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Architectural integration of ETICS in building rehabilitation

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ABSTRACT

ETICS (external thermal insulation composite system) is one of the most frequently used thermal retrofitting solutions in the construction market. This study examines the architectural integration of this system in the rehabilitation of façades. When thermal retrofitting of the outer envelope is required to comply with thermal code demands ETICSs have to be harmonised with the various elements of the façade. To that effect, several proposals for the architectural integration of the system are made, and relevant parameters of costs, durability, feasibility and architectural integration are analysed for each of the solutions.

1. Introduction

This study's main goal is to integrate ETICS (External Thermal Insulation Composite System) in the rehabilitation the façades of residential buildings constructed since the second half of the 20th century. It is well known that these buildings often do not comply with today's minimum standard requirements of thermal comfort, given the characteristics of their outer envelope, as demonstrated in various studies [11]. Furthermore, they are responsible for a large segment of the overall energy consumed through warming and cooling. However, the construction sector is becoming increasingly aware of the financial and ecological benefits of thermal retrofitting [20].

The rehabilitation of buildings is a part of sustainable development and also a cultural attitude, since it contributes to the preservation of cities as they develop [28]. This explains the rising importance of the durability and sustainability of buildings in various studies [22,17] and of maintenance planning in all stages of the building process, from design to end of service life [26].

Several solutions have been developed for the external claddings of buildings in recent decades, based on new materials and technologies that need to be analysed under a variety of conditions [4], side by side with thermal retrofitting solutions. These solutions have offered improvements in terms of durability, thermal performance and finishing surface [6]. This is the case of ETICS, an external thermal retrofitting solution that is being increasingly widely used in many countries [3]. It is suitable for façade rehabilitation, since it enables relevant anomalies to be corrected and provides exterior aesthetic renovation [25].

Notwithstanding the system's well-known advantages, described in various sources [13,21,6], one of its drawbacks is that it changes the façade's characteristics, which has to be discussed when architectural integration is an issue. However, given the objectives of thermal retrofitting the outer envelope and complying with the present-day thermal code demands, harmonisation of ETICS with the façades is both feasible and necessary. The solutions for the architectural integration of ETICS presented here are based on existing ones and applied to rehabilitation/thermal retrofitting projects and the various elements that constitute a façade.

The solutions and their evaluation are seen as a starting point for decision-making and further advancing the architectural integration of ETICS in building rehabilitation.

2. Methodology

The research reports on the application of ETICS to housing building façades. Most of the buildings used in the analysis were located in Lisbon City, although the conclusions are general to any residential building of traditional construction. The execution process and the main difficulties in rehabilitation situations are analysed, in particular the harmonisation with the various elements that make up a façade, where unwanted changes in its external appearance may result. The various constructive solutions

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for external walls were illustrated with the aid of the specialised literature and a photo survey of a considerable number of residential buildings. The walls studied were made mostly of ceramic hollow brick masonry, which support various typical solutions for integrating the system according to the procedures and characteristics of ETICS solutions already installed.

The first step in designing the solutions is to make rough drawings of each one, supported on the existing façade elements. After detailing and illustrating the solutions the results are analysed and evaluated empirically in terms of parameters such as architectural integration in the façade, practicability, level of costs and durability. The measures taken to integrate the system in rehabilitation work are described.

The characteristics of the components of ETICS were taken into account when preparing the details, from the substrate to the final finishing coat and the fastening elements/solutions.

3. Thermal retrofitting with ETICS

Thermal retrofitting solutions for external walls to insulate them have advantages over those applied either to the interior of these walls or inside the air-box of double-panel walls. These systems significantly improve thermal comfort and they are mostly chosen for functional aesthetic reasons [24], besides preventing the risk of internal condensation when compared with other solutions.

One such solution is ETICS, which perform well in masonry walls and offer the same durability as a traditional rendered façade [19]. These systems are known to be aesthetic solutions, with good thermal resistance, thus contributing to efficient energy consumption. It is therefore important that they are applied with the minimum of execution errors in order to guarantee the system's technical performance and durability, as long as the buildings are maintained correctly [27].

