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Evaluation of Thermal Sensation in Office Buildings: A case study in the Mediterranean

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Abstract

The existing institutional framework is expressing, both in Europe and in Greece, the strong drive for improving the existing buildings stock, by means of compulsory measures, as buildings account for almost 40% of the primary energy consumption in Europe. Especially, when referring to office buildings, the existence of increased cooling requirement accounts for very high consumption values (up to 60% of the overall), whilst at the same time the occupants experience significant levels of discomfort. Therefore, the occupants' well-being as well as their productivity are affected.

Within the framework of this study, an evaluation of both thermal comfort and indoor air quality conditions is carried in two office buildings. Both buildings are located in northern Greece and were constructed after 1980 and before 2010, in accordance with the first Greek Thermal Insulating Regulation. In situ measurements were carried during the winter period for the one building and the summer for the other. The measured parameters are the air temperature, the humidity levels and the levels of CO_2 emissions specifying the indoor conditions. Furthermore, a revealed preference survey was conducted in order to specify the parameters affecting the occupants' reaction concerning the indoor thermal conditions through the usage of regression model analysis.

The interpretation of occupants' reaction to indoor conditions and the human's sensation of thermal comfort, based on monitoring the existing environmental conditions and determining probable correlation with individual characteristics are very promising.

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Keywords: office buildings; thermal sensation; mediterranean countries; regression analysis

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1. Introduction

Nowadays, the need to improve the buildings' energy efficiency is more than ever compulsory. The European along with the national legislation framework concerning the energy efficiency of the building delineate the institutional needs and expectations to create a sustainable and less consumed urban environment. In detail, the establishment of the 20-20-20 targets for 2020 and the European Directive 2012/27, a modification of the 2010/30/EU and 2009/125/EU, emphasize the need to improve the existing building, as 40% of the Europeans' building stock is constructed before 1960, and to construct energy efficient buildings[1,2,3].

The building sector accounts for almost 40% of the primary energy consumption in Europe and is divided into residential and non-residential buildings, where non-residential accounts for 26% of the total floor area, while residential for 74%[4]. Concerning the energy consumption, Odyssee Database outlines that 161.45 Mtoe (1.02 Mtoe/employee) while 300.32 Mtoe (1.42 Mtoe/dwelling) were the total energy consumed in 2013 by the tertiary and residential sector, respectively[5].

Within this study, office buildings are selected for the evaluation, as they constitute about 23% of the non-residential buildings (the second biggest category) [6]. Specifically, the main objective of this paper is the evaluation of the indoor air conditions and the occupants' thermal sensation. Concerning the indoor conditions, the specified parameters are the air temperature, relative humidity and CO_2 levels. Those parameters are needful as they affect the occupants' needs, health and productivity in the work place and need to be taken into account during the designing and any probable refurbishment stage.

Finally, concerning the thermal sensation, despite the traditional models of thermal comfort set by P.O. Fanger or Zhang, where a variety of individual characteristics (clothing, activity) and indoor conditions (radiative temperature, air temperature, humidity levels) are evaluated [7,8], an alternative approach is presented in this study. In this approach, individual perception along with building characteristics are collected through a revealed preference survey and are evaluated, achieving an interpretation of the human sensations based on the perceived indoor conditions and the occupants' needs and attitudes.

2. Buildings' Description

The two under evaluation buildings, are typical examples of office buildings located in northern Greece. The one is located in Elassona while the other one in Thessaloniki. Greece based on her climate and national legislation, is divided into 4 climate regions, both under evaluation buildings, belong to the 3rd cooler zone presenting both warm and cold seasons during the year. Also, both buildings are located in the urban landscape, however in case of Elassona, the microclimate conditions differ as she is a provincial city with sparse buildings, whereas in the case of Thessaloniki, the under evaluation building is located in the densely built urban centre but with its main façade in atrium. In order to evaluate the indoor environment conditions, a description of the buildings' structural elements and HVAC systems is essential.

2.1. Office Building in Elassona

As aforementioned, the one under evaluation building is located in Elassona (Figure 1a). It is a two-storied building with a basement, a ground-floor, a mezzanine and a first floor. The entire building is occupied by offices, except for the ground floor and the mezzanine in the south-west region, which is occupied by stores. Its construction was carried out between 1965 and 1967 and therefore was prior to the introduction of the Greek Thermal Insulation Regulation that took place in 1979. Its successor is the Regulation on the Energy Performance of Buildings, known as KENAK, which was adopted in 2010. Then, in 2013 the Greek Law 4122/2013 was published, introducing the definition of the net zero energy buildings for both commercial and private buildings [2,9,10].

Concerning the current state of the building, the two main areas of interest are (a) the building's envelope and (b) the HVAC systems. For the building's envelope, it should be outlined that its main orientation is south-west, with a variety of openings both in north-west and north-east facades and only a few in the south-east. Moreover, the building has been refurbished in 2000 and the old, single glazed windows were replaced with double glazed, aluminum framed ones. Also, no external sun-protection systems exist, there are however internal blinds. The