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The Level of Awareness and Forecast of Usage of Building Information Modelling by Ghanaian Construction Firms

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Abstract:- Building information modelling is increasingly being used by most of the world's construction industries, constantly changing design procedures, construction, facility management and maintenance. BIM, a technological transformation in the construction industry, has projected numerous benefits to improve upon all the inefficiencies in the world's construction industries. Subsequently, it has been adopted by Germany, Finland, the United States, the United Kingdom, Singapore, Australia, and Hong Kong to mention but a few. Unfortunately, the construction industry in Ghana has yet to recognize the full prospects of BIM technology. This paper seeks to find out the level of awareness and forecast the level of usage by construction firms in Ghanaian construction. In effect, survey research was adopted which incorporated the issuing of a closed-ended structured questionnaire. Out of 130 questionnaires distributed, 102 questionnaires were returned in all appropriateness representing 79% of the responses. The respondents comprised architects, quantity surveyors, construction managers, project managers, civil engineers, and structural engineers, among others practising with firms or organizations with good reputations, registered with the necessary statutory authority, and actively involved in construction activities within the Ghanaian construction industry. The field survey was divided into BIM and non-BIM users. 72.5% of the professionals were just aware of BIM, which indicates a relatively high level of awareness. Subsequently, only 23.5% were aware and currently using BIM whilst 27.5% were neither aware nor using BIM. It also showed how most firms are not planning to use BIM as part of their daily work ethics accumulating 52.6% of the construction firms whilst only 47.4% of the firms are planning and preparing to use BIM. Autodesk AutoCAD & Autodesk Revit recorded the highest BIM tool usage with 37.5% and Project Visualization was the most used BIM application with a mean score of 3.958 that is used 80% of the time. The study concluded on a note that government, professional bodies, and construction firms must help propagate the awareness, implementation, and usage of BIM.

Keywords:- *Building Information Modelling (BIM), Awareness, BIM Tools, BIM Levels, BIM Applications, Ghanaian Construction Industry, Ghanaian Construction Firms.*

I. INTRODUCTION

The construction industry has encountered multifold criticism all around the world due to its inefficiency and absence of productivity which has been blamed on the fragmented disposition of delivering projects (Khalfan and Anumba, 2000). However, various initiatives were introduced into the construction industry to accomplish the substantial drive for continual advancement in how the industry works (Malik *et al.*, 2000). As a result, several revolutions in its production methods and operations have occurred over the years (Egan, 1998; Egan, 2002). BIM was one of them, the technological innovation for the construction industry (Poirier *et al.*, 2015). This started to transform the methods in which buildings were designed, appeared, acted and built (Eastman *et al.*, 2008). The introduction of BIM constitutes one of the most fascinating advancements in designing, operating, managing and maintaining buildings (Ayarici et al., 2009). It provides answers to some extent or almost all the construction industry's problems that are providing the grounds for efficient collaboration, effective communication among all parties of a project and streamlining the design and construction methods resulting in enhancing the overall efficiency of the construction industry (Kubba, 2012; Abubakar *et al.*, 2014).

According to Hussin *et al.* (2013) the disintegrated, one-off, and complicated manner of the construction industry, is usually challenged by habitual problems such as time overrun which is 70% of projects carried out, cost overrun normally 14% of contracts cost, and generation of waste which is about 10% of material cost. As a result, Azhar *et al.* (2008) asserted that time overrun and cost overrun are prime problems in both developed and developing countries but the tendency in developing countries is additionally harsh, thus these overruns at times surpass 100% of the predicted cost of the project. A considerable reference point is how Shaibu *et al.* (2004) identified that the construction industry in most countries is associated with poor performance, depicted in delays and cost overruns. On another platform, Dadzie *et al.* (2012) affirm that the construction industry in Ghana is enduring project failure and inadequacies in the field of delays, exorbitant variation of projects, disapproved health and safety practices, escalated contract sums which is a familiar knowledge known across the board but the painful truth is that, several construction projects frequently sustain delay with the predominant variation order increasing the contract sum;

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consequently, doubling the actual tender figure. Rahman *et al.* (2013) contended that attaining completion of the construction project is a basic prerequisite. Still, it seems impossible for projects to be finished on time, which has become a phenomenal problem in the world. A report produced by the Construction Industry Development Board in 2007 revealed that design inaccuracies account for half of project failures, construction errors for 40%, and material faults for 10%. This clearly indicates that the Ghanaian construction industry has numerous issues that require attention (Ofori, 2012). As a result, the construction industry's performance on projects in developing countries including Ghana, is unsatisfactory regarding its cost, productivity, time and quality (Ofori, 2001). Hence, there are escalating calls for the industry to change (Elmualim & Gilder, 2014).

Nevertheless, BIM has numerous solutions to the challenges plaguing the construction industry since it considers every component of the building: all the geometries, quantities, relationships, information, and facilities concerned with construction (Zuppa *et al*., 2009). For instance, the conventional flow of information among stakeholders of a project was the only way stakeholders had to be clarified on subjects, elaborate, and render information concerning the project however, the technological world today has birth forth a software and a tool called BIM, to provide a single platform in which exchange of information, visualization and among others can be achieved (Garber, 2009; Azhar, 2011). Ayarici *et al*. (2009) stated that, of late several pilots and live projects have been finalized and recorded in Finland, Sweden, Norway, Germany, France, Singapore, the UK, and Australia, which verified the competence of BIM usage in the construction process. However, developing countries are starting to show up on the scene (Sawhney, 2014). According to a survey by McGraw-Hill Construction (2008), a general adoption of BIM is ongoing across the construction industry with its usage anticipated to grow rapidly both inside firms and across the Architecture, Engineering, and Construction (AEC) industry in the years to come.

This necessitates the need to explore the level of awareness, its usage, and the extent to which construction firms in Ghana are willing to implement BIM as well as its application in their projects.

II. LITERATURE REVIEW

➢ *Building Information Modelling*

Building Information Modelling (BIM) depicts a new paradigm shift in the Architecture-Engineering-Construction (AEC) industry which has swiftly reshaped the construction industry (Azhar *et al*., 2012; Wu *et al*., 2013; Succar, 2009; Lu & Li, 2011). Revolutionized technology and processes have speedily changed the pattern used in the conception, design, construction and operation of buildings (Hardin, 2009; Yah *et al*., 2008). These days, BIM is a hot topic (Tomek & Matejita, 2014; MyoungBae & JinUk, 2012) which stands for the process of developing and using a computerized generated model that can simulate a facility's planning, designing, construction and operation (Azhar *et al*., 2010). One of the most likely to succeed development in the AEC is BIM and until now, without a single globally recognized definition (Codinhoto *et al*., 2013; Jensen *et al*., 2013; Jongeling, 2008; Kymmell, 2008). Kuroshi *et al*. (2010) posit that one can be tempted to qualify BIM as an ambiguous term because it may be viewed from a different angle by academics and industry practitioners, nevertheless, that will be dependent on the term being regarded as a tool or a process. Aranda-Mena *et al*. (2009) add that BIM with its many definitions can be viewed from a specific stance with the architects chiefly involved with the design aspect of BIM, structural application of BIM by the engineering firms, and among others but there exists a generally recognized definition as the process of producing building models although the variation lies within the definition of the nature of the process. However, the many different definitions of BIM demonstrate a portion of the comprehensive capabilities of BIM philosophy (Talebi, 2014). That produces a language with similar output and meaningfulness to everyone, depicting the actual picture (Ghauri *et al.*, 2010). But in this research paper Building Information Modelling is defined as "a digital representation of physical and functional characteristics of a facility and a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition" (NBIMS, 2010). This was selected because, despite the wide variety of BIM definitions, it is a reliable and generally agreed that BIM is a process that enhances the building's performance throughout the course of its whole life cycle rather than just a basic 3D model. (Lu *et al*., 2013).

