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The contribution of Building Information Management to Structural Engineering

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Abstract

It is noted worldwide that, the construction industry is faced with challenges of mismanagement, miscommunication and low quality products. Further, the construction players are investing their funds in dangerous projects and significant challenges with respect to site coordination and collaboration between the different disciplines. The introduction of Building Information Modeling (BIM) technologies can positively contribute to the structural engineering industry. BIM contributes to improved problem solving, development of innovative ideas as well as creation of complex designs. BIM as well enables structural engineering students to improve on structural design documentation as well as minimize errors during the design phase. The current research paper describes the benefits of implementing BIM to the construction industries in Botswana and other Africa countries. In addition, challenges to the adoption of BIM to the construction industry are discussed and strategies to address the constraints are proposed. A qualitative phenomenological approach was used to conduct the study and a thematic analysis facilitated data analysis. Findings indicate that BIM technology can help the construction players improve communication, coordination and collaboration in management of construction projects. Also, BIM enables structural engineers to improve on visualization and simulation of problems and enhance consistency of data. BIM software has made life easier in structural engineering by helping engineers visualize, design, analyze, document and build projects more efficiently, accurately and competitively. The collaboration of BIM tools such as the Autodesk tools, Revit architecture, Advanced Steel, Revit Structure, Revit MEP, Bentley System and CSI tools such as SAP 2000 has helped structural engineers overcome construction challenges such as clash designs, delays and project costs overruns. In conclusion, BIM tools should be highly advocated in structural engineering to help improve the design and structure of buildings and architects.

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Keywords—Construction industry, building information modeling, technology, strategies, constraints, construction projects.

INTRODUCTION

The construction projects can be considered by their nature to be uncertain, risky and complicated. These attributes are evident in remote construction projects which have unique problems caused by factors such as remoteness of the project site itself that also contributes to loss of control over management and communications [1]. The aspects of little managerial skills as well as lack of human resource and infrastructural input contribute to challenges in construction projects. Coordination and communication have been the main challenges in remote and poorly managed construction projects [1]. The conventional management methods have been found to be defective in handling such problems which forced scholars to suggest approaches such as advanced computer based management system that ensures effective information management and communication.

The construction industry has long been observed to contribute to the economy of a country. However, the construction industry is faced with issues such as poor quality of work, dirty construction sites, occurrences of accidents, delays and dangerous sites conditions. The advent of ICT and increased technology innovation such as Building Information Modeling (BIM) has helped manage most construction projects and contribute to the success and productivity of the construction industry [2]. The BIM technology has been observed to be suitable for both risky and complex construction industries. The BIM has been applied in various countries such as United Kingdom, Malaysia, Australia, HongKong and Denmark among others. BIM awareness is on the rise as those who have not adopted it intend to. Data show that BIM awareness is on the rise in UK which is observed to the most common project design in UK in the next five years from 2017. Data show that 97% of the communities in UK have the awareness in BIM as depicted by figure 1 [3].

In addition, BIM adoption in the Middle East countries is also rising. Countries like Dubai, UAE are increasingly integrating BIM in their construction industries due to the increased development of the countries' economy. However, BIM adoption in Africa is low as most of the countries are in their developing states. Despite the increased awareness of BIM in Nigeria, the adoption is still low due the constraints in the implementation of both process and technology [4]. The implementation of BIM in South Africa is a challenge due to constraints in personnel inadequacies in terms of training, education and skills development. Figure 1 and 2 demonstrates the adoption of BIM in European countries and Middle East countries.

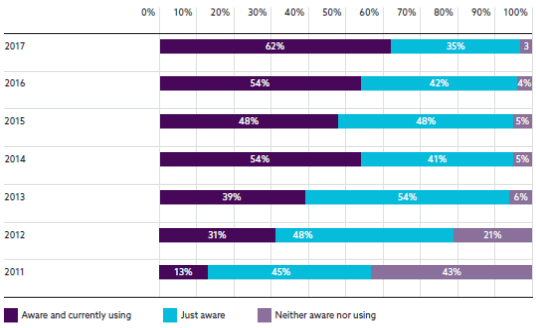


Figure 1.BIM Awareness in UK community. Source: [3].

