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Assessment Of Building Information Modelling (BIM) And Application For Energy Efficiency In Buildings

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***Abstract*—The damage caused by energy in buildings is on the increase due to energy-intensive solutions that were provided to create comfort for the building users in terms of providing heating, cooling, ventilation and lighting in the buildings, these cause severe depletion of precious environmental resources which it end-product is global warming. In view of this problem and its comparable, the concept of sustainability arose and today the United Nation (UN) is working to see that sustainability is achieved all across the world with the Sustainable Development Goals (SDGs). Nevertheless, the advancement in Architecture and technology came about with another concept of Building Information Modelling (BIM), which in relation to energy efficiency, helps in analyzing building designs before construction. This project report aimed at verifying how reliable these technologies and concept can be in examining energy consumptions and efficiency of buildings at the design stage. In conclusion this research inferred from the results and findings of the studies and concluded that BIM tools are reliable in energy analysis.**

Keywords—building information modelling, energy efficiency, cooling, heating, ventilation and lightning.

INTRODUCTION

Subsequent to the evolution of the concept of sustainability, the world has not been experiencing rapid movement towards attaining a sustainable environment until in 2015, as the United Nations (UN) adopted the Sustainable Development Goals (SDGs). This became a turning point for planet earth and the human race. Access to reliable, affordable, modern, and sustainable energy for all is one out of the seventeen goals of sustainable development, which this project report is expected to discuss more of it.

The development and growth of a country is proportionate to it needs for energy Abdelwahaba & Medromia, (2018). Recent studies show the need for sustainable building facilities with minimal environmental impact is increasing, as a result of high energy consumption. Azhar, & Ahmad, (2010).

Today, a lot of firms in the Architecture, Engineering, and Construction (AEC) industry have realized great changes in the operations of IT-based processes Gal & Jensen, (2008). Gradually the two-dimensional Computer Aided Design (CAD) software are being replaced by three-dimensional software and technologies. This software, known as Building Information Modelling (BIM), are the emerging IT based information systems that promotes analysis, teamwork, integrated design, assembly, and other building operations.

BIM provides more reliable information of the architecture project design, energy analysis, cost information, schedules, structural design, etc., than the traditional laboratory way of analysis and manual production of cost information and other schedules.

HISTORY OF BUILDING INFORMATION MODELLING (BIM)

The historical background of BIM began with the utilization of computer-aided design (CAD) in the 1950s and 1960s. In this time, Hanratty built up the first computer-aided machining (CAM) in the year 1957. Computer aided design is then created in 1963 by Ivan Sutherland by making a graphical interface named Sketchpad. Sketchpad was a program in which the user could graphically communicate with the program through a screen, a light pen used to draft, and a set of buttons that enabled the user to enter parameters and imperatives (CM Eastman et al., 2008).

The change from two dimension (2D) to three dimension (3D) was amid the 1970s by the French Aerospace Company who created CATIA. CATIA is one of the renowned programming in aviation, car and shipbuilding businesses. In the 1980s, 3D as presented by CATIA is as of now known and coming out on top.

Afterward, in the 1980s to 1990s, Autodesk turn into a prominent designer and driving in the information technology (IT) industry with their item AutoCAD. Nonetheless, at same time, Bentley, as Autodesk's rival, additionally presented new items. Before long, the advancement of different rivals in IT development expanded immensely. The different programming offers distinctive capacity and devices, in this manner, the progress from 2D to ND additionally changed and they could take care of different issues by utilizing the particular software.

From 3D display, the 4D model was acquainted with help partners, particularly in the AEC industry in overseeing schedules and resources with respect to time. Afterward, 5D was created to identify with cost estimating. This 5D model is profitable to cost estimators in checking the estimated cost of activities. The advancement of 6D is identified with sustainability and 7D more to facilities management. Nevertheless, the improvement of ND is subject to the capacities. According to Beveridge (2012), 8D was distinguished as coordinated project delivery and maintainability, 9D for acoustics, 10D for security, and 11D was for warmth. This demonstrates the progress of BIM began in the 1950s and proceeds to the present day.

