EXTERNAL THERMAL INSULATION SYSTEMS WITH CERAMIC SKIN

María Bento Fernández

Head of façade systems

ITeC - Instituto de Tecnología de la Construcción de Cataluña.

1. ABSTRACT

The use of external thermal insulation composite systems (ETICS), so widespread in Central Europe, is becoming increasingly common in Spain thanks to certain technical advantages afforded by this particular façade insulation system, especially because they overlap in two of the construction sector's main driving forces today: energy efficiency and refurbishment.

The most traditional and best-known external thermal insulation systems are those in which the finish is a continuous cladding formed by several layers of mortar laid over insulating material. However, new insulation systems are beginning to emerge on the market, in which the finish is made up of rigid slabs (most often ceramic, but also stone or other materials).

This external insulation with rigid modular cladding offers a number of advantages over conventional systems but is also an innovative solution that justifies specific analysis and technical assessment of its behaviour and performance.

With that premise in mind, this paper aims to inform manufacturers and technicians from the ceramic sector of the following aspects:

- The different construction systems being used (mainly in other countries), which in some cases already have benchmarks for their certification at European level,
- the main concepts concerning ceramic tiles and other components of insulation systems that need to be taken into consideration,
- the possibilities that exist of these systems attaining certification.

2. INTRODUCTION

External thermal insulation composite systems (ETICS) are building systems designed to improve the energy efficiency of buildings by affording further insulation through façade cladding in both new constructions and refurbishment.

These systems are installed on top of the main envelope (substrate), which must have suitable strength and stability to withstand the ETICS (a fundamental consideration in refurbishment projects). While masonry walls and concrete are the most common substrates, the ETICS could be used on any other type of envelope (e.g.: interlocking thin slat cladding) once it is confirmed to be compatible and capable of supporting the ETICS.

ETIC systems consist of the following layers (see figures 1.1 and 1.2):

- **Thermal insulation**: a product whose main function is to provide the system with insulating properties.

  The most commonly used materials are pre-fab products with a harmonised standard, such as rockwool (RW), expanded polystyrene (EPS), extruded polystyrene (XPS), rigid polyurethane foam (PUR) and phenolic foam (PF), although other insulating materials can also be used.

- **Outer skin**: a set of components that form the façade cladding providing protection from the outside environment and the façade's final aesthetic appearance.

  The best-known and most customary ETICS have a continuous outer skin made up of different layers of mortar, including when necessary, primers or decorative layers. However, implementing an outer skin with discontinuous components of different materials, which includes ceramic tiles, is also possible. This discontinuous outer skin is finished off with cement grouting between individual pieces.

- **Fixing components:**

  Two distinct types of joints exist in any ETICS:

  - the joint between the insulation and the supporting substrate;
  - the joint between the outer skin and the insulation, especially for systems with a discontinuous outer skin.

  Also, each type of fixing can be implemented in a number of ways:

  - Joint with adhesives or mortar;
  - Joint by means of fixing anchors, profiles, or other mechanical devices;
  - A mixed joint that combines both types of the above components.

- **Components that regulate and improve the compatibility between different materials**: these are mostly mortars laid on embedded mesh with or without additional reinforcement that provide a smooth transition between the different layers of the ETICS and which in some cases also serve as fixing items.

  The system consists of the following distinct layers:

  - A base layer (usually reinforced with fiberglass mesh) that is placed over the insulation to improve compatibility between the insulation and the outer skin.
  - A levelling layer of the supporting substrate, which is applied on old substrates in refurbishment projects, where necessary.

- **Auxiliary components**: components used as a solution for individual spots in the ETICS finish, e.g.: mastics, corner profiles, finish profiles, flashing, etc.