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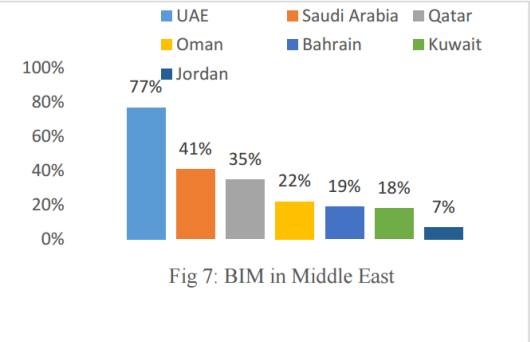


Figure 2.BIM adoption in Middle East countries. Source: [5]

Reference [2] describes that the Malaysian government is advocating for the implementation of the of the BIM in construction projects due to its benefits of facilitating solving problems in the construction industry such as preventing disputes between construction players, minimizing project delay as well as decreasing construction cost. BIM has helped structural engineers to stay competitive and keep pace with today's economy. BIM has helped structural engineers to better handle and visualize components as well as ensuring data accuracy and reduction in drafting errors [6].

Business Information Modeling is described as "digital representation of physical and functional characteristics of a facility that serves as a shared knowledge resource that forms a reliable basis for decisions during its life cycle, from inception onward" [7]. BIM involves the characteristics of collaboration between distinct stakeholders at varying phases of facility lifecycle to insert, extract, update or modify information in the model to reflect the roles of that stakeholder. BIM combines different threads of information into one operating environment thus, reducing different documents needed in the site [7]. The BIM is observed as an incorporation of software tools and techniques in the lifecycle of building and construction process. BIM focuses on enabling viewing and visualizing of buildings in 3D entities. The rapid technology advancement has led to the adoption of BIM in the construction industry including emerging Smart Building Environments (SBE) that incorporates embedment of smart objects such as sensors and actuators leading to intelligent interaction between humans and computing and communication technology in day-to-day activities [8].

The BIM software is based on Object Oriented Programming. The presence of new 3D tools is allowing structural engineers and designers to create models for documentation and coordination. The BIM software helps in developing buildings in 3D dimensions that utilize the X, Y and Z dimensions [6]. The Autodesk Revit is considered as the market leader in building and construction that utilizes BIM. The Autodesk Revit is greatly compatible with civil engineering software such as SAP2000, ETABS and Robot Structural Analysis. Revit allows the user to develop walls and assign attributes to it such as exterior texture among others [6]. Figure 3 demonstrates the use Revit architecture in modeling. Despite the popularity and domination of Autodesk Revit, several other modeling systems such as Bentley Systems are applied. Figure 4 describe the awareness and usage of various BIM modeling tools and software among UK residents.

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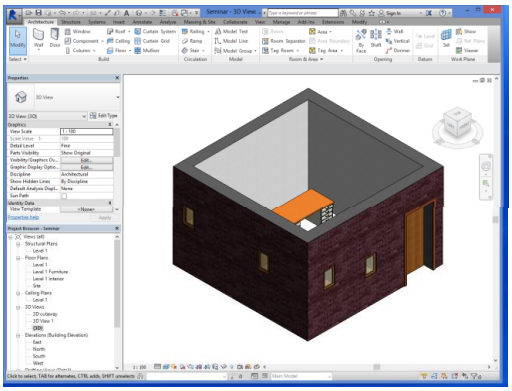


Figure 3.Use of Revit architecture in modelling of buildings. Source: [6]

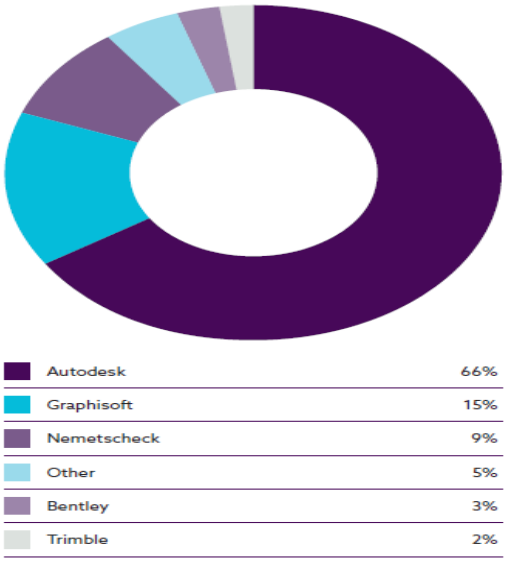


Figure 4. Mainly used BIM models among communities in UK. Source [3].

Problem Statement

The construction industry is facing huge challenges forcing structural engineers to improve quality, value and productivity. Challenges in the construction industry include delays, production of low quality products, cost overrun as well as dependence on old technology [9]. In addition, challenges in poor management and miscommunications have resulted in low quality drawings and architects. Also, issues such as inadequate project pre-planning and uncertainty in project process integration contributes to misinterpretation and miscommunication that lead to misguided and inappropriate decision making process [1]. There has been slow adoption of BIM technologies in the construction industry due to challenges of its implementation. The adoption of BIM in Botswana is still a challenge due to constraints in technology and people. Local companies owned by Botswanans are not familiar with BIM however, only few international companies know a little about BIM. There is need for the awareness of adoption of BIM among structural engineers. Increase in training activities on the use of BIM tools will contribute to the increase in the adoption of BIM and its contribution to the structural engineering. Moreover, several international companies have adopted BIM and given testimonials on its importance and contribution to positive results.