➢ *What BIM Is Not?*

The simplest means to truly grasp BIM is to clearly recognize what BIM is not because there are numerous common misinterpretations regarding BIM (Jernigan, 2008). A considerable reference point is how Eastman *et al.* (2011) emphasized the misconstrued description of BIM by software developers who depict their product capabilities as the definition of BIM causing a state of confusion in the definition of the BIM technology. According to Jernigan (2008), the notion that BIM is composed of a single model or database is one of the most prevalent misconceptions about it. In reality, BIM is composed of several interconnected models and databases. On another platform, Eastman *et al.* (2011) stipulate that some tools function as BIM technology tools but are not, for instance, Models that hold 3D data only with or without object characteristics, for example, Google SketchUp application; Models without the support of behaviour which is non-intelligent parametric objects; In order to define the building, models consisting of several 2D CAD reference files need to be combined. Furthermore, Models permit the modification of dimensions in one view without instantly updating other views to reflect those modifications (Eastman *et al.*, 2011).

➢ *The Ghanaian Construction Industry and BIM*

The Ghanaian construction industry is a big industry, considered one of the principal forces driving the economy; dealing with every economic activity, aimed at creating, renovating, rehabilitating, consolidating, restoring, renewing, refurbishing, and extending fixed assets to buildings, civil engineering constructions, enhancement of land and

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development (Amoatey et *al*., 2015; Osei, 2013). Ofori (2012) stipulates that the construction industry is all-around, cutting across every geographical aspect of the economy, taking into consideration, the buildings, roads, dams and bridges. Consequently, the construction industry contributes to the general gross domestic product (GDP) of Ghana, increasing from 7.6% in 1996 to 9.9% in 2011 and ascending again to 11.8% in 2013 and rising again to 3.24% in 2022 (Ghana Statistical Service, 2022). Osei (2013) further explains that the construction industry's input to the total industrial development expanded from 29.8% in 1993 to 34.3% in 2000 and accounted for 15% of the country's annual GDP in recent times (International Trade Administration, 2024). In 2011, its contribution was assessed to have stepped up to 37.4%, implying that it has a boundless possibility of instigating growth and creating many jobs (Amoatey *et al.*, 2015). However, a survey conducted into the construction industries of the developing countries with Ghana inclusive encountered significantly numerous challenges (Ofori, 2012). Fugar *et al*. (2009) assert that the Ghanaian construction industry is plagued by several issues including cost and time overrun due to expansive delay, poor quality works, long duration of pre-contract award process, and low output among others. Consequently, Ofori (2001) stipulates that, due to these challenges, the construction industry performs poorly on projects in developing countries, including Ghana particularly in the areas of cost, productivity, time, and quality. Accordingly, Aibinu & Jagboro (2002); and Oyewobi *et al*. (2011) stressed that if the construction industry is to provide value for money and meet the demands of its clients effectively then there is a need to improve performance and efficiency. Hence, BIM is unavoidable (Adriaanse, 2014; Institution of Civil Engineers, 2012; McGraw-Hill Construction, 2010, 2012; Samuelson & Björk, 2014; Williams, 2015). Presently, with the rising technological advancement, BIM is increasingly being used in many countries to facilitate the buildings' conception, design, construction, and functioning. (Wong *et al*., 2009). Numerous advanced economies worldwide have reported outstanding BIM implementation results (Abubakar *et al*., 2014). Studies conducted using data from 32 key projects that used BIM by Stanford University Center for Integrated Facilities Engineering (CIFE), identified the advantages of using BIM as the following: eliminating up to 40% of unplanned changes, 3% of veracity in cost estimation, up to 80% of time used in producing a cost estimate is cut down, Clash detection can save up to 10% of the contract value and cut down on project time by up to 7% (CIFE, 2007). Given this, there is an urgent need for the construction industry in Ghana to be enlightened on BIM and be aware of the emerging technology in the global construction industry.

III. METHODOLOGY

The study employed survey research by distributing questionnaires to get the opinions of construction industry professionals. The questionnaires were self-administered and electronically retrieved, that is some of the data were collected using Google Forms by sharing links through various WhatsApp groups. Babbie (2013) asserted that this method should be applied in situations where it is practically difficult to determine the precise number of individuals in a population, which is why these professionals were chosen through a purposive sampling method. Additionally, it is important to note that the primary rationale behind the purposive sampling method is that the respondents needed to be well-versed in and have utilized any of the developing technologies prior to being given a questionnaire (Acquah et al., 2018).

Hence the target population was almost all construction professionals namely, architects, quantity surveyors, construction managers, project managers, civil engineers, and structural engineers, among others practicing with firms or organizations with good reputations, registered with the necessary statutory authority, and actively involved in construction activities in the Ghanaian construction industry.

- *Structure of the Questionnaire*

The questionnaire was structured into three sections, the first contained information about each of the respondents. The second section established whether a respondent was aware and using BIM termed as a BIM user. Respondents not aware of BIM were termed as Non-BIM. This established the level of awareness of BIM and forecast for its usage. The third section entails the level of users among the BIM users. The questionnaire had three sections: four (4) primary demographic questions for all the respondents, two (2) specific questions for non-BIM users, and five (5) questions for the BIM users to extract significant information.

- *Questionnaire Desi*gn

The questionnaires adopted highly structured and closed questions to enable respondents to choose from a range and a list of multiple-choice answers making the respondents' work easier. The questionnaire was issued to two different respondents -: non-BIM users and BIM users.

In all, a hundred and thirty (130) questionnaires were distributed by the researcher with a hundred and two (102) retrieved for analysis representing 79% depicting a high number of responses. Seventy-eight questionnaires were retrieved from non-BIM users indicating 76% and Twenty-four questionnaires from BIM users depict 24%. A total number of twenty-eight (28) questionnaires for both BIM and non-BIM users were not completed or either inappropriate for analysis.

