BUILDING INFORMATION MODELLING, A TOOL FOR GREEN BUILT ENVIRONMENT

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ABSTRACT

To create any green built environment, it is of primary importance that project stakeholders including designer, energy modeller, estimator, climatologist, environmentalist, etc. contribute and become accountable towards the same. Building information modelling (BIM) is one such tool which not only stands as a 3D geometric modelling tool, but also supplies useful information, data about several aspects throughout the life-cycle of a project such as construction process, design and development of a facility, quantities and scheduling, fabrication process, and provides information required for facilities managers, stakeholders. Hence BIM based approach could also be extended for designing and developing green built environment. This piece of research explores role of building information modelling methodology in the development of green built environment. A BIM based approach assists professionals during the conception of green built environment in predicting the outcome(s) of its construction to minimise its impact on the environment throughout its life-cycle. A building model developed on the principles of BIM virtual representation of building can be presented to person/expert from non-construction/architectural background. It can provide appropriate data on demand to perform energy analysis and hence facilitates very complex and so call tedious process of sustainable design, such as day-lighting, morphological analysis, computational fluidic dynamics (CFD), material takeoff, estimation, scheduling, energy modelling, resource planning, and so on.

Keywords: BIM standards, building models, energy analysis, stakeholders, sustainable.

INTRODUCTION

In an era of constantly growing construction sector with parallel frequent technological up-gradation to support it, there is a need to promote and facilitate the green built development. Green building signifies a design that emphasizes on the optimization of the use of natural resources for building construction in-order to save environment. The green building impacts are remarkable in the environmental, economic as well as the social realm. Its attributes can be broadly mentioned as eco-friendly design, reducing the use of natural resources thus fulfilling sustainability. Primarily but not limited to, green building design considerations are maximization of daylight for indoor spaces, natural ventilation, energy consumption control and reducing pollution. Green building design concept is the core approach to the green built environment. This piece of research presents information about BIM gathered from extensive review of literature relating to BIM, green building design, sustainable construction, etc. The key focus of this research is to accelerate the adoption of BIM by construction industry considering the fact that sustainability is part of the key agenda by several governmental as well as non-governmental organisations across the world.

BUILDING INFORMATION MODELLING (BIM)

The need for tools to prepare conceptual and final designs along with a centralised file system to save information and reduce overall time related to construction project was noted by Bailey et al. (2008) and continuous development of object oriented CAD resulted in BIM, filled the above gap. The purpose of BIM is to support and explore design concepts and building forms from the earliest possible design stages of the project and, to maintain a project vision through construction documentation.

According to the National Institute of Building Sciences (NIBS), BIM is "*a digital representations of physical and functional characteristics of a facility*" (American Institute of Architects, 2008, p. 536). Succar (2009) defined BIM as "*a methodology to manage the essential building design and project data in digital format throughout the building life-cycle*". Hill (2007) noted that BIM had emerged as a critical catalyst for interoperability and often, used for 3D visualisation and clash detection. Revit was developed on the principles of BIM as "*a complete, discipline-specific building design and documentation systems platform supporting all phases of design and construction documentation*" (Revit, 2007). It is reported as a critical cornerstone for the exchange, management and integration of project information across diverse platforms (Han, 2005).

BIM benefits and limitations

The interoperable nature of a building model helps to increase collaboration amongst stakeholders and provides information required by a facility manager throughout the life-cycle of the facility. Bailey *et al.* (2008) described BIM not only as a 3D geometric modelling tool, but also it supply construction related information into the process of design and development of a facility, with the advantages such as; automated quantities and scheduling on time, provides information required for planning construction process, automating the fabrication process, and provides information required for facilities managers. Hence BIM based approach are often referred as 4D, 5D, so on. Table 1.1 presents the benefits and limitations of BIM, as revealed from the extensive literature review focusing on BIM.

Table 1.1. BIM benefits and limitation

BIM benefits	BIM limitations
Gives comprehensive coherent understanding of a project as a whole, while controlling each individual departmental area	Difficult to share complete model because of quantity of available construction related information
Enhanced visualisation and data management	Need increasingly sophisticated data management at the building objects level
Model can be used for simulation and visualisation at any stage	Rarely single technology is used across the project by consultants, design team

Data is stored centrally and automatically updated	Sometime BIM does not provide the flexibility needed by the engineers
Better co-ordination as all the data is available in one file	Design file size and complexity of data management in BIM is tedious
Good as-built model can support a maintenance and renovation at any stage	Hard to predict the future of the construction sector thus future of the BIM
Increased collaboration, audit ability and maintainability	BIM being new technology, there are limited legal and contractual framework in regards to BIM liability

(Source: Azhar et al., 2009, Higgs and Stokes, 2008, Hoover and Schubert, 2007, Sheth et al., 2010, Sheth 2011)

Development of BIM

Azhar *et al.* (2009) reported that to perform any kind of building performance analysis in the early design stage, a comprehensive set of building knowledge related to a form, materials, context and technical systems is required.

