

# **DESIGN AND DEVELOPMENT OF NEW SYSTEMS FOR INSTALLING CERAMIC COVERINGS**

**M. Llorens<sup>(1)</sup>, M. Bartolomé<sup>(1)</sup>, J. Mira<sup>(1)</sup>, E. Uviedo<sup>(2)</sup>**

(1) Instituto de Tecnología Cerámica (ITC). Asociación de Investigación de las Industrias Cerámicas (AICE) Universitat Jaume I. Castellón. Spain.

(2) Asociación Española de Fabricantes de Azulejos y Pavimentos Cerámicos (ASCER). Castellón, Spain

## **ABSTRACT**

This paper sets out the results of a project whose purpose was to develop dry tile installation methods. The main aim of the systems proposed is to reduce floor and wall tile installation times, avoiding the use of wet adhesives and simplifying the work involved, by means of tile installation systems that do not require wet tile fixing and are more economical than those available in the market, with no detriment to tiling finishes or working life.

Based on these criteria, several solutions were found from which prototypes were developed. The two most viable solutions for floors and walls are then looked at in more detail.

## 1. INTRODUCTION

Traditional ceramic floor and wall tile installation systems consist of a set of orderly steps, which require adequate time to correctly create the surface. These processes produce large amounts of rubble and dust which make it impossible to use or handle surfaces until the cement or adhesive used has completely set.

The systems presented here are the result of the project "Design and development of new systems for installing ceramic coverings", developed by Alicer, the ITC Design and Architecture Department, with the support of the Spanish National Plan for Scientific Research, Development and Technological Innovation 2008–2011.

The initial task in the project consisted of defining the specifications that should be taken into consideration, as well as solutions for installing floor and wall tiles. With these specifications, numerous solutions were proposed, of which the five most suitable for laying floor tiles and the three best for fixing wall tiles were chosen. Prototypes were made with all of these and their conformity to the specifications proposed was studied, thus obtaining a viable, patented solution for ceramic flooring and another for wall cladding.

## 2. SPECIFICATIONS

The first stage of the design process was to propose the specifications, which were used as guidelines for defining the path to obtain solutions. These provided objective comparative criteria that enabled the viability of the solutions proposed to be evaluated.

### 2.1. Flooring specifications

Some of the specifications for the flooring were as follows:

1. It must be easy to install.

Ease of installation involves two aspects. First of all, there is a possibility that users will be able to install the product themselves, but if a tradesperson is required, a simple process will reduce installation costs by saving time.

2. It must require the smallest possible number of components (whether additional pieces or adhesives).

The idea is that only a small number of components should be required for installation, thus minimising the number of pieces or adhesives.

3. Changes to existing flooring should be minimal.

It should be possible to install the product with only minimum modifications to the existing floor, so that levelling, installation of other supporting elements, etc., should be minimal.

4. It must be durable (the joints between the tiles must be hard wearing).

The durability of the system is defined by the resistance of the joints. The system is considered valid as long as the joints between the tiles are appropriate.

## 2.2. Wall cladding specifications

Some of the specifications for wall cladding were as follows:

1. No bearing substructure should be required.

The intention was to achieve the simplest possible system, so that no intermediate substructure should be required between the wall and the new cladding.

2. The fastening system should be hidden.

Once a tile was in place, the system used to hold it in place should be invisible.

3. The system should be light.

The ease with which tiles are installed should make the process cheaper. The weight of the final product should also have a favourable impact on the cost of raw materials and transport.

4. It must be reparable.

It must be easy to replace damaged components, including tiles and any additional parts.

## 3. SOLUTIONS

Taking these specifications as a base, ideas were proposed that could provide possible solutions to the problem posed. The most feasible proposals for the purpose of the project were then chosen.

