Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 78 (2015) 561 – 566

Energy Procedia

6th International Building Physics Conference, IBPC 2015

Analysis of user behavior profiles and impact on the indoor environment in social housing of mild climate countries

Nuno M. M. Ramos[a,*], António Curado[a, b], Ricardo M. S. F. Almeida[a, c]

[a]*CONSTRUCT-LFC, Faculty of Engineering (FEUP), University of Porto, Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal*
[b]*Polytechnic Institute of Viana do Castelo, School of Technology and Management, Department of Engineering Sciences and Technology, Avenida do Atlântico, 4900-348 Viana do Castelo,Portugal.*
[c]*Polytechnic Institute of Viseu, School of Technology and Management, Department of Civil Engineering, Campus Politécnico de Repeses, 3504-510 Viseu, Portugal.*

Abstract

An enhanced knowledge of the users' behavior is critical for an effective design, since their presence and activities have a strong effect on indoor climate. They on one hand produce thermal loads, moisture loads and pollutants and, on the other hand, perform control actions for shaping the indoor environmental conditions according to their demands. This paper contributes to a methodology for the definition of user behavior, by exploring opportunities and limitations of in-situ investigations. As part of a wider investigation, a dwelling surveyed for one year provided an example of how temperature, relative humidity and CO_2 concentration combined with user actions logs can be used for qualitatively draw user profiles and account for the impact on the indoor environment. A connection between moisture production activities and window opening was established. Also in this example, the poor ventilation during winter, with limited window opening, lead to excessive CO_2 concentration as a trade of for relatively acceptable indoor temperature.

Peer-review under responsibility of the CENTRO CONGRESSI INTERNAZIONALE SRL

Keywords: User behavior; temperature; relative humidity; ventilation

* Corresponding author. Tel.: +351 22 508 1770.
E-mail address: nuno.ramos@fe.up.pt

Peer-review under responsibility of the CENTRO CONGRESSI INTERNAZIONALE SRL
doi:10.1016/j.egypro.2015.11.736

1. Introduction

Buildings' hygrothermal performance is highly dependent on user behavior. Occupants' presence and activities have a strong effect on indoor climate as they on one hand produce thermal loads, moisture loads and pollutants and, on the other hand, perform control actions that aim to shape the indoor environmental according to the users expectations (e.g. operating HVAC systems or opening/closing windows). Therefore, an enhanced knowledge of the users' behavior is critical for an effective design.

Several researchers studied the effect of occupancy and user behavior on the energy use of residential buildings [1-4]. On the other hand, in building simulation, assumptions are made on how the occupants operate the building and occupancy profiles and activities are required as input data. This information is typically found in standards and regulations. It's important to understand how accurately these simulations perform to bridge the gap between predicted and actual energy consumption in buildings [5-7]. Taking moisture as an example, the comparison between the work by Yik et al [8] and Pallin et al [9] highlights the different approaches and different results regarding the definition of loads. Moreover, the task becomes challenging if stochastic analysis is intended.

In this work, the specific case of social housing in mild climate countries is studied. An enhanced knowledge of the user behavior is pursued so that a clear view of their expectations and actions can arise from the study. The objective is to explore the links between users, hygrothermal performance and indoor air quality based on a complete year's monitoring.

This paper presents a contribution to a methodology for the assessment of user profiles, hygrothermal loads and resulting indoor environment. The analysis is built on a sample dwelling that was monitored for one year [10]. The work presented in this paper is part of a wider ongoing study, extended to 50 social housing dwellings that will provide a deeper insight with a strong statistical base.

2. Case study and methodology

2.1. Building characterization

A large social housing retrofitting program was implemented in Porto, Portugal. The interventions included the upgrade of envelope thermal properties and ventilation systems. One flat of one of the renovated neighborhoods was chosen as case study for this work. The flat has 3 bedrooms for a total of 5 inhabitants and the following geometric features: net floor area of 64 m^2; exterior wall area of 37 m^2; window area of 12 m^2; and volume of 160 m^3. Typically, the Portuguese social housing users have a low income and try to spend the lowest possible amounts of energy in heating and cooling. In this study, users were asked about their heating habits having answered that they do not heat the house. Considering that the mechanical extraction in kitchens initially installed is only turned on by the users during cooking hours, an almost passive behavior of the flat was observed.

2.2. Equipment and method

The hygrothermal performance was evaluated for a full year by the continuous measurement of air temperature and relative humidity and the indoor air quality was assessed, during the same period, by the CO_2 concentration. Both were measured in the living room and in one bedroom.

The hygrothermal variables were recorded every ten minutes by means of data loggers HOBO-U12-011, with a precision of ±0.35 ºC and ±2.5% and a resolution of 0.03 °C and 0.03%, for temperature and relative humidity, respectively. The CO_2 concentration level was measured with the TelAire 7001 associated to a data logger HOBO-H08-007-02. This system has a maximum error of ±50 ppm. The exterior conditions were recorded every ten minutes in the nearby LFC weather station.

CO_2 concentration level was used as an indicator of indoor air quality and as a mean of determining outdoor air ventilation rates according to the procedures established in ASTM D624-12 [11]. CO_2 is considered a cost effective solution and has been tested as tracer gas by several researchers [12-14]. Air change rate (n) can be calculated from the mass balance equation of the CO_2 (knowing the source emission and the outdoor concentration). In this study, the monthly average air change rate was estimated using 15 calculations in each month. The chosen period was in