IV. RESULT AND DISCUSSION

The analytical tool used in deriving the outcomes discussed below was descriptive statistics, Statistical Package for Social Sciences (SPSS) version 21. The presentation of the results and discussion was divided into two major sections namely; Non-BIM users and BIM users.

- *Demographic Information*

Table I and Fig. 1 below describe the nature of the firms in which each respondent operates. 35.3% of respondents were with construction firms. Architectural firms recorded the second-highest number of respondents with 19.6%. Others including consultancy, surveying firms, and were third at a

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pace of 12.7%, closely followed by Architectural - Engineering - Construction firms with 11.8%, and respondents with Engineering firms also accrued 7.8%. Construction - Engineering firms had 6.9%. Architectural - Construction firms and Architectural - Engineering firms recorded the least number of respondents, 2.9% apiece. In totality, it can be concluded that most of the respondents were within or are attached to a construction firm which is 56.9% of the total respondents.

Table 1 Respondents' Nature of Firm

Number	Nature of Firm	Number of Respondents	Percentage(%)
1	Architectural	20	19.6
2	Engineering	8	7.8
3	Construction	36	35.3
4	Others	13	12.7
5	Architectural – Engineering	3	2.9
6	Architectural –Construction	3	2.9
7	Construction – Engineering	7	6.9
8	Architectural - Engineering – Construction	12	11.8
	Total	102	100

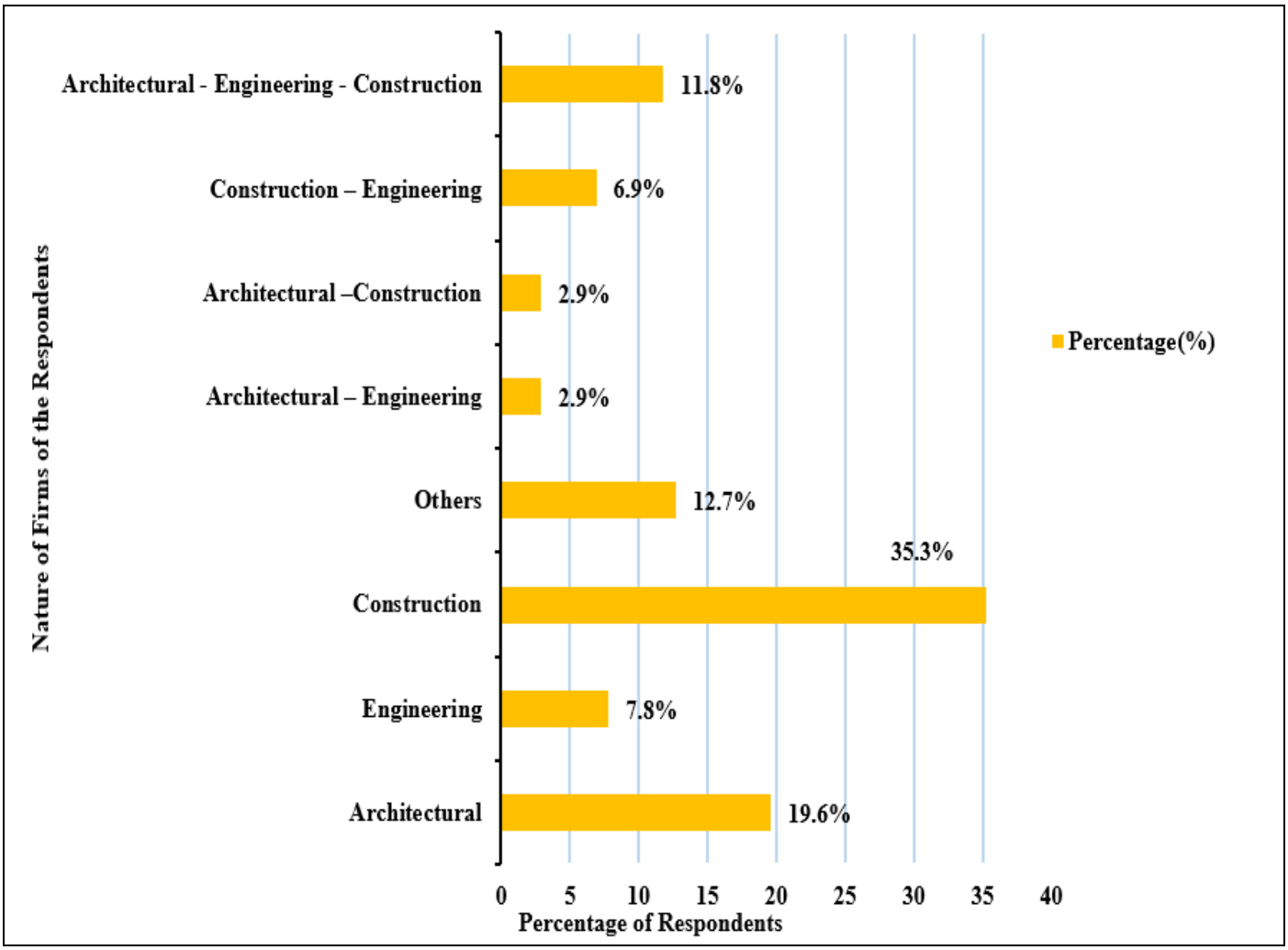

Fig 1 Respondents' Nature of Firm

According to table 2 and Fig. 2, illustrates the period of existence of the firms. 29.4% of the respondents to the field survey were attached to firms whose establishment were over 30 years; closely followed by 28.4% of practicing firms of 6–10 years. Respondents' Firms of 11–20 years of establishment were ranked third with 17.6%, followed by respondents' Firms of 21–30 years had 12.7%, and the last firms under 5 years had 11.8%. Hence, it can be deduced that most of the respondents were attached to firms with over 30 years of establishment (29.4%). This indicates that the firms have a strong legacy and dominance in the construction industry.

