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BIM Enabled Approach for Performance-Based Design:
Process, Renewable Technology, Design Rules and Assessment

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ABSTRACT

A significant amount of energy is consumed by buildings due to ineffective design decisions with little consideration for energy efficiency. Yet, performance parameters should be considered during the early design phase, which is vital for improved energy performance and lower CO_2 emissions. BIM, as a new way of working methodology, can help for performance-based design. However, it is still infancy in architectural practice about how BIM can be used to develop energy efficient design. Thus, the aim is to propose a strategic framework to guide architects about how to do performance-based design considering the local values and energy performance parameters. The research adopts a multi case study approach to gain qualitative and quantitative insights into the building energy performance considering the building design parameters. The outcome is a new design approach and protocol to assist designers to successfully use BIM for design optimization, PV technology use in design, rules-based design and performance assessment scheme reflecting local values.

KEYWORDS

BIM-Based Design Approach, Building Information Modelling, Building Performance, Design Optimisation for Energy Efficiency, Energy Analysis

1. INTRODUCTION

Buildings' energy consumption has significantly increased recently. This is due to the growth of population, increased time spent indoors, more request for indoor environmental quality and for building functions, and finally global climate change (Cao et al., 2016). Energy efficient building is seen as a solution to energy scarcity and CO_2 emissions. However, it is still not adopted totally in building design as a strategy, e.g. in Turkey. This necessitates the consideration of building design criteria as they strive towards protecting nature at the highest possible level and providing the most suitable environment for people within building (Gür, 2007).

The energy consumed by buildings in Turkey is 175 KWh/m^2. While in European countries, the amount of energy used is around 100 KWh/m^2 (Kazanasmaz et al., 2014). This is greatly due to the inefficient building design with hardly any consideration of the environmental impact and energy assessment (Mangan and Oral, 2016). It is necessary to ensure efficient energy use in Turkey because buildings are responsible for around half of the total energy consumption (Eskin & Türkmen, 2008).

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Design parameters should be studied, taking into consideration the environment that is a vital for developing a well-suited and energy efficient building design.

There are several design factors that can influence the building energy performance and can be managed properly for better energy efficiency. Enhancing the thermal performance of the envelope materials will lead to the less building energy consumption. The envelope materials work as a promising solution for both less energy consumption and better indoor environment (Han & Taylor, 2016). They can be enhanced by decreasing the thermal transmittances (U-value) combined with the passive energy actions (Cao et al., 2016). Appropriate shading design and selections are important to achieve energy efficiency and comfortable indoor environments. Proper design of overhangs shading systems will play a great role in reducing the unnecessary solar gains in buildings (Ali and Ahmed, 2012).

As cited by Cho et al. (2012), building location plays an important role in designing energy efficient buildings and it is usually considered in the design of new buildings. The building shape can also lead to energy efficiency. For instance, compact building shape will have minimum heat losses through its envelope materials and decreased exposure of weather conditions than complex building shape. This is due to the decreased surface area exposure (Bauer et al., 2009).

The ability that a building must naturally heat or light its internal spaces may significantly influence energy efficiency and reduces energy use. This is often measured by building orientation (Abanda and Byers, 2016). The application of renewable energy will not only lead to further modernization of the energy sector, but also achieve national economic and sustainable development goals (Inglesi-Lotz, 2013). Renewable energy can ensure the sustainability of electricity supply while reducing carbon dioxide emissions (Sulaiman et al., 2013).

Presently, the design and construction practices do not allow the timely and active application of energy efficient methods and technologies on buildings. (Cho et al., 2012, Arayici et al 2018). In this regard, building performance simulation enables designers to investigate various design alternatives and choose the most energy efficient alternatives (Aksamija, 2013). The use of BIM in building energy simulations has deeply enhanced the process of building energy analysis allowing for better decision making and appropriate prediction of building performance.

Bahar et al. (2013) mentioned that, presently there is a high request for high-performance buildings. That is why, BIM based energy analysis is greatly required because BIM can allow the use of reliable and well-organized information about building and it enables improved forecasting and decision making about the building performance. The main question of this study is: What is the approach for performance-based design and optimization through the use of BIM?

The next section accumulates the literature findings to scope for a performance-based design approach.

2. SCOPING FOR A DESIGN APPROACH

Achieving sustainable and efficient building design performance, critical design decisions should be made by the stakeholders at the design stage of a building. Building Information Modelling (BIM) can be used for energy and performance simulations, where the analysis process can be integrated with the design process. However, the main issue in implementing performance-based design is how to successfully combine various technologies that exist in various domains and deliver complete performance analysis of the building in a collaborative manner during the design process. The absence of integration in the design process leads to an incompetent design process (Cho et al., 2012). This is due to fact that BIM paradigm greatly requires collaboration between various stakeholders (Jeong and Kim, 2016; Arayici et al., 2018).

BIM design and energy analysis software are currently different and necessitate exchanging of data and information (Aksamija, 2013). Methods for information exchanges between BIM and energy analysis software are mainly dependent on the purpose of the analysis and what type of information is needed.