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Selecting design strategies using multi-criteria decision making to improve the sustainability of buildings

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ABSTRACT

The building sector is one of the largest consumers of natural resources and energy in the world. Design strategies to improve the energy efficiency can decrease the negative impacts of a building. In order to evaluate and select the most appropriate design strategies for buildings, they should be analysed through a multidisciplinary approach based on sustainable development. The objective of this study is to propose a method that combines adaptive thermal comfort, climate change, life cycle assessment, life cycle cost analysis and multi-criteria decision making to help selecting the best design strategies to improve the sustainability of buildings. The method presented herein is based on a system of indicators that allows a comprehensive evaluation of design strategies. A multi-family social building, located in Milan, northern Italy, was used as a case study considering a 100-year lifespan. Six design strategies were evaluated. The EnergyPlus computer programme was used to estimate the annual energy demand for air-conditioning alone, with and without the design strategies. Three different databases were used to perform the life cycle analysis. For the life cycle cost analysis, the cost of each strategy was estimated based on the pricelist of the Milan Chamber of Commerce (*Camera di Commercio di Milano*). The results show that there will be an average increase of 53% in the cooling energy demand and a decrease of 49% in the heating energy demand in 2080 compared to the consumption in 2017. The design strategy with the highest level of sustainability was a reinforced concrete frame with rectified bricks, followed by a reinforced concrete frame with cellular concrete blocks and by cross-laminated timber (X-Lam) and wood fibre. This research highlighted the need for the use of a multi-criteria method to ensure the right selection of design strategies to obtain more sustainable buildings.

Keywords: Energy Efficiency; Life Cycle Assessment; Life Cycle Cost Analysis; Multi-Criteria Decision Making; Thermal Comfort; Sustainable Buildings.

1. Introduction

The building construction sector is considered one of the largest consumers of natural resources and energy. Buildings consume 30–40% of all primary energy and natural resources over their lifespan (construction, operation, maintenance and demolition) and account for 30% of the global emission of greenhouse gases [1,2]. An appropriate choice of design strategy reduces the energy demand of buildings [3-5] and improves the indoor comfort conditions for the inhabitants [6-7]. Assaf and Nour [8] stated that through the correct use of energy efficiency strategies the energy demand can be reduced in 38% in new residential and commercial buildings. Perez et al. [6] studied

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