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Long term energy efficiency study on different wall envelopes in Latvian climate conditions

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Abstract

Five test stands have been built in Riga, Latvia equipped with sensors (temperature, solar radiation, humidity, etc.) to measure energy efficiency and thermal comfort conditions. Roof and floor constructions are made the same. For the walls building envelopes differ and typical materials used in Latvia (aerated concrete, ceramic building blocks, wooden log and plywood frame with rock wool insulation) are compared. Only rock wool is used for insulation to provide moisture transport through the construction. For study to be comparative thermal transmittance of all five test stands have been calculated equal (U=0.15…0.16 W/(m^2·K)). The aim of research is to compare the integral calculation results with measured ones. Another aim is to compare the energy consumption and humidity results of last heating season to previous years and see if the initial conditions still influence the energy consumption. The heating during the period is done using electric heaters instead of heat pumps as in previous years, so that the coefficient of performance is unity. The results show that even during the fourth full heating season initial humidity in aerated concrete construction still haven't completely evaporated and the thermal transmittance is decreasing towards the theoretically calculated data provided by manufacturer. Linear heat loss coefficients are calculated for corners and results show that for such small buildings the corners' impact can be considerable.

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Keywords: Energy efficiency monitoring, moisture in buildings, linear heat loss coefficients

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1. Introduction

Since the beginning of year 2013 energy efficiency study is done in Riga, Latvia where five test buildings are equipped with sensors to monitor energy efficiency and indoor environment quality. Similar studies [1,2] have been done throughout the Europe but this is the first in Latvian climate conditions. The subjects are often treated separately even though one influences other. In this case however, both thermal comfort and energy efficiency is being monitored and their interaction analyzed. The heating, cooling and ventilation are mainly done with air-air type heat pump but different heating methods have been tried that are further discussed in section experimental setup. The floor and ceiling constructions are made equal so that wall envelopes can be compared. Envelopes themselves are made of different materials but with the same calculated U-value considering manufacturer's data. The test ground is shown in Fig.1a and the schematic picture of sensor placement is shown in Fig.1b.

Humidity and temperature sensors are placed not only in the inner and outer environment but also inside the construction that allows to read the humidity inside it. The results section includes humidity changes in construction for the whole monitoring time. The energy efficiency study is also done where energy consumption is being tracked in each of the test building. With heat pumps it is difficult to know the exact amount of heat released in the inner environment so only comparative study between different houses could be done so far. In heating season 2015/16 electric heaters have been used and therefore the results can be compared with integral model calculations that is also done in this study.

Fig. 1. (a) Test ground (b) Schematic sensor positions.

2. Experimental setup

2.1. Test ground

The test houses are localized in the urban environment, under natural conditions in Riga, Latvia, characterized by cold, maritime climate. Duration of the average heating period is 203 days, the average outdoor temperature during the period is 0.0°C, the five coldest day average temperature -20.7°C, the average annual temperature is 6.2°C and the daily average relative humidity is 79% [3, 4]. The selected location is the University of Latvia Botanical Garden territory; all five houses are placed on equal relation to the sun and the surrounding shading objects.

The experimental constructions are designed to minimize differences in output data of energy consumption and indoor climate measurement data analysis and interpretation. Each experimental stand imitates a free-standing building with an interior room (9 m^2 floor area, ceiling height of 3 m) with a window on the south façade and a front door on the north façade – see Fig.1. Each building is placed on pillars and has no contact with the ground. To minimize the effect of thermal bridges, window and door installations are placed in the insulation layer.

The basic materials used for the ventilated facade exterior wall construction are (see Fig. 2):

- perforated ceramic blocks (440 mm) with flexible stone wool insulation outside (CER), U=0.151 [W/(m^2K)];
- aerated concrete blocks (375 mm) with flexible stone wool layer outside (type AER), U=0.153 [W/(m^2K)];