Automation in Construction 70 (2016) 26–37

Contents lists available at ScienceDirect

Automation in Construction

journal homepage: www.elsevier.com/locate/autcon

Green building assessment tool (GBAT) for integrated BIM-based design decisions

Bahriye Ilhan *, Hakan Yaman

Istanbul Technical University, Istanbul, Turkey

ARTICLE INFO

Article history:
Received 6 February 2015
Received in revised form 12 February 2016
Accepted 1 May 2016
Available online 2 June 2016

Keywords:
BIM
BREEAM
Green building assessment
IFC
Integration
Sustainability

ABSTRACT

The benefits of BIM such as effective decision making, improved analysis, easier access to information and simpler green building certification provide an optimised solution for sustainable design and construction. This study proposes an IFC-based framework within an integrated BIM and sustainable data model for the design stage of the building project life cycle. We present the green building assessment tool (GBAT), which implements the proposed model and aids the design team in the generation of documentation necessary for obtaining green building certification. It extracts the necessary data from BIM models for calculating the green rating and provides feedback for further evaluation. A sample project is run and a green rating score table for the BREEAM materials category is obtained for validation of the model. This tool serves as a proof of concept that green data relevant for BREEAM certification can be automatically processed and used to inform the design.

© 2016 Elsevier B.V. All rights reserved.

1. Introduction

The necessity of integrated data approach has resulted in the "building modelling" concept, which is the development of a single model of the architectural project incorporating the 2D, 3D and material property information for both schematic and detailed design [12]. Building information modeling (BIM) facilitates integration, interoperability and collaboration in the construction industry [39], by providing a three-dimensional (3D) representation of a project including all the parameters of its components. BIM has become the centre of the building project life cycle for the requirements of performance analysis, planning, programming, cost and time data organisation, and the provision of construction documents, in addition to design and visualisation. Resource scarcity, sustainability challenges and stricter decrees for recycling and resource efficiency in buildings motivate the architecture, engineering and construction (AEC), facility management (FM) and deconstruction communities to manage resources more efficiently [41]. Policies, laws and regulations around the world now require the sector to adopt sustainable innovation in terms of products and processes to encourage more sustainable outcomes [17,20,36]. BIM is ideally suited to the delivery of information enabling improved design and building performance. Two major beneficial features of BIM in relation to sustainable building design are those of integrated project delivery (IPD) and design optimization [4,42]. Traditional CAD-based design requires a great deal of human intervention and the whole process is time consuming and costly. However, with BIM, designers can optimise the building design efficiently in the very early stages of the whole process and produce a better solution. Since the construction industry has become more interested in environmentally friendly buildings that can provide both high performance and monetary savings [24], the development of more sophisticated and robust platforms is now necessary to maintain the level of achievement reached so far. Accordingly, BIM must increase its capacity to integrate environmental analysis and improve interoperability. The advancement of technology will assist both the goal of sustainability and BIM itself in establishing standards of excellence in the future. Nevertheless, and most importantly, the AEC industry and owners must be willing to incorporate these tools as standard practice. Additionally, parties must be willing to cooperate with one another so that an optimal collaborative effort is provided for sustainable building projects [11]. Lack of interoperability of sustainable data has the effect of limiting the application of BIM in building design and needs to be addressed earlier in the planning stage. Throughout the ongoing development in this area, the overall practical effectiveness of BIM still needs to be analyzed and validated [16,29,32].

1.1. Problem statement

Since most sustainable decisions are made during the design stage, integrating the sustainable data into this process via BIM is critically important to solving decision-making dilemmas. The challenge then, as Brahme et al. [8] point out, is to find a way of using detailed tools even during the early stages of design when values for many of the variables for the building's technical sub-systems are not yet available, and

* Corresponding author. Tel.: +90 212 293 1300 2238; fax: +90 212 251 4895.
E-mail address: ilhanba@itu.edu.tr (B. Ilhan).

http://dx.doi.org/10.1016/j.autcon.2016.05.001
0926-5805/© 2016 Elsevier B.V. All rights reserved.

to provide the designer with quantitative predictions of the building's future performance [6]. Currently BIM software is still a long way from being fully integrated with the various databases required for sustainable building projects. In some cases, a team may need to import information to the BIM model from an outside source, such as a database of weather data or material properties. Better and more seamless integration between BIM and sustainable design will come with time as the industry continues to standardise file formats, as data sets are developed, and as owners, clients and designers begin to demand more from application developers [27]. The integration therefore requires considerable effort and time such that the evaluation of sustainable data ends up being performed after the design stage in most cases. This is a common and well-understood problem by many involved in sustainable projects.

