



## Research paper

# Benefits of building information modelling in mitigating claims and disputes of construction projects in Jordan

Ibrahim Moh'd Sarairoh<sup>1</sup>, Akram Suleiman<sup>2</sup>,  
Mohammad I. Al Biajawi<sup>3</sup>, Saleem Alziadin<sup>4</sup>

**Abstract:** Claims play an important role in construction projects as they can have a significant financial impact that can affect the overall cost and schedule of the project. The introduction of Building Information Modeling (BIM) is changing the traditional methods of the construction industry and has strengthened the influence of the planning process on the entire life cycle of a construction project. Therefore, this research attempts to identify the function of Building Information Modeling (BIM) in mitigating such claims and disputes. To achieve the aim of this research, 380 assessments done by industry specialists were examined using the mean ranking method, the normalization process, the RII and factor analysis. The results of this study quantify the main causes of claims and disputes associated with the contractor and owner, such as financial problems of the contractor (RII 0.792), delays caused by the contractor (RII 0.784), delays in payment of completed work to the contractor (RII 0.794), oral change orders from the owner (RII 0.790). In addition, the results revealed several potential benefits of BIM that include efficient communications between stakeholders (RII 0.852), better visualization (RII 0.846), 3D-Coordination and clash detection (RII 0.830). This survey contributes to the current form of information by identifying the main sources of disputes and claims in projects. In addition to revealing the benefits of BIM that industry experts can use to improve project performance.

**Keywords:** benefits, BIM, building information modelling, claims, construction project

<sup>1</sup>Assistant Prof., Al-Zaytoonah University of Jordan, Faculty of Engineering and Technology, Civil and Infrastructure Engineering Department, Amman, Jordan, e-mail: [i.sarairoh@zuj.edu.jo](mailto:i.sarairoh@zuj.edu.jo), ORCID: 0000-0002-8427-4847

<sup>2</sup>Associate Prof., Al-Zaytoonah University of Jordan, Faculty of Engineering and Technology, Civil and Infrastructure Engineering Department, Amman, Jordan, e-mail: [a.suleiman@zuj.edu.jo](mailto:a.suleiman@zuj.edu.jo), ORCID: 0000-0002-2665-1384

<sup>3</sup>PhD., University Malaysia Pahang Al-Sultan Abdullah (UMPSA), Faculty of Civil Engineering Technology, Persiaran Tun Khalil Yaakob, 26300, Gambang, Pahang, Malaysia, e-mail: [mohammedbajawi1994@gmail.com](mailto:mohammedbajawi1994@gmail.com), ORCID: 0000-0001-6840-4878

<sup>4</sup>Eng., Al-Zaytoonah University of Jordan, Faculty of Engineering and Technology, Civil and Infrastructure Engineering Department, Amman, Jordan, e-mail: [s.alziadin@zuj.edu.jo](mailto:s.alziadin@zuj.edu.jo), ORCID: 0009-0000-8874-1898

## 1. Introduction

The construction area in Jordan acting a vital role in promoting economic advance and occupies a significant position in the country's growth policies. The construction industry in Jordan, as in any country, is generally recognized for its efficient contribution to the country's social and economic development [1]. According to [2], The construction domain is one of the largest productive domains in Jordan, which plays an effective role in achieving the goals and aspirations of society. The construction sector contribution to the national Gross Domestic Product (GDP) of Jordan in 2013, 2014, 2015, 2016, 2017, 2018 and 2019 is about 4.7%, 4.9%, 4.7%, 4.4%, 4%, 3.7% and 3.5% respectively (Jordanian Department of Statistics, 2019). As mentioned by [3], the construction industry is distinguished from other industries by many advantages, the most important of which is the participation of many stakeholders in the implementation of the required projects according to the provisions and specifications of the contract. Disagreements and arguments are more likely to arise between those involved in implementing and developing construction projects as a result of their different cultures, backgrounds and experiences. Therefore, the mentioned elements do the industry of construction unique and difficult to operate unlike other manufacturing industries [4].

In the opinion of [5], to develop the construction operations and make its cycle more efficient, the construction industry still needs further improvement and innovation. It is possible to achieve this development by adopting technological progress and automation. Furthermore, the construction projects are very complex and motif to a high degree of uncertainty, so, the possibility of disputes and claims occurring between the stakeholders is high within this industry. In another study, [6] explained that absence of communication, unclear information, inadequate information, differences in design, misapprehension of contract documents are certain of the key sources of disputes and claims that arise among participants. Moreover, some studies have shown the importance of communication in construction projects, and their results revealed that lack of cooperation negatively leads to project failure. An example of such studies is [7], whose results revealed that the construction industry in the MENA region affords many challenges throughout the project life cycle; In addition to these challenges comes lack of communication, which sometimes guides to project setback or fully time and cost overruns. Besides, [8] stated that the lack of a proper communication system is a high-ranking barrier to sustainability implementation in Jordan.

Nowadays, due to the increasing complexity of construction projects, disputes have unavoidably arisen. Therefore, it has become necessary to use modern technologies and methods, in addition to relying on advanced and correct contractual methods [7]. In the opinion of [8], the problem of claims in the construction industry also requires a lot of attention because it is considered the most disturbing event in the projects. In addition, [9] said that claims continue on construction projects and usually result from many reasons that regularly contribute to project delays and increased project costs. Furthermore, [10] added: claims be inclined to create delay of construction work, time expansion in implementing projects and delays in payment for work done. Therefore, claims administration subsists to guarantee that variances that offer increase to claims do not accelerate into arguments [11].

