*https://erjm.journals.ekb.eg*
*ISSN: 1110-1180*

DOI: ---------

**ERJ**
**Engineering Research Journal**
**Faculty of Engineering**
**Menoufia University**

# Advantages of Building Information Modeling Technology (BIM) in Structural Design and Construction Stages

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**ABSTRACT**
Building Information Modeling has recently spread worldwide and is commonly used in construction projects. Whereas in Egypt, despite the fact of the increased awareness of the BIM, the actual use of BIM by consultants and contractors remains limited. BIM in Egypt is still in the development phase, and it requires more efforts to become widely used by construction societies. This research studies the effect of applying BIM in the design and construction stages of high-rise buildings, and how it increases the quality of co-ordinations between all disciplines, which affects directly the productivity of construction projects in high rise building. This research tries to find the ideal usage of BIM in the design and construction stages and to find out how the direct application of BIM in selecting structural design. The methodology used for this research approach depends on a detailed literature review, a field survey for the building information modeling in Egyptian construction field as it is intended to use the questionnaire answers from a group of engineers that used the technology and followed by statistical analysis of the collected responses to the questionnaire. The obtained results showed that using BIM technology in high rise buildings projects can increase the productivity and provided a high level of visualization that could be missed by traditional design methods. The term "build before you build" best describes how digital prototyping with BIM was used to test the design. It provided the opportunity to explore different options with the client.

***Keywords***: *Building Information Modeling (BIM); Construction; High-rise buildings; Analytical Model; Structural Design Systems.*

## 1. Introduction

It has been recently observed that Egypt like other developing countries attempts to evolve and keep up with scientific development in the construction industry field. This is driven by applying the new processes that control its resources and improve the quality of its projects .

Construction industry is defined as an economical sector for transforming different available resources into a built structure which will serve the socio-economic development. Construction industry is responsible for the following processes: planning, designing, procuring, constructing for the produced structure which includes (buildings, roads, bridges, airports, other transportation systems, their facilities and underground structures including tunnels and mines) .[1]

By recent observation of growing in technology, many areas of production and business are being refined and redefined leaving the construction industry behind. At the same time, process of construction is still basically the same as it was hundreds of years ago, from a set of drawings, a building is being erected. The most important part is that these drawings are never without errors and omissions, causing many delays, multiple change order items, and finally late projects completion which needs in return to be more developing and advancing to avoid those errors and delay.[2]

Later over the years, new technological ways have been developed by engineers using many updated and advanced programs to help in all aspects of their specific profession. In return, contractors depended on large construction equipment to perform tasks, and computer programs to help in estimating and scheduling process to know whether or not the construction project will be profitable and if the construction company will continue in the business. Yet both engineers and contractors are assisted by numerous advances in technology between them in the construction industry but still using the 2D representation. [2]

As a result of the rapid involvement of BIM in the construction industry as a new helpful technology to project stakeholders, there will be a plenty of considerations and differences that should be taken and released to safely shift from the classic scheme of design and construction into the new BIM technology and its applications in addition to implementation of all the stages of the project [2].

**2. Aim and 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 field as it is intended to use the questionnaire answers from a group of expert engineers used the technology or have a good knowledge about it and followed by statistical analysis of the collected responses to the questionnaire.

**3. Definition of BIM**

Building information modeling is defined as a cooperative technique in work which is supported by a digital process using combination of software programs which develop more proficient ways in designing, developing and preserving assets. BIM can be used for saving and managing the information of the project through its lifecycle [3].

So, BIM can be used to mix between the new technological software programs and the new construction techniques in the site to have fewer errors and more accurate model. Here BIM could be the key for the development and growth of national and international construction markets [3].

BIM introduces a systematic technology that not only serves the construction process, but it also aids stakeholders in easy and correct decision making for more safe work arrangements, saving for energy and efficiently using surrounding environmental sources during construction and after facility delivering. So, it focuses on the life performance of the facility and the overall economy by ensuring delivery of high-quality construction process [3].

BIM also offers a chance to promote greater transparency and collaboration between suppliers and consequently, there will be a reduction in waste (procurement, process, and material) through all levels of the supply chain all over the project lifecycle [3].

This chance will be also for all construction knowledge and society by the rapid adoption of BIM by clients and all parties of the construction organization [3].