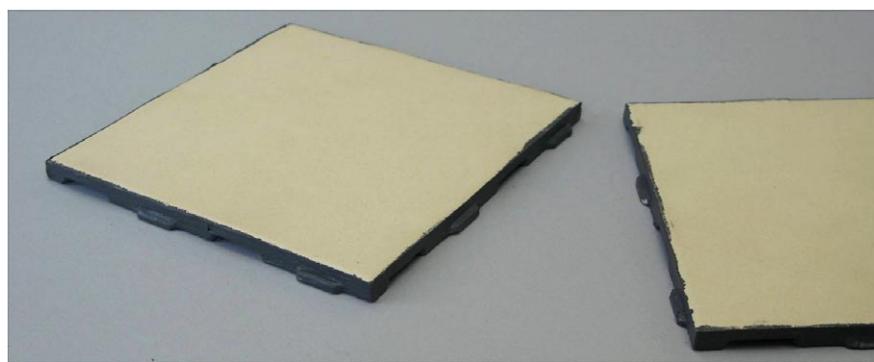
### 3.1. Solutions for floors

#### 3.1.1. Tongue and groove system

The tiles are joined using tabs on the edge of the ceramic tile, by inserting these into the grooves in the adjacent tiles. To improve system performance, ceramic surfaces that are in contact with each other are coated with an elastomer to prevent breakage and improve the coefficient of friction between them.

The system comprises a single type of tile that addresses all flooring needs. This tile is designed to be manufactured by dry pressing.

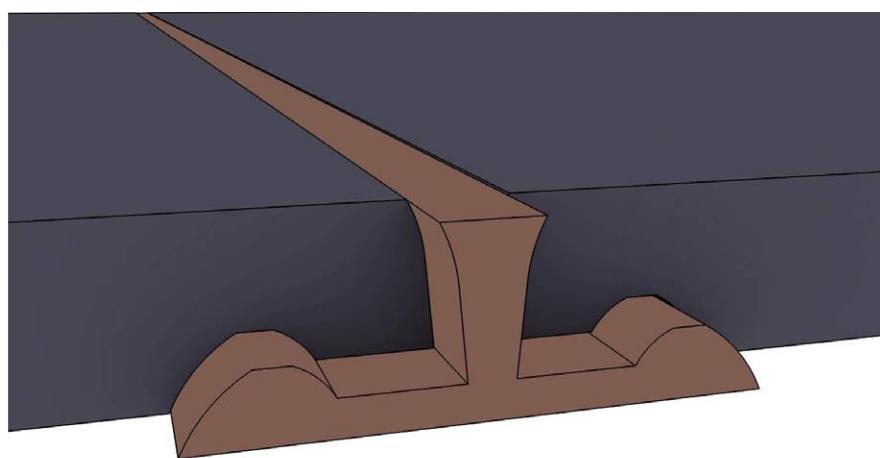
The prototype created was very easy to install, because the tiles were easy to put together; however, special care needs to be taken with the tongue and groove fit, because if the tabs fit loosely they can rattle and not hold the tiles in place. If they are too large they will not fit into the grooves in the adjacent tiles, making it impossible to install them. Also to be taken into consideration is the fact that the tabs are the most fragile part of the system, so they must be sized correctly to avoid breakages.



*Figure 1. Prototypes of the tongue and groove system*

### 3.1.2. Joint and groove system

Tiles are joined together using extruded elastomer plastic joints whose cross-section features protrusions that fit into grooves along the length of each ceramic tile. The idea is to set the tile in the joint and the groove, thus holding the tile in place.



*Figure 2. Schematic illustration of the joint between two tiles.*

The grooves are not the result of post-processing but are created during tile pressing. The rubber of the top punch in the press, which creates the back of the ceramic tile, has a shape that, as well as forming the rib, also makes the grooves on the back of the tile.

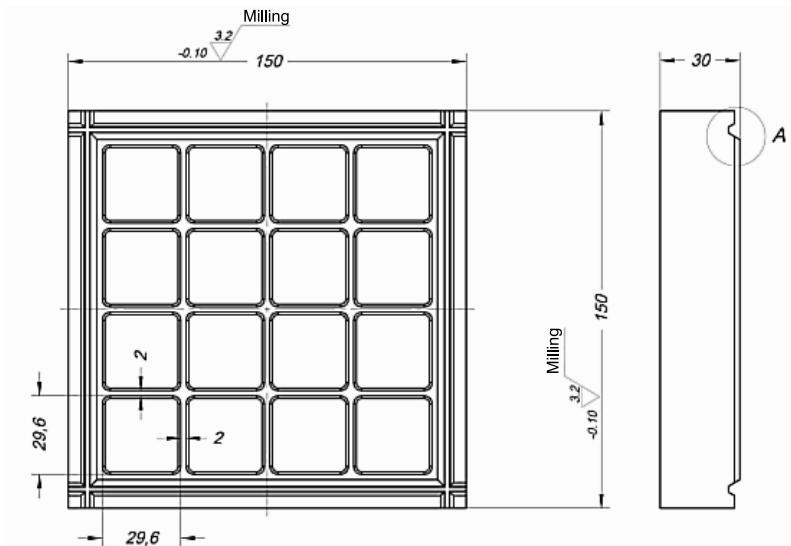


Figure 3. Elevation and plan of the press punch

The composition of the elastomer is an important factor in this product strategy, and it must be ensured that it reproduces as closely as possible the edge of the ceramic tile so that the joint is totally cohesive.



