KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI

ASSESSING THE BENEFITS AND BARRIES OF THE USE OF BUILDING INFORMATION MODELING (BIM) IN THE GHANAIAN BUILDING CONSTRUCTION INDUSTRY

BY

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MASTER OF SCIENCE CONSTRUCTION MANAGEMENT

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DECLARATION

I hereby declare that this work is my own work towards the Master of Science degree and that to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

This work is dedicated with love to the following personalities:

My dear wife Dr. Mrs. Abena Kwafo-Armah,

Our daughter, Naa Ayele Armah and son, Nii Ayi Armah

My mother, Miss Regina Abena Asabea Addo.

Abstract

Building Information Modelling "BIM" has become a well-known collaboration procedure in the Building Construction Industry. Property/Home Owners are challenging Architectural, Engineering and Construction companies to provide some form of BIM Services. Evidence exist on the implementation of BIM in the Building construction field in other parts of the world especially in Australia, United Kingdom and many parts of the United States of America. Surprisingly, its implementation is yet to even be discussed in literature in Ghana and other African developing countries. The study, therefore is aimed at exploring the benefits and barriers confronting BIM implementation in the Ghanaian Building Construction Industry. The aim was anchored on the following objectives to identify areas of possible BIM use to identify paybacks with use of BIM looking at the Ghanaian Construction Industry; and to also identify the barriers to its implementation. Data collected was further analysed using mean score ranking and relative importance index. The study adopted survey approach whereby Primary data was collected from respondents including construction managers and other professionals in the Building Construction Industry, Architect, Engineers, and Quantity Surveyors etc. The study identified Building Information Modelling uses for construction, preconstruction and post construction phases as well. The study concluded BIM as tool to assist Building construction planning. The significant benefits with the use of BIM is the improved conception of the task of construction, enhanced communication between project players and improved scheduling proficiency. Despite these potentials, the following key barriers were identified against the implementation, BIM set-up costs, Lack of awareness on it, Risk Exposure, and. Culture opposition. From findings, it is recommended that BIM (4D modelling) ought to be implemented in the Building Construction Industry and an Act of Parliament to give it a legal backing in order to explore the full potentials and further be developed as a standard in the Ghanaian Building industry. The study exhibits a significant

epitome in the area of BIM in Ghana. The study is of utmost utility to construction professionals.

Keywords: Building Information Modelling (BIM), Building Construction Industry,

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Contents

CHAPTER ONE

GENERAL INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Building Information Modelling (BIM) is an illustration of development process with the employment of computer made model to develop scheduling, building as well as design other operations of a structure. This model is a data-rich, quick, object-oriented, as well as a parametric digital demonstration of structural facility where views and right data for assorted users' requirements can be extracted and examined for the generation of information needed to make better decisions for an improved delivering process of a facility (AGC, 2005). Within the Construction Industry, assessment of cost is a costly, time consuming and a significant phase of a construction project (Frazure, 2011). Estimated cost is influenced by decisions made all through the construction works by the clients, the contractors and the construction professionals as well. Hergunsel (2011) testified that the result of making early decisions by these stakeholders in the project have a great effect on the final project cost. Building Information Modelling has nevertheless attained a widespread attention in recent times in the industry of Architecturing, Engineering and Construction. BIM is therefore the representation of development and computer-generated n-dimensional (n-D) models to enhance the forecast, plan, building, in addition to set-up of construction facility thus ensuring an efficient cost and time of the project.

According to Saman et al (2005), reducing of efficiency in manpower in the building Industry demands additional labour hours per contract dollar amount. This goes on to confirm that Construction Industry require the expansion for labour saving ideas. The principal causes of lacking labour efficiency in the built environment are related to its disjointed pattern as a result of the acceptance of conventional supply of project method which uses 2 Dimensional

Computer Aided Drafting (CAD) know-how as well as the extent of building companies (Hergunsel, 2011). Hence all, the orthodox construction supply of project method, Design-Bid-Build, wreckage functions of members throughout the design as well as building stages obstructs the collective participation of the builder or the building manager through the project.

To this level, in the earliest stages of a project, mainly during the programming, schematic and preliminary stages that crucial design decisions are made that largely dictate the economics of the project. The industry has been adopting Information Technology tools like "Building Information Model" that provide both the owner and the management organization with detailed specific information about the building.

The initial step to the adoption of 3D/4D know-how in the Building Diligence was introduced as a 3D solid BIM in later part of 1970s. Throughout this period, industrialized sector undertakes discovery plan, investigation, as well as reproduction of 3D products. 3D BIM in the Built Environment was stalled "through the cost of 3D calculating influence as well as advanced by the effective extensive implementation of CAD" (Eastman, 2008). The industrial commerce comprehended, expended enough capital in know-how and held the "probable advantages of combined study abilities, decrease in mistakes, as well as the change concerning works mechanization". They functioned organized with BIM device suppliers to decrease as well as exclude the technical software impediments.

BIM is a digital illustration of bodily and efficient features of a structure. BIM is a collective information reserve for information about a structure founding a dependable foundation for conclusions throughout its life-cycle; well-defined as current as of earliest commencement to destruction. In lieu of the experts convoluted in a scheme, BIM allows a computer-generated info model to be given as of the plan team to the chief builder as well as subcontractors then

on to the client; collectively expert enhances control-exact info to the sole mutual model. The tendency of info losses that usually followed once a different squad proceeds 'possession' of the project, as well as offers additional broad information to clients of multifaceted facilities. BIM extent the entire concept-to-occupation time-span. To guarantee skilled managing of info developments through this extent, a BIM leader can be hired. BIM leader is reserved by a plan construct squad on the user's behalf after the pre-plan stage forwards to improve as well as to monitor the object-oriented BIM alongside planned plus dignified act purposes, assisting various building information models that ambition examination, plans, take-off as well as logistics. Industries are likewise considering now advancing BIMs in numerous heights of points, as contingent on the use of BIM, information is required, as well as there is wavering BIM exertion related with creating BIMs at diverse stages of feature.

1.2 PROBLEM STATEMENT

Scheduling a construction process is a thought-provoking and necessary doings in the accomplishment as well as administration of building projects (Hendrickson, 2000). From Chevallier and Russell cited in Heesom and Mahdjoubi, (2004), proper scheduling is the most significant parts of a building project as well as the realization of the scheme is critically predisposed by it. Nevertheless, Kelsey cited in Heesom and Mahdjoubi, (2004) that evolving proof shows a scarcity of talent in the building scheduling extent, by means of a falling knowledgeable total of designers devising the capacity or understanding to excellently design developments. A variety of scheduling methods is studied as well as applied however they are not sufficiently competent to fulfil the need of building parties. There exists a huge discrepancy among the implementation as well as plan (Allen & Smallwood, 2008). Drawings are produced by a computer generated device as 2D charts or plans from extensive period with the nonexistence of spatial structures of real building (Wanga, Zhanga, Chaub, & Anson, 2004). Doings founded critical path method (CPM) which is more activity based has

become a more preferred method to plan work nowadays. From Akbas cited in (Jongeling and Olofsson, 2007), additional struggle in the adoption of CPM planning for building scheduling is linked to the spatial configuration of project. Examining detailed CPM schedules with 2D drawing might end up being difficult, which limits the likelihood to notice challenging sequences, errors and prospects. Contradictory clarifications of the plan can be established by diverse participants when observing the 2D data and CPM plan. Factor like these greatly affect the performance of Projects. The Building Industry must deliberate on the use of knowledge to develop technique in the Industry to create building extra striking to both stakeholders as well as probable personnel.

1.3 AIMS AND OBJECTIVES

1.3.1 Aim

The primary aim of this reading was to explore potential benefits and inherent barriers in the usage of BIM in the Construction Industry of Ghana.

1.3.2 Objectives

For the achievement of overall aim, the research objectives below were set;

- To determine the areas of implementing BIM in the Construction Industry of Ghana;
- To identify the benefits that comes with the adoption of BIM in the Ghanaian Building Industry; and
- To identify the barriers to BIM implementation in the Construction Industry of Ghana.

1.4 JUSTIFICATION OF STUDY

Considering only the design process in the development process of construction, most systems of the construction procurement need design work which must be finished in an environment which comprises multidisciplinary teamwork. Even in the same discipline, the design process is naturally deceptive and monotonous, that is, among the other Engineering, Architect and Construction disciplines. In the design evolution arises other complications relating to acquisition of data management as well as multi and inters disciplinary teamwork. Mostly, the design team associates even those from a like discipline make use of different software tools to work along (Arayici and Aouad, 2010). Nour (2007) gave an instance of such situation that a building structure can be divided into three different sections, that is, amongst three different architects for the design; where the three can use different software tool for the incorporation of their work at all end. The entire construction lifecycle increases in complication, uncertainty and vagueness when considered. Many governments and other authorities have given in for BIM in recent years in the industry of building construction for the purpose of providing the needed information discussion between concerned parties. The technology of BIM offers more effective business process and with its associated project management practises like the complete improvement of construction knowledge in the course of the full lifecycle of a construction project (Arayici and Aouad, 2010). However, in achieving these and other unmentioned benefits, BIM interested parties must go through an understanding change management system which ITcon (2012) can involve assistance from outside. The industry of construction interested parties in recent times uses much unproductive processes and as a result change has now become eminent (NBIMS, 2007).

1.5 METHODOLOGY OF THE STUDY

The methodology adopted a two-stage approach; desk study and field research. Subsequently, the research employed a quantitative method of enquiry. A critical evaluation of relevant literature was done for the purpose of determining the hypothetical paradigms underpinning the subject and helps to elucidate BIM in the Ghanaian Building Construction Industry. The review sourced credible and scientific data from the existing literature through journals, unpublished thesis, journals of corporate bodies and books.

The second stage, field research, involving data collection, targeted data and information collection. By using series of questionnaires data and information were gathered from the various respondents in the construction industry who were tested using purposive sampling methods. The information on the questionnaires included also Likert scale rating of the dependent variables to permit easy classification and synthesis. The data were further analysed using relative importance index, mean score rankings (index) and descriptive statistics.

1.6 SCOPE

This study was limited explicitly in making use of the current BIM applications to improve the building management process. The varied responses of the construction professionals in the design and construction process were discussed. Since the Building Industry is so diverse, the construction manager's role may vary considerably from one project to another hence his or her ability to use the software. Subsequently, literature sampled looked at Construction companies using BIM (4D Modeling). Geographically it was limited to Accra thus the contractors and consultants were considered.

1.7 Summary

The decisions resolved in the project involving the clients and the building construction professionals have a enormous impact the ultimate cost of the construction. Higher percentage of clients have little or no ability to visualize the final stages of a construction project and hence have no idea or understanding of the cost impact of their conclusions made. Results from this thesis after the assessment of the existing BIM applications will presented BIM into the Construction Industry of Ghana so as to allow clients and construction professionals to visualize the project, pilot the essential world, ensures the changing of materials into the project, and then compute the cost effect on these conclusions made. Thus, the visual constituent of the essential actuality development tool needed by the clients to understand the cost effect of changes and hence would save money from the project by making such decision even before the beginning of the project.

1.8 DISSERTATION ORGANIZATION

The structure of the thesis is in five (5) interdependent chapters, and followed the following outline. Chapter 1, "General Introduction" presented the background to the study and the problem necessitating research efforts. The research aims, research questions, objectives, and scope are all contained in this chapter. Chapter 2; contained the literature review. The review provided an extensive coverage on earlier works. Chapter 3 also presented the research methodologies adopted for the study. Chapter 4 presents the analysis and presentation of the data and discussion of the study results. The last chapter (chapter 5) presents a summary of the findings of the study, conclusion and recommendations.