BIM is about to coordinate between software applications in a common model to facilitate overlapping between project parties' tasks. This model develops design and construction documentation by virtually constructing building on the computer before actually building it. BIM can be used in the project by a wide or small range, it depends on the breadth and depth of its application and use on the project, so it is scalable, but it does not depend on the magnitude and complexity of the project [4].

**4. Advantages and disadvantages of BIM**

The project team of design stage may consist of (but not limited to): surveying, architecture, civil engineering, electrical engineering, mechanical engineering, structural engineering, landscape architecture, fire/alarm engineering, communications, interior designs, owners, tenants, construction managers, commissioning, etc. All these members contribute with their data and executed work to the BIM model, and this may continue till and after construction stage which will interfere with general trades, site/excavation, steel construction, mechanical construction, electrical construction, fire sprinkler construction, concrete construction, roofing, masonry, glazing, elevator controls, finishes, technology, and landscaping [2]. So, the expected advantages and disadvantages of all these systems can be abbreviated in the following brief:

**4.1 Advantages of BIM**

1. Any errors or conflictions in the design can be discovered early before starting construction.

2. Any modifications that happened in the model can be corrected easily in all dimension 3D model, 4D model (time) and 5D model (cost) as any change in 3D model will automatically be reflected to a change in time and cost by using BIM which communicates between all factors (models) of the project.

3. BIM introduces an easy technique for drawing the building model and extracting its data and drawings which in return will save time consumed in both design and construction. Also, it will help in expecting a preplan for the building construction cycle.

4. Reduce the overall cost of the project by decreasing time consumed during change of orders and reducing time waste that happens during construction phase which will control the cost during the project lifecycle.

5. It has a benefit of reducing effort during copying any change in one view of the model as it can transfer and pass it for all the other views. For example, when putting a door in the plan view, it

will pass automatically to the 3D view. Also, all the section of the model as the program will insert it into the schedule and cost plan for the model in the 5D model so the same concept is for replacing any item in the plan, it will automatically be updated all over the model.

6. It gives the opportunity to the owners and designer (all the parties of the project) to compare between available alternatives through the design stage to know the properties of each alternative, the consequence, and capabilities of using it to easily take the right decision for the project.

7. To easily know the right flow of each system, insert in the model to prevent any collapse or conflict between systems (civil, architectural, mechanical, electrical, communication, fire and HVAC systems).

8. As we can achieve a correct expected method of statement for every activity to be easily and correctly viewed by all the project parties.

9. BIM introduces a high control system on time by overlapping between 3D model and the time dimension in a 4D model to follow the construction sequence during project lifecycle and overcome any delay that may happen during project phases especially construction phase.

10. BIM concerns with choosing the best alternative for the design of the solar system and construction methods through the lifecycle to achieve most appropriate energy consuming to save environment.

11. It can animate the model to discover the ability to use that building later for the task it is built for, is it suitable for this usage or not. And it shows the expected movement inside the site, and the available spaces to be used as storage areas for project materials.

12. Produce parametric elements with little effort which suit the available areas in the model with all the data concerned to these elements and its sources including the real dimensions for them and the needed openings for each element in the building to apply it in reality without rework or waste.
13. Improved accuracy and efficiency of cost estimating process as it increases the quality of the takeoff reports.

14. Achieving client's satisfactions by rapid and accurate exchange and saving for project data [2, 5, 6 and 7].

**4.2 Disadvantages of BIM**

1. BIM permits suppliers to insert their data direct to the model so there will be a plenty of data loaded into the model that will result in overlapping between data without knowing the main source of it so who can carry the blame of any missing or wrong data (Some data can be missed by the action of transfer from one supplier to another or by any fault of the supplier that cause an actual problem in the credibility of the data).

2. For the entrance of a new technology in the construction industry, there may be missing in the rules and standards of the technology. This may cause the less documented standards of the BIM in the contract, or it may be ignored.

3. There is an obvious doubt in the ability to check all the data transfer from one program to another and it will need a great effort to check it again.

4. We cannot save the history of changes in the BIM method as any change happen in the model cannot be saved on the program and cannot know who made that change, as a result, we cannot revise any past views before that change.

