



Building Information Modeling in Syria: Obstacles and Requirements for Implementation

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Abstract

The crucial need for innovative sophisticated, and complex Architectural, engineering, and construction (AEC) industry projects with in-depth details makes traditional methods inappropriate for the completion of projects with desired efficiency, performance and productivity. Therefore, AEC projects in Syria suffered from myriad issues such as Behind the Schedule, over budget, inferior quality, low productivity, without sustainability and more. However, Building information Modelling (BIM) proves its capability to solve these issues. The aim of this study is to identify the obstacles and the critical influencing factors for applying BIM in Syria in the AEC industry. Extensive investigation for literature review and structured online questionnaire designed to achieve the study's aim. SPSS and Excel were used to analyze the results. This study classified the obstacles related to three category: 1) Planning, Design and Auditing systems, 2) BIM System, 3) Management, Financial and Legal factors. In spite of, the government and clients play the vital role to mandate BIM, the mixed approach (top-down and bottom-up) is recommended to expedite BIM implementation. This study provides a novel contribution by identifying the main obstacles and developing new strategies for applying BIM in AEC and reconstruction which enhance projects quality, performance and efficiency.

Keywords: BIM; AEC industry; Reconstruction; Obstacles; Requirements for applying; Project management; Syria

1. Introduction

Recently, the AEC industry witnesses a leap in its contribution to nations' economies (Banawi, A., 2017). Therefore, the AEC industry projects turn out to be complex and over detailed in coping up with the innovative, creative, and ingenious era. The traditional methods failed to deal with those requirements result in myriad issues, so there is an urgent need for new methods. The developed countries use BIM to solve those issues reaping the benefits of implementing BIM to achieve the project participants' requirements and the clients' satisfaction (Elhendawi, A.I., 2018).

However, the traditional systems deal with each project phase and its teams separately, the main feature of BIM is the integration of the different project phases (project management life cycle) and its teams. Therefore, BIM enhances the collaboration, the coordination, homogeneity and Interoperability (the use

of a single software database system) between the project parties from the same stage and the different stages (conception and initiation, definition and planning, execution, performance and control, and project close) (Omar, H.S., 2015). For example, the integration between the deferent teams (from the initial idea, design through construction, maintenance and operation ended to demolition phase) reduce the design errors, save time and money, enhance the effectiveness of facility management such as providing accurate as-built drawings to facilitate maintenance and operation and so on (Azhar, S., et al., 2015).

In spite of, the traditional system concentrated in three-dimensional (3D) from different disciplines (architectural structural Mechanical and electrical power (MEP) engineers) separately, BIM coordinate those models into one model and adding more 'dimensions' of data to the information models the time (4D), cost (5D), sustainability 6D, and Operation and maintenance/Facility Management (FM) 7D model (McPartland, R., 2017).

The importance of study stems from the necessity of developing methods used in AEC industry project lifecycle in Syria to keep up with what is currently being applied in different countries of the world. To overcome the problems of the current projects and exploit the benefits of new methods. Currently, we are on the threshold of the reconstruction phase “Rebuild Syria”. While the most projects suffering from over budgets, behind the schedule, and low quality (Shaban, M., 2017). BIM is widely expanded worldwide in the AEC industry, however in our Arab region including Syria, it is in its first stage (Omar, H.S., 2015). Therefore, the aim of this study is to identify the constraints and requirements of applying the BIM system in the Syrian AEC industry. In addition to determine the best stage for the application of this technology as a first stage before the full application especially in the reconstruction phase.

2. Literature Review

Overview:

The reality of Syrian Construction Industry

The delay of the projects and the excess cost have become a common feature in this age due to the increasing complexity of the modern construction industry and its multiplicity. In recent years, several studies claimed that the main causes of delays and inefficient projects management in the AEC industry are: 1) Poor or weak design, 2) lack of integration within the design team themselves, and with execution team, 3) The absence of an integrated system to facilitate coordination between project parties as a result of the weakness of the contractual legal framework (Mandhar, M. and Mandhar, M., 2013, Sanderson, S., 2013, Ahmed, S., et al., 2018).

Table (1) summarizes the most frequent reasons for delays and inefficient management in construction projects in several countries, including Syria.

Table 1 : Summary of the causes of delays in projects and poor management efficiency in Syria (Shaban, M., 1998, Shaban, M., 2006, Ahmed, S., et al., 2018)

<i>The researchers</i>	<i>Delays and inefficient management cause</i>
Shaban (1998), (2006)	<i>Many change orders</i> <i>Poor design</i> <i>poor supervision and documentation</i> <i>weakness communication and coordination between the parties to the project</i> <i>Slow decision making by supervision and other project parties</i> <i>Contract system based at the lowest price</i> <i>Failure to apply modern project management methodologies</i> <i>The contract system is incomplete / There is no design contract and another for supervision</i> <i>There is no clear methodology for the supervisory function</i>
Ahmad, Dlask, Shaban, Selim (2018) Mia, Hassan, Omran, Varnes (2008)	<i>Change orders by the owner</i> <i>Planning and scheduling problems</i> <i>Cash flow delay by the owner</i> <i>Cost estimates and inaccurate time</i> <i>Weak site management</i> <i>Poor communication between project team members</i> <i>Weak contract management</i> <i>Poor technical performance</i> <i>Unclear scope of work</i>

From table (1) and through the study of the reality of the Syrian construction industry, we find that they are characterized by the following:

1. Poor design and integration lead to significant changes in the design by all parties during the execution phase.
2. The widespread use of the tender system on the basis of the lower price, in addition to the many change orders, has become a source of concern and failure for many construction projects. The conflicts are increasing and there are a lot of aggressive attitudes towards the parties of the project and increasing the cost in the project contracts. The traditional bidding system is design-bid-build paradigm and the bad application. The system may be better designed, but the best alternative is the Integrated Project Delivery (IPD) in which all parties to the project share the risks of design and execution together, each according to their contribution to it, and share the increased productivity and good results of the project's success. The IPD system can work well if the project using a precise and accurate BIM system (Eastman, C., et al., 2009, Sacks, R., et al., 2010).
3. The productivity of the construction industry has not improved during the past 40 years, compared with other productive sectors, which increased by 200% except for agriculture (Matarneh, R. and Hamed, S., 2017).
4. The complexity of buildings and projects generally increases and takes longer to construct them, while the design duration is relatively short.
5. The parties to the project and its stakeholders are no longer limited to the core parties of the owner, designer / supervisor and contractor, but new parties such as the supplier, the insurer, the financier and subcontractors, the end user, professional associations and other local and government departments - environment and others who also affect the project (Mandhar, M. and Mandhar, M., 2013, Ahmed, S., et al., 2018).
6. The problem of delaying supplies to the project and coordination between the subcontractors for not being in the project management system except in later stages.
7. Waste in project resources due to the rework of defective works or to correct design defects. The key to achieving this is the transition to the BIM system, which aims to have clear design information as a common knowledge resource for all practical participants' construction as a whole, reducing the need to re-search and obtain information or to reformat and formulate this information to a specific party.

Most of the above problems will be eliminated or ended if the BIM system is fully applied, but this transition is very challenging and requires a major change in the work mentality and in the construction industry systems in all its aspects. This study will attempt to explore the challenges of implementing the BIM system in the Syrian construction industry and its applicability in different stages of the project and its prospects for the reconstruction phase.

Building Information Modelling:

Michael, R. et al. (2012) reported that Building Information Modeling (BIM) is a "digital set of adopted software applications to facilitate coordination and project collaboration between all project/construction partners.". Whereas Teicholz, P.M., (2013) claimed that "It is a multidimensional model (3D, 4D[time]and 5D [cost]) in which it is possible, by default, to link or attach an undetermined amount of information relating to the typical project elements / construct as a set of characteristics both visible and invisible.". Furthermore, Barrinton, S. (2010). argued that "BIM is a digital representation of the physical and functional characteristics of a building or project, and is a shared knowledge resource for information about the formation of origin and a reliable decision-making base throughout its entire life cycle from the beginning/idea and later to the end of the planned life of the project. "

The BIM is used to describe an advanced technology for 3D CAD design for modeling and managing buildings and related information. The BIM models of traditional CAD models demonstrate that the software models in the BIM models are clear to the software as image / Or as a reflection of the actual building components, unlike the graphics models in the two-dimensional computer design files " (Sacks, R., et al., 2010).

