Journal of Contemporary Research in the Built Environment ISSN: 2636-4468
Volume 3, Number 2, September 2019

APPLICATION OF BIM TO CONSTRUCTION MATERIAL WASTE MANAGEMENT: STAKEHOLDERS' PERCEPTIONS IN SELECTED STATES OF SOUTH-SOUTH, NIGERIA

Etorobong K. Umoren, Timothy O. Adewuyi[1] and Monday Otali
Department of Building, University of Uyo, Uyo, Nigeria

ABSTRACT

Purpose: Construction material waste management (CMWM) is one enigma that has given the construction stakeholders brain-cracking efforts to tackle possibly employing all the available strategies at their disposal and new inventions possible to come to a sustainable level. This study investigated the application of BIM in solving the problem of construction material waste which is one of the options yet untapped by construction stakeholders in the study area.
Design/methodology/approach: A survey research design method was used with 197 valid participants who are construction professionals stratified into their respective State of residence or professional domicile within the South-South geopolitical zone of Nigeria. Data were collected with structured questionnaires which were analysed using relative importance index, mean score and Kruskal Wallis H test for the hypotheses.
Findings: High cost of integrated software, lack of trained professionals to handle the tools, and lack of awareness of the technology are the three most important inhibitors of BIM for CMWM. The availability of trained professionals to handle BIM tools, knowledge of BIM applications, and developing a strategic implementation plan by organisations and firms are the three foremost factors facilitating the use of BIM for CMWM. The study revealed that the perceptions of the respondents on inhibitors to the usage of BIM for CMWM do not differ significantly while their perceptions on facilitators varied significantly among the selected States.
Research limitation/implications: The study relied on the expertise of the 197 professionals sampled in the three selected States to represent the six States in the South-South geopolitical zone of the country. It also depends on only fifteen inhibitors and ten facilitators influencing the application of BIM for CMWM which may not be exhaustive enough to uncover the realism.
Practical implication: The study unveiled the critical demand on the players in the construction industry in the study area for the exploration of BIM for minimising waste for enhancing project performance and advancing the course of Architectural, Engineering and Construction (AEC) professions.
Originality/value: The study uncovered the state-of-art about the management of construction material waste in the study area.

Keywords: Application of BIM; BIM; construction material waste management; stakeholders; inhibitors; facilitators.

[1]timothyadewuyi@uniuyo.edu.ng

1. INTRODUCTION

The construction industry is one of the major contributors to the nation's structural and economic growth because of the vastness of its products. The realisation and the need for developing countries to meet up with the developed ones, and for the growth to be progressive; demands a series of obstacles to be overcome. One of such obstacles has been the issue of construction material waste which mostly occurs as a result of construction activities and reported to have become knotty due to the large volume of waste produced across the globe (Osmani, 2013). The construction industry in which these activities take place is responsible for producing a whole variety of on-site wastes, the amount and types of which depend on parametric functions such as the stage of construction, type of construction work, direct or indirect stakeholders, design change contributions, and practices throughout the project lifecycle (Liu *et al*, 2015). Jaillon and Poon (2014) also confirmed that waste could be attributed to the constant uptake of construction, demolition and renovation activities during which villages are built into towns, towns into cities and cities into megacities.

Among the researches into construction waste minimisation techniques undertaken so far, Liu *et al.* (2015) observed lack of a comprehensive approach that can effectively combat material waste in different phases of construction, and as such the construction industry is still in search of effective waste management tool to tackle the menace of construction waste and to enhance a profitable end product. Akinade *et al.* (2016) showed that the waste management tools earlier adopted were not robust enough to combat construction waste. The recent and a more reliable technology discovered which is capable of numerous benefits in the construction industry at any stage including solving the problem of waste on building sites is Building Information Modelling (BIM) (Ahankoob, 2012). Amuda (2016) observed that different, but related, construction industry parties are at variance with each other in solving problems of material waste. Rather, each of the parties is focusing on their specific area of functionalities and ignoring the adverse effects of their respective separate decisions on the other aspect of the entire project. Whereas, it is inevitable to collaborate and integrate construction project process among the various parties involved as it brings about effective coordination, effective communication and fast achievement of project objectives. Therefore, BIM's adoption or its implementation is a matter of necessity as it is capable of providing a common platform that tracks all construction stages and processes. BIM is capable of a sudden transformation of the construction industry from the traditional fragmented method of project delivery to a method which can create newly coordinated, collaborated and information exchange opportunity among the parties involved in a project (Teo, Seah & Chioh, 2006).

Furthermore, it has been reported that rework is a significant factor contributing to the costs and time overruns of construction project while the genesis of the duo is traceable to the magnitude of material waste generated on building sites (Hwang, Zhao & Yang, 2019; Adewuyi & Idoro, 2017; Adewuyi & Odesola, 2015; Adewuyi, 2012). Concomitantly, factors such as lack of communication between construction parties, omissions, design mistakes, and change orders have been identified to be some of the causes of rework whereas all these adversarial effects on a construction project can be effectively curbed with the implementation BIM. Hwang, Zhao and Yang (2019) enunciated the versatility of BIM to ensure better control of the construction process and enablement of internal coordination, cross-disciplinary collaboration, decision-making, risk management, and productivity improvement.

From the foregoing, it is obvious that the problems of construction material waste can be tackled with the implementation of BIM, thus enhancing the growth and rapid transformation of the construction industry in every part of the world. Unlike most developed countries, which are currently at best working at Construction 3.0 level (Rastogi, 2017), most of the developing countries in Africa are still struggling with the adoption of third level of construction revolution, especially Nigerian construction industry, which could be likened to that of India and Yemen that have unwillingness to accept new technology (Walmikey & Kulkarni, 2016;), is yet to fully embrace such development. In such circumstances, it is imperative for construction professionals to be aware of the gains of full adoption of current technological developments. Therefore, there is a need for application and implementation of a more efficient tool such as BIM to help tackle the issue of construction material waste which appears not to have embraced or received enough attention by construction professionals or shreds of evidence of such are lacking. Hence, there is a need to look at the influence of BIM on construction material waste management towards enhancing the reduction of waste and improving the image of the construction industry in Nigeria. Two research questions guided the purpose of the study and they are to be addressed in the search of influence of BIM on material waste on building sites: (i) What are the inhibitors to the application of BIM for managing material waste in the study area? (ii) What are the facilitators of applying BIM to curb material waste management on building sites? For the purpose of the study, the objectives of the study are to:

i. Examine the inhibitors to the application of BIM for construction material waste management on building sites in the study area;
ii. Determine the factors that facilitate the use of BIM for managing waste on building sites in the study area.

