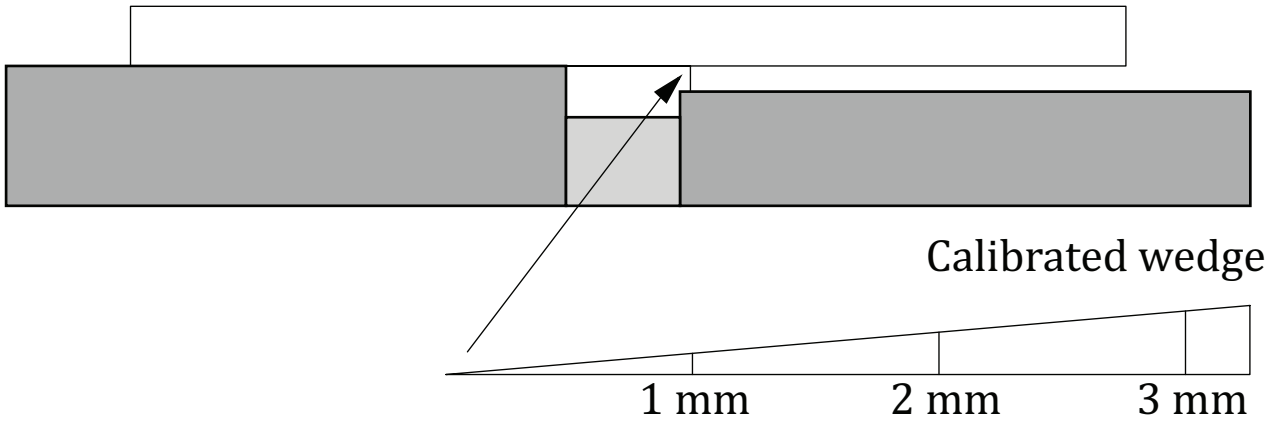


Figure 5 — Lipping measurement

Reference limits: Tolerance = 1 mm max, for joints < 6 mm wide; 2 mm max, for joints ≥ 6 mm wide.

8.2.2.4 Levelness

Applicable to thin ceramic floor tiling, except at perimeters, etc., recognizing though that certain sloping conditions should not be levelled where it would impact adjoining spaces and doorways, etc., or where needed to maintain drainage, and only when desired by the project owner..

Method: Use of a levelling device (water level, optical level, laser level, etc.).

Reference limits: Tolerance = ± L/600, where L = measured length between fixed data, in mm

Remarks: Greater accuracy may be needed at partitions, door openings and where fittings are to be installed directly on the floor.

8.2.2.5 Plumbness

This is applicable to thin ceramic wall tiling where desired by the project owner and recognizing that when tiles are fixed with adhesive, the finished tiling tolerance will depend upon that of the background.

Method: Use of a plumb rule.

Reference limits: Tolerance = ± h/600, where h = measured height of the wall, in mm.

8.2.2.6 Width and straightness of joints

This is applicable to both floor and wall thin ceramic tiling.

The joints between thin tiles and panels are an important feature of any tiling installation, particularly when small tiles, wide joints, or contrasting coloured grouts are specified. The width of the joints between thin tiles and panels should be even and of regular dimension (subject to the manufacturing size and tolerance for the type of thin tile or panel specified). Generally, thin ceramic tile or panel joints should be straight in alignment unless the thin tiles or panels are, by design, irregular in shape. Tiles should not be butt jointed. Special attention is recommended at “eye level” for thin ceramic wall tiling and for large areas of thin ceramic floor tiling where the joint lines can be sighted.

8.2.3 Durability

This is applicable to both thin ceramic floor and wall tiling.

Reference limits for durability cannot be established in quantitative terms, even though it should be acknowledged that thin ceramic tiling is presented to and considered by the users as a durable covering for walls. Some thin ceramic tiles may also be suitable for some lightly pedestrianized floors.

Acceptable levels of durability can be achieved by careful choice, at the thin tiling design stage, of the materials (with suitable performance) and the thin ceramic tiles or panels, taking into account both the environment and the characteristics of the background. The thin ceramic tile or panel characteristics which are more relevant from the durability point of view are, for example, frost resistance, in the case of external thin wall tiling exposed to freezing conditions, and resistance to abrasion and to chemical attack. In the case of floors, resistance to static, dynamic, and impact load. A significant contribution to durability comes from correct specification of materials, installation and appropriate usage of the thin tiling.

8.2.4 Safety

8.2.4.1 General

The specification should define the safety requirements.

NOTE Safety requirements can be defined in national regulations.

8.2.4.2 Slip resistance

This is applicable to thin ceramic floor tiling.

Prescribed levels of slip resistance can be achieved, in principle, through a careful choice of the thin ceramic tiles or panels.

Thin ceramic floor tiles and panels usually have a high degree of slip resistance when clean and dry. Textured surface tiles may provide good slip resistance even in wet conditions.

