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Performance evaluation of non-conventional constructions: Case study in a temperate climate

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ABSTRACT

The development of new construction solutions is fundamental to enhance the building stock energy performance, and thus promote sustainable development in the building sector. These solutions must be sensitive to both the energy performance and the environmental performance. The aim of the work presented in this paper is the energy performance evaluation of non-conventional envelope solutions that were applied in a test building built at the University of Minho's Azurém campus. The evaluation was carried out by means of data analysis of in situ measurements, and also the use of energy and daylighting simulation tools. Prior to the simulations it was necessary to calibrate the model and create a climatic data file representative of the real weather conditions. From this evaluation it was possible to assess the potentialities of different construction solutions. The non-conventional solution presented a similar energy performance but a better environmental performance than the conventional solution, due to the use of lower embodied energy materials. It was also proved that, with minor modifications, the non-conventional solution can produce a better energy performance than the conventional one, evidencing the potential of application of these solutions.

1. Introduction

One of the most important challenges that modern civilization has to face is the problem of climatic changes and environmental degradation. Although it is not possible to pinpoint the individual responsible, it is well known that these challenges are closely related to the current excessive energy consumption and forms of obtaining it [1].

In the building sector, one of the main challenges is the higher thermal comfort requirements of the general population, which has led to an increase in the heating and cooling energy consumption. Nowadays the building sector in the EU is responsible for about 40% of the final energy consumption - of which 68% is due to residential buildings - and 1/3 of the greenhouse gas emissions [2–4]. Thus, this is a very important sector when dealing with the achievement of sustainable development. Many different actions can be implemented in this sector to improve the energy efficiency of buildings, e.g. adopting more restrictive energy regulations [5–7], applying construction materials with less embodied energy, implementing more effective construction solutions, take advantage of renewable energy sources, educating and raising the awareness of all the stakeholders [8–10].

In order to study and present low energy solutions for buildings in temperate climates, experimental test buildings were built at the University of Minho's Azurém campus, in Guimarães. According to Peel, Finlayson and McMahon [11], this region falls within the Köppen-Geiger climate classification of Temperate with dry and warm summer (Csb).

These experimental buildings are real scale buildings where several construction solutions can be tested. In light of the discussions on the advantages of Test Cell application in building thermal design [12], instead of following the conventional configuration applied in common Test Cells [13,14], a decision was made to approximate the design of the test buildings to the typical design in use, so as to compare buildings with different envelope solutions but also different design options. One of those buildings was intended to be a Sustainable Test Building (Fig. 1 - STB), featuring an improved zoning pattern that combines a heavyweight zone and a lightweight zone, as well as an optimised wall/glazing ratio for the proposed orientation.

For a more precise evaluation of the solutions presented by the STB, a Conventional Test Building (Fig. 1 - CTB) was built using one of the most common Portuguese solutions, which consist in

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