Two hypotheses were postulated as derived, each from the two objectives of the study.

Ho1: There are no significant differences in the mean responses to the inhibitors of BIM application for construction material waste management (CMWM) in the study area.

Ho2: There are no significant differences in the mean responses of factors facilitating the use of BIM for construction material waste management (CMWM) in the study area.

2. Review of Related Literature

Building information modelling (BIM) is one of the three-dimensional technological tools as well as data communication technologies commonly employed by professionals (designers, planners, and constructors) in construction industry which can incorporate systematic and efficient integration of data identification and acquisition technologies, hence a digital representation of physical and functional characteristics of a facility (Won & Cheng, 2017). It entails the use of computer-generated models to simulate the planning, design, and construction of projects. It is a concept that is transforming the construction world internationally at the third level of the construction revolution. It is in the course of revolutionizing the construction industry due to its powerful platform for collaboration, interoperability, integrated project delivery, and knowledge sharing among others (Eastman *et al*., 2011). The richness of a BIM system depends on the value of data integrated into it over the last few decades, and the pattern of the relationship among the BIM systems are constantly being studied by scientists with the application of new dimensions to achieve a maximum result. BIM is used to develop a collaborative construction process that includes design, build, operate and maintenance of buildings. However, the adoption of BIM in Nigeria is very slow; it is used mostly for schematic design and presentation of drawings by Architects but yet to be duly embraced by other professionals in the construction industry with dereliction of a platform for collaborative project delivery as was also reported of China by Xu *et al*. (2018). Onungwa, Uduma-Olugu, and Nnezi (2017) showed that BIM has a high impact on client satisfaction, time for completion, quality and presentation of different concepts in schematic design. It also showed a high impact on conflict resolution, supervision, construction programming and quality of completed jobs during the post-contract stage. Won and Cheng (2017) asseverated the potency of BIM for waste generation estimation and integrated waste management system development.

2.1. Facilitators of BIM for construction waste managements

BIM embeds numerous benefits and as far as the Nigerian construction industry is concerned, these enormous benefits are yet to be fully utilised as compared to the other developed countries of the world. Indubitably, some factors are responsible for the full utilisation of BIM in the developed countries specifically facilitating its use for construction waste management. From literature, these factors are numerous but include trained professionals' availability to handle BIM tools. When there are readily trained personnel on the ground for the purpose of using this tool, many seemly insurmountable issues can be handled. Abubakar *et al*. (2014) enunciated some of the favourable parameters that can enhance the application of BIM for managing construction material waste on-site to include: knowledge of BIM applications, developing a strategic implementation plan by organizations and firms, inclusion in schools' curriculum, fast level of awareness, development of compatible tools, affordability of BIM software packages, ability to survive in the market (Sexton & Barrett, 2003; Shen & Tam, 2002). In Eastman *et al*. (2011), the interviewees of a focus group organised for the research agreed that parametric modelling which enables automatic capturing of design parameters for performance analysis is a benefit of BIM. It was observed that employing BIM, right from the design stage, can help remove human errors while the data is being entered. The ability to use BIM to virtually construct a building prior to construction of the actual building provides an effective means to check its constructability in the real world and to resolve any uncertainties during the process. This allows for more efficient, better-designed structures that limit the waste of resources, optimize energy usage, and promote passive design strategies (Won, Cheng & Lee, 2016; Ahankoob *et al*., 2012).

The aforementioned benefits with some others favour and enhance the application of BIM for construction waste management and have been articulated by previous studies. Xu *et al*. (2018) enumerated such enablers from previous studies to include financial savings, three-dimensional (3D) visualization, reduction of design errors and rework, a better understanding of the project, improved collaboration among stakeholders, and decreased project duration (Gholizadeh *et al*., 2018; Poirier *et al*., 2017; Ahn *et al*., 2015; Migilinskas *et al*., 2013). One of the aspects assumed to be of benefits to the construction firm with the adoption of BIM, according to Azhar (2011), is cost estimating. The study observed that BIM software has the ability to perform quantity take-off and automatically adjust and accommodate any changes occurring throughout the design and construction processes as well as reduces cost estimation time by 80%. Walmikey and Kulkarni (2016) articulated the grey areas enhancing the management of construction material wastes through the use of BIM to include: conflict, interference and collision detection, construction sequencing and planning, reducing rework, synchronizing design and site layout, detection of errors and omissions (clash detection), and accurate quantity take-off.

2.2. Inhibitors to BIM application for construction waste managements

Despite the several benefits embedded with BIM's application; numerous factors still barricade its implementations. In the studies of Yuan, Shen, and Wang (2011) five groups of major obstacles for carrying out CWM were identified, based on the results of factor analysis, encompassing weak awareness and inadequate training, insufficient support from the local government. Extant literature have shown that there are some factors that may hinder the application of BIM to manage material waste including difficulties in operation (Hair *et al.*, 2014), interoperability issues (Gledson, Henry & Bleanch, 2012), maintaining BIM files (Alabdulqader, Panuwatwanich & Doh, 2013), organizational innovativeness (Lee & Yu, 2016), and individual innovativeness. These findings are in consonance with the studies of Azhar (2011) submitting that the lack of initiative and training, varied market readiness and reluctance to change the existing work practices are debacles to implementation of BIM for managing construction waste, together with survival in the market as stressed by Sexton and Barrett (2003), and Shen and Tam (2002). By investigation into literature, researchers such as Abubakar, Ibrahim, and Bala (2013); Eastman *et al*. (2011); and Aranda *et al*. (2009) outlined some of the major inhibitors to the implementations of BIM to include: challenges with collaboration and teaming, legal changes to documentation, ownership and production, changes in practice and use of information and implementation issues and so on.

