Use of BIM (Building Information Modelling) as an integrated tool to plan, design and manage critical construction projects

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ABSTRACT

Building Information Modelling is defined as an integrated system which can integrate different types of functional characteristics in the physical facility model, for the large construction projects. In, Architecture, Engineering and Construction (AEC) industry, BIM is being adopted a lot in larger construction projects because it enables us to integrate different types of information in the single model. 4D modelling technology, visually representing the construction schedule time along with the 3D model components, has the potential to aid this learning process by providing a common visual language for students. Thus, BIM provides the tremendous opportunity for the AEC professionals for increasing the overall efficiency of the construction management process his paper narrates some important facts about the actual Implementation of project management function with the use of BIM concept. BIM enables us to link the virtual three dimensional models with the actual time of the project and actual cost of construction and by synchronizing all this parameter it becomes easy to optimize the overall efficiency of the project.

Keyword : *BIM, 3D Modelling, 4D Time scheduling , 5D Cost estimating*

1. INTRODUCTION

Building Information Modelling (BIM) is a digital representation of physical and functional attributes and characteristics of a facility. A BIM is a knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle. Building information models (BIMs) are files (often, but not always in proprietary formats and containing proprietary data) which can be extracted, exchanged or networked to support decision-making regarding a building or another built asset. Current BIM software is used by individuals, businesses and government bodies who plan, design, construct, operate and sustain diverse physical infrastructures, such as wastewater, water, gas electricity, refuse and roads, bridges, ports, tunnels, etc. BIM brings together all of the information about every component of a building, in one place. It makes it possible for anyone to access that information for any purpose, e.g. To integrate different aspects of the design more effectively. In this way, the risk of mistakes or discrepancies is reduced, and abortive costs minimized.

2. OBJECTIVES OF THE STUDY

The principle objectives of the whole research work may be as follows:

1. To identify the impact of BIM for addressing the cost and time overrun issues of large construction projects.
2. To study and examine the different types of software tools used for efficient implementation of building information modelling.
3. To investigate the potential use and implementation of Building Information Modeling in different construction industry in various countries.
4. To identify the potential benefits of BIM in the different construction projects and its impact on project management process.
5. To address the future requirement and upcoming challenges in the construction industry with the use of BIM (Building Information Modelling) for better and efficient construction.
6. To study the different questionnaire surveys carried out by enthusiastic research for the level of opinions of the AEC professionals working in different BIM consulting firms in all over the world

3. CRITICAL LITERATURE REVIEW

The following are the critical literature reviews based on various researches done in the field of Building Information Modelling in the past two decades:

Han Yan et al. (2002) and Peter Damian et al. (2002) described questionnaire survey data as of a survey of about 70 individuals of the BIM adoption, benefits, and barriers on AEC industry. It is found that BIM has a very high adoption in the US than in the rest of the world. From the questionnaire survey resulted as, 16% AEC companies from the United Kingdom (UK) are using BIM to design their projects, and 33% AEC industrial compnies are using BIM in the US. **[26]**

Koo et al. (2005) and Fischer et al. (2005) showed the effectiveness of 4D models in the evaluation and execution of a construction schedule. They also emphasized on the need for further advancement of 4D tools in their study. They also showed that 4D models are superior to previous tools like critical path method (CPM) networks and bar charts. **[13]**

Vinoth Kumar J. et al. (2009) and Mahua Mukherjee et al. (2009) explored the scope of BIM in India. They had designed the survey to identify the status of a BIM application in India and acceptance and adoption of BIM in current scenario. They had investigated the potential capacity of BIM, when used in the field by many experts reflected with better communication and integration of construction information across different construction firms, allowing for better decision making and efficient work processes. **[14]**

Douglas E. Chelson et al. (2010) carried out an investigation to analyze the effect of BIM on construction site productive. The projects where BIM was implemented have 10% of the RFI (Request for Information) that one construction project would have so that contractors realize an average reduction of 9% in time schedule and management. Rework reduced and due to site problems savings for contractors in their major construction is 9% of the total cost of project. Their questionnaire survey is also reflecting that after finishing BIM projects, an average 90% of their survey claimed that they don't want to do another construction project without the use of BIM in their future projects. **[8]**