According to [7], BIM technology as an effective and powerful tool has the ability to change projects for the better; the visualization feature in BIM has an important role in enhancing cooperation between the participants in the construction team. Moreover, BIM gives the participants the opportunity to experiment with 3D technology, as the stakeholders can get the full idea of the project before starting the real construction operations. This improves the performance of the project and its workflow through obtaining correct and accurate information, based on the foundations of systematic entry.

Disputes and claims in the Jordanian construction industry lead to delays in the implementation of the most of projects and an increase in their costs. Therefore, this study aims to identify the important factors in the emergence of disputes and claims in the Jordanian construction sector. In addition to showing the role of BIM and its benefits in improving the construction industry in Jordan and reducing disputes and claims, knowing that the use of BIM in Jordan is still limited.

## 2. Literature review

Construction projects in Jordan, as well as in most countries of the world, are faced with many challenges, the most important of which are disputes and claims between stakeholders. The emergence of most of these disputes is due to many requirements and changes by the employer, in addition to the increasing complexity in the implementation of construction projects, as well as the spread of modern technologies that require special standards.

The global construction industry faces many obstacles such as low level of productivity, weak cooperation between stakeholders, in addition to low revenues in general [12]. According to [13], as a result of these chronic problems in the construction industry, the number of claims and disputes has increased over the past decades. Frequent claims and disputes created significant cost overruns and delays, which led to a weakening of working relationships between project participants and consequently adversely disturbing the success of construction projects [14].

As stated by [15], the emergence of some events during the execution of construction projects leads to many disputes and claims, which in turn lead to a rise in the budgets of projects and an extension of their implementation time. All of the interest stakeholders are considered responsible for compensation, whether financial or temporal, as a result of the change in the terms of the contract stipulated previously between the contracting parties. Consequently, claims and disputes have come to be inevitable events in the construction industry. In fact, in the Jordanian construction industry and during the past ten years, the incidence of claims and disputes as well as their seriousness has risen clearly. The persistent claims facing construction projects require an urgent and effective solution. As a result, and recognizing their importance to the project's success, over the years many researchers have investigated the sources of the claims and disputes.

According to [16], several analytical studies indicated that claims increase the cost of projects by between (10–25%), in addition to increasing project implementation time by an estimated percentage (25–50%). Furthermore, [17] displayed that the cost of disputes is estimated at 0.5 to 5 percent of the total project cost. To resolve the problems of disputes and claims construction industry, many studies such as [18–20] confirmed that BIM technology is

an active approach and solution to smooth the administration of disputes and claims in the construction industry. In addition, studies have indicated that BIM has the chance to decrease design error, contractual problem and improve communication between stakeholders.

The current research offers an assessment of the outcomes of an empirical study of the sorts and reasons of construction claims and disputes in the Jordanian construction industry. Then recommendations are made to minimize claims on construction projects. The outcomes of this study are expected to assistance construction companies to stay away from the major sources of claims and disputes and thus decrease delays and cost overruns in construction projects.

### **3. Claims and disputes in the construction**

#### **3.1. Definition**

A claim is understood as a demand for a further cost over and above the amount settled upon in the contract, by one of the parties to the contract, in order to obtain financial or time compensation, or both, as a result of additional works or harms occasioning from works that were not covered in the original contract [21]. According to [22], claims are generally defined as any demand from the contractor for an additional amount other than the contractually agreed amount. As stated by [21], dispute is offered as a clash that needs a terminal resolution, which is aided by the mediation of a third party. Additionally, a dispute is defined as a sort of conflict, which apparent itself in recognizable and reasonable matters. It requires misunderstanding over problems able of determination by negotiation, mediation, or third party arbitration [23]. Additionally, a dispute as mentioned in the Law Dictionary is a disagreement or variation of view between the two parties [24]. It can be said that disputes are popular in the projects of construction. It may occur due to disagreements between any of the stakeholders. Moreover, disputes have a detrimental effect on projects in general, as they create additional costs for projects in addition to delaying their implementation, and weaken their performance and productivity.

Claims and disputes have caused stress to the construction industry in the countries of the world in general and Jordan in particular. Disputes and claims establish a continuous challenge for construction projects, as they cannot be avoided or resolved easily. Numerous studies have looked at identifying the sources of disputes and claims in the construction projects so as to mitigate them and promote and improve the construction industry. According to [7], due to increasing in the difficulty of construction projects, the number of claims and disputes has increased significantly in recent times. This led to considering the occurrence of disputes and claims as a fundamental part of the construction projects.

Decision makers must know and understand the roots of disputes in an attempt to find the best ways to resolve and mitigate them. As [25] mentioned, claims are divided into two categories: impact claims and change claims. 51% of the overall quantity of claims is known as change claims, and their appearance is due to the occurrence of changes by the client, either in the design or in the construction change at the site. While 49% of total claims are generally considered impact claims, their occurrence is attributed to changes due to regulations and different site conditions.

[3] revealed in their study, because of the existence of conflicts that have become a regular presence in projects, many stakeholders express concerns about the execution of projects, especially in terms of quality, duration, budget, and others. Another study [26] added that many projects at the present time are being delayed for a long period of time, almost exceeding months, due to the occurrence of conflicts between the stakeholders, in addition to the projects bearing additional costs that exceed the amounts allocated in the budget according to the terms of the contract. Most of the studies concluded that among the solutions to reduce the reasons of disputes and claims in the construction projects is the use of modern technologies and their employment in the implementation of projects. Accordingly, this study examines the impact and role of (BIM) in the development of the construction industry. This technology helps to reduce the causes of disputes and claims in the construction industry by exploiting the desired benefits from the application of BIM technology in projects. After referring to previous studies and examining them carefully, the usual roots of disputes and claims in the construction projects have been listed in Table 1.

