Beneficial Effects of BIM For Pre-Empting Waste During Planning and Design Stage of a Building

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Abstract

Efficient waste management practices in construction are pivotal for sustainable development, particularly in emerging economies like Nigeria. The construction industry significantly contributes to environmental degradation through waste generation. This study explores the effectiveness of Building Information Modelling (BIM) in pre-empting construction waste during the planning and design stages. Utilizing a quantitative research approach, data were collected from 340 construction professionals in African Nigeria. The analysis revealed that BIM enhances waste mitigation by improving information sharing among stakeholders, optimizing resource use, and facilitating better project coordination. Notably, factors such as improper project planning and poor workmanship were identified as primary contributors to waste generation. BIM's capabilities in automated waste analysis, improved design documentation, and the use of prefabrication were highlighted as key strategies for waste reduction. The findings underscore BIM's potential to foster sustainable construction practices by minimizing waste and promoting efficient resource management.

Keywords: BIM, Waste Mitigation, Planning & Design Stage and Sustainable Construction

1. INTRODUCTION

Nowadays, the environmental cost resulting from the construction process has become increasingly substantial. The construction industry is highly resource-based and often produces large amounts of waste which can often contradict the goals of sustainable development as formulated in Paris 2015 (Haas et al., 2015). Additionally (Moh et al., 2014) as Nigeria transitions into the status of a developed nation by 2020, the number of construction projects is expected to increase significantly. The Nigerian government has been focused on the construction industry as an area of interest to reduce carbon emissions, energy utilization, and use of material assets. The construction industry in Africa accounts for 9.5 % of Africa's total workforce, including professionals, skilled, and non-skilled workers (Yong, 2018). construction waste generation has become a pressing problem in Africa (Dixit, 2017). Moreover, due to the rapid development of the construction industry, a lot of construction waste is generated in the country. Housing demand and major infrastructure projects are responsible for increasing the amount of construction waste generated (Zainun et al., 2016). Although construction waste is growing, the Sustainable Construction Strategy (Esa, 2017) Sets the target of landfill waste reduction. This is a requirement as construction activities the world over including Nigeria have increasingly grown (Wijewickreme, 2016). Esa (2017) affirmed that this objective has been accomplished aside from the expanded exhuming of waste and called for further waste counteractive action activities, including planning out waste. Additionally, the reduction of construction waste has been driven by financial and natural contemplations because of the expense of waste, which was identified with landfill charges that rose from £32/ton in 2008 to £80/ton in 2014. The Green Overlay to the Work Plan identifies the strategy for constructing project design undertakings in different main stages and has been familiar with offering processes to help architects and project stakeholders execute viable design methodologies (e.g. energy and water efficiency, carbon and waste reduction) in their design projects (Mohamed, 2018). Nevertheless, In the Green Overlay, however, little consideration has been given to building waste minimization (CWM). They currently lack the profound management devices to assist in the strong evaluation and execution of CWM through the construction of configuration stages. (Loonen et al., 2019). Construction waste will have an aggressive impact on the environment, the economy and society; these effects will reduce the amount of profitability and thus extend the overall implementation of growth (Loonen et al., 2019). Murgia et al. (2018) further explained that Construction waste is either directly or indirectly produced through building operations. For example, a portion of the waste plasterboard is dangerous and could affect the regions concerned. However, no attempts were produced to create BIM-aided CWM designs and methodologies for decision-making, which is the objective of this paper. In the background of this research, Esa (2017) explained that construction waste is delivered either directly or unintentionally from construction activities. Hence, waste, for example, plasterboard is hazardous and could contaminate the encompassing areas. Construction waste is defined as the pollution brought about by construction activities which brings about negative effects on the environment and leads to economic misfortune (Stavins, 2019).

2. CONCEPT OF BUILDING INFORMATION MODELLING

Building Information Modelling (BIM) is a joint instrument used by Architectural, engineering and construction industries dependent on many software results (Latiffi et al., 2013). Papadonikolaki et al. (2017) referenced that, BIM is used for representation and reproduction, conflict recognition and enhancing project implementation and even as far as coordination and communication. When producing layout planning or details, BIM permits designers to explain building parts with facts / Parameters that can be used for assessment to fulfil the prerequisites for sustainable design. Similarly, BIM is used for visualisation and simulation by Architects and engineers to enhance their knowledge of design and intensify their longitudinal thinking (Kelly, 2015). (Wong & Fan, 2013) The improved coordination and communication from the working procedures of BIM can help in the delegation of responsibilities; BIM is used to prevent and manage disputes between project parties, which is referred to as a conflict scene. These guidelines, however, concentrated on vitality efficiency and carbon reduction and a little on CWM. In the literature, there is a lack of design development tools and management tools for CWM (Al-Keim, 2017). The sustainability of a building relies upon many interrelated and interdependent elements and these elements are influenced by design decisions given by various stakeholders of a construction project (Salihi, 2016). Between relations and between conditions that are viewed as basic for supportability assessment request standard evaluation and structured data created by different members of the various stakeholders of project design and configuration group. Along these lines, a collective and effective building information system is required to guide the investigations (Eastman et al., 2011). In a conservative non-BIM strategy work process, generally, progressive execution assessment of the building design is normally performed after finishing the compositional structure (Khosrowshahi et al., 2012).