5. The cost of training for the staff may cause an anxiety for many companies trying to involve in BIM field as it will consume time and cost for the engineers to learn and apply BIM technology in their work but on the other hand, every company saves a certain budget to keep competitive to market.

6. BIM software and hardware will need to have a certain budget plan for introducing them in the company instead of old used software and hardware [2 and 5].

Generally according to (Han Yan and Peter Damian) [8] paper for identifying benefits and barriers of building information modeling which depends on questionnaire data, it is said that the role of BIM in any project can improve its design phase which will help engineers to safely make any change with minimum errors and with an automatic check for work to avoid manual checking.

Also, the role of BIM in construction phase can help in managing construction time and cost of the project. That is beside the contribution of BIM process in improving the documents cycle in the project and the communication between project stakeholders.
But on the other hand, BIM has its barriers which are still discussed and in trials to be solved. Some of people opinion could be a barrier when they think

that the traditional technique in design is suffice for their work so they don't want to learn about BIM or try it [8].

**5. Benefits of BIM for Designers**

BIM process is a way for a new generation that will have an easier understanding for complex project and easier dealing with them which will help in exploring more detailing about construction industry that is so important for designers in engineering field [9].

BIM makes integration between project engineering services as it introduces information flow through the project lifecycle and integration between project data with existing simulation and analysis ways used by consultants. Also, it gives a detailed model used in the construction including specifications and cost estimate for the project items [9].

Some of the uses of BIM for designers: -

**5.1. Cost estimate**

Most of BIM programs enable extracting items data of the project automatically including item's number in the model, area, and volume. This helps the designers in carrying out value engineering analysis during design phase by considering alternatives which will help in the best use of resources in the project and aid in achieving a practical assessment throughout design [9].

**5.2. Building System Design, Analysis, Simulation, and Checking**

Regarding the environmental approach for saving energy consumption in construction field, the building should satisfy structural, environmental conditioning, freshwater distribution, wastewater removal and power distribution [9]. For reaching these targets, it may need to be studied and analyzed early to select the most appropriate materials and specifications needed for the building [9].

Most of the used software programs for the analysis need a 3D model for applying the analysis, and according to BIM tools, it can be used in that field [9].

The interface between BIM tools and analysis application helps in presenting an analytical data model that contains detailed building geometry which leads to the accurate needed analysis for the building [9].

**5.3. Drawing and Document Production**

Drawing's production is one of the BIM most popular benefits, but by time the drawings will stop to be used as the design representation and the model will replace it. It is expected that BIM model will be the primary legal and contractual source of information [9].

**5.4. Specifications**

BIM contributes to regulation of building data, so it saves each element technical specification and exports it from the final designed model in tables including the needed materials, quality grades, construction procedures, finishes and other information required for designer to build his plan depending on that data [9].

Between the design and construction stages, BIM plays the role of integration between them to the best handling for the model and applying it. Some of the benefits from using BIM tools in that integration are: -

1. Determining the critical items in the building to build the procurement plan according to their construction time schedule.

2. Using BIM tools to compare between alternatives for value engineering during developing design.

3. Early mentioning of design constraints according to construction issues so that design could be compatible with construction needs and also for early taking decisions when the changing in design has less impact on the project.

4. Reduce errors happening from differences between construction model and the manufacturing models so eliminating rework time.

5. Reduction of coordination errors taking place during overlapping between different systems of construction [9].

**5.5. Design review**

1. BIM helps in reviewing the design issues and going through the building to check its reliability.

2. Early identification of problems reduces risks during project phases and helps solving them.

3. Easy definition of design tasks and users responsible for each task.

4. Help in following the problem solving to reach by the design to higher quality [9].

**6. Design of the Questionnaire**

There is a number of recommendations should be taken in consider while designing any questionnaire such as: -

1. Questions should be clear, simple, specific and relevant for the research aims.

2. General questions should precede the specific questions.

3. Avoiding the inconspicuous words such as frequently, usually, and regularly.

4. The inclusion of a middle option increases the validity and reliability of a response scale.

5. Respondents should have the knowledge with research subject and their experience with this subject appropriated.

6. Building Information Modeling Questionnaire Consist of Seven Sections. Each section of it tries to identify some keys helping to improve and find best practices of applying BIM in design and construction stages as Following: -