Table 1. Causes of disputes and claims in the construction industry

<b>Causes of claims and disputes relating to owner</b>	
<b>Causes</b>	<b>References</b>
Delay in payments to contractor	[10, 27–31]
Delay in handing over site	[27, 32–38]
Shortage of workers knowledge for contract requirements management	[12, 39, 40]
Excessive change orders by owner	[30, 31, 41, 42]
Delays approval of shop drawings	[43–46]
Slow decisions	[12, 33, 38, 47]
Design change by the owner	[48–50]
<b>Causes of claims and disputes relating to contract documents</b>	
<b>Causes</b>	<b>References</b>
The difference between the executed quantities and the quantities in the contract	[40, 63, 64]
Incomplete contract documents	[30, 34, 41, 42]
Design errors	[35, 38, 42, 51, 52]
The difference in the types of contracts	[33, 40, 53]
<b>Causes of claims and disputes relating to contractor</b>	
<b>Causes</b>	<b>References</b>
Delay caused by contractor	[31, 36, 38, 47, 51]
Poor planning and management by contractor	[27, 31, 52–54]
Contractor financial problem	[12, 34, 42, 55, 56]
Poor quality of contractor's work	[34, 35, 45, 52]
Reworks due to implementation errors by contractor	[57–59]
Poor qualifications, skills, and experience of the technical staff	[42, 55, 60, 61]

*Table continued on the next page*

*Table continued from the previous page*

<b>Causes of claims and disputes relating to project</b>	
<b>Causes</b>	<b>References</b>
Change scope of the project	[34, 62, 63]
Complex implementation of the project	[64–67]
Change of project location	[33, 34, 68, 69]
<b>Causes of claims and disputes relating to contractual relationship</b>	
<b>Causes</b>	<b>References</b>
Shortage of coordination and communication between the parties	[28, 55, 70, 72]
Giving bid to the lowest bidder	[34, 35, 50, 56, 73]
Inadequate time to prepare and verify the bid accurately	[34, 35, 74–76]

#### **4. Role of desired benefits of BIM in mitigating causes of claims and disputes in the construction industry**

The traditional methods currently used in designing and managing projects are characterized by their simplicity, and therefore contain many defects in addition to their inability to unravel the difficulties facing projects in the construction work. According to [21], these defects are represented in the separate drawings of the project, as each describes specific parts of the project. Additionally, there is no sharing between the project parties, as information and project documents cannot be easily and easily exchanged between them. This makes it difficult to follow the phases of the project's workflow in the construction industry.

Currently, modern technologies have provided the appropriate programs that enable the stakeholders to easily manage and understand the virtual ideas of the project. BIM technology is among the most famous of these technologies, as it contains one model that provides most of the requirements for project success in terms of clash detection, visualization, and follow-up of all stages of project implementation together within one system [77]. Moreover, BIM is an attractive solution to the problems of the industry of construction and its improvement in terms of design, construction, visualization and operation of buildings.

Furthermore, the construction industry in the Jordanian construction sector in particular and in many countries in general suffers from many difficulties and challenges that impede the progress of the construction industry. There are many factors that delay the project and lead to the occurrence of claims and disputes between stakeholders. The origin of these reasons is due to factors related to the employer, contractor, contract, contractual issues, or as a result of external factors affecting the progress of the project. As [15] mentioned, BIM has the ability to reduce many of the causes of disputes and claims, as BIM functions provide accurate quantities, and reduce changes and design errors, variation orders and defects in drawings and specifications. Besides, Building Information Modelling works to improve organization and collaboration among designers through its functions, including 3D visualization, clash detection, and coordination amongst the parties involved in the design.

On the other hand, many previous studies have identified various factors that drive to faults in design, specifications and drawings, which in turn lead to project delays and the emergence of disputes between stakeholders. Based on the principle of Fishbone as explained by [15], BIM contains features that improve project performance, avoid design errors, and thus reduce disputes and claims between contract parties. Among the most important of these features is that BIM technology can provide the interchange of data and understanding among designers and improve coordination and communication between them in addition to clash detection, which leads to successful the productivity of the design procedure for the project in all its stages.

As mentioned by [78], Building Information Modeling innovation is among the latest inventions in the construction industry, which has accelerated the finding of appropriate solutions to the complex problems facing construction projects. As many previous studies have confirmed that when BIM is used by those with experience in construction, BIM has the necessary potential to reduce design errors, as well as provide project duration and budget, in addition to improving project workflow and improving its performance. Moreover, BIM improves cooperation among stakeholders and increases opportunities for coordination between them. Also, [79] added that all this determines and influences the build ability of the project. Moreover, according to [80], BIM technology speeds up and improves decision-making, as well as reduces conflicts in design and improves project performance in general. The multiple benefits of BIM also have the ability to reduce the risks and dangers facing construction projects during their implementation. According to [81], BIM simplifies information involvement and enhanced communication and cooperation between project team. Also, added that understanding the impact of risks is one of the most feasible ways to reduce the possibility of delays. Many of the desired benefits of applying BIM in the construction industry, which have been selected from previous literature, are demonstrated in Table 2.

