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Investigating the Opportunities to Improve the Thermal Performance of a Case Study Building in London

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ABSTRACT

This study was carried out to investigate the opportunities of improving thermal performance by focusing on envelope effects of a building located in London. Firstly, through a broad literature review of the previous conducted case studies, an investigation of all the building envelope aspects and parameters influencing the thermal performance of the building was conducted to provide critical information of thermal performance of the envelope components within the UK buildings. Then, onsite measurements were carried out to obtain the building's base case heating load using the standard CIBSE GUIDE A 2017 heat load calculation methodology. Neglecting thermal bridging in the heating calculation showed 8% reduction in the building's total heating load. Also, 17% reduction in energy consumption and CO2 emissions was achieved by applying polyurethane-foam and polystyrene-boards as cavity and external wall insulations, respectively. Moreover, the effect of applying both insulation in the energy consumption, CO2 emissions, cost and payback period analysis was analysed.

KEYWORDS

CO2 Emission, Energy Consumption, Heat Transfer, Sustainability, Sustainable Energy, Thermal Comfort, Thermal Insulation, Thermal Load

INTRODUCTION

In this paper the assessment of opportunities to improve envelope performance and to provide thermal comfort for a case study building located in London, would be carried out using manual calculation method provided by CIBSE GUIDE A 2017. The building comprises 25 (1-bedroom) studio flats built in 1970.

The doctrine of environmental sustainability assessments is based on reducing the energy consumption and carbon dioxide emissions; reducing the growth of environmental emissions (Farsi, et al., 2017; Hosseinian_far, et al., 2010). One of the most disturbing problems with which all the countries around the world are struggling is the global warming which is a consequence of climate change and the CO_2 emitted mostly by human activities and purposes. Almost all the emitted CO_2 in the environment comes from the energy consumption by the industries, transportation and housings.

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In order to decrease the greenhouse gas and CO_2 emissions, the UK government has decided to reduce 60% of the carbon dioxide emissions by 2050 as of the levels in year 1990 (Hosseinian-Far, et al., 2017).

However, there are still some unclear points left about the different divisions' involvement and the financial instruments of reducing CO_2 emissions from the atmosphere after 2020. The building sector has had a considerable contribution in 0.7% of the total energy consumption reduction from 142,174 (ktoe) to 141,175 (ktoe) in the UK in 2017 (ECUK, 2018). Moreover, since 1970, the domestic sector has followed the transportation division in terms of the consumed energy by 28%. In this paper, the main focus will be on optimizing thermal comfort and the energy consumption of the case study building by taking the envelope influence into consideration. Compared with the other countries around the world, the UK has almost the oldest building stock. Due to an absence of building standards in the past, nowadays housing sector is one of the most insufficient energy consumer divisions. This problem means almost 45% of the total CO_2 emissions within the UK is resulted from the buildings (Hosseinian-Far, et al., 2017; Daneshkhah, et al., 2017; Government, 2018; HM Government, 2010). A huge amount of studies have been carried out during the last decades, especially after applying building regulation since 1970, to investigate the amount of energy consumed in the buildings. The envelope assessment has been considered as a valuable tool to save energy in buildings. This paper investigates the effects of the envelope in the energy consumption of a case study building by taking two important factors of thermal transmittance (U-Value) and admittance (Y-Value or thermal bridging) into account through load calculations validated by CIBSE guides. Housing sector in the UK have a high potential for application of energy efficiency improvements. The energy consumption of the UK housing in 1997 has been reduced by 4569 (ktoe) and reached 40,116 (ktoe) in 2017 (ECUK, 2018). The high potential of the energy saving in the building sector has been shown by previous studies. Although, there has been a significant improvement implemented by the UK government, still the domestic sector has a potential of 32% of carbon emission reduction among the other divisions regarding 5th carbon budget (Rosenow, et al., 2018).

The UK housing have 3 major divisions: flat or bungalow, detached and semi-detached or terraced house (Palmer & Cooper, 2011). In order to meet the 80% CO_2 emission reduction and energy consumption target, the UK government has produced a Standard Assessment Procedure for Energy Rating of Dwellings (SAP, 2012) to classify the new and existing buildings and provide regulatory measurement for designing and retrofitting purposes.

"The state of mind which expresses satisfaction with the thermal environment is defined as the thermal comfort". This condition varies in terms of the climate, occupants clothing, activity level of people inside the building, nature of the body and type of the building (Tasssou & Jouhara, 2017).

The factors affecting the thermal comfort are divided into two main categories: environmental factors and personal factors. The environmental factors include, the sun light, air temperature, mean radiant temperature, relative air speed and humidity. However, metabolic heat production and the type of occupants' clothing form the personal factors influencing the thermal comfort (CIBSE GUIDE A, 2017).

In a study, (Myhren & Holmberg, 2008) defined the thermal comfort as a range of air temperature around 37 °C associating skin temperature between 32-32 °C which the human body performance is in the best position. Moreover, the thermal comfort can be described as the anticipation of a suitable condition inside the buildings for the occupants which relates directly to the time and place (Chappells & Shove, 2005). In a study (Derks, et al., 2018), analysed nurses' perception of the thermal comfort within the hospital ward. The results showed that by taking seasonal and oriental conditions into account, the easiest way to provide better thermal condition is to design different zones in the hospital wards as the perception of thermal comfort of staffs differs from the patients considerably. In addition, in a further study (Luo, et al., 2018) assessed the indoor thermal comfort of four college-aged subject groups in different locations where lived only in northern, migrated from south to the north, lived only in south and had moved from north to the south in China. The results illustrated that

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