STATEMENT OF PROBLEM

Analyzing energy efficiency is vital before design or construction of building because failure to do so presents some negative repercussions such as personal health problems, severe depletion of precious environmental resources which it end-product is global warming etc. and many developed countries use BIM to analyze energy consumption and as a result they noticed positive outcomes such as efficacy, building delivery, time, cost management etc. However, there are a lot of people that are yet to be convinced in

developing countries about using technologies like BIM rather they stick to the traditional way of analyzing building performance or in some cases they shy away from a lot of building performance analysis. In view of all these problems, this research project would investigate the efficacy of using BIM for analyzing energy consumption and efficiency prior to construction.

AIM AND OBJECTIVE OF THE RESEARCH

1. The aim of this research is to enlighten how effective BIM tools are in the analysis of energy consumption and efficiency in building structures.

POSSIBLE OBJECTIVES OF THE RESEARCH

i. To identify the benefits, challenges and drivers of employing building information modelling on performance analysis in building energy efficiency.

ii. To conduct a survey in order to establish the efficacy of using BIM on performance analysis in building energy efficiency.

iii To recommend on the usage of BIM on performance analysis in building energy efficiency.

SIGNIFICANCE OF THE STUDY

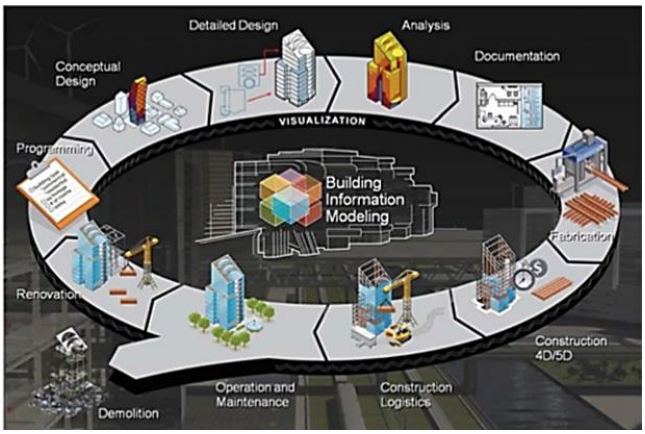
It will provide reasons why firms in the AEC should rely on BIM in the provision of energy analysis of their designs. It will benefit future researchers to understand the concept of BIM and how necessary it is to participate in achieving sustainable development. It will benefit the authorities in charge of providing a sustainable environment to encourage the AEC community in working towards sustainable developments. It will serve as a reference material for future researchers from fields of Architecture, Engineering, and Construction, Abdelwahaba & Medromia, (2018).

CONCEPTUAL FRAMEWORK

BIM can be seen as a virtual procedure that incorporates all perspectives, orders, and frameworks of a facility inside a solitary, virtual model, permitting all colleagues (clients, designers, engineers, contractors, subcontractors etc.) to team up more precisely and proficiently than customary procedures. BIM has a significant impact on increasing efficiency during the architectural design and construction phases of a project, Abdelwahaba & Medromia, (2018).

As the model is being made, colleagues are always refining and altering their segments as indicated by project specifications and strategic changes to guarantee the model is as precise as conceivable before the construction physically starts Carmona & Irwin, (2007). The establishments of BIM are laid on two columns, correspondence and cooperation. The successful usage of BIM requires early contribution of all project stakeholders. It implies that the customary project delivery frameworks (i.e. design-bid-build) have exceptionally constrained role in BIM-based projects.