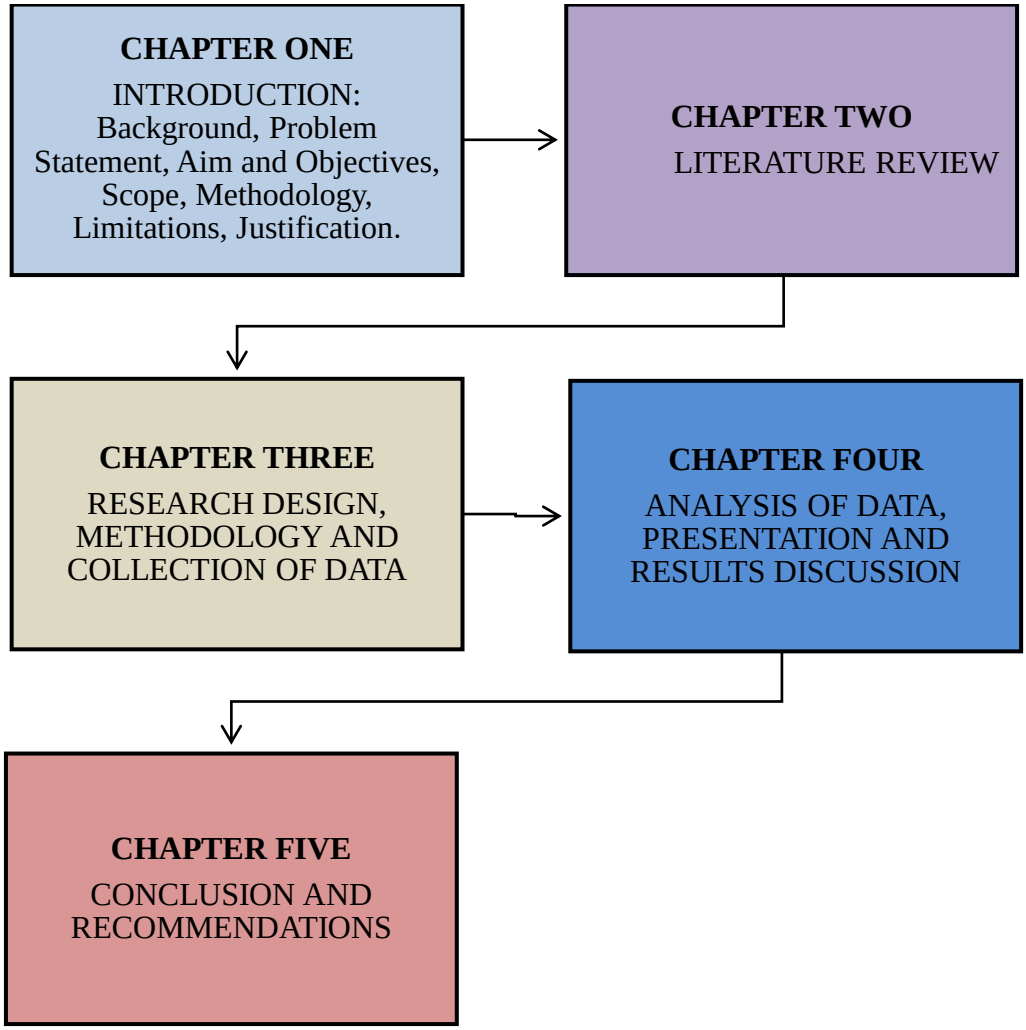

Figure 1.1 Summary of workflow of the Thesis organization

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION TO BIM

Building Information Modeling (BIM) has been one of the greatest achievements of the architectural, Engineering as well as Building industry for the past century. BIM can be employed to conceptualize computer-generated models of a constructing digitally. These digital prototypes encompass correct geometrical information of the construction elements as well as further essential information required to upkeep the manufacture and purchasing undertakings. It also comprises numerous of the roles prerequisite to model the lifespan of a construction, providing the stage for fresh proposal as well as building competences. When resourcefully employed, BIM enables an extra incorporated design as well as building method that marks in great excellence of constructions at abridged scheme time as well as cost (Eastman *et al.*, 2011).

"BIM is a group of data that is planned in such that the information can be used by various parties. BIM is a digital model of a construction that information on a project is put in storage. It can be 3D, 4D or even 5D (containing cost) – accurate up to 'nD' (a period that shelters some further info)." Building SMART (2010)

BIM targets at enhancing teamwork among participants, decreasing the period required for certification of the scheme as well as creating massive foreseeable development results. BIM has enormous impending as well as flexibility as a repository for information on the project (Building SMART, 2010).

2.2 Construction planning methods

Through the improvement of the built environment, several techniques employed in building scheduling like Gantt chart, critical path process as well as linear programming. The literature review summarized such prevailing approaches, their merits as well as demerits.

2.2.1 Gantt chart

Gantt chart is a planning of time that was proposed by Henry L. Gantt, a precursor who introduced relating "systematic managing approaches" within the industry. Gantt chart occurs as numerous options that method as well as employment be contingent on possibility of the schemes A Gantt chart portrays significant undertakings plus their periods standard in accordance with scheduled plan as well as definite presentation. Currently, Gantt chart remains attractiveness as a result of the benefit that it is precise stress-free to communicate then employment. Yet, Gantt chart go pear-shaped to exist the connection among scheme undertakings. From the graph planning, it is difficult to conclude what undertakings are significant. Nevertheless, Gantt chart is not so greatly useful in assisting project squad ascertain the influences of interruption or variation of actions on each other (Nunnally, 2007).

2.2.1.1 Critical Path Method (CPM)

Throughout the time from 1957 to 1958, substantial development in scheduling provided delivery to Critical Path Method (CPM). Further innovative than Gantt chart, CPM not merely display undertakings essential for the schemes, it also offers information on the connection among different tasks. In overall, an appropriate set-up of CPM necessitates an upright formulation of subsequent: i) a work breakdown structure comprising the relevant tasks, ii) approximation of undertakings completion time as well as iii) requirement of the interdependence among undertakings (Santiago and Magallon, 2009). According to

Andersson and Christensen (2007), CPM is inept to survive with source restrictions as concerns repeating actions. While CPM assumes that capitals are unrestricted for creating the works, this is not factual in authenticity. Accordingly, it is unbearable to forecast whether there is deficiency in capitals or encounters among tasks concerning the application of capitals. This difficulty will result to delays in the building progressions in addition interruptions can be expected. Moreover, in a building project, similar actions can be completed at diverse positions in building site as well as at similar time while CPM trail to pact with such undertakings.

2.2.1.2 Linear scheduling method/Location-based scheduling

Linear scheduling method (LSM) also named location-based scheduling (LBS) existed initially prepared in the primary 1950s (Anderson and Christensen, 2007). It is principally functional for building schemes like various housing elements, railway, high-rise structures as well as highway. LSM assists designers to evade generating plans that can source bangs among repeating undertakings in addition to confirm the continuous course of resources functioning throughout the project life cycle (Nunnally, 2007). Nevertheless, LSM there is little responsiveness from building actors. For the reasons being that it is precise problematic to alter the level of feature for info when been put in the plan. Furthermore, LSM software also needs huge total of input info at the initial stage of scheduling as well as planning (Andersson and Christensen, 2007).

2.3 BIM AS A METHOD OF SCHEDULING

BIM is principally a three dimensional digital illustration of construction as well as its inherent features. It is completed of intellectual constructing constituents that contains information qualities plus parametric guidelines for different item. For example, a door made of certain material as well as measurement is parametrically connected plus introduced by a

partition. Additionally, BIM offers reliable as well as organized outlooks then depictions of the digital model together with dependable information for different outlook. A lot of time is saved by planner's as different outlook is matched over the manufactured-in intellect of the model. From the National BIM Standard, BIM is "a digital exemplification of bodily as well as practical characteristics of a structure in addition to mutual understanding resource for info on a structure founding a consistent root for choices throughout its life-cycle; well-defined as present from initial commencement to demolition" (National BIM Standard-United State, 2010). BIM is the procedure as well as preparation of near plan as well as building through its lifecycle. It is a stage to part information as well as interconnect among scheme partakers. If the builder employs the model to connect the BIM notion in 3D and does not advance adopt the built-up info in the BIM, then this is denoted as "Hollywood" BIM. Builders might expend the "Hollywood" BIM to gain contract. Though, they do not grasp the complete potential value of BIM. Intermittently, BIM is adept inside in a single institute of the project but not joint with administrations. This is devoted to as "isolated" BIM. BIM may be employed for formation as well as for energy exploration. Architectural firms may even have an interior business. Though, the designer can choose to offer the designs in 2D as well as limit the BIM contact. This obstruct the contribution of the building manager (CM) except the CM generates a fresh model. (Vardaro, 2009) A cooperative method can be the "societal" BIM that permits the participation of the designer, architect, building manager, as well as subcontractors in the BIM model. At the BIM meetings, the construction manager and subcontractor can deliver practiced building info to the design squad. Additionally, the building manager can employ the BIM to generate constructability accounts, organize, design, plan as well as cost estimation. Once cooperation energies like MEP organization between the builders, planners as well as designers are accomplished, specialty builders can then employ the info from BIM to mass-produce products.

2.3.1 Project Transfer Techniques and BIM for Construction Managers

conventional Design-Bid-Build, Building Managing at Risk, Design/Build as well as Assimilated Project Delivery (APD) methods are the supreme shared supply of project approaches that firms presently performs. No difficulty that supply method is selected, the builder or the building manager can adopt BIM. Building leaders or builders can employ BIM to excerpt quantities of task to formulate cost estimations. Likewise, dominant 3D renderings can deliver. Furthermore, plan assimilated BIM identified as 4D BIM is employed for animatronics, safety study, as well as to make site logistic policies. Building managers employ BIM to succeed task with Subcontractors.

The architect, normally the chief planner in construction schemes as well as building manager works openly for the client. The production specialists are part of the planner's squad. The designer and the engineer primary progress the plan of the structure. On finishing point of the plan stage, the building managers' likewise regarded as over-all builder in the conventional style afford for the work. When bid is awarded, the building commences. This is not a firm trail delivery of project system. Thus, the method doesn't include initial participation of the building squad throughout the plan. If the designers produced a 3D parametric model for the scheme, BIM will short the info of the builder throughout the planning stage. Usually, Design-Bid-Build eliminates the advantages of partaking the building input throughout plan stage once the capability to effect the cost is the maximum as portrayed in figure 2. Models may not be shared between the architect and the engineer as a result of risks, problem trepidations, illegal reprocess of knowledgeable possessions as well as fallacy of the info encompassed in the model.