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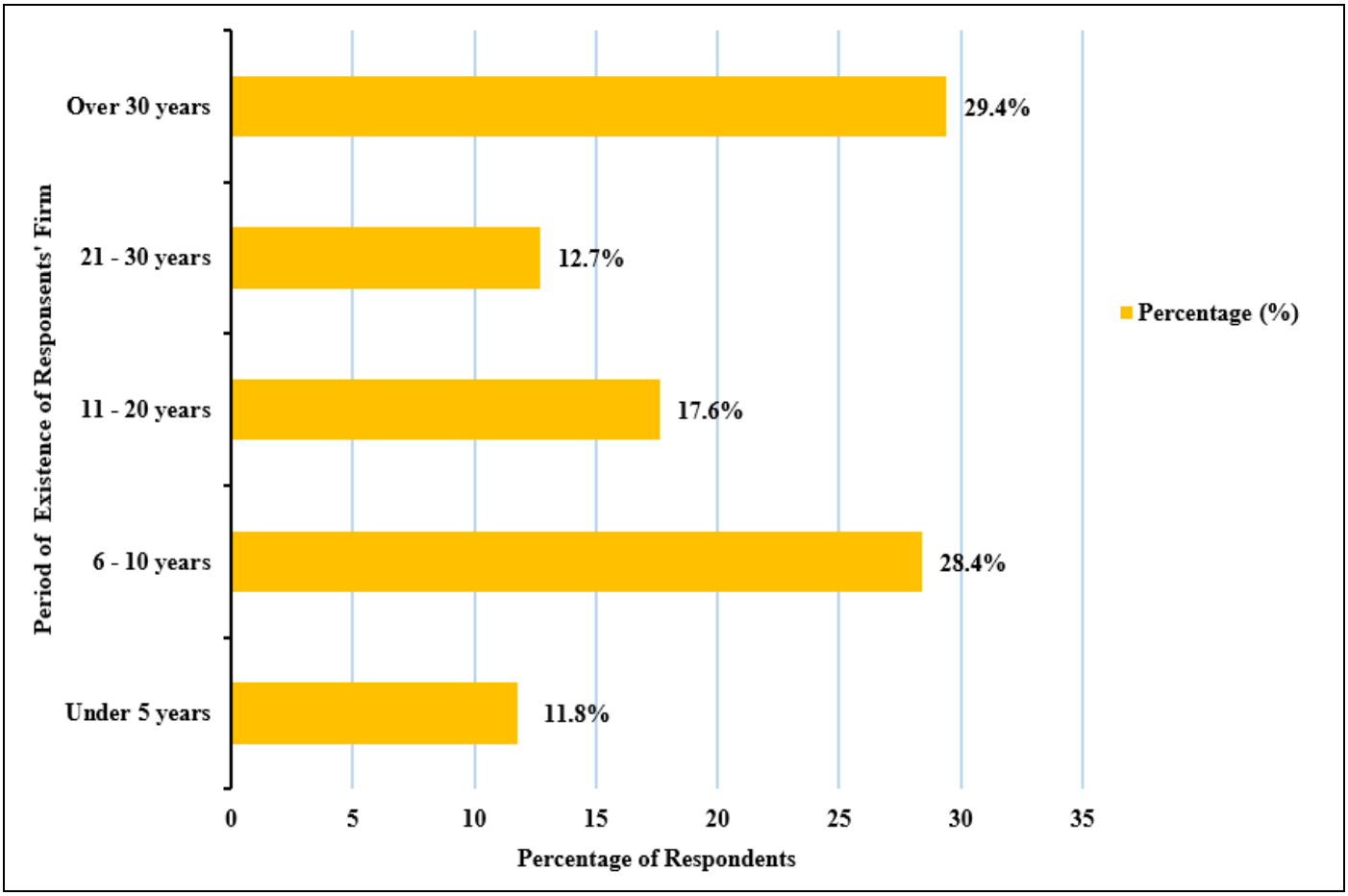

Fig 2 Period of Existence of Firm

Table 2 Period of Existence of the Firm

Number	Period of Existence of the Firm	Number of Respondents	Percentage (%)
1	Under 5 years	12	11.8
2	6 - 10 years	29	28.4
3	11 - 20 years	18	17.6
4	21 - 30 years	13	12.7
5	Over 30 years	30	29.4
	Total	102	100

Also, table 3 and Fig 3 describe the profession of the respondents. 29.4% of the respondents were quantity surveyors recording the highest number of respondents followed by 24.5% were Architects. 22.5% were Project managers, Civil engineers followed by 10.8%. Moreover, the structural engineers had 6.9%. Others including Electrical Engineers, Land Surveyors, Facility Managers, and others had 5.9%. Hence, it can be inferred that most of the respondents who participated in this survey worked as Quantity Surveyors (29.4%) of the total respondents.

Table 3 Profession of Respondent

Number	Profession of respondents	Number of Respondents	Percentage (%)
1	Project Manager	23	22.5
2	Civil Engineer	11	10.8
3	Architect	25	24.5
4	Quantity Surveyor	30	29.4
5	Structural Engineer	7	6.9
6	Others	6	5.9
	Total	102	100

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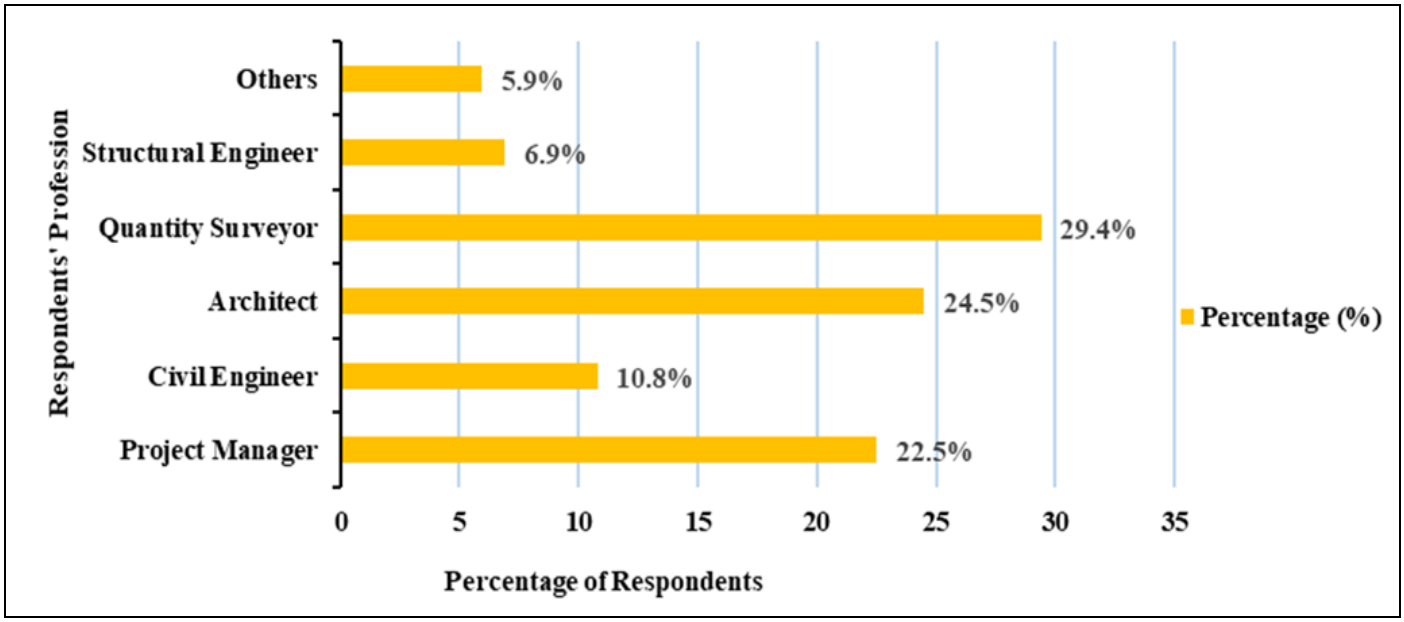

Fig 3 Years of Experience

Finally, Table 4 and Fig. 4 were used to gather the years of experience of the various respondents. Of those surveyed, 37.3% have worked more than five years (6 to 10 years). Subsequently, 31.4% of the respondents had less than five (5) years of work experience. Respondents who have worked for more than ten years (11 to 15 years) accumulated 16.7%. Also, respondents with over fifteen years of working experience (16 to 20 years) with 7.8%. Finally, respondents with over twenty years working experience (Over 20 years) gathered 6.9%. It is noticeable that the majority of the respondents have worked for more than five years (6 to 10 years) building up a percentage of 37.3% of the total respondents. It indicates rich experiences and knowledge amongst the respondents which translate into deriving reliable and valid information from the respondents.

