

OUTDOOR INSTALLATION GUIDE FOR LOW POROSITY CERAMIC PAVING IN AREAS SUBJECT TO FREEZING



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1).- INTRODUCTION

Tiled floors outdoors differ from those indoors in that they are subjected to greater differences in temperature, which cause contraction and expansion, and are more exposed to water and ice.

For example, it should be taken into account that due to the differences in thermal expansion coefficients, for a 10 linear metre terrace and a thermal shock of 50 °C (between -15 °C and +35 °C), the differential movement between the ceramic surface and the load bearing structure (concrete) can be 4 to 5 mm.

Defects that appear due to fatigue caused by **freeze-thaw cycles** usually take the form of conchoidal fractures with chipped areas. These are caused by the tension generated by the water that is retained inside the pores of the ceramic tile as it freezes (its volume increases by approx. 9%), and in extreme cases the surface of the paving can be completely destroyed.



Conchoidal fracture



Numerous fractures

2).- REGULATIONS & EXPERIENCE

Annexes H and G of the **ISO 13006** international regulations on ceramic floor tiles (European regulations **EN 14411**), which correspond to the standardised groups **B1b** (earthenware floor tiles with a water absorption level of $0.5\% < E < 3\%$, commercially known as “*frost proof earthenware*”) and **B1a** (porcelain earthenware with a water absorption level of $E < 0.5\%$), establish the compulsory requirement that all tiles should pass the frost resistance test outlined in the **ISO 10.545-12** regulations.

This test consists of impregnating tiles using the vacuum method (600 mbar) and subjecting them to 100 freeze-thaw cycles, lowering the temperature to $-5\text{ }^{\circ}\text{C}$ at a rate no quicker than $20^{\circ}\text{C}/\text{hour}$. This temperature is maintained for 15 minutes, and finally the tiles are submerged in water to reach a temperature of over $+5\text{ }^{\circ}\text{C}$, and maintained at this temperature for a further 15 minutes.

However, **Annex J** of the aforementioned regulations does not consider it a compulsory requirement to pass the frost resistance test for earthenware paving belonging to the standardised group **B11a** – in other words, dry pressed ceramic floor tiles with an open porosity (measured as their capacity to absorb water) of $3\% < E < 6\%$. It is merely a “*testing method that is available*”. The adaptation of this type of tile to outdoor environments will depend on the required slip-resistance properties and the risk of frost in the area in which they are installed.

Apart from the regulations, however, our experience has shown that “**FROST PROOF**” **TILES ARE THOSE THAT HAVE BEEN CORRECTLY INSTALLED FOR THAT PURPOSE**, regardless of whether their open porosity (measured as their capacity to absorb water) is 1%, 2%, 3%, 4%, 5%, 6%, etc.

Recent studies have shown that a ceramic tile’s resistance to freezing depends on the average size of its pores, rather than on the absolute value of open porosity. Therefore, it depends on the ease at which the ceramic tile becomes saturated with water. Very porous tiles never become saturated and will resist freezing better than tiles that have a high percentage of earthenware (the pores of which are easily saturated). It should be taken into account that a bottle of water left in a freezer will only shatter if it is full.

For this reason, old roof tiles and unglazed fired clay resist freezing conditions perfectly. Although the rain soaks the tiles, they dry quickly in the sun and the large pores never become saturated.

However, the typical conchoidal shaped chipping on glazed surfaces is caused by tension generated inside the tile due to an increase in volume as the water freezes. Constant freeze-thaw cycles cause fatigue of the ceramic nearest the glaze, where the temperature is lowest, until it breaks completely.

Logically, the higher the porosity of the (glazed) paving used in a specific project, the greater the possibility of this problem occurring and the greater the flaws. But the **FROST PROOF BEHAVIOUR OF THE TILED FLOOR** (and the entire multilayer system) will depend on the **COMPREHENSIVE TECHNICAL PROJECT** that is drawn up, with instructions on how to **PLAN AND CARRY OUT THE INSTALLATION CORRECTLY**, in order to guarantee the durability of the tiled floor.

Experience confirms that in areas where freezing temperatures are common, **the presence of water in the multilayer system is constant or frequent**. In such circumstances, the freeze-thaw cycles cause chips to appear on the glazed surface (except for porcelain earthenware paving), while the rest of the system is deteriorated due to the presence of **soluble salts** that rise from the lower layers by capillary action. The saturation of these salts and their crystallization produce tension that produces a break in the adhesive union, the anchoring material, the installation surface, and the ceramic tile itself, in an expansion process similar to that which is produced when water freezes.