Additionally, there are numbers of constraints that may pose challenges to the full implementation of BIM which were highlighted and enunciated by other authors such as lack of demand from the client, insufficient evaluation of BIM value, lack of governmental policies or standards, cultural resistance at higher management levels, high investment required, insufficient BIM training and education, organizational change and adjustment in management pattern, and insufficient understanding of BIM technology or practicability (Xu *et al*., 2018; Çıdık *et al*., 2017; Lee & Yu, 2016; Tang *et al*., 2015; Sackey *et al*., 2014). According to Xu *et al*. (2018), some critical factors tend to influence the application of BIM but may be favourable or otherwise depending on how well they are managed by the construction stakeholders involved. These include development of building information standards; planning and management; collaboration among project member; BIM expertise within project teams; legal issues relevant to BIM use in the contract; project characteristics such as location, type, and nature; and budget (Said & Reginato, 2018; Papadonikolaki & Wamelink, 2017; Cao *et al*., 2016; Eadie *et al*., 2013).

3. RESEARCH METHODOLOGY

Building Information Modelling (BIM) is a cutting-edge technology and as such, it is a professional tool meant only for professionals' use; hence the study adopted a survey research design approach using a structured questionnaire to extract information from cognate construction professionals using stratified random sampling technique. The population of the study was limited to only registered building construction professionals such as Architects, Builders, Quantity Surveyors, and Engineers practicing, employed or residing within the selected States of Akwa Ibom, Cross River and Rivers in the South-South geopolitical zone of Nigeria. The sampling frame for the respondents was derived from the directories of the professional bodies in the study area. The number of such professionals was estimated to be 250 which form the basis of the number of questionnaires administered.

Internal consistency reliability for the instrument of data collection was analysed with the use of Cronbach alpha, which according to Sijtsma (2009), has proven very resistant to the passage of time. The result obtained showed a value of 0.859 - 0.901, depicting a good internal consistency. According to Akinade *et al*. (2018), Cronbach alpha coefficient of reliability (α) with a value greater than 0.7 is acceptable and depicts a good internal consistency.

The questionnaire was structured in such a way that proper information was extracted and it comprises three sections. Section A involved the respondent's characteristics such as the years of experience and extent of their familiarity with the use of BIM, to ascertain the authenticity of their responses. Section B collected data on the inhibitors to the application of building information modelling to material waste management while Section C evaluated the facilitators for the application of BIM on material waste management.

A five-point scale was used to rate the respondents' perceptions of the factors facilitating or inhibiting the application of BIM to material waste management respectively. The scale ranges from 1-5; which are "1" for Very Low, "2" for Low, "3" for Moderate, "4" for High and "5" for Very High. The scaling method was necessary in order to efficiently capture the opinions of the respondents without any iota of doubt as it is easily understood by the respondents, thereby enabling the collection of more information as it allows a wider range of choices. The responses to the questionnaire survey were subjected to both descriptive and statistical analyses using Relative Importance Index (RII) and Mean Score analysis while the hypotheses were tested using the Kruskal Wallis H test which is a non-parametric equivalent of t-test. Based on five-point Likert scale adopted, a construct is deemed significant if it had a RII value of 0.60. The cut-off was computed by summing the weights and dividing by the total number of weighting items and highest weight respectively: $(1+2+3+4+5)/5/5 = 0.60$. Thus, an attribute that have RII that are higher than 0.60 are defined as being significant, those with RII equal to 0.60 are moderate, while those less than 0.60 are insignificant. This approach, adapted from Ujene (2014), is with the expectation that the use of 0.60 as reference value will effectively cover only important variables in terms of their influence. Similarly, a cut-off point of 3.00 was utilised for significant mean score value where the analysis was based on mean score computation such that $(1+2+3+4+5)/5 = 3.00$.

4. Data Presentation and Discussion of Results

Two hundred and fifty (250) questionnaires were administered for the purpose of this study but one hundred and ninety-seven (197) questionnaires were properly filled and returned which were used for data analysis to achieve the objectives of the study. The one hundred and ninety-seven questionnaires returned represents 79% response rate which is within an acceptable range. In the twenty-first century, it has been submitted that there should be higher expectations for survey response rates. Expectations on response rates approximating 60% for survey research should be the goal of researchers and undoubtedly that of editors, associate editors including the peer reviewers (Fincham, 2008).

The result of the respondents' years of experience is shown in Figure 1. In Akwa Ibom

State, the results revealed that 45.3% of the respondents had 6-10 years of experience which is the highest among all the categories and in that range in that State and equally among all the selected States in the study area and 5.7% for 16-20 years, and with none of the respondents possessing up to 21 years of experience. This may be the reflection of the recently established built environment academic disciplines in the tertiary institutions within the area, especially the uptake of postgraduate studies in such disciplines. The products of such development clusters much around this area which inadvertently influences the number of practicing professionals in the built environment in the area. This is also mirrored with the 'bottom-loaded' pattern in the category of 1 – 5 years of experience constituting 30.2% in that State.

The result from Rivers State indicates that the highest proportion of 29.5% of the respondents are in the category of 16 – 20 years of experience which is far higher than the other two selected States and most likely revealing a pattern of drift of professionals in that category from Akwa Ibom and the Cross River States to Port Harcourt in Rivers State, being more of metropolitan city in the region. This situation can be much alluded to as observation is made of the spread of years of experience of professionals across all other categories ranging from 1 - 5, 6 - 10 and 11 - 15 years of experience unlike the uneven distribution pattern in the other two States. In Cross River State, for instance, 30.4% of the respondents had 1 – 5 years of experience and this represents the largest percentage compared to the other two selected States in that category. This is a replica of the phenomenon in Akwa Ibom State as the Cross-River State government recently upgraded the State-owned Polytechnic to University status. About thirty-four percent (33.9%) of the respondents in the category possessing above 25 years of experience must have been products of the defunct Polytechnic of Calabar. Nonetheless, the attributes of the respondents with respect to years of experience generally show that the respondents' understanding of the subject matter of this study is not in doubt. This necessitated their inclusion in the survey for this study as their inputs were significant for data collection.