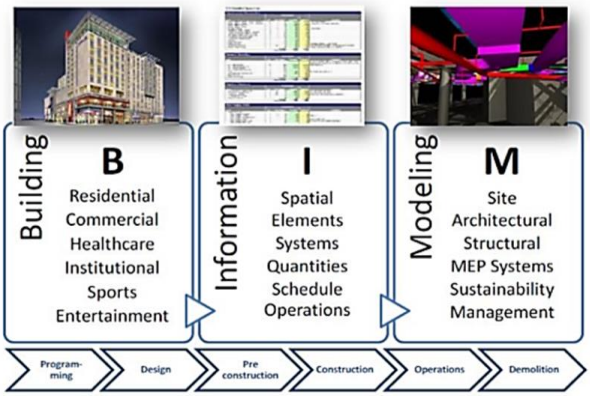
Figure 1.0 Conceptual Framework of Building Information Modelling.



Source: Ramesh, Kannan M, (2013).

From innovation viewpoint, building information modelling is a venture recreation comprising of the 3D models of the project segments with connections to all the required information associated with the project planning, design, development or activity as portrayed in Figure 1 Kymmell, (2007). The BIM innovation hailed from the object-oriented parametric modelling procedure, Azhar & Leung, (2008). The expression "parametric" depicts a procedure by which a component is altered and a neighboring component or assembly is naturally acclimated to keep up a formerly settled relationship, Stine, (2012).

Figure 1.1 Visual Representation of BIM Concept.

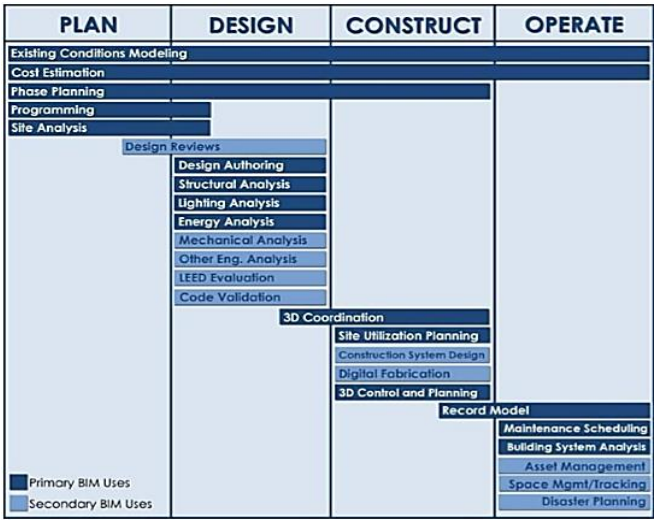


Source: Salman Azhar, Khalfan, & Maqsood, (2015).

USES OF BUILDING INFORMATION MODELLING

BIM is a significant rising trend in the architecture and construction industry because of its ability to help visualize the construction project throughout its entire lifetime. As indicated by Kreider & Messner (2013)

Showing BIM Uses



Source: Kreider & Messner (2013)

Building Information Modelling (BIM) and Building Energy Modelling (BEM)

The rise of BIM in the building sector has permitted expanded teamwork effort among building design and construction project stakeholders, Chuck Eastman, Teicholz, Sacks, & Liston, (2011); Heydarian, Pantazis, Gerber, & Becerik-Gerber, (2015); O'Donnell et al., (2013); Schlueter & Thesseling, (2009). In the conventional project delivery technique, the work of designers, structural specialists, MEP engineers, contractors, and different other building experts occurs in relative disengagement to each other. Nonetheless, BIM-based project delivery encourages teamwork effort among the

project partners (Chuck Eastman et al., 2011); Heydarian, Pantazis, et al., 2015; O'Donnell et al., 2013; Schlueter & Thesseling, 2009). For this situation, data presented to the different gatherings would all be able to be shared and incorporated around a focal building information model (Salman Azhar, Brown, & Farooqui, 2009).

Adding to that, immersive virtual environments (IVEs) join pre-development mock up that introduces a feeling of genuine space to the future clients and building information models that take into consideration testing of various outline options (Heydarian, Carneiro, et al., 2015; Heydarian, Pantazis, et al., 2015). Utilization of IVEs gives architects and engineers the chance to gather data about tenant conduct (Heydarian, Pantazis, et al., 2015). This data can be extremely useful for settling on decision during the project configuration stage.