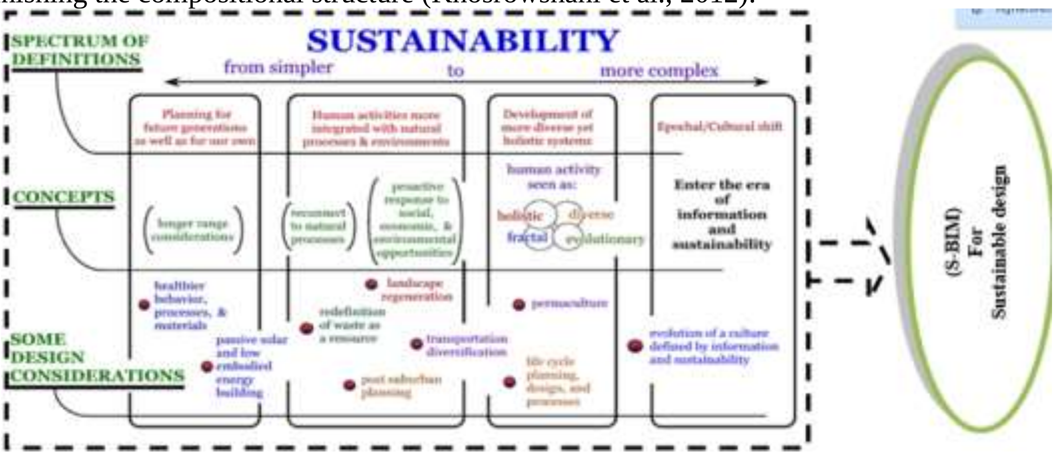

Fig.1. Working definition of sustainability for Planning and design (Salihi, 2016).

3. METHODOLOGY

This study used the quantitative research approach, and data were collected using a questionnaire. The questionnaire used was administered by the researchers to the respondents in the study area. The samples in this study are construction professionals in some parts of the Nigerian construction industry. The size of the sample was 340 which conforms with the rule of thumb for a sample size according to Krejci and Morgan's (1970) simplified tables. A simple random sampling method was used to select the study sample (Keyton, 2014). The study's operational approach is strongly influenced by the quantitative method using the chosen survey strategy, as numerical data were collected and analysed. It was uncovered that these sorts of studies are completed using quantitative measures (Oviawe & Oshio, 2011). The analysis was carried out using descriptive statistics such as mean ranking, (CFA) test, correlation, regression analysis, and hierarchical multiple regression using smart PLS-SEM with no graphics presented to evaluate and assess the relationship between variables. The results were presented using tables, figures and charts. includes 212 quantity surveyors, 310 architects, 115 builders and 313 civil engineers, making a total of 950 populations as the sample frame of the study were construction professionals. Therefore, the study utilized a total of 340 respondents as the sample for the study.

4. RESULTS AND DISCUSSION

Survey questionnaires were administered to respondents after restructuring the questions on the effectiveness of BIM for mitigating waste on building design constructs as required for pilot survey results. A total number of 340 questionnaires with an 85% response rate were retrieved from the study area. Similarly, a total number of 302 (87%) questionnaires were used in the analyses after removing incomplete data and outliers descriptive analysis was measured to investigate the normality of the data as recommended by Pallant (2011). Therefore, according to Doloi et al. (2011), the measurement model met the reliability and validity criteria for the latent variables and observed variables. Furthermore, a reliability test was also carried out to measure the reliability of constructs. Results indicated that a Cronbach's alpha value of .889 was obtained for Satisfaction, .900 for Loyalty, and .844 for the effectiveness of BIM in mitigating waste on building designs. Descriptive analysis was also performed to evaluate the causes of construction waste and the results are displayed in Table 2.
Results indicated that a Cronbach's alpha value of .889 was obtained for Satisfaction, .900 for Loyalty, and .844 for the effectiveness of BIM in mitigating waste on building designs.

