# Building Information Modelling (BIM) as an Efficient Solution to Middle Eastern Construction Project Delays

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**ABSTRACT**

**The construction and building industry is considered one of the essential players in the economic sector that contributes significantly to creating jobs and generating financial resources. This study provides a review of the construction industry's capability available in the Middle Eastern countries, the development process, and its importance for the economic growth. It analyzes what causes construction projects to go over budget and behind schedule in an attempt to draw conclusions that can be applied to a broader body of research. Delays are costly in terms of time, money, quality, and safety. Some adverse outcomes of project delays are disputes between employer and contractor, lower revenue and productivity, and incomplete projects. This research investigates the reasons behind the construction setbacks in the Middle East and what can be done to rectify the situation. Moreover, it examines the Building Information Modeling (BIM) as a tool to reduce the construction delays. The BIM permits the digital construction of facilities before their physical structure, which aids in time management, reduces risks, improves security, and resolves problems.**

***Keywords-construction industry; building industry; delays; Building Information Modeling (BIM)***

## I. INTRODUCTION

The construction industry is one of the economy's largest sectors in all developed or developing countries. Construction and design represent a complex process as they deal with many aspects of the same object and take a long time to be implemented. The construction and contracting companies face many challenges and risks during project implementation, ranging from exceeding the specified budget or the project schedule, the inability to meet the required quality conditions and standards, and possible accidents at the construction site. Therefore, good planning and preparation are essential. A modern technology tool that contributes to reducing and avoiding such risks is the BIM [1, 2].

In the last two decades, there has been a remarkable growth in the construction sector. The construction industry has become one of the most important sources of economic input for the countries of the Middle East in the light of the recent rises in the oil and gas prices, Gross Domestic Product (GDP) increase, population expansion, and finance reorganization. The building construction, for example, is projected to have been multiplied among the Gulf Cooperation Council (GCC) members over the next several years [1].

Construction delays are described as the time that passes after the original deadline for the project completion or the deadline agreed upon by the parties [3]. The widespread nature of the problem of building delays in Middle Eastern countries has attracted significant critical attention. It is observed that the delay pattern has become the rule rather than the exception particularly in developing nations [4].

The rate at which building projects meet deadlines can be considered a measure of their effectiveness. Many unknown and potential obstacles might cause the project schedule to be disrupted [4, 5]. The main causes affecting construction delay can be client, consultant, contractor, and financial resources. Cooperative delay factors include the laws and customs of the nations involved, the nature of the project, the actions of other parties, the need for adjustments, and the weather, among others. Considering the aforementioned elements and circumstances, it is evident that delays vary from country to country and even from one project to the next within the same country. Therefore, no set of characteristics or variables applies to all building endeavors. There is little question that the contractor delay results in increased operating expenses. Moreover, a penalty fee and other costs may be associated with project delay. It is also possible that the delay may lead to lost revenue, income, and disagreements or dissatisfaction among the project's stakeholders. Cost overruns, disputes between contractual parties, the need for an arbitrator to decide on complex situations, and litigation are the primary repercussions of construction delays [6].

Authors in [1] reported that creative strategies for project management are needed to guarantee on-time and under-budget completion of GCC's scheduled projects and investments over the next five years. BIM and similar systems have grown more important in the Middle East to mitigate the negative consequences of building delays. Researchers advocate using BIM as a viable solution to solve the problem of cross-disciplinary inefficiencies on construction projects [7]. BIM utilizes computer simulations to plan, construct, and maintain buildings. It is a repository for information exchange and coordination between parties involved in building projects. The practical applications of 3D Computer-Aided Design (CAD) are only the beginning [8].

BIM is one of the contemporary technologies in the construction sector that contributes to reducing risks and delays in construction projects and increasing efficiency into completion. It is used in all stages of the project life cycle, from the initial design to operation and maintenance. This technology allows architects, civil engineers, contractors, owners, and end users to work on a single project and share information easily, which helps improve communication between all parties involved. It can also be combined to automate specific procedures, enhance construction site safety, and improve construction quality. [8-10].

BIM increases the efficacy of communication between all stakeholders by putting them into a digital platform for a virtual construction activity. They can communicate and exchange information in every digital phase of the project, which are:

- Programming.
- Conceptual Design.
- Detailed Design.
- Analysis.
- Documentation.
- Fabrication.
- Construction – 4D/5D.
- Construction Logistics.
- Operation and Maintenance.
- Demolition.
- Renovation.