As mentioned by the US GSA (BIM Guide, 2015), on account of a customary energy modelling approach, an energy modeler utilizes customarily made drawings and makes an autonomous model in an energy modeling instrument. This may prompt distortion of the drawings, irregularities, rearranged model, and vast measure of time expected to make an energy model. Then again, BIM-based energy modelling mechanizes this procedure, and make reliable and more perplexing energy models (BIM Guide, 2015). In BIM-based project delivery, building energy modelling (BEM) is coordinated into building design, construction, and operation/maintenance more effectively as energy performance is assessed using the principal BIM model without reproducing building geometry in certain BEM stages (i.e., gbXML-empowered BEM devices). Also, BIM-based sustainability assessment gives the result quicker as compared with the conventional techniques (Salman Azhar et al., 2009). Despite the fact that there is a requirement for more elevated amounts of interoperability among BIM and BEM tools, Bynum, Issa, & Olbina, (2012), the effectiveness and precision of BIM-based energy modelling is continually enhancing, Kim & Anderson, (2012).

USE OF BEM IN THE BUILDING DESIGN PHASE

Huge numbers of the most imperative decisions associated with energy efficiency are made at an early stage in the design process, Salman Azhar et al., (2009); Cemesova, Hopfe, & Mcleod, (2015); Donn, Selkowitz, & Bordass, (2012); Kim & Anderson, (2012); Schlueter & Thesseling, (2009). In this manner, the utilization of BEM tools can be exceptionally helpful during the planning stage Attia, Gratia, De Herde, & Hensen, (2012); Bambardekar & Poerschke, (2009); Bynum et al., (2012); Schlueter & Thesseling, (2009). BEM simulations can be utilized to evaluate the energy advantages of different design options and along these lines encourage architects and clients settle on better choices associated with building performance, BIM Guide, (2015); Donn et al., (2012) and lifecycle cost advantages Stadel, Eboli, Ryberg, Mitchell, & Spatari, (2011). Building designers utilize BEM as a design tool to break down the performance of building design emphases through

BEM simulation (Donn et al., (2012). In the design stage a requirement for the qualitative examination of design choices is more important than precision of simulation results (Attia et al., 2012; Bambardekar & Poerschke, 2009). The Chartered Institution of Building Service Engineers (CIBSE) (Charterd Institution of Building Service Engineers, 1998) proposed two strategies for synchronizing BEM in design: (1) applying simplified simulation instruments in the early design stage and more definite tools in the comprehensive design stages, and (2) utilizing a complex single simulation instrument in all the design stages. The benefit of the second strategy is that with the utilization of the single tool a similar building energy model is utilized by various colleagues in all the design stages. This methodology likewise takes out blunders that may happen because of utilization of various BEM tools, Morbitzer, Strachan, Spires, Cafferty, & Webster, (2001).

So also, Hemsath (2013) proposed utilizing various BEM tools all through the design stages relying upon the design stage and the extent of simulation. BEM can enable architects to accomplish sustainable structures by giving tools that can be utilized for energy analysis, choosing materials and products that have low environmental effect, and assessing projects for LEED compliance (Chuck Eastman et al., 2011). Stadel et al. (2011) indicated how certain BIM tools (e.g., Revit) that can rapidly perform quantity takeoffs can be utilized in connection with certain BEM software (e.g., Green Building Studio™ Revit Plugin, IES VE™ Revit Plugin, and SimaPro). These tools can be utilized for performing lifecycle assessment with the end goal to appraise the environmental impact of building materials from the inception to completion stages.

Donn et al. (2012) represented the compelling usage of BEM reproductions in the beginning periods of the design procedure using the building performance approach. The objective of their assessment was to survey the utilization of definite simulation instruments during early design stages when there is more liberty to investigate different design ideas and more remarkable capacity to enhance building performance. The two primary criteria that Donn et al. (2012) utilized for deciding a high-quality simulation tool were speed and precision.