Table 2. Desired benefits of applying BIM in the construction industry

<b>Desired benefits of BIM application</b>	<b>Authors</b>
Early decision making	[82, 83]
Reductions design errors	[84–86]
Improve design	[68, 79]
Clash detection	[87–89]
Improve early involvement of main stakeholders	[90, 91]
Enable visualization of the built environment	[76, 92, 93]
Better communication and coordination	[19, 94]
Reduce rework in construction	[95, 96]
Accurate and updated information	[86, 97]
Project cost reduction	[14, 88]
Project time reduction	[11, 19]
Improve project documentation	[79, 90, 98]
Minimizes disputes and claims	[13, 19, 20, 74, 99]
Improving team building skills	[68, 100, 101]

## 5. Methodology

To achieve the objectives of such survey, the methodology was a mixture of a comprehensive literature review and questionnaire survey to discover the most efficient reasons of occurrence of disputes and claims in the industry of construction. Fig. 1, shows the main stages of the methodology of conducting the current study. In the first stage, data correlated to the causes of disputes and claims in the construction industry were collected, in addition to identifying a number of key benefits expected from the application of BIM technology and its role in reducing disputes and claims between project stakeholders. The data collected in the first phase was used as a basis for forming the questionnaire, which was widely applied to the engineers of the construction projects working within the main stakeholders as contractors, consultants and owners. After that, the obtained data were analysed using the SPSS program to attain the desired goals of this research.

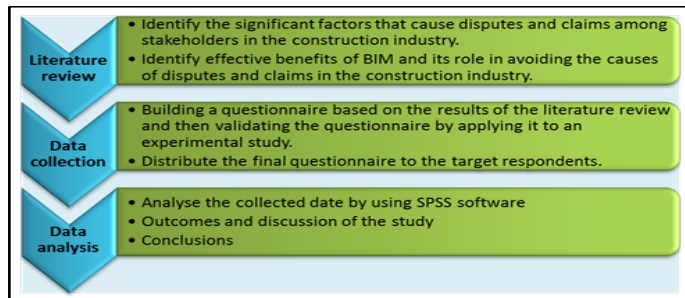


Fig. 1. Methodology flow chart

## 6. Data collection analysis

Depending on participants' profiles, the response rate was 78%, where 380 responses were obtained out of 500, which indicates that the study sample has a great interest in this topic. The study showed that the demographics of the study sample were as follows: 42.1% are contractors, 38.90% are consultants, and 19.00% of the respondents are owners. The study revealed that most of the respondents are holders of a bachelor's degree, with a participation rate of (80.50%). Moreover, the study indicates that most of the respondents are civil engineers with a percentage of 78.40%. In terms of work experience, most of the respondents have more than 10 years of experience with a rate of 42.10%, which gives the survey a significant contribution.

After completing the data collection, it was analyzed using the mean score of the classification items, percentages and the use of descriptive statistics. The Relative Important Index (RII) was used to rank the causes of disputes and claims in the construction industry, and also to rank the expected benefits of the adoption of BIM technology. The (RII) values were found according to the following equation as stated by [100].

$$(6.1) \quad RII = \sum \frac{W}{(A * N)}$$

where,  $W$ : Characterizes the weight given to every part by respondents and ranges from 1 to 5,  $A$ : Characterizes the highest weight (in this case = 5)  $N$ : Characterizes the total number of respondents which equals (380). Additionally, the Spearman rank correlation coefficient was applied to quantify the strength of agreement between contractors, consultants, and owners in rankings the causes of disputes and claims in the construction industry in addition to rank the benefits of BIM adoption, as was used by [99].

## 7. Results and discussion

### 7.1. Causes for the claims and disputes relating to the contractor (CCDC)

The causes of disputes and claims in the construction industry are ranked in this study using the Relative Importance Index (RII) technique. RII was mostly used in construction industry research by several studies, for example, [101] used RII to rank the advantage and barriers of integrating BIM with geographic information systems (GIS) in Iraqi construction projects. Additionally, to determine the severity of those causes in this study, the normalized values of the causes were calculated. As mentioned by [101], when selecting serious causes of disputes and claims in the construction industry, only causes with normalized values equal to or greater than 0.50 were taken into account by using the following equation:

$$(7.1) \quad \text{Normalized Value} = \frac{\text{mean} - \text{minimum mean}}{\text{maximum mean} - \text{mean}}$$

Also, Exploratory Factor Analysis (EFA) is a statistical technique used in this research to reduce many correlated variables into a relatively small number of clusters [95]. According to [95], EFA is usually executed to discover the latent factors that account for the patterns of collinearity among multiple variables; this technique helps the current study to identify the most important causes of cost disputes and claims in construction industry by reducing the number of initial variables to a smaller set of variables.

As shown in Table 3, the practical experience of the respondents contributed significantly to their understanding of the causes of disputes and claims in the Jordanian construction industry. The educational level of the respondents also contributed to identifying the most important of those reasons that hinder the development of the construction sector in Jordan and create conflicts between stakeholders. This study includes 11 causes of claims and disputes in the construction industry relating to contractor as mentioned in Table 3.

Based on the normalized vales of more than 0.5 only 7 factors have been listed as a seven critical causes of disputes and clams relating to contractor in the Jordanian construction projects. These causes are including: (Contractor financial problem (RII 0.792), delay caused by contractor (RII 0.784), rework due to errors during construction phase (RII 0.778), low price contract due to aggressive competition among contractors (RII 0.766), poor skills and

experience of the technical staff (RII 0.758), poor planning and site management by contractor (RII 0.756), inaccuracy of project cost estimation by contractor (RII 0.754). Moreover, each of these significant reasons had an RII value more than the average RII value for those reasons as it was 0.751. The above results of this study are consistent with many previous studies, the most important of which are: [12, 47, 52].