Moreover, the American Institute of Architects (AIA) defines the BIM as a "model-based technology model linked to the database of project information." In the *Encyclopedia of Engineering, Wikipedia* states that the BIM system includes engineering dimensions, spatial relations, the geographic information, the quantities and properties of the components of the building/project properties" (Breen, G., 2018).

The basic idea of the BIM system is the collaboration, see Figure 1, between project stakeholders throughout the project life cycle to insert, extract, update, or modify information in the BIM processes to support and highlight project roles (NBIMS Project Committee, 2008).



Figure 1. Relations /Collaboration between the parties to the project [43]

The BIM system has been found to be the basis for solving problems and errors resulting from the fragmentation of a project / building system - splitting the process of designing and establishing the project into separate phases - or managing all the information we need in a specific project to be combined with a single repository accessible / Source of information) by all participants, and the ease of integrating all project documents (NBIMS Project Committee, 2008). Figure 1 shows how each project party or stakeholders can access directly the project's shared database, and modify the necessary documentation and incorporate it into the database to make it accessible to all. By looking at above figure we find that the BIM system is characterized by the following (Liu, R., et al., 2010, Shaban, M., 2017).

1. Less paperwork considering that information exchange is fully electronic
2. Provide the latest information for everyone.
3. Provide a complete record/ register of the project
4. A full review of all project information.
5. A single database of project information rather than "isolated islands/silos".
6. Great potential for reuse of information in the operation and maintenance phase.

Thus, the BIM system provides the opportunity to speed up processes that were usually executed sequentially. In addition to that, BIM allow us to perform some activities simultaneously or parallel – e.g. synchronization of design processes with execution and execution with operation. BIM proves its capability to reduce project time and increasing profits (Omar, H.S., 2015, Elhendawi, A.I., 2018).

- The United States is the first country to implement the BIM system, the General Services Administration (GSA) has printed the BIM Manual Series, the National 3D-4D-BIM Program and its applications in more than 35 projects (Eastman, C., et al., 2009), And the US Army Corps of Engineers has developed a plan for the full implementation of this system on all projects in 2012 at the latest. In July 2010, the Pennsylvania State University (PSU) developed the BIM Implementation Plan, which was the result of the so-called building SMART Alliance Project, in which it was suggested that the level of detail/development in the LOD should be described in addition to the standard data structure in order to effectively manage the project (Eastman, C., et al., 2009, The BIM Hub, 2014, Banawi, A., 2017). In Britain, in May 2011, the Prime Minister's Office printed the Government's Construction Strategy, in which he announced that he would coordinate government efforts among various stakeholders to enable them all to cooperate effectively through the BIM system. In Hong Kong since 2006, the BIM system has been implemented in more than 19 public housing projects in the design and implementation stages. The Hong Kong Housing Authority (HA) developed their own in-house BIM standards and user guide for both the architect and the rest of the design team engineers for the proper use of the BIM system during the design phase. Hong Kong established the BIM Institute of BIM and special conferences are held each year (Eastman, C., et al., 2009, Banawi, A., 2017). There are many studies around the world that have been subjected to the application of the BIM system in the construction industry for example (Liu, R., et al., 2010, Kiani, I., et al., 2015).

Obstacles hinder BIM implementation:

Banawi, A.,(2017) summarized the main obstacles to applying BIM as: 1) The market is not ready, 2) the clients do not demand BIM , 3) Training Costs and the learning curve are too high, 4) The difficulty of having everyone on board to make BIM effort worthwhile, 5) Too many legal barriers exist and they are too costly to overcome, 6) Issues of model ownership and management will be too demanding on owner resources, 7) Designers or Architectural Engineering firms do not usually prove empirically the benefits of BIM to customer, 8) Construction Insurance companies do not have BIM projects risk specific policies, 9) Technology risk and barriers technology is ready for single-discipline design but not integrated design, 10) BIM is not having a full support of upper management or decision makers.

However, Matarneh, R. and Hamed, S., (2017) summarized them as:1) Lack of support and incentives from construction policy makers, 2) standards and codes are not available, 3) Lack of awareness about BIM, 4) No client demand. 5) Resistance of change, 6) Lack of a BIM specialist, 7) Necessary training is

not available, 8) Cost (software, hardware upgrade, training, and time), 9) BIM requires radical changes in our workflow, practices and procedures.

Whereas Omer, (2015) categorized the main obstacles in to five groups as follows:

1. Management obstacles
2. Technical obstacles
3. Surrounding environment obstacles
4. Financial obstacles
5. Legal/contractual obstacles

Furthermore, as a result of extensive investigation for the literature review the key obstacles are shown in (table 2).

Table 2: Key obstacles that impede BIM implementation

Ser.	Obstacles for applying BIM
Management obstacles	
1	Inadequate BIM experience (know-how) to change [3,22].
2	Inadequate support from the top managements to adopt BIM [5,6,41,56,57].
3	Resistance to change [17,21,47,57]
4	Difficulties correlated to workflow transition due to changes in roles and responsibilities [21,33]
Technical obstacles	
1	Inefficient Interoperability [14,16,39]
2	Difficulties of managing BIM Model [13,18,24]
3	Lack of skilled resources and complexity of BIM software [17,28,30,31,39]
Surrounding environment	
1	Lack of demand from the governments/clients to use BIM [13,15,17,29,56]
2	Not all stakeholders are using BIM [18,31,39]
Financial obstacles	
1	Costs associated with the implementation of BIM [14,16,17]
Legal/contractual obstacles	
1	Unclear Intellectual Property Rights (IPR) [6,21,28,47]
2	AEC Traditional procurement methodology [24,33,47]

BIM implementation requirement:

Kiani, I. et al. (2015) reported the main requirement of BIM applying are: 1) Introduce BIM in university curriculums, 2) Training the staff, 3) Conceive the clients about the importance of BIM, 4) Provision of legislation of BIM usage, 5) Reducing the price of BIM software.

However, Liu, R. et al. (2010) divided the factors influencing applying BIM into two category: external forces as: 1) Competitive strength, 2) Influences from other cooperating parties, 3) Influences from competitors. In additional to internal readiness as: 1) Top Management Attitude, 2) Financial Cost importance, 3) BIM training.

Whereas, several researchers and professionals argued that, the key push factor to rapid BIM implementation in the AEC industry is that the governments and clients demand strictly using BIM in their projects (Moreno, C., et al., 2013 Chien, K., et al., 2014, Elmualim, A. and Gilder, J., 2014).

Furthermore, Omer (2015) argued that Surrounding environment and competitive pressure push the organization to implement BIM. Figure 2 shows the organizations attitude awards BIM

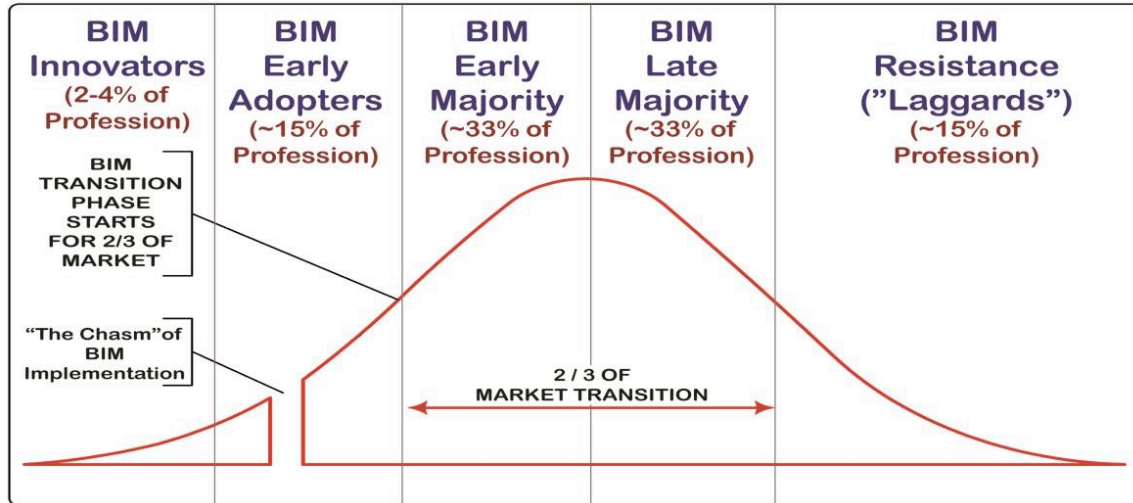


Figure 2. BIM adoption lifecycle (Moore, G., 2003).