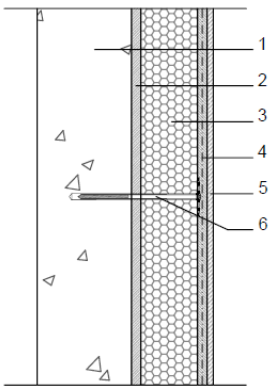

Figure 1.1: *Example of ETICS with continuous external skin.*

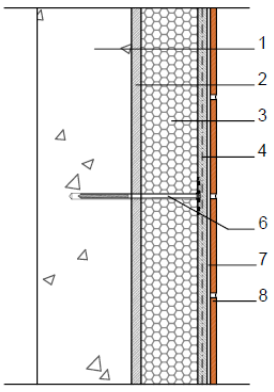

Figure 1.2: *Example of ETICS with discontinuous external skin.*

Key:

1. Substrate
2. Adhesive
3. Insulation
4. Base layer
5. Continuous cladding
6. Mechanical fixing
7. Discontinuous cladding adhesive
8. Discontinuous cladding

3. ALTERNATIVE CONSTRUCTION MODES

In order to sort and classify the possible alternatives for building an external thermal insulation composite system, the following groups are distinguished:

- In regard to the type of skin:

  Con. Continuous, made up of a suitable number of layers of mortar coating.

  Dis. Discontinuous, made up of rigid discontinuous cladding such as tiles, slabs, panels, etc.

- In regard to how it is made:

  OS On-site application: installed directly on site to build a complete system from individually supplied parts.

  PU Pre-fabricated units: systems made from pre-fabricated units comprising the insulation and all or part of the outer skin.

  This construction system only makes sense when discontinuous cladding is used to build the outer skin. The main advantages are the speed with which it can be fitted and a more accurate joint between the insulation and the outer skin, as it is made in the factory.

- In regard to the fastening method:

  Add. 100% adhesion: the entire system is fastened by means of chemical (mortar or adhesive) systems, with no mechanical fixings.

  Fix. 100% mechanical: the entire system is held by means of mechanical fixing items; this construction system only makes sense when discontinuous cladding is used to build the outer skin.

  Mix. A combined system, in which both mechanical and chemical fastening aids are combined at joints. Most ETIC systems are classed in this group, both for the joint between the insulation and the substrate and for the joint between the outer skin and the insulation.

The diagrams in Figures 2.1 to 2.8 are examples of how the various different groups can be combined.

The most widely-used type of construction nowadays is a continuous outer skin, applied on site with a combined fixing system (figure 2.2). The standard for European certification of solutions based on a continuous outer skin (Figures 2.1 and 2.2) is the ETAG 004 European Assessment Document.

However, as shown in the diagrams, there are more ETICS design variations that use some type of discontinuous cladding for the outer skin than alternatives with a continuous skin, so the potential for innovation is greater with this type of ETICS.

Nevertheless, developing systems with a cladding-based ETICS is no small achievement and represents a technological challenge for both manufacturers of the product and the various stakeholders who use the system (specifiers, fitters, etc.).

Some types of discontinuous cladding systems already have benchmarks for European certification e.g. pre-fabricated cladding with mechanical fixing to the supporting substrate (figures 2.7 and 2.8), for which the standard used is the ETAG 017 European Assessment Document (this cladding is known as "vêture" in France).

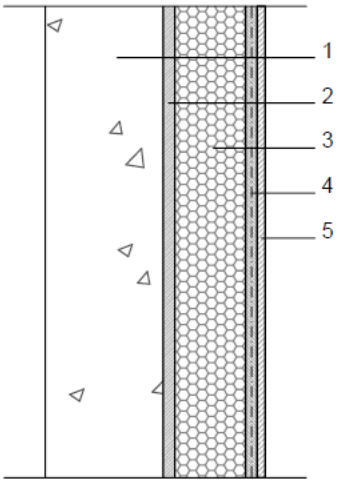

Figure 2.1: *Con.OS.Add. ETICS*

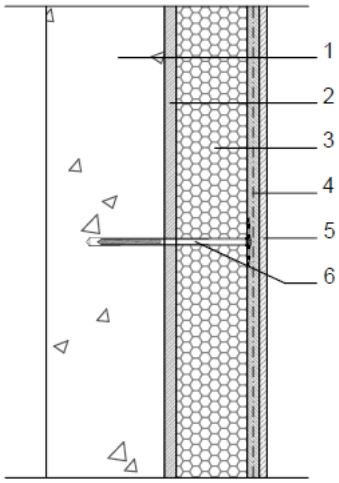

Figure 2.2: *Con.OS.Mix. ETICS*

Key:

