AN INVESTIGATION OF BUILDING INFORMATION MODELING (BIM) IMPLEMENTATION IN THE PALESTINIAN AEC

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ABSTRACT

The effectiveness of implementing Building Information Modeling (BIM) in the Architecture, Engineering and Construction (AEC) industry is steadily increasing in the recent years. This study examined the role of BIM implementation in one of the Middle East countries, particularly in Palestine. It explores the extent of BIM implementation benefits against obstacles and the main design aspects where the Palestinian AEC industry used to implement BIM to enhance its performance. The study adopted the qualitative strategies where a semi-structured interview technique with a sample of Palestinian Engineering Firms was carried out. The findings show that BIM implementation in Palestine has some shortage in the MEP aspects which affects the completion of the BIM lifecycle. Therefore the sequence line of BIM lifecycle in the Palestinian firms is still incomplete. Also, the findings indicate that the extent of the optimal use of BIM is associated with the extent of implementing BIM at the different design aspects, as well as the size and complexity of the project. Therefore, the need for BIM model is becoming more essential to attain its impact as an engineering solution for the complex systems with various aspects.

Keywords: Building Information Modeling, Palestinian AEC industry, Design Aspects, BIM life-cycle.

Introduction

The construction industry is considered one of the effective factors that affect the economic sector, and it is considered one of the best ways of stimulating economic activities. However, the construction industry has a lot of criticisms according to problems related to poor performance in project delivery, inefficient collaborations and low innovation level. In this regard, the efficiency, quality, sustainability, life cycle, cost and the satisfaction of all stakeholders need to be improved. For this reason, building information modeling (BIM) is considered as a key solution to raise the value of the construction industry production and revive the industry to the zenith of growth (Alizadehsalehi et al., 2020; Sodangi et al., 2018). There have been different ways within the architecture, engineering and construction (AEC) industry to define BIM, but all of them complete each other and lead to the same meaning. International standards define BIM as "shared digital representation of physical and functional characteristics of any built object which forms a reliable basis for decisions" (ISO, 2010).

The desire to achieve the projects with minimum cost, best quality, and reduce project delivery time plus the everlasting quest to exceed owners' expectations create the need for BIM, BIM offers the potential to achieve these objectives (Azhar et al., 2008; Salman, 2011). In addition, the data in these 3D drawings are graphical entities only, such as lines, arcs and circles (Azhar et al., 2008), in contrast to the intelligent contextual semantic of BIM models, where objects are defined in terms of building elements and systems such as spaces, walls, beams and columns (Azhar et al., 2008; Kamardeen, 2010). The main output for BIM implementation is a 3D model consist of smart parametric objects, where users could extract all information related to the building. BIM is not just a software to make three-dimensional model, BIM support 8D design. It describes the geometry, spatial relationships, geographic information, cost estimation, time management (Arshad et al., 2019; Azhar et al., 2008), sustainable design, life cycle management, and accident prevention (Kamardeen, 2010), which means it supports integrated design. Moreover, the client can live with the virtual model, and change any undesired design until the client's demands were met (Georgiadou, 2016; Nadeem et al., 2015), which improve client satisfaction and improve customer–client relationships (Azhar, 2011; Georgiadou, 2016; Saleh, 2018). BIM software have built-in cost estimating features, material quantities are automatically extracted and changed when any changes are made in the model (Abanda et al., 2017). Clash detection is one of the main benefits for BIM since BIM models are created

with accurate and to-scale information. In contrast, despite the great benefits of BIM, it has some risks, which makes engineers and other stakeholders skeptical about its implementation. One of the risks that might face the designers is the protection of copyright and the ownership of the BIM data. Since the owner assumes that the property of the model belongs to him, hence all the data has become his property which may contain private data for the company (Arshad et al., 2019). Another risk the designers may face is the data entry control. The responsibility of updating BIM data and ensuring its accuracy entails a great deal of risk.

