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STRATEGIES FOR THE IMPLEMENTATION OF GREENBIM IN A DEVELOPING COUNTRY

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ABSTRACT

Incorporating BIM and green buildings is a continuous task in the construction industry to achieve sustainable designs and achieve energy efficiency and performance. It entails integrating BIM, building energy performance assessment and sustainable design. Achieving GreenBIM in the construction industry has, however, struggled to achieve this successfully. This study identified the strategies for achieving the implementation of GreenBIM in a developing country context. Data was collected using a well-structured questionnaire from construction industry professionals in South Africa. The collected data were appropriately analysed. It was found that industry leadership, support assistance and promotion of BIM education programmes were the top three strategies for achieving GreenBIM. The study identified and ranked the strategies. This is important for industry stakeholders to achieve the implementation of GreenBIM.

KEYWORDS

BIM, Sustainability, South Africa, sustainable construction, SDG

INTRODUCTION

Most times, humans, through their various activities, ignore the environmental impact. The performance of different activities made by human beings, including a vast role played by the construction industry, has resulted in environmental imbalance. Ofori, (2007) observed that the construction industry impacts heavily on the environment. Construction activities cause excessive resource use, water scarcity, high demand for energy, and environmental pollution in different forms among others (Ametepey & Ansah, 2015; Wieser et al., 2021). For instance, during the lifecycle of a building, it is responsible for +/-37% of the global energy-related $CO2$ emissions directly and indirectly (Green Building Council South Africa (GBCSA, 2021)). Thus the construction industry products significantly impact the environment. However, the adoption of different measures, including materials, techniques and practices (Ofori, 2007), has been adopted to achieve a lower environmental impact and lately, the adoption of technologies in the construction industry to achieve this goal (Adekunle et al., 2021; Ejohwomu et al., 2021). One of the initiatives in terms of the use of materials to reduce environmental impacts is the adoption of green buildings. The green building concept involves the use of different materials

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and processes throughout the building lifecycle aimed at reducing environmental impact and promote resource efficiency. It therefore contributes to keeping the environment in an environmentally balanced state.

Oguntona et al., (2019) opined that green buildings have outstanding benefits and notable structures compared to regular buildings. Some of the identified benefits of green building include better indoor air quality, protection of the ecosystem, improved energy efficiency, improved health and well-being of building occupants, less maintenance cost, increased marketability, and lower airborne disease transmission, among others(GBCSA, 2021; Oguntona et al., 2019). These benefits affect homeowners, end users, operators and other stakeholders in the construction industry. Parashar & Parashar, (2012) presented a green building as an implementation of constructing a building to be environmentally friendly and resource-efficient throughout the lifecycle of the building. A green building is a building that includes design, development, and operational practices and processes that fundamentally lower the negative effect on the environment. As mentioned earlier, combating the impacts of the environmental effects of the construction industry products and processes also involves the adoption of technology. Building information modelling (BIM) is critical and has a lot of identified benefits for the product, process, and people, among other aspects in the construction industry (Adekunle et al., 2022; Becerik-Gerber & Rice, 2010; Okereke et al., 2021). The combination of these two births the GreenBuilding information modelling (GreenBIM/GBIM) concept.

The implementation and benefits of green building and Building Information Modelling (GBIM) have significantly been recognised in the construction industry(Cassino et al., 2010). GreenBIM involves using BIM tools to achieve improved building performance goals and sustainability on a project throughout its lifecycle (Cassino et al., 2010). The adoption of BIM on green projects enhances the achievement of the project objectives throughout its lifecycle. The implementation of Green Building Information Modelling assists in improving and reducing the use of high energy, natural resources, and pollution and enhances end users' comfort and health. The interaction and integration of green building and Building Information Modelling improve and ensure the achievement of green objectives and sustainability outcomes throughout the building lifecycle. The implementation of Green Building Information Modelling is vital in analysing and understanding the sustainability of materials and other building performances during green building projects (Bonenberg & Wei, 2015). This study is aimed at identifying the critical strategies to achieve GreenBIM implementation in the South African construction industry.

The South African construction industry has been observed to be confronting some challenges impeding its efficiency. A critical one especially considering the target of achieving infrastructural development by 2030 (National Planning Commission, 2011) is the construction material challenge being experienced by the industry (Dithebe et al., 2018; Windapo & Cattell, 2013). Achieving the adoption of GreenBIM in the South African construction industry is important to achieve lower resource depletion and improves water efficiency. Furthermore, it contributes to the efforts of achieving sustainability and lean construction in the South African construction industry. One of the principles of lean construction is the reduction of waste (Sacks et al., 2010), which aligns with the benefits of GreenBIM. GreenBIM is a critical factor for achieving sustainability through environmentally sustainable design (Dall'O' et al., 2020). Also, the implementation encourages less waste production among others (GBCSA, 2021). It thus promotes material efficiency in the South African construction industry and sustainability right from the design stage.