Table 4Years of Experience

Number	Years of Experience	Number of Respondents	Percentage (%)
1	Less than 5 years	32	31.4
2	6 to 10 years	38	37.3
3	11 to 15 years	17	16.7
4	16 to 20 years	8	7.8
5	Over 20 years	7	6.9
	Total	102	100.0

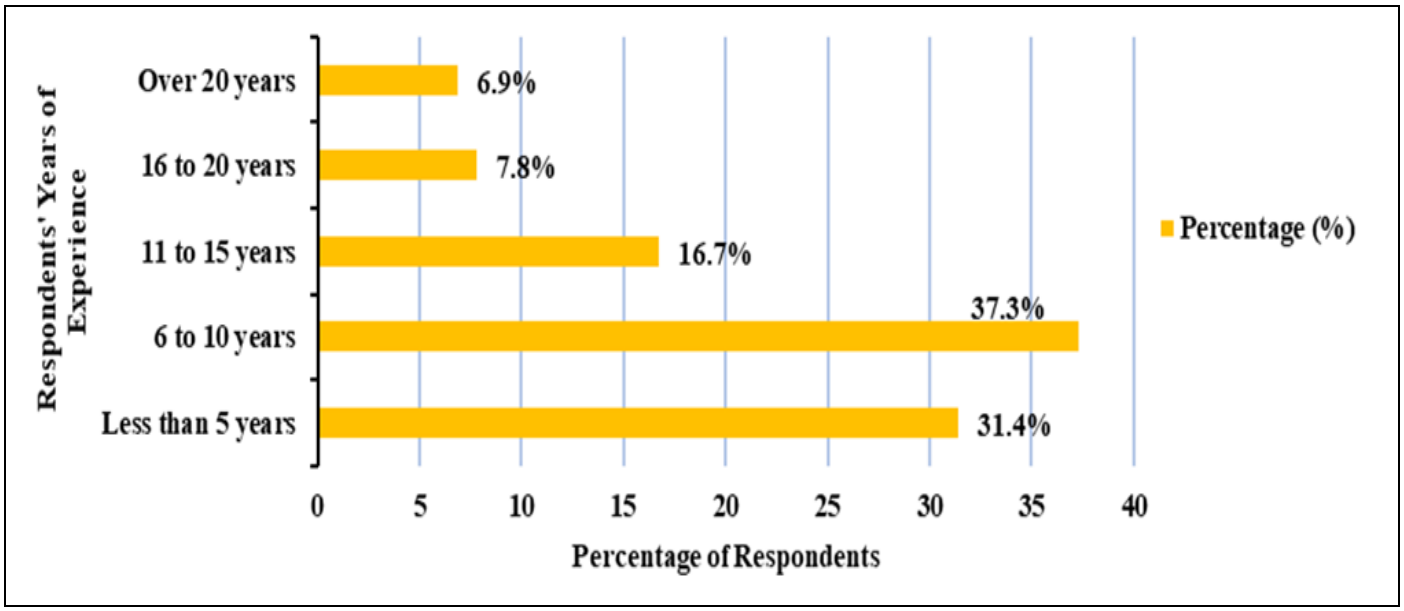

Fig 4 Years of Experience

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➢ *Level of Awareness of BIM and its Usage*

From Table 5 below and Fig. 5, it is obvious that a percentage of the respondents have heard and are aware of BIM, recorded at 72.5%, seventy-four (74) out of a hundred and two (102) respondents. Twenty-eight (28) respondents have never heard of BIM and its application, representing 27.5%. This was consistent with surveys conducted by Ugochukwu *et al*. (2015) and Aakanksha (2010) in Nigeria and India respectively. They all came up with about 70% of their respondents being aware of BIM and about 30% of respondents not aware of BIM. This outcome depicts that a great number of professionals in the construction industry are aware of this great technological drift in the world's construction industries. Also, it is noticeable in Table 5 that a great number of the respondents do not use BIM for the day-to-day administration of their projects. Professionals who do not use BIM in their works recorded seventy-eight (78) respondents out of a hundred and two (102), representing 76.5%. Twenty-four (24) respondents use BIM and its application for the day-to-day administration of their projects representing 23.5%. According to a survey by Ugochukwu *et al*. (2015), no professional in Nigeria's construction industry uses BIM, which contradicts this finding.

Table 5 Awareness and Usage of BIM

DESCRIPTION	YES	NO
Awareness of BIM	72.5%	27.5%
Usage of BIM	23.5%	76.5%
Total	102	100%

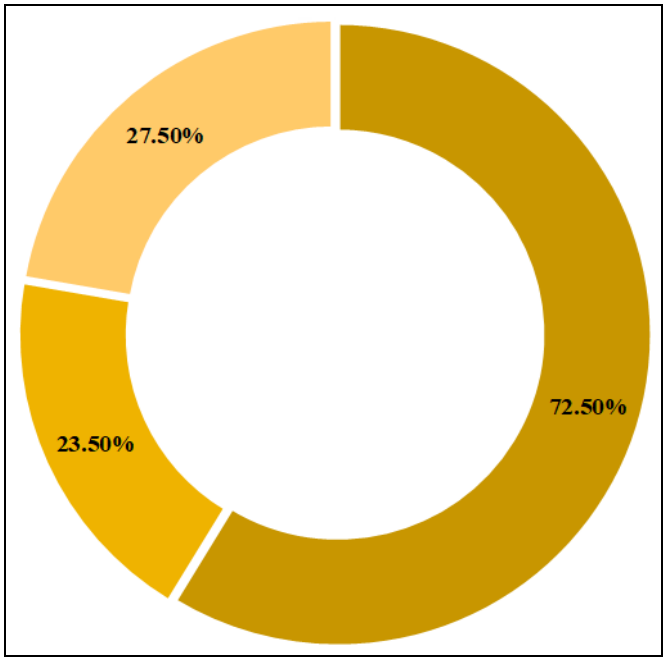

Fig 5 Awareness and usage of BIM

➢ *Plans to use by Non-BIM users*

The survey further classified the seventy-eight (78) of the respondents who do not use BIM as part of their day-to-day administrations of their projects as Non-BIM users and analyzed them to obtain information about their firms, whether the firms are planning to use BIM or not and the forecasted time it will be implemented in the firm.