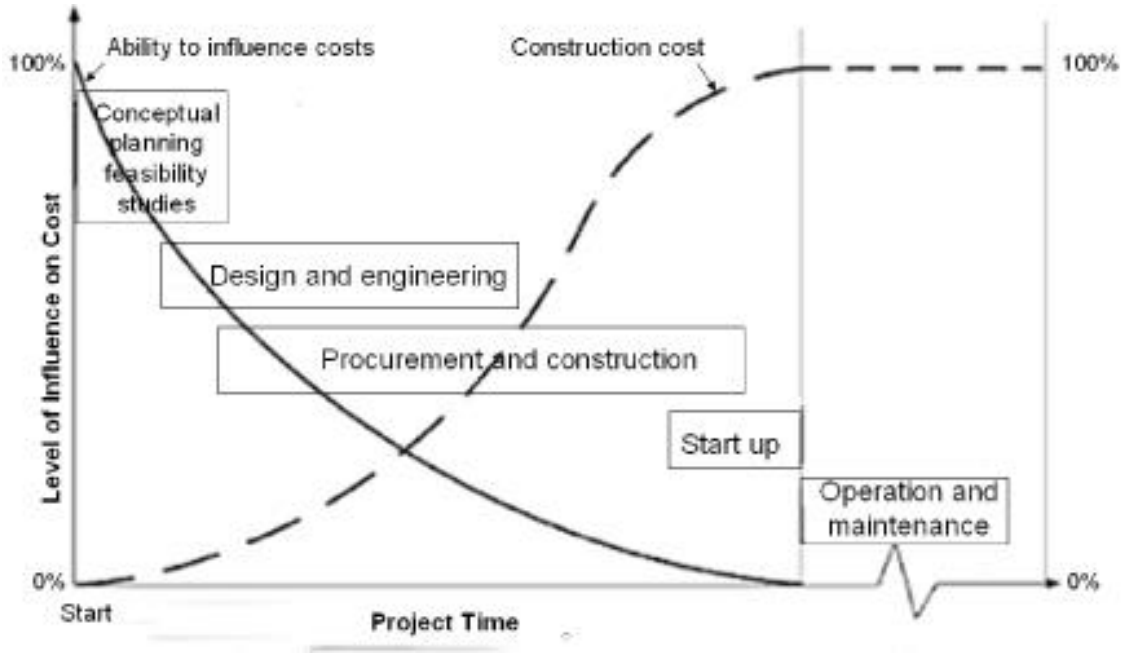

Figure 2: Project Life Cycle - ability to effect cost (Eastman, 2008)

In Building Managing at Risk supply technique, equally the planner as well as the building manager openly work for the client. They can pool resources as well as accompaniment for each other's undertakings plus account to the employer. Once BIM is employed, this method transmits the possibility such as the conventional process that the engineers and the designers might not need to part their models as a result of risks like accountability trepidations, as well as illegal reuse of knowledgeable possessions. Likewise, Building Managing at Risk method generally includes the before-building facilities.

2.4 Use of BIM in Construction Management

The adoption of BIM by project players is evolving. Figure 3 portrays the employment for the scheduling, plan (before building), building as well as set-up (after building) stages:

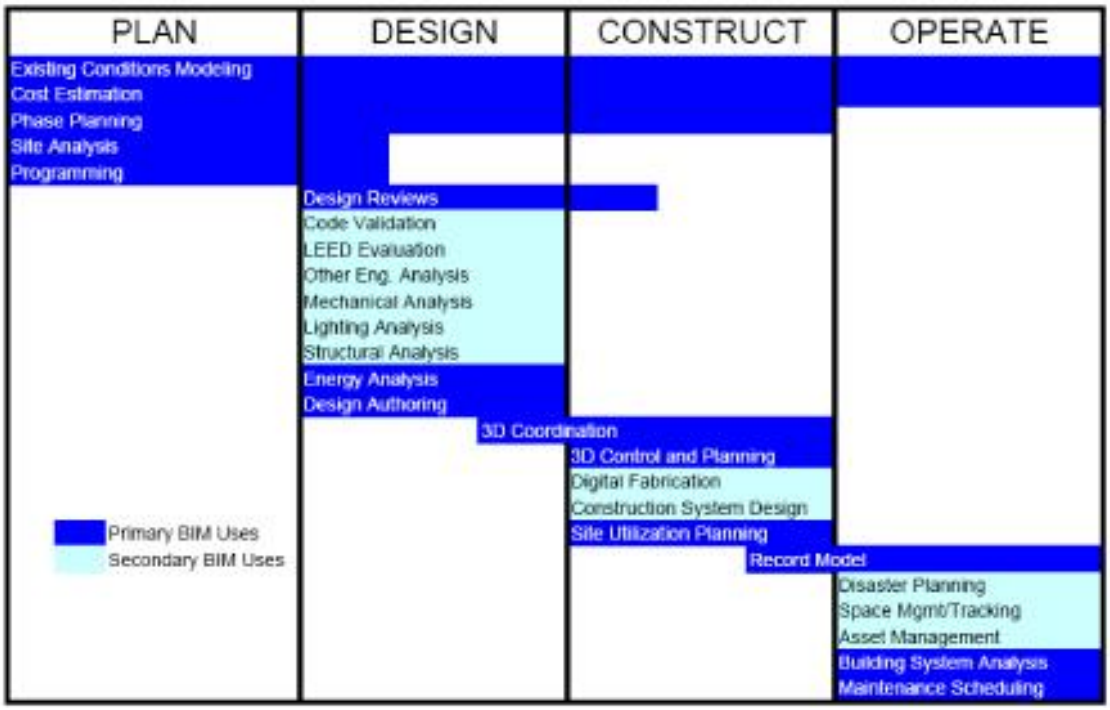

Figure 3: BIM adoption through a Construction Lifecycle (Messner, 2009)

Throughout the planning stage, the adoption of BIM can u its influence on a project since the ability to impact cost is the highest. The team can innovatively come up with ideas and provide solutions to issues before problems become high cost upsurge influences to the scheme. This is attained throughout the collaboration as well as organization of the whole scheme team. Consequently, it is very significant to devise a great alliance. BIM mainly improves the cooperative exertions of the squad. The engineer and designer can examine their plan thoughts counting energy exploration. The building manager can deliver constructability, follows, value as well as business accounts. 3D management among subcontractors as well as sellers can also commence throughout initial phases of plan. The client can communicate visually if the plan is what he expectant. General, the BIM indorses teamwork to various projection players. Throughout the post building stage, upkeep planning, construction scheme examination, asset managing, as well as space managing plus following, tragedy scheduling, then to withstand the construction through its lifecycle.

2.4.1 Visualization

BIM is an unlimited conception device. It delivers a 3D computer-generated demonstration of structure. Throughout the tendering stage of the scheme, the building manager can make available renderings as well as systematic of the model to improved communication of the BIM perception in 3D. Visualization offers a well thoughtful of the final product. Thought procedure takes away of transporting the dissimilar conventional 2D outlooks to drive into 3D outlook of a feature. Additionally, computer-generated mock-ups like structure covering could be delivered to the planner as well as the client. This would benefit envision, improved know, then create conclusions on the beauty as well as the performance of the model in space. As exposed further down in addition open in the BIM Forum Conference in San Diego, computer-generated mock ups are employed to analyzed 3D shop designs of the construction envelope (Khemlani, 2011). This assist in communication as well as group means between the scheme players. It encourages scheduling, in addition to systematics in curtain wall building. Though a computer-generated mock up is cost effective in link to a bodily mock-up, a bodily mock-up can be critical if participant like a gathering of the construction like a curtain wall prerequisite to go over a sequence of bodily examinations.

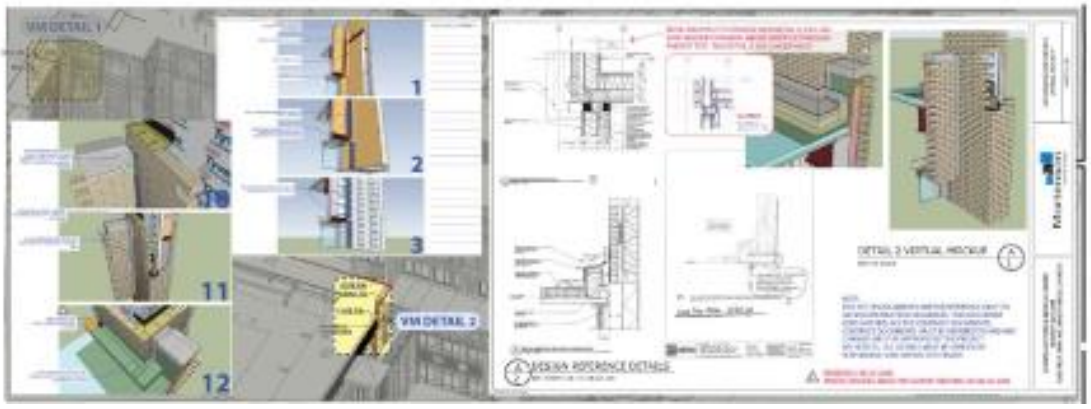

Figure 4: Exterior Envelope Virtual Mock up for 3D Shop Drawing Review (Khemlani, 2011)

2.4.2 3D Coordination

Cooperation of the building squad together with the designer, engineer as well as the client is best to be taking place on initial phases of plan stage. Then, BIM will directly be engaged. If the designer is merely offering 2D designs, hence, the building manager must convert the 2D designs to 3D conceptions. Once the area builder, particularly the MEP builder as well as the structural engineer are convoluted, they require to spatially organize their task. The 3D dexterity can commence immediately when the concept is made to confirm that any similar space meddling or clearance clashes are fixed. Usually, the organization exertions of building manager as well as general builder in improved building assist to eradicate design mistakes enormously as well as to improved understand gaining of period the task to be completed.

2.4.3 Prefabrication

Prefabrication decreases ground cost of labor as well as time then upsurges correctness in a decent excellence building. Several devices in addition to choices freely obtainable in a measured environs of the workplace to achieve task perfectly, as well as less expensive in a shorter time period. Prefabrication needs plan as well as site precision. BIM deliver this degree accurateness by counting the stipulations, arrangement, appearances, as well as the 3D graphics. Nonetheless, the building squad requisite that BIM is interoperable with the software employed by structural fabricators. Thus the builder can employ the BIM as well as make specifics for the product in their manufacture software. When the information is accepted, the structure can be made-up by means of Computer Numerical Control (CNC) technologies. Moreover, the building executives need to succeed the obtaining plan of the materials. Generally, the fabricated materials need to be transported to the work place on time. Problematic steel links industrialized in BIM can be joined offsite.

Besides, BIM aids to judicious modify plans to eradicate the adoption of beam diffusions that may effect as of MEP skirmishes. A decent organization of these permeations through BIM know-how supporters decisive the beam permeation sites as well as assemble offsite. Manufactured beam permeations would save outstanding time, cash as well as exertion in difference to onsite beam permeations. Furthermore, roof permeations for concrete roofs must be sleeved preceding to concrete placement at the roof. Additional steel to each diffusion may be prerequisite. These diffusions can be synchronized by BIM once the general builder are on board (LeBlanc, 2010). Curtain wall structures either panelized or stick structure, might be employed by means of BIM to produce fragments as well as modules. Panelized curtain wall structures might be measured for the plan drives. Stick structures necessitate the adoption of gathering of different modules at work place while the panelized structures now derived manufactured by various components that contain lining, coating, bordering, stone etc. BIM can be employed to design and construct Walls, rooms, and houses. These components can be manufactured with roughed mechanical, electrical, plumbing (MEP) modules. Finishing MEP associates can be completed after the manufactured components are gathered at work place. This tools can be essential nature of organization with MEP builders. Commonly, BIM may assist attain the application of the MEP roughing job through supporting cooperation of data altercation among subcontractors. BIM can benefit to manage amid casework installers as well as MEP builders. BIM may be employed to improve the info interchange of the products among players.

