Al-Azhar University Civil Engineering Research Magazine (CERM)
Vol. (39) No. (1) January, 2017

Building Information Modeling (BIM) in the Egyptian Construction Industry

Ahmed S. Essawy[1], Mohamed A. Elmikawi[2], Rana M. Hosney[3]

1- Emeritus Professor of Concrete Structures, Structural Eng. Dept., Ain Shams University, Cairo, Egypt.
2- Assoc. Professor, Structural Eng. Dept., Ain Shams University, Cairo, Egypt.
3- Master Degree Student Structural Dept., Ain Shams University, Cairo, Egypt.

ملخص البحث

استيعاب العمليات الإدارية المستخدمة والمقترحة حديثا في مجال المشاريع الإنشائية في مصر يهدف هذا البحث إلى أيضا تم التركيز في دراسة البحث ومحاولة استخدامها بالشكل الصحيح ليتم الاستفادة منها في مراحل المشروع المختلفة. على كيفية تطبيق عملية نمذجة معلومات البناء خلال مراحل المشروع وأهمية كل خطوة في تنفيذها. هذا بجانب تحليل لا راء شريحة مختارة ممن قاموا بتطبيق هذه العملية سابقا.

يقدم أيضا البحث نماذج لمشاريع سابقة تم استخدام عملية نمذجة معلومات البناء بها لمعرفة تأثيرها، بالإضافة إلى إنشاء نموذج خماسي الأبعاد ودراسة مدى تأثيره على المشروع والفوائد التي من الجائز الحصول عليها عند تطبيقه.

Abstract

This paper introduces an overview for the point of the study which aims to understand the Building Information Modeling process (BIM) in Egyptian construction industry, and how to better utilize it to manage projects during its different phases.
This is besides establishing a statistical analysis for the point of view of a selected group of engineers whom have a previous experience in applying BIM in their work.
The research introduces a study for two case studies which applied BIM in their work to realize the effectiveness and benefits of using BIM in construction projects. This is in addition to submit a 5D model for one of the two case studies to show its benefits and effectiveness on project. And finally it summarizes the comparison points between traditional process and BIM process in construction field.
Keywords:
Building information modeling, Construction Industry, 5D Model, Egypt

1. Introduction

The Construction Industry represents a major factor in the development of nations. Infrastructure, air & sea ports, roads, bridges & tunnels, factories, hospitals, hotels as well as residential and commercial buildings are all products of the construction industry. The development of these projects is in response to the increasing demand by customers and by governments to improve the quality of life and well-being of its citizens. Hence, there is a need for better tools and the increased use of technology to improve the efficiency in the delivery of these projects.
Construction projects all over the world face many types of waste during their development phases starting with the design phase passing by the construction and delivery phase, so

researches have studied means to manage this waste which in return will help to achieve more efficient projects that will reduce the consumption of resources and energy.
Building Information Modeling (BIM) is considered as a new management process that has been applied in a number of countries to improve the efficiency of project delivery. Recently, research has focused on carrying out studies related to this new process, its goals and uses that may be helpful in developing the construction industry. BIM has been used in a variety of projects with different uses but it still needs to be studied by examining its ability to reduce waste in projects and its ability to be applied according to country regulations.
Currently, the Egyptian construction industry is facing a major challenge to develop various types of projects all over the country to build modern Egypt. This industry needs to be better managed to accommodate the growth of the local construction market. Hence, this research is carried out to study the concept of applying a management tool, BIM, in the Egyptian construction industry and assess some of BIM benefits and risks during the construction process. Also it studies applying BIM with its higher dimensioned model not only the 3D model, so it introduces the benefits of 5D model on an actual case study and study its effectiveness and benefits based on this case study. On the other hand, the study for a real project helps in develop a comparison between traditional and BIM processes.

2. Research Methodology

The methodology used for this research approach depends on a detailed literature review, a field survey for the building information modeling in Egyptian construction industry as it is intended to use the questionnaire answers from a group of experienced engineers used the technology or have a good knowledge about it and followed by statistical analysis of the collected responses to the questionnaire, also, the research depends on a created 5D model to a selected case study to preview some of the BIM benefits in construction projects and comparing between using this technology or the conventional method in construction projects.

2.1 Design of the Questionnaire

It has been selected to make a questionnaire on the research point to get a clear vision about using building information modeling in Egyptian construction industry so it will study the following three main sections (using BIM in Egyptian construction industry- expected benefits of BIM- expected risks of BIM).
The data used in the questionnaire have been collected and illustrated through an extensive brainstorming depended on the literature review for the most recent researches and studies made in BIM in different places in the world, then they have been listed to be used in the questionnaire.