Therefore, BIM innovators and BIM early adaptors have more competitive advantages compared to their competitors. Competitive advantages is a considerable pressure and external pushing forces for BIM non-users to adopt BIM or they will be out of the game (Liu, et al., 2010, Chan, C., 2014, Eadie, R. et al., 2014).

Moreover, Projects complexity and profit declination is considered one of the main factors push the BIM adoption. While, the BIM implementation could be the viable solution to save the waste of time and its relevant issues. Furthermore, BIM implementation offers a viable advantage to overcome the reduction of productivity problems (Eadie, R. et al., 2014, Elmualim, A. and Gilder, J., 2014, Azhar, S., et al., 2015).

Therefore, the main factors influencing the BIM adoption can by derived from how to overcoming the stipulated obstacles for applying BIM above as shown in table 3:

Table 3: Overcoming the Obstacles for applying BIM

Ser.	Obstacles for applying BIM	Removing the Obstacles
Management obstacles		
1	Inadequate BIM experience (know-how) to change	- Introduce BIM in university curriculums (Long term) and Training the staff (short term) (Kiani, I., et al., 2015, Omar, H.S., 2015).
2	Inadequate support from the top managements to adopt BIM	- Top management should be convinced to support this change to take the decision of making BIM as obligatory (Linderoth, H., 2010).
3	Resistance to change	- The successful change can be established through two steps: Understanding the need for change and recognizing the benefits than getting ready for the change which involves the people, processes, and technology (Kotter, J. & Schlesinger, L., 1989). - Bottom-up and top-down approaches should be adopted concurrently (Arayici, Y. et al., 2011). - Applying successful strategies for change management to eliminate any potential change resistance (Arayici, Y. et al., 2011, Eastman, C., et al., 2011).
4	Difficulties correlated to workflow transition due to changes in roles and responsibilities	There is a crucial need to change from the traditional to an integrated procurement strategy, which requires a paradigm shift of mindset to accept the changes and reshaping roles and responsibilities, sharing the risks and rewards among the construction players (Sebastian, R., 2011, Haddad, G., 2014, Love, P. et al., 2014).

Technical obstacles		
1	Inefficient Interoperability	IFC schemes can overcome the conflicts that may appear of using different software of BIM models (Liu, R., et al., 2010, Eastman, C., et al., 2011, Ku, K. and Taiebat, M., 2011).
2	Difficulties of managing BIM Model	Assigning a model manager or as called BIM manager is essential to eliminate the BIM model-related risks who is authorized to edit data for the master federated BIM model (Thompson, D. and Miner, R., 2007).
3	Lack of skilled resources and complexity of BIM software	For the sake of providing the market with BIM skilled resources, governments support AEC university students' curriculum with integrated guidelines for BIM training programs in addition to the help of BIM software vendors to enable the trainees to keep up with the latest BIM skills in the shortest time (Azhar, . S., 2011, Chan, C., 2014, Gu, N. and London, K., 2010).
Surrounding environment		
1	Lack of demand from the governments/clients to use BIM	Conceive governments and clients about the importance of BIM (Elhendawi, A.I., 2018, Kiani, I., et al., 2015, Omar, H.S., 2015).
2	Not all stakeholders are using BIM	Governments and clients mandate BIM and Conceive BIM non-user about BIM benefits (Elhendawi, A.I., 2018).
Financial obstacles		
1	Costs associated with the implementation of BIM	Governments should providing training programs to educate organizations' staff on how to implement and use BIM and offer awareness sessions through professional institutes and academia to promote the organizations' awareness of the significance and benefits of BIM, to encourage them for investing in BIM." (Chan, C., 2014). Government should collaborate with software vendors to make training programs (Hore, A., 2006).
Legal/contractual obstacles		
1	Unclear Intellectual Property Rights (IPR)	Several professional executives and researchers reported that the IPR detailed with responsibilities and rights of all parties and level of data transfer (LOD) should be submitted in a contract document by the government in standard document or by the client (Gu, N. and London, K., 2010).
2	AEC Traditional procurement methodology	IPD was proposed to be the appropriate construction procurement strategy suitable for BIM, where IPD is defined as a "project delivery approach that integrates people, system, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value of owner, reduce waste, and maximize efficiency through phases of design, fabrication and construction" (AGC, 2010).

There are few studies that have dealt with the obstacles to applying the BIM system in Syria. Some studies focused on the benefits of application, especially in the design stage. This is due to the absence of actual and complete application of the BIM system in the Syrian construction industry. The application of this system systematically, and in the absence of controls or manual as used in the countries that began to apply it, in the study (Haddad, G, 2014) found the usefulness of applying the BIM in the design phase in terms of cost and time to obtain design documents compared to With the traditional CAD system In this study, the researcher investigated the effect of change orders in the design documents and the levels or results of this change on the whole project using the BIM system. Developed a software method within the Rivet program to track the impact of change orders in the project. The study (Ahmed et al, 2018) dealt with the possibility of applying BIM within the Syrian construction projects and concluded a series of economic, technical, organizational and human challenges facing the application of BIM in construction projects Syria. There are some studies that dealt with other aspects of the application of BIM in the Syrian construction industry. However, these studies did not address the obstacles to applying BIM in the Syrian construction industry and the changes that must be made in advance. The opportunity is great now, especially as we are on the threshold of the beginning of the reconstruction phase to bring about a significant change in the Syrian construction industry through the application of modern technologies, including the BIM system, which is discussed in this research.

3. Research Methodology

Data collection

The first stage is an extensive investigation for literature review was conducted to make a clear understanding of the key barriers and main influence factors to BIM implementation. Whereas, **the second stage** is a questionnaire was designed to collect information from the construction industry (in Syria) in the public and private sectors as well as academics in Damascus and Homs in 2017 between February and August. The survey was prepared by pilot study through preliminary interviews where ten initial active/structural interviews were conducted with professionals involved in reconstruction projects in various stages from planners, designers, contractors, and supervisors to identify the main obstacles to the implementation of the application and the prospects for its implementation in the reconstruction phase. The questionnaire consists of three main parts:

1. Introduction to research and its purpose.
2. General information about respondents, such as position job title, experience, type of entity, public sector or private organization, experience in the BIM system.
3. A table containing the main obstacles / main factors of the challenges of application of BIM in the Syrian construction industry obtained from the previous studies and from the active interviews and those identified by the researcher based on his experience, and it enumerate (25) factors, which are distributed to three groups (Table 4) :
 - (A) Set of factors/obstacles related to planning, design, and auditing (1 to 9);
 - (B) Set of factors related to the BIM system itself (10 to 17);
 - (C) Administrative, financial and legal factors (18 to 25);

Respondents were asked to determine the degree of importance for each worker/obstacle using Likert scale (Very High, High, Medium, Low, and very Low) based on own experience in the field of design, implementation and project management in general and in the field of special use and applicability in local Syrian conditions, particularly in reconstruction projects etc., In addition, respondents were asked to add any factor not included in the table with its importance. A total of 90 questionnaires were distributed to various stakeholders in the construction projects in Syria by e-mail and direct hand delivery. Seventy-six forms were received or retrieved, and four forms were rejected for lack of validity, accordingly, the data were analyzed from 72 completed forms in this study, however the sampling size are 100.