Therefore, the installation project must make allowances for all that may be necessary **TO AVOID WATER PENETRATING THE MULTILAYER SYSTEM**.



Installation using the thick-bed technique + water



Saltpetre at the joints

The most recent Spanish technical documents (section 5, the bibliography) establish a series of basic recommendations for the installation of ceramic floor tiles outdoors in areas subject to freezing. The most important are the following:

- Use the **thin-bed** installation technique with specific **type C2** cement based adhesives for exteriors according to the European **EN 12004** regulations (see CE Marking).
- If necessary, position a **waterproof** membrane between the gravel base (drainage layer) and concrete base to prevent water rising by capillary action from the subsoil, irrigation water, seepage, etc.
- Design a **minimum slope** to ensure the drainage of rainwater and drains, and therefore prevent pools of water forming on the ground.
- Design and correctly carry out **movement and installation joints**, using grouting materials suitable for outdoor environments (**type CG2**).
- Correctly **maintain** the paving and drains.



Deteriorated joints



Evidence of stagnant water

THE THICK-BED INSTALLATION TECHNIQUE (UPON A THICK BED OF TRADITIONAL CEMENT BASED MORTARS) DOES NOT GUARANTEE GOOD ADHESION, AND WE STRONGLY ADVISE AGAINST IT FOR OUTDOOR ENVIRONMENTS THAT ARE SUBJECT TO FREEZING.

3).- RESPONSIBILITY CLAUSE

Since the final decisions concerning the installation of ceramic paving is not our responsibility and we are not in charge of the technical side of the installation, **the only guarantee given by TAU CERÁMICA for its products commercially known as “FROST PROOF”, is that they have satisfactorily passed the frost resistance test according to the ISO 10.545-12 regulations**, as it is clearly mentioned in the description of the icons figuring in our catalogue. We are not responsible for any problems that may derive from incorrectly planning/carrying out any installation, or installation work that does not comply with the requirements outlined in the technical documents on the installation of ceramic paving outdoors in areas subject to freezing.



FROST PROOF

4).- OUTDOOR INSTALLATION OF TILES

Below you will find **NOTES ON THE INSTALLATION OF CERAMIC FLOOR TILES OUTDOORS AND IN AREAS THAT ARE SUBJECT TO FREEZING** taken from the bibliography listed at the end of this guide. We strongly recommend consulting the bibliography for further information on most of the points we have briefly outlined below.

4.1).- Type and state of the substrates

The work plan for the installation of ceramic tiles must include a correct understanding, preparation and carrying out of the **supporting substrate** (usually concrete bases), **intermediate layers** (levelling screed, waterproof layer, etc.) and the **ceramic paving**, which must be compatible with the adhesives to be used.

