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Towards an improved Thermometric method: convective and radiative heat transfer for heat flux measurement through an indirect approach

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Abstract - Actual thermal performance of building walls need to be assessed through on-site tests. Several measurement procedures have been proposed during the last decades. Nonetheless, among them the Thermometric (THM) method has been poorly explored in literature, hence opportunities for improvements can be highlighted. The THM technique is a quite a new and non-standardized procedure for wall thermal characterization, based on the well-known Newton's law of cooling. This law needs the heat transfer coefficient knowledge and there is no agreement about the value to apply when the THM method is used. In this work, a low-cost experimental apparatus characterized by a heated wooden sample was realized. Sensors were installed to measure heat fluxes through a common heat flux plate. The obtained values were compared with the heat flows achieved via the THM method, where dimensionless groups analysis was performed for computing suitable heat transfer coefficients obtained from real time data processing. The aim of this work is to lay the groundwork for overcoming the disagreement related to the value of the total heat transfer coefficient in the THM method by proposing and consolidating an alternative approach. The results show that the proposed data processing for the THM method can provide satisfying results in terms of indirect heat flux measurements, showing extremely low percentage differences (ranging from +1.16% to +3.56%) if compared with the HFM method.

Keywords: Heat flux measurement; Heat-flow meter; Thermometric method; Nondestructive test; Data post-processing.

1. Introduction

It is well known that every building during all phases of the entire life cycle consumes significant amounts of energy [1]. The building stock is responsible for around 35% of energy needs globally and 40% in Europe [2]. Nowadays the ever-growing urbanization has made the concept of sustainable building more and more widespread [3]. The new sustainable buildings are designed applying careful planning that has energy saving as one of its main objectives [4]. It is evident how the energy performance is a central topic with the aim to reduce the environmental impact of new constructions and built heritage [5]. Investing in sustainable building techniques and technologies leads to an increase in the thermal performance of the building envelope [6].

The thermal characterization of buildings is carried out using thermal resistance (R-value) or thermal transmittance (U-value) as quantitative parameters [7]. In order to obtain a low energy impact building, it is necessary to consider R-value or U-value of walls as a key parameter [8]. The U-value represents the heat flow that crosses a building component per unit area divided by the difference of temperature across the structural element. The assessment of the thermal performance of buildings varies according to the case of new buildings or existing structures.

In the first case both the geometry and the materials of the walls are known. According to the Standard ISO 6946 [9], the heat flux through a wall, characterized by a certain number of layers of known thickness and material, can be calculated as the ratio between the temperature difference across the wall and the thermal resistance. The R-value of each layer is defined as the ratio between the thickness of the layer and the thermal conductivity of the material.