Table 3. Mean, SD, normalized, RII and rank values for causes of *d* claims and disputes relating to contractor in the construction industry

Items	Mean	SD	Normalization	RII	Rank
CCDC1	3.96	1.039	1.0000*	0.792	1
CCDC2	3.92	1.058	0.9024*	0.784	2
CCDC3	3.78	1.131	0.5609*	0.756	6
CCDC4	3.58	1.210	0.0731	0.716	10
CCDC5	3.77	1.119	0.5366*	0.754	7
CCDC6	3.65	1.178	0.2439	0.730	8
CCDC7	3.55	1.178	0.0000	0.710	11
CCDC8	3.60	1.172	0.1219	0.720	9
CCDC9	3.83	1.118	0.6821*	0.766	4
CCDC10	3.89	1.166	0.8293*	0.778	3
CCDC11	3.79	1.192	0.5854*	0.758	5

\* Normalized value more than 0.50.

On the other hand, the factor analysis test shown that the KMO value of the causes of disputes and claims relating to contractor is (0.916), the Bartlett Sphericity Approximate Chi-Square test value is 5709.762, and the significant  $P = 0.000$  ( $\text{sig} < 0.05$ ), in which indicated that the sample size is adequate in this study [89]. As shown in Table 4, the results of factor analysis grouped the causes of disputes and claims relating to contractor into two components, which are financial challenges and management problems. Contractor financial problem, delay caused by contractor were ranked in first and second position in the (component 1), with factor loadings of (0.945, 0.925) respectively. Moreover, (poor skills and experience of the technical staff), (poor planning and site management by contractor) were ranked in first and second position in the (component 2), with factor loadings of (0.778, 0.743) respectively.

Based on the results revealed in this study, it can be concluded that the financial challenges facing contractors in the Jordanian construction sector may lead to delays in the implementation of projects. As shown in Table 4, it is possible that awarding the bid to the contractor with

the lowest price is a major reason for the financial problems faced by contractors in Jordan. Furthermore, the weak management of the contractors and the lack of skills possessed by the contractor's staff, all of which lead to inaccuracy in estimating the real cost of implementing the project as well as its implementation period. Many researchers agreed with the results of this study, which are related to the causes of disputes and claims related to the contractor. The most important of these studies include: [12, 31, 38, 62].

Table 4. Results of factor analysis for causes of claims and disputes relating to contractor in the construction industry

Items	Causes of claims and disputes in the construction industry	Component 1	Component 2
	Financial challenges		
CCDC1	Contractor financial problem.	0.945	
CCDC2	Delay caused by contractor	0.925	
CCDC10	Rework due to errors during construction	0.870	
CCDC9	Low price contract due to aggressive competition among contractors	0.828	
	Management problems		
CCDC11	Poor skills and experience of the technical staff		0.778
CCDC3	Poor planning and site management by contractor		0.743
CCDC5	Inaccuracy in project cost estimation by contractor		0.717

## 7.2. Causes for the claims and disputes relating to the contractor (CCDC)

As can be seen in Table 5, the results of the RII and normalization analysis identified the important factors which lead to claims and disputes among the shareholders in the Jordanian construction projects. Only eight factors have normalization values  $\geq 0.50$  namely: delay in payments for the contractor's completed work (RII 0.794), oral change orders by client (RII 0.790), variations in the owner's decisions (RII 0.786), delays caused by client (RII 0.780), type of project bidding and award (negotiation, lowest bidder) and least qualified contractor (RII 0.778), slow decision making (RII 0.772), delay to deliver the site to the contractor (RII 0.770), variations in quantities due to new requirements from client (RII 0.768). The outcomes of the current study are consistent with those of preceding studies, for example: [10, 12, 37, 50].

Alternatively, it is observed in the reality of construction projects in Jordan, the delay in the owner's payment of the contractor's payments negatively affects the progress of the project's work. Also, the constant change orders by the owner, in addition to the difference in decisions and perhaps the slowness in taking decisions at times, all of these factors were confirmed by the respondents in this study as a reason for the occurrence of disputes and claims between the stakeholders.

Table 5. Mean, SD, Normalized, RII and rank values for causes of claims and disputes relating to owner in the construction industry

Items	Mean	SD	Normalization	RII	Rank
CCDO1	3.90	1.049	0.8478*	0.780	4
CCDO2	3.95	1.045	0.9565*	0.790	2
CCDO3	3.97	1.161	1.0000*	0.794	1
CCDO4	3.61	1.107	0.2174	0.722	9
CCDO5	3.84	1.210	0.7174*	0.768	8
CCDO6	3.56	1.058	0.1087	0.712	11
CCDO7	3.51	1.152	0.0000	0.702	12
CCDO8	3.93	1.163	0.9130*	0.786	3
CCDO9	3.58	1.141	0.1522	0.716	10
CCDO10	3.86	1.145	0.7609*	0.772	6
CCDO11	3.89	1.183	0.8261*	0.778	5
CCDO12	3.85	1.486	0.7391*	0.770	7

We note in Table 6, the findings of the factor analysis grouped the causes of claims and disputes relating to owner in the construction industry into two components, which are financial problems and management problems. Delay in payments for the contractor's completed work, oral change orders by client, delays caused by client and type of project bidding and award (negotiation, lowest bidder) and least qualified contractor are the significant factors in the component 1. Furthermore, variations in the owner's decisions, slow decision making, delay to deliver the site to the contractor and the problems due to incorrect drawings issued by client are the factors that mentioned in the component 2.