This study examines BIM implementation in one of the Middle East countries, particularly in Palestine, in terms of three main issues. The first issue is about what are the main design aspects (Architectural, Structural, as well as Mechanical, Electrical and Plumbing "MEP") where the firms in Palestine used to implement BIM model in their design process. The second point that have been examined is the extent of BIM implementation benefits against obstacles in the Palestinian AEC industry. Finally, the study examined the relationship between the effectiveness of BIM implementation and the size of the project. Abuhamra and Enshassi (AbUHamra & Enshassi, 2017) pointed out a number of obstacles that facing BIM implementation in the Palestinian AEC industry. These obstacles are: lack of awareness of the benefits that BIM can bring to stakeholders and engineering offices, lack of engineers skilled in the use of BIM programs, lack of education or training on the use of BIM whether in the universities or any governmental or private training centers, lack of demand and disinterest from clients regarding using BIM technology, and lack of governmental regulations to fully support BIM implementation.

Methodology

It was observed that the literature about BIM implementation in Palestine is almost nonexistent and not exhaustive. In contrast the literature about BIM implementation in the word is extensive. A qualitative evaluation for the current state of BIM implementation and its benefits in Palestine is adopted. Qualitative strategies are used because qualitative approach is very effective to explore issues about which little is known (Corbin & Strauss, 2015). Also, the qualitative research provides stronger basis for analysis and interpretation because it is grounded in the natural environment of the phenomenon in the business environment (Srivastava & Thomson, 2009). Interviews have been chosen as a qualitative method since there is few companies are available. Moreover, interviews as a qualitative method are believed to provide a 'deeper' understanding of social phenomena than would be obtained from purely quantitative methods, such as questionnaires. The purpose of the interviews is to explore the perspective, experiences, beliefs, motivation and/or disadvantages (Gill et al., 2008). Semi structured interviews were adopted since it is the most suitable type to get more detailed data and to allow the interviewee to diverge in order to pursue an idea or response in more detail (Gill et al., 2008). Interviews with seven different firms have been done. These firms cover consulting engineers and contractors. Four of the seven companies implement BIM for projects to be implemented in Palestine only, and the other three firms use BIM for projects in Palestine and other countries in the Middle East. For collecting data, the researchers contacted Engineering Association-Jerusalem which represent all registered engineering firms in Palestine to obtain a name list of practicing firms. An invitation letter to participate in the research was emailed for these firms. The targeted population was restricted to those firms that use BIM in their projects. Out of 165 invitations, 25 replied and only 7 firms participated in the research**.**

Results

BIM Implementation at the Different Design Aspects: In terms of the number of the aspects that have been conducted using the BIM approach, the interviewee firms were ranged in their BIM implementation from one aspect to the five main engineering aspects; architectural, structural, and MEP. Firm number (6) used the BIM software for the architectural aspects only. Another two firms (number 2 and 7) used the BIM tools for two aspect; architectural and structural. Firms

(number 2) revealed that they were firstly using BIM for more than two aspects but later they found that the use of 2D CAD for mechanical and electrical aspects is more efficient in their projects since it consumes less time compared with the use of BIM software. The interviewee at this firm pointed that "BIM implementation for electrical and mechanical aspects is time consuming, and the 2-D CAD is easier and faster for those two aspects". However, the other interviewees (1, 3, 4, and 5) preferred to use BIM approach in their design process at the main five engineering aspects; architectural, structural and MEP. For example, an interviewee at firm 5 said: "I prefer to use BIM model from the first stage of my project to the construction stage passing through all the fields". As well, interviewee No 3 said that "BIM software is an efficient and useful for quantity surveying. It facilitates the quantity surveying operation since the quantities result from the model and the accuracy of the quantities depends on the accuracy of the model". Figure 1 represents the BIM usage percentage for each aspect for the seven firms.

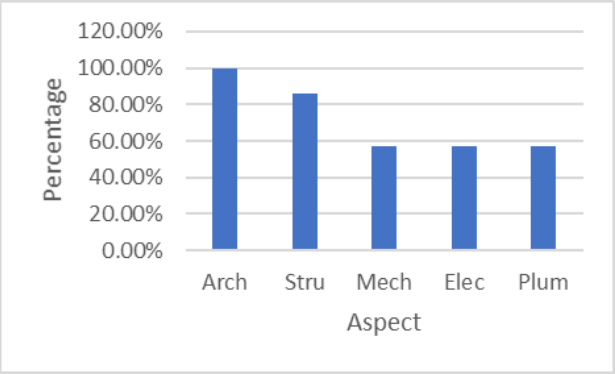

Fig. 1. BIM implementation percentage at different design aspects.