Data Presentation and Analysis

Respondents' Profile:

The data were dumped, sorted and then analyzed using statistical methods using Excel and SPSS software. Table (4) provides information on the management or organization in which the respondent operates in terms of type, size, and scope of work. Slightly more than half of the sample works in the government sector and is the primary concern of the construction industry, its overall development and the management of reconstruction program projects. The information also shows that 37.3% of the business organizations or departments in which the respondents work are engaged in the field of design and supervision, and 50.4% work in the field of implementation and project management in general.

There is 5.6% for regional planning and real estate development and 6.7% for training and education. Therefore, we will need to qualify technical and administrative workforce /staff for the application of BIM. This means that the sample is balanced in terms of structure to include all categories and entities that are directly related to the construction industry and the application of the BIM system.

Table 4: General information about the respondent organization

Type of organization	Ratio%
Public sector	52.6
Private sector	47.4
Organization size/number of employees	Ratio%
0-10	41.7
10-50	27.8
50-100	13.9
100- 200	9.7
more than 200	6.9
Type of organization	Ratio%
Buildings execution	20.8
Infrastructure execution	15.7
Supervision and designs	37.3
Project management	13.9
Regional planning and real estate development	5.6
Education / Training	6.7

Table 5: General information about the respondent's work

Responder's specialization	Ratio %
Execution Engineer	23.6
Design / supervision consultant	36.6
Project Management (Heads of sections + Project Managers)	20.0
Academic Education / Research / Training	12.5
Professional departments (Engineers Syndicate)	7.3
Years of experience (in construction)	Ratio %
0-5	18.1
6-10	27.8
11-20	23.6
more than 20	30.6
Experience in the application of BIM(years)	Ratio %
no experience	40.2
1-2	27.8
3-5	18.1
5-7	8.3
more than 7	5.6

Table (5) shows information about the respondent's work, in which 80.2% works directly in the construction industry, 19.8% is related to this industry in one form or another. Universities and research centers play an important role in the implementation of BIM research, especially for the role of the various training institutions in qualifying the necessary human labor, especially in light of the migration of a lot of technical staff and skilled HR and well-qualified workers during the past years due to lack of security and lack of job opportunities.

Since the experience in the field of BIM is poor among the workers in the construction industry - as the sample shows, despite its weak or individual application in some projects by some consulting offices, it is not implemented as a large-scale system that needs to qualify labor and physical resources to move from the traditional system-CAD to the modern BIM system, when asked about the experience available in this field, we find that 40.2% of the respondents have little experience in this field, and the rest have different experiences and modest application of BIM, especially in the design stage.

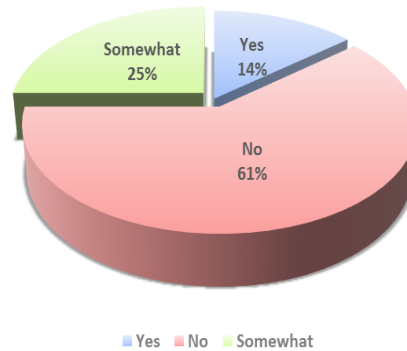


Figure 3. the degree of knowledge of the respondents with the BIM system

The most of respondents (55.1%), are unaware of the importance of the BIM system and do not have the knowledge and skill to apply it at the present time due to their direct participation in projects using this system. Hence, the importance of this research to inform the decision-makers in the Syrian construction industry and the reconstruction program of the current situation of the BIM system and its importance and challenges to its application and prospects for possible implementation in construction projects in the reconstruction phase.

The answer to the question: Do you have knowledge and skill using the BIM system? The results were distributed as follows: 61% of the respondents does not have the knowledge and skill, and this actually corresponds to the obstacles or results obtained above, especially in terms of non-spread of the culture of BIM between the project parties and those concerned and the lack of adequate training for engineers and the migration of qualified personnel, 39 % Of the sample have the knowledge and skill of applying the BIM individually in the design phase only, see Figure 3.

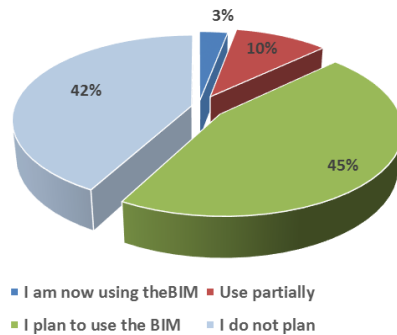


Figure 4. Prospects for the use of BIM now and in the future in the Syrian AEC industry

As shown in figure 4, 45 % of the respondents planned to use BIM and only 13 % already use BIM, however, 42 % do not plan to use BIM. This is another confirmation to the need for convincing all the AEC industry projects participants about the BIM benefits.

4. Results and discussions

The most of respondents (61%) argued that BIM can be applied at the design stage, as shown in Figure 5. This is confirmed by (Haddad, 2014), While 21% claimed that BIM can be applied at the design and implementation stages. This result does not with the line of what Elhendawi, 2018 and Omer, 2015 reported which they claimed that BIM can be applied in any project stage through its lifecycle. The respondents (72%) believe that BIM suitable for the reconstruction phase, as the opportunity is ready to modify the environment of the laws governing the construction sector, see Figure 6.

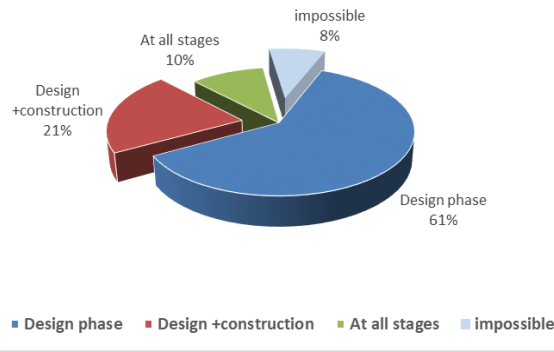


Figure 5: Preferred BIM application now

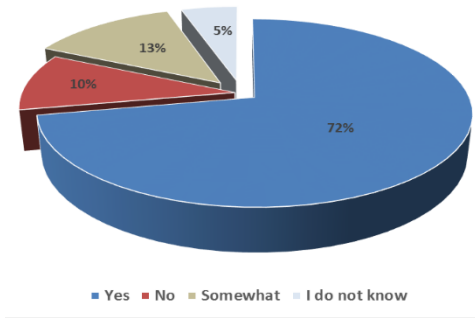


Figure 6. Appropriate application of BIM in the reconstruction phase

Reducing design document inconsistencies, ie, reducing design errors leading to change orders, which in turn lead to disputes among project parties and thus increase its cost and duration. The responses were distributed as follows: 25% and 53% felt that the BIM system could significantly reduce design defects and defects, Figure 7.

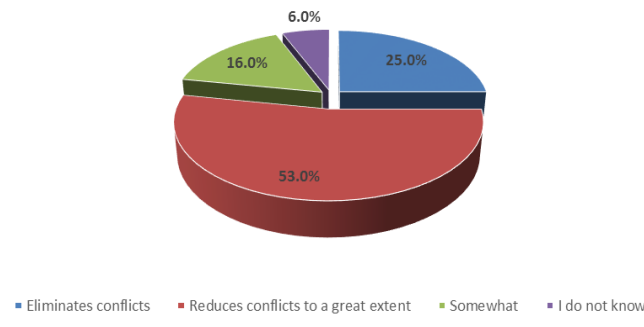


Figure 7. BIM's contribution to reducing design document inconsistencies

Obstacles of applying the BIM system in the Syrian construction industry:

Table (6) shows the factors of the obstacles and challenges of applying the BIM system in the Syrian construction industry with their importance.