Purpose

The purpose of conducting this study is to develop a framework and a plan for initiating Building Information Modeling to the Botswana's structural engineers. Botswana is among the developing countries with minimal integration of technology in the construction industry [10]. The initiation of the BIM in the construction industry will aim to boost the production and quality of products and services in the construction industry and contribute to structural engineering in Botswana.

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Research Questions

1. What benefits does the Building Information Modeling have to the structural engineers in Botswana?
2. What are the constraints to the adoption of the Building Information Modeling among structural engineers in Botswana?

MATERIALS AND METHODS

Research Methodology

The research methodology provides framework that helped the researcher to structure and execute the data collection and analysis process. The research approach used was the qualitative research method. Qualitative research method was chosen as it focuses on exploring and interpreting a phenomenon. In addition, qualitative research focuses on non-numerical data [11]. Qualitative research study focuses on theoretical findings and discoveries as well as deals with a small number of non-representative samples [12]. The design also used was the phenomenology research design that focuses on describing people's perceptions about their surrounding environment. The phenomenology as well describes human experience of the world people lives in [13]. The study thus, used primary qualitative data selected from structural engineers in Botswana.

Population and Sampling

The target population is identified as a defined whole accumulation of units from which sampling takes place [14]. The target population of the study was structural engineers in the building and construction industry in Botswana. The sampling process that entails extracting a sample from the population used was the purposive sampling. Reference [15] indicated that purposive sampling is suitable for the phenomenological qualitative research where participants are expected to meet specific criteria during the selection moment. The criteria used in this study were that the structural engineers must have worked in the construction industry for more than 3 years in Botswana and managed a team of at least 5 people. The purposive sample considered to sample 3 structural engineers.

Procedures

Interview processes were used for the collection of information as it helps in exploring details from participants and encourages participants to express their own thoughts and feelings [16]. The participants were given an informed consent that stated the purpose of the study and the contributions of every respondent to the study. The consents were sent via email and respondents invited to attend to interviews via emails and phone calls. The interviewer controlled the interviewing process.

Data Analysis

Data was analyzed by use of thematic analysis. Thematic analysis concerns itself with identifying common themes among various participants [17]. The themes were identified and categorized manually based on researchers informed knowledge. Thematic analysis helped to categorize related information and the contributions of Building Intelligence Modeling to construction industry was identified.

Ethical considerations

The ethics of confidentiality and anonymity of participants was adhered. The ethics were achieved by not including personal details in the research study. In

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addition, biasness was minimized when reporting and interpreting the data.

RESULTS

This section focuses to present the results from the interviewed respondents. The first section focuses to present the overall demographic characteristics of respondents while the other section discusses the objectives of the study. The results indicate that sample consisting of three participants two were males while one was a female structural engineer. The mean age for the respondents was 43 years with the minimum age of35 years and the maximum age of52 years. In addition, the mean years of work experience was seven years with the minimum of4 years and the maximum of10 years of work experience.

Research Question One

The research question focused to assess the benefits of Building Information Modeling to the structural engineers in the construction projects in Botswana. The results indicate that the participants were aware of Building Information Modeling and had implemented in their projects. Additionally, the participants viewed the Building Information Modeling as a digital representation of building project and work flow that helps in designing buildings. The representation and workflow is facilitated by use of software package. The participants added that BIM facilitates collaboration to enable project success. The participants indicated that BIM have numerous advantages that facilitate the progress of construction projects.

The main theme emerging in this question is that BIM have facilitated improved communication and collaboration among project team members. Effective communication and collaboration among team members results in efficient handling and sharing of tasks that facilitates success of the project. The participants added that BIM have helped their construction projects by lowering ofproduction costs as well as total reduction in cost of other infrastructures. BIM have facilitated provision of quality products, services and operations. One of the participant described that using the 3D architecture in BIM have facilitated provision of quality drawings, architects and buildings as compared to the old technology. The participants demonstrated the necessity of BIM to structural engineering field as to help engineers reduce drafting errors as well lower designing cost. Also, participants indicated that BIM enables structural engineers improve on visualization and simulation of problems and enhance consistency of data. BIM software has made life easier in structural engineering by helping engineers visualize, design, analyze, document and build projects more efficiently, accurately and competitively. The collaboration of BIM tools such as the Autodesk tools, Revit architecture, Advanced Steel, Revit Structure, Revit MEP, Bentley System and CSI tools such as SAP 2000 has helped structural engineers overcome construction challenges such as clashes in designs, delays and project costs overruns.