Clearly, construction professionals would benefit from an integrated tool that helps optimise the process of material, equipment and systems selection at every stage of the construction project life cycle [7]. Material selection and use, site selection and management and systems analysis are the main areas of sustainable design with a direct relationship to BIM [19]. This paper presents a framework for such an integrated BIM platform, which would also facilitate the generation of documentation required for green building certification. The framework bridges the gap between the green building assessment processes and BIM, simplifying design stage decision making regarding sustainability.

1.2. Aim and objectives

The purpose of this study is to address the problem of BIM and sustainability integration through the development of an automated tool, which can process BIM models, generate a draft green building assessment and highlight potential sustainable design improvements for the user. To this end, the following points are addressed:

1- Extension of the data contained in the BIM model within the BIM software to enable a building assessment (e.g., storing in the BIM model extra material properties, whether materials are reused or responsibly sourced) and ensuring the data are encoded into the saved BIM model file
2- Creation of a database of materials with the necessary green properties and interfacing it with BIM software to reduce the user effort required to produce a suitable BIM model containing the extra green data
3- Processing the BIM model file to extract data relevant for the green building assessment (e.g., selected materials and their surface area)
4- Calculation of the green score from the extracted data and presentation of the results in a clear and intuitive manner to the user, highlighting potential areas for improvement.

The proposed model aims to provide guidelines for the design of a project's sustainable features at the design stage when they are most needed. It will allow timely decision making by offering an evaluation of the alternatives for sustainability performance and enable the utilisation of pertinent data stored in the BIM model for green building certification.

1.3. Methodology

Due to its flexibility in exchanging data between different types of software used in the AEC industry [14,28,46], an IFC-based framework is intended for the proposed model. The framework builds a relationship between the BIM and the green building rating processes. The main objective is to designate green properties to the BIM objects using the IFC model schema, which is an open, international and standardised specification for BIM data exchanged and shared among software applications used by the various participants in a building, construction or facilities management project. To create BIM designs with sustainable information, the property sets and green materials library should be embedded within the software. The user, then, can determine the necessary data for certification and evaluate the decisions. For an effective response to the aim and objectives, a two-step methodology is adopted in this study: (1) model development process and (2) user process (Fig. 1).

The model development process involves the following sub-processes:

- Developing the property sets in the IFC standard: The major green building assessment systems are first investigated and the list of possible categories for IFC schema is created according to the analysis. Following this, the property sets are developed.
- Producing the green materials database (GMDB) and the green materials library (GML). The GMDB consists of an Excel xls file and the GML is contained in an ArchiCAD® template file.

The tool addresses the Materials category of the BREEAM Europe Commercial 2009; in principle, it could be extended in the future to cover the remaining 9 categories. The materials database is produced manually for 68 out of the approximately 1500 materials in the Green Guide to Specification but could be produced automatically from the BREEAM materials database if a suitable application program interface existed. The GML is produced by manually entering the 68 selected materials into ArchiCAD® and translating the human readable textual description into a computer readable form (specifically the "Element Definition" field of the Green Guide to Specification is translated into ArchiCAD®'s building element and material property).

The user process is the validation of the developed framework via a case study and includes two main sub-processes:

- Generating BIM model: Sustainable BIM model is generated based on the template file and exported to IFC format.
- Calculating the data for green documentation: The green building assessment tool (GBAT) extracts the related data, makes the calculations according to the green ratings and presents the available credits as the output. The tool was developed in Visual Studio 2013 integrated development environment (IDE) using C# programming language due to its being a modern and very high level programming language.

2. Related work

Green BIM, as an emerging trend, has been increasingly discussed for more sustainable outcomes. BIM is examined from the general sustainability aspect in various studies.

Initial studies focus on the state of the art of BIM for sustainable design and construction. An online survey designed by McGraw-Hill Construction for 2010 Green BIM Study [31] was conducted with a range of industry professionals who use BIM tools to assess the level and scope of BIM tools to help achieve sustainability and/or building performance objectives. The results of the study show that BIM is considered an essential tool for green construction and is expected to be in extensive use in the near future. Greater use of integrated design is highlighted in this study as one of the key areas of potential growth for Green BIM. Azhar [3] conducted a questionnaire survey to evaluate the state and benefits of BIM-based sustainability in design and construction firms who use BIM technology and/or sustainable design/construction practices in most of their projects.

On the other hand, Ilhan and Yaman [21] focused on the current state of BIM in sustainability by performing interviews with the Turkish architectural firms that participated in certificated sustainable projects in order to find out the key indicators for better BIM and sustainability integration solutions. The results show that BIM is not used thoroughly for sustainable projects, including all building production processes, due to lack of qualified staff and allocated budget. Moreover, the difficulty of developing sustainable material and an IFC database, along with the

Download English Version:

https://daneshyari.com/en/article/6696181

Download Persian Version:

https://daneshyari.com/article/6696181

Daneshyari.com