- *Forecast of the usage of BIM among Non-BIM Users*

Two questions were asked under the forecast of the usage of BIM. The first question was to obtain information on firms' preparedness to implement BIM, and whether the various firms are planning to use BIM or not. This was to forecast the expected level of usage and preparations concerning the usage of BIM. In addition, the expectation of the usage of BIM within a specified period was also asked to obtain the forecasted use of BIM within the expected time.

A considerable reference outlined from Table 6 and Fig. 6 indicates how most firm are not planning to use BIM as part of their daily work which recorded the highest number of respondents, forty-one (41) representing 52.6% of firms in the Kumasi metropolis; and firms planning and preparing to use BIM had a percentage of 47.4% with thirty-seven (37) respondents. It can be deduced that firms in Ghana are not ready to shift from their traditional method of the day-to-day administration of their projects to the implementation of BIM.

Table 6 Firm Planning To Use BIM

DESCRIPTION	FREQUENCY	PERCENT%
Yes	37	47.4
No	41	52.6
Total	78	100

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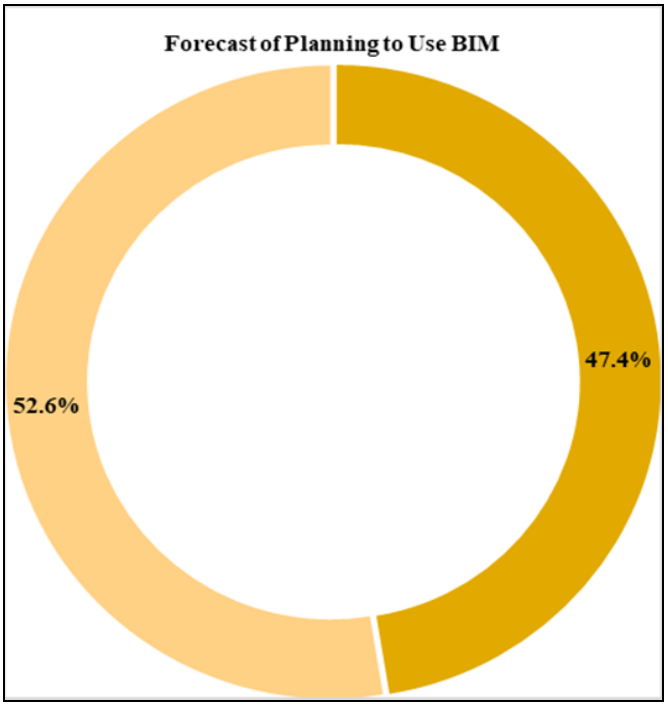

Fig 6 Forecast of Planning to use BIM

Not planning to use BIM any time soon	52.6%	
Planning to use BIM	47.4%	

As evidently seen in Table 7 below Non–BIM users were asked the expected period they a re likely to use BIM. Out of the seventy-eight (78) non-BIM users, thirty- three (33) of them had no idea about the expected period within which their firms would use BIM and recorded 42.3%. Twenty–four respondents projected the use of BIM in the next one (1) to three (3) with 30.8%; closely followed by respondents with projection of less than one year with 10.3% assuming eight (8) respondents. Additionally, respondents with projection to the usage of BIM in the next three (3) – five (5) years recorded 7.7% with 6 respondents of non-BIM users; followed by respondents with a projection of five (5) to ten (10) with 5.1% and 4 respondents respectively. The expected use of BIM in the next ten years recorded 3.8% with a total number of three (3) respondents. From this, it can be inferred that most responses from the various firms had no idea of when their firms would plan to implement and use BIM as part of their work. This insinuates that until legislation from the government of Ghana is passed concerning the implementation of BIM across the Ghanaian construction industry, firms' reluctance to implement and use BIM will occur throughout the years ahead.

Table 7 Forecast of the usage of BIM by Non-BIM within an Expected Time

DESCRIPTION	FREQUENCY	PERCENT%
Less than 1 year	8	10.3
1 - 3 years	24	30.8
3 - 5 years	6	7.7
5 - 10 years	4	5.1
More than 10 years	3	3.8
None	33	42.3
Total	78	100

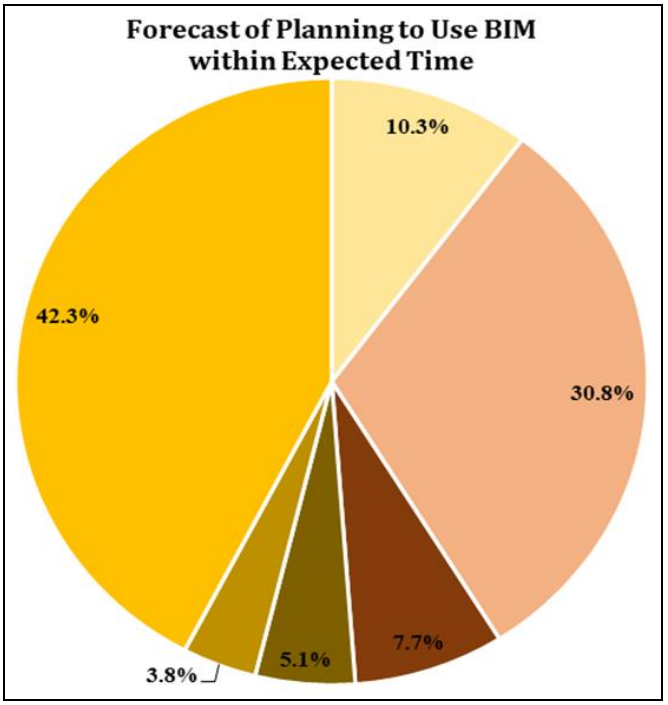

Fig 7 Forecast of Planning to Use BIM within Expected Time

Planning to use BIM now or within 12 months	10.3%	
Planning to use BIM in the next 1 - 3 years	30.8%	
Planning to use BIM in the next 3 - 5 years	7.7%	
Planning to use BIM in the next 5 - 10 years	5.1%	
Planning to use BIM in the next 10- 20 years	3.8%	
No the idea of using BIM	42.3%	

➢ *BIM Usage by BIM Users*

This section was provided to obtain in-depth fundamental information from respondents who use BIM as part of their work. The survey further classified the twenty-four (24) of the respondents who do use BIM as part of the day-to-day administrations of their projects as BIM users and analyzed them to obtain information about their firms' length of usage, size of projects, BIM level, and the kind of BIM software used.