STRATEGIES FOR THE IMPLEMENTATION OF GREENBIM

To achieve a reduction in the impact of construction activities and products on the environment, it is important that GreenBIM is implemented. GreenBIM promotes the achievement of the sustainability pillars of environment, economic and social, on both new building projects, refurbishment or major maintenance operations (Maltese et al., 2017). Various studies have identified some strategies for achieving GreenBIM implementation in the construction industry. A quick look into existing literature suggests that most studies have looked at the strategies to implement green building and BIM separately, but only a few have focused on GreenBIM. Hence most times, the strategies are derived from separate studies for achieving GreenBIM.

The McGraw-Hill report (Cassino et al., 2010) opined that to achieve GreenBIM implementation, there must be a seamless integration of software. According to the report, many software in use is not able to achieve this. Another factor identified by the study is the development of modelling standards towards achieving GreenBIM implementation. (Shukra & Zhou, 2021) opined that there must be an improved capacity in the functionality of BIM software for achieving the green building aspects.

The use of incentives as a strategy to achieve green building was critically examined by Olubunmi et al., (2016). Through a literature review, the study classified incentives into internal and external and examined them from the different stakeholders' perspectives. Similarly, Ebekozien et al., (2022), through a literature review, identified the development of policies as a strategy for achieving green building practices. These identified factors can also be applicable to the achievement of GreenBIM in the construction industry.

For construction industry professionals, there is a need to develop the required skills and expertise required to implement GreenBIM. Like other innovations adopted in the construction industry, there is a need to develop the required skills and competencies (Aliu, Aghimien, Aigbavboa, Ebekozien, et al., 2022). Required competencies for implementation are critical to the diffusion of new technologies and innovations in the construction industry. One critical aspect of the strategies for this study is that they are similar to those required for the implementation of Building information modelling.

RESEARCH METHODOLOGY

The study aims to identify the critical strategies required for implementing GreenBIM in the South African construction industry. A quantitative approach was adopted to achieve this, whereby a well-structured questionnaire was randomly administered to industry professionals online (background information on the professionals are provided under the findings). The research instrument was divided into two sections to collect data on the respondents' background (section A), and the other section (Section B) concentrated on the respondents perspective on the study focus. The section B of the research instrument was designed with the respondents showing their level of agreement from a five-point Likert scale for each of the presented ten strategies for GreenBIM implementation. The questionnaire presented respondents with ten strategies, and they were requested to rank the strategies on a five-point significance Likert scale. This approach has been shown to be effective in collecting data on different subjects in the construction industry and understanding professionals perspectives (Aliu, Aghimien, Aigbavboa, Oke, et al., 2022; Oladiran & Onatayo, 2019) and in studies involving emerging technological trends in the construction industry (Adekunle et al., 2022; Akinradewo et al., 2022; Ikuabe et al., 2022). A total of sixty-four responses were retriefved for the study.

To establish the reliability of the measurement instrument, a reliability test was conducted using the Cronbach’s Alpha. A value of 0.996 was achieved. This is considered a good value in light of the 0.7 minimum requirements for reliability (Kaiser, 1974; Pallant, 2010). Other tests conducted on the collected data include the mean, standard deviation and the Kruskal-Wallis test.

FINDINGS

BACKGROUND INFORMATION OF RESPONDENTS

The respondents for the study consist of sixty percent holders of a bachelor's degree, twenty percent of the respondents hold a diploma, 9.2% of the respondents have a Masters degree, this is followed by 7.7% possessing a Matric certificate, and 1.5% are PhD holders. The profession of the respondents comprises 33.8% Quantity surveyors, 21.5% construction managers, 16.9% electrical engineers, and 12.3% of the respondents are civil engineers. Other professions in the respondents are Architects (7.7%), Mechanical engineers (3.1%), safety managers and town planners (1.5% respectively). Respondents possess various degrees of industry experience; most of the respondents have between 0 – 5 years (67.7%). Other respondents possess 5-10 years of experience (26.2%), 15-20 years (3.1%) and 1.5% possess experience above 20 years in the construction industry. Furthermore, the respondents predominantly work with contracting organisations (32.3%), followed by those working with government parastatals (27.7%), 20% work with private organisations/clients, and 18.5% are consultants. The heterogeneity observed in the demography reveal the respondent are suitable for the survey.

STRATEGIES FOR IMPLEMENTING GREENBIM

Table 1 shows the respondents ranking of the strategies to implement green BIM in the South African construction industry. Based on the responses from the respondents, industry leadership was ranked first with (MIS=3.66; SD=1.250), support assistance from construction industry stakeholders was ranked second with (MIS=3.64; SD=1.252), quality of GreenBIM Model was ranked third with (MIS=3.63; SD=1.291), promote Green BIM educational programmes (MIS=3.63; SD=1.303) was ranked fourth, develop Green BIM training (MIS=3.63; SD=1.374) were ranked fifth, national standards was ranked sixth with (MIS=3.63; SD=1.202), business changes was ranked seventh with (MIS=3.58; SD=1.206), green BIM legal contracts was ranked eighth with (MIS=3.56; SD=1.296), government support was ranked ninth with (MIS=3.53; SD=1.272) and project procurement systems - integrated project delivery was ranked tenth with (MIS=3.52; SD=1.345).