The first line of columns (7,6,5,4,3) of this table shows the descriptive scale used in the questionnaire as explained above. This scale has been converted to a quantitative scale - to the degree of importance of each of the factors listed in the scale - according to the Likert scale where the number 1 means that the factor is negligent and falls to 5 and means that the factor is very important. The figures in columns (7,6,5,4,3) in Table (6) are the percentage of respondents' responses to the importance of each factor. In the eighth column, the Mean Rank value was determined to the degree of importance of the factor according to the Likert scale. In column 9, we listed the order of factors by the degree of importance. The degree of importance has been classified into areas as follows:

The degree of importance (the intensity of the effect) is distributed over an area of $5-1 = 4$, and we have the degree of importance divided into five levels. Thus, the importance of each field is $(4/5) 0.8$, (for example low importance is from 1.00 to 1.80). From the ninth column we find that there are six very important factors / Critical factors, 12 are high important factors and 7 are moderately important factors. We did not find a weak or negligent factor and this is consistent with the effort to determine these factors from previous studies and direct interviews was conducted with some professionals in construction projects.

Table 6: the main obstacles hinder using the BIM system in the Syrian construction industry

No.	Factor description	Negligent	Poorly important	Moderate importance	High importance	Very important	Average	Ranking
		1	2	3	4	5		
A) A set of factors related to Planning, Design and Auditing systems								
1	Lack of clear design team	0.0	12.5	23.6	25.0	38.9	3.90	13
2	Do not specify the qualifications of the design project manager	6.9	25.0	15.3	27.8	25.0	3.39	19
3	Individualism in the design process	4.2	8.3	11.1	41.7	34.7	3.94	11
4	Formal audit / transition to audit during design implementation	6.9	23.6	26.4	22.2	20.8	3.26	24
5	The design code and its Appendix must be modified in accordance with the BIM system	1.4	8.3	6.9	25.0	58.3	4.31	2
6	(traditional and according to the BIM system)The absence of a contract for studies and design	2.8	15.3	18.1	19.4	44.4	3.88	14
7	The absence of a unified project costing and control system at the design and execution stages	6.9	18.1	26.4	27.8	20.8	3.37	21
8	No clear and unified system to determine the owner's requirements of the in the project	8.3	18.1	16.7	41.7	16.7	3.45	18
9	Not to apply modern techniques in project management in the design and executive stage	11.1	16.7	23.6	20.8	27.8	3.38	20
B) The set of factors related to the BIM System								
10	The weakness of the BIM culture among workers in the construction industry	1.4	5.6	8.3	22.2	62.5	4.39	1
11	Cost of software (legal licensed) and hard equipment required	12.5	11.1	13.9	18.1	44.4	3.71	16
12	Cost of training on the new system	4.2	6.9	9.7	16.7	62.5	4.26	3
13	Difficulty of change: Transport from the traditional CAD system to the BIM system	2.8	4.2	19.4	29.2	44.4	4.08	7
14	Compatibility problem between different software platforms used	0.0	8.3	22.2	36.1	33.3	3.94	10
15	The issue of creativity / intellectual property of schemes and creative ideas /	0.0	2.8	18.1	30.6	48.6	4.25	4
16	Absence of occupational engineering insurance system	11.1	13.9	30.6	20.8	23.6	3.32	23
17	Difficulty applying the BIM system in the executive stage / Lack of qualified contractors	2.8	4.2	12.5	27.8	52.8	4.24	5
C) A set of Management, Financial and Legal factors								
18	Difficulty involving the contractor in the early stages of the project	1.4	4.2	27.8	25.0	41.7	4.01	8
19	Contractor's access to and modification of project documents during implementation	2.8	5.6	25.0	23.6	43.1	3.99	9
20	The need to modify the contracting systems in the project environment in accordance with the BIM	0.0	4.2	15.3	33.3	47.2	4.24	6
21	The need for a new, dynamic and diverse contractual environment	2.8	20.8	6.9	19.4	50.0	3.93	12
22	Procurement system or supplying/ project processing and subcontracting	16.7	20.8	19.4	26.4	16.7	3.06	25
23	Lack of transparency in the procedures accompanying the project contracts	0.0	13.9	27.8	37.5	20.8	3.65	17
24	Do not apply clear methodologies for project management and tracking	2.8	13.9	16.7	30.6	36.1	3.83	15
25	Difficulty of communication between project parties	8.3	16.7	30.6	22.2	22.2	3.33	22

Poor important Moderate High importance Very important

Critical factors/ very important factors

Returning to the ninth column, we find that the factors that are of great importance and which should be taken into consideration are mainly related to the application of the BIM system and the changes that are necessary to be made in the Syrian construction industry laws and regulations directly in the different phases of the project. Design, contract, implement and follow up the addition of factors related to training and the issue of intellectual property taking into account global developments in the field of construction contracts. The distribution of these "very important" factors is clearly shown in Figure 8, which shows the importance of these groups covering various aspects of the Syrian construction industry. "The need to modify the design code and its accessories in accordance with the BIM system" of Group A, concerning the systems of advance planning, design and auditing, emphasizes the need to modify the design code in accordance with the BIM techniques and application guide to promote the use of this technology. The consulting firms that apply this technology will not be able to compete with the offices that apply the traditional methods of design-CAD system due to the high cost of the BIM technology at this stage due to the weakness of local expertise in this field and the cost of using licensed software, knowing that this technology will provide financial savings from the total cost of the project, since it allows for good coordination and coherence between the design, implementation, and improvement of the via-bility of a private building and that the time available for business planning and design a few somewhat.

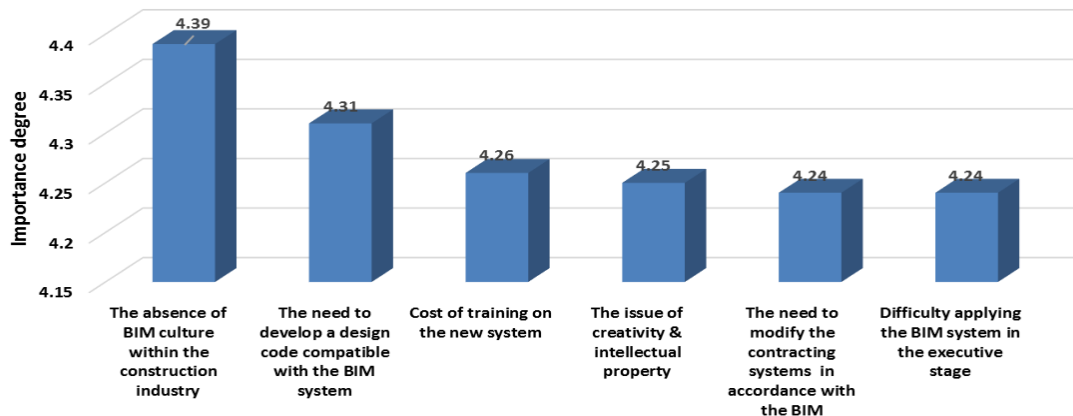


Figure 8. the very important obstacles to the application of BIM in the Syrian AEC industry

Among the group of factors related to the B-system, Group B, we have four factors, namely: "the poor of the culture and importance of the application of BIM among the workers in the construction industry." This fact is that the spread of this culture is limited to university students and new graduates, the actual application or experience in the construction industry on a limited scale. This factor obtained the largest value of the frequency ratio/rate with an average value of 4.39. The "cost of training on the new system" came in third place and this reflects the urgent need to train cadres/crews on this new technology before starting to apply it on a large scale, especially in light of the migration of expert engineering cadres during the long Syrian's crisis years. Furthermore, although there is limited training on this technology by the Engineers Syndicate and others. The fourth issue is "Intellectual property of creative designs and ideas": The issue of intellectual property or "engineering compatibility/context" is not yet in the engineering field in Syria. Engineering work, especially design, is creative. It is, therefore, necessary to develop intellectual property protection systems to include the design works of the projects as well, especially at the present time, as it is possible to easily steal and reproduce as the design today is electronic mostly, and in the fully implemented BIM system, the problem seems larger and clearer. In this case, some parts of the finished or semi-final design are electronically traded between the project parties, except for the access of the other stakeholders (from the owner, contractor, etc.) to the project database, In the past or the traditional drawing paper system, the engineer kept a transparent copy of the drawing documents "transparent drawing paper" and the owner or other cannot obtain additional copies without returning to the design engineer, which preserves his professional or intellectual rights. Currently, because of technical development, it is easy reproduction and photocopying of engineering drawings though Another decent project. Therefore, this matter is very important and requires special legislation by the supervising bodies concerned with practicing the engineering profession such as the Engineers Syndicate.