Assessing the speed of a simulation tool is important with the end goal so as to give input rapidly enough to stay aware of the quick pace of the design process. Precision is important to guarantee that the outcomes are solid, Ryan & Sanquist, (2012). and the succeeding design choices are successful, Donn et al., (2012). The building performance sketch was contrasted with the BIM-based simulation work process in which a moderately complete, entire building data model is first concluded and afterward design cycles are broke down dependent on criticism from the simulation instrument, Donn et al., (2012). The BIM-based work process necessitates that the building design is generally complete, Salman Azhar et al., (2009).

METHOD OF DATA ANALYSIS

The descriptive analysis used is mainly the frequency table obtained by analyzing data from

our observation and questionnaires. In this type of sampling techniques, same percentage of the total number of people interviewed and observation will be taken and used in test to provide information about the general data needed for this research work, Nwogu, (1997).

SAMPLING AND SAMPLING TECHNIQUE

The target population were randomly selected using stratified random sampling techniques in which all the target population has equal chance of appearing in the sample (probability sampling), with a new avoiding biased sampling based on the sample reason that the study is purposive research involving only Architecture students and professional outside.

DATA AND DATA COLLECTION TECHNIQUES

Data represents all the information used by the researcher to achieve the aim of the research. In this research, data was collected by selected techniques. These data were gotten from specific sources in this context, 500 level Architecture students.

DATA COLLECTION TECHNIQUES

The data collection technique used by the researcher were distribution of well-structured questionnaires and observation which was carried out by the researcher.

SOURCES OF DATA

PRIMARY DATA

The main source of primary data was a set of well-structured questionnaires administered to 500 level Architecture students, MAU, yola. Other key sources of data were mainly from observation and oral interviews.

SECONDARY DATA

Secondary data for this study was obtained from literacy work in textbooks, journals, newspaper, internet and also relevant government/private agencies or bodies.

METHOD OF DATA COLLECTION

According to Thirkettte, (1972). we have two types of data collection methods. These are the primary and secondary data collection. He also defined secondary data as data collected for other purposes. This kind of data requires corrections and changes; examples include journals and magazines. Secondary data collection is data that has been collected by another researcher before while primary data is data collection for the first time.

Data collection also involves the process of preparing and collecting data, for example, as part of a process improvement or similar project. The purpose of data collection is to obtain information to keep record, to make decisions about important issues, or to pass information on to others. Data are primarily collected to provide information regarding a specific topic. For the purpose of this research work, both primary data method that will be used is the random sampling method.

DATA ANALYSIS TECHNIQUE

i) Frequency: The rate of occurrence of something, in this case questions. The responses of the respondents would be analyzed based on the frequency of answers to particular questions.

ii) Tables: Tables are used to collect information which has to do with differences or

categorization. It shows the distinction between information or data. Tables would be used to categorize totals of the respondents so as to determine the percentage.

iii) Percentage: The amount, number or rate of something in reference to 100 or to a total figure. This would be used to determine the percentage of agreed statements or disagreed statements by the respondents.

RESULTS AND DISCUSSION

Introduction

This section contains the presentations of the research findings after the analysis of the collected data. The results of the analyzed data shall be discussed based on questionnaire and observation. Interesting findings were made from the analysis of the data. A total of 40 questionnaires were administered, in which 35 were duly completed and returned. It is on this basis that the data collected from the field were analyzed.

DATA PRESENTATION

This page provides all the results generated from the questionnaire administered.

The frequency and percentage were used in analyzing and interpreting the outcome of the respondents for the research work. However, in finding the % of the respondents to each question. The frequency of the respondents to the question is divided by the total frequency expressed in 100%.

$$X = \frac{\text{FREQUENCY OF PARTICULAR QUESTION X 100\%}}{\text{TOTAL FREQUENCY}}$$

PRESENTATION OF QUESTIONNAIRE FINDINGS

Have you heard about Building Information Modelling?

