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ScienceDirect

Energy Procedia 132 (2017) 478–483

Energy Procedia

www.elsevier.com/locate/procedia

11th Nordic Symposium on Building Physics, NSB2017, 11-14 June 2017, Trondheim, Norway

Investigation of Different Configurations of a Ventilated Window to Optimize Both Energy Efficiency and Thermal Comfort

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Abstract

The study in this article investigates 15 ventilated window typologies with different pane configurations and glazing types in climates of four European countries (United Kingdom, Denmark, France and Germany) in order to identify the optimum typology with regard to their energy balance and impact on thermal comfort. Hourly simulations of the heat balances of the windows are conducted on four days representing different typical weather conditions according to the method described in EN ISO 13790. U and g values used in the calculation method are calculated in European software tool (WIS) for the calculation of the thermal and solar properties of commercial and innovative window systems. Additionally, comfort performance is evaluated by inlet air temperature and internal surface temperature of the windows calculated by WIS software.
The results of the study show the energy and comfort performance of different ventilated window typologies and provide optimally ventilated window typologies for climates of these four European climates. The typologies with solar control or Low-emissivity (Low-e) coatings and typologies with double glazing on the outside have better performance in terms of either minimizing the energy consumption or optimizing the thermal comfort. The provided optimal window typologies can be used in residential and commercial buildings for both new constructions and renovations.

Peer-review under responsibility of the organizing committee of the 11th Nordic Symposium on Building Physics.

Keywords: ventilated window; configuration; energy consumption; thermal comfort

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Peer-review under responsibility of the organizing committee of the 11th Nordic Symposium on Building Physics
10.1016/j.egypro.2017.09.660

1. Introduction

Houses and apartments are nowadays the most energy intensive sector and their operation takes up to 40% of the total amount of energy use in Europe. Windows have a significant effect on building performance and several aspects have to be taken into account when developing new concepts for refurbishment [1]. In many existing buildings, mechanical ventilation is very difficult and expensive to provide and there is a need for the development of alternative window and ventilation solutions.

Five window typologies were simulated indicating that better energy performance can be achieved with the help of ventilated window in the subtropical and temperate climate zones [2]. Appelfeld et al. [3] conducted experimental analysis showing that a ventilated window can potentially contribute to energy savings and the ventilated window might be most suitable for a window unit with low ventilation rates. Different models and calculation methods have already been developed to investigate the performance of ventilated windows [4,5].

A comprehensive investigation needs to be implemented for different window typologies and both the energy demand and the thermal comfort of the different window typologies need to be evaluated. The study investigates 15 different window typologies (e.g. glazing type, glazing position, coating position and cavity width, etc.) under two different ventilation concepts (heating mode and cooling mode). Energy demand and thermal comfort (internal surface temperature and inlet air temperature of the window typologies) have been calculated under different weather conditions in four European countries and the most energy efficient solution providing acceptable indoor thermal comfort has been identified.

2. Description and method

The investigations were performed on the 15 different window typologies illustrated in Figure 1. Typology 3 is used as a reference case. The reference case is a closed cavity window and the others are variations of windows with different pane and glazing configurations and a ventilated cavity. In general, the samples are simulated to test the effect of:

- Coating on a single glazing
- Single glazing outside
- Single glazing inside
- Coating position (surface facing inside or surface facing outside)
- Coating type (solar control or Low-e)

The ventilation concepts shown in Figure 2 are used in the simulation. In summer the active mode is the Cooling mode while in winter the Heating mode is active.

The goal of the cooling mode is to minimize the amount of solar radiation passing through the window. For a traditional window configuration, some amount of solar radiation striking the window is absorbed in the glazing panes and then transferred to the room by convection and radiation. Natural ventilation through the air gap can cool down the glazing panes and the heated air can be expelled to the outdoors removing some amount of solar radiation. In addition, the air to the room is supplied directly from the outside in the cooling mode. The main idea behind the heating mode is minimizing the heating load from the heating system to the room by means of utilization of solar radiation for preheating of the ventilation air. Also, the energy losses from the room through the inner skin of the window will return back to the room with the ventilation air. The preheating of the ventilation air will also reduce the risk of draught.

Simulations of the window performance have been carried out for three orientations; north, south and west and for four different locations. The locations are Copenhagen (Denmark), Finningley (United Kingdom), Nice (France) and Würtzburg (Germany). The calculations are time-consuming, so only these four locations are selected to representing