Don Chen et al. (2011) and G. Bruce Gehrig et al. (2011) aimed a research to define the feasible workflow based on BIM for satisfying the Body of Knowledge (BOK) necessities in Construction engineering education, such as project administration, control and construction scheduling, cost estimating, and contract documents. Their research work is describing the processes for examining the strengths and weaknesses of each software package, and recommended a procedure for implementing BIM in Construction education curriculum. Finally, they conclude by proposing BIM software ages that were studied are Autodesk Revit and Vico office - Virtual Construction Software Suite. **[9]**

Salman Azhar et al (2011) scrutinized the research with the aim of identifying recent trends, benefits, risks, and future challenges for BIM in AEC industry. The questionnaire study was made to investigate the current movement and future challenges of BIM implementation in AEC industry, which ensures that the use of BIM led to increased productivity, better engagement of project staff, and reduced Contingencies. The future of BIM is both exciting and challenging. They also reasoned with the promise that the increasing role of BIM will enhance collaboration and

reduce fragmentation in the AEC industry and eventually contribute to improved functioning and slimmed down labor costs. **[5]**

Azhar, S et al. (2012) and Malik Khalfan et al. (2012) gave a summary of BIM with emphasis on its core concepts, use in the project life cycle and benefits for project stakeholders by analyzing various case studies. Equally a number of enthusiastic researchers, practitioners, software providers and organizations working professionally on BIM are working hard to resolve these challenges, the future of BIM is bright and exciting. **[6]**

Ahmed Alabdulqader et al. (2012) and Jeung-hwan et al. (2012) examined the current role of BIM in Australia with the intention to deliver an updated perspective on the recent applications on the role of BIM within the AEC industry of Australia. The findings emphasized the present issues and problems related to the application of BIM technology such as: physical properties, issues related to responsibility and data ownership, and issues related to security. The results also reflected that the number of present adoption obstacles being faced by different firms and organizations working in the AEC industry of Australia, such as interoperability, resistance to shift and lack of BIM awareness and understanding. **[2]**

Yibrah W. Weldu et al. (2012) and Dr. Gerald M. Knapp et al. (2012) performed a research aimed to prepare technique that based on spatial reasoning and topological relationships between the building elements in a BIM to spontaneously create a physically and technologically meaningful sequencing of construction for the building components while automating linking of these activities with objects of BIM for purposes of 4D schedule and visualization. They discovered a method to automatically generate the activity based construction schedule and their visualization based on 4D, by gathering the data stored in building information models. The algorithmic reasoning and system architecture composed with the expected outputs has been presented. [**23]**

Daniel Forgues et al. (2012) and Ivanka Iordanova et al. (2012) carried out a comparative study of estimating software based on BIM which are commercially available, and an examination of the changes in work performs and workflows acquired by the adoption and implementation of such software by a company of construction. This inquiry analyzes the varieties in work practices and work flows within a construction firms as they go towards adopting Building Information Modelling (BIM) estimating process. There are so many efficient advantages of BIM-based cost estimating, there are also some fixed considerations for estimating and calculating at the different phases of design conception. **[11]**

Yusuf Arayici et al. (2012), Charles Egbu et. Al. (2012) and Paul Coates et al (2012) has analyzed issues and challenges related to the remote construction projects. They have offered some grounds of how BIM can give assistance to mitigate some of the central challenges of remote construction projects such as effective communication, procurement management, accurate building quantity take-off and time scheduling, and instituting a shared agreement between the contractor located at typical sites but involved in the similar remote construction projec. **[3]**

Jin-Lee Kim et al. (2012) interrogated that how BIM is useful for effective visualization in construction training. Results showed that the method helps students to successfully determine the details of building quantity takeoffs of materials. Doing continuous modification and improvement of course materials and functions, the recommended BIM teaching approach is expected to contribution students achieve a good reason and apply to learn to unknown issues and optimize accomplishment of previously defined learning output through a diagnostic feedback loop. **[15]**

Whyte, J. et al. (2012) proposed a research based on Research Challenges, Contributions and Opportunities for BIM in AEC (Architecture, Engineers and consultants) industry. These studies bring out strong current interest of research, for example, in designing new BIM tools that address sustainability and life cycle concerns in helping professional Make sense of these tools in practice; in the political and societal consequences of new and different ways of working with modern techniques of designing and checking models. **[24]**