    - Section A - Personal / Work Information's
    - Section B - Using BIM in Egyptian construction industry
    - Section C - Benefits of using BIM
    - Section D - Using BIM technology for structural analysis
    - Section E - BIM and cost control
    - Section F - Effectiveness of BIM in the safety of the project
    - Section G - Constraints in using BIM / reasons for not using BIM

The questionnaire designed to have answers with a gradual degree for answers as follow: -

- A: strongly agree (100%)
- B: agree (75%)
- C: neutral (50%)
- D: disagree (25%)
- E: strongly disagree (0%)

**7. Questionnaire Analysis Techniques**

In the aim of having a trusted and convincing evidence of the returned benefits and the power of using BIM in Egyptian construction industry a sample size has been calculated. Also, the responses to the questionnaire will be analyzed according to statistical analysis which considers the population side and the probabilities study of the survey responses.

The following part will discuss these issues in detail according to the next steps in this research: -

**7.1. Calculation of Sample Size**

Defining the main targeted population was the following step. The population consists of experts in design engineers, construction engineers, technical office engineers, QA/QC engineers, planning engineers, project managers, consultant managers, owner/client managers, professors, teaching assistants and random respondents.

Since the number of targeted populations is almost unknown, professional internet network was used to assess in the process of estimating the population size.

The population size has been predicted to approximately reach 500000 individuals; field experts agreed on this size [10]. After that, the survey's questions are designed to be easily understood and their contents are checked for validity by a pilot study considering the targeted population. The minimum number of participants in the pilot study is extracted from the below equation [10].

$$n = \frac{LN(1-\gamma)}{LN(1-\pi)} \qquad (1)$$

Where:

$\gamma$ is the confidence level, taken as 95%

$\pi$ is the probability, taken as 0.05

By applying Equation (1), the pilot study should be answered by a minimum of 59 participants. 60 individuals between field experts and university professors have participated in the pilot study. Reliability test (Cronbach's alpha model) has been conducted to check pilot-study questions' reliability. The Cronbach's alpha was found to range from 0.877 to 0.95 for all questions at 95% confidence level and 5% margin of error [10].

After ensuring that the questionnaire is properly designed and well understood by the respondents, the survey was distributed in the form of an online electronic questionnaire to a randomized sample of expert's engineers, who represent their construction entities. Additionally, there were no limitations towards the types of projects they work on. Project types ranged from all sectors of the construction industry including commercial, industrial and residential. For the ease of answering the questionnaire in different cultural regions, the survey was translated into Arabic.

Since the survey was designed to target all engineers, and the targeted sample was hard to be contacted due to its size, hence why LinkedIn was used to distribute the survey. The questionnaire was available online for respondents between 25 Jun 2020 and 25 Dec. 2020. The minimum number of participants to answer this questionnaire is calculated by the following equation [10].

$$n = \frac{\frac{z^2 * p(1-p)}{e^2}}{1+\frac{\frac{z^2 * p(1-p)}{e^2}}{N}+1} \qquad (2)$$

Where:

N is the population size, taken as 500,000
e is the margin of error as a percentage expressed as a decimal, taken as 5%
z is the z-score, taken as 1.96 for 95% confidence level
p is the population proportion, expressed as a decimal, taken as 0.5.
Applying Equation (2), the minimum number of participants is approximately 384. Afterward, the reliability test (Cronbach's alpha model) has been conducted to test how the answers reflect the real situation of the AEC industry and check if they are not randomly answered.
The Cronbach's alpha was found to be greater than 0.8 for all questions at 95% confidence level and 5% margin of error. Correlation analysis and statistical data summary were performed on the collected data as well.

### 7.2. Methods of Analysis

The researcher has conducted statistical analysis techniques for checking study hypotheses using SPSS v 24 Statistical analysis techniques were mentioned as follows:

- Frequency table
- Descriptive statistics (Mean, Standard Deviation)
- T test
- Cronbach`s alpha

## 8. Analysis of Questionnaire

### 8.1. Frequency Tables for Section (A) Personal / Work Information's

Table (1) and Figure (1) show that the percentage of different engineering departments who contribute to this questionnaire

Table 1- Frequency Table of Disciplines

| Discipline | Frequency | Percent (%) |
|---|---|---|
| Architecture Engineers | 80 | 20.8 |
| Civil Engineers | 261 | 68.0 |
| Electrical Engineers | 16 | 4.2 |
| Mechanical Engineers | 27 | 7.0 |
| Total | 384 | 100 |