The results of many previous studies, as shown in Table 1, confirmed the factors reached by factor analysis, which are shown in Table 6. In fact, these factors play a major role in the emergence of claims and disputes between the parties to the contract. The owner's financial problems play a major role in delaying the project and causing disputes between him and the contractors. The failure of the contractor to receive his financial payments on time causes him great confusion and may lead to faltering in the progress of the project. The mismanagement of the owner and the lack of appropriate planning have an effective effect on increasing the cost and time of the project, and thus the existence of disputes between the owner and the contractor, and they may not be resolved except in court.

Table 6. Results of factor analysis for causes of claims and disputes relating to owner in the construction industry

Items	Causes of claims and disputes in the construction industry	Component 1	Component 2
	Financial problems		
CCDO3	Delay in payments for the contractor's completed work	0.984	
CCDO2	Oral change orders by client	0.969	
CCDO1	Delays caused by client	0.990	
CCDO11	Type of project bidding and award (negotiation, lowest bidder) and least qualified contractor	0.898	
	Management problems		
CCDO9	Variations in the owner's decisions		0.878
CCDO10	Slow decision making		0.783
CCDO12	Delay to deliver the site to the contractor		0.717
CCDO5	Problems due to incorrect drawings issued by client		0.710

According to the prior findings in this study the main causes of claims and disputes in the Jordanian construction industry are summarized as in Fig. 2.



Fig. 2. Main causes of claims and disputes in the Jordanian construction industry

### 7.3. Benefits of adopting (BIM) in reducing claims and disputes in the Jordanian construction industry

As discussed in prior sections, and as shown in Table 2, many studies have been reviewing the benefits of BIM at present, in addition to its role in improving the construction industry by evading the causes of conflicts and claims between stakeholders. In Jordan, no study has yet examined the role of BIM technology in avoiding the causes of disputes and claims in the

construction sector. In this study, as shown in Table 7, the respondents confirmed seven of the most vital benefits of BIM adoption. All of these benefits have a normalized value more than 0.500, which prove the importance of those benefits.

Table 7 shows seven significant benefits of BIM adoption, these factors namely: efficient communications between stakeholders (RII 0.852), better visualization (RII 0.846), 3D-Coordination and clash detection (RII 0.830), better construction planning and monitoring (RII 0.802), reduce project cost (RII 0.796), reduce project duration (RII 0.780) and minimize design errors (RII 0.778). It can conclude that these benefits are important features of BIM that assistance construction team in avoiding many problems such as clashes, variation orders, delays and uncertain quantities. On the other hand, for example, visualization and clash are two powerful BIM benefits, facilitating better decision-making, decreasing delays, enhancing site performance and reducing design change.

Additionally, one of the primary benefits of BIM is to enhance the coordination operation by automatically connecting project plans through the 3D model. Thus, the conflict between project parties is directly evident by connecting the different disciplines (structural, architectural and mechanical), reducing delays in project delivery, and not greater than the budget. Clash detection functions categorize collisions or interferences to multidisciplinary objects.

Table 7. Mean, SD, Normalized, RII and rank values for potential benefits of BIM adoption in the construction industry

Items	Mean	SD	Normalization	RII	Rank
BIMB1	4.26	1.456	1.0000*	0.852	1
BIMB2	4.01	1.735	0.6667*	0.802	4
BIMB3	3.90	1.241	0.5200*	0.780	6
BIMB4	3.98	1.657	0.6267*	0.796	5
BIMB5	3.63	1.010	0.1600	0.726	9
BIMB6	3.53	1.328	0.0267	0.706	11
BIMB7	4.23	1.012	0.9600*	0.846	2
BIMB8	4.15	1.431	0.8533*	0.830	3
BIMB9	3.66	1.098	0.2000	0.732	8
BIMB10	3.51	1.578	0.0000	0.702	12
BIMB11	3.57	1.768	0.0800	0.714	10
BIMB12	3.89	1.431	0.5067*	0.778	7

\* Normalized value more than 0.50.

Moreover, results of factor analysis for potential benefits of BIM adoptions in the construction industry as shown in Table 8 are confirmed the RII results that were mentioned in Table 7. These findings show the importance of BIM in improving collaboration and coordination

among stakeholders. Where BIM helps facilitate the exchange of information between the construction team, in addition to the early detection of most of the problems that may face the project implementation process through the visualization method, which is one of the main benefits of BIM.

Table 8. Results of factor analysis for potential benefits of BIM adoption

Items	Causes of claims and disputes in the construction industry	Component 1	Component 2
	<b>Communication factors</b>		
BIMB1	Efficient communications between stakeholders.	0.967	
BIMB2	Better construction planning and monitoring	0.935	
BIMB7	Better visualization	0.890	
BIMB8	3D-Coordination and Clash Detection	0.868	
	<b>Financial factors</b>		
BIMB4	Reduce project cost		0.788
BIMB3	Reduce project duration		0.776
BIMB12	Minimize design errors		0.717

The findings of this study agree with several of past studies that are mentioned in Table 2. It can be said that the findings of this study agree with several of past studies that are mentioned in Table 8, which could help in mitigating claims and disputes in the Jordanian construction projects. Fig. 3, summarized the role of benefits of BIM in reducing claims and disputes in the construction industry.