Extent of BIM Implementation Benefits: In this study, the interviewees affirmed a number of the benefits of BIM implementation in their design process at their firms. They pointed that there are several reasons why their firms are cheered for putting BIM under applications at their design process. Saving time and money was one of the main benefits of using BIM that have been highlighted by the interviewees. It was founded that all of the seven firms were used BIM software to save time and money. By using model-based process by using one of BIM software, less time is needed for editing; where any editing in any view, all views will be updated automatically. Firm No. 2 give a good example for time saving in the editing process. Architect said "once I want to change the floor height by using 2D drawings it may need many hours to edit the drawings according to the new height, while by using Revit model it can be changed in a few seconds". Moreover, Firm No 4 pointed that "by using BIM model, number and time of meetings between parties to solve any problem or to discuss any issue related to project and doing changes will be less".

The second benefit of BIM implementation is clash detection. The first five firms pointed that they have been used BIM for detecting the clashes between the different design aspects, and two of them focused on electromechanical clashes (firms No 3 and 4). Firm No 4 give a good example for clash detection between structural and MEP aspects as well as between the different MEP aspects during the construction stage. The supervising engineer said that "during the construction stage of one of our projects there was a clash between structural and mechanical aspects, this clash lead to double pipes quantity and changing the HVAC system. Then the construction stage has been stopped until a BIM model had been built for all the aspects in the project. This model helps to avoid all other clashes and to solve the existing problems and avoid further delay". The following figures related to one of the interviewee firms. It is representing real examples for clash detection have been detected between different aspects using BIM model, each of these problems has been handled on its own. Figure 2 represents one of the cases for structural and mechanical clashes. It shows the clash between the sewage pipes and the drop beam. While Figure 3 expresses the clash between the mechanical and electrical aspects, where it shows the clash between the electrical line and the mechanical pipes. Likewise, Figure 4 represent clash detection between structural and electrical. One of the firms clarify why the BIM model could help to detect the clashes. This is marked in the statement of firm No 3 where he gives two main points make the BIM software's user able to identify the clashes. He pointed out that "the

software could check and explore the clashes and highlight the location of the clashes and then data is being sent to the user with some instructions to solve the problem".

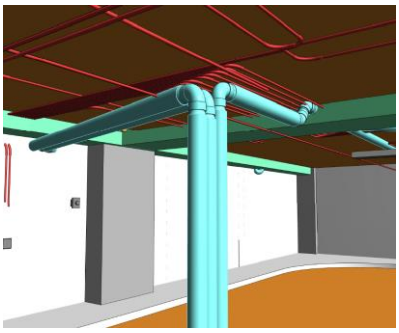

Fig. 2. Mechanical structural clashes.

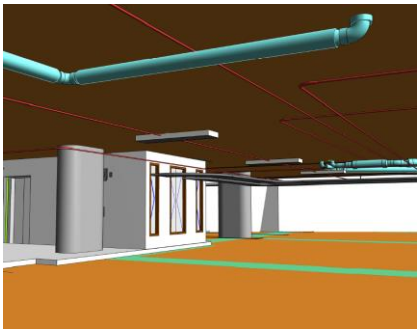

Fig. 3. Mechanical Electrical clashes.

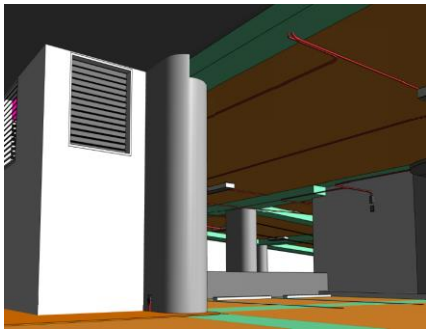

Fig. 1. Structural electrical clashes.