Research Question Two

The research question identified the constraints hindering the adoption of Building Information Modeling among structural engineers in the construction industry in Botswana. Participants gave various responses although themes were identified from the responses. The main theme addressing the constraints to BIM adoption was inadequate training and skills in

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operating the Business Information Modeling. The training constraints have resulted in slow adoption and awareness of the BIM technology. Structural engineers lack Revit training which is considered as essential in the construction industry. In addition, participants indicated constraints to BIM adoption was inadequate infrastructural resources and finances for funding implementation of BIM projects. One of the participants indicated that inadequate finances have resulted to challenges in purchasing BIM tools such as Revit Architectural. The training courses available are inadequate and are also expensive to enroll in. The participants called for immediate intervention to the constraints by the government of Botswana.

DISCUSSION

The section discusses the results of the findings in relation to the research questions. There were two research questions which focused to discuss the benefits of the Building Information Modeling technology to the construction industry and also the constraints to the adoption of Building Information Modeling. The participants first described Building Information Modeling as a digital representation of workflow of building designs and projects that is facilitated by software packages. The findings are confirmed by several scholars [7] [8] [18]. The participants indicated that Building Information Management has helped them excel in the building and construction industry. BIM has been attributed to have numerous benefits including facilitating communication and coordination of team members in the construction projects [2] [7].

In addition, BIM technology integration in the construction industry has helped in reducing construction costs and also facilitated in engaging in risky ventures. Reference [2] indicated that BIM technology has enabled construction players to venture their projects in dangerous sites and also engage in risky ventures. BIM has also enabled reduction of infrastructural costs. Reference [8] indicated that BIM technology through the integration of 3D architecture has facilitated the improvement of quality of architectural designs and buildings. Participants indicated that BIM help in reduction of design and drafting errors as well lower designing cost. BIM has facilitated rise in visualization and problem simulations in structural engineering field thus contributing to data consistency [6].

The study also assessed the constraints to BIM adoption of construction players whereby inadequate training and skills to operate BIM was the main challenge. The findings are consistent with several studies [9] [2]. Moreover, participants described constraints to BIM adoption as inadequate finances to purchase BIM tools. Similar findings were observed by [2].

CONCLUSIONS

There is recent increase in challenges in construction industry such as mismanagement, miscommunication and low quality products. In addition, construction players are investing their funds on projects located in dangerous sites, occurrence of accidents, increase in delays, and experiencing poor coordination and collaboration which requires intervention. Structural engineers indicated increased benefit associated with BIM integration in the building and construction industry. BIM has facilitated effective communication, collaboration and coordination of team players which have resulted to success of projects. In addition, with the integration of 3D architecture in BIM, the quality of products, designs of buildings and architects is also

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increasing. Additionally, BIM has enabled easy handling of problems among structural engineers which results in data stabilization. The collaboration of BIM tools such as the Autodesk tools, Revit architecture, Advanced Steel, Sost-X, Revit MEP, Bentley System and CSI tools such as SAP 2000 has helped structural engineers overcome construction challenges such as clash designs, delays and project costs overruns. However, despite the increased benefits of BIM in the construction industry, the pace of adopting BIM is very low in Africa compared to European counterparts due to the challenges of adopting BIM that is attributed by structural engineers viewing BIM as disruptive technology that transforms construction industry to a new direction. The adoption of BIM to eradicate traditional methods is facing huge challenges such as making construction players understand how BIM offers more benefit compared to 2D drafting, education and training as well as process of upgrading technology.

RECOMMENDATIONS

The increased constraints to BIM adoption are hindering its adoption rate in the construction industry, the progress of construction projects and in overall economic conditions which thus, requires adequate intervention. The participants described several intervention measures that would help in increasing adoption of BIM. The participants indicated that the government should heavily intervene by providing training opportunities and courses and also providing funding and finances to support BIM projects. Similarly, the researcher plans to intervene on the issue by proving training courses in Building Information Modeling. This can be achieved by the researcher advancing on the skills by enrolling in short training courses in Revit Structure, Robot Structural, ETABS/SAP2000 as well as programming languages such as Python and Dynamo.

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REQUEST FOR TRAINING BY THE AUTHOR

Similar initiatives are conducted in Malaysia whereby the Malaysian government is giving grants to undergraduate students to obtain training on BIM. The government ensures that undergraduates receive training in using BIM tools such as Revit Architectural, Revit Structural and Navisworks and are awarded BIM certificates [2]. The author thus, focuses to enroll in short training courses to advance the skills and knowledge about BIM tools. The author therefore, plans to enroll in training webinars at Graitec whereby the university in which the author is attached will help in developing a budget to enroll in BIM training.

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