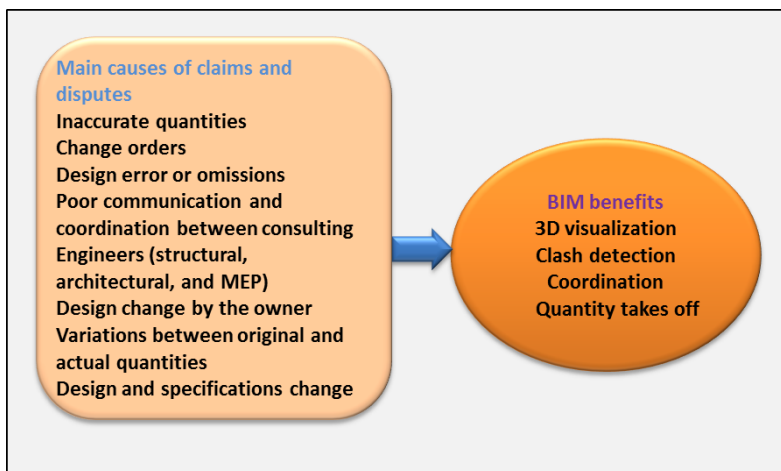


Fig. 3. Role of benefits of BIM in mitigating claims and disputes between stockholders in the construction projects

## 8. Results and discussion

Disputes and claims between stakeholders are expected to lead to the failure of construction projects in most cases. It is known to many that the success of projects in general has an effective role in the growth of the economy of developing countries such as Jordan. Therefore, this study used an alternative data set to identify the factors that lead to the emergence of disputes and claims among the implementation team in the Jordanian construction industry. These factors were determined based on the data provided by the participants in the questionnaire and were analyzed statistically as previously discussed. Obviously, disputes and claims are inevitable. Moreover, the results of this study revealed the great similarity between the causes of claims and disputes that were reached and the reasons that were chosen from the previous literature. This indicates the need to work on finding appropriate solutions to avoid disputes and claims in projects in the construction industry in general.

It can be said that many of the causes of disputes and claims in most construction projects in Jordan are due to for the parties to the project (owner, consultant, and contractor). The significant causes of disputes and claims as revealed by the current study, which related to (owner, consultant, and contractor) as shown in Fig. 3, namely: design errors, delays, change order, payment problems, site problems, errors in bid, contractual problems and lack of communication. For example, contractor financial problem (RII 0.792), delay caused by contractor (RII 0.784). As well as causes related to owner, which include: delay in payments for the contractor's completed work (RII 0.794), oral change orders by client (RII 0.790), variations in the owner's decisions (RII 0.786), delays caused by client (RII 0.780), type of project bidding and award (negotiation, lowest bidder) and least qualified contractor (RII 0.778), slow decision making (RII 0.772), delay to deliver the site to the contractor (RII 0.770).

The study showed that BIM plays a vital role in mitigating claims and disputes due to its large number of benefits. Some of these benefits include efficient communications between stakeholders (RII 0.852), better visualization (RII 0.846), 3D-Coordination and clash detection (RII 0.830), better construction planning and monitoring (RII 0.802), reduce project cost (RII 0.796), reduce project duration (RII 0.780) and minimize design errors (RII 0.778).

The current study recommends the importance of relying on advanced technologies, means of communication, and advanced computer programs in Jordanian construction projects, which reduces the possibility of the occurrence of the claims and disputes. The use of BIM in the construction industry is an attractive solution to most problems facing projects, especially in the design phase. Therefore, the study recommended the decision makers in the Jordanian construction industry need to provide the necessary financial allocations for the use of BIM in projects, especially in construction projects, due to the effective role that BIM plays in reducing claims and disputes between stakeholders.

## References

- [1] M. Alhusban, "Conceptual Procurement Framework for Building Information Modelling Uptake to Enhance Buildings' Sustainability Performance in the Jordanian Public Sector", PhD thesis, University of Portsmouth, 2018.

