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ScienceDirect

Procedia Environmental Sciences 38 (2017) 155 – 161

Procedia Environmental Sciences

International Conference on Sustainable Synergies from Buildings to the Urban Scale, SBE16

Experimental Thermal Performance Assessment of a Prefabricated External Insulation System for Building Retrofitting

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Abstract

External Thermal Insulation Composite Systems (ETICS) are increasingly used for the energy-efficient retrofit of buildings. This paper evaluates the in-situ thermal performance of a prefabricated composite panel made of PIR and concrete, by full scale testing of a prototype installed at the KUBIK test facility. Experimental results from measurement show a reduction in the thermal resistance of the ETICS assembly compared to theoretical design values. A number of phenomena have been identified causing multidimensional heat flow of conductive and convective nature, such as thermal bridges at floor slabs and anchors, and thermal bypass of the insulation causing airflow behind the ETICS.

Peer-review under responsibility of the organizing committee of SBE16.

Keywords: building envelope; energy efficiency; retrofit; ETICS; heat transfer; thermal resistance; experimentation; performance gap

1. Introduction

According to the Sustainable Building and Climate Initiative of the UN[1], buildings are responsible for 40% of the global energy needs, yet commercially available technologies can provide energy saving potentials between 30% and 80%. In a European context, considering its large building stock relative to demographic projections, the burden of reducing the energy demand of the built environment will largely lie in the energy efficient retrofit of existing buildings. This is recognised and supported by EU-level legislation such as directives on Energy Performance (EPBD)[2] and Energy Efficiency (EED)[3] of buildings, a harmonised Construction Products Regulation (CPR)[4], and funding granted by the Horizon 2020 Framework Programme for Research and Innovation initiatives.

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Peer-review under responsibility of the organizing committee of SBE16.
doi:10.1016/j.proenv.2017.03.097

Heat losses through the building envelope (walls, roofs, floors and glazed areas) account for over 60% of the energy use of conventional buildings. Many of these losses occur through uninsulated walls, thus the addition of thermal insulation is one of the most robust and efficient solutions for improving their energy efficiency. External Thermal Insulation Composite Systems (ETICS) are increasingly favoured over internal insulation approaches, due to a number of advantages like (a) lower disruption to occupants, (b) no loss of internal space, (c) lower risk of surface or interstitial condensation as the existing substrate is kept close to internal temperature, and (d) more efficient thermal performance allowed by a continuous insulation layer that prevents thermal bridges at junctions with intermediate floors and walls.

However, there is increased awareness of a 'performance gap'[5] resulting in a mismatch between predicted and measured energy use in buildings, which is often attributed to a combination of causes like occupant behaviour, defective workmanship and unrealistic design assumptions. This issue poses clear implication for strategic EU targets, especially considering that the underperformance tends to grow as the technology becomes more complex[6]. In order to find solutions for these shortcomings and improve our knowledge of their underlying causes, there is a critical need for in-situ tests of construction systems, as built and in service conditions.

This study evaluates the thermal performance of a prefabricated ETICS assembly in a retrofit application, by means of a prototype that was designed and built to be representative of a solution as implemented in the market. The thermal resistance expected from theoretical design values is compared to data from the experimental assessment, discussing possible causes for the variance between these.

2. Case study

This study measures in-situ thermal performance of a prefabricated ETICS solution that is mechanically anchored to existing floor slabs. The ETICS product, developed within the ETIXc project[7], is a composite panel comprised of PIR thermal insulation and a photocatalytic concrete external finish.

Fig. 1. Test area at first floor of west-facing façade in KUBIK facility: (a) original brick wall before installation; (b) ETIXc prototype installed.

The test was carried out over a portion of the west-facing façade of the KUBIK test facility in Derio, Spain (43° 17′ N 2° 52'W). KUBIK by Tecnalia[8] is a full scale experimental infrastructure focussed on research and