2.2 Analysis for General Information of the questionnaire sample

The selected sample for answering the questionnaire is classified as 41% of the sample is from contracting field and 59% is from consultancy field. And according to years of experience 65% is between zero and five years of experience and the remaining percentage is ranges between 5-10years, 10-15 years, 15-20 years and more than 20.

Also according to years of experience in BIM from zero to five years is 95% and 5% for more than five years' experience in BIM
The following table is the classification of the sample field of work in the system of construction:

Sample specialization	Percentage
Civil	22%
Architectural	12%
BIM(coordinator- manager-engineers)	20%
Project management	41%
Electromechanical	5%

2.2 Questionnaire Analysis Techniques
In the way of accepting the discussed points in the questionnaire or reject it, the questionnaire answers were subjected to statistical analysis to have simply an evidence in reject or accept using the new BIM process in Egyptian construction industry.
Hypothesis test depends in four main steps which are:

1- State the null hypothesis H0 (the statement being tested, usually phrased as "no effect" or "no difference") and the alternative hypothesis Ha (the statement we hope or suspect is true instead of H0).
2- Calculate the value of the test statistic.

Mean $\bar{x} = \sum (\text{weight} * n)/n$
N=number of responses
Calculate population variance σ2 and sample variance s2
$\sigma 2 = \Sigma (X - \mu)^2 / n$
$s^2 = \Sigma (X - \bar{x})^2 / n - 1$
$\bar{x}$=sample mean
μ=population mean
Population mean interval=sample mean (+) or (-) confidence interval
Calculate population standard deviation σ and sample standard deviation.
$\sigma = \sqrt{\sigma^2}$
$s = \sqrt{s^2}$
$z = (\bar{x} - \mu) / SE$
$SE = \sigma / \sqrt{(n)}$

3- Draw a picture of what Ha looks like, and find the P-value.
4- State your conclusion about the data in a sentence, using the P-value and/or comparing the P-value to a significance level of your evidence.

As you have to Set the significance level, assuming it by assuming the confidence level you need and α will be equal to 100- assumed confidence level.
Compare the *P*-value to α. If the *P*-value is less than (or equal to) α, reject the null hypothesis in favor of the alternative hypothesis. If the *P*-value is greater than α, do not reject the null hypothesis.

2.3 5D development

Steps for establishing 5D model:

1- Receiving 3D model files from consultant

To start creating the 5D model we used the extracted 3D model for the structural system (concrete skeleton) from the consultant files, then it is used to collect the needed data to create the 5D model which are (list of elements found in the model to use it later in creating time schedule- dimension of the model elements to calculate its duration on the time schedule-calculated bill of quantity extracted which contains accurate quantities for the building elements and will used later for the aim of comparison between BIM and traditional method in quantity surveying).

2- Establishing the time schedule for the model

Creating a time schedule for a 3D model is the next step which depend on the extracted data from the last step. Here the elements on the model translated into activities in the time schedule which linked together according to intended execution plan for the site. Also, the expected duration for the construction of every element is added to the time schedule according production rates in the site.

3- Create coding system for the elements on the time schedule

A coding system has been created to help in the transparent of the data and coordinate between systems and soft wares, this coding system assumed to communicate between the 3D model files and the file of time schedule for the structural model so it depend on the elements on the time schedule and also in the 3D model, from that point every element in the time schedule will take a code and it will be the same code for it in the 3D model and it will be used later in the combination between them to arise the 5D model for the selected case study.

4- Apply the coding system to the 3D model to be easily coordinated with the other two dimensions

After determining the needed code system for the model it has to be assigned to the time schedule and the 3D model.

5- Import 3D model and the time schedule into a software program to coordinate them and make the 4D model

In this step the 4D model is created by importing 3D model and time schedule to one program that depend on the combination between 3D and time through the its codes which ensure the correct overlapping as the element has the same code in 3D model and the time schedule.

6- Assign cost breakdown on the 4D model to form 5D model

According to the given 3D model accurate quantities have been calculated and a calculation for the cost of the one unit of the element is done according to the market prices (for the determined materials of elements in the model) so that the total quantity of the element

could be multiplied with its total price (material, labor and equipment prices) and assigned to the elements in the 3D model and time dimension to achieve the 5D model.

The main concept in this step is to coordinate between all dimensions in one model to start comparing using this model through the project phases or using the traditional model which depend on 2D model for the project.

The only guarantee for this step that it will be combined according to a coding system so that each element will meet its data according to its code and also any change happen for this model will automatically reflect to all the data of that element, also any comments or reports are wanted to be assigned to that element, it will be assigned according to its code to ensure that the data is put into its right place.