Table 2: BIM for Pre-Empting g waste on (n=261)

Variables	Mean	Std. Deviation	Rank
Improved sharing of waste information between stakeholders using BIM	**4.5691**	**0.8991**	**1st**
Use of BIM as a waste management tool Automatic	**4.3681**	**0.9681**	**2nd**
capture of waste analysis design parameters	**4.2372**	**0.6671**	**3rd**
Improved contractual document management	**4.0462**	**1.2262**	**4th**
3D printing for prefabrication	**4.0351**	**1.0253**	**5th**
Improved waste minimization commitment among stakeholders	**4.0132**	**0.9862**	**6th**
BIM federated model to be developed for use by all teams	**3.9121**	**0.9551**	**7th**
Transparency of duties during the design phase Enables	**3.8711**	**0.6721**	**8th**
Computer-assisted simulation scenario and waste performance	**3.711**	**0.1512**	**9th**

It was observed that Improved sharing of waste data among BIM stakeholders in the research region

by an average of 4,56931 was ranked 1st, while the Use of BIM as an instrument for coordination for designing out waste in the study area with a mean of 4.3681 and ranked as the 2nd factor that can enhance the effectiveness of BIM for mitigating waste in designing towards sustainability in the Nigeria construction industry in Table 4,
Therefore, this research found that waste in building design and waste in building construction is a major determinant for improving waste toward sustainable construction. Use communication and information technology like BIM was ranked 1st and enhancing a participatory approach by involving stakeholders was ranked lowest. Improved sharing of waste information between stakeholders using BIM in the research region 1st and reducing and controlling the use and dispersion of toxic materials were ranked lowest.

5. DISCUSSION

This study is based on the assessment of BIM's effectiveness in mitigating and minimising waste in construction design toward sustainable development in the construction industry in Malaysia. Furthermore, the study also sought to determine the factors affecting waste management, and the effectiveness of BIM toward mitigating waste for sustainable construction and develop a framework that can be used to promote sustainable construction by minimizing and mitigating waste in the Nigerian construction industry for better sustainability. It is important to note that the finding of this study demonstrates that the use of BIM as a coordinating instrument for measuring waste and building information (BIM) is a technique that is supported by various tools and methodsThis finding confirmed the result of a focus group discussion conducted by (Akinade et al., 2018; Eadie et al., 2015; Redmond et al., 2012).
Eliminating and mitigating waste in the design stage to improve waste information sharing among stakeholders using BIM is the second enhancer that yielded better results among the group of variables under the design factor. Using BIM techniques to enhance current construction power modelling practices, methods of exchanging data between BEM and BIM instruments have appeared in this issue, attesting that waste from incorrect data could result in the demands of these stakeholders influencing design progress. More so, Building Information Modelling (BIM) is a phenomenon that is emerging. Efficiency and minimizing waste in the plant's design, construction and operation. These improvements are facilitated in the communication between stakeholders. That the BIM must include (McCuen, 2009) and the interchange process. This result was supported by (Arayici et al., 2012; Azhar & engineering, 2011; Bryde et al., 2013). The overhead result was spotted by (Bryde et al., 2013; Wang et al., 2014; Yalcinkaya & Singh, 2015; Zhang et al., 2013). Finally, the above finding of this study found that the effectiveness of BIM for mitigating waste in building design: a framework for sustainable development can solve issues on Building Information Modelling (BIM) as an emerging architectural / engineering/building (A / E / C) instrument used by all project stakeholders to design, document and enhance interaction. Using BIM approaches can mitigate and minimize waste material benefits.

6. CONCLUSION

This study recounts the results of a survey undertaken on the effectiveness of BIM for mitigating waste in building design: a framework for sustainable development in the Malaysian construction industry. This method allows project teams to use BIM models to simulate architectural and structural design demands and to quickly compare the outcomes to make needed design modifications to mitigate and minimize waste products. During the design phase, the BIM rebar optimization strategy also promotes cost-effective decision-making. This is because the philosophy of design is based on. It is therefore the responsibility of architects and design professionals to ensure that waste is given high priority during design compared to the time and cost of the project. Designers are therefore encouraged to educate stakeholders about waste management's economic and environmental benefits. In addition, despite BIM's benefits in enhancing building performance, none of the current ones. From the above, this study evaluated the constraints of current building waste management instruments and

identified industry stakeholders ' expectations when using BIM tools.
This research introduces dual contributions in a simplified debate: (1) Use of communication and information technology like BIM (ii) Improved sharing of disposal data between stakeholders using BIM. BIM helps to solve interdisciplinary issues in this sense. While lowering project costs and duplication of effort, this will enhance team efficiency. Furthermore, the main output of this article is to implement a new methodology for mitigating and minimizing waste products in the design and construction phase by incorporating BIM models with methods for sustainability. As one of the biggest contributors to building waste, toxins were selected to be the focus of this study during design and construction. For better communication and compression algorithms, the cutting losses of reinforcement bars can be significantly reduced.

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8. REFERENCES

For in-text references, please see the examples below (use Harvard style).

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