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Impacts of energy retrofits on hygrothermal behavior of Finnish multi-family buildings

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Abstract

This paper presents impact of energy retrofit on hygrothermal behavior in three multi-family buildings. One of the buildings underwent deep energy retrofitting, one had focused energy retrofits, and one building was a non-retrofitted control building. The average indoor temperature during heating season was relatively high in all studied buildings. The temperatures near the coldest spot of the building envelopes were within guideline values, and some improvements could be noticed in the deep retrofitted building.

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Keywords: Energy retrofit, multi-family building, temperature, thermal index.

1. Introduction

In 2010, European Commission issued the recast of Energy Performance of Buildings Directive (EPBD), in order to reduce the building energy consumption and strengthen the energy performance requirements, requiring that by the end of 2020 all new buildings are so-called nearly zero-energy buildings (nZEBs). Also existing buildings subjected to major retrofits meet minimum energy performance requirements adapted to the local climate [1]. Finnish standards for energy efficiency of buildings are already relatively high, limiting the potential for reducing energy loss throughout the building envelope. According to a recent survey, over 90% of the Finns are satisfied with indoor temperatures

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during winter, and there is no difference between Northern and Southern Finland in this respect [2]. Nevertheless, the EPBD is being implemented in Finland, which could have impact on hygrothermal performance on new and retrofitted buildings.

With respect to Finnish housing stock, most of the existing apartment buildings have been constructed in 1960-1980 [3] and part of them has already been renovated. In addition, a large quantity will be renovated in the next few decades, providing an opportunity to improve energy efficiency. From the environmental health point of view, a new decree on housing and health was issued in 2015 [4]. The decree has specified new action limits, while the guideline values [5] are still the same. According to the decree, the indoor temperature should be between +18…+26 °C. Recommended guideline [5] for “good level” of room temperature is 21 ºC and “adequate level” is 18 ºC. During the heating season, indoor temperature (T) should not exceed 23… 24 ºC. The surface temperature of building envelope should not be lower than +16…+18 °C. The indoor relative humidity (RH) should be between 20…60 RH%.

Thermal index is a relative value which takes into account surface, indoor and outdoor temperatures. It is defined as a difference between internal surface temperature and external temperature, divided by the difference between internal temperature and external temperature (Equation 1) [6].

$$f_{Rsi} = (T_{s,min} - T_o)/(T_i - T_o) \qquad (1)$$

where $T_{s,min}$ is minimum surface temperature, T_o is outdoor temperature (°C) and T_i is indoor temperature (°C). Based on Finnish housing health guide, the limit values for thermal index (f_{Rsi}) are 0.87 and 0.81 for external walls and 0.97 and 0.87 for floors, respectively.

This paper is focused on assessment of hydrothermal parameters in selected Finnish multi-family buildings. The used methods are reported in INSULAtE-project report [7].

2. Case studies

2.1. Case study buildings

Multi-family buildings that were planned to be retrofitted during the 5-year INSULAtE-project were eligible for the study. The study area included several regions in Finland (Tampere, Hämeenlinna, Imatra, Helsinki, Porvoo, Kuopio). The buildings were chosen from among volunteers: primary criteria were planned retrofits, which had to be related to energy efficiency and finished before the fall of 2015. Also some control buildings, which were not retrofitted during the project, were included. The case study buildings were divided into three groups:

• Deep energy retrofitted (DER) buildings, represented more comprehensive energy efficiency measures, addressing multiple systems at once (e.g. adding thermal insulation the building envelope, changing windows, changing heating and ventilation system).

• Focused energy retrofitted (FER) buildings, which included system upgrades (e.g. changing windows or installing heat recovery into exhaust ventilation system).

• Control buildings (CONTROL), where no energy retrofit actions were performed.

This paper presents hygrothermal analyses focused on selected case buildings, one from each three group.

Table 1. Characteristics of the selected buildings.

	Year of construction	Number of storeys	Ventilation	Construction type	Retrofit actions
DER	1954	4	Natural	Wood-framed walls	Thermal insulation of walls, new windows
FER	1980	7	Mechanical exhaust	Pre-fabricated concrete walls	Heat recovery
CONTROL	1980	7	Mechanical exhaust	Pre-fabricated concrete walls	No actions