Each phase of the project may be loaded with potential drawbacks, but these can be mitigated through clear communication and simple access to all relevant data by all stakeholders. Virtual problem-solving in the building will decrease or eliminate the need for costly additional work [11]. Many experts have proposed BIM as the panacea for building projects where the participants are inefficient [7]. It represents a paradigm of shifting from paper-based toward digital communication. In recent years, BIM has become prevalent in the construction industry. It can speed production, cut costs, and improve quality [12]. More than 48% of owners surveyed in 2008 believed that the project's final product was the main achievement. With the use of BIM, communication was optimized. The potential for value creation and recycling is higher. With BIM, design changes may be rapidly implemented in response to site-specific issues. Overruns in both time and money can be avoided if better communication is achieved [13].

## II. OBJECTIVE

This study aims to identify and assess the most significant causes of building delays across the Middle East, as well as verify, discover, and highlight the significant benefits of adopting BIM in construction at all project phases. This can be accomplished through the following objectives:

- Adopting a descriptive comparative analysis of previous studies to determine what causes the most major delays in Middle Eastern building projects. Additionally, investigating the key reasons for the delays in construction projects and how they might be prevented by studying papers from the relevant research field that have examined the delay factors and organized them into categories.
- Conducting a questionnaire and face to face interviews to investigate the viewpoint of stakeholders, namely contractors, owners, and consultants, and assess the significant delay reasons of construction projects.
- Proposing BIM as a time-saving answer to the problem of construction project delays and assessing the potential benefits of using it to prevent and mitigate cost overruns.

## III. REVIEW OF LITERATURE

Multiple researches and studies have been carried out to identify the most common reasons why construction projects run late, whether in the Middle East or elsewhere, with many of them having been found. Different countries have different delay factors because of the inherent diversity of their economies, cultures, laws, and resources [14].

Thirty-one studies have been evaluated on the topic of the causes of delay. The findings have been classified based on

how closely they relate to the existing sources of delay. Table I summarizes twenty-seven out of the thirty-one studies, which were selected because they provided an objective and thorough description of the causes. It shows the number of each project type in each region demonstrating that, among the Middle Eastern countries, Saudi Arabia (KSA) has conducted the most research on root-cause analysis, followed by the United Arab Emirates (UAE), with seven and six publications, respectively. The other group, Lebanon, Turkey, Iran, Qatar, Egypt, and Bahrain, were all examined together in one research.

TABLE I. PROJECT TYPE MAPPING OVER THE MIDDLE EASTERN COUNTRIES

| Project type | General Constructions | Individual Buildings | Infrastructure | Oil & Gas | Pipeline | Road | Total |
|---|---|---|---|---|---|---|---|
| Bahrain | - | - | - | - | - | 1 | 1 |
| Egypt | 1 | - | - | - | - | - | 1 |
| Iran | 1 | - | - | - | - | - | 1 |
| Jordan | 2 | - | - | - | - | - | 2 |
| KSA | 4 | 2 | - | 1 | 1 | - | 8 |
| Kuwait | - | 2 | - | - | - | - | 2 |
| Lebanon | 2 | - | - | - | - | - | 2 |
| Oman | 1 | - | - | 1 | - | - | 2 |
| Qatar | - | 1 | - | - | - | - | 1 |
| Turkey | 1 | - | - | - | - | - | 1 |
| UAE | 3 | 1 | 1 | 1 | - | - | 6 |
| Total | 15 | 6 | 1 | 3 | 1 | 1 | 27 |

The selected studies are organized into groups according to the different types of projects that were studied. This categorization provides further detail and clarifies why the various projects have unique delay causes. Delays in general construction projects were found to be the most common kind, followed by delays in individual building and oil and gas projects. In addition, the most current studies on construction delays exhibit no consensus on what constitutes a significant delay, possibly owing to the fact that researchers look at the subject from many different angles.

The present study attempts to provide an overview of the construction delays, by identifying the leading reason for these delays, based on the views of contractors, owners, and consultants in the construction industry. Table II depicts the studies that analyzed the current state of affairs and involved in-depth discussions regarding possible reasons for delays. Experts from nations like Saudi Arabia, Kuwait, Lebanon, Turkey, Iran, Qatar, Egypt, Bahrain, and Jordan ranked the causes.