7- Make the comparison between BIM and traditional method for the case study

According to the research aims to put concentration on BIM benefits on construction industry and especially for Egyptian construction industry a great attention directed to create a BIM model and put it in comparison with the project without created that model and when using the conventional method.

Here it is worth to be mentioned that other researches have discussed BIM as the future of the construction management for the construction projects, they also talked about applying it in several case studies in a number of countries but all of this research and studies had been done out of Egypt zone so it studies the concept of applying BIM by their strategy and facilities so it will have some difference when applying this technology in Egypt as every place has its surrounding conditions, facilities, resources and strategies' in work that may affect transfer of the knowledge of a new technology and the way it will be applied by.

3. Research Conclusion

The research conclusion is divided into two section according to research methodology which depend on questionnaire analysis and the applied 5D model on the selected case study.

3.1 Results from questionnaire analysis:

- Results for Section (one) on Using BIM in Egyptian Construction Industry and its Knowledge in Egypt

1. Participants' point of view is in favor to use BIM as there is the enough capabilities of using it in Egypt.
2. Understanding BIM concepts and applying it is straight forward.
3. It was not clear if it would rapidly spread in Egypt or not.
4. Lack of knowledge by BIM and some customers may cause obstacles in spreading BIM in Egypt.
5. BIM can be a new managerial process that may help in enhancing the project efficiency and productivity.

- Result of Section (two) on Benefits of Using BIM in Construction Industry

From participants' point of view BIM can achieve the following benefits:

1. Increases safety and improves risk management.
2. Ensures cost, time and document control for the project.
3. Facilitates value engineering process
4. Introduces clash detection process
5. Delay mitigation.
6. Improves and accelerates cost estimation and makes it more accurate.
7. Provides visual representation of project model.
8. Helps in resource allocation and extract construction plans (logistic-execution)
9. Helps in applying sustainability and energy saving
10. Helps in understanding project different plans (execution plan, logistic plan, safety plan, etc.).
11. Increases the productivity of the project.
12. Helps in asset management and facility management.
13. Decreases errors, variation orders and enhance quality of project.

- Results of Section (three) on Risks in Using BIM in Construction Industry

From participants' point of view BIM has some risks which are:

1. Missing control and responsibility of the inserted data.
2. Limited knowledge of standards and rules of applying BIM.
3. There is an obvious doubt in the ability of check all the data transfer from one program to another.
4. History of changes in the BIM method and persons who made the changes could not be traced.
5. Any missing or incorrect data in the model will effect project phases performance
6. The adoption of a new technology will consume some time and the risk of changing from traditional method to BIM technology method.

3.2 Results from case studies:

The following comparison between BIM process and conventional process is carried according to the established 5D model for one of the two selected case studies on this research:

Conventional process	BIM process
- Time consumed in design: For conventional method, it takes large time in drawing the 2D drawings and then transfer it after revising it well between other systems in design (architectural, structural, electrical, mechanical, firefighting, and other) then revising again.	For BIM it just 3D model and all users can enter and put their data to shorten the time consumed in transferring the model from one user to other and ensure that the model is unique between users.
In selected case study it is observed that using BIM reduced the consumed time in design	
- Time consumed in detecting errors and correct them. The error in conventional method cannot detect early during design phase so it can cause transferring of error to	In BIM errors of design detected early during design phase and during overlapping between project systems (architectural, structural, electrical, mechanical and other systems), also error of overlapping can be detected early