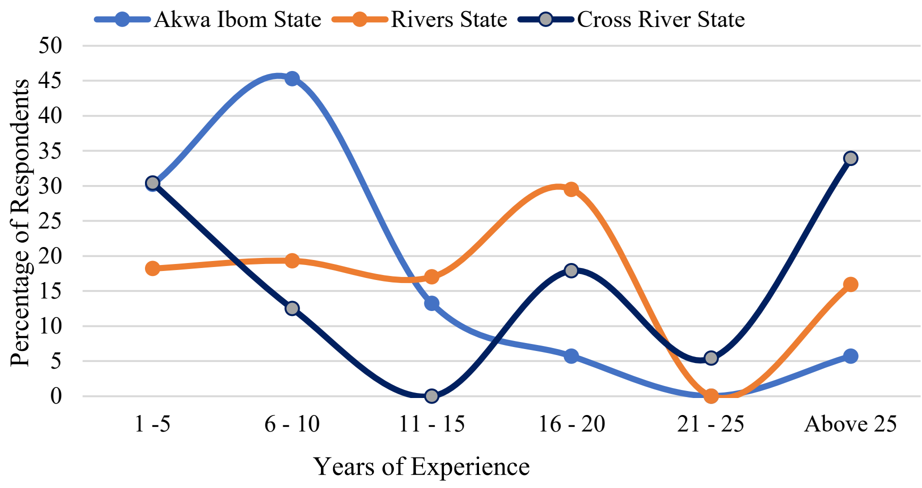

Figure 1: Distribution of Respondents According to Years of Experience

Figure 2 presents the distributions of the respondents' familiarity with BIM technology and the results shows that in Akwa Ibom, a cumulative of 81.1% of the respondents are just having knowledge of the BIM technology within 0-3 years, while 18.9% recorded a 4-5 years familiarity with BIM technology and none of the respondents were familiar with BIM technology for more than 5 years. This shows a very low level of BIM knowledge and usage within this study area. This indicates that the result is in line with the assertion that BIM is a new innovative yet to gain ground within the Nigerian construction industry (Abubakar *et al*., 2014), especially in this study area. This is equally the replication of the argument that the bulk of the professionals in this part of the study area are recently trained products educationally. For Rivers State, 67% of the respondents are familiar with BIM technology just within the past 3 years, only 10.2% are familiar with the use of BIM for up to 5 years, and 22.7% of the respondents indicated having the knowledge of BIM technology for more than 5years. This shows a high level of knowledge of BIM technology among the construction professionals in this part of the study area. This might not be unconnected with the presence of multi-national construction giants working for the various oil companies within the area. It also portrays the presence of long-term trained experienced and versatile professionals in the area. Results from Cross Rivers State indicated that 62.5% were familiar with BIM tools just within the last 3 years, while 25.0% acquiesced to be familiar with BIM within 4-5 years and 12.5% agreed to have knowledge of BIM technology for more than 5 years. These results indicate a low usage of BIM technology in the study area or perhaps a frequent usage of lower version of BIM technology like 3D Building design model, and no or low exposure to the higher version.