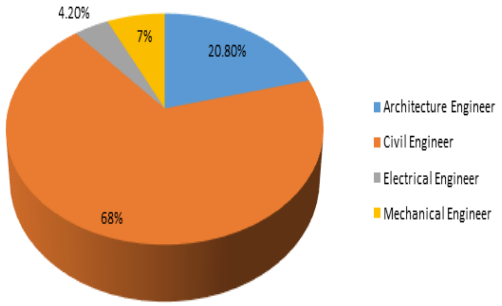


Figure 1-Percentages of Disciplines

Figure (2) shows that the percentage of companies with 100 employees or less is 31%, the percentage of companies with 100 - 200 employees is 7.3%. In addition to that, the percentage of companies with 200 - 500 employees are 4.2%. Also, the fig. shows that the percentage of companies with more than 500 employees is 42.9% and the percentage of universities education institutions is 14.6%.

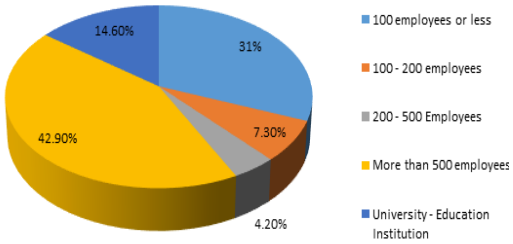


Figure 2-Percentage of Companies Sizes

From Figure (3), it can be seen that the percentage of organizations that adopted BIM 1 year ago is 44.8%, organizations that adopted BIM 2 years ago is 18.2%, ; organizations that adopted BIM 3 years ago is 6.3%, and those who that adopted BIM 4 years ago is 6%. Likewise, the fig. presents that the percentage of organizations that adopted BIM 5 years ago is 7% and the percentage of organizations that adopted BIM more than 5 years ago is 17.7%.

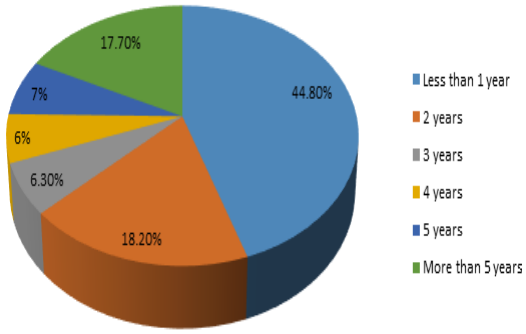


Figure 3-distribution of companies according to years of BIM adoption

**8.2. Descriptive Statistics for section (B) Using BIM in Egyptian construction industry**

Table (2) shows the Descriptive Statistics for Using BIM in Egyptian Construction Industry and shows that the degree of agreement for this dimension varies between 2.9 and 4.8. The third sentence has the highest degree of agreement (4.8 out of 5). The eighteenth sentence has the lowest degree of agreement (2.9 out of 5).

Table 2-Descriptive Statistics for Using BIM in Egyptian Construction Industry & its Knowledge in Egypt