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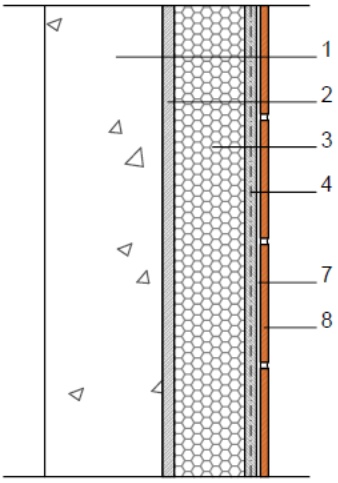

Figure 2.3: *Dis.OS.Add. ETICS*

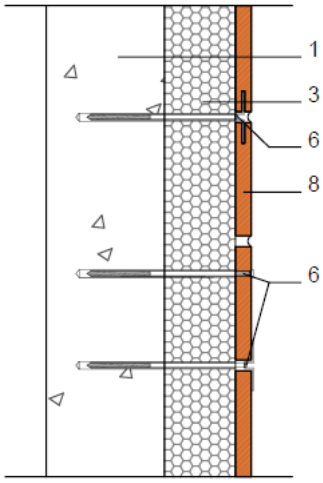

Figure 2.4: *Dis.OS.Fix. ETICS*

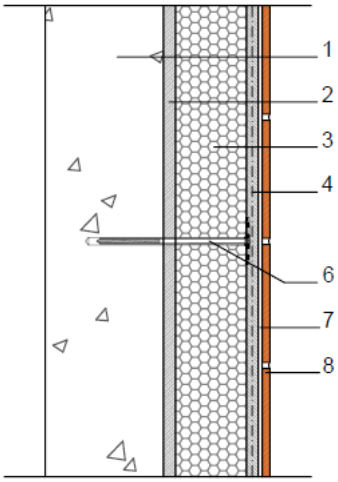

Figure 2.5: *Dis.OS.Mix. ETICS*

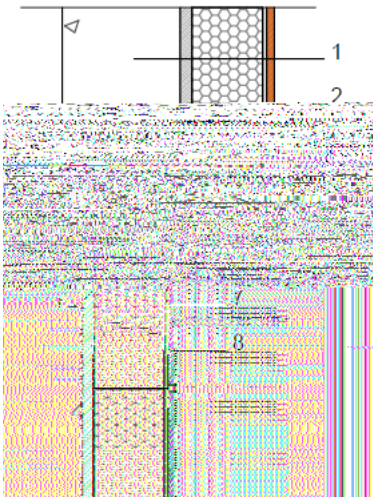

Figure 2.6: *Dis.PU.Add. ETICS*

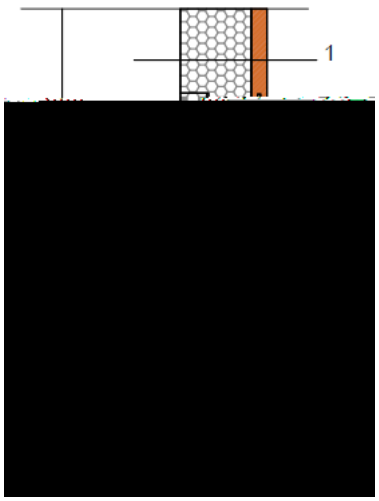

Figure 2.7: *Dis.PU.Fix. ETICS*

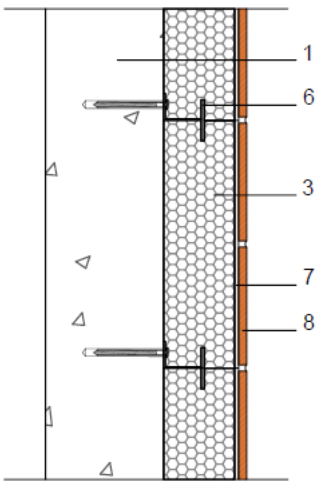

Figure 2.8: *Dis.PU.Mix. ETICS*

4. ETICS WITH CERAMIC SKIN

It is logical that in those countries where ceramic cladding materials have a greater presence (Spain, Italy and Portugal), manufacturers are beginning to develop and market ETICS systems in which the outer skin is made of ceramic tiles.

