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The effect of positive pressure on indoor air quality in a deeply renovated school building – a case study

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Abstract

This paper is a case study of ventilation and indoor air quality (IAQ) investigations in an extensively repaired comprehensive school in Finland. Our main hypothesis is that positive pressure between air indoors and outdoors can be used for decreasing the concentration of harmful chemical and microbiological agents in indoor air, as well as occupants´ complaints about IAQ, in a building waiting for new repairs or with unsolved IAQ problems. Research was undertaken on a building consisting of 12 classrooms, and served by one air handling unit. It found that the ventilation system was crucially unbalanced. However, IAQ measurements did not explain occupants´ symptoms, which were suspected to be related to the impurities leaked through the building envelope caused by the high negative pressure. To eliminate the potential harmful effects of the building related sources and infiltration airflows, the air handling unit was adjusted to generate a 5-7 Pa positive pressure for a period of 4 months. In the next planned phase of the study, moisture content of the structures during the heating season will be measured, as well as potential changes in perceived IAQ and microbial contamination.

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Keywords: Positive pressure; mechanical ventilation; indoor air quality; school building

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1. Introduction

According to the National Building Code of Finland [1], buildings should be maintained at negative pressure, especially in a cold climate countries where keeping structures dry is one of the main issues. A moderate 5-10 Pa negative pressure (negative difference between indoor and outdoor pressure) is achieved by the ventilation design of buildings, and it prevents exfiltration of the moist indoor air into the structures. However, preventing infiltration of the possible impurities from the structures or surroundings, caused by high negative pressure, is crucial for maintaining a good indoor air quality (IAQ). In the worst case, unbalanced ventilation can lead to a continuous pressure fluctuation. Moist air exfiltration could cause microbial growth and material deterioration inside structures, and infiltrations through the damaged structures could bring in harmful compounds. In air tight buildings with a mechanical ventilation system, the balancing and controlling of the ventilation system and pressure differences is essential [2]. While improving energy efficiency is of high importance in new buildings or renovation processes, the role of the well-balanced ventilation should not be forgotten. Pressure difference measurements are found to be important when evaluating the effect of improving energy efficiency on the perceived IAQ [3]. Using the common IAQ measurements alone to determine occupants´ circumstances indoors can lead to misinterpretations and leave unsolved problems in the building. Proper ventilation measurements should be an essential part of every IAQ investigation [4].

The aim of our research project was to find out whether occupants´ complaints and symptoms could be decreased with positive pressure in a multi-problematic building, which have been under extensive repairs, yet where the IAQ is still poor. The research project includes two parts: (1) Ventilation and IAQ measurements before and after ventilation balancing and generating positive pressure, and moisture excess calculations; (2) Microbial samples from extract air filter, occupants´ symptom questionnaire and moisture behaviour inside the structures. The first part will be presented in this paper, and the second part will be published in a separate journal paper.

2. Materials and methods

2.1. Study design, location and building characteristics

This study is a two-step intervention study, in which the first part was carried out between April and September 2016, and the second part will continue until April 2017. The study was carried out in a comprehensive school in Vantaa, Southern Finland. The school was selected in co-operation with Vantaa Real Estate Centre in the spring of 2016, based on its repair history, and the fact that a reasonable and controllable part of the building could be separated for implementing the positive pressure intervention without major ventilation system changes in the building.

The school was built in 1968 and fully renovated 2003-2005. It has a mechanical supply and exhaust ventilation system with heat recovery. The mechanical ventilation system in all classrooms and corridors was installed in 2002. Each classroom has 2-3 supply air duct diffusers and 1-2 extract air grilles. Air flow rates are adjusted by dampers in the main air handling unit and with regulation and measuring devices connected to each terminal device. The studied section of the building as seen from the outside, and the typical supply and extract terminal units of a classroom in the section are shown in Fig. 1a and 1b.

Almost 700 students aged 11-15 years, and over 50 teachers and other staff work daily in the school. Occupants have had IAQ related symptoms and discomfort since the renovation, and several microbial and structural investigations have been made since 2004. Moisture and mould damage have been observed and repaired in some parts of the building. Ventilation problems have been one of the main concerns of the occupants, and ventilation adjustments have been made several times in different parts of the building over the past years. Also air leakages, especially of the structures in contact with the ground, have been widely sealed. Even so, the school has many classrooms and other spaces where occupants have complained of IAQ related symptoms and discomfort. At the time of this research project, investigations were ongoing in the building and some microbial growth and major air leakages were found. Repairs in the whole building will take place during 2017.