| Sentence | Mean | S.d. | T | Sig. | Decision |
|---|---|---|---|---|---|
| Do you think that BIM is important for AEC industry? | 4.71 | 0.639 | 52.531 | 0.000 | Reject |
| Did your company decide to utilize BIM? | 3.91 | 1.188 | 15.028 | 0.000 | Reject |
| Do you recommend using BIM in Mega projects? | 4.84 | 0.457 | 78.835 | 0.000 | Reject |
| Do you recommend using BIM in Medium projects? | 4.35 | 0.753 | 35.099 | 0.000 | Reject |
| Do you recommend using BIM in small projects? | 3.51 | 1.133 | 8.870 | 0.000 | Reject |
| Do you recommend using BIM in any scale projects? | 4.07 | 1.047 | 19.974 | 0.000 | Reject |
| Do you believe using BIM allows companies to win more work? | 4.53 | 0.704 | 42.487 | 0.000 | Reject |
| Do You Believe That Adopting BIM workflow will lead to better works? | 4.69 | 0.578 | 57.262 | 0.000 | Reject |
| Do you know the difference between Revit and BIM? | 4.30 | 1.053 | 24.186 | 0.000 | Reject |
| Do You Think That Many Engineers Have Wrong Information's About BIM? | 3.87 | 0.908 | 18.780 | 0.000 | Reject |
| Are you currently using any BIM software programs on any projects? | 3.83 | 1.345 | 12.067 | 0.000 | Reject |
| Is it necessary that all engineering discipline should have BIM knowledge? | 4.26 | 0.876 | 28.193 | 0.000 | Reject |
| Is it necessary that the project manager should be BIM expert? | 3.86 | 0.968 | 17.500 | 0.000 | Reject |
| Do you think we have enough possibilities to spread BIM in Egypt? | 3.74 | 0.937 | 15.474 | 0.000 | Reject |
| Do you think BIM helps in fast, easy and more accurate quantity surveying? | 4.61 | 0.665 | 47.527 | 0.000 | Reject |
| Do You Think That BIM Is Future? | 4.71 | 0.598 | 56.076 | 0.000 | Reject |
| Are you familiar with standards of the Egyptian BIM code? | 3.42 | 1.247 | 6.549 | 0.000 | Reject |
| Do you work according to the standards of the Egyptian BIM code? | 2.97 | 1.295 | -0.512 | 0.609 | Accept |
| Do you think that the Egyptian BIM code needs many changes? | 3.33 | 1.055 | 6.092 | 0.000 | Reject |
| Do you have experience of using any BIM standardized file Formats, such as (IFCs)? | 3.09 | 1.341 | 1.370 | 0.171 | Accept |
| Do you understand the „LOD“ required at each of the Project delivery stages? | 3.86 | 1.302 | 12.896 | 0.000 | Reject |
| Do you understand the "Level of Information" required at each of the project delivery stages? | 4.02 | 1.099 | 18.150 | 0.000 | Reject |

**8.3. Descriptive Statistics for Section (C) Benefits of using BIM**

Table (3) shows Descriptive Statistics for benefits of using BIM it can be seen that the degree of agreement for this dimension varies between 4.1 and 4.6. The second sentence has the highest degree of agreement (4.6 out of 5). The seventh sentence has the lowest degree of agreement (4.1 out of 5).

Table 3-Descriptive Statistics for benefits of using BIM

| Sentence | Mean | S.d. | T | Sig. | Decision |
|---|---|---|---|---|---|
| Are you aware of BIM and its benefits? | 4.37 | 0.884 | 30.355 | 0.000 | Reject |
| Does BIM Really Improve conflicts detection? | 4.61 | 0.740 | 42.560 | 0.000 | Reject |
| Do you think BIM helps in the quality control for the project? | 4.46 | 0.757 | 37.703 | 0.000 | Reject |
| Does BIM Really Improve communication between project parties? | 4.58 | 0.681 | 45.502 | 0.000 | Reject |
| Does BIM help the engineers understand the execution plan and the construction steps? | 4.53 | 0.681 | 43.979 | 0.000 | Reject |
| Can BIM model give you a good vision for every part of the project with its documentations like (NCRS, ITPS and laboratory results) and represent it in the model? | 4.28 | 0.845 | 29.704 | 0.000 | Reject |
| Do you think BIM help in distributing the resources in the project and make a storage plan for the material? | 4.13 | 0.777 | 28.488 | 0.000 | Reject |

**8.4. Descriptive Statistics for Section D Using BIM technology for structural analysis**

Table (4) shows the Descriptive Statistics for Using BIM Technology for Structural Analysis and shows that the degree of agreement for this dimension varies between 3.2 and 4.46. the seventh and ninth sentences have the highest degree of agreement (4.46 out of 5). The fourth sentence has the lowest degree of agreement (3.2 out of 5).