The next factor, "The difficulty of implementing the BIM system in the execution phase / lack of qualified contractors", which ranked fifth in terms of impact, reflects the inability to apply BIM now in the execution phase due to the lack of qualified contractors to deal with the BIM system, on the one hand, The implementation of current Syrian contract does not allow the contractor to interfere and change the design or access to the project database during design or contracting. Therefore, this factor is related to workers 20 and 21 on the need to modify the contracting systems so that they are diverse and dynamic to meet the requirements of reconstruction projects. Group C: Administrative, Financial and Legal Factors: Working Group No. 20: "The need to amend the contracting systems in the project environment in line with the BIM / Syrian contracting law" is a major obstacle to the wide application of the BIM system. There seems to be an urgent need to modify the contracting laws to keep pace with the BIM system and its environment based on its global experience and application guide in accordance with the local conditions of the Syrian construction industry.

High-level factors

Within this classification, most of the obstacles to the application of the BIM system in the Syrian construction industry are (12) factors. We will discuss the most important factors, as they fall within the three groups. See Figure (9). Design and Audit We have four factors out of nine (55.55%) with numbers (1,3,6,8). This is normal because the BIM system focuses on the effort at this important stage of the project. The design phase in the CAD traditional system is very flawed as a result of the nature of this method, where the individual character of the design and lack of cooperation and coordination between the specialist (8) "The absence of a clear and uniform system for determining the owner's requirements in the project according to the BIM system (the extent of the owner's participation in the design phase)" is particularly important if the owner does not have special engineering

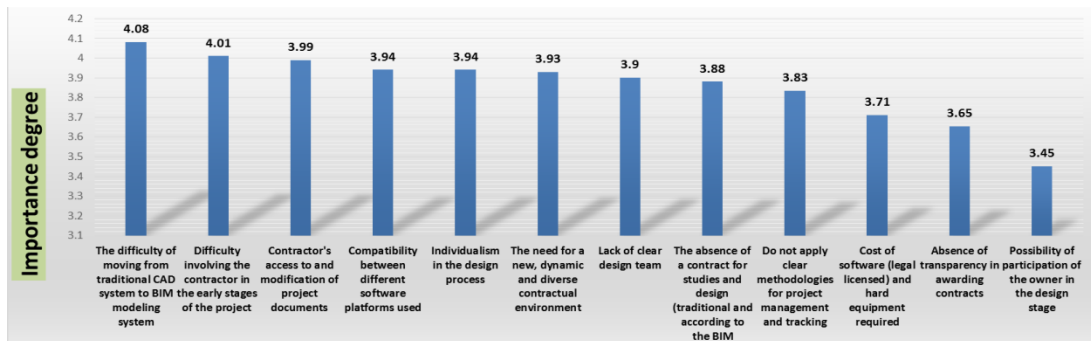


Figure 9. Obstacles to apply BIM in the Syrian Construction Industry (high importance)

expertise in large and complex projects, The designed product is limited and defective - does not meet all the requirements of the owner or non-economic, and is free of defects and errors, which will lead to generate many change orders by all parties of the project, especially by the owner, during the execution phase and thus delay and increase in cost and the rise of disputes between the parties ... One of the most important factors here is the number (3) individual spirit/ behavior in the design process, (6) The absence of a special contract for studies and design (traditional and according to the BIM system) reflects the weakness of the system of engineering contracts in Syria. (1) The absence of a clear design team, also related to the former workers, noting the absence of a specific design team in the traditional system while the BIM system bases on collective teams (interactive collaboration). There is no doubt that this group of factors is important because it is related to the design and design that determines the cost of the project. The designer has the greatest impact on the design cost which is: (49-55) % of the project cost (Omar, H.S., 2015).

In the second group, the factors related to the BIM system have three factors out of (8) ie (37.5%), which indicates the importance of the factors of this group that accompany the application of the BIM system. Factor 13 introduces the difficulty of change: (4.08) this factor reflects the reality of the difficulty of changing and moving from the relatively low-cost work traditional system to the new; that requires training, experience, and fear of the unknown this is apart from the high-cost possibilities. Factor 14, "Compatibility between the various software platforms used" and factor 11, "The cost of software (licensed and required) and the necessary hard equipment" are interrelated because this is considered a significant obstacle due to the difference between the software used in this field and the lack of possibility the use of legally licensed software which is considered to be high cost compared to the income of the Syrian engineer or consulting office, especially at this stage.

Within the third group (c): the administrative, financial and legal factors we have five important factors out of eight ($5/8 = 62.5\%$). The most important of these are factors (18,19,21,23,24) . The involvement of the contractor in the early stages of the project - in accordance with the current , contracting system ", " the contractor's access to and modification of project documentation during implementation "and" the need for a new dynamic and diversified contractual environment ". This is considered one of the main

obstacles to the development of the Syrian construction industry. The amendment of the laws governing this sector is very difficult and takes place at very different intervals ... so that the development in the global construction industry, in particular, the design and contracting methods implementation, there is a great need for dynamic contracting systems that take into account the project conditions, size, complexity, and importance. "Lack of transparency in work / administrative and financial corruption associated with project contracts" and "failure to apply clear methodologies for project management and follow-up" are also linked to each other and contracting systems and the adoption of clear methodologies for project management, meanwhile the modern project management methodologies, including the BIM system, are integrated design, implementation and investment systems that reduce waste and financial and administrative corruption

Factors of medium importance

Within this level of classification, there are a number of factors that must be addressed as well. In Group A, the majority of these factors are (2,4,7,9), which relate to the need to determine the qualifications of the design project manager and the current design audit mechanism. The design system is clearly more effective in the BIM system as a result of teamwork and full coordination between the different design team. Errors are also discovered immediately before implementation. The effect of possible changes on the design is also known. Another important factor is the absence of a uniform system of cost among designers, especially since the BIM system uses a specific cost system to be implemented effectively. Within Group B and Group C we have three factors that hinder and delay the application of BIM in the Syrian construction industry, but should be noted that these factors are not limited to the BIM system, it prevent the obtaining of high performance indicators for the construction industry within the traditional system, but in the BIM system their effect will be greater, Figure (10).

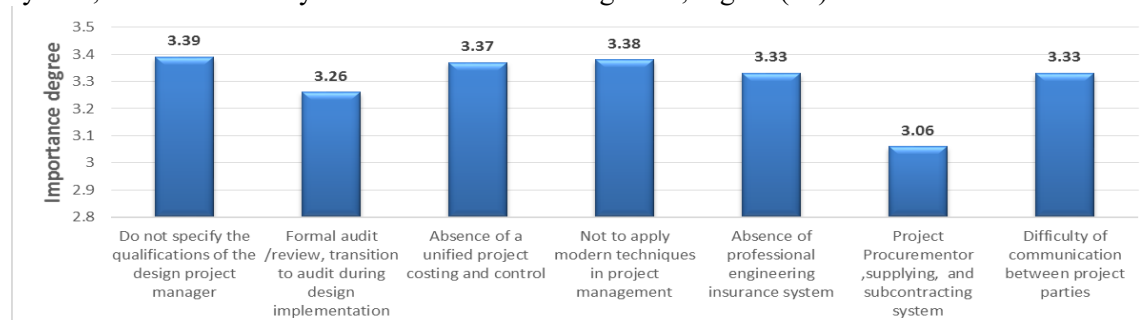


Figure 10. factors impeding the Application of BIM in the Syrian AEC Industry (Medium importance)

Therefore, the obstacles of applying the BIM system in AEC industry in Syrian can be summarized and ranked as shown in figure 11.



