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Permeability measurements of a passive house during two construction stages

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Abstract

Usually air permeability is measured for a specific building only once: either when the building construction is was just finished or when the building is already in use. In this paper we present a novel aspect. We researched if there is any variation of the building permeability during its construction. We followed the evolution of the building airtightness during the construction of a passive house carrying out permeability measurements in two different phases: (1) airtight construction but not finished and without HVAC, and (2) finished construction with HVAC. For each phase, we used a blower door experiment stand to measure the airflow at different indoor-outdoor pressure differences in two conditions (depressurization and pressurization). We obtained air change rate at 50Pa well below the maximum limit characteristic to passive house. However an intriguing result was found: the measured permeability for the finished building is slightly bigger than the measured permeability for the unfinished building. On one side the better finishing of the walls and windows lead to an airtightness improvement, but on the other side the new HVAC wall penetrations and HVAC terminals (inlets and exhausts) lead to an airtightness aggravation just enough to turn over the improvement brought by the better state of building finishing.

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1. Introduction

Passive houses are constructions meant to ensure comfortable indoor conditions with a minimum energy spent for heating or cooling. To this ambitious goal contributes the envelope insulation, window quality, building form, *air*

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tightness, orientation, climate and other heating, ventilation and air-conditioning (HVAC) systems. Usually, the annual energy demand of Passive Houses is 75 to 95% lower than that of a traditionally insulated building of the same geometry [1]. Moreover, better air quality is achieved inside the space. Langera et al. [2] studied the indoor environment of more than 20 new passive houses and compared the data with 21 new conventional built houses. They found by measurements that the formaldehyde concentrations and volatile organic compound have lower values in passive houses. Among all the above mentioned parameters, air permeability of any building has a tremendous impact on the energy balance and indoor comfort of occupants. Air tightness is not only an ordinary way of energy savings, it is crucial to avoid any construction damage. If a building is not correctly air sealed, gaps in the construction will lead to significant humidity passage.

Correct sealing is now one of the most important aspects when constructing a building and special attention should be focused in this direction since the beginning of construction.

In case of Passive Houses, a very low air leakage rates are obtained by creating a single and continuous airtight barrier, in order that the air change rate to be less than or equal to 0.6 air changes per hour, under test conditions. For example, a field measurement study of the air tightness on 32 detached houses realized by Kalamees [3] showed that the mean air leakage rate at the pressure difference of 50 Pa for the entire database was 4.2 $m^3/(hm^2)$. The mean air change rate at the pressure difference of 50 Pa from the entire database was 4.9 vol/h. This was translated into high energy consumption, fluctuating air temperature, cold floor and air draught that have negative impact on human health and comfort. The air permeability is mainly tested and measured using the standardized Blower Door pressurization technique [3, 4] and other simplistic methods (e.g infrared thermal images, smoke detectors) can be used for visualizing the air leakage.

Many other permeability experimental studies were carried out all over the word: United States [5], Greece [6], Finland [7], Spain [8], France [9,10], Italy [11], Australia [12], and Canada [13] in order to find out prediction models for the infiltration airflow after the building was finished and in use. In all these studies the researchers carried out airtightness measurement for several buildings with only one measurement per building.

In this research we have a novel perspective. We follow the variation of the permeability of a passive house during its construction, before it is finished.

The main purpose of this article is to draw correct conclusions about the impact of different construction stages on the air permeability. The research team had the chance to follow the entire construction process of a Passive House built in Bucharest, Romania. For each construction stage the air permeability was measured using the Blower Door System for precise results. If simple at the beginning, this research process turned to be a long and complex one, thus the study conclusions make it valuable to the actual bibliography by its distinctive approach.

Nomenclature

Q_{P1D}	Infiltration airflow when the building is in construction phase 1 under depressurization (m^3/h)
Q_{P1P}	Exfiltration airflow when the building is in construction phase 1 under pressurization (m^3/h)
Q_{P1}	Average infiltration airflow when the building is in construction phase 1 (m^3/h)
Q_{P2D}	Infiltration airflow when the building is in construction phase 2 under depressurization (m^3/h)
Q_{P2P}	Exfiltration airflow when the building is in construction phase 2 under pressurization (m^3/h)
Q_{P2}	Average infiltration airflow when the building is in construction phase 2 (m^3/h)
Δp	Indoor-outdoor pressure difference (Pa)

2. Description of the passive house

The passive house taken into account in this work is the building called “Politehnica”, built within the campus of the “University Politehnica of Bucharest” at the following coordinates: 44.4380 N Latitude, 26.0470 E Longitude (76.6 m Altitude). In fact, this construction contains two family semidetached houses: the “East House” and the “West House”. These two houses are placed in a common external envelope (Fig. 1). The main geometrical characteristics of the building are given in Table 1 [14].