OPTION	FREQUENCY (f)	PERCENTAGE (%)
Yes	29	82.85
No	6	17.15
TOTAL	**35**	**100**

Source: Field survey (2021)

Based on table 4.1, 82.85% of the respondents have heard about Building Information Modelling, while 17.15% have not heard about it.

Table 4.2: Do you make use of any Building Information Modelling tool?

OPTION	FREQUENCY (f)	PERCENTAGE (%)
Yes	20	57.14
No	15	46.86
TOTAL	**35**	**100**

Source: Field survey (2021)

Table 4.2 indicates that 57.14% of the respondents make use of Building Information Modelling tools, while 46.86% do not.

Table 4.3: Which among these Building Information Modelling tools do you operate?

OPTION	FREQUENCY (f)	PERCENTAGE (%)
AutoCAD Architecture	7	35
ArchiCAD	7	35
Revit Architecture	6	30
None	0	0
TOTAL	**20**	**100**

Source: Field survey (2021)

From the above table, 35% of the respondents operate the AutoCAD Architecture BIM tool,

35% also make use of ArchiCAD, 30% operate Revit Architecture BIM tool.

Table 4.4: Which among these primary Building Information Modelling functions do you use the tools for?

OPTION	FREQUENCY (f)	PERCENTAGE (%)
3D Architectural Modelling	7	35
Parametric Design	4	20
Both	9	45
None	0	0
TOTAL	**20**	**100**

Source: Field survey (2021)

From table 4.4 above, 35% of the respondents use BIM for 3D Architectural Modelling, 20% use the BIM tool for Parametric Design purposes while 45% use BIM for both 3D Architectural Modelling and Parametric Design.

Do you know Building Information Modelling can be used for Energy performance analysis in buildings?

OPTION	FREQUENCY (f)	PERCENTAGE (%)
Yes	15	42.85
No	20	57.15
TOTAL	**35**	**100**

Source: Field survey (2021)

From table 4.5 above, 42.85% of the respondents are aware of Building Information Modelling use in evaluating Energy Performance analysis in buildings, while 57.15% are unaware.

Table 4.6 Do you think Energy performance analysis of buildings using BIM will ensure energy efficiency?

OPTION	FREQUENCY (f)	PERCENTAGE (%)
Yes	29	82.85
No	6	17.15
TOTAL	**35**	**100**

Source: Field survey (2021)

From the table above, 82.85% of the respondents suggest that Energy Performance analysis of buildings using BIM will ensure energy efficiency, while 17.15% do not agree to such suggestion.

DISCUSSION

From the above findings, it can be suggested that BIM tools are an important aspect in carrying out of various architectural tasks. There is the need for more awareness to be given, especially in terms of BIM application for energy efficiency in buildings, particularly in the design stage which will ensure more energy efficient buildings and also sustainability of the built environment.

SUMMARY

This project report has highlighted the importance of the professionals in the AEC industries in venturing into BIM. It also points out the significance of attaining sustainable development. It was established from literature that BIM users benefits from its different advantages such as cost benefits, sustainability on a life cycle basis, time factor, building delivery etc.

CONCLUSION

Inferring from the results and conclusions of the findings that this project report looked into, it is easy to say that energy consumption analysis can be successfully carried out using BIM and it will help architects in decision making at design stage towards attaining an energy efficient building which would contribute a lot in achieving sustainable development.

RECOMMENDATIONS

• Professionals in the AEC should make BIM a must use so as to attain the best of performance of building throughout it life cycle.

• BIM should be introduced and taught in schools so that the younger generation would be useful in the future of the AEC industry.

• Energy efficiency simulations should be made mandatory by the planning authorities because it will contribute greatly to the achievement of sustainable development.

• The users of BIM should always acquaint themselves to updates in softwares and BIM related technologies as these technologies get better versions after versions.

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