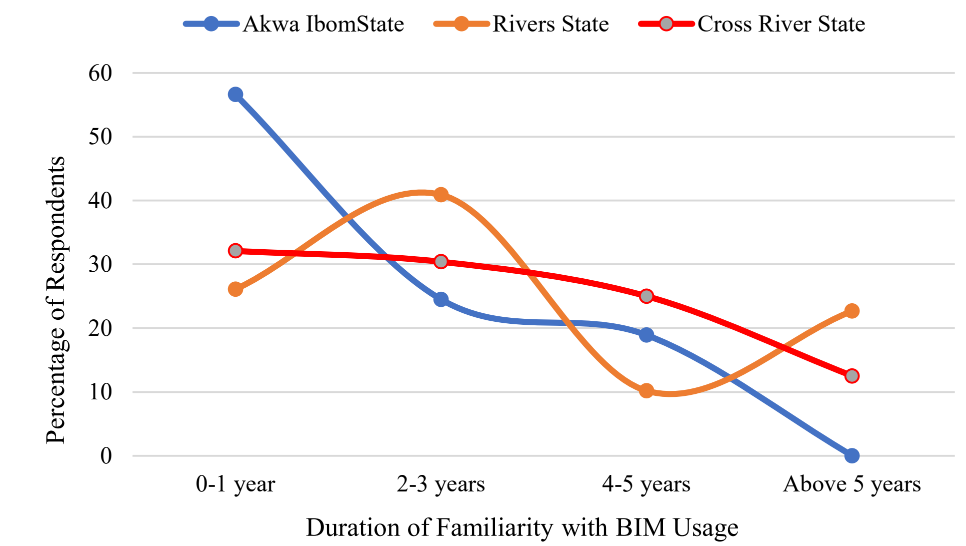

Figure 2: Respondents' Familiarity with BIM

4.1. Examination of inhibitors to application of BIM for CMWM

The inhibitors to the application of BIM for construction material waste management on building projects were examined. The breakdown of the ranking in terms of the overall mean score values comprising all respondents from the three selected States for the 15 studied inhibitors ranged from 2.76 to 3.68, indicating that not all the studied inhibitors were rated by respondents as significant inhibitors influencing the application of BIM to CMWM. The fifteen variables studied with their mean scores are presented in Table 1 which shows that ten (10) of the constructs are significant based on the cut-off value of 3.00 for mean score. It is revealed that high cost of integrated software with a mean score of 3.68 is the most significant barrier to the application of BIM for construction material waste management (CMWM) based on the results from all the selected States. The result also reveals that lack of trained professionals to handle BIM tools and lack of awareness of BIM technology are the second and third significant inhibitors, respectively, to the application of BIM on CMWM in the study area. In the same vein, clients' requirements (lack of interest from client) occupies the fourth place among the significant inhibitors of BIM's application to CMWM. Other constructs such as lack of enabling environment to guide implementation, frequent power failure, lack of standardisation and inappropriate pricing format, and poor internet connectivity were equally rated to be significant barriers to application of BIM to CMWM. These findings are consistent with the studies of Babatunde and Ekundayo (2019) and Abbas *et al*. (2016) who found that poor internet connectivity; BIM being resource-intensive; lack of government lead/direction; inadequate/erratic power supply; and BIM as being problematic for people with weak general IT skills were among the critical barriers to the incorporation of BIM into the curriculum of studies for undergraduates in Nigerian Universities.

Table 1: Inhibitors to the Application of BIM for CMWM

Inhibitors	AKS		RVS		CRS		All States	
	MS	R	MS	R	MS	R	MS	R
High cost of integrated software for all professionals	3.98	4	3.69	1	3.36	3	3.68	1
Lack of trained professionals to handle the tools	3.85	5	3.68	2	3.45	2	3.66	2
Lack of awareness of BIM technology	4.30	2	3.45	4	3.30	5	3.64	3
Clients' requirements (lack of interest from client)	3.74	6	3.44	5	3.46	1	3.53	4
Lack of enabling environment to guide implementation	3.34	7	3.55	3	3.14	10	3.38	5
Frequent power failure	4.43	1	2.88	10	2.95	13	3.31	6
Lack of standardisation and inappropriate pricing format	3.13	10	3.35	6	3.32	4	3.28	7
Poor internet connectivity	4.02	3	3.08	8	2.55	15	3.18	8
Social and habitual resistance to change	2.98	13	3.17	7	3.27	7	3.15	9
Manual review of extracted quantities necessary	3.13	9	3.06	9	3.05	11	3.08	10
Changes in practice and use of information	3.11	11	2.69	12	3.30	6	2.98	11
Presence of substandard BIM models	3.15	8	2.57	15	3.18	8	2.90	12
Challenges with collaboration and teaming	2.74	15	2.77	11	3.16	9	2.87	13
Legal and contractual constraints	3.11	12	2.59	14	2.96	12	2.84	14
Legal changes to documentation, ownership and production	2.92	14	2.69	13	2.70	14	2.76	15

AKS = Akwa Ibom State; RVS = Rivers State; CRS = Cross River State; MS = Mean; R = Rank

Noticeably, the mean score ratings provided by the respondents for each of the constructs studied across the three selected States in the South-South geopolitical region of Nigeria vary across the States. This indicates differences in the aspect of challenges encountered by construction professionals among the States in view. The efforts by the BIM-experienced professionals to convince the built environment clients seem abortive because of low awareness of the benefits derivable among the clients in the study area. However, the number of the significant inhibitors in each of the States showing a mean value of not less than 3.00 (MS > 3) are not less than nine. This implies that the extents to which these inhibitors influence the application of BIM to CMWM is on the high side and efforts of the construction professional should be seriously channelled towards these factors for effective combat against construction material waste management. Legal changes to documentation, ownership, and production was accorded the lowest ratings with a mean score of 2.76 with the implication that it is of least significance as a factor thwarting the application of BIM to the management of construction material waste.

4.2. Test of differences among the selected States of inhibitors to application of BIM to CMWM

Hypothesis one was postulated to ascertain if the variations noticed across the selected States in the ratings of the studied inhibitors is significant or otherwise. This is to determine if there is a significant locational effect in the level of application of BIM to CMWM among the States in the study area. Kruskal Wallis H test was used at a 5% significance level, a p-value < 0.05 result in the rejection of the hypothesis while $p > 0.05$ means that the hypothesis is accepted. The result presented in Table 2 shows a p-value of 0.26 for hypothesis one, hence, the null hypothesis was accepted, meaning that there are no significant differences in the mean responses to the inhibitors of BIM usage among the States under consideration for this research. This implies that the extent of the effect of one barrier in one State has the same relative effect in the other States under consideration. It could also imply that the construction professionals operating within the States are exposed to similar working conditions.

Table 2: Test of Differences of Inhibitors to Application of BIM for CMWM

State Identification	N	Mean Rank	df	Sig.	Decision
Akwa Ibom	15	27.40			
Rivers	15	19.90	2	0.264	Accepted
Cross River	15	21.70			

4.3. Determination of facilitators of the use of BIM for CMWM

Determination of the factors that can facilitate the use of BIM for CMWM in the selected States was carried out. The ten facilitating factors were evaluated using the five-points Likert scaling method and the result is presented in Table 3. The analysis of the data collected from the respondents showed that all the variables were significantly rated based on RII value of 0.60 as cut-off point. The results revealed that the availability of trained professionals to handle BIM tools, with RII value of 0.77, was ranked highest factor followed by knowledge of BIM applications with RII value 0.75, and developing a strategic implementation plan by organizations and firms with RII value of 0.74 in the third rank. This implies that the more the construction professionals are exposed to and trained in the use of BIM the faster the reduction of material wastage in the construction industry will be attained.