construction phase when it is discovered on site so there will be a large time consumed in correct this error and this also will cause a cost increase due to delaying.	and errors of transferring data can be detected early. So this will reduce time consumed in discovering mistakes and recover it and will reduce cost consumed in correcting mistakes when the change in decisions is lower cost consuming at the beginning of the project.
In selected case study it is observed that the consultant benefited by using BIM in overlapping between different system in project and detect errors between them through clash detection option so it will reduce time and cost of project.	
- Owner requirements visualization and making decisions In conventional 2D drawings, it doesn't have the option of visualizing project model as a real view in design stage to represent owner requirements for any decisions or changes will take place before starting project construction. Also, it doesn't have the option of extracting any needed data from the model when owner asked for.	BIM has the option of visualization of the 3D model of the building with its different views and sections when it is needed immediately. And it represented the owner requirements as it will be constructed in future and allow and changes and decisions early so it reduce the time and cost waste and improve the quality of the extracted model data and quality of the overall project.
In selected case study it is observed that consultant used BIM to visualize the project model to the owner to present his requirements in the model and give the owner the chance for any changes before project start.	
- Time consumed in rework in different views After presenting the design to owner there may be a rejection of some design features In conventional method for changing the rejected design in the 2D drawings, it will need a modification in other views so it will take time in rework in all views.	Using BIM will help in automatically change the modified items in all view so it will save time consumed in rework.
In selected case study it is observed that consultant used BIM for reducing time consumed in rework for different views	
- Choosing the desired materials and compare between alternatives For conventional method, it is just a 2D drawings so the material cannot be specified on the element so there may be a confliction between owner requirements and the designs created by designers. Also, the steps of finishing cannot be easily understood from 2D drawings.	For BIM model, it is so easy to tag the material will be used for the elements of the building. Also, the supplier name can be tagged with all the data concerned with the material needed for the project. All of this will help the designer to put alternatives and compare its characteristics to reach the final decision.
In selected case study it is observed that consultant put some of the data about used materials in the project and get their schedule but it is not used for comparing between alternatives or for applying value engineering process as consultant so it is proposed to use the 5D model to compare between alternatives in their effect on cost and time so it can lead the owner to the right decision and lead the contractor if it will be profitable for him or not.	
- Importing any documents belongs to project For conventional method, there is no option of adding the project document and check it through model so there were differences in engineering documents and that will cause errors in site and problems during construction phase.	In BIM process, it can be tag any documents in the model to be a reference for the user to prevent the expected faults as a result of the contradictions between engineering documents.
In selected case study it is observed that consultant didn't use this option so it is proposed to use for achieving more benefits and managing the project. Example of document (quality control forms that will update by time in site)	
- Computing quantities of the project automatically Conventional method doesn't have the option of automatically computing the quantities of the building from	BIM process introduces software programs that have the ability to compute quantities of the project material automatically from the model as it depends on dealing

the 2D drawing and this leads to quantify material manually which usually cause more errors in computed quantities from real so it is discovered late and cause the worries for the owner and the contractor.	with the model as its real element. This will reduce time and cost wasted during using manual method.
In selected case study it is observed that consultant depended on computing some of the project quantities from the model and depend on the manual method in others this can be as a result of his less experience in using software of the fear of less accuracy of the extracted data. Consultant used BIM model to compute some architectural material and didn't use it for structural material. But by using BIM for computing structural material it is cleared that there is a difference between it and manual method for more the 30 % which will affect the overall cost of the project so it is advised to use BIM model for more accurate data, reduction in time and cost consumed in manually quantity surveying and reduction of error may resulted from manually computing data.	
- Understanding project sequence of work Conventional method doesn't have the option of displaying the construction sequence of work through time so some of the contractors cannot understand some method of construction and this will lead to the misunderstanding of owner needs and cause errors and rework.	BIM can introduce the 4D model to easily understand every project nature and method of construction so the owner and contractor can put their requirements in a plan of time and sequence of work. This will decrease waste of time and cost consumed and reveal cash flow of the project.
In selected case study it is observed that consultant didn't use that option and the owner didn't request in his contract but it is advised to use it for the above benefits and as applied in the above case study.	
- Keep updating data through the model and extracting as-built model at the end of the project In conventional method any update or changes happen in site needs to put its data on the drawings will consume time in transfer it between all views and systems and knowing its consequences.	In BIM model any update or changes happen in site can be easily saved in one view and automatically transferred to the other views and systems and can know its consequences easily also it will lead to accurate as-built model that help the owner in facility management.
In selected case study it is observed that consultant will not use BIM model to follow the project during construction phase but the project will be delivered through 2D as-built drawings for the owner.	
- Cost estimate for project For conventional method, the only way for estimated project cost is depending on the manually calculated quantities and assign the cost in the resulted quantities and this will lead to non-accurate cost estimate according to the inaccuracy of the calculated quantities as there may be mistake in quantifying or any missing in data.	BIM introduces an automatic calculating system for the quantities of the project, so also, it allows assign cost to every material and calculate the final estimated cost for the building.
In selected case study it is observed that this task is not applied by consultant in his project but it is proposed through the 5D model explained above.	

So the conclusion for the selected case studies is as follow:

It was clear after reviewing the two case studies that there is a risk of using it as a continuous process from the start of the project to the end and the only agreed opinion that it can be used for the visualization of the project as a 3D. Some of the other benefits of BIM can be used but with a small scale and others were suggested to be used in this research.