Table 1: Strategies for GreenBIM implementation

Strategies	Mean	Std. Deviation	Ranking
Industry leadership	3.66	1.250	1
Support assistance from construction industry stakeholders	3.64	1.252	2
National standards	3.63	1.202	3
Quality of Building Information Modelling Model	3.63	1.291	4
Promote Building Information Modelling educational programmes	3.63	1.303	5
Develop Building Information Modelling training	3.63	1.374	6
Business Case	3.58	1.206	7
Building Information Modelling Legal contracts	3.56	1.296	8
Government support	3.53	1.272	9
Integrated project delivery	3.52	1.345	10

Table 2 presents the Kruskal-Wallis H statistics, where it was tested if there is a significant difference in the response based on the professional classification. It is observed that there is no significant difference in the responses except for "integrated project delivery" where the value achieved is 0.02. This is lower than the 0.05 established as the significant level (Pallant, 2010). Similarly, this was tested for the categories of respondents based on their familiarity with the GBIM concept, and it was revealed that there was no significant difference in the responses. It thus means respondents perceive the strategies similarly, irrespective of their familiarity with the GBIM concept.

Table 2: KW statistics of responses

	Professionals		**Familiarity with GBIM**	
	Kruskal-Wallis H	Asymp. Sig.	Kruskal-Wallis H	Asymp. Sig.
Government support	2.309	0.315	1.225	0.874
Industry leadership	0.277	0.871	2.717	0.606
Business Case	0.634	0.728	0.973	0.914
National standards	3.196	0.202	1.360	0.851
Develop Building Information Modelling training	1.829	0.401	3.070	0.546
Promote Building Information Modelling educational programmes	4.963	0.084	2.420	0.659
Integrated project delivery	7.800	0.020	3.242	0.518
Quality of Building Information Modelling Model	2.438	0.296	1.592	0.810
Building Information Modelling Legal contracts	2.613	0.271	1.994	0.737
Support assistance from construction industry stakeholders	1.814	0.404	2.368	0.668

DISCUSSION

The result suggests that there must be industry leadership to achieve GreenBIM implementation. This has been observed to be the case in most countries regarding BIM implementation (Edirisinghe & London, 2015; Smith, 2014). Although leadership can be provided by the government or other stakeholders, in some cases, a hybrid approach was adopted. It is, however, worth noting that the strategy adopted is often times tailored to the context and the prevailing factors (Adekunle et al., 2022).

Another result worthy of note is that respondents ranked integrated project delivery low. Cassino et al., (2010) identified integrated design and software integration as critical components for achieving GreenBIM. However, the promotion of BIM training for industry professionals and integrating BIM into educational curriculums are considered very critical to achieving GreenBIM implementation in the South African construction industry. There is a need to develop standards and frameworks to support the implementation of GreenBIM in the South African industry. Additionally, GreenBIM training frameworks to achieve the technical competencies required must also be developed. It thus implies that for GreenBIM to be adopted, all stakeholders must be actively involved and play significant roles.

The results also underscore the digital transformation of the construction industry specifically the adoption of BIM. The benefits, impacts and value of BIM implementation in the construction industry has been extensively researched (Adekunle et al., 2022; Akintola et al., 2016; Becerik-Gerber & Rice, 2010; Dakhil & Alshawi, 2014; Mostafa et al., 2018; Seyis, 2019). These studies has established the importance of BIM to the construction industry.

However, a critical aspect which has rather been given less attention but which is considered important to the implementation of GBIM is the quality of the BIM model. Considering the vital role of BIM in the impmentaion of GBIM, the quality of model geberated is considered critical in achieving GBIM. Thus there must be high level impelemtation of quality assurance process to ensure that BIM models produced are of meets the required industry standards.

CONCLUSION

This study identified the critical strategies for the implementation of GreenBIM in the construction industry. It revealed that to achieve GreenBIM implementation; there must be industry leadership; this might be undertaken and provided by the government. However, considering the respondents' response, there is a need to create awareness and practical benefits of GreenBIM for the South African construction industry to be done. Various professional bodies and private sustainability champion groups must embark upon this. However, there is a need for policy development to support the implementation and provide the legal framework. Therefore, GreenBIM leadership must be provided by a hybrid approach whereby the government and other stakeholders play different but intentional roles to achieve an industry-level GreenBIM adoption. This is imperative to achieve sustainability goals and promote lean principles of waste reduction, especially from an industry that contributes heavily to the environment. The strategies identified are important to achieving sustainability in the construction industry. It should be noted that this study was conducted in the South African construction industry context; however, the findings can be improved on by other researchers. Also, the findings can be adopted by other developing countries with similar contextual variables. In addition, the variables adopted in the study are majorly related to existing BIM studies as thereis a dearth on GBIM studies in the study area. Further research can be conducted on the assessment of the maturity of GreenBIM in developing countries and the framework for achieving industry-wide diffusion.

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