- *The Length of usage and Size of BIM Projects*

In order to determine the degree to which BIM is being utilized, respondents were asked to specify the firms' length of usage, size of projects, BIM level, and the kind of BIM software and its applications on projects. This will help to

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gain the length of time within which the various respondents' firms have implemented BIM and the size of the project that is undertaken inclusive of BIM.

According to Table 8 below, respondents within firms who have been using BIM for more than two years (2 –5 years) emerged with 50% that is twelve (12) respondents whilst respondents who have been using BIM for a year and above (1-2years) recorded 33.3% equals to eight (8) respondents and lastly, respondents who have been using BIM for more than five years (5-10years) had (4) four respondents that is 16.7%. This shows a high level of usage amongst the respondents between (2-5 years), amassing 50% of the respondents.

Table 8 The Length of Usage

DESCRIPTION	FREQUENCY	PERCENT%
1 - 2 years	8	33.3
2 - 5 years	12	50.0
5 - 10 years	4	16.7
Total	24	100.0

- *Size of BIM Projects*

Furthermore, size of BIM project was determined by the various respondents which is evidently shown in Table 9. BIM project sizes less than GH 10,000 and Over GH 1 million recorded 20.8% denoting five (5) respondents for each of the BIM projects respectively. Also, BIM project sizes of GH 10,000 - GH100, 000 and GH 200,000 - GH 500,000 had a percentage of 16.7% apiece, representing four (4) respondents. Lastly, BIM project sizes of GH 10,000 - GH100, 000 and GH 500,000 - GH 1 million had 12.5% with three (3) respondents. It insinuates there is a normal distribution amongst respondents in the size of BIM projects used.

Table 9 Size OF BIM Projects

DESCRIPTION	FREQUENCY	PERCENT%
Less than GH10,000	5	20.8
GH 10,000 - GH100,000	4	16.7
GH 100,000 - GH 200,000	3	12.5
GH 200,000 - GH 500,000	4	16.7
GH 500,000 - GH 1 million	3	12.5
Over GH 1 million	5	20.8
Total	24	100.0

- *BIM Level*

The ubiquitous level of BIM in the construction industry attracted a question to be asked. The purpose of this question was to decipher the level that BIM respondents' firms had reached which would identify the kind of knowledge and technological advancement the Ghanaian construction industry had reached.

According to Table 10 below, out of the twenty-four BIM users 37. 5% denoting nine (9) respondents have not heard or had any idea about the BIM levels. Respondents' firms at BIM level 0 with 33.3% representing eight (8) number of respondents. Respondents' firms at BIM level 1 had 29.2% constituting 7 respondents. Finally, BIM levels 2 and 3 received no responses from the respondents. It can be deduced that there is an inadequate degree of knowledge and technological advancement among firms in the Ghanaian construction industry since the BIM levels show the stages of implementation, usage, and collaboration among all disciplines in the construction industry in Ghana.

Table 10 BIM Levels for Respondents' Firm

DESCRIPTION	FREQUENCY	PERCENT%
Level 0	8	33.3
Level 1	7	29.2
Level 2	0	0
Level 3	0	0
Have not heard of it	9	37.5
Total	24	100.0

- *BIM Tools*

In the usage of BIM, there are numerous tools provided by various software vendors for its use on the BIM platform. Therefore, there was a need to determine the kind of tools and software that various respondents were utilizing. The various tools embedded in the software were queried to identify the predominant tools used in the construction industry. Respondents using Autodesk AutoCAD & Autodesk Revit had 37.5% with the highest frequency value of nine (9), followed closely by Autodesk Revit 25% with a response rate of six (6) respondents, sequentially followed by Autodesk AutoCAD had 12.5% denoting three (3) respondents. Last but not least Autodesk AutoCAD & Autodesk Revit &Graphisoft ArchiCAD and Others came up with 8.3% respectively with a

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response rate of two (2) respondents. Ultimately, Graphisoft ArchiCAD and Bentley MicroStation had 4.2% with one respondent respectively. A closer look at Table 11 demonstrates a high consumption of Autodesk products with 45.83% that is eleven (11) respondents, closely followed by others (other products) with 8.3% representing two (2) respondents, followed by Graphisoft ArchiCAD, Benley MicroStation with 4.2% each denoting one respondent.

Table 11 BIM Tools

DESCRIPTION	FREQUENCY	PERCENT%
Autodesk AutoCAD	3	12.5
Autodesk Revit	6	25.0
Graphisoft ArchiCAD	1	4.2
Benley MicroStation	1	4.2
Autodest AutoCAD & Autodesk Revit	9	37.5
Autodest AutoCAD & Autodesk Revit &Graphisoft ArchiCAD	2	8.3
Others	2	8.3
Total	24	100.0

- *Applications of BIM*

To find out how frequently the BIM users used applications embedded in BIM, respondents were asked to rank how frequently they use the applications embedded in BIM on a Likert scale of 1-5 that 1 = Not all; 2 = Rarely (Less than 20% of the time); 3 = Sometimes (about 50% of the time); 4 = Frequently (about 80% of the time) 5 = Every time. In doing so, the relative importance index (RII) method was used to establish the respondent's ranking on each of the applications of BIM. This calculation sets the variables in order of rank and illustrates how the first to be ranked is more important than the subsequent ones. The RII was calculated as: Relative importance index (RII) = Σ w / (A x N) - - -, ($0 \leq$ index ≤ 1) (Abubakar *et al*., 2014) Where: w = weighting given to each variable by the respondents and ranges from 1 to 5; where 1 is not all and 5~ every time, A = the highest weight (that is 5 in this case), and N = total number of respondents (that is 24 in this case). The mean score was used in ranking the variable, but where the means of the variables occurred to be the same, standard deviation - the degree to which the variables vary from the mean was used to differentiate the differences. In evaluating the frequency with which various BIM applications were used in the Ghanaian construction industry, the factors that registered RII<0.500 Muhwezi (2014) were considered hardly ever used applications.19 variables in all were adopted from Campbell (2007); CICRP (2009); and Azar (2011) to obtain respondents' views on the application of BIM.

Table 12 shows that Project Visualization emerged first with a mean score of 3.958 skewed toward 4 which is a frequently used application (80% of the time). Project visualization is a 3D modeling tool for communicating design intent to project stakeholders. This helps the clients and other end users to see the proposed building in a 3D model to the traditional flat, floor plans, and sections among others. Project visualization had an RII of 0.792 indicating frequently used BIM applications. The Second most frequently used was Design Reviews. Design Reviews Tools allow team members to actively engage in reviewing, marking-up and revising 3D models and designs. It had a mean score of 3.292 portraying that it is used from time to time (50% of the time) and an RII of 0.658 depicting frequent usage. Parametric Object closely marked this with a mean score of 3.292 and an RII value of 0.658 depicting that, it is 50% of the time used by the respondents. Parametric Object is when changes made in views, plans, sections, schedules, and bills of materials of a model are automatically adjusted and updated. Site Planning & Site Utilization emerged 4th with mean and RII values of 3.000 and 0.600 respectively. Site Planning & Site utilization refers to graphically representing on-site permanent and temporary structures throughout all stages in the construction process followed by Scheduling &construction sequencing which refers to adding the time factor of the construction schedule to the 3D model of BIM. This emerged 5th with mean and RII values of 2.875 and 0.575 respectively. Next was Cost estimation which came 6th with a mean score of 2.667 lopsided towards 3 and an RII value of 0.533 demonstrating a 50% of the time frequently used application. Closely followed by 3D Control &Planning; Structural analysis and Existing conditions modelling which had the same mean and RII values of 2.417 and 0.483 respectively, deducing rarely used applications, they were ranked 7th, 8th, and 9th respectively using their standard deviation values.