TABLE II. REASONS FOR BUILDING DELAYS ACCORDING TO LITERATURE

| Country | The main delay causes. | Ref. |
|---|---|---|
| Bahrain | Contractor misplanning - Inexperienced staff – Owners' delay. | [18] |
| Egypt | Change orders - Finance issues - Untrained management - Late payments - Part payments. | [19] |
| Iran | Change views - Poor planning - Decision-making inefficiency - Late payments - Poor administration. | [20] |
| Jordan | Order/design changes - Weather delays delivery - Bad design - Site issues. | [21] |
| KSA | Monetary issues - Design changes/error - Payment delays - Contractor payment delays - Permit issues - Contractor financing issues - Poor scheduling - 'Lowest bid wins' - Poor management - Labor shortages cause shop drawing delays - Construction owner changes. | [3, 22-27, 28] |
| Kuwait | Altering orders - Owners' budgets - Owners lack building experience. | [29, 30] |
| Lebanon | Contractors prioritize contracts - Owners fear about finances - Lack of project management consultation. | [31, 32] |
| Oman | Delay building materials - Poor stakeholder communication and vendor contact in the engineering and procurement stages - Unmanaged contractor schedules - Contractor mismanagement and oversight - Subcontractor issues, poor scheduling. | [33, 34] |
| Qatar | Supply delays - Design changes - Estimates, improper cash flow planning - Labour shortage. | [35] |
| Turkey | Contractor-owner disputes - Poor communication. | [36] |
| UAE | Poor project planning - Worker inefficiency - Poor site oversight - Staff shortage - Slow sketching and approval - Owner's slow decision-making. | [37-42] |

The literature analysis came up with several vital elements that influenced the development of buildings in the Middle East. Numerous recent articles define BIM as a basic method and practice of virtual design and construction throughout all project development stages. According to [1, 15], an effective option could be utilizing the BIM to help project owners better see the end results of their work.

## IV. ADOPTION OF BIM

Reviewing and understanding the results of BIM adoption in a similar area is crucial for the accurate assessment of the modern construction management technology adoption by the Architecture-Engineering-Construction (AEC) industry in Middle Eastern nations. A comprehensive literature search was performed based on the factors that led to the widespread acceptance of BIM and the advantages of its implementation.

### *A. Acceptance of BIM*

BIM was developed to simulate, analyze, and predict potential issues and sources of delay encountered during a project's building phase. The software used in BIM has improved over time. Therefore, the original application has spread to other areas, such as time and cost management, green certification, safety, maintenance, and infrastructure for AEC

projects [16]. According to [17], employing BIM in building projects had the following benefits:

- Estimation times were cut by 80%.
- There was a larger than a tenfold decrease in Requests For Information (RFIs) and charging orders.
- An output increase of 20-30% was observed in the field.
- A reduction of overruns by up to 40% of the budget was noted.
- The most reliable estimate of price (up to 3% accuracy) was observed.
- The project duration was shortened by 7%.
- It was noted that clash detection can save up to 10% of the entire contract value.

### *B. Advantages of BIM*

The benefits of BIM adoption have been the subject of several types of research. The rate of BIM utilization in the North American construction sector projects climbed progressively from 28% in 2007 to 49% in 2009, and 71% in 2012 [43]. The percentage of British construction industry professionals using BIM increased from 13% to 31% between 2010 and 2011 [44]. BIM was developed in the first place to meet the demand for design automation software [45]. Estimates, green ratings, energy performance, schedule monitoring, safety plans, and a solid control baseline may all be generated with the help of design automation provided by BIM. Clash detection in the early design phases is another time-saving benefit of BIM. The advantages of BIM in construction project management include better client coordination, reduced rework, fewer mistakes, enhanced sustainable design and construction, improved building and financial planning, enhanced design flexibility, fewer unanticipated costs, and improved risk evaluation [46]. Therefore, academics have always been interested in developing new technologies [47]. BIM adoption and promotion in the building industry are quickly becoming standard practices [43].