2.4.4 Building Scheduling and Checking

Building scheduling contains planning as well as arrangement of designs to organize computer-generated building in time as well as space. The plan of the anticipated building development may be combined to a computer-generated building. The use of planning boons while as the 4D. There involve two corporate planning approaches which can be utilized to

make 4D BIM. These comprise critical path method (CPM) as well as line of balance. For the Critical Path Method, each activity is enumerated, connected to additional activity, as well as allocated periods. Interdependency of an undertaking is combine as either predecessors or successors to extra activity. Furthermore, the period of the activities is arrived. Founded on the dependence as well as period of the activities, the lengthiest trail is well-defined as the utmost CPM. The activities clear in the lengthiest path are well-defined as the critical activities. They don't have any float. Thus, when these activities are not finished in expected period, the overall time of the scheme may be pushed extra out. CPM is usually adopted process that assist schemes stay in plan. Line of Balance technique employs position as the foundation for planning. This method is other to the CPM. It is beneficial for repeating works to upsurge the productivity labor. In this technique, the duration of activity is founded on the offered group size as well as the arrangement of the position. Productivity of labour can be changed as required to precisely characterize the building plan. The scheduling by employing BIM advances place operation, space organization, as well as info of product. Moreover, the location operation contains of established capacities, site undertakings development, as well as trailers location plus tools as well as hoist assembly. Likewise, once the structure is sheltered in, the space organization should be accomplished for the roughing as well as eventually final undertakings.

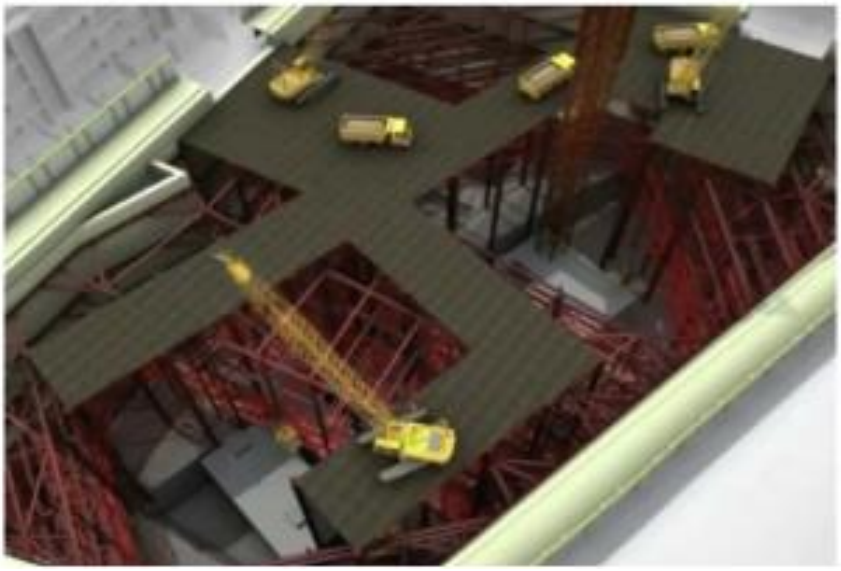

Figure 5: Hennesy Centre Safety and Site Logistics Planning (Collins, 2011)

4D BIM can be employed as a conception equipment's to identify the care structures that might be needed at Altered periods. Founded on these annotations, the Provisional shelter connected assemblies like rails as well as fences can be molded in the BIM in addition to the protection related undertakings can be assimilated into the plan. When the model is employed as a scheduling equipment for protection, the 4D model can be employed to discern protection provisions engaged at the workplace.

Scheduling as well as checking is an exceptionally imperative measure of building. The CM employs numerous 4D module facilitated equipment to improve the excellence control procedure

2.4.5 Cost Approximation

The two main features of a cost approximation are measurement as well as pricing. Quantities from a BIM can be put in to a cost databank or an excel manuscript. Though, estimating cannot be completed from the model. Cost estimating needs the technology of the cost estimator to examine the nature of a material as well as exactly how they develop fixed.

If the pricing for a definite activity is not obtainable in the databank, cost estimator might necessitate an additional analysis of the component for additional precise pricing. For example, if placement of concrete activity is in position, the component can version for the amount of feature for the formwork, concrete, rebar, wire mesh, pour stop etc., however not contain it as part of the quantity take-off extraction. Cost estimator might necessitate this level of element from the component to know the component price that entails of the material unit cost, labor unit cost, profit as well as overhead. In BIM, the information output is as upright as the information input. General, BIM know-how is a countless device to enhance the efficiency of the estimators by quantity extraction from the component particularly if the building as well as planning squad work collaboratively.

2.4.6 Record Model

Building Managers might afford a record BIM to the client at the completion of a scheme. The component includes the assimilation of the as-builts from the subcontractors. Furthermore, different object property in the component may include relations to submittals, processes as well as preservation, then guarantee info. Central databank can support the services section to discover info at ease. Record model can be employed to succeed safety as well as security info like extra illumination, danger power, way out, fire alarm, fire extinguishers, smoke detector as well as sprinkler classifications (Liu, 2010). In conclusion, the services division can employ the model to produce cost as well as plan influences for conservation plus renewal schemes. Generally, record model can be employ to improve service managing as well as upkeep. Introduction of BIM as a record model is a region in the procedure of expansion. Similarly, the client requires to be keen to assign capital to coach personnel, inform as well as keep up the record BIM (Keegan, 2010). As the benefits of the record model are recognized, the client will be additional difficult of the record BIM. A exact record model that covers the possibility of the scheme as well as the requirement of the

services division can support the client accomplish plus uphold the construction enormously. Autodesk Navisworks Accomplish is sound recognized for its clash uncovering characteristics. Though, it emanates with a structure denoted as Timeliner to improve building plans. Timeliner can connect Ms Project, as well as Primavera project manager by numerous BIM (Revit), CAD plus Laser Scan arrangements.

2.5 BIM Tools

Numerous BIM tools exist. This segment will categorize these tools. The subsequent table, 6, describes BIM tools as well as their main meanings. The list consists of MEP, structural, architectural, as well as 3D BIM software's. Several of these software's are adept of planning as well as cost approximation.

Product Name	Manufacturer	Primary Function
Cadpipe HVAC	AEC Design Group	3D HVAC Modelling
Revit Architecture	Autodesk	3D Architectural Modelling and Parametric Design
AutoCAD Architecture	Autodesk	3D Architectural Modelling and Parametric Design
Revit Structure	Autodesk	3D Architectural Modelling and Parametric Design
Revit MEP	Autodesk	3D Detail MEP Modelling
AutoCAD MEP	Autodesk	3D MEP Modelling
AutoCAD Civil 3D	Autodesk	Site Development
Cadpipe Commercial Pipe	AEC Design Group	3D Pipe Modelling
DProfiler	Beck Technology	3D Conceptual Modelling with real time cost estimating
Bentley BIM Suite (Micro Station, Bentley Architecture, Structural, Mechanical , Electrical Generative Design)	Bentley Systems	3D Architectural, Structural, Mechanical, Electrical and Generative Components Modelling
Fastrak	CSC (UK)	3D Structural Modelling
SDS/2	Design Data	3D Detailed Structural Modelling
Fabrication for Auto CAD MEP	East Coast CAD/CAM	3D Detailed MEP Modelling
Digital Project	Gehry Technologies	CATIA based BIM System for Architectural, Design, Engineering and Construction Modelling
Digital Project MEP System Routing	Gehry Technologies	MEP Design

ArchiCAD	Graphisoft	3D Architectural Modelling
MEP Modeler	Graphisoft	3D MEP Modelling
HydraCAD	Hydratec	3D Fire Sprinkler Design and Modelling
AutoSPRINK VR	MEP CAD	3D Fire Sprinkler Design and Modelling
FireCAD	Mc4 Software	Fir Piping Network Design and Modelling
CAD-Duct	Micro Application	3D Detailed MEP Modelling
Vectorworks Designer	Nemetschek	3D Architectural Modelling
Duct Designer 3D, Pipe Designer 3D	QuickPen International	3D Detailed MEP Modelling
RISA	RISA Technologies	Full Site of 2D and 3D Structural Design Applications
Tekla Structures	Teckla	3D Structural Modelling
Affinity	Trelligence	3D Model Application for early concept design
Vico Office	Vico Software	5D Modeling which can be used to generate cost and schedule data
PowerCivil	Bentley Systems	Site Development
Site Design, Site Planning	Eagle Point	Site Development

Figure 6: BIM Management as well as Planning Tools (Reinhardt, 2009)

2.6 COST ESTIMATING IN BIM

Cost approximating method includes execution quantity takeoff (QTO) Quantity takeoff list (QTO): a list of element as well as material quantities required for the scheme plus the addition cost information to the list. conventional QTO method with CAD designs includes choosing distinct features in CAD designs, by means of the software to automatically support the measurements for the take-off, as well as inputting the quantities into the QTO elements (Khemlani 2006). This procedure necessitates estimators to employ substantial expanse of period on creating the QTO of the complete design. As the choosing in addition quantifying procedures are founded on physical processes, the mistakes as well as omissions occur throughout the QTO course. The calculations need be steered earlier the scheme really commences besides this may need an advanced degree of exactness throughout the approximating procedure for builders. As BIM components are object-founded by in-built parametric info, it is at ease to put-in the measurement of the items in BIM as well as the

QTO through BIM designs will be extra correct by fewer faults as well as oversights. QTO procedure can be enhanced by advanced accurateness as well as fewer time by means of BIM know-how. Planning the QTO items by cost databanks, that can be built-in in BIM components or a separate outside cost databank, estimators can produce an additional precise in addition to reliable cost estimation of the structure through marginal exertion. There are three key choices to influence BIM for measure takeoff as well as to upkeep cost approximation.

They contain:

- Spread construction object quantities to approximating software

- Linkage of BIM equipment openly to the approximating software

- Usage, BIM quantity takeoff tool

2.6.1EXPORT QUANTITIES TO ESTIMATING SOFTWARE

Utmost BIM tools afford by software suppliers comprise structures for extracting the QTO off the BIM component. This equipment likewise comprises characteristics to relocation quantity takeoff information to a worksheet or an outside databank. In the United States only, above 100 profitable approximating parcels that protected these wants as well as numerous are obvious to constructions of convinced tenancies (Eastman et al. 2008). Microsoft Excel™ is generally employed approximating equipment that is likewise suitable for utmost estimators to extract QTO from BIM component (Kristofferson 2000. For instance, engineers as well as designers can employ Revit Architecture™ to definitely transfer the material info preliminary BOQ plus material takeoffs into MS Excel Worksheet, therefore extra precise cost estimations might be available at the initial phases of the development lifecycle. Though,

this method necessitates considerable arrangement as well as consistent BIM procedure—like adequate information on the object component—to produce the essential QTO info from the model. The additional substitute is to adopt BIM device with the capability to connect BIM model openly to an approximating suite in the plug-in or third-party device. Numerous of the larger approximating model suites today delivers plug-ins to many BIM devices. For example, Innovaya™ employs a plug-in equipment to connect to "Sage Timberline." This permits the client to link modules in the structure model openly by gatherings, methods, or objects in the approximating set in Sage Timberline™. The gatherings of construction workings will shadow the guidelines in Sage Timberline, therefore totally info prerequisite to progress a whole cost estimation can be produced from BIM Prototypical straight as well as the construction info will be extremely combined then accumulated. Though, builders might want to collaborate with subcontractors once they task on dissimilar approximating suites in this method.

Table 4 Plug-in tools for cost estimation

Product Name	Manufacturer	BIM Use	Supplier Web Link
Success Estimator	U.S. Cost	Estimating	www.uscost.com
Graphisoft Estimator	Graphisoft	Estimating	www.graphisoft.com
Innovaya	Innovaya	Estimating	www.innovaya.com

2.6.2 QUANTITY TAKEOFF TOOL

An extra substitute is to employ specific quantity takeoff equipment that support information from several BIM equipment. Operators can select a takeoff device mainly intended for their wants shorn of taking to study entirely the characteristics confined in a particular BIM device (see Table 5). These takeoff devices characteristically comprise precise characteristics that connect straight to objects as well as gatherings, clarify the model for exact 'item info', as

well as produce graphic takeoff drawings. These devices afford changing degree of provision for programmed extraction as well as labor-intensive takeoff characteristics. The operator collects the item in the model as well as dimensional information will be moved from the model to QTO list for additional rating.