Table 4-Descriptive Statistics for Using BIM Technology for Structural Analysis

| Sentence | Mean | S.d. | T | Sig. | Decision |
|---|---|---|---|---|---|
| Does the using of BIM technology help in determining the choice of the structural system for high-rise buildings? | 3.68 | 1.008 | 13.319 | 0.000 | Reject |
| Does the using of the Revit program help in the process of changing the structural system easily? | 3.80 | 0.903 | 17.461 | 0.000 | Reject |
| Does the using of the Revit program help in the process of putting loads of constructions easily? | 3.68 | 0.961 | 13.802 | 0.000 | Reject |
| Dose the using of the Revit program makes it easier to place loads than the various structural analysis programs such as (Etabs – Robot)? | 3.20 | 1.046 | 3.708 | 0.000 | Reject |
| Dose the using of the Revit program easier to draw the structural system (analytical model) than the structural analysis programs such as (Etabs - Robot)? | 3.69 | 1.052 | 12.851 | 0.000 | Reject |
| Does BIM Really Improve design quality? | 4.40 | 0.802 | 34.290 | 0.000 | Reject |
| Does BIM Really Improve Reduced redesign issues | 4.46 | 0.764 | 37.424 | 0.000 | Reject |
| Do you think using AutoCAD (2D) helps you to avoid the defects of design phase that cause the repetition of the work? | 3.28 | 1.251 | 4.405 | 0.000 | Reject |
| Do you think that Revit gives you more accurate data to avoid any errors may happen during design? | 4.46 | 0.781 | 36.613 | 0.000 | Reject |

**8.5. Descriptive Statistics for Section (E) BIM and cost control**

Table (5) shows the descriptive statistics for the questions for the benefits of using BIM for cost control and shows that the degree of agreement for this dimension varies between 4.4 and 4.6. The seventh sentence has the highest degree of agreement (4.6 out of 5). These sentences second, fourth and sixth have the lowest degree of agreement (4.42 out of 5).

Table 5-Descriptive Statistics for BIM & Cost Control

| Sentence | Mean | S.d. | T | Sig. | Decision |
|---|---|---|---|---|---|
| Do you think it is useful to use BIM in value engineering? | 4.47 | 0.794 | 36.177 | 0.000 | Reject |
| Does BIM Really Improve Reduced overall project cost through the project lifecycle? | 4.42 | 0.787 | 35.266 | 0.000 | Reject |
| Does BIM Really Improve management of projects schedule milestones and Increased speed of delivering its? | 4.52 | 0.704 | 42.178 | 0.000 | Reject |
| Do you think BIM decreases the percentage of risk in the project? | 4.42 | 0.757 | 36.792 | 0.000 | Reject |
| Do you think the overlap between the 3D model and the time dimension through a 4D model will make more control by following each step in one model? | 4.49 | 0.723 | 40.330 | 0.000 | Reject |
| Is using 5D model combined with 3D, construction schedule and cost of the building so that every step happen will be translated to cost and time will help in understanding the complex project nature? | 4.42 | 0.791 | 35.277 | 0.000 | Reject |
| Do you agree that BIM is the "Future of project information Management"? | 4.60 | 0.711 | 44.188 | 0.000 | Reject |

**8.6. Descriptive Statistics for Section (F) Effectiveness of BIM in the safety of the project**

Table (6) shows the Descriptive Statistics for Effectiveness of BIM in the Safety of the Project and shows that the degree of agreement for this dimension is almost 4. The third sentence has the highest degree of agreement (4.02 out of 5). The first sentence has the lowest degree of agreement (3.9 out of 5).

Table 6-Descriptive Statistics for Effectiveness of BIM in the Safety of the Project

| Sentence | Mean | S.d. | T | Sig. | Decision |
|---|---|---|---|---|---|
| Does Building Information Modeling Really Improve Reduced safety risks? | 3.90 | 0.845 | 20.957 | 0.000 | Reject |
| Do you think that the digital walkthrough provided by Revit program will help to increase project safety? | 3.99 | 0.793 | 24.385 | 0.000 | Reject |
| If you can represent the resources plan on the Building Information model and make a safety plan for them then do you think that BIM can help in decreasing the risk of accidents happen in the project? | 4.02 | 0.744 | 26.898 | 0.000 | Reject |

**8.7. Descriptive Statistics for Section (G) Constraints in using BIM**

Table (7) shows the Descriptive Statistics for Constraints in Using BIM and shows that the degree of agreement for this dimension varies between 3.3 and 4.4. The first sentence has the highest degree of agreement (4.4 out of 5). The fifth has the lowest degree of agreement (3.3 out of 5).