A questionnaire research was undertaken through LimeSurveyTM - a web-based surveying application - to highlight BIM applications in minimizing delay in building projects [48]. Companies in the United Kingdom that were currently using BIM in their project management were the focus of this particular questionnaire, concentrating on the effects of BIM. Ninety-two respondents were chosen randomly from a broader pool of survey takers and contacted to verify that they were employed by businesses in the United Kingdom utilizing BIM. They were asked to rate the significance of BIM on a scale from one to five, with five being the most significant influence and one the least. The respondents were drawn from various fields, including architecture, building services, management, quantity surveying, civil and structural engineering, facility management, building surveying, BIM consultancy and drafting, construction, mechanical, electrical, plumbing, mechanical design, and construction law. The results (Table III) revealed that 92% of respondents ranked cooperation as the most significant component in the success of BIM, followed by the fact that BIM is more of a method than a tool, and it may help save expenses by a significant amount [49]. Authors in [49] also listed the financial benefits of BIM adoption (Table IV), showing that clients profit the most when BIM is used in a building project, with no overrun costs and reduced delay contributing to outstanding quality. In addition authors in [50] demonstrated the value of using BIM and maintaining it throughout a building project (Table V).

TABLE III. BIM EFFECTS

| BIM effects | Rank 1 | Rank 2 | Rank 3 | Rank 4 | Rank 5 | Overall Rank |
|---|---|---|---|---|---|---|
| BIM requires collaboration. | 8 | 1 | 2 | 20 | 61 | 1 |
| BIM is a method, not a technology. | 6 | 2 | 6 | 21 | 57 | 2 |
| BIM will save resources (materials, resources, and cost) | 8 | 4 | 6 | 30 | 44 | 3 |
| BIM improves precision. | 5 | 3 | 18 | 23 | 43 | 4 |
| New contracts are needed for BIM. | 2 | 9 | 16 | 37 | 28 | 5 |
| BIM is unclear in the industry. | 2 | 18 | 17 | 37 | 18 | 6 |
| Resources and training are needed for BIM. | 4 | 19 | 20 | 29 | 20 | 7 |
| Clients will drive BIM. | 4 | 14 | 30 | 28 | 16 | 8 |
| BIM makes communities more sustainable. | 7 | 10 | 27 | 36 | 12 | 9 |
| BIM is easier to adopt in SMEs. | 8 | 13 | 41 | 22 | 8 | 10 |
| BIM requires government-subsidized training. | 11 | 24 | 29 | 15 | 13 | 11 |
| BIM relies on 3D visualization. | 19 | 23 | 30 | 14 | 6 | 12 |
| Some SMEs cannot afford BIM. | 21 | 29 | 25 | 8 | 9 | 13 |

TABLE IV. FINANCIAL BENEFITS OF BIM

| BIM beneficiaries | Rank 1 | Rank 2 | Rank 3 | Rank 4 | Rank 5 | Final Rank |
|---|---|---|---|---|---|---|
| Clients | 1 | 2 | 10 | 27 | 37 | 1 |
| Managers | 0 | 0 | 14 | 29 | 31 | 2 |
| Vendors of software | 1 | 2 | 17 | 20 | 37 | 3 |
| Contractors | 0 | 2 | 11 | 40 | 22 | 4 |
| Building users/occupants | 3 | 5 | 18 | 30 | 18 | 5 |
| Consultants | 3 | 6 | 17 | 34 | 16 | 6 |
| Specialist contractors | 0 | 6 | 26 | 27 | 15 | 7 |
| Suppliers | 2 | 17 | 27 | 20 | 8 | 8 |

TABLE V. RANKING BIM IMPLEMENTATION SUCCESS FACTORS.

| | % Negative benefit | % Positive benefit |
|---|---|---|
| Better communication | 0 | 37.14 |
| Better coordination | 8.57 | 34.29 |
| Better organization | 5.71 | 5.71 |
| Cost saving | 5.71 | 60 |
| Defined scope | 0 | 8.57 |
| Improved quality | 0 | 34.29 |
| Reduced risk | 2.86 | 17.14 |
| Software issues | 20 | 0 |
| Time-saving | 8.57 | 34.29 |

Another area of research is the key factors that led to BIM adoption. Researchers in [49] identified some of them by surveying the top 100 UK construction companies operating worldwide online. The relative importance of those key factors was calculated using a formula (RII). The results displayed that clash detection was the primary motivator for adopting BIM, followed by government and competitive pressure (Table VI).