Also, Automatic quantity take-off; Energy analysis; Programming &phase planning (4D modelling); Building maintenance scheduling; Mechanical analysis; Conflict, interference & collision detection, and Digital fabrication had their means skewed toward 2 (2.167; 2.125; 1.917; 1.833; 1.792; 1.750 and 1.750 respectively) implying rarely used applications, less than 20% of the time used by the respondents. These variables were ranked sequentially as10th, 11th, 12th, 13th, 14th, 15th and 16th. They had RII values of 0.433, 0.425, 0.383, 0.367, 0.358, 0.350 and 0.350 respectively. From Table 4.6.1, Building maintenance scheduling and Mechanical analysis had none of the respondents using these applications all the time, this denotes that probably, building maintenance and mechanical analysis are hardly carried out on buildings in the Ghanaian construction industry. *Subcontractors & supplier models Systems coordination; Facilities Management* and Forensic analysis had their means skewed toward 1(1.417, 1.417, and 1.333 respectively) meaning these applications are not used at all by the respondents. These criteria were ranked successively as the following 17th, 18th, and 19th with none of the respondents using these applications all the time. These criteria had RII values of 0.283, 0.283, and 0.267 respectively.

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It can be inferred that most of the respondents do not use these applications at all. Out of the 19 variables, 9 variables had more than half of the respondents rating them as applications not used at all. Also, only 6 out of the 19 variables had RII values greater than 0.500 implying 13 variables (applications) are hardly ever used. This implies that most construction firms in Ghana are lagging behind the world's technological shift in the world's construction industry.

Table 12 Application of BIM

	BIM USER	FREQUENCY OF RANKING					TOTAL	∑W	MEAN	RII	RANKING
NO.	APPLICATION OF BIM	1	2	3	4	5					
1	Project Visualization: 3D renderings can be easily generated	2	1	6	2	13	24	95	3.958	0.792	1st
2	Cost estimation	7	7	2	3	5	24	64	2.667	0.533	6th
3	Automatic quantity take-off	11	5	3	3	2	24	52	2.167	0.433	10th
4	Parametric Object: changes made in views, plans, sections, schedules, and bill of materials are adjusted and updated automatically	8	1	2	2	11	24	79	3.292	0.658	3rd
5	Design reviews	6	1	6	2	9	24	79	3.292	0.658	2nd
6	Scheduling and construction Sequencing	7	4	3	5	5	24	69	2.875	0.575	5th
7	Programming, phase planning (4d modeling)	12	5	2	2	3	24	51	2.125	0.425	11th
8	Conflict, interference, and collision detection	15	4	2	2	1	24	42	1.75	0.350	16th
9	Structural analysis	11	3	4	1	5	24	58	2.417	0.483	8th
10	Digital Fabrication	14	6	1	2	1	24	42	1.750	0.350	15th
11	Mechanical analysis	14	5	3	0	2	24	43	1.792	0.358	14th
12	Energy analysis	16	0	3	4	1	24	46	1.917	0.383	12th
13	Building maintenance scheduling	10	8	6	0	0	24	44	1.833	0.367	13th
14	Forensic analysis: graphical illustration of failures, leaks, evacuation plans	19	3	1	1	0	24	32	1.333	0.267	19th
15	Facilities management	17	5	1	1	0	24	34	1.417	0.283	18th
16	Existing conditions modeling	12	2	2	4	4	24	58	2.417	0.483	9th
17	Site Planning and Site Utilization	6	3	5	5	5	24	72	3.000	0.600	4th
18	3D Control and Planning	11	2	4	4	3	24	58	2.417	0.483	7th
19	Subcontractors and supplier models Systems coordination	18	3	2	1	0	24	34	1.417	0.283	17th

V. CONCLUSION AND RECOMMENDATION

In this technological era, every industry is, in one way or another experiencing a technology shift with which the construction industry is not left at bay. The Ghanaian construction industry has failed to transform its conventional methods of operation in contrast to other construction industries worldwide. This was made clear by the field data collected from the respondents' questionnaires. The principal aim of the study was to determine the level of awareness and forecast level of usage by Ghanaian construction firms. Consequently, objectives were established to find in the Ghanaian construction industry. In this respect, these recommendations emerged.

A policy must be formulated by the government of Ghana to push forward the implementation of BIM. This agenda can be easily pushed forward by the Government of Ghana since it is the most influential and biggest client in the country. As in the case of the United Kingdom, the government has made it imperative for all government projects involving substantial amounts of money to use BIM. This strategy can be deployed in Ghana by the government of Ghana to increase the usage of BIM in Ghana.

There is an urgent need to integrate BIM into the curriculums of every construction-related course in higher educational institutions. This will go a long way to do away with the shortage of inadequately trained BIM personnel in the construction industry. The addition of BIM to higher educational institutions should not only be an introduction to BIM embedded in other courses such as IT but must be made to be a stand-alone course taught for more than one semester with practical works attached to it.

The various internationally recognized professional bodies in Ghana such as the Ghana Institute of Engineers (GhIE), Ghana Institute of Surveyors (GhIS), and Ghana Institute of Construction (GIOC), must educate their members on various technological advancements in the AEC industry. For instance, 'BIM', so that its awareness can be propagated across the whole construction industry and ensure its implementation. Subsequently, the industry can keep up with the modern trends happening in the world's construction industries. This must be prioritized by the professional bodies to ensure that all the professionals are aware, ready to learn and use it for their day-to-day activities.

Construction companies must organize training and on-the-job training for workers /staff incorporating innovations and technologies for workers to be acquainted with the current trends in the construction industry. Collaboration and coordination with companies leading in the implementation of BIM can help obtain expert advice on the implementation of BIM by most Ghanaian construction companies.

This Research work opened up numerous research gaps that need to be carried out. These are recommended for future research: Case studies on a completed BIM project in Ghana must be undertaken to prove the tangible benefits of BIM in the Ghanaian construction industry. Research work should be undertaken to develop models that will guide construction, architectural, and engineering firms in the implementation of BIM and how to integrate BIM into the traditional

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procurement e-procurement methods and more research work on BIM relating to specific disciplines in the Ghanaian construction industry.

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