Table 3: Facilitators of the Use of BIM for CMWM

	Akwa Ibom		Rivers		Cross River		All States	
Facilitators	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**
Availability of trained professionals to handle BIM tools	0.78	1	0.82	1	0.69	1	0.77	1
Knowledge of BIM applications	0.73	5	0.82	1	0.68	3	0.75	2
Developing a strategic implementation plan by organizations and firms	0.77	2	0.77	4	0.67	4	0.74	3
Inclusion in school's curriculum	0.75	3	0.79	3	0.62	7	0.73	4
Fast level of awareness	0.66	7	0.75	5	0.69	1	0.71	5
Development of compatible tools	0.75	3	0.75	5	0.56	9	0.69	6
Affordability of BIM software packages	0.72	6	0.71	7	0.55	10	0.67	7
Ability to survive in the market	0.64	9	0.70	9	0.63	6	0.67	7
Government policy and legislation	0.66	7	0.65	10	0.66	5	0.66	9
Individual's innovativeness	0.60	10	0.71	7	0.61	8	0.65	10

Availability and accessibility of trained professionals to handle BIM tools will enhance the convenience to upgrade the level of awareness of BIM to curb construction waste in the study area. Knowledge of BIM application which was ranked in the second position could be spawned as a result of the low familiarity level of BIM usage by construction professionals in the study area, hence, with the outburst of more trained professionals on the tools, the low familiarity level of BIM can be overcome. Knowledge of BIM applications is undoubtedly a major stepping stone to the investigation of advanced embedded functions of the technology, hence, when the statutory bodies, organizations, and firms responsible for the continuous development of the built environment professionals find it compulsory to inculcate the habits of introducing new benefitting technologies into their programmes, knowledge and the use of BIM will gracefully find its way to spread across the Nigerian construction industry. Similar findings were obtained by previous studies (Badrinath *et al*., 2016; Babatunde *et al*., 2018) where availability of trained staff (from academia and industry) using BIM to teach the students; BIM software availability and affordability; enabling environment-provision of IT infrastructure; cooperation and commitment of professional bodies to BIM's implementation; and awareness of BIM tangible benefits were pinpointed as important drivers of BIM implementation. The result also shows that the ratings of the factors decrease from Rivers through to Akwa Ibom and to Cross River State. This could be attributed to the fact that construction professionals in Rivers State indicated the largest percentage of years of experience which revealed a high level of BIM expertise in that State compared to others. Therefore, the differences noted in the ratings led to the postulation of hypothesis two which was put to test to confirm if the respondents in any of the selected States perceived the facilitators differently based on the variation in the years of experience, the use and familiarity with BIM technology.

4.4. Test of differences among the selected States of facilitators for application of BIM to CMWM

Table 4 presents the result of the second hypothesis tested for the differences in the mean responses to the factors facilitating the use of BIM for CMWM among the selected States. The result yielded a p-value of 0.003 leading to the rejection of the null hypothesis, hence it was concluded that there are significant differences in the mean responses of the factors facilitating the use of BIM for CMWM among the selected States in the study area. Examination of the mean ranks shows that there is wide range between that of Cross River State and those of other two States. The variation might have resulted from the variability in experiences and exposure of the respondents across the study area.

Table 4: Test of Differences of Facilitators to Application of BIM on CMWM

State Identification	N	Mean Rank	df	. Sig.	Decision
Akwa Ibom	10	16.55			
Rivers	10	21.65	2	0.003	Reject
Cross River	10	8.30			

5. Implications for Research, Practice and Society

This study has unveiled the critical demand on the players in the construction industry in the study area for the exploration of BIM for minimising waste for enhancing project performance and advancing the course of Architectural, Engineering and Construction (AEC) professions. It also shows the demand for professional development on the potentials of BIM for minimising waste including all other benefits offered by BIM. Both public and private clients are expected to demand for the use of BIM and the government should put up policies for the implementation of BIM for project delivery.

6. Conclusions and Recommendations

The realisation and the need for developing countries to close the gaps between them and the developed ones necessitate progressive growth and demand a series of obstacles to be overcome. This study investigated the influence of BIM in solving the problem of construction material waste management (CMWM) which is one of the options yet untapped by construction stakeholders in the study area. The study unveiled the critical challenges confronting the players in the construction industry in the study area with respect to their inability to acquire needed software and necessary training to keep abreast with their counterparts in developed countries in curbing the 'evils' of CMWM which BIM enhances. The high cost of integrated software, lack of trained professionals to handle the tools, and lack of awareness of the technology are the three most important inhibitors of BIM for CMWM. The availability of trained professionals to handle BIM tools, knowledge of BIM applications, and developing a strategic implementation plan by organisations and firms are the three foremost factors facilitating the use of BIM for CMWM. The study revealed that the perceptions of the respondents on inhibitors to the usage of BIM for CMWM do not differ significantly, therefore conclusions were reached that there are no significant differences in the mean responses to the inhibitors of BIM usage for CMWM. Conclusions were made that the construction professionals operating within the study area are exposed to similar working conditions. But the respondents' perceptions of facilitators of BIM for CMWM varied significantly among the selected States. It was concluded that there are significant differences in the mean responses of the factors facilitating the use of BIM for CMWM among the selected States in the study area. Observations were made that the variation might have resulted from the variability in experiences, familiarity with and exposure to BIM technology of the respondents. The study submits that statutory bodies, organizations and firms responsible for the continuous development of the built environment professionals should make it compulsory to introduce new benefitting technologies into their programmes to enhance the knowledge and application of BIM for CMWM.

References

Abbas, A., Din, Z. and Farooqui, R. (2016). Integration of BIM in Construction Management Education: An Overview of Pakistani Engineering Universities. *Procedia Engineering*, 145, 151-157. https://doi.org/10.1016/j.proeng.2016.04.034.

Abubakar, M., Ibrahim, Y. M. and Bala, K. (2013). An Assessment of Readiness of the Nigerian Building Design Firms to Adopt Building Information Modelling

Technologies. *Proceedings of the Fifth International Conference for Construction Engineering and Project Management (ICCEPM)*, January 10, Anaheim, California.

Abubakar, M., Ibrahim, Y.M., Kado, D., and Bala, K. (2014). Contractors Perception of the Factors Affecting Building Information Modeling (BIM) Adoption in the Nigerian Construction Industry. *Computing in Civil and Building Engineering*, 167–178. https://doi.org/10.1061/9780784413616.022

Adewuyi, T. O. (2012). Construction Material Waste Planning and Control Technique on Building Sites in South-South of Nigeria. PhD Thesis, Department of Building, Faculty of Environmental Studies, University of Uyo, Uyo.