Example of this is Autodesk QTO™ can spontaneously extract QTO from the construction model conferring to group data steamrolled on the item model as well as it also permits physical alteration of the takeoffs founded on the operators' individual predilection. Afterward, the QTO incline can be transferred to the MS Excel worksheet in addition operators can improve the quantities by any suitable cost databank. The QTO method in this can be completed spontaneously as well as categorize the items founded on the "Group" info steamrolled on the object model. One benefit of this technique is that operators cannot relate to the gatherings founded on the exact cost approximating suite; at all appropriate cost information can be planned by the QTO list afterward the quantities are produced

Table 5 Software list—quantity takeoff tools

Product Name	Manufacturer	BIM Use	Supplier Web Link
Revit Architecture	Autodesk	Architecture and Site Design	www.autodesk.com
MicroStation	Bentley	Creating and Reviewing 3D models	www.bentley.com
Dprofiler	Beck Technology	Conceptual Design And Cost estimation	www.beck-technology.com
ArchiCAD	Graphisoft	Conceptual 3D Architectural model	www.graphisoft.com

2.6.3 DEALING WITH ELECTRONIC AND PAPER-BASED CAD DRAWINGS

Though BIM is a quickly emerging know-how in Building Commerce, traditional building design setups like broadsheet drawing as well as traditional CAD designs are quiet directing the market of the current constructions. As specified in earlier unit, related to these conventional designs, the BIM project contain of item-founded parametric prototypes that comprise exclusively the limits however the supplementary guidelines, stipulations as well as other non-geometric stuffs plus characteristics like supplies, distinct association, etc The changing procedure might take operators substantial period of time, however BIM know-how can support operators through limitation of scheme time as well as decreasing scheme cost. For instance, U.S. Department of Energy (DOE) scheduled to create a fresh $100 million, 45,000 square-foot extensive-explosives Persistent Multifaceted Scheme in Texas. Once the orthodox CAD leaflets remained 95% completed, DOE selected to change current CAD plan into BIM model.

2.6.4 CONVERTING CONVENTIONAL CAD DRAWING TO BIM

Software tools like Revit Architecture by Autodesk, MicroStation by Bentley as well as ArchiCAD by Graphisoft, that are capable to change traditional CAD designs to BIM records. For instance, Revit Architecture 2011 can introduction or connect CAD Records employing the ‘Import CAD’ as well as ‘Link CAD’ Tools through the geometry information in the CAD Records. Through expending the geometry information as a preliminary stage in BIM model, the operators can also plan the other things in this well-defined model. After the entire information is calm as well as full into the BIM model, operators can make the QTO from the transformed BIM model to achieve cost approximating of the scheme.

2.7 CASE STUDIES

To produce new consistent outcomes, a full of 3 case readings covering schemes by a diversity of possibility were judiciously designated from the collected works. The case

readings were designated custody in outlook the variety of schemes. The schemes likewise different from small to large scaled schemes located in diverse measures of the globe.

2.7.1 Case study 1 (Kymmell, 2008)

This involve application of computer-generated plan as well as building equipment on a large health care scheme as well as defining its influence on the presentation of the building procedure. Computer-generated plan plus building (VDC) device were employed in the scheme to achieve the subsequent purposes.

- Mechanical Electrical Plumbing (MEP) organization;
- 3D MEP model for fabrication exertions;
- 3D clash uncovering to ascertain as well as resolution of skirmishes;
- Accomplish the procedure by means of the Last Planner System;
- Produce the 4D models for MEP coordination plus
- Modernize the 4D models for organization.

Unique dire query talked in this reading was, what significance sort out the adoption of VDC device deliver? foremost, the plan squad must undoubtedly ascertain the return on investment for the user for employing VDC device, as the 3D/4D BIM is an outlay for the user similar some additional. Currently, 3D BIM and organization involve additional period than traditional drafting in 2D space and superimposing the drawings for coordination on a light table. Moreover, 3D/4D BIM necessitate extremely knowledgeable as well as qualified team to perform the development that are in small source then luxurious to tolerate. However, the understanding showed that employing VDC device in a cooperative organization exertion permits a scheme squad to attain larger value throughout building. In 6 to 9 months, the health care scheme described an arrival on savings of 2 to 3 times the original savings in VDC. Investments happened over elimination of skirmishes between dissimilar schemes, better prefabrication, reduction in alteration guidelines, as well as an upsurge competence of task by the removal of task space skirmishes. The profit on savings consequently accrued

from the period project finished to the period all the undertakings for the MEP schemes finished. Afterward the application of the VDC device for BIM as well as organization, the health care scheme squad projected that on a $94.5 million agreement the user invested nearly $1.2 million. Significant attained in the scheme are as follows:

Improved field efficiency:

The HVAC subcontractor gathered 20 to 33% upsurge in field efficiency as a result of prefabrication of schemes that was probable through the adoption of VDC device for MEP organization. Nil field clashes between organizations demonstrated as well as organized by means of VDC device There were nil field clashes on the health care scheme between systems that were organized as well as displayed by means of VDC device. The managers' projected that characteristically there would be around 100 to 200 skirmishes that get determined on the field on a parallel scheme shorn of the application of VDC device.

Only six RFIs related to field conflicts.

There were only six demand for info (RFI) delivered concerning the field skirmishes. These RFIs remained the clashes among organizations that were not encompassed in the BIM practice. The scheduling constancy was followed in the development by means of the percentage strategy complete (PPC) metric, that

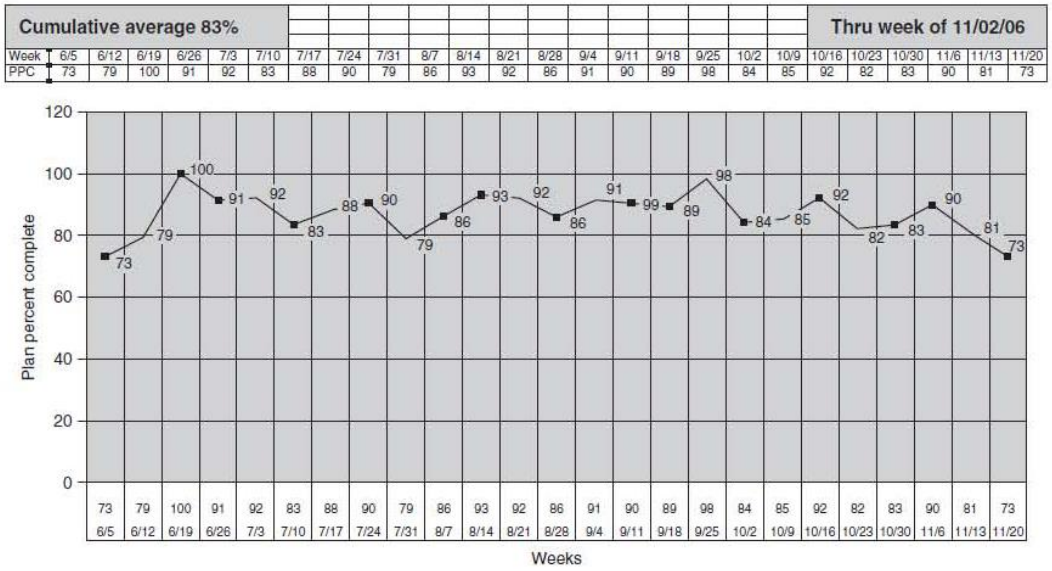

Fig 7 Percent plan complete over project duration

2.7.2 Case study 2 (Kymmell, 2008)

This reading is about a builder making a computer-generated plan as well as building (VDC) device plus including them into their normal procedures. The VDC package fixated on 3D excellence support, 4D planning, as well as 5D cost approximation. The builder's directors were influenced from the initial that the VDC procedure will be useful for them, thus less exertion was paid on profit on investment (ROI) readings. Relatively their attention was to plan as well as progress values, courses, plus structure for the operative transfer of different method then to authenticate outcomes to improvement sureness in the fresh BIM device. Fairly initial in the project stage, two facts developed clear.

- A quantity projected by building a model is much more dependable than one projected from orthodox means as well as 2D official papers plus designs.
- The period finished in developing a model substitutes the period consumed in taking off quantities as of 2D documents as well as designs.

Through correct principles, procedures as well as teaching, making a model is as fast as extracting information from the 2D official papers as well as designs. That is, the period expended is assessing the 2D official papers equivalents the period in making a 3D model which will aid us envision the 2D documents more adeptly then exactly.

2.7.3 Case study 3 (Eastman, Teicholz, Sacks, & Liston, 2011)

Case study 3 throws more light on the use of BIM considering big construction project. BIM process was incorporated in a project after the design by the owner using 2D tools which was present. For support of design, clash detection, organization of work, 4D planning and quantities takeoff, the BIM tools were used. Design team is made of different professional team with the structural engineer team, quantity surveyor team, architect team, and the mechanical and electrical engineer team. Initially all these four teams were using the 2D drawing for communication among themselves but later created the 3D model using BIM tools. The design consultants manually acknowledged the clashes making use of the orthodox techniques which involved the overlaid drawings on light table which pointers to clash recognition and controlling to be confronted by the freelancer. By the BIM tools application, several errors together with clashes were identified before tendering and construction. Substantial cost saving was realized by the BIM adoption as related to the traditional 2D process. BIM tools were similarly employed to execute developed building method which improves construction tradition. The building concept was unified together with its detailed programme forming the 4D model. The 4D model supported the conception of the order of building work with its spatial and safety subjects been known with respect to construction. The nature of procedures use was prudently monitored to ensure that the plan used was reliable and has the ability to improve the process. Cost and time savings on construction site resulted due to operational planning.

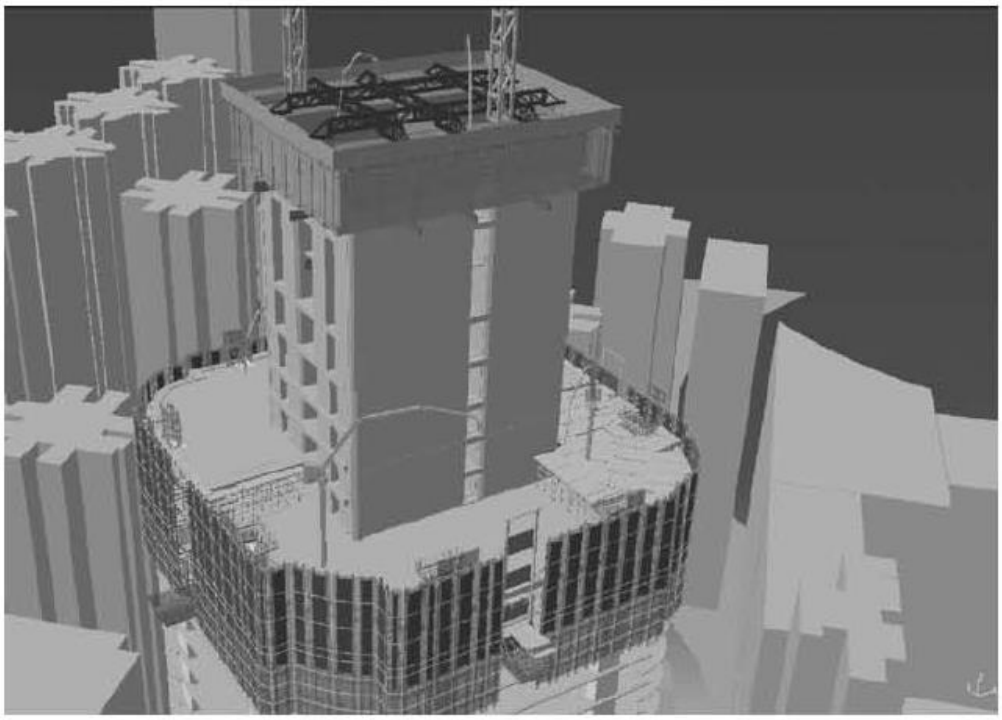

Figure 8: Imagining of the construction process

CHAPTER 3

RESEARCH METHODOLOGY

3.1. INTRODUCTION

This research aimed at assessing the usages in addition to advantages of BIM for building professionals as well as the limitations of BIM established planning. Methodology may be defined as the way that research is undertaken making consideration of the activities with which the research should cover during collection of data, processing terms of the discipline, collection and assessment of particular data with the drive of assisting the researcher to comprehend the targeted sample by the linking of firms to their system and gauge their performance together with their challenges. Furthermore, methodology specifies the needed information for the design of data collection procedures; it manages the process of data collection and examines the results afterwards; it also links findings and their repercussions (Proctor, 2003).