Amol A. Metkari et al. (2013) and Dr. A. C. Attar et al. (2013) examined the impact on traditional conventional building design methods with the implementation of BIM and also identified a cases study subject field which resulted in improved productivity, better coordination, and reduced error. He also finds some facts that by implementing BIM method 80% reduction in time to prepare estimates and 10% savings on construction cost through clash detection. He also showed the results that with achievement of 20% saving through construction process simulation. **[16]**

Atul Porwal et al. (2013) and Kasun N. Hewage et al. (2013) tried to justify that the Maturity and adoption of BIM depend mainly on the client or the owner in construction projects. The suggested contractual arrangement for the project resulted in improved productivity, better coordination, and reduced error, and rework. The execution of the BIM-Partnering framework proved to be a necessary measure in assessing the organization's capabilities of BIM adoption, both current and potential. **[19]**

Z. Zahrizan et al. (2013), Nasly Mohamed Ali et al. (2013) and Ahmad Tarmizi Haron et al. (2013) carried out a quantitative approach to explore the adoption of BIM in construction industry of Malaysia. The

result discloses that construction industry in Malaysia are facing some issues and difficulties to implement BIM because they don′t know how, where and when to start as there is no national BIM standard and guideline for them to track and follow. **[28]**

D. Forgues et al. (2013) and I. Iordanova et al. (2013) established the Building Information Modeling (BIM) and integrated design process (IDP) has been distinguished with two major approaches to address the problem and issues of fragmentation in the construction industry. The planned approach contributes to speed up the co-generation of new information patterns within the projected environment. They too found that IDP is almost worthless without the utilization of simulation tools. They had also done a pilot project which assisted them to try various methods and instruments and to build up a more robust research protocol. **[12]**

S**hen Xu et al. (2013), Kecheng Liu et al. (2013) and Llewellyn C. M. Tang et al. (2013)** presented a new philosophic stance for estimation of cost to address the evolution of cost estimation based on modelling and addresses the importance of contextual information and the needs of extension of pricing information according to the worldwide operation of cost estimation by using the IFC standard. The data needed for the cost estimation can be summarized into 5 aspects: the building product information, the cost item information, the quantity information, the resource information and the price information. **[25]**

Ajibade Aibinu et al. (2013) and Sudha Venkatesh et al. (2013) performed a research to find out the condition of the market trend for adoption of BIM by cost consultants in the Australian building industry. They as well have offered insights into the BIM experiences of quantity surveyors and Australian cost consultants and has prepared a document the progress made toward the role of BIM characteristics and features, which gives that only 20 % of the quantity firms were performing cost estimation with BIM, thus the acceptance of BIM is not deep enough in the Australian building industry. **[1]**

Hyounseok Moon et al. (2014), Hyeonseung Kim et al. (2014) and Vineet R. Kamat et al. (2014) determined an optimizing theory with the determination to get an organized methodology and data processor arrangement for a simulation of optimal construction schedule that reduces overlapping activities for the enhancement of the operational performance of the project**.** The schedule management based on BIM system was developed in this study, which can compare and simulate an optimal schedule and an initial schedule by 4D object type. Thus, a project manager and project supervisors can efficiently visualize and manage those overlapping activities. **[18]**

Robert Eadie et al. (2014) and Henry Odeyinka et al. (2004) have examined the issues related to implementation barriers of the BIM. They have validated the significance of the obstructions and barriers to BIM Changed on adoption and experience. The research showed that to successfully overcome the barriers in the implementation of BIM, a company must perform to the softer issues surrounding internal 'change management' in addition to the harder technical problems and issues. **[10]**

Dan Russell et al. (2014) and Yong K. Cho et al. (2014) proposed a research study to distinguish the impact of Virtual Design and Construction (VDC) building and information modelling (BIM), technologies in construction training and education for the architectural, engineering, construction, and facilities management (AEC/FM) industry. BIM has been transforming the CEM (Construction Engineering and management) education and the construction market to overcome the fragmented nature of construction processes. **[21]**

M. F. I MOHD-NOR et al. (2014) and Michael P. Grant et al. (2014) presented a survey to look into the insight of how architect firms in Malaysia are coping up with the introduction of BIM in the country. A quantitative survey was done on all the architectural firms in Malaysia amounting to 535 firms, which results suggest a trend that the responds rate decreases as from smaller firms to bigger firms. **[17]**