Figure 4. Prototypes of the joint and groove system

### 3.1.3. Friction system

This uses the force of friction between the edges of the ceramic tiles to hold them in place. The edges are coated with an elastomer material to improve the friction coefficient between tiles and to absorb irregularities to ensure fit and prevent rattling and vibrations. The flooring should be confined by structural elements such as exterior and interior walls or skirting boards, and at all times be unattached to the support and elements confining it. It is the pressure created by the wedges placed between the perimeter tiles and the walls that will prevent the pieces from moving horizontally or vertically.

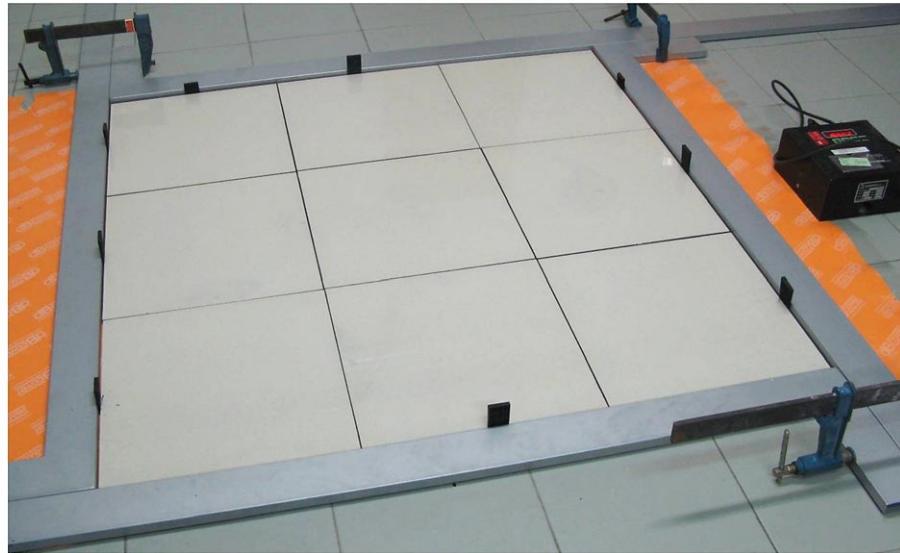


Figure 5. Prototype of the friction system

The prototype consisted of nine tiles installed on an insulating substrate, surrounded by a metal frame and pressured by plastic wedges. The tensile strength was measured with the dynamometer, yielding average values of 19.86 kg, making this one of the most promising lines to develop.

### 3.1.4. Joint system

The connection between the pieces consists of an extruded plastic joint whose shape matches that of the edge of the pressed ceramic tiles. When the tiles are fitted between four walls, they are kept in place on all sides by the effect of the joint.

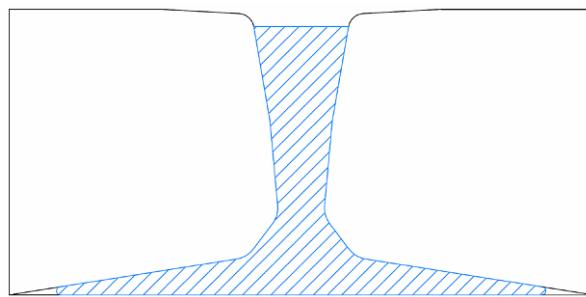


Figure 6. Scheme of the joint between ceramic tiles

To assemble the prototype, nine tiles were placed in the same metal frame used for the friction system prototype, also pressured by installation wedges. When their tensile strength was tested, this yielded an average value of 17.36 kgf, although it has yet to be seen whether this value remains the same for larger surface areas.

What is most interesting about this system is that there is no need to modify the manufactured ceramic tiles in any way, but only to ensure that the bottom ed-

ges are properly smoothed to ensure optimum fit with the joints, allowing the tiles to be installed more quickly than by traditional methods. As well as these parts, plastic joints, wedges and an insulating bedding substrate are needed for the ceramic tiles.