3.1 Research Design

Oppenheim (1992) reported research design to be the "basic plan or approach of the research, and the logic behind it" which aids the researcher in the drawing of research sample. For this reason, the research design acknowledged the research philosophy, logic, method, outcome and purpose of the research.

The research explored the benefits and the limitations of BIM implementation in the Ghanaian Construction Industry. The research design mostly specifies among the various types of research approach the one adopted and the plans of the researcher for the application of scientific controls to ensure better interpretation of result (Polit and Hungler, 1999).

In quantitative research, researchers are allowed to acquaint themselves to the problem or the model to be considered. The study is based on the opinion that BIM has received little response both in scholarship and practice. For a required data to be collected, this research adopted the Hybrid methods for its data collection. The definition of hybrid methods is the mixing of data or methods for the purpose of throwing light on a topic from a varied perspectives or views. As a result, face-to-face semi structured interviews and questionnaire was directed to professionals in the Construction Industry. This research therefore adopted the realistic philosophy for the enablement of collecting data from professionals.

Research Approach

For the selection of research approach, Partington (2002) disputed that it relies on the goal as well as the purposes of the study. Before selecting the right study designs, three criteria should however be considered; that is, the nature of the research topic, time availability, and degree of risk as stated by Creswell (2003).

The two methods used in establishing what is true or false in a research and for the drawing of conclusions are induction and deduction. Whereas induction technique is undertaking in a less structured qualitative research method, deduction technique is preferred using structured qualitative research method.

This research tries to take a broad view of the findings for the purpose of representing the whole population and as a result making the choice of the deduction approach the greatest fitting. Deduction approach aims at generalizing findings from sample to population with the inductive aims of examining new ideas or the generation of theory (Saunders *et al.*, 2007).

3.2 Research Strategies

Saunders *et al*., (2007) defined research strategy to be the blueprint from which the researcher uses in answering specific research questions specifying the source from which required information was collected by the researcher and making consideration the limitations in the collection of data process like the time, ethical issues, location, money etc. The research focus is not the method one strategy is committed to but whether it deemed suitable strategy to answer the research question or not.

Usually, survey is connected to the deduction approach and as a result questionnaire is used in obtaining data which is one of the methods of collecting data. But to this strategy however, questionnaire is not the only data collection method; there exist other methods which include structured observation and interviews. These two methods help the researcher to gather enough data from a sizable population in a very economical manner. Therefore for easy understanding and easy data comparison, this strategy is used. However, since the survey strategy allows the researcher to have more control over the research process, time criteria on the design and piloting of questionnaire were taken into consideration by the researcher.

This research consequently adopted this survey strategy for its collection of data process looking at the advantages from the above paragraph.

3.3 Methods of Data Collection

For any research, data collection are categorized into two according to Saunders *et al*., (2007); secondary and primary data. A lot of researchers prefer starting with re-analyzing previously collected data for other purpose in order to give answer or to start answering the research questions and its objectives supporting the research. Collection of new data follows after which involve collection of data using the primary data techniques to solve a specific

problem at hand. In this research work there are two data types, that is, the secondary and the primary data, with the intention of helping the researcher to obtain the necessary information desirable during gathering of data from recognized professionals. The primary and the secondary data together are considered the best comprehensive source of information because of their role in aiding the validity of the research, that is, the secondary data provides basic information whiles the primary data provides more deeper and accurate information looking to the BIM implementation process and its tools and techniques from varied opinions. However, the focus of this study limits the research to the benefits and barriers to BIM implementation in the Building Construction Industry of Ghana where the researcher investigates the quality opinions from all professionals in the construction project.

The purpose of the secondary data is to help the researcher gain the needed information in answering any ambiguous questions during the process of implementation. In addition, secondary data improves the savings of time, money and effort by researcher due to implementation of BIM and availability in comparisons with other prior studies.

3.4 Target Population

The definition of the targeted population is a fundamental step in all research works and it requires a lot of attention and some form of exertion in order to achieve a reliable and a valid research. The total number of a particular group of people, events or other related things of interest which the researcher wishes to examine is what is known as the research population (Sekaram, 2003). A targeted sample must therefore be clearly identify and chosen by the researcher for the answering of research question so as to attain the needed findings and results. The starting of research population in all research works is the complete listing of all the organizations within a particular population giving all equally chance to be selected with which afterwards the researcher then determines the targeted ones out from the list.

However, as the study required elucidating the practice rates of BIM by participants of the Ghanaian Building Industry, the primary source of data was recognized as being companies convoluted in the BIM. In order to be able to conclude study results back to a population, as well as generate precise and significant outcomes, revealing of Ghanaian Building Industry in general, a method of random sampling from the Ghanaian Building Professionals and Contractors.

3.5 Sampling Procedure

Selection of the targeted sample becomes a major element in all research works; that is, recognition and misrecognition of the target sample has its own benefits and drawbacks. Nevertheless, it is practically impossible to survey the whole population in answering the research question, which implicates high survey cost, difficulties in gaining access to all the targeted organizations and a prolong time for collection of data its analysis. A subset of the population or the 'sample' is, thus, used to gain information about the entire population (Henry, 1990). A comparatively small sample if appropriately selected can be informative about the total population.

Bryman (2004) had reported that, sampling procedures tells us on how part of the population used in data collected was carefully chosen. That is, the research population becomes the world of units where the sample is carefully chosen. Survey research is concerned with making inference about a population on the root of data from a sample. To use appropriate techniques is basic idea of sampling so that a sample can be drawn, which allows for statistical inference and generalization back to the population. Conversely, it is palpable that the smaller the size of the targeted sample, the more likely it is for the research to be practical, relatively cheaper and time saving one in terms of collection data and its analysis.

Purposive sampling technique was utilized in the determination of sample for this study. A total sample size of twenty-nine (29) was used.

3.6 Questionnaire

Oppenheim (1992) reported the design of questionnaire to be an integral part of the design of research stage. For a quantitative study like this, the biggest confront for the design of questions is to safeguard that each and every response can be expressed numerically, for the simple reason, statistics and econometrics perceive those variables as a stronger measure in analysis. According to Frazer and Lawley (2000) and Oppenheim (1992), within a questionnaire a question can either be an open-ended one, a close-ended one or at times a mixture of both depending of the likely outcome. Frazer and Lawley (2000) reported four main methods to which questionnaires are administered. They include mail questionnaire, personally administered questionnaire, telephone questionnaire, and internet questionnaire.

A self-structured questionnaire survey (personally administered questionnaire) was adopted for the study which according to Oppenheim (1992) is the most generally used technique as far as collection of quantitative data in management survey is concern. It is again from Oppenheim (1992) report the most ensured way of higher response rate from professionals, the cheapest cost in comparison with the other methods, accurate sampling and the least interviewer bias. Self-structured questionnaire survey requires minimum exertion by the interviewer than the verbal and telephone surveys. Nevertheless, this method of survey includes written questions usually designed to provide possible answers that ensure easy answering to respondents. The main shortcoming of self-structured questionnaire is respondents' control of time for the return of responses which reflects on the overall time increase.

3.7 Analysis of Data

For a good design of questionnaires, questions propound to the professionals were edited thoroughly to ensure consistency, readability and completeness so as to meet with the set objectives. Data after effective scrutiny were arranged in a manner that enhanced easy analysis. Number of data from the questionnaire was fed into packages of softwares for analysis. Microsoft excel together with Statistical Package for Social Sciences (SPSS 16.0) were afterwards used to analyze the data. Frequency tables, percentages, bar charts and other descriptive were used to analysis the results. It was required from respondents to make provision for responses by marking a number on a 5-point Likert Scale for easier answering. The five-point Likert scale scoring system mentioned earlier formed the basis of calculating the mean score for each of the factors; the relative ranking of the factors by all respondents, was then determined by comparing the individual mean score and the standard deviation for each criterion. Table 3.1 indicates the systems of rating for questions within the set questionnaire.

Table 3.1: The Questionnaire System of Rating

Likert Scale/Rating Score	**Level of Importance**
1	Least importance
2	Less Important
3	Moderately Important
4	Very Important
5	Most Important

CHAPTER 4

ANALYSIS AND DISCUSSION

4.1INTRODUCTION

The chapter four was dedicated to the analysis of BIM impact on construction planning against traditional planning methods and it was again to determine 4D BIM impact, its advantage as well as barriers for the building scheduling procedure which are ascertained by revising the case readings and other pertinent literature. The analysis consists of mean score ranking of identified variables were used in the presentation of results. This method allows for a good analysis of the information collected due to the nature of the survey and the percentage of the variables that were used in the analysis and discussion.

Out of the 40 questionnaires sent out to the professionals in the sample frame, 35 of them were returned with 5 questionnaires being rejected due to incomplete filling out. The details in case by the returnees were that the reading was not significant to their industry. In the Case of Ghanaian Construction Establishments some of the info needed was ‘private to their industry; as a result, only 29 were involved for analysis representing 72% for a response rate. The 72% of a response rate is comparable to preceding readings in the building (Shash 1993; Kometa and Olomolaiye 1997) which gained reply rates of 28% and 23% correspondingly. As the chief aims of this reading were to identify the present practice rates of BIM acceptance, with an outlook to creating the supported advantage as well as barriers connecting to the acceptance of BIM to the influence on scheme results. The succeeding sections highlight the analysis and discussion of the demographics and dependent variables (i.e. the barriers and benefits).

4.2 ANALYSIS OF DEMOGRAPHIC VARIABLES

The section is devoted to the analysis of the background of the respondents and covered inter alia the profession of the respondent, their awareness level on BIM, etc. Such analyses are necessary because the background of the respondents is to give credibility of data collected; and thus the findings of the study.

4.2.1 Categories of Respondents

A total of twenty-nine (29) professionals completed the questionnaire with the majority drawn from Project Managers (10), whereas Architects were seven (7), Two (2) Engineers. Five (5) respondents also indicated Quantity Surveyors followed by Managing Directors (4). The rest was a Structural engineer (1). Responses from the twenty-nine (29) professionals were not although consistently spread through the functions, but however, the outcomes from these responses show that the sample population held important locations when it comes to their organizations, which would consequently be anticipated to have a grasp concerning the existing does as well as procedures in the organizations of the professionals and Construction Industry at wide.