Adewuyi, T. O. and Idoro, G. I. (2017). Relationship between Construction Material Waste and Project Cost. *Journal of Environmental Design*, 12(1), 8-20.

Adewuyi, T. O. and Odesola, I. A. (2015). Factors Affecting Material Waste on Construction Sites in Nigeria. *Journal of Engineering and Technology*, 6(1), 82-99. https://journal.utem.edu.my/index.php/jet/article/view/237

Ahankoob, A., Khoshnava, S. M., Rostami, R. and Preece, C. (2012). BIM Perspectives on Construction Waste Reduction. *Management in Construction Research Association (MiCRA), Postgraduate Conference*, Malaysia, January, 195–199.

Ahn, A. H., Kwak, Y. H. and Suk, S. J. (2015). Contractors' Transformation Strategies for Adopting Building Information Modelling. *Journal of Management in Engineering*, 32(1), 05015005. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000390

Akinade, O. O., Oyedele, L. O., Munir, K., Bilal, M., Ajayi, S. O., Owolabi, H. A., Alaka, H. A., Bello, S. A. (2016). Evaluation Criteria for Construction Waste Management Tools: Towards A Holistic BIM. *International Journal of Sustainable Building Technology and Urban Development*, 7(1), 3-21. https://doi.org/10.1080/2093761X.2016.1152203

Akinade, O. O., Oyedele, L. O., Ajayi, S. O., Bilal, M., Alaka, H. A., Owolabi, H. A., and Arawomo, O. O. (2018). Designing Out Construction Waste Using BIM Technology: Stakeholders' Expectations for Industry Deployment. *Journal of Cleaner Production,* 180, 375-385. https://doi.org/10.1016/j.jclepro.2018.01.022

Alabdulqader, A., Panuwatwanich, K. and Doh, J. H. (2013). Current Use of Building Information Modelling Within Australian AEC Industry. *Proceedings of the Thirteenth East Asia-Pacific Conference on Structural Engineering and Construction* (EASEC-13), Sapporo, Japan, September 11-13, C-3-1., C-3-1.

Amuda, Y. G. (2016). BIM Interoperability and Information Standardisation. A Paper presented at The Nigerian Institute of Quantity Surveyors 3- Day National Workshop/2016 Annual General Meeting on Building Information Modelling (BIM): *The Concept, Applications and Benefits in Project Development*, 8th – 10th November, Port Harcourt, Nigeria.

Aranda, M. G., Crawford, J., Chevez, A. and Froese, T. (2009). Building Information Modelling Demystified: Does it Make Business Sense to Adopt BIM? *International Journal of Managing Projects in Business,* 2(3), 419-434. https://doi.org/10.1108/17538370910971063

Azhar, S. (2011). Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. *Leadership and Management in Engineering*, 11(3), 241-252. https://doi.org/10.1061/(ASCE)LM.1943-5630.0000127

Babatunde, S. O., Ekundayo, D., Babalola, O. and Jimoh, J. A. (2018). Analysis of the Drivers and Benefits of BIM Incorporation into Quantity Surveying Profession: Academia and Students' Perspectives. *Journal of Engineering, Design and Technology*, 16(5), 750-766. https://doi.org/10.1108/JEDT-04-2018-0058.

Babatunde, S. O. and Ekundayo, D. (2019). Barriers to the Incorporation of BIM into Quantity Surveying Undergraduate Curriculum in the Nigerian Universities. *Journal of Engineering, Design and Technology*, 17(3), 629-648. https://doi.org/10.1108/JEDT-10-2018-0181

Badrinath, A.C., Chang, Y.T. and Hsieh, S.H. (2016). A Review of Tertiary BIM Education for Advanced Engineering Communication with Visualization. *Visualization in Engineering*, 4(1), 9-17. https://doi.org/10.1186/s40327-016-0038-6

Cao, D., Li, H., Wang, G. and Huang, T. (2016). Identifying and Contextualising the Motivations for BIM Implementation in Construction Projects: An Empirical Study in China. *International Journal of Project Management*, 35(4), 658–669. https://doi.org/10.1016/j.ijproman.2016.02.002.

Çldlk, M. S., Boyd, D. and Thurairajah, N. (2017). Innovative Capability of Building Information Modeling in Construction Design. *Journal of Construction Engineering*, 143(8), 04017047. https://doi.org/10.1061/(ASCE)CO1943-7862.0001337.

Eadie, R., Browne, M., Odeyika, H., McKeown, C. and McNiff, S. (2013). BIM Implementation Throughout the UK Construction Project Lifecycle: An Analysis. *Automation in Construction*, 36, 145–151. https://doi.org/10.1016/j.autcon.2013.09.001.

Eastman, C., Teicholz, P., Sacks, R. and Liston, K. (2011). *BIM Handbook: A Guide to Building Information Modelling for Owners, Managers, Designers, Engineers and Contractors*, 2 ed., New York: John Wiley & Sons, Inc.

Fincham, J. E. (2008). Response Rates and Responsiveness for Surveys, Standards, and the Journal. *American Journal of Pharmaceutical Education*, 72(2), 1-3.

Gamil, Y. and Rahman, I. A. (2019). Awareness and Challenges of Building Information Modelling (BIM) Implementation in the Yemen Construction Industry. *Journal of Engineering, Design and Technology*, 17(5), 1077-1084. https://doi.org/10.1108/JEDT-03-2019-0063

Gholizadeh, P., Esmaeili, B. and Goodrum, P. (2018). Diffusion of Building Information Modeling Functions in the Construction Industry. *Journal of Management in Engineering*, 34(2), 04017060. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000589.

Gledson, B.J., Henry, D. and Bleanch, P. (2012). Does Size Matters? Experienced and Perspective of BIM Implementation from Large and SME Construction Contractors. *Proceedings of 1st UK Academic Conference on Building Information Management* (BIM), 5-7 September, Northumbria University, Newcastle upon Tyne, UK.

