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Full scale experimental performance assessment of a prefabricated timber panel for the energy retrofitting of multi-rise buildings

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Abstract

A prefabricated timber façade system is presented for the energy retrofitting of buildings. Large panel dimensions facilitate the installation of this system, with reduced disturbance to building users and increased overall quality in terms of thermal bridge mitigation and air tightness of architectural junctions. A full scale proof of concept test is performed, where several prefabricated timber panels were installed over a pre-existing brick façade, their junctions tested, and the differential thermal performance of the system is evaluated. It is concluded that the overall thermal performance of the system is satisfactory in terms of overall U-value, thermal bridge coefficient and, temperature factor. Furthermore, and based on experimentally obtained data, a dynamic characterization of the harmonic thermal response of the system is performed.

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1. Introduction

Building envelopes are the physical interface between indoor and outdoor conditions, and their response to variations on these conditions such as temperature oscillations and incidence of solar radiation, substantially defines the heat dynamics of buildings. Roofs, façades, and glazed areas are responsible for over 60% of heat losses in conventional buildings.

Considering the large building stock and demographic projections in Europe, the quest in energy performance improvement is related to the already existing and ageing building stock. With modern building energy codes in Europe dating back to the 1970s, there has been a steady development and deployment of a variety of thermal insulation systems, such as external thermal insulation systems (ETICs) and ventilated façade systems.

With similar approaches to many other construction processes, building energy retrofits are personnel intensive processes, where raw materials such as insulation, reinforcement meshes, plasters, etc. are delivered on site, and manually installed by crafts. Although increasing care is paid to details in the construction process, large discrepancies are found between design and as-built performance of buildings, and its thermal insulation systems. Many sources are identified for the gap in energy performance, one of the main being poor workmanship.

In this paper an industrialized timber panel is proposed for the energy retrofitting of building envelopes. This panelized system is manufactured in a factory and delivered on-site. Factory production controls minimize performance loss due to poor workmanship. Once delivered on-site, panels are anchored to structural elements in the façade, and junctions are executed in a standardized way.

Within the development of the BERTIM timber façade, a full scale test was constructed comprising a 2-store-high setup, in order to ensure constructability of the system, test the production-transport-installation sequence, and on-site assess the thermal performance of the system. This setup was constructed in the KUBIK by Tecnalia test facility, over a pre-existing brick façade. Brick façades comprise the majority of the building stock in many countries such as Spain, and this particular façade was originally constructed according to thermal performance levels in the 1970s. The building envelope retrofit was sized in order to guarantee a large reduction of the thermal transmittance of the wall, ensuring compatibility of the wall with current energy performance standards.

The presented study shows the thermal performance of this system by means of numerical and experimental thermal assessments, and its differential thermal performance assessment when compared to the existing brick façade.

2. The BERTIM timber panel system and industrialized approach to building energy retrofits

BERTIM [1] proposes a building energy retrofit process focused on the deployment of high performance, minimally intrusive industrialized envelope systems. The Timber-based system is manufactured in large prefabricated envelope sections which are then delivered and installed with minimal on-site works.

In its conception, industrialized Timber-based panels with variable dimensions are allowed. This allows adaptation to variable floor heights, modulation of windows, etc. In some cases, panels spanning over several floor are possible. With this approach specific panel costs per surface are reduced, and on-site installation works facilitated.

The BERTIM system comprises not only envelope insulation elements, but also allows integrating ducts and pipes within the system to allow for the retrofitting of building HVAC systems with minimal intrusion.

In the following figures, the composition of BERTIM panels for insulation and HVAC integration are presented.