When dealing with the slip resistance of thin ceramic tiling, the following aspects should be considered:

— the slip resistance of a thin ceramic tiled floor in service depends on the characteristics of its surface (tiles and joints), and these may change over the lifetime of the floor;

— slip resistance is adversely affected by the presence of contamination; the most common contaminant is water but others including oil, grease, soap, dust and sand are also possible;

— Where applicable, frequently wetted floors should be laid with falls adequate to prevent standing water and compliant with local building regulations. Falls within 1:80 (1.25 %) and 1:40 (2.5 %), for example, are usually adequate depending upon both the thin tiling surface structure (type and size of the tiles, width and path of the thin tile/panel joints), and the nature and frequency of wetting anticipated. Drainage channels and outlets should always have sufficient volume/capacity to be adequate for most extreme wetting conditions anticipated as communicated by the project owner and where use of the tile surface is planned when wet;

The required or specified slip resistance can usually be maintained by frequent and effective cleaning with appropriate detergent and cleaning tools.

8.2.4.3 Hygiene

For areas in which there are specific requirements as far as hygiene is concerned, most thin ceramic tiles and panels are suitable.

For those areas where thin tiles or panels must be easy to clean and, if necessary, easy to disinfect, this requirement should be specified. If so specified, the grout for tile joints should be (i) easy to clean, (ii) low absorption, and (iii) resistant to cleaning systems.

8.2.4.4 Fire resistance

Thin ceramic tiles and panels used as finishings for floors or walls (internal and external), installed with adhesives can be considered as fire resistant.

8.2.4.5 Thermal and acoustic insulation

Where necessary, these specific requirements of floors or walls covered with thin ceramic tiles or panels can be achieved through the appropriate design of the background structure, prior to the installation of the tiling.

8.2.4.6 Impermeability

In general, thin ceramic tiling — that is the thin ceramic tiles or thin ceramic panels together with associated bedding and jointing — cannot ensure waterproofness. If it is required, a waterproofing membrane appropriately positioned underneath the thin tiling, will be necessary (tanking).

9 Initial cleaning, protection, and maintenance

9.1 General

Consideration should be given to the protection of finished and partly finished thin ceramic tiling from damage or contamination from following trades. At all times, the thin ceramic tiling should be kept clean and free from cement, plaster droppings, and any materials likely to cause stains and project specifications should detail who has that responsibility.

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

— efflorescence (by rising water or drying out),

— residual cement film (grouting),

— surface sealing materials (see protection), and

— cleaning agents which are unsuitable or which react negatively with hard water.

9.2 Initial cleaning

The cleaning of thin ceramic tiling should be carried out during the installation and the grouting operations. All cementitious residues should be cleaned off with water as soon as possible.

Where reaction resin adhesive and grouting materials are used, particular care and attention must be paid to ensure cleanliness of the working area and removal of any residual contamination from the thin ceramic tiling within the open time of the reaction resin material in accordance with the reaction resin manufacturer's instructions.

If necessary, immediately after installation and grouting are completed, the surface of thin ceramic tiling should be cleaned by the tile fixer in order to remove any contamination and all materials that may be likely to cause stains. Taking into account that

— cleaning operations may need to be carried out at a specified time after grouting, and

— before and/or after cleaning with aggressive chemical agents, wetting, and/or rinsing with clean water is necessary.

Advice about cleaning with chemicals should be obtained from the appropriate manufacturers.

9.3 Protection

The application of a temporary protective layer can, where necessary, be part of the tiling installation process. If it is required this should be specified and agreed in advance.

9.4 Treatment

9.4.1 Surface waterproofing treatments

In order to avoid absorption of water or other liquids and the soiling of floors, hence improving the performance of the thin ceramic tiling against stains, it may be necessary, depending upon the type of thin tiles or panels and grout, to apply special surface treatment using specified products, i.e. water repellent sealers. This should be done strictly in accordance with the manufacturer's recommendations and in such a way as to prevent the tiling surface becoming slippery. The party responsible for applying any special surface treatment should be specified.

9.4.2 Temporary thin ceramic tile or thin ceramic panel sealers

These are sometimes used to protect porous or rough surfaced tiles from bedding or grouting residues adhering and can normally be easily removed using alkaline detergents.

9.5 Maintenance

Personnel responsible for maintenance should be fully aware of any particular risk of misuse likely to occur, and this should include recommendations for cleaning. Repair and restoration may be necessary in time. For this purpose, original tile materials should be used and therefore, it is recommended that the owner reserves a quantity of the thin ceramic tiles or thin ceramic panels used for possible future replacements. Maintenance generally consists of regular cleaning with water (warm) and sometimes a pH neutral detergent diluted solution then rinse with plenty of water. For stains which are difficult to remove, it may be necessary to use special cleaning products and procedures. It is advisable to test the effect of these products on a sample tile before they are applied to installed thin ceramic tiling.

Bibliography

[1] ISO 7976-1:1989, *Tolerances for building — Methods of measurement of buildings and building products — Part 1: Methods and instruments*

[2] ISO 13007-2, *Ceramic tiles — Grouts and adhesives — Part 2: Test methods for adhesives*

[3] ISO 13007-4, *Ceramic tiles — Grouts and adhesives — Part 4: Test methods for grouts*

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