Moreover, the accurate drawings produced by BIM model is one of the strongest motivations in many firms to use one of 3D BIM software. A proof of this is that all the seven firms use the drawing extracted from BIM model, four of them convert these drawings to CAD for license issues, and three of them- who work for project in other countries than Palestine- use the drawing extracted from BIM software without converting them to any other format. Apart of this, getting an accurate updated quantity from BIM model is a significant advantage for using BIM. Five out of the seven firms use BIM model to get accurate quantities since it is time consuming to make accurate quantity surveying manually specially for mega projects. Two other points are worthy of mention were highlighted by interviewee No 3; firstly, by using one of the BIM software, designer could acquire the cost estimation either for all the elements of the project or for a specific element or material. The other worthy point of the cost estimation using BIM model is that the built-in feature of cost estimating could give an updated quantities and cost with any change in the model element. Firm No 4 pointed out that "the accurate quantities is the main advantage since the accuracy of quantities affects the accuracy of cost and time. In another meaning if the quantities is not accurate, then the cost and time schedule for the project will be inaccurate". Firms No 2 and No 3 pointed out that the documentation issue is another significant point for using BIM model. They emphasize that since all data about the project will be in one file, then it is easy to reach and extract any information about any element in the whole project. Firm No 3 added that "the model usually contains hyperlinks lead to any needed data outside the model and any information about any element in the model can be easily obtained from the model". Another point was raised by the interviewees is using the 3D BIM model for operation and maintenance. It was founded that four firms (2, 3, 4, and 5), provide the client with the model to use it for operation and maintenance as requested by the client.

Although several benefits have been pointed out at the discussion with the firms, but still there are some sceptics of the interviewees who highlighted some concerns about the BIM implementation in Palestine or in the region. One of these concerns is BIM model ownership. Many Firms provide the client with the model against additional money even some of them expressed his concerns about possession the ownership to another person. Only one firm (firm No 1) does not give the model for the client never. The designer thought that the ownership of the model is for the company only since it contains a lot of information, components and elements designed and built by the company. Similarly, firm No 3 added that "the client can take the

model, but sometimes there are some elements or systems of the BIM model were built by the firm for the first time. If these elements or systems were built especially for the firm, then the ownership of them should be for the firm only". Another risk that have been discussed with the firms is the data entry control. All of the interviewees firms, except the sixth firm, agreed that there should be a BIM execution plan to be followed. Each engineer enters his data, then there should be a supervisor to ensure that the data is correct. Finally, the BIM manager check the whole data, this series allow double check for the entered data. Moreover, the study found that there are a lot of problems in terms of misunderstanding of the concept of BIM implementation. For example, some engineers think that BIM means just using BIM tool regardless whether this tool is used only for one aspect or for all aspects in an integrated manner. In other cases, some people don't differentiate between the software such as Revit and the BIM process. The researchers realize this point when they contact some firms asking them to arrange for an interview if they are using BIM in their design process. When the meeting was held, the researchers found that they just use the Revit software as a 3D modelling software. Of course, these firms were not listed in the above seven firms.

Furthermore, even in the firms who have some implementation for BIM approach, the number of electrical and mechanical engineers who implement BIM there is still few. Firm No 4 explained that the reason for not using BIM for mechanical and electrical aspects is the lack of the interaction of the mechanical and electrical engineers with the site. He added "from my experience, mechanical and electrical designers usually work from the office and rarely visit the site, thus the 2D mechanical and electrical design that submitted for licensing are just lines and usually cannot be executed in the site. Execution is carried out away from the drawings and depending on the technical staff experience since the technical staff have experience suffice to achieve small projects with simple basic systems due to repetition". Furthermore, the lifecycle of BIM implementation is incomplete as, mostly, the contractor doesn't use BIM model. A part of this, firm No 2 pointed out that according to practice in Palestine for the private small and medium project, the equipment of the mechanical and electrical design in terms of its specifications are chosen by the contractor at the construction stage which make building a BIM model at the design stage is a complicated and useless process. Conversely, in rare cases, the designer does not implement BIM but the contractor does. The engineer at the firm No 3 explained his experience in this situation as he was the contractor for a similar case. He said "one of the problems which we face is that the data required for building a BIM model is not available or be delayed.