S. Scheer et al. (2014) and R. Mendes Jr et al. (2014) demonstrated an integration for practical application of 5D BIM model with cost planning and scheduling**.** They had specifically demonstrated how to pull data from the BIM model for uses for planning, managing and control on site structure. The chief conclusions of the survey confirm the positive and negative benefits of using 4D and 5D BIM modelling found in the literature, such as assisting lean construction principles in the construction industry. **[22]**

Pingyu YAN et al. (2014) and Xifeng XIE et al. (2014) had done a research investigating various applications of BIM in large building projects. They had successfully scrutinized different functions of BIM technique applied to plan management are presented in conjunction with relevant experiences of BIM pilot projects. They found that the major field of application of BIM is as 3D model with construction schedule management, project cost estimation, effective visualization, clash and collision detection, and simulation of total project time. **[27]**

G. Carbonari et al. (2015), S. Stravoravdis et al. (2015) and C. Gausden et al. (2015) presented the methodology for successful BIM implementation for managing an existing construction activities and identifying a development framework and documenting the problems and hindrances that occurred during the execution of the conceptual stage**.** The benefits derived from the use of BIM for the management of buildings should be extended to existing buildings that currently have no models. **[7]**

Rahimi A. Rahman et al. (2016) and Suleiman Alsafouri et al. (2016) made a research based on identification of BIM skills required for a successful career. They found that BIM skills increases the likelihood of having the title project manager and assistant project manager at 9.1% and 24.2% higher, respectively, while having a weak correlation with the decrease in years of having either title. **[20]**

Behnam Atazadeh et al. (2016), Mohsen Kalantari et al. (2016), and Abbas Rajabifard et al. (2016) demonstrated the feasibility of BIM models for managing complex ownership rights in a 3D digital data environment. They found that BIM models with ownership information would potentially contribute to the performance of these models in better management of facilities throughout the lifecycle of buildings. **[4]**

4. MAJOR FINDINGS OF THIS LITERATURE REVIEW

We have identified the following major areas in which different types research work had been carried out in the last two decades:

1. The current Indian construction industry is facing critical challenges for level of efficiency and productivity, which can be addressed by the use of BIM tools to effectively integrate the design data and build a 3D Model for effectively visualize the virtual building model prior its actual construction.
2. The major infrastructure projects carried out in past decades in India had severely affected with the time overrun, thus BIM 4D scheduling and 4D simulation can be done effectively to complete each and every activity with prior defined time and thus complete the whole project within the time limit.
3. From the questionnaire results, 16% AEC companies from the UK are using BIM to design their projects, and 33% AEC companies are using BIM in the USA. Thus, there are still some barriers for adoption and implementation of BIM.
4. It had been observed from many questionnaire surveys that BIM adoption in not yet penetrated deep into the AEC industry of the Indians, but a small part of the industry has adopted BIM into their project and achieved the efficiency and productivity.
5. A questionnaire survey carried out in a gulf country aimed to discover the barriers for adoption and implementation of BIM is resulting in lack of country specific protocols which can limit the BIM learning and training opportunities.
6. The low level of adoption of the BIM in AEC industry is considered as a result of low level of Maturity and unawareness of software skills for BIM depends mainly on the organization approach and less number of the BIM experts into the organization.
7. The Major Questionnaire survey is also resulted as a big reason for low level of adoption of BIM is lack of expertise and lack of experience for AEC professionals, thus they majorly rely on the traditional approach to construction management.
8. The questionnaire survey intended to find the opinions of AEC professionals about BIM adoption in their projects, in which it is found that BIM adoption is a lot higher in the US and UK than in the other parts of the world.

