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Reliability of interior thermal insulation as a retrofit measure in historic wooden apartment buildings in cold climate.

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Abstract

The performance of the interior insulation as a retrofit measure in historic wooden building was analysed. The designers' view is that an interior insulation of 50mm mineral wool with vapour barrier is a safe solution. Probability of failure using mold growth risk as an indicator was calculated using stochastic method. Sensitivity analyses revealed that the existence of the vapour barrier is most influential. In addition, the insulation material layer is of critical significance. Of the boundary conditions the moisture excess has a higher effect than indoor temperature. The calculated probabilities showed high risk. Therefore, the considered insulation solution is an unreliable retrofit measure.

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Keywords: hygrothermal performance; interior insulation; retrofit; historic building; moisture safety.

1. Introduction

There is a need to improve thermal comfort and energy performance of the historic buildings to meet modern requirements. Interior insulation is a possible solution when the architectural appearance is of high value and must be preserved. However, internal insulation may cause hygrothermal risk, therefore special requirements for the renovation solutions are set. To achieve a moisture safe renovation solution, careful design and risk analysis are needed.

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Typically, to assess the hygrothermal performance and the moisture risks of the constructions the deterministic approach is used in the design process. The reliability can be defined as the probability for a solution to function without failure during a given interval of time. The reliability concept fundamentally requires the assessment of probabilities, calling for the application of probabilistic methodologies rather than deterministic techniques [1]. The different parameters influencing the hygrothermal performance of the retrofit measure have a stochastic nature. A stochastic method enables variations in material properties, climatic conditions, boundary conditions and differences in wall assemblies to be considered. The analyses can be carried out through testing the influence of a single input parameter to testing all input parameters.

In several studies stochastic approach have been applied in the analysis of hygrothermal performance. The influence of material properties is reported in [2, 3, 4], the influence of one part of the wall assembly in [5], the performance assessment of interior insulation in [6], the performance of the building envelope in [7]. Previous studies have mainly focused on the influence of the stochastic nature of the material properties or on the performance of some parts of the wall assemblies.

As a rule of thumb, the view established among designers is that a 50 mm of interior insulation of mineral wool with a vapour barrier is a safe solution and can be easily applied as a retrofit measure in Estonia. For our case study the measurements were performed inside the retrofitted walls in the typical historic wooden apartment building [8]. After one and a half year, the occupants of the apartment started to complain about their children's health problems. The walls were opened and heavy mold growth was detected. Also, the opening of the retrofitted walls revealed differences between the design and the execution. The question about the reliability of the interior insulation arose. This paper analyses the probability of failure occurrence taking into account different scenarios regarding the interior thermal insulation used as a retrofit measure in historic wooden apartment buildings in cold climates.

2. Methods

Using a stochastic approach, the performance of the interior insulation as a retrofit measure in a historic wooden apartment building was analyzed. Based on the measurement results, the simulation model was validated in the WufiPro5.3 (WUFI) [9]. The calibrated model was used to calculate the temperature and RH conditions in the wall.

The outdoor climate conditions, indoor climate loads, different retrofitted wall assemblies and quality of workmanship were used as the varying input data parameters (see Fig. 1). The wall assembly with the average design values and with the average indoor temperature and moisture excess is considered as base case. The hygric properties of the material layers are described in more detailed manner in [9].

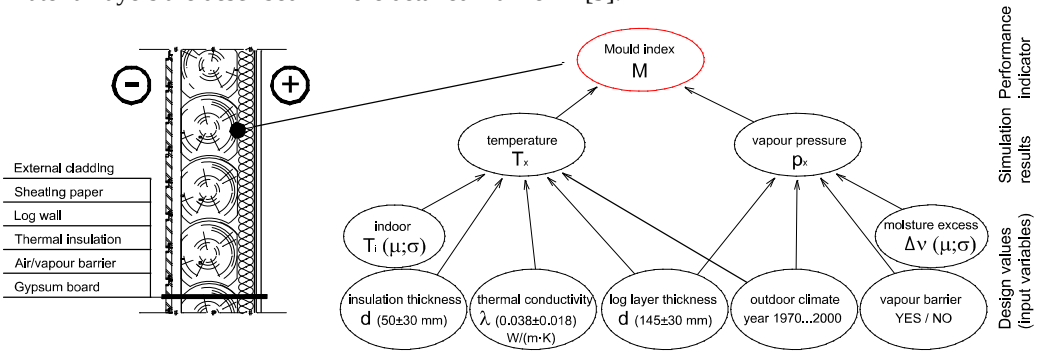

Figure 1. Design variables for the hygrothermal simulation model.

In this study the mold growth is considered as the performance indicator for risk assessment. According to [10], mould is one of the most hazardous contaminants of the indoor air and has to be prevented in any circumstances. Expected risk and durability of materials to mould growth can be predicted by calculating the mould index (*M index*) using the dynamic temperature and relative humidity histories of the subjected material surfaces [11]. *M index* was