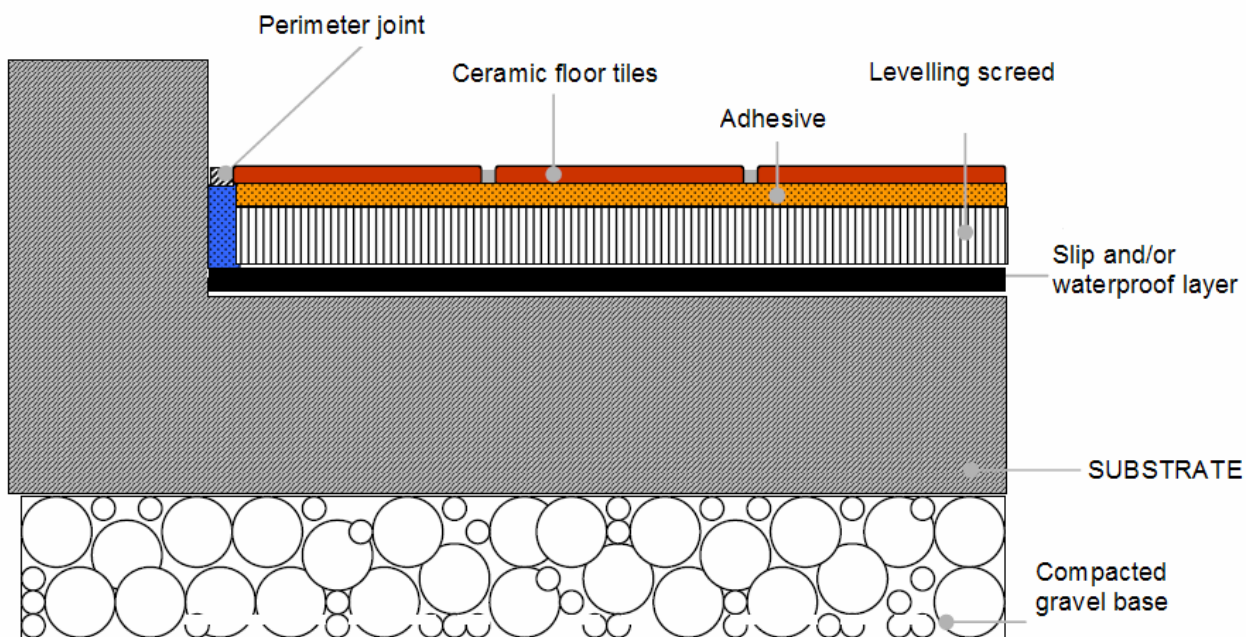


FIGURE 1

Always install tiles in mild favourable weather conditions:

- Temperatures between + 5 °C and + 30 °C.
- Do not install tiles if frost is forecast, in direct sunlight or at the hottest times of the year. In hot weather the substrate should be dampened.
- Do not install tiles in the rain.
- Wind reduces the open time of the adhesive.

To ensure the durability of the paving, the following points must be taken into account:

- The use of cement substrates that are correctly measured out and cured (drying and hardening times must be respected), resistant to water, and that **prevent damp rising by capillary action from the subsoil**. A damp substrate is unstable and could cause adherence problems, as well as deformations and contractions that could in turn cause the paving to break or lift over time.
- To obtain good adhesion on the surface upon which the tiles are to be installed, the original firm surface has to be uncovered, and therefore thorough cleaning of the substrate is required. Any remains of dust, grease, paint, efflorescence, slurry, plaster, etc. interfere with adherence.
- Due to the fact that the performance of cement based adhesives is reduced above 5-10 mm thickness, it is not possible to correct uneven substrates by applying more adhesive when using the **thin-bed** installation technique. Therefore it is essential to work on perfectly flat surfaces. However, adhesives have recently appeared on the market that make it possible to install tiles using a **medium thickness** of adhesive of up to 15 mm, and correct deviations from levelness of 10 mm when measured with a 2-metre rule.

Greater deviations from levelness should be corrected by applying a **levelling layer**. It is important to remember that the floor tiles will merely reproduce every irregularity on the substrate, if this is overlooked.

- The roughness of the surfaces on which the adhesive is to be applied provides mechanical anchorage, which helps improve adhesion. It is therefore advisable to mechanically alter excessively smooth substrates such as vibrated concrete, prefab concrete or the levelling layer itself.
- When the tiles are to be subjected to considerable stress due to changes in temperature or movement of the structure, it is advisable to place a slip or desolidation layer (plastic sheet or similar) between the levelling screed and the substrate.
- In areas of frequent rain, it is advisable to **waterproof the substrate** with asphalt fabric or similar, or at least leave a suitable drainage layer beneath the substrate, such as a compacted gravel base (see Fig. 1).
- Slopes of at least 1-2 cm/m are also needed **to ensure the drainage of rainwater and prevent pools of water forming on the paving**. Any existing drains must be protected to prevent water outlets from becoming blocked.

4.2).- Applying the adhesive

The **thin-bed technique** must be used for the installation of tiles outdoors in areas subject to freezing, with anchoring materials in accordance with the characteristics of the tiles (see CE Marking). In general, recommended adhesives are **C2 type cement based adhesives**, as specified in the European regulations **EN 12.004**.

Furthermore, when using low porosity ceramic floor tiles, this installation technique usually causes the tiles to sink shortly after installation. Therefore, even if the installation has been carefully carried out on the same flat surface, after a while each tile will settle differently and the end result will be very disappointing.

To ensure good durable adhesion, the following factors must be taken into account:

- Follow the manufacturer's recommendations carefully when preparing the adhesive.
- The adhesive should be mechanically mixed to ensure a homogeneous paste that is free of lumps.
- The **double gluing** technique (when adhesive is applied to both the substrate and the ceramic tile) ensures that ceramic tiles will adhere perfectly, and prevents gaps from forming between the tiles and substrate.
- "**Combing**" the glue on the substrate with a notched trowel (suitable for the size of tile) ensures an even layer of adhesive that is spread evenly over the surface.
- Once the tiles are in position, each one must be vigorously beaten to ensure it is firmly in place. Tiles must be lifted from time to time to check that the adhesive is **setting correctly**. This requirement and the use of thicker ceramic floor tiles with a breaking load of over 3,000 N, is essential in areas intended for not only pedestrian traffic.
- Any remains of adhesive must be removed from the joints so that they may be grouted correctly afterwards.