5. HISTORICAL DEVELOPMENT OF BIM

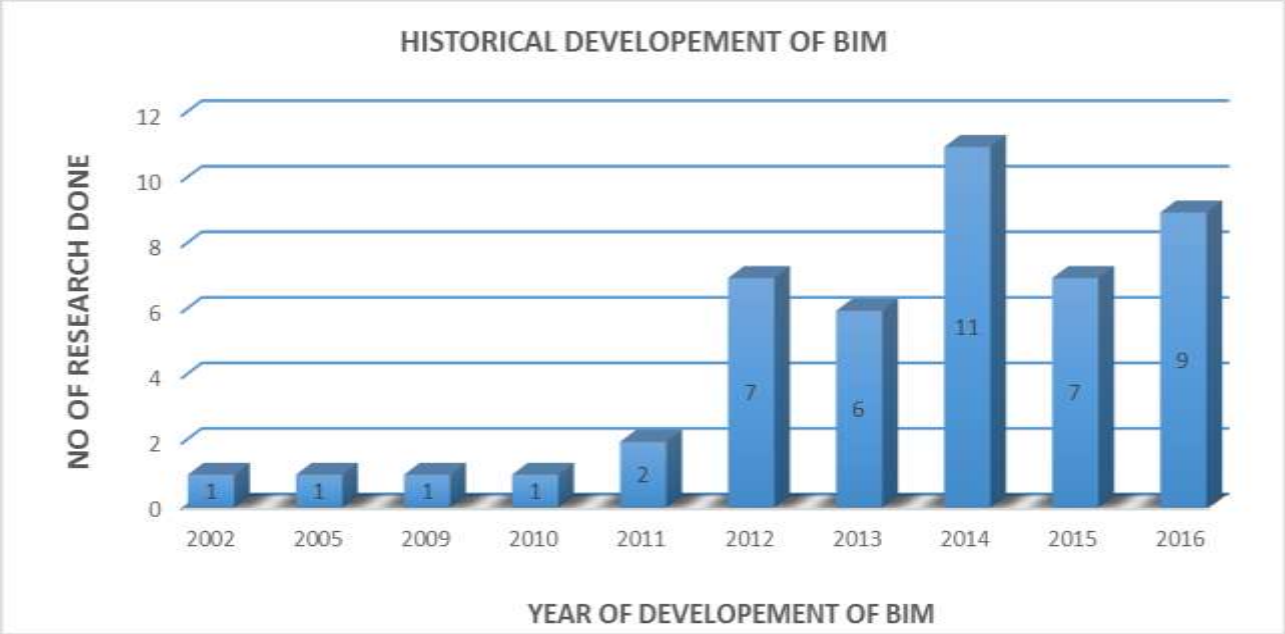

fig. 1 Historical Development of BIM

1. **1975:** The research paper titled as "The use of computers instead of drawings in building design" established the foundation of concept of CAD drawings.
2. **1980 - 2000:** Eventually the concept of BIM was developed by various software providers and enthusiastic professionals.
3. **2002:** Adoption of BIM is started increase in the AEC industries of the developed countries as UK and USA.
4. **2005:** The capacity of 4D BIM was explored for efficient scheduling of time in construction projects which proved that it is much better than the other traditional methods.
5. **2007:** BIM has made substantial gains in no of user, mainly as a tool for developing residential and small commercial projects in Europe AEC industry.
6. **2009:** BIM has stated getting momentum in the Indian construction industry. The level of adoption and acceptance of new BIM technology was deeply analyzed.
7. **2010:** Systematic implementation of BIM in large construction projects started showing the positive results as optimization of time and cost.
8. **2011:** The awareness of potential benefits of BIM has dramatically increased as the education and training of BIM based software tools are increased.
9. **2012:** BIM has started gaining use for life cycle cost management of large and complex construction projects by the architectures, engineers and consultants, as the large number of software providers were entered into the market.
10. **2013:** Different software tools were developed for automatic quantity takeoffs and easy time scheduling and effective model based cost estimation which provided boot to the project management process in the designing phase. The use of BIM has also increased in the Australian and Malaysian construction industry.
11. **2014:** BIM was further developed for 6D as sustainability and 7D as facility management as an integrating tool to link different tools of BIM for generating more information.
12. **2015:** Better visualization tools for BIM was developed for better aesthetic views but simultaneously the implementation of BIM raised issues with certain limitations that limits the rate of adoption, because of the lack of specific standards and country specific codes.
13. **2016:** 5D BIM was successfully implemented and demonstrated by different enthusiastic researchers which gave positive results with optimizing overall time and cost.

6. CONCLUSIONS

Thus, implementation of latest technology in construction industry helps to increase overall efficiency and better productivity. There is a gradual increase in the technology of 2D is drawing to 3D drawing and now with the use of BIM people can define the project parameter up to 7D. Different software tools are used to get desired results in planning and designing. At last a hope is made by various enthusiastic researches that, adoption and implementation of BIM will increase dramatically in the future, simultaneously with an increase in the level of awareness. Thus, for Indian construction industry education of BIM should be promoted to increase the awareness about the potential capacity of the BIM. Adoption of BIM in North America is 71% giving highest percentage whereas in India it is at lowest level of awareness and adoption 22%.

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