According to the utilized benefits by the contractor and consultant in the presented case studies, BIM proves its useful role in construction management but it still used on small scale in Egypt and with limited experience so the users from Egyptian companies are still

doing errors when using BIM and reluctant to applying and circulating BIM in all their coming projects.
From the owners' standpoint, BIM proves its importance in applying and achieving owner needs. So according to the construction market and the way in reducing errors and saving energy, it is advised to keep pace with construction market and trying to exploit BIM technology in future projects in Egypt.
It was clear from case studies that construction project faces many errors during the design phase that may have effect on project time, cost and quality which could lead for inefficient and disappointing results in the project. However, using some of the BIM features in project phases from the start of the project would help in avoiding this error and obtain more efficient project.
From the applied part of the 5D model suggested in this research, it is evident that it is effective to use a 5D model for both design and construction phases and also after project delivery. It was also proved that some of BIM benefits in the second case study will positively affect project overall cost and time.
It is concluded from the studied cases that BIM is a complete process from the start of the project passing through its phases until the end of the project and after delivering it to the owner. It also contributes to achieving a controlled system to follow project steps and help the owner to reach his goals.

3.2 Final Conclusion:

From results stated above and accomplished from research methodology it is concluded that BIM is recommended to be used in the Egyptian construction industry especially that its needed capabilities are readily available as it will contribute in achieving many benefits in Egyptian construction industry. But, it is not clear if it would rapidly spread in Egypt or not as a result of the presence of less knowledge about it and the existence of some risks that may be an obstacle in the way of developing BIM in Egypt.
This is beside that research submitted some of the applied benefits using an actual case study and comparing between using conventional method or BIM according to an applied 5D model that proved its importance in increasing control in different project phases.

4. Research Contribution:

This research contributes to investigating the following points:

1- Accomplishment of the feasibility of BIM use in Egyptian construction industry and the relevant risks.
2- A study of the benefits of utilizing BIM in the Egyptian construction companies and projects.
3- Study for the risks that may prevent BIM's use in the Egyptian construction industry.
4- Analysis for suggested extension of 3D BIM Models to a more comprehensive 5D model in construction management.

REFERENCES

1- Hosney, R.M, Elmikawi, M.A, Essawy, A.S, (2016), "Building Information Modeling in Egyptian Construction Industry", MSc Thesis, Structural Engineering Department, Ain Shams University, Egypt.
2- Hymas D. (2012). " building information modeling the designer" CIC east and IDBE
3- Department for Business Innovation & Skills BIS. (2012). " Building information modeling" United Kingdom Government
4- Bloomberg, M. , Burney, D. , Resnick, D. (2012). " BIM Guidelines " Department Of Design And Construction, New York
5- CIC. (2010). " BIM project execution planning guide version 2" the Pennsylvania state university
6- Baker, C., Beliveau, A., Sylvia, N., Williams, M. (2012). " Construction Management through Five-Dimensional Building Information Modeling with Alternative Design Considerations" Master Of Science Thesis, Faculty of Worcester Polytechnic Institute
7- Hergunsel, M. (2011) " Benefits of Building Information Modeling for Construction Managers and BIM Based Scheduling" thesis for master of science in faculty of Worcester Polytechnic Institute
8- D.B. Hammad, A. G. Rishiand M. B. Yahaya (2012) " Mitigating Construction Project Risk Using Building Information Modeling (BIM)" Building Technology Programme, Department of Technical Education, College of Education Azare Bauchi State, Nigeria
9- Arayici Y., Egbu C., Coates P. (2012) " Building Information Modeling (BIM) Implementation and Remote Construction Projects: Issues, Challenges, and Critiques" ITCON journal of information technology in construction
10- Rajendran P., Seow T.,Goh K. (2014) " Building Information Modeling(BIM) Tools in Design Stage to Assist in Time for Construction Project Success" International Journal of Conceptions On Management and Social Sciences.
11- Thurairajah N., Goucher D. (2013) " Advantages and Challenges of Using BIM: A Cost Consultant's Perspective Associated "The Associated Schools of Construction
12- Yan H., Damia P. (2008) " Benefits and Barriers of Building Information Modeling " 12th International Conference On Computing in Civil and Building Engineering, Beijing.
13- Talebi S. (2014) " Exploring Advantages of Challenges Adaption and Implementation of BIM in Project Lifecycle" 2nd BIM International Conference On Challenges to Overcome Lisben, Portugal.
14- Majcherek E. (2013) "Building Information Modeling in The Business of Architecture" degree project in Entrepreneurship and Innovation Management second cycle Stockholm, Sweden.
15- Azhar S, brown J. (2009)." BIM-based sustainability analysis: an evaluation of building performance analysis software" International Journal of Construction Education and Research.
16- Eastman C., Teicholz P., Sacks R., and Liston K. (2011) " BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors" John Wiley and Sons Inc.