Recent installations must be signposted well to prevent the paving from being walked upon until the time recommended by the adhesive manufacturer has elapsed.

4.3).- Types of joints

The **substrate** is usually a continuous surface that is subjected to contractions and expansions caused by changes in temperature, structural movements, the effects of water or damp, chemical reactions or the retraction of the cement itself. For this reason, if the joints are carried out correctly there will be no sign of these natural movements of the substrate on the paving.

4.3.1).- Structural joints

Measurements of structural joints must be perfectly detailed on the building project, and they must be established by the architect or specialised engineer.

Tiles must be installed according to the structural joints required by the building.

Structural joints are usually finished off by filling them in with materials of durable elasticity.

4.3.2).- Perimeter joints

The purpose of these joints is to separate the ceramic floor tiles (together with their respective layer of adhesive) from any other tiled walls or floors, such as where walls and floors meet, and where tiles come up against other building elements such as columns, and window or door frames. They prevent the ceramic tiles and adhesive from coming into contact with the aforementioned elements, in order to avoid an accumulation of stress.

Joints are always necessary between walls and floors on surface areas of over 7 m². The joints should be between 5 and 10 mm wide, and can be hidden by the skirting board or adjacent wall or floor covering.

Perimeter joints must always be carried out correctly and must serve their purpose: therefore they must be free of any remains of building material and **must reach the slip layer, asphalt fabric or substrate**. They must therefore be planned before laying the levelling screed, because otherwise it would be impossible to carry them out properly.

An analysis of the most common problems reveals that one of the most frequent causes for tiles lifting is the lack of perimeter joints, or those that have not been carried out correctly.

4.3.3).- Expansion joints

Their purpose is to allow any differential deformations caused by thermal and/or hygroscopic variations between the floor tiles, the adhesive layer and the substrate.

Expansion joints are usually designed on site, and therefore it is useful to have certain minimum criteria for measuring them. For example:

- Minimum width: 5 mm, but usually 8 mm.
- It is advisable to divide the surface area to be tiled into smaller sections of not more than 25 m², **or into 9 m² sections in extremely adverse weather conditions.**
- Expansion joints must be carried out correctly and must serve their purpose: therefore they must be *flexible, watertight, and well-adhered* and **must reach the slip layer, asphalt fabric or substrate** (see figure 2).
- Expansion joints can be filled in with profiles or elastic materials.

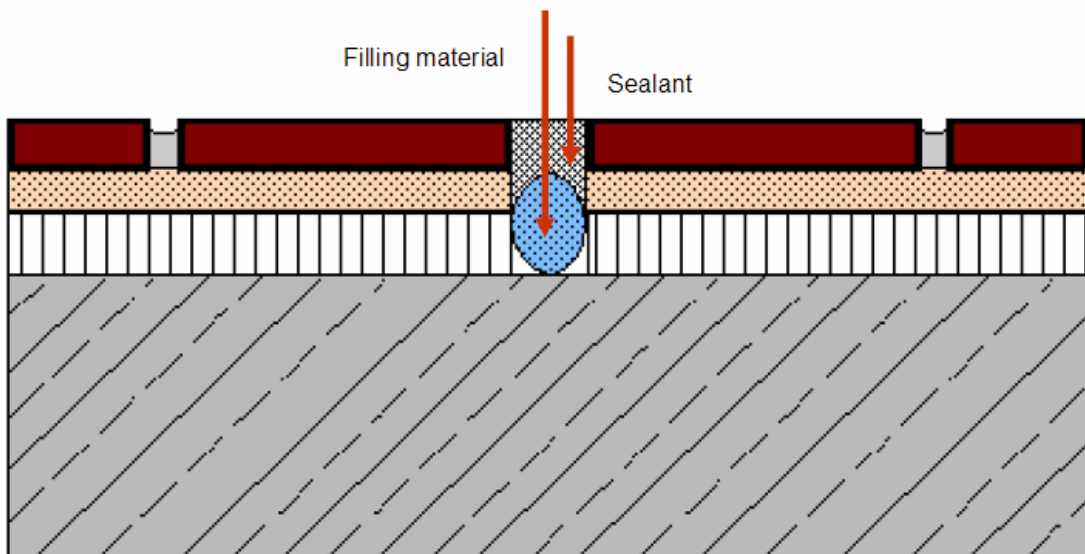


FIGURE 2

4.3.4).- Installation joints

For **outdoor tile installations**, the surface area of the joints must be 6-12% of the total surface area of the paving.