Relationship between the Size of the Project and BIM Implementation: It is noticed, through the interviews, that some of the firms linked between the size of the project and the necessity of using BIM process at their project. Firms No 1 and 2 agreed that using BIM software is essential for large projects since high level of management and control for time and cost are needed. Moreover, Firm No 3 added that "large projects usually have complex systems and it is difficult to make coordination between all aspects and systems using 2D drawings". The reason beyond that is that the size of the project, the complexity of the used systems, and the number of these systems make the coordination very difficult. However, there are many firms such as Firm No 1 added that the BIM implementation (especially architectural and structural aspect) has always added value regardless of the size of the project.

Discussion

This study examined BIM implementation in Palestine in terms of three main issues. The first issue was about what are the main design aspects (architecture, structure, and MEP) where the firms in Palestine used to implement BIM model in their design process. The study revealed that not all the firms who use BIM model in the design process are using it in all main design aspects. Chart in Figure 1 shows that architectural and structural aspects are the most areas where firms used to implement BIM model. Also, the results show that MEP aspects are the less fields where firms use the BIM model. Even one of the firms think that the 2D CAD is more efficient for MEP in terms of

consuming time, but actually this was not the main reason for this less of use. The real reasons why BIM implementation is inconsiderable at the MEP aspect are illustrated below.

One of the firms refers this slight usage of BIM at the MEP aspect to the lack of MEP engineers' interaction with the site especially for small and medium projects. The interviewee there reveal that the MEP design is mostly submitted for licensing purpose and therefore 2D drawing is sufficient and it is mostly away from the execution. This led to less motivation and less technical experience for those engineers to implement the BIM techniques in their design process. Another interviewee considers that the reason for the insufficient level of BIM implementation at MEP aspects is the poor coordination between the MEP system designers and the contractors who carries out these systems. However, to solve this problem the level of coordination between the designer and the contractor must be improved to a higher level than the current situation. As the contractor is mostly unknown at the design stage, then the best way to enhance this coordination is to build an initial BIM model by the designer. This initial model of these disciplines will be modified later by the contractor as the amendment is easier and faster. By this way, the contractors are pushed to become a part of the BIM process indirectly, which encourages them to adopt this pattern of thinking.

As aforementioned, one of the main benefits of BIM implementation is clash detection between the different aspects and different systems of the design, therefore now that there is a low level of BIM implantations at the MEP aspects, then the efficiency of using BIM is very low and not in the required extents. In this case the clash detections will be limited to architectural and structural only which is considered less complex than at the MEP aspects due to crowd systems there. However, the use of 2D drawings is mostly does not enough to make the details of the project clear for the electrical and mechanical engineers and this means that every specialized engineer/s will make a design without taking into consideration the other aspects and the clashes will be explored during construction. As a result, the extent of take benefits of BIM implementation is associated with the extent of implementing BIM at different design aspects; the more aspects where the BIM is used, the more benefits of BIM theme.

The second point that have been examined in this study is the extent of take benefits of BIM implementation against the obstacles in the Palestinian AEC industry. A number of benefits has been sought by the BIM users in the AEC firms in Palestine. These benefits were range in terms of its extent from one firm to another. The findings show that time saving was the most beneficial point for using BIM model. That because time saving can be achieved at any stage or any aspect of using any tools of BIM process. In other words, even the designer didn't implement the BIM concept at all the aspects, he/she still can take benefits of using it for a certain aspect. However, other benefits are related in some way with the number of the aspects where BIM is implemented as aforementioned in the clash detection point. The benefit of clash detection was the second heist beneficial point. Even though not all the interviewees use BIM at all main design aspects, but either they still detect the clashes between architectural and structural or they still realize its effect at the MEP aspects by their experience, they still didn't use it for the above-mentioned reasons. Continuous updating and high accuracy are two keywords for motivating engineers to implement BIM concept at their design process. The software such as Revit that support BIM concept can be considered as a parametric software. That means any change in any element of the project in terms of its properties like dimension, price, material, or any other attributes will be reflected automatically in all outputs of the model either drawings or quantities which lead to accurate output in case of the model is accurate. Also, two firms benefit from BIM implementation in documentation issue. BIM implementation creates archiving system that facilitate the documentation and reduce the required time to access the related files. BIM process convert the building mass to a mass of data. This mass of data contains different elements with a full information and description.