Figure 11. Ranking of the Obstacles of applying the BIM system

Requirements for the implementation of the BIM system in Syria:

As a result of this research, and through the results of the questionnaire, and by studying the reality of the construction industry in Syria and compared with the applications of the BIM system in developed countries, we find that the successful application of the BIM system in Syria requires a fundamental change in the systems of the Syrian AEC industry. It is necessary to reconsider the entire system of the construction industry in all its aspects, specifically, the changes should be in the following aspects (Mia, R., et al. 2008, Breen, G., 2018):

A. Legal and legislative requirements:

1. Developing a contract for the design phase or engineering consultancy (design + supervision).
2. Modifying the Intellectual Property System for design ownership.
3. Improve the Syrian contract law so that the contractor can be involved in the design stage.
4. Enact laws that are binding or applicable at all stages of the project.

B. Set of administrative and cultural factors:

1. The need to spread the culture and benefits of BIM among those involved in projects or

the AEC industry.

2. Encourage interactive collaboration within the project design team.
3. The need for large-scale training of cadres for this technique
4. Introduce this system in the curriculum of engineering colleges.
5. The need for a time frame plan for future application.
6. The importance of project participants recognizing the actual benefits of applying the BIM.

C. Technical and financial factors

1. Modification the Syrian concrete design with the BIM requirements.
2. Provide BIM software compatible with software developed locally in the field of design.
3. The need to invest in the engineering software industry and its applications in accordance with the BIM system.
4. Promote the widespread use of this technology to reduce the cost of acquiring its own software.

5. Conclusion

However, the traditional systems in the AEC industry deal with various phases of the project totally separation and absence of integration manner, BIM totally integrates the phases from the initial design to the maintenance and operation.

BIM and IPD are a significant qualitative development in the management of the AEC industry. The companies or departments that will adopt these systems in its engineering work are only eligible to compete later in the global market. Experts emphasize that the BIM system will be the main way to design, construct and manage projects, which is the way to reduce waste of resources. Therefore, this study aimed to find the obstacles and how it can be overcome to rapidly BIM implementation in Syria. An extensive investigation for previous studies and a structured questionnaire conducted to achieve this aim. This research finds that, BIM adaption need a cultural change in the construction industry as a whole to make sure that this will contribute to the growth and development of the AEC industry.

This study finds the top factors that impeding the BIM applying are: 1) The absence of BIM culture among AEC industry projects participants, 2) The need to develop a design code compatible with the BIM system, 3) Cost of training on the new system, 4) The issue of creativity and intellectual property, 5) Difficulty applying the BIM system in the executive stage due to the lack of qualified contractors, 6) The need to modify the contracting systems in accordance with the BIM, 7) The resistance of change: transfer from the traditional system to the BIM, 8) Difficulty involving the contractor in the early stages of the project, 9) Contractor's access to and modification of project documents during implementation, 10) Compatibility problem between different software platforms used, 11) Individualism in the design process, 12) The need for a new, dynamic and diverse contractual environment, 13) Lack of clear design team, 14) The absence of a contract for studies and design (traditional and according to the BIM system), 15) Do not apply clear methodologies for project management and tracking. The questionnaire respondents claim that there is a great opportunity to implement the BIM system in the reconstruction phase, especially in the design stage as a first step. The study recommends that the most important structural changes that should be made in the structure of the legislation governing the Syrian construction industry before starting to apply to maximize the benefit and achieve the highest return. In the current circumstances of the construction industry in Syria, it is very difficult to implement the entire system, but it can be implemented in stages, such as the design stage, especially in the reconstruction phase, which requires great engineering effort and cooperation among all stakeholders, including civil society as an end user of the project. It is necessary that the Association of Engineers, Contractors, and ministries involved in the construction industry organize specialized workshops and training courses on

this system and its implementation mechanism, in order to develop a framework plan for its implementation within a specified period of time.

In the future, we recommend that other issues related to the application of the BIM system in Syria should be considered, for example, the impact of the BIM system on reducing and settlement project disputes.

References

- [1]. AGC, 2010. AGC's Building Information Modeling Education Program (Unit 4, BIM Process, Adoption, and Integration-Participant's Manual). First ed. Arlington, s.n.
- [2]. Ahmed, S., Dlask, P., Shaban, S. and Selim, O., 2018. Possibility of applying BM in Syrian building projects, *engineering for rural development Jelgava*, 23.-25.05.2018.
- [3]. Arayici, Y. et al., 2011. BIM adoption and implementation for architectural practices. *Structural survey*, 1(29), pp. 7-25.
- [4]. Arayici, Y., Egbu, C. and Coates P. 2012. Building Information Modelling (BIM) Implementation and Remote Construction Projects: Issues, Challenges, and Critiques. *Journal of Information Technology in Construction*. Vol. 17 pp. 80-90. ISSN 1874-4753.
- [5]. Azhar, . S., 2011. Building Information Modeling (BIM): Trends, Benefits,Risks, And Challenges For The AEC Industry. *Leadership and management in engineering*, 3(11), pp. 241-252.
- [6]. Azhar, S., Khalfan, M. & Maqsood, . T., 2015. Building information modelling (BIM): now and beyond. *Construction Economics and Building*, 4(12), pp. 15-28.
- [7]. Banawi, A., 2017, July. Barriers to Implement Building Information Modeling (BIM) in Public Projects in Saudi Arabia. In *International Conference on Applied Human Factors and Ergonomics* (pp. 119-125). Springer, Cham.
- [8]. Barrinton, S. (2010). Guide to BIM. [ebook] Barrington Architecture & Design Ltd. Available at: <https://issuu.com/barringtonarch/docs/barringtonguidetobim> [Accessed 10 Aug. 2018].
- [9]. Berger, G. (2007). *Change Orders -- The Bane of All Construction Projects*. [online] For Construction Pros. Available at:<https://www.forconstructionpros.com/business/article/10300253/change-orders-bane-of-construction-projects> [Accessed 1 Jul. 2018].
- [10]. Blackwell, B., 2012. Building information modelling: Industrial strategy: government and industry in partnership. *UK Government, the Department for Business, Inniovation and Skills. London*.
- [11]. Breen, G. (2018). *CPD: Building Information Modelling | CPD | Construction Manager Magazine*. [online] [Constructionmanagermagazine.com](http://www.constructionmanagermagazine.com). Available at: <http://www.constructionmanagermagazine.com/cpd-zone/bim-creating-platform-build/> [Accessed 1 Jul. 2018].”
- [12]. Breen, G., 2012. CPD: Building Information Modelling. *The Construction Manager Magazine*, March 2012. Atom: London.
- [13]. Brewer, G., Gajendran, T. & Le Goff, R., 2012. Building information modelling (BIM): Australian perspectives and adoption trends, Australia: Centre for Interdisciplinary Built Environment Research (CIBER).
- [14]. Bryde, D., Broquetas, M. & Volm, J., 2013. The project benefits of building information modelling (BIM). *International journal of project management*, 7(31), pp. 971-980.
- [15]. Chan, C., 2014. Barriers of implementing BIM in construction industry from the designers' perspective: a Hong Kong experience. *Journal of System and Management Sciences*, 2(4), pp. 24-40.
- [16]. Chien, K., Wu, Z. & Haung, S., 2014. Identifying and assessing critical risk factors for BIM projects: Empirical study. *Automation in construction*, Volume 45, pp. 1-15.
- [17]. Eadie, R. et al., 2014. Building information modelling adoption: an analysis of the barriers to implementation. *Journal of Engineering and Architecture*, 2(1), pp. 77-101.
- [18]. Eastman, C., Teicholz, P., Sacks, R. & Liston, K., 2011. *BIM Handbook, a Guide to Building Information Modelling*. 2nd ed. Hoboken: John Wiley & Sons, Inc.