One important aspect to be taken into consideration is that, depending on the complexity of the abutments to be addressed (ramps, stairs, electricity and plumbing installations), it may be necessary to install certain key tiles with a wet installation system that securely fixes the tiles that cannot be adequately secured by this system. It should also be noted that if a ceramic tile breaks, the system will lose the static equilibrium that keeps it all in place, so that it is vital to replace broken tiles. One point in the favour of the system is the speed and ease with which joints and tiles are installed.

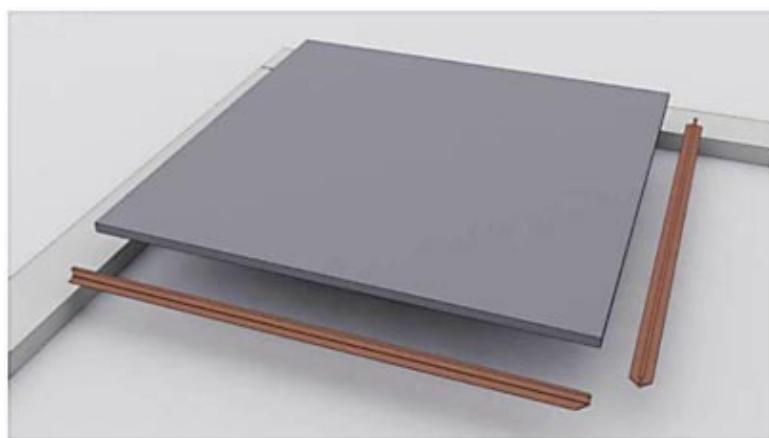


Figure 7. Scheme of the joint system assembly

### 3.1.5. Powder adhesive system

The system uses a powder adhesive to fix the ceramic tiles together. The powder adhesive is swept over the ceramic tiles until the tile-to-tile joints are filled. The adhesive hardens when it has been spread and has come into contact with the air, sticking to the edges of the tiles to form joints and to the supporting surface, bonding them together and preventing any horizontal movement.

Tensile strength was tested with the dynamometer, yielding an average value of 23.20 kgf, which represents the greatest strength of the created prototypes, though installation time was longer and more similar to that of wet tile installation. As a result, the system was ruled out on the grounds that it was too complex to install.



Figure 8. Installation of the powder adhesive system prototype

### 3.2. Solutions for walls

#### 3.2.1. System with independent mounting brackets

The system involves mounting ceramic tiles on internal walls using a metal substructure consisting of aluminium brackets with an upward-facing hook section.

Four anchors with downward facing hook cross-section are adhered in the ceramic tile. An elastic plug is fitted in the part of the anchor that comes into contact with the aluminium structure to prevent unwanted vibrations and keep this from being a source of noise.



Figure 9. Independent bracket system prototype

It should be taken into account that in this type of system, appropriate layout and mounting will be key factors to a successful installation.

#### 3.2.2. Rigid joint system

In this system, tiles are mounted on the wall by just using an extruded plastic joint, whose cross-section matches the edge of the pressed ceramic tiles.

The joints are fixed horizontally to the wall with a spacing between the joints

that is equivalent to the tile at issue.

The tiles are held securely in place as a result of the tile extraction angle from the pressing die: this provides the ceramic tiles with slightly sloped sides, instead of the tiles having sides that are at right angles to the longest sides, so that a wedge-shaped joint can hold them in place.

The fastening of the joint to the wall and fixing of the tiles are aspects that require further study in these strategies.



Figure 10. Scheme of the rigid joint system assembly

### 3.2.1. Roll-up mesh system

This is a mesh on which the ceramic tiles are hung. The mesh comprises vertical strips of canvas, strung together with horizontal aluminium battens on which the ceramic tiles are hung. This configuration allows the mesh to be supplied rolled up, making it convenient to transport and handle. The mesh is attached to the wall using a suitable system (adhesive, bolts, etc.) depending on the background.