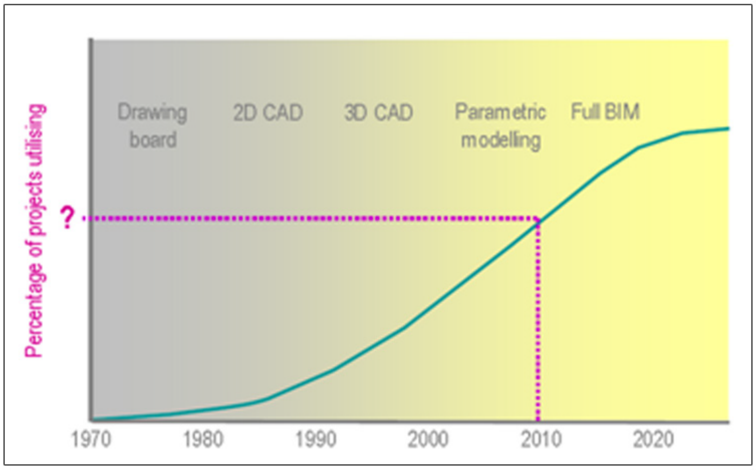

Figure 1.1. Development of BIM from drawing board

Exchange of project-related, trustworthy building information is important for integration and collaboration purposes as part of a building designing and development process (Van, 2009).

Dix (2009) presented the development of BIM from drawing board (see Figure 1.1) in the construction industry in chronological order and predicted that by 2020 BIM will be fully developed, however, it is difficult to estimate the percentage of BIM utilisation and its adoption in the industry.

Applications of BIM

Review of literature related to BIM in construction industry highlighted various possible applications of the same with consideration to stakeholders with varied requirement. Cyon (2003) reported that BIM offers a level of management control, typically ignored by the conventional construction processes, such as handmade drawings, CAD. BIM helps to apply additional knowledge such as information related to occupancy, operational hours to the building process and a 3D model, whereas a study by Azhar *et al.* (2009) concluded that BIM facilitates very complex process of sustainable design, such as day-lighting, solar access, material takeoff, estimation, scheduling and energy modelling.

BIM based software tools can support sustainable design and export building information and data related to materials, room volumes, furthermore, into green building extensible markup language (gbXML) and Industry Foundation Classes (IFC). To perform energy analysis using Green Building Studio (GBS) and to study building performance employing Ecotect Analysis software by Autodesk developed on the principles of BIM is less time-consuming process. Whereas, using 3D Studio Max helps to evaluate indoor lighting analysis in support of green building accreditation, such as LEED, BREEAM.

BIM assists professionals (such as architects, designers, consultants) in predicting the outcome(s) of a building before construction to minimise its impact on the environment throughout its life-cycle. A model developed on the principles of BIM is data rich, object-oriented, intelligent and parametric digital representation of the facility and can provide appropriate data on demand to several users for various analysis purposes (Azhar *et al.*, 2009). Also, it links virtual building model, project life-cycle information, and physical and functional characteristics of a project. These characteristics make BIM a highly interesting option for complex building projects, thus suitable for design and development of green built environment.

‘*Sustainability Analysis*’ using BIM

Previous studies on communication between designers (architects) and simulation experts, (for example, Sanguinetti *et al.* (2009), Dunsdon *et al.* (2006), Ellis and Mathews (2001), Morel and Faist (1993)) often referred to the need to integrate design data with virtual models to predict performance of a facility, or the presentation of simulation results to evaluate the design process.

A conceptual framework for BIM-based ‘*Sustainability Analysis*' developed by Azhar *et al.* (2009) for construction companies is presented in Figure 1.3. The left hand column indicates the project phases, the middle column depicts the various sustainability analysis features, and the right hand indicates the interaction of external entities such as customers or project partners.