- [19]. Eastman, C., Teicholz, P., Sacks, R. and Liston, K., 2009. *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors*. John Wiley & Sons.
- [20]. Elhendawi, A.I. (2018) "Methodology for BIM Implementation in KSA in AEC Industry." School of Engineering and the Built Environment, Edinburgh Napier University, UK.
- [21]. Elmualim, A. & Gilder, J., 2014. BIM: innovation in design management, influence and challenges of implementation. *Architectural Engineering and design management*, 10((3-4)), pp. 183-199.
- [22]. Gu, N. & London, K., 2010. Understanding and facilitating BIM adoption in the AEC industry. *Automation in construction*, 8(19), pp. 988-999.
- [23]. Haddad, G, (2014), Comparison of the Use of Building Information Modelling System, Master Thesis, Tishreen University, Syria.
- [24]. Hardin, B. & McCool, D., 2015. BIM and construction management: proven tools, methods, and workflows. S.I. John Wiley & Sons.
- [25]. Hore, A., 2006. Use of IT in managing information and data on construction projects Use of IT in managing information and data on construction projects—a perspective for the Irish construction industry. Ireland, Information Technology in Construction Project Management Engineers Ireland Project Management Society Talk
- [26]. Kiani, I., Sadeghifam, A.N., Ghomi, S.K. and Marsono, A.K.B., 2015. Barriers to implementation of Building Information Modeling in scheduling and planning phase in Iran. *Australian Journal of Basic and Applied Sciences*, 9(5), pp.91-97.
- [27]. Kotter, J. & Schlesinger, L., 1989. Choosing strategies for change. In *Readings in Strategic Management* (pp. 294-306). UK: Macmillan Education.
- [28]. Ku, K. & Taiebat, M., 2011. Ku, K. & Taiebat, M. (2011). BIM Experiences and Expectations: The Constructor's Perspective. *International Journal of Construction Education and Research*, 7(3), pp. 175-197.
- [29]. Kunz, J. & Gilligan, B., 2007. Values from VDC/BIM Use. [Online] [Accessed 13 September 2017].
- [30]. Linderoth, H., 2010. Understanding adoption and use of BIM as the creation of actor networks. *Automation in construction*, 19(1), pp. 66-72.
- [31]. Liu, R., Issa, R. & Olbina, S., 2010. Factors influencing the adoption of building information modeling in the AEC Industry, In *Proceedings of the International Conference on Computing in Civil and Building Engineering*. Nottingham, Nottingham University Press, pp. (139-145).
- [32]. Liu, R., Issa, R. and Olbina, S., 2010, June. Factors influencing the adoption of building information modeling in the AEC Industry. In *Proceedings of the International Conference on Computing in Civil and Building Engineering* (pp. 139-145).
- [33]. Love, P. et al., 2014. A benefits realization management building information modeling framework for asset owners. *Automation in construction*, Volume 37, pp. 1-10.
- [34]. Mandhar, M. and Mandhar, M., 2013. BIMing the Architectural Curricula: Integrating Building Information Modelling (BIM) in Architectural Education. *International Journal of Architecture*, 1(1), pp.1-20.
- [35]. Matarneh, R. and Hamed, S., 2017. Barriers to the Adoption of Building Information Modeling in the Jordanian Building Industry. *Open Journal of Civil Engineering*, 7(03), p.325.
- [36]. McPartland, R., 2017. BIM dimensions - 3D, 4D, 5D, 6D BIM explained. [Online] Available at: <https://www.thenbs.com/knowledge/bim-dimensions-3d-4d-5d-6d-bim-explained> [Accessed 10 August 2018].
- [37]. Mia, R., Hassan, B., Omran, J. and Varnes, F. (2008) Methodology of Project Management Evaluation and Performance Modeling to Improve the Quality of Project Implementation Strategies in Syria, *Doctoral Thesis*.
- [38]. Michael, R., David, J. and David, R. (2012). BIM Guidelines. [ebook] New York: New York City Department for Design +Construction. Available at:

- http://www.nyc.gov/html/ddc/downloads/pdf/DDC_BIM_Guidelines.pdf [Accessed 10 Aug. 2018].
- [39]. Migilinskas, D., Popov, V., Juocevicius, V. & Ustinovichius, L., 2013. The Benefits, Obstacles and Problems of Practical BIM Implementation. *Procedia Engineering*, Issue 57, pp. 767-774.
- [40]. Moore, G., 2003. *Marketing Strategies from Silicon Valley's Cutting Edge*. 7th ed. Oxford: Capstone Publishing Limited a.
- [41]. Moreno, C., Olbina, S. & Issa, R., 2013. *School of building construction*, USA.: university of Florid.
- [42]. National Institute of Building Sciences, 2015. National BIM Standard-United States Version 2. Wikipedia (2018). *Building information modeling*. [online] En.wikipedia.org. Available at: https://en.wikipedia.org/wiki/Building_information_modeling [Accessed 1 Jul. 2018].
- [43]. NBIMS Project Committee, 2008. The National Institute of Building Sciences online and available from www.nisb.org. [Accessed 18/07/6]
- [44]. Omar, H.S., 2015. *Solutions for the UAE architecture, engineering, and construction (AEC) industry to mandate building information modeling (BIM)* (Doctoral dissertation, The British University in Dubai (BUiD)).
- [45]. Sacks, R., Radosavljevic, M. & Barak, R., 2010. Requirements for building information modeling based lean production management systems for construction. *Automation in Construction*, 5(19), p. 641–655.
- [46]. Sanderson, S (2013): Russian Revolution. *The Construction Manager Magazine*. Knutt E. (ed.) pp. 32-34. Atom: London.
- [47]. Sebastian, R., 2011. Changing roles of the clients, architects and contractors through BIM. *Engineering, Construction and Architectural Management*, 18(2), pp. 176-187
- [48]. Shaban, M., 1998, December. The Role of Design errors in increasing the cost of construction and investment engineering projects executed in Syria, *38th Science Week publications*,
- [49]. Shaban, M., 2006, October. Claims in Construction Projects "due to Design Errors and Change Orders", *Journal of Building Technology*, No. 9, *Ministry of Municipal and Rural Affairs*, pp. 64-71, Riyadh, Saudi Arabia.
- [50]. Shaban, M., 2012. Modern Management of Projects Using Earned Values - Concept and Application - Publications of the Research Centre - *Institute of Public Administration* - Riyadh-Saudi Arabia. pp.: 60-70.
- [51]. Shaban, M., 2017, November. Prospects for using BIM in the reconstruction of Syria. *BIMArabia Magazine*. (25).
- [52]. Teicholz, P.M., 2013. Labor-productivity declines in the construction industry: causes and remedies (a second look). *AECbytes Viewpoint*. Ryal-net. B. M and Kaduma. L. A. (2015): Assessment of Building Information Modelling (BIM) Knowledge in the Nigerian Construction Industry, *International Journal of Civil & Environmental Engineering IJCEE-IJENS* Vol: 2015 No: 06.
- [53]. The BIM Hub (2014). Building Information Modelling: What is it and what are the legal issues arising from its use? Available online at <http://thebimhub.com/en/2014/08/19/building-information-modelling-what-is-it-and-what/> (accessed 19th August 2014)
- [54]. Thompson, D. & Miner, R., 2007. Building Information Modeling - BIM: Contractual Risks are changing with Technology. [Online] Available at: http://www.aepronet.org/wp-content/uploads/2014/03/GE-2006_09-Building-In [Accessed 15 November 2017].
- [55]. Tollefsen, T., 2003 Digital FM; building information modeling used to improve the performance of buildings over the life-cycle, *Faculty of Architecture and Fine Art*, Norwegian University of Science and Technology, NO-4971 Trondheim, Norway,
- [56]. Won, J., Lee, G., Dossick, C. & Messner, J., 2013. Where to focus for successful adoption of building information modeling within organization. *Journal of Construction Engineering and Management*, 11(139), p. 04013014.

- [57]. Yan, H. & Demian, P., 2008. *Benefits and barriers of building information modelling*. s.l., Ren, A., Ma, Z. and Lu, X. Proceedings of the 12th International Conference on Computing in Civil and Building Engineering . IN: (ICCCBE XII) & 2008 international conferencing.