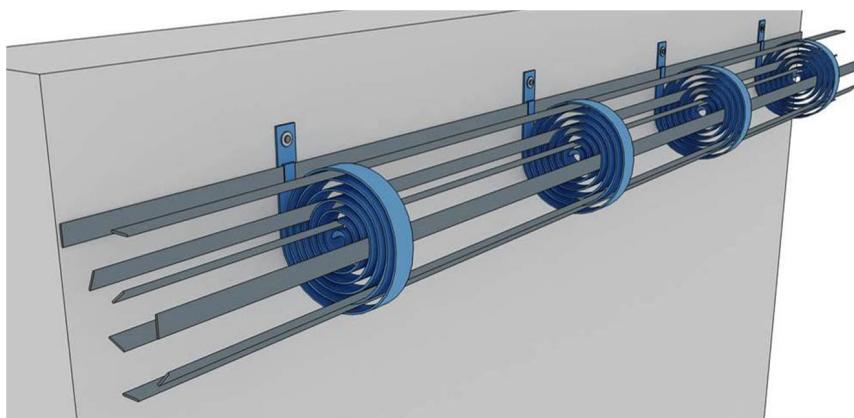


Figure 11. Scheme of the roll-up mesh system assembly

The ceramic tiles are hung on the horizontal battens with small metal hooks adhered to the rear with epoxy resin. Both on the back of the hooks and the joint between the battens and canvas strips (on the side facing the wall) foam plugs are adhered to absorb surface irregularities, vibrations and rattling.



Figure 12. Details of the system: Adhered hook, strip and batten

The general feeling regarding the prototype is good. The tiles are securely fixed and can be rapidly and easily laid out and installed on the roll-up mesh.

To perfect the system it will be necessary to develop a way of joining adjacent meshes together and addressing abutments with corners, windows, installations, columns, etc. It would also be interesting for the points where the mesh needs to be fastened to the wall to be indicated by the manufacturer, these being points that it may be necessary to strengthen if the weight of the tiles makes the canvas rip at the fastening system hole.

## 4. CONCLUSIONS

The different solutions were compared to evaluate how suitable each would be to meet the specifications proposed for floors and walls. With this analysis, it was determined which system would best address the needs for which they had been designed.

### 4.1. The best floor system

#### 4.1.1. Friction connectors

Of all the characteristics of this system, the most important were deemed to be ease of installation and manufacturing, economy of materials and the possibility of installing tiles without needing to do anything to the existing floor surface.

Also interesting were the conclusions of the results of impact studies with a steel ball, which show that the use of an appropriate substrate (any of those detailed in the report) is critical to the viability of the system, because it favours tile bedding, absorbs any incidental irregularities in the original floor and the impact energy suffered by the tiles.

These tests have also highlighted the fact that flat back tiles without any ribs are far more resistant to impact because, as they have a larger surface area in contact with the substrate, they transmit this energy more efficiently. It is, therefore, recommended that the rib design in the top press punch should be eliminated.

#### 4.1.2. Joint connectors

Among the most highly valued aspects of the system was the fact that the system involved few added manufacturing costs (well-smoothed standard tiles and a plastic extrusion), the possibility of installing tiles without needing to modify the original floor and the system's capacity to adapt to possible abutments.

The same considerations mentioned for the above system (use of a suitable substrate and rib-free rear) are also applicable to this system.

### 4.2. Best wall system

#### 4.2.1. Roll-up mesh

This system consists of canvas strips and aluminium battens that are attached directly to the wall. The ceramic tiles are then hung on these, using hooks stuck to the tile back.

Among its different characteristics, the most highly valued were speed and ease of installation and handling (roll-up solution), the solidity of the resulting surface and its registrability, understood as easy replacement of tiles.

### 4.3. Final considerations

These systems make the tile installation process significantly simpler, providing time savings of between 50 and 75% in comparison to traditional installation techniques. Materials and post-processing are also cheaper than those of existing dry installation systems, since a plastic tray need not be adhered to the tile back, though certain considerations do need to be taken into account:

- It is necessary to use a suitable substrate that will allow small, occasional irregularities to be absorbed on the surface to be clad or tiled (insulating surfaces in the case of floors and foam plugs in the case of walls).
- The surfaces on which they are installed must be perfectly flat and level.
- In cases of complex abutments (ramps, stairs, building installations), it may be necessary to install incidental tiles with the traditional wet installation system.

The ideas presented here are intended to stimulate companies that want to extend their product portfolios in the market of dry installed technical products. We believe that the information gathered in this research will help companies that are in the process of developing and launching these types of products.

## ACKNOWLEDGEMENTS

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