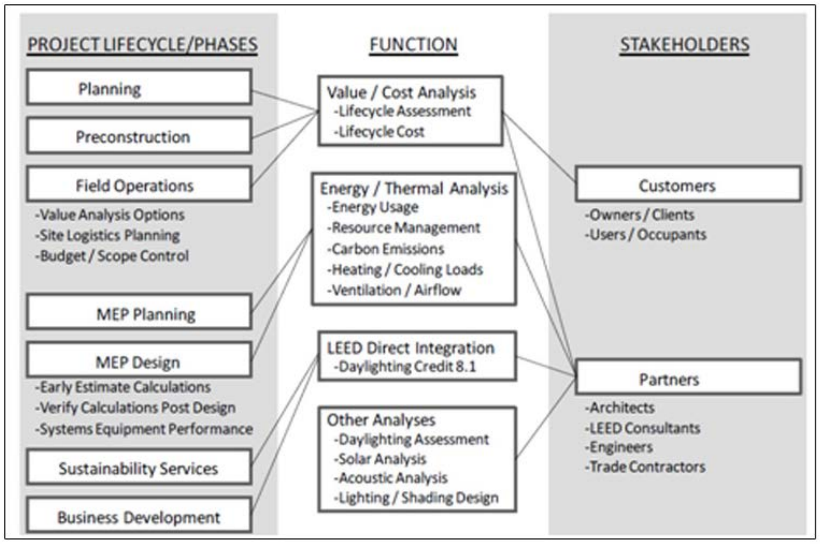

Figure 1.3. Conceptual framework for BIM-based sustainability analysis

The above framework was proposed to facilitate design process and to provide integrated energy analysis in the process. It is interesting because, it is one of the ongoing studies relevant to BIM in relation to sustainability analysis. This indicates that BIM can facilitate tedious process of sustainable design. This study explores the capability of BIM in performing various tasks, such as solar studies, material takeoffs, and cost estimation.

Sanguinetti *et al.* (2009) tested an automated energy analysis framework (see Figure 1.4) on two courthouses at the preliminary concept design stage and presented to General Services Administration (GSA) in the USA. The aim was to explore issues involved with a '*BIM-driven concept design process*' that integrates building simulation to evaluate design.

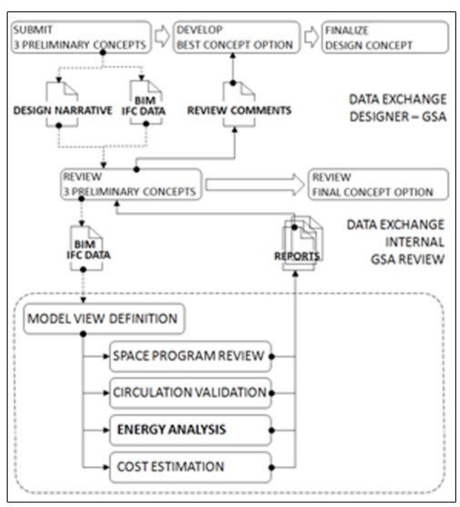

Figure 1.4. Automated assessment for USA courthouses

The study was conducted in two phases, first, to map BIM for building simulation modelling (BSM) and second, to analyse impact of design options on energy performance.

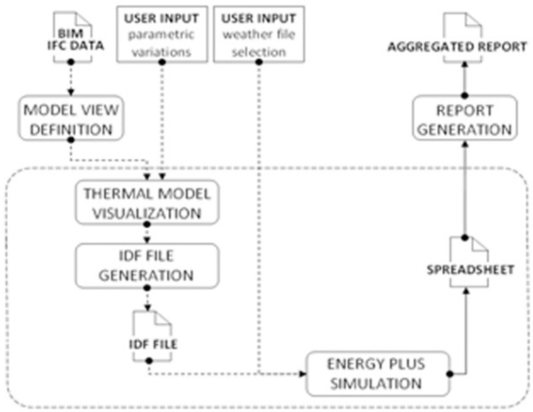

Figure 1.5. Automated energy analysis

The authors concluded that to support design evaluations and decision making during the concept design stage, BIM provides explicit information with the help of early integration of energy simulation by assessing conceptual design. The model developed by Sanguinetti *et al.* (2009) as an energy evaluation module is presented in Figure 1.5.

Succar (2009) proposed three '*BIM fields*' and several participants (actors) associated with those fields (see Figure 1.6).

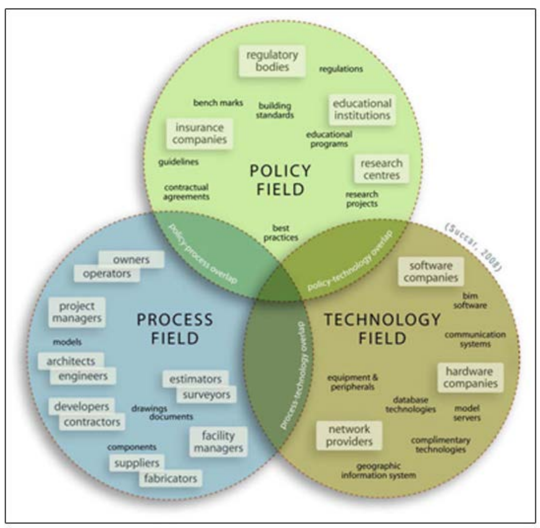

Figure 1.6. Three interlocking fields of BIM activity

As part of the study, the integration of BIM is divided into the following three key steps.