- [2] O. Al Awad, "The uptake of advanced IT with specific emphasis on BIM by SMEs in the Jordanian construction industry", PhD thesis, University of Salford, 2015.
- [3] E.U.R. Khawaja and A. Mustapha, "Mitigating Disputes and Managing Legal Issues in the Era of Building Information Modelling", *Journal of Construction in Developing Countries*, vol. 26, no. 1, pp. 111–130, 2021, doi: [10.21315/jcdc2021.26.1.6](https://doi.org/10.21315/jcdc2021.26.1.6).
- [4] A. Rauzana, "Causes of conflicts and disputes in construction projects", *IOSR Journal of Mechanical and Civil Engineering*, vol. 13, no. 5, pp. 44–48, 2016, doi: [10.9790/1684-1305064448](https://doi.org/10.9790/1684-1305064448).
- [5] O.C. Narh, E.E. Owusu, K. Oduro-Apeatu, and T.W.J. Narh, "An exploratory study of professional conflicts and disputes within the construction industry", *International Journal of Managerial Studies and Research*, vol. 3, no. 12, pp. 44–65, 2015.
- [6] S. Soni, M. Pandey, and S. Agrawal, "Conflicts and disputes in construction projects: An overview", *International Journal of Engineering Research and Applications*, vol. 7, no. 6, pp. 40–42, 2017.
- [7] A. Suleiman, "Causes and effects of poor communication in the construction industry in the MENA region", *Journal of Civil Engineering and Management*, vol. 28, no. 5, pp. 365–376, 2022, doi: [10.3846/jcem.2022.16728](https://doi.org/10.3846/jcem.2022.16728).
- [8] A. Aljboor, R. Imam, and R. Alawneh, "Barriers to achieving sustainability in highway construction projects: The case of Jordan", *Sustainability*, vol. 15, no. 13, art. no. 10081, doi: [10.3390/su151310081](https://doi.org/10.3390/su151310081).
- [9] E. Kasapoğlu, "Risk management in construction", in *Sustainable Buildings: Interaction between a Holistic Conceptual Act and Material Properties*, A. Almusaed and A. Almssad, Eds. IntechOpen, 2018, pp. 49–71.
- [10] Y.M Al Malki and M.S. Alam, "Construction claims, their types and causes in the private construction industry in the Kingdom of Bahrain", *Asian Journal of Civil Engineering*, vol. 22, no. 3, pp. 477–484, 2021, doi: [10.1007/s42107-020-00326-z](https://doi.org/10.1007/s42107-020-00326-z).
- [11] R. Komurlu and D. Arditi, "The role of general conditions relative to claims and disputes in building construction contracts", *New Arch-International Journal of Contemporary Architecture*, vol. 4, no. 2, pp. 27–36, 2017, doi: [10.14621/tna.20170203](https://doi.org/10.14621/tna.20170203).
- [12] M.O. Sanni-Anibire, R. Mohamad Zin, and S.O. Olatunji, "Causes of delay in the global construction industry: a meta analytical review", *International Journal of Construction Management*, vol. 22, no. 8, pp. 1395–1407, 2022, doi: [10.1080/15623599.2020.1716132](https://doi.org/10.1080/15623599.2020.1716132).
- [13] J. Wang, S. Zhang, P. Fenn, X. Luo, Y. Liu, and L. Zhao, "Adopting BIM to Facilitate Dispute Management in the Construction Industry: A Conceptual Framework Development", *Journal of Construction Engineering and Management*, vol. 149, no. 1, art. no. 03122010, 2023, doi: [10.1061/\(ASCE\)CO.1943-7862.0002419](https://doi.org/10.1061/(ASCE)CO.1943-7862.0002419).
- [14] S. Assaf, M.A. Hassanain, A. Abdallah, A.M.Z. Sayed, and A. Alshahrani, "Significant causes of claims and disputes in construction projects in Saudi Arabia", *Built Environment Project and Asset Management*, vol. 9, no. 5, pp. 597–615, 2019, doi: [10.1108/BEPAM-09-2018-0113](https://doi.org/10.1108/BEPAM-09-2018-0113).
- [15] R.A.R. Ibraheem and A.M.R. Mahjoob, "Facilitating claims settlement using building information modeling in the school building projects", *Innovative Infrastructure Solutions*, vol. 7, no. 1, art. no. 40, 2022, doi: [10.1007/s41062-021-00646-2](https://doi.org/10.1007/s41062-021-00646-2).
- [16] S.N. Bhangwar, A.H. Memon, and F.A. Memon, "Effect of Claims on Project performance", *Tropical Scientific Journal*, vol. 1, no. 2, pp. 41–54, 2022.
- [17] M. Francis and T. Ramachandra, "Investigating the Causes of Disputes from the Perspective of Project Characteristics", in *Proceedings of 2021 4th International Conference on Civil Engineering and Architecture*, T. Kang and Y. Lee, Eds. Singapore: Springer, 2022, pp. 575–585, doi: [10.1007/978-981-16-6932-3\\_50](https://doi.org/10.1007/978-981-16-6932-3_50).
- [18] B. Ali et al., "BIM-based claims management system: A centralized information repository for extension of time claims", *Automation in Construction*, vol. 110, art. no. 102937, 2020, doi: [10.1016/j.autcon.2019.102937](https://doi.org/10.1016/j.autcon.2019.102937).
- [19] M. Marzouk, A. Othman, M. Enaba, and M. Zaher, "Using BIM to identify claims early in the construction industry: Case study", *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, vol. 10, no. 3, art. no. 05018001, 2018, doi: [10.1061/\(ASCE\)LA.1943-4170.0000254](https://doi.org/10.1061/(ASCE)LA.1943-4170.0000254).
- [20] V. Shahhosseini and H. Hajarolasvadi, "A conceptual framework for developing a BIM-enabled claim management system", *International Journal of Construction Management*, vol. 21, no. 2, pp. 208–222, 2021, doi: [10.1080/15623599.2018.1512182](https://doi.org/10.1080/15623599.2018.1512182).

- [21] H.I. Aidibi, "Studying the effect of BIM on construction conflicts and disputes using agent-based modeling", Master's thesis, American University of Beirut, 2016.
- [22] R. Ansari, et al., "Decision Support System for Analyzing Key Performance Indicators in Construction Projects Management", *International Journal of Engineering*, vol. 35, no. 5, pp. 865–874, 2022, doi: [10.5829/ije.2022.35.05b.03](https://doi.org/10.5829/ije.2022.35.05b.03).
- [23] Y. Zhang and J. Fu, "Utilization of Autonomous Tower Crane in the Construction Process", in *Construction & Robotics: Research driven project*, S. Brell-Cokcan and T.J. Adams, Eds. Aachen: RWTH Aachen University, 2021, pp. 122–139.
- [24] D. Perez, J. Gray, and M. Skitmore, "Perceptions of risk allocation methods and equitable risk distribution: a study of medium to large Southeast Queensland commercial construction projects", *International Journal of Construction Management*, vol. 17, no. 2, pp. 132–141, 2017, doi: [