TABLE VI. WEIGHTED LIST OF BIM MOTIVATORS

| Key Motives | Agg. RII | Rank |
|---|---|---|
| Clash Detection | 0.815 | 1 |
| Government Pressure | 0.791 | 2 |
| Competitive Pressure | 0.788 | 3 |
| Accurate Construction Sequencing | 0.767 | 4 |
| Cost savings from reduced rework | 0.760 | 5 |
| Client Pressure | 0.755 | 6 |
| Improve Built Output Quality | 0.743 | 7 |
| Time Savings | 0.722 | 8 |
| Improve Design Quality | 0.718 | 9 |
| Improve Operative Communication | 0.702 | 10 |
| Enhance Client Whole-Life Value | 0.691 | 11 |
| Desire for Innovation | 0.690 | 12 |
| Construction Process Safety Design | 0.687 | 13 |
| Scheduling/Register Automation | 0.667 | 14 |
| Increase pre-fabrication | 0.660 | 15 |
| Streamline Design Activities | 0.659 | 16 |
| Cost Savings through Reduced RFI's | 0.657 | 17 |
| Facilitate Management Activities | 0.623 | 18 |
| Total | 12.893 | |

## V. METHODS AND MATERIALS

### A. Methodology

General descriptive methods, including the survey questionnaire and semi-structured interviews, were deployed to accomplish the study's primary goals. Evaluation, diagnosis, planning, and adoption of action were carried out using a mixed-methods approach inspired by action research. The participants were given a questionnaire including a total of fifteen questions. The first ten questions focused on the most typical causes of building project delays in the Middle East. The questionnaire was structured in a way that allows assigning relative relevance and frequency rankings to the many root causes which were to be uncovered. The respondents were asked to rate their feelings about the top 10 construction delay issues cited in the literature on a scale from 1 (very low) to 5 (extremely high). The remaining five questions that can be answered with a simple (Yes) or (No) assessed the respondent's background in applying BIM in the Middle Eastern building business.

The research collected information through semi-structured, in-person interviews with high-profile UAE clients, consultants, and contractors, who participated in a 3D BIM project. Standard questions were followed by more in-depth investigation on the history, current applications, and prospects of BIM. The duration of each interview was adjusted between 30 and 45 minutes. The literature review in this work served as the basis for developing a questionnaire and interview questions.

### B. Collecting and Analyzing Data

This research applies what is already known about BIM implementation to the Al Mafraq Hospital BIM project in Abu Dhabi, United Arab Emirates. The objective is to provide a comparative analysis of the BIM adoption in the Middle East by demonstrating the advantages of doing so in reducing the delay effects. The data on the BIM implementation in the UAE were gathered through semi-structured interviews with the client, consultant, and contractors involved in the Al Mafraq Hospital-UAE project. All respondents were notified, and a copy of the questions was sent to their email addresses. In contrast, the questionnaire was sent out to a random sampling of Middle Eastern businesses. To provide a systematic method for BIM, data regarding the primary reasons for construction delays and the existing state and difficulties of BIM implementation in the Middle East were also collected to produce a quantitative assessment. Figure 1 illustrates the methodology process of the implemented research.

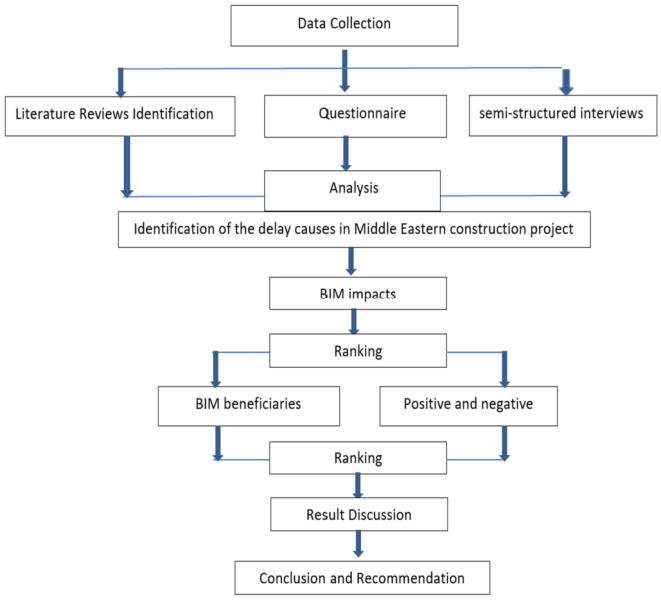


Fig. 1. Methodology flow chart.