Technology step: migration from drafting based to object-based workflow.

Process step: model based collaboration.

Policy Steps: involves integrated practices.

A linear view of BIM is presented in Figure 1.7; it shows life-cycle from pre-BIM to Integrated Project Delivery (IPD).

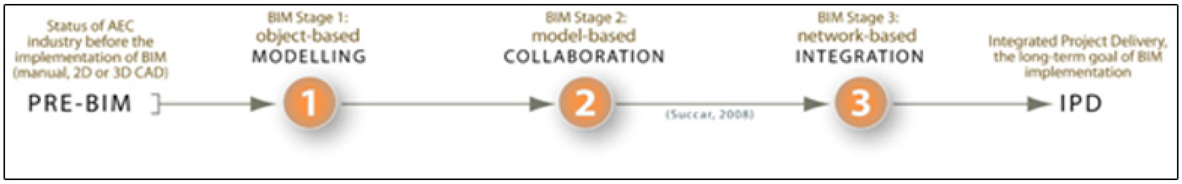

Figure 1.7 Three stages of BIM maturity - linear view

Success

A BIM can optimise overall construction time by highlighting bottlenecks and site constraints during construction work. In the USA, since 2007, it is mandatory to use BIM within design process on any project funded by the GSA (Revit, 2007). Bailey *et al. (2008)* reported that integration of BIM within the process may not reduce design and documentation time, but can minimise the effort, time, and money required during the various construction phases. Moreover, good BIM improves participants' efficiency and effective collaboration, thus speeding-up the entire process (Van, 2009) and produces operative information (the information relevant to and which allows sustainable design decisions to be made).

Huang *et al.* (2008) reported that 28 per cent of design firms in the USA are using BIM and projected that the number will increase by 200 per cent in the near future. A study by Hill (2007) in regards to implementation of BIM in New York revealed that 80 per cent are using BIM for 3D rendering and half of engineers use it for interference detection. Also, around 50 per cent of experts use BIM for parametric manipulation of designs; and 46 per cent use for structural analysis. Importantly, many organisations working in the development of green built environment have reported several benefits due to adoption of BIM on projects as explained earlier and further.

Barista (2007) shows how Revit, a BIM based tool, was used for several green built environment related to healthcare projects and reported benefits such as simulating process, reduced project cost, shortened schedules, better project quality, improved material distribution, better patient and staff flow and co-ordination between mechanical, electrical and plumbing (MEP) activities. The use of BIM helped off site co-ordination to resolved problems before construction and reported a 20 per cent reduction in MEP and labour cost because of fewer revisions and errors.

Cooper (2008) found BIM can address the hospital's changing infrastructure needs with consideration to human issues. Barista (2007) stated, *"BIM is a perfect fit for healthcare because of the complex nature of these buildings, the repetitiveness of the activity within the building, and the need to really nail the process"*.

The benefits cited above for BIM on green built environment are also confirmed by various experts such as Bovey, (2008), Cooper (2008), Manning and Messner (2008), Oberlin (2008), Howell and Batcheler (2004), Sheth (2011).

SUMMARY

In this part of research the importance and development with key consideration being green built environment of BIM are discussed. A need to identify tools, at the beginning of the project with sustainability as an agenda, to be implemented during the project to get an idea about data input needed throughout projects and to understand resources required throughout the process is highlighted. Also, it is required to get an idea about data output obtained throughout the project and to predict energy consumption throughout the life-cycle of the facility if sustainability has to be achieved truly.

If an assessment scheme requires some unique data not supplied by the modelling tool employed on the project, then during the project there will be a need to employ some additional tools resulting in price escalation, delay in project, quality of project, etc. thus partially it is anti-sustainability approach. Nevertheless, it is concluded that BIM is a necessary part in-order to design green built environment. On the basis of above discussed points clearly there is a link between BIM and designing green built environment. Also, it can be concluded that BIM is not just 3D modelling software, which is often considered, but it is a tool for easy data sharing, 3D modelling, scheduling, estimation of cost, etc. It is very important that further development and integration of BIM along with sustainability agenda is considered as top priority.

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