Such systems offer new architectural possibilities and benefits that combine thermal insulation with the aesthetic and compositional characteristics of ceramic tiles, i.e. façades with traditional look and insulating "core".

Essentially, ceramic-based ETICS can be considered as equivalent to traditional ceramic tiling with a built-in layer of insulation between the supporting substrate and the outer skin. Therefore, when it comes to designing and selecting materials to form part of an ETICS, available knowledge about traditional cladding systems[1] and the individual performance of each component can be employed, although that does not mean that comprehensive assessment of how the entire system will behave no longer needs to be undertaken.

In designing the system, the challenge is to achieve suitable compatibility between the different materials and their performance, mainly in terms of the fixings between them. Without going into excessive detail, these are some of the aspects to be taken into account:

As far as the ceramic tiles are concerned, the main features that need to be considered are thickness, mass, size, water absorption, dimensional stability and permeability to water vapour:

- Thickness and mass primarily influence the mechanical strength required of the fixing items and the insulation.
- Format and dimensional stability influence the shear stresses that may be exerted between layers and therefore the durability of joints, especially adhesive joints.
- Water absorption directly affects the ETICS absorption of moisture and consequently the façade's overall impermeability, as well as compatibility with bonding mortars or adhesives.
- Permeability to water vapour in ceramic tiles is very low[2], i.e., they are highly impermeable to water vapour and form vapour barriers, so façade breathability takes place through the joints between tiles. Therefore, joint design will have a direct effect on the ETICS performance and the insulation material used also needs to be taken into account.

As far as the insulation is concerned, apart from its ability as a heat barrier, the characteristics to consider when designing an ETICS are permeability to water vapour (for example, foam has low permeability to water vapour) and those relating to its strength and deformability (tensile strength, shear stress, compression, etc.) depending on the type of construction in mind.

Therefore, in ETICS designs with an adhered outer skin, tensile strength perpendicular to the tile face and shear strength of the insulation must meet minimum

[1] See for example the presentations: Adhesion and deformability of cementitious adhesives and grouts for the installation of ceramic tiles and other modular rigid slabs – José Luis Porcar (Qualicer 2006) and Ceramic tiling pathologies – César Díaz Gómez (Qualicer 2004)

[2] Standard UNE EN ISO 10456 provides comparative data on the hygrothermal properties of various materials

values in proportion to the total mass of the outer skin (ceramic tile and grouting) plus the mass of the base layer, if any.

On the other hand, in ETICS arrays that use 100% mechanical fastening[3], e.g. when tiles are fixed by anchors directly into the substrate through the insulation (Figure 2.4, a product known as "vêtage" in France), the compression strength of the insulation is more critical than the tensile strength and shear stress of the tile.

This means that some low-strength materials (e.g. standard rock wool) should be discarded for such building designs.

As far as fixing anchors are concerned, there are two factors of paramount importance – firstly, that they have sufficient strength and also that they provide adequate compatibility and transition between the materials in the layers to be joined (including types of substrate). That will determine adhesion and deformability in mortar and adhesive-based joints and the strength and deformation of components in mechanical joints.

Specifications of most of the characteristics listed above for individual components can be obtained from manufacturers' declarations required by the regulations governing CE marking (thermal insulation panels are covered by UNE EN 13162 UNE EN 13166, ceramic tiles by UNE EN 14411, mortar by UNE EN 998-1 or UNE EN 15824 and adhesives by UNE EN 12002) or other non-harmonised references.

However, as it is also necessary to test the behaviour of the ceramic ETICS as a construction system, the first step is to identify the characteristics applicable to it as a whole:

- reaction to fire;
- water absorption;
- water vapour permeability;
- performance under changes in environmental conditions (temperature and humidity or freezing and thawing);
- impact resistance;
- mechanical strength of joints and components (adhesion, shear, pull-off, etc.);
- improved air-borne noise abatement;
- thermal resistance;

Without intending to underestimate the complexity of such systems and their potential performance, it could be said that while some of these features are clearly influenced by certain individual components (e.g. the insulation in terms of noise and heat containment or ceramic tiles in terms of water absorption, mechanical strength and impact resistance), other characteristics (reaction to fire, water vapour permeability, reaction to variations in environmental conditions and mechanical strength of joints) are affected by the combined behaviour of all the components and therefore require overall assessment.