Installation joints play an important aesthetic role and enhance the beauty of the ceramic tiles, whilst compensating for small differences in size.

They involve separating individual tiles from each other at a regular distance. The use of crosspieces and wedges is recommended to ensure that the tiles are perfectly in line, and that the joints have the same width.

They help absorb deformations caused by the substrate and alleviate the stress caused when subjected to loads. If the tiles are jammed together, the joints cannot help to relieve any accumulated stress, which may cause the tiles to lift.

There is a wide range of grouting materials available on the market suitable for different types of tiles and environments: water-repellent, deformable, acid-resistant, etc. In general, **CG2 type** materials are usually recommended, as specified in the European regulations **EN 12.004**.

For each type of product, the manufacturer should specify the amount of time that should elapse before grouting the joints.

WARNING!

All types of joints (structural, perimeter, expansion and installation joints) must be designed and carried out correctly.

It is not advisable from any technical point of view to install tiles without joints, particularly in areas with frost proof requirements, due to the risk of problems that may arise in the paving.

As a general rule, tiles must be installed with 3 mm or 4 mm joints (never less than 2.0 mm).

Tiles installed in a staggered or herringbone pattern require minimum installation joints of 5.0 mm between each tile.

4.5).- Cleaning the paving

When the installation work has come to an end, any remains of adhesive and grouting products should be removed using a **commercial acid descaling product** designed especially for ceramic floor tiles and diluted with three parts water. It must not remain in contact with the surface to be cleaned for more than 5 minutes, and the surface must be rinsed immediately with plenty of water.

Never use hydrochloric acid or cleaning products that may contain hydrofluoric acid. Test a small area that will not be visible (or a tile that has not been laid) to check that the cleaning product will not damage the paving.

The following points must also be taken into account:

- Recently installed paving must never be cleaned with an acid cleaner because the cement will not yet have set and the acid will react with it. This may damage the joints or deposit insoluble compounds on the surface of the floor tiles.
- The surface should be impregnated with clean water prior to any chemical treatment, to prevent any of the agents used being absorbed by the grouting material, and then immediately rinsed with plenty of water.
- Metal spatulas or abrasive scourers should not be used.

This type of work must be carried out by experienced cleaners, taking into account the characteristics of the floor tiles, which in our case must bear the icon “**HYGIENIC**” (resistant to household cleaning products, consult catalogue) and the manufacturer's recommendations.



HYGIENIC

Finally, since the floor tiles are not the last element to be incorporated into a building, it is necessary to provide **suitable protection** from possible damage that may be caused by subsequent work. Floor tiles should therefore be covered in cardboard, thick plastic or a layer of sawdust.

5).- BIBLIOGRAPHY

- **“Manual – Guía Técnica de los Revestimientos y Pavimentos Cerámicos”** (Technical guide of ceramic wall and floor tiles), published by the Institute of Ceramic Technology of Castellón County Council.
- **“Colocación de Pavimentos y Revestimientos Cerámicos”** (Installation of ceramic floor and wall tiles), by the Institute of Ceramic Technology (ITC) and collaborators, in addition to technicians from the adhesive and complementary products industry.
- **“Normas Tecnológicas de la Edificación” (NTE)** (Technological building regulations).
- **“Guía de la Baldosa Cerámica”** (ceramic tile guide), put together by a committee of engineers from the Territorial School of Architects in Castelló (C.O.A.C.V.), the State Architecture and Housing Office (COPUT), the Institute of Ceramic Technology (ITC-AICE) and the Spanish Association of Manufacturers of Tiles, Floor Coverings and Ceramic Tiles (ASCER).
- **“Guía Electrónica de la Tecnología de Colocación de Baldosas Cerámicas (Proyecto Colocación)”** (Electronic guide to the technology of installing ceramic floor tiles: tile installation project) by the Institute of Ceramic Promotion (IPC) and a committee of experts made up of technicians from the main companies in the sector.
- **“Manual Técnico de Aplicación de Pavimentos y Revestimientos Cerámicos”** (Technical manual of applying ceramic floor and wall coverings) by the Tile Journal (AZ Publications).