Table 7-Descriptive Statistics for Constraints in Using BIM

| Sentence | Mean | S.d. | T | Sig. | Decision |
|---|---|---|---|---|---|
| Do you think BIM technology will need an extra effort from your company to train engineers for using it? | 4.39 | 0.890 | 30.617 | 0.000 | Reject |
| Will using of BIM technology take a long time to be understood by the project parties? | 3.86 | 0.902 | 18.724 | 0.000 | Reject |
| Do you think it is easy to learn and use BIM software? | 3.90 | 0.844 | 20.852 | 0.000 | Reject |
| Do you think the cost of training of BIM is high? | 3.89 | 0.870 | 19.992 | 0.000 | Reject |
| Owners Not Requesting | 3.31 | 0.972 | 6.196 | 0.000 | Reject |
| Do you think that there is a problem from un-satisfaction of changing from the traditional methods of design to the BIM method from the engineers and the project parties? | 3.87 | 0.790 | 21.653 | 0.000 | Reject |

**9. Reliability (Cronbach's Alpha)**

The Reliability of assessment measure indicates how it is free from random error and it is varied depending on the sample that it is used with. Cronbach's Alpha is an indicator for the scale's reliability. Also, it can measure the internal consistency. Ideally, Cronbach's Alpha should be above 0.7.[11]

Table (8) show that all dimensions are reliable as the values of Cronbach's Alpha are more than 0.7 for these dimensions: using BIM in Egyptian construction industry & its knowledge in Egypt, benefits of using BIM, using BIM technology for structural analysis, BIM & cost control and effectiveness of BIM in the safety of the project, and the value of Cronbach's Alpha is almost 0.7 for the last dimension: constraints in using BIM.

The results of the reliability analysis mean that the study results will not differ significantly if the study is conducted for the same respondents several times. Finally, the results of the reliability analysis showed that all study dimensions are reliable which means that study results will not differ significantly if the study is conducted for the same respondents several times.

Table 8-Reliability Analysis

| Dimension | No. of items | Cronbach's Alpha |
|---|---|---|
| Using BIM in Egyptian construction industry & its knowledge in Egypt | 23 | 0.825 |
| Benefits of using BIM | 7 | 0.856 |
| Using BIM technology for structural analysis | 9 | 0.822 |
| BIM & cost control | 7 | 0.911 |
| Effectiveness of BIM in the safety of the project | 3 | 0.863 |
| Constraints in using BIM | 6 | 0.688 |

**10. Conclusions**

Working with BIM on high-rise projects has great benefits. While working with such projects we can integrate the design drawings with a 3d virtual model. Sources say that this technology helps in reducing the overall project cost. This indicates increase in benefit more than what it would be without using BIM technology. Integrated project design ensures more accuracy, less cost and quick turnaround. Design validation process eliminates chances of design issues and interferences between disciplines to a great extent. Just like reduction of cost, project execution and construction time can be made quicker using advanced BIM Modeling technology.

Hence it can be safely concluded that BIM Services can be extremely viable for construction of High-rise buildings. With Building Information modeling gaining traction into the construction industry, good opportunities and process tools available most of the construction companies, General contractors and Architectural firms are diversifying into this process. It is touted that in this highly competitive age, utilization of Virtual Design Construction will certainly give an edge to companies using it and, then it companies which does not.

**11. Recommendations**

It is recommended that several research works must be done in the near future concerning the following:

1. Applying building information modeling workflow in long span bridges design and construction.

2. Continuously update the code of practice for building information modeling.

3. Start to make BIM educational content that may considered in project design and management course in engineering faculties.

4. Start to force companies to apply building information modeling in their projects.

Finally, the study has taken the concept of BIM comprehensively. It has included all parties who participate in the AEC industry as well as it has studied BIM at all stages of the lifecycle of the facility. The researcher had to do this because this research is the first step in studies about BIM in the area. However, it would be better to allocate the study at a certain stage of construction project.

Therefore, it is recommended that future researchers should study BIM application in other areas of world. They should also specify more their studies, such as studying the subject of BIM adoption from consultant's perspective or contractor's perspective. The study can also be conducted about using BIM in a defined phase of the AEC industry. Furthermore,

as a part of any future research, it is suggested to create a BIM model for any construction project that constructed with the traditional way (without BIM). After that, the researcher can study a defined step (such as cost estimation or quantity take - offs of materials for making a comparison between the results in both cases (before and after BIM).

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