4.2.2 BIM Usage Rates

This segment accounts on the adoption of BIM within Ghanaian Building building organizations. Only a marginal (13.79%, n = 4) of the companies were presently by means of some level of BIM. On the contrary, the widely held, 25 (86.20%) testified as not expending BIM. Given the low described practice of any form of BIM know-how, the percentage responses reported here characterize marginal outlooks.

The data collected also displays a connection among the use of BIM and the size of the industry. The results recognized that none of the companies with annual revenue of less than $7 Million were presently using any form of Building Information Modelling. These

consequences are reliable with literature which recommends that ‘execution costs of BIM were professed by builders, as theoretically exorbitant in the short term’

4.3 ANALYSIS OF DEPENDENT VARIABLES

This section presents and discusses the analysis of the dependent variables. It does so by using two main statistical tools; relative importance index and mean score. The findings are presented in tabular and graphical forms to elucidate the discussions.

4.3.1 Awareness of BIM

Business thoughtful of the know-how ‘BIM’ to attain the first goal, viz. that of ‘determining the present mindfulness of BIM considering participants of the Ghanaian Building Industry.

The outcomes presented that, a substantial section (41.37%, n = 12) presently have either never heard of, or only have some information of BIM. Whilst, only a collective total of (27.58%; n = 8) comprising BIM users (n = 4) and non-BIM users (n = 4) believed they had a moderate understanding. Significantly, only a minority, (6.89%; n = 2) of the respondents had a highly competent understanding of BIM. This respondent was drawn from the non-BIM utilization organization. These outcomes thus approve with literature that there is presently an open lack of thoughtful of BIM in the wider Ghanaian Building Industry. An important opinion to note from the outcomes, in terms of business as well as responsiveness of BIM, was that, apart from the awareness, the correct usage and the benefits of BIM Adoption – The Case of Ghanaian Construction Establishments respondent, none of the outstanding respondents whose organizations were employing BIM designated they had more than a moderate knowledge of the advantages linked with this modern technology.

4.3.2 Benefits of BIM Usage

Table 1 lists the ten benefits in the implementation of BIM. The top four advantage (mean score > 4.0) were: 1. 'Improved constructability' (mean = 4.33, RII = 0.87); 2. 'Improved visualization' (mean = 4.22, RII = 0.84); 3. 'Improved productivity' (mean = 4.07, RII = 0.82); and 4. 'Reduced clashes' (mean = 4.04, RII = 0.81).

Table 4.1 Means, Relative Importance Index and Importance Levels of the Benefits surrounding the adoption of BIM in the Ghanaian Building Industry

Benefits	**Mean**	**RII (MS/5)**	Rank
Improved Constructability	4.33	0.87	1
Enhanced Visualization	4.22	0.84	2
Improved Productivity	4.07	0.82	3
Reduced Clashes	4.04	0.81	4
Improved quality and accuracy	3.85	0.77	5
Improved Client Satisfaction	3.81	0.76	6
Increased Competiveness	3.59	0.72	7
Improved Information Sharing	3.33	0.67	8
Improved sustainability	2.96	0.59	9

The least significant advantage, placed eighth, ninth and tenth correspondingly were: 8. 'Improved information sharing' (mean = 3.33, RII = 0.67); and 9. 'Improved sustainability' (mean = 2.96, RII = 0.59).

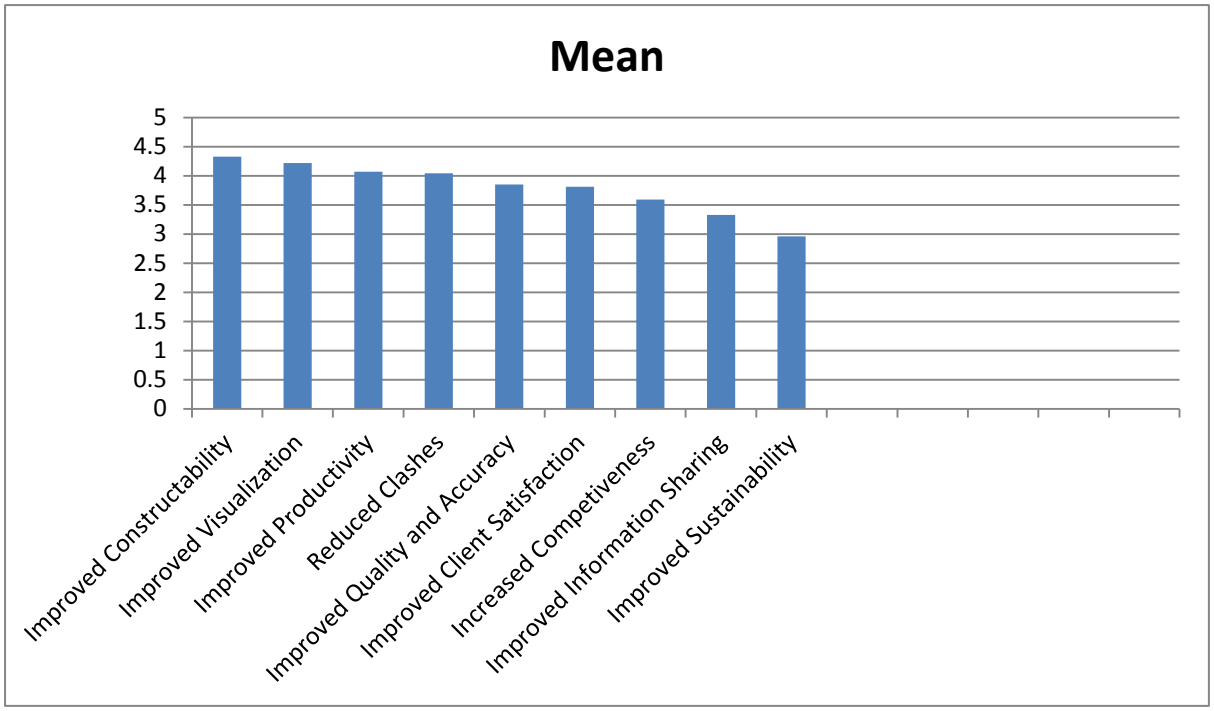

Fig. 9 representing the means scores of the Benefits of BIM

Table 4.2 Means, Relative Importance Index of the Barriers surrounding the use of BIM in the Ghanaian Building Industry

Barriers	**Mean**	**RII (MS/5)**	**Rank**
Lack of Knowledge in the use of BIM	4.83	0.71	**1**
Software Compatibility	4.70	0.65	2
BIM Cost Setup	4.03	0.54	3
Risk Exposure	3.07	0.42	4
Cultural Resistance	3.00	0.40	5
Incompatibility with SMM	1.12	0.32	6
Fragmented Nature of Construction Industry	1.04	0.27	7

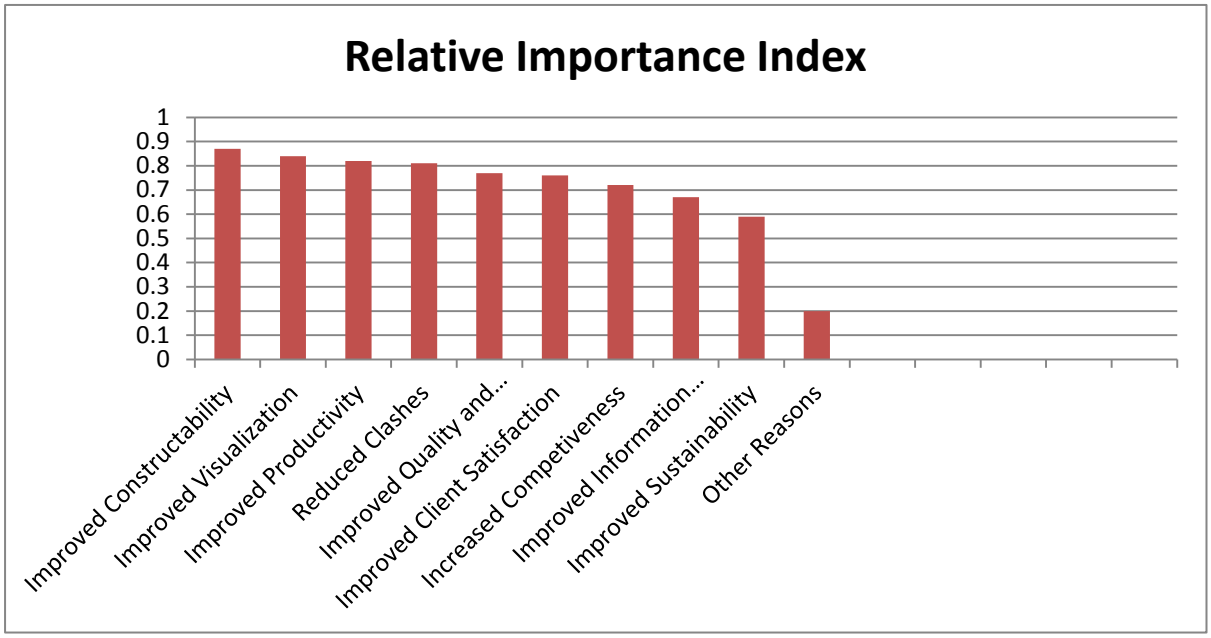

Fig. 10 representing the Relative Importance Index of the Benefits of BIM

4.3.2.1 Improved constructability

'Improved constructability' ensuing in time, cost and excellence advantage was the most extremely rated (mean = 4.33, RII= 0.87). This result is regular with other readings from CRC for Building Innovation (2007and Underwood and Isikdag (2010), which designated the main advantage of BIM was the capability to have a comprehensive and precise set of data for easy recovery for the life of a facility, providing advantage not only throughout building, but also throughout its life. Likewise, enhanced constructability through reduced building costs can be accomplished through BIM implementation (CRC for Construction Innovation, 2007). Consequently, this study (CRC for Construction Innovation, 2007) pointed to 'enhanced scheme efficiency' and also has the facility to 'prevent reworking', due to initial pickup of issues such as clashes

4.3.2.2 Enhanced visualization

The second highly ranked benefit of BIM adoption was that of 'Enhanced visualization' (mean = 4.22, RII = 0.84). This result is reliable with other readings from Kymmell, (2008) to CRC for Building in Innovation (2007). For instance, Newton and Chileshe conferring to Kymmell (2008), the principal difficult in the scheduling as well as building procedure is incorrect conception of the project. Kymmell (2008) additional elucidates that, if a project is not fully pictured, agreed as well as communicated, it cannot be characterized properly in the contract documents which may cause difficulties later in the building procedure that will be much costlier to rectify. Consequently, this permits builder to be much more precise when collation materials, serving avoid expenditure and over-ordering.

4.3.2.3 Improved productivity

'Improved productivity' developing as a consequence of enlightening cooperation amid all gatherings intricate in a construction task, counting the customer, designers and other professionals such as architects, engineers and contractors was the third ranked benefit (mean = 4.07, RII = 0.82). The above outcome agrees with other studies like the CRC for Construction Innovation (2007), which identified this feature of 'improved efficiency' as an imperative one in refining efficiency of exact schemes as well as industry in common. The reading (CRC for Construction Innovation (2007), exposed that the adoption of BIM permissible for planners to work on a single model fairly than having each associate re-forming as well as making info.

4.3.2.4 Reduced clashes

'Reduced clashes' resultant in decrease costly differences throughout building as well as the succeeding interruptions which could effect in liquidated damages actuality claimed resulting

in time, cost and quality benefit was the fourth ranked benefit (mean = 4.04, RII = 0.81). Conferring to a study piloted by BIM in Ghana (2010), the implementation of BIM permits possible clashes among diverse craft or disciplines to be picked up early in the plan stage. Solving inconsistencies and the clashes between works of dissimilar disciplines may arise in the simulated environment which in turn can significantly shift the time commitment for professionals from the phase of construction into the phases of design, with significant effects on fee arrangements and project team administration.