[3] The nature of the ceramic material and tile thickness condition certain means of mechanically fastening the tile directly to the substrate, especially if such fastening items are required to be concealed.

In short, although the behaviour of individual components forming part of a ceramic ETICS is commonly known, it is essential that assessment at complete system level be carried out for each proposed construction solution.

5. CERTIFICATION OF CERAMIC SKIN ETICS

Nowadays, ETICS (including ceramic skin systems) are considered to be innovative products although, regardless of that "tag", as stated, it is essential to assess and determine whether the specific combination of components (selected by the manufacturer to create an ETICS scheme) will perform suitably for the intended use as a complete system.

At the European level[4], harmonized technical specifications already exist for certain types of ETICS (see section 2 above) that enable the corresponding CE marking to be obtained:

- ETAG 004 for systems with mortar cladding (Figures 2.1 and 2.2), and
- ETAG 017 for pre-fabricated units fixed mechanically to the supporting substrate and rigid cladding (Figures 2.7 and 2.8);

Both documents qualify as European Assessment Documents (EAD).

However, there are still many other designs that would not be covered by the above reference documents. In those cases, a new harmonized technical specification (a new EAD) needs to be developed.

In this regard, manufacturers of ceramic skin ETICS currently have the following options for obtaining the CE mark:

1) Use ETAG 017 as the EAD, as long as the system consists of pre-fabricated units mechanically fastened to the supporting substrate;
2) Develop a new specific EAD for the product defined by the manufacturer presenting the corresponding request.

In either case, ETICS manufacturers should approach a Technical Assessment Body (TAB) (the ITeC is one such body) to directly implement a European Technical Assessment (ETA) in the first case, or an EAD followed by an ETA in the second case, which implies a longer process.

On the exclusively Spanish national level, under the terms provided for in Article 5.2 of the TBC on compliance with the TBC by innovative products and systems, an option for a new ETICS system is to achieve favourable technical assessment of the suitability of the system for the intended use, such as a Suitability for Use Document (SUD) granted by the ITeC and which is a recognised document in the Technical Building Code (TBC).

Also, given the great importance that proper on-site execution has for these systems, it is recommended that installers and/or fitters have certificates that

[4] In paragraph 1 of the presentation made at Qualicer 2014 'Practical experience in the implementation of ETAG 034 for ceramic external wall cladding kits. CE marking of kits in accordance with EU Construction Products Regulations No. 305/2011', the author explains the procedure for obtaining CE marking under the EU Regulations on Construction Products (EU) No 305/2011 as well as the terminology and acronyms of the various documents.

recognize their skills, expertise and ability to work with the specific ETICS system. Such certificates should be issued by an authorised body (the TBC General Registry (for such purposes, for example the CTP (Certificate of Technical Proficiency) awarded by the ITeC.

6. CONCLUSIONS

Although to date ETICS systems have not consolidated their presence enough in southern European countries, concepts such as building refurbishment and energy efficiency (the basic driving forces of today's construction sector) serve to ensure that such façade insulation systems have significant potential here.

The great versatility of design variations means that ETICS systems using discontinuous cladding have much greater possibilities for innovation than conventional continuous mortar-based skins. In this sense, ceramic ETICS are a real opportunity for manufacturers in the ceramic sector.

However, it not a question of simply bringing together different components that individually may have defined benefits but rather to ensure they perform together as a whole system – therefore, proper design and assessment are vital in order to be able to guarantee performance by the complete system.

For that reason, ETHICS should have a certification scheme, at either Spanish domestic or European level, to confirm their performance specifications.

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[16] *Adherencias y deformabilidad de los adhesivos y materiales de rejuntado cementosos para la colocación de baldosas cerámicas y otros aplacados rígidos modulares*. José Luis Porcar. Qualicer 2006. http://www.qualicer.org/recopilatorio/ponencias/ponencias.php

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