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The impact of internal aerogel retrofitting on the thermal bridges of residential buildings: An experimental and statistical research

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ABSTRACT

In this research, internal thermal superinsulation in residential buildings is experimentally and statistically evaluated in terms of potential thermal bridging effects. As a consequence of significant deviations in thermal resistance values in buildings at post-retrofit, large amounts of heat losses occur through non-insulated building elements such as separating walls. Therefore, it is of vital importance to determine the level of energy loss due to such thermal bridges through an internal thermal superinsulation retrofit conducted in a typical UK building. 20 mm thick fibre–silica opaque aerogel blanket is implemented internally on the walls of a test bedroom, and the heat flux from the separating wall is measured and compared for the cases of pre and post-retrofit. The results reveal that the average amount of heat loss through the non-insulated separating wall at the post-retrofit is 5.86 W/m^2, whereas it is only 0.66 W/m^2 at the pre-retrofit. The results are also verified through a statistical model, which is presented for the first time in literature. The novel model is capable of providing information about potential energy loss from non-insulated walls as a function of location.

1. Introduction

The role of domestic buildings on global energy consumption is unequivocal [1]. Intensive cost-effective measures are therefore undertaken worldwide to reduce the energy demand of buildings. Energy-efficient retrofitting is of prime interest for mitigating heat loss through building envelope. In this respect, especially the passive measures such as retrofitted insulation are considered as a solution for the external walls to be able to meet the latest standards towards low/zero carbon buildings [2]. However, the mere retrofit of an external wall with insulation does not have a remarkable impact on multi-dimensional heat loss, if additional attention is not paid to the heat flow due to thermal bridges [3]. Thermal bridges simply describe a situation in a building envelope where the uniform thermal resistance notably changes, resulting a significant amount of heat loss across the building element. Winter heat loss and summer heat gain through building envelope are greatly affected by thermal bridges. As reported by Theodosiou and Papadopoulos [4], thermal bridges are responsible for about 30% of the heating demand of Greek buildings. They have not only a vital impact on the thermal behaviour of the building envelope but also thermal comfort of the occupants. The indoor air quality might be reduced by undesired condensation and mould growth depending on the difference in the temperature gradient [5]. Thermal bridges in buildings can be split into two categories. The first type is the linear thermal bridges, which are observed at the intersection of two or more building components, and expressed by a linear thermal transmittance in W/mK. The second type is the point thermal bridges, which are situated at three dimensional corners, and characterized by a point thermal transmittance in W/K.

Intensive efforts are made for an easier understanding and accurate evaluation of thermal bridges in domestic buildings [6]. It is clear from literature review that the theoretical and numerical methods are mostly preferred by researchers in the analyses of thermal bridges [7]. However, these techniques are based on strong assumptions in most cases, which remarkably affect the reliability and the accuracy of the research [8]. A lot of commercial software is also utilized for the assessment of potential thermal bridges in the building elements [9]. However, they have limited skills in most cases, and hence incapable of providing a realistic evaluation especially in terms of defining the boundary conditions. Catalogues are also available to characterize several examples of thermal bridges

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Fig. 1. The photograph of the test house and the test bedroom.

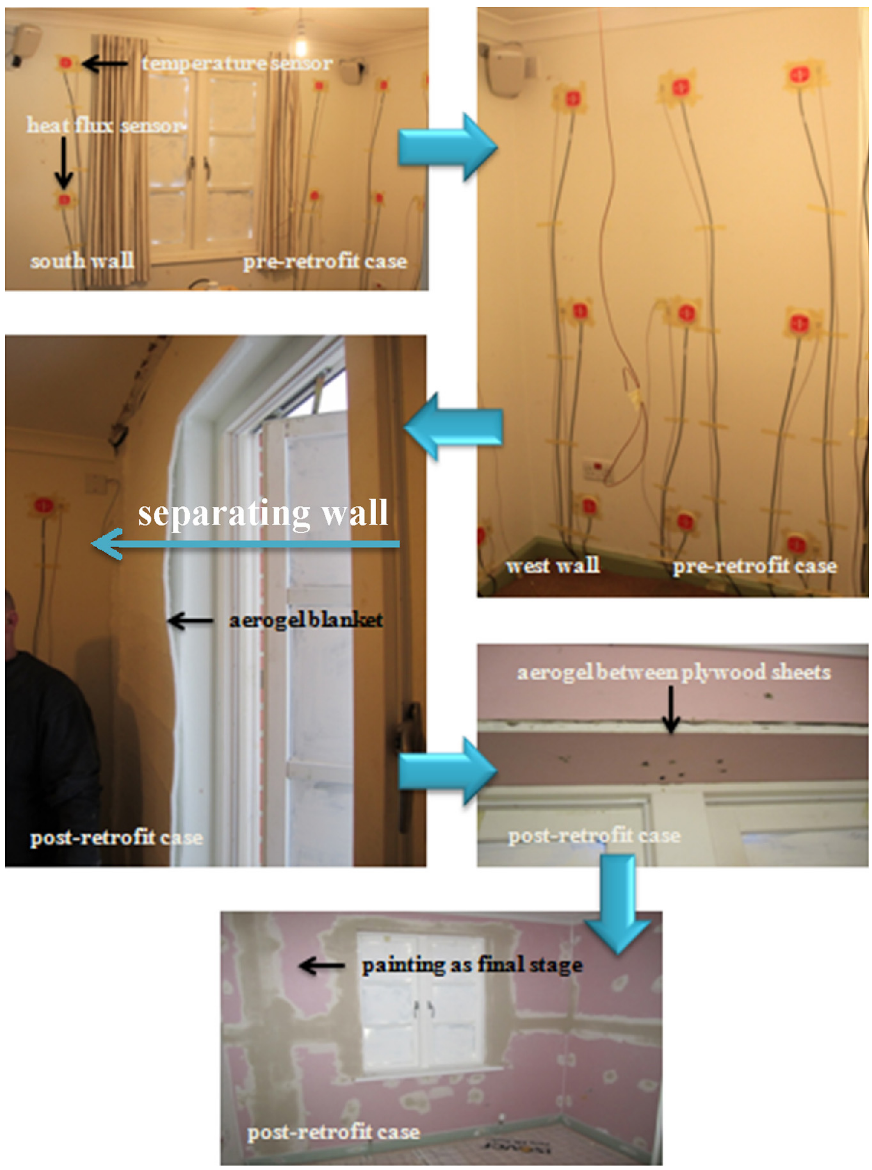

Fig. 2. Aerogel retrofitting from pre to post-retrofit case.

for particular parameters such as material type, dimension and thermophysical properties [10]. The tabulated values of thermal bridges might be considered as a rapid way of preliminary assessment of the building envelope, but they generally do not have a good accordance with the results of actual operating conditions as reported by Larbi [5].

In addition to the aforesaid techniques for the evaluation of thermal bridges, an experimental methodology can also be conducted through standardized test approaches for a more realistic assessment. However, experimental-based researches on thermal bridges are very limited in literature since they are laborious, expensive and time-consuming. Nevertheless, to address the pioneer works might be useful to be acquainted with the importance of the concept. Zalewski et al. [11] experimentally investigate the role of thermal bridges on the heat loss through prefabricated building walls. Dynamic behaviour of thermal bridges on the heat transfer is evaluated on a test wall over a two days period. The results indicate that the thermal bridges are responsible for a significant amount of heat loss through building walls and the heat flux values greatly change by the location of fluxmeters. This work