### C. Sample Size and Selection Criterion

Three hundred clients, consultants, contractors, and experts from Middle Eastern construction projects were sent the survey questionnaire via Survey Monkey. The survey was a regional

effort, reaching out to construction professionals in Bahrain, Egypt, Iran, Jordan, Saudi Arabia, Kuwait, Lebanon, Oman, Qatar, Turkey, and the United Arab Emirates. The participants were chosen from various construction project specializations to avoid favoritism. The diversity of the sample makes it easier to recommend BIM implementation as a solution and improves the quality of the data analysis. The Al Mafraq Hospital also interviewed ten participants. The/A client, a representative from project management, a design consultant, and the two main contractors make up the convenience sample for this study. The sample was selected to conduct a comparative analysis of BIM implementation in the Middle East because it exemplified how BIM can help reduce the causes of construction delays.

## VI. THE CHOSEN METHODS

### A. Comparing and Assessing

To determine whether Middle Eastern countries are ready to embrace BIM, it was necessary to conduct both theoretical and practical research using qualitative and quantitative approaches. However, a mixed-method research uses many methodologies to investigate a research topic. The following are some of the arguments which defend the adoption of both methods [51]:

- Explaining and understanding the results.
- Enhancing a design.
- Examining a phenomenon.
- Creating and evaluating a new tool or method.
- Overcoming design flaws.
- Serving a theory.
- Answering a question on several levels.
- Exploring a theoretical approach.

Both approaches are essential to the investigation for two major reasons:

- An accurate assessment of the situation, compiling and contrasting both data-gathering technologies is necessary to provide a foundation for ongoing and future research on the same issue.
- Through a comparison and an analysis of the existing case studies, the current research aims to deal with the construction concerns about BIM adoption in the examined region.

### B. Advantages and Disadvantages

In [52], it was stated that the mixed-method research yields more convincing findings than the single-method research. In addition, in [50], it was argued that the combination of the two approaches chosen for this study would offer significant advantages. Those benefits included bridging the gap between the two approaches, being straightforward in reporting and describing, summarizing and classifying qualitative data, accounting for unexpected results.

Both approaches may, however, have a number of potential drawbacks. For instance, using a questionnaire to collect data necessitates data analysis tools, while it is not always clear what motivated the researchers' choices. In addition, prejudice is possible in some circumstances, and most responses tend to be uncertain. Furthermore, there are occasionally unclear data and findings. On the other hand, face-to-face interviews are regarded as data-gathering techniques that are both time-consuming and individual/involve a small participant sample, as it is impossible to have more than one interview at the same time.

## VII. RESEARCH INFLUENCE ON THE TOPIC

Any building project, no matter where it is, runs the risk of being late because of variance. The delay has negative implications on time, quality, cost, and safety. Long-term delays strip a project of its financial justification, which can make project completion difficult. Furthermore, legal issues between the employer, contractor, and consultant, decreased production and income, and large-scale incomplete projects are all consequences of construction project delays. There has been a great amount of studies and inquiries about building delays in the Middle East. Yet, the possibility of incorporating BIM into the building projects' life cycle in the Middle East is attractive.

One immediate advantage of this study is that its participants attempt to go into areas that have received little attention from prior BIM researchers in the Middle East. When examining the potential application of BIM in the area, few case studies and examples were found. Except for a few projects in GCC nations (e.g., UAE and Qatar), Most Middle Eastern construction industry professionals have never used, adopted, or recognized BIM's main effect on reducing project delays. Case studies of BIM implementation in the United Kingdom were analyzed to demonstrate the importance of this technique. Another outcome is that the knowledge about BIM is spread to the targeted building industries in the research area. As a result, the advantages of BIM in Middle East countries have become known, which could eventually lead to compulsory BIM deployment in the area.

## VIII. CONCLUSION

Delays in construction projects represent a main problem in Middle Eastern countries, which costs money, time, quality, and safety. The long delays shake the financial situation of the project and cause various legal issues between the participants making its completion difficult. By investigating the perceptions of specialists, the present study identified the crucial reasons behind the delays that occur in construction projects in the study region.

Building Information Modeling (BIM), nowadays, plays an important role in construction engineering projects and the operation industry. The current study demonstrated that the adoption and implementation of BIM are slowly taking place in construction industry projects in Middle East countries. When investigating the possibility of adopting and implementing BIM in the Middle East, a few cases of BIM application were identified, especially in the UAE and Qatar. It was also found that many construction industry professionals in the Middle

East did not have information about how to use or acknowledge the major impact of BIM in reducing project delays. The advantages of BIM, can eventually lead to making it compulsory in Middle East countries.

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