4.3.3 BIM Implementation- Barriers

Part of the research, the study sought to establish the barriers undermining the success in BIM implementation in the Building construction industry of Ghana. Interview section was held among 8 participants. Subsequently, the barriers were analyzed quantitatively by the relative importance index and mean score ranking were used. The study considered that analysis of such nature would inevitably drive the implementation of BIM if the barriers are resolved. The succeeding subsections present the barriers.

4.3.3.1 BIM setup Costs i.e. Software, Training and Hardware Costs

BIM set up cost was ranked by the respondents as the second major barrier to BIM implementation in the Construction Industry of Ghana. a mean value of 4.03 and an RII value of 0.54 was obtained by Barriers(see Table 4.2). Software and hardware upgrades are considered as significant barriers to BIM implementation, particularly for SMEs (McGraw-Hill Construction, 2012). Indeed one participant observed that relatively bigger firms are able to meet the BIM costs, but for SMEs that constitute a larger portion of the Building Construction Industry it is fairly expensive. Thurairrajah and Goucher (2013) observed that considerable resources are expended on the implementation of BIM in the form of strong training requirement which in some situation turn out to be time-consuming. The findings of

this study largely agree with McGraw-Hill Construction (2012) and Thurairrajah and Goucher (2013).

4.3.3.2 Software Compatibility

There was no variation in the agreement of respondents with regard to this barrier – software compatibility. Lack of software compatibility was observed by the participants as a major barrier to the implementation of BIM. One participant commented 'it's not about physical compatibility of the software, it's about the working knowledge of the software with other software'. Another commented 'If the lead Architect is using Archichad and everybody else is using Revit there's still that gap which makes it very difficult for estimating in 5D'. For full exploitation of BIM and its benefits, Thurairrajah and Goucher (2013) argued that inter-operability i.e. the smooth exchange of information across all BIM disciplines, is very imperative. However, the fragmented and the solitude nature of the construction industry increasingly drives vendors of various software in proprietary formats that restrict the exchange of critical building data between multiple organisations (Stanley and Thurnell, 2014); and such incompatibility between the BIM model and estimating platforms is seen as a major barrier to BIM implementation (Olatunji, 2011). It was therefore not surprising the barrier was ranked first (refer Table 4.2) and no variation in the agreements of the respondents.

4.3.3.3 Risk Exposure

There was only slight overall that increased risk exposure discourages companies', e.g. legal issues such as ownership of BIM models, however 3 Participants seemed undecided. The legal issues such as who has rights to the information contained in the BIM models, who is in charge of the information that is in the model, what happens when there are errors in the model and other responsibilities that relate to the model need to be addressed (Boon, 2009),

Klein (2012) concurs, and reports 'before the full potential of BIM can be released with parties working in collaboration, there needs to be an innovation in contracts and insurances that underwrites stakeholders for financial'. The study agrees with the assertions and studies above and suggests a barrier to the implementation of BIM.

4.3.3.4 Incompatibility with Current Standard Methods of Measurement (SMM)

There was a great deal of mixed opinion between the participants on this issue of BIM's incompatibility with current Standard Methods of Measurement (i.e. 'NZS 4201: 1995'), preventing QS firms from adopting 5D software for BOQ production. One participant asserted that NZS 4202: 1995 is incompatible with 5D, 'except for about 5 trades, like Blockwork, Brickwork, Concrete and maybe Suspended Ceilings. However everything else much composite items.'

This sentiment is common in the literature; Matipa *et al.* (2010) suggest that current Standard Methods of Measurement were developed for more paper based surveying. In New Zealand, there is little use of 5D BIM to produce efficient BOQs; Stanley & Thurnell (2013) report few participants agreed that there is currently an increased use of 5D BIM for the production and pricing of Schedules (Bills) of Quantities (SOQs) during tender/bid stage'. However, Boon and Prigg (2012) assert that marginal benefits can be achieved through the extraction of certain building items such as doors, windows, volumes of concrete, steelwork quantities, and services trades. The compatibility of the BIM software with SMM in Ghana has not been explored. However, respondents were of the view that this would not be a major barrier and was thus ranked 5th obtaining a mean score of 1.12 significantly below the hypothesized mean of 3.0. Although significant, the lack of understanding and implementation appeared to obscure the comprehension and interpretation of this particular barrier. This is perhaps the plausible explanation for the low mean score of this barrier (refer Table 4.2).

4.3.3.5 Lack of knowledge in the Usage of the Software (BIM)

The major factor identified by respondents as an impediment to the implementation of BIM was lack of knowledge or technical know-how in the usage of BIM. The variable was ranked first with a mean value of 4.83 significantly above the hypothesized mean of 3.0. Whilst the model professes to be a very good tool, it is only as good as the information put into it (G and T, 2012). This reflects the old adage of garbage in, garbage out. Knowledge of the model use is still scanty in the Ghanaian Building Construction Industry. This militates against the use and implementation of the model in Ghana.

4.3.3.6 The Construction Industry and Its Fragmented Nature

Out of the 8 participants, only 2 disagreed to the fact that the potential of BIM is never undermine by the fragmented nature of the Industry. Master spec (2012) sees the fragmented nature of Construction Industry to be one of the central barriers to BIM implementation, and suggests that a shift in current workflows is required. Olatunji *et al*. (2012) assert that BIM, and in particular 5D BIM, requires the collaboration, data base integration and commitment of companies to the use of BIM software, and that as these are as are still in a separated and fragmented state, it further limits the effectiveness of 5D BIM.

There was a high level of agreement from participants that a lack of an electronic standard for BIM software to Standard Methods of Measurement limits the potential of 5D BIM. One participant indicated the need for an electronic standard for BIM by saying.

4.3.3.7 Cultural Resistance

The conservative nature of the construction and its slow nature reaction to change may see to be a major barrier to the use of BIM in the Construction Industry of Ghana. In this study, 6 of the 8 participants involved extensively in the discussion observed and agreed to the notion

that cultural resistance would serve as an impediment to the success implementation of BIM and especially its effectiveness for cost modelling. One summarized that ‘We’re basically going from horse drawn carts to motor vehicles’; suggesting that the change is abrupt and would thus suffer resistance.

Evidence exists in other parts of the world, for instance, a recent case study in New Zealand related how several BIM capable project participants were not prepared to share BIM information between firms (Brewer et al., 2013). According to Boon and Prigg (2012), the cultural difference on a project may even pose another barrier and observed that cultural resistance is a major threat than any technological challenge arising from BIM. Apparently, the older generation of QS are reluctance to use BIM, however, the upcoming generation seems hopeful and optimistic (ibid).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1INTRODUCTION

In this chapter, the study is concluded by summarizing the issues that have been discussed in-depth. Also, how the various research objectives were achieved are presented followed by the main conclusions and recommendations of the study.

5.2 REVIEW OF OBJECTIVES

The main aim of this research, as noted previously, was to explore the potential benefits and inherent barriers in the implementation and usage of BIM in the Ghanaian Building Construction Industry. In achieving this aim, four objectives were outlined. They are:

- To determine the areas of the uses of BIM within the Building Construction Industry;
- To identify the advantages that come with the use of BIM in the Ghanaian Construction Industry; and
- To identify the barriers that pertain to the usage of BIM and method of organization in construction project for proper utilization of the benefits the technology gives to the Ghanaian Construction Industry.

A methodological approach involving a literature review process, a questionnaire development, interview section and administration stage and finally a data analysis section using relative important index and mean score ranking, benefits of and barriers to the implementation of BIM, were used.

Here, the research objectives are revisited to highlight the extent to which they were attained through the various stages of the research.

Objective 1: To determine the areas of the uses of BIM in the Building Industry

An extensive review of other related literatures was conducted together with various disciplines within the building construction industry tapping relevant experience from other jurisdiction including the New Zealand, London and other places. Ares identified for the application of BIM include among other things, Quantity Surveying, Architecture, Mechanical and Electrical Service, etc.

Objective 2: To identify the benefits that comes with the usage of BIM in the Construction Industry of Ghana.

In achieving this objective the various benefits identified from literature was subjected to critical analysis involving Relative Importance Index and Mean score rankings. The study revealed that eight significant potential benefits and these are benefits with mean value above 3.00. These are 1. Improved Constructability; 2. Improved Visualization; 3. Improved Productivity; 4. Reduced Clashes; 5. Improved quality and accuracy; 6. Improved client satisfaction; 7. Increased Competitiveness; and 8. Improved Information Sharing.

Objective 3: To identify the barriers associated with BIM implementation in the Construction Industry of Ghana.

Similarly, this objective was realized using both quantitative and qualitative. Interview was conducted and subsequently, statistical tools used i.e. (Relative Importance Index and Mean score ranking). The study revealed four major barriers to the successful implementation. However, the other barriers cannot be overlooked as they all pose threat to the implementation of BIM. The major barriers are: Lack of knowledge in the usage of BIM, Software compatibility, BIM cost setup; Risk Exposure and Cultural resistance.

5.3 SUMMARY OF CONCLUSION

This study presents the views of the participants signifying the building organizations in Ghana concerning the alertness, correct practice, difficulties, as well as promoted benefits of implementing BIM. Using descriptive statistics and standard deviation, benefits of BIM identified from literature review and questionnaires were analyzed for the purpose of ranking their significance. Matters neighboring the implementation, practice in addition to mindfulness levels were analyzed by means of techniques of occurrences to degree the central tendency. It can be established 'constructability' is observed by the participants as the extremely ranked advantage that originates from practice of BIM. The extra exceedingly ranked advantage was found to be 'enhanced visualization', 'improved efficiency' as well as 'a decrease in clashes'. The consequences show the least significant advantage as that of 'the capability of BIM to upsurge viability. The most important insinuation ascending from this reading is that the aids neighboring BIM suggestively overshadow its adverse features. Though there was an absence of implementation of BIM between the respondents, it was proven that improved training as well as responsiveness of BIM required to befall done the business, in order for more upsurge approval to take place in Ghana. The reading has delivered approximately fresh visions into some of the reasons for the little consciousness levels, slow acceptance then the observations of the advantage of BIM connected to the Ghanaian context.

5.4 RECOMMENDATIONS FOR FURTHER RESEARCH

As the research revealed BIM implementation can bring with mouthwatering benefits. The merits and demerits of BIM implementation are accordingly explored. Following this the recommendation below are made;

- BIM has become prominent tool in the Building construction planning process after the conduction of the studies. Nevertheless, further studies can also be conducted into the extent of the benefits of 4D modeling in construction planning to ascertain its effectiveness. That is, if BIM is highly effective regarding the Construction Industry then why is it narrowly accepted in the industry especially in Ghana?
- For significance to construction projects, BIM as well as its advantage have established to be a solid factor. To better explore these advantages, it is recommended that the application of BIM tools and partnership of the construction team must be ensured. Conversely, BIM tools have some impediments and hence require further attention by the Construction Industry professionals. A study into the harmonious collaboration of the building professionals in the implementation BIM is essential.

5.5 LIMITATIONS OF THE STUDY

- As with every survey based research there are bound to be limitations which need to be acknowledged. It is important to acknowledge the relative small sample size used for the study. Correspondingly, analyses of the dependent variables were constrained by the fact that those variables with mean less than the hypothesized mean is subjective; and the possibility that the mean scores may change when a larger sample size is chosen.
- Notwithstanding, the demographic profile of the respondents suggest that they have reasonable experience in research which should generate some credibility in the responses received.
- Also, the difficulty in getting construction professionals to answer was also a challenge in this research.

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