On the other hand, deficiencies of BIM implementation in the Palestinian AEC industry are still there and in a crucial situation. One of the most important deficiencies is that the firms who adopt the use of BIM concept in their design process is still very rare. One more point is the sequence line of BIM implementation in the Palestinian firms is still incomplete. The imperfection of the sequence line of BIM implementation become more evident as the lifecycle of the design process getting close to the end. Figure 5 shows the general sequence line of BIM implementation of the Palestinian firms, where the lifecycle of BIM implementation starts `with the highest level at the design stage especially architectural and structural model and finish with almost no use at the operation stage.

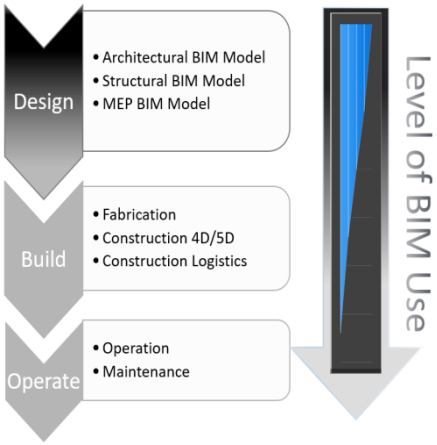

Fig. 5. Sequence of BIM implementation for Palestinian firms.

The third point is the relationship between the effectiveness of BIM implementation and the size of the project. According to this study, it is found that most of the firms link between the size of the project and the necessity of BIM implementation and agreed that BIM implementation is essential for large projects to facilitate project management and coordination between different aspects. Also, some firms believe that BIM implementation is associated with the number and complexity of the systems which are used in the project. As the size of the project increases, the number of parties involved in the project and the number of systems, and its diversity is increased. That make the traditional pattern of problem-solving and interpret data unable to provide optimal solutions. Therefore, the need for BIM model with the above-mentioned benefits is becoming more essential to attain its impact as an engineering solution in architectural, structural and MEP context. However, BIM implementation still add value regardless of the size of the project. That because in the small project the firms mostly tend to use BIM model at the architectural and structural aspects where they can achieve a minimal level of benefits in terms of coordination between the two aspects, updating cost estimation, saving time, and some other gains. All the parties however are agreed that the influence of BIM implementation in the small project is not effective as in the large project. As a result, the study substantiates that there is a direct relation between the effectiveness of BIM implementation and the size of the project.

Conclusion

In summary, BIM is not a software; BIM is a thought, a concept, and a methodology. The main BIM product is a virtual intelligent 3D Model based process loaded with construction and engineering useful information that can be utilized in all different design aspects through the whole project lifecycle. This study concludes that even a number of benefits of BIM implementation have been highlighted, but the concept as well as the benefits of BIM implementation are still uncommon and not in its desired potential in Palestine. It is appeared that there is a misconception of BIM implementation and few firms have the right approach of using BIM with its peak efficiency. Furthermore, according to most of these few companies; BIM implementation level is still beyond the hoped practices.

The main concept of BIM is the integration; the optimum benefits will be obtained if BIM implemented in a complete cycle and in a sequence line. The results show that BIM implementation in Palestine has some shortage in the MEP aspects within the design stage which affects the completion of the BIM lifecycle. Therefore, the extent of the optimal use of BIM is associated with the extent of implementing BIM at the different design aspects; the more aspects where the BIM is used, the more benefits of BIM theme. Moreover, the study affirm that there is a direct

relation between the effectiveness of BIM implementation and the size of the project. The need to use BIM concept grows as the size of the project and the number of the systems within the design process is increased. Therefore, the need for BIM model is becoming more essential to attain its impact of engineering solution for the complex systems and aspects. To improve BIM implementation in Palestine, first of all, the right concept of BIM should be illustrated and make it clear for all engineers and stakeholders. Also, a specific definition for BIM should be identified and in a later stages a code to identify BIM implementation conditions and stages could be issued to facilitate BIM implementation and reduce misunderstandings. Also, it is advisable for the official bodies to make BIM implementation as a recommended or compulsory process to submit designs. For example, if the Engineering Association relies on electronic scrutiny instead of the current traditional scrutiny and all design companies connect to one server in the engineering association then the data will be automatically filled and checked. This will strengthen the BIM concept and leads to finding uniform code for the drawings and reducing the number of engineers required for scrutiny.

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