Hair, J. F., Hult, G. T. M., Ringle, C. M., and Sarstedt, M. (2014). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. United State of America: SAGE Publications.

Hwang, B. G.; Zhao, X. and Yang, K. W. (2019). Effect of BIM on Rework in Construction Projects in Singapore: Status Quo, Magnitude, Impact, and Strategies. *Journal of Construction Engineering and Management*, 145(2), 04018125-1 - 04018125-16. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001600

Jaillon, L. and Poon, C. S. (2014). Life Cycle Design and Prefabrication in Buildings: A Review and Case Studies in Hong Kong. *Automation in Construction*, 39, 195-202. https://doi.org/10.1016/j.autcon.2013.09.006

Lee, S. and J. Yu. (2016). Comparative Study of BIM Acceptance Between Korea and the United States. *Journal of Construction Engineering*, 142(3), 05015016. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001076.

Liu, Z., Osmani, M., Demian, P. and Baldwin, A. (2015). A BIM-aided Construction Waste Minimisation Framework. *Automation in Construction*, 59, 1-23. http://dx.doi.org/10.1016/j.autcon.2015.07.020

Migilinskas, D., Popov, V., Juocevicius, V. and Ustinovichius, L. (2013). The Benefits, Obstacles and Problems of Practical BIM Implementation. *Procedia Engineering*, 57, 767–774. https://doi.org/10.1016/j.proeng .2013.04.097

Onungwa, I. O., Uduma-Olugu, N. (2017). Building Information Modelling and Collaboration in the Nigerian Construction Industry. *Journal of Construction Business and Management,* 1(2), 1-10.

Osmani, M. (2013). Design Waste Mapping: A Project Life Cycle Approach. *Proceedings of ICE-Waste Resource Management*, 166, 114–127.

Papadonikolaki, E., and Wamelink. H. (2017). Inter- and Intra-organizational Conditions for Supply Chain Integration with BIM. *Building Research and Information*, 45 (6), 649–664. https://doi.org/10.1080/09613218.2017.1301718.

Poirier, E. A., Forgues, D. and French, S. S. (2017). Understanding the Impact of BIM on Collaboration: A Canadian Case Study. *Building Research and Information*, 45(6), 681–695. https://doi.org/10.1080/09613218.2017.1324724

Rastogi, S. (2017). Construction 4.0: The 4th Generation Revolution. Proceedings of the 2nd Indian Lean Construction Conference (ILCC). IIT Madras Campus, Chennai, July 27-29, C288-C298.

Sackey, E., Tuuli, M. and Dainty, A. (2014). Sociotechnical Systems Approach to BIM Implementation in a Multidisciplinary Construction Context. *Journal of Construction Engineering*, 31(1), A4014005. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000303.

Said, H. M. and Reginato, J. (2018). Impact of Design Changes on Virtual Design and Construction Performance for electrical Contractors. *Journal of Construction Engineering and Manageement*, 144(1), 04017097. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001417.

Sexton, M. G. and Barrett, P. S. (2003). A Literature Synthesis of Innovation in Small Construction Firms: Insights, Ambiguities and Questions. *Construction Management and Economics*, 21(6), 613 - 622. https://doi.org/10.1080/0144619032000134147

Shen, L. Y., and Tam, W. Y. V. (2002). Implementation of Environmental Management in the Hong Kong Construction Industry. *International Journal of Project Management*, 20(7), 535 -543. https://doi.org/10.1016/S0263-7863(01)00054-0

Sijtsma, K. (2009). On the Use, the Misuse, and the very Limited Usefulness of Cronbach's Alpha. *Psychometrika, Springer; The Psychometric Society*, 74(1), 107-120. https://doi:10.1007/s11336-008-9101-0

Tang, L., Jin, R. and Fang, K. (2015). Launching the Innovative BIM Module for the Architecture and Built Environment Programme in China. *WIT Transaction on the Built Environment,* 149, 145–156. https://doi.org/10.2495/BIM150131.

Teo, A. L., Seah, K. and Chioh, J., (2006). CEMS - A Better Standard for Measurement of Building Works in Singapore. Singapore Institute of Surveyors and Valuers.

Ujene, A. O. (2014). Integrating Environmental Priority Concerns in Building Planning and Production in Niger Delta, Nigeria. *Journal of Architecture, Planning and Construction Management,* 4 (2), 37-56.

Volk, R., Stengel, J. and Schultmann, F. (2014). Building Information Modelling (BIM) for Existing Buildings — Literature Review and Future Needs. *Automation in Construction*, 38, 109–127. https://doi.org/10.1016/j.autcon.2013.10.023.

Walmikey, P. and Kulkarni, P. (2016). Construction Waste Management Through the Applications of BIM. *International Journal of Advanced Research in Science and Engineering,* 5(Special Issue 1), 193-200.

Won, J., Cheng, J. C. and Lee, G. (2016). Quantification of Construction Waste Prevented by BIM-Based Design Validation: Case Studies in South Korea. *Waste Management*, 49, 170 - 180. http://dx.doi.org/10.1016/j.wasman.2015.12.026

Won, J. and Cheng, J. C. P. (2017). Identifying Potential Opportunities of Building Information Modeling for Construction and Demolition Waste Management and Minimization. *Automation in Construction,* 79, 3–18. http://dx.doi.org/10.1016/j.autcon.2017.02.002

Xu, J., Jin, R., Piroozfar, P., Wang, Y., Kang, B., Ma, L., Wanatowski, D. and Yang, T. (2018). Constructing a BIM Climate–Based Framework: Regional Case Study in China. *Journal of Construction Engineering*, 144(11), 04018105-1 - 04018105-14. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001568

Yuan, H., Shen, L. and Wang, (2011). Trend of the Research on Construction and Demolition. *Waste Management*, 31(4), 670 - 679. https://doi.org/10.1016/j.wasman.2010.10.030.