3.1. The system

ETICS was first used in the early 1960s in Europe [18,25] and North America [8], with the economic crisis and later on the oil crisis [5], when the cost of heating buildings and the scarcity of fuel led to a demand for solutions that would reduce energy consumption by avoiding thermal losses by improving the thermal insulation of the building envelope.

One of the main concerns has been to provide masonry walls with a good thermal performance, in both existing buildings and new construction. Reportedly, the system has rarely been unsuccessful from this point of view [18,27].

ETICS is made of a thermal insulation board, usually expanded moulded polystyrene (EPS) glued to the substrate, a thin coat of synthetic or mixed binder reinforced with a flexible mineral mesh such as fibreglass, a base and primer coat and a finishing layer of a thin coat of synthetic binder [21,7].

The surface finishing that it provides is similar to that of traditional render, with a sand paint coat, even though texture and other materials' characteristics may vary, and it guarantees a renovated façade in a rehabilitation operation without having to completely remove the original cladding, as long as this duly checked [12]. The system still allows some diversity in terms of finishing since it supports discontinuous claddings such as ceramic and stone. It is stressed that these claddings are not covered by the ETAG 004 guide [14], as noted by Malanho and Veiga [21].

When the masonry consists of hollow ceramic bricks the mechanical fastening cannot be properly ensured and the system and cladding must be glued in a suitable manner.

The watertightness of the cladding, together with the stress distribution via the reinforcement, which reduces the risk of cracking, protects the system from rainwater infiltration. For single-panel walls the system has a competitive cost. It can be applied over heterogeneous substrates since it adapts to their minor discontinuities and settlements, and over areas with small/thin relatively stabilised cracking [14].

3.2. Application of ETICS in rehabilitation

ETICS must follow some principles when used in rehabilitation works. First, the outer envelope to be cladded and the detailing of the system design must be studied so that the solutions chosen can be adapted to the façade's characteristics, using adequate materials and employing a careful execution [12], with the correct preparation of the substrate.

According to the literature [12,16], catalogues and advice from ETICS installers, some of the principles to be followed relate to protecting the system from rainwater, protecting façades accessible to the public from impacts, the minimum thickness of the insulation, the exposure of the façades to certain degradation agents and the type of finishing envisaged. Therefore, when the system is detailed and installed it must be ensured that water cannot penetrate through the joints with other construction elements by fitting drip moulds at the lower limits of the system (Fig. 1) and in protruding elements and preventing water from dripping directly onto the façade.

Furthermore, the perforated profiles at the edges of the cladding must be covered with a sufficiently thick finishing coat [16]. The system must be designed to slope towards the exterior so as to drain water, and there must be a 3–4 cm projection horizontal to the façade's plane, with drip moulds at the end of the protruding elements. There must be a groove or a small duct in the edges of parapets or window sills to stop the water from draining onto the wall.

In rehabilitation it is important to evaluate and, if necessary, alter the design of the edge finishings and upper protection of the façade panels. The design/shape of any eaves or cornices may have to be changed.

If a wall is likely to be affected by factors such as wind and rain exposure and risk of impact then special care is required when choosing the system. Wind exposure matters to systems that are directly adhered to the substrate and it is recommended that an auxiliary mechanical fastening is used, as long as the substrate allows it [12,16].

Similarly the colour envisaged for the wall depends on its exposure to sunlight, since darker shades tend to absorb more heat and so lighter colours tend to be chosen. Using dark colours in ETICS can increase the deterioration rate, given the higher thermal gradient effect (see more in Refs. [10] and [23]). As a reference value, claddings should not have a solar radiation absorption coefficient (α) higher than 0.7, unless the wall is protected from solar radiation, direct or indirect. If a façade cladding has several colours (Table 1) and the difference of this coefficient between adjacent colours is higher than 0.2, a joint must be created [16]. Other sources also report that the colour of the cladding can be evaluated through the luminosity coefficient (measured in HBW), which measures the reflection of incoming light (radiation) and whose minimum values should be between 20% and 30%. As a reference white has a value of 100% and black of 0% [12].

Maintenance work [27], as a guarantee of the system's durability, is directly linked to its potential anomalies and their repair, in particular the development of stains and cracking. Previous research has focused on anomalies in ETICS [1,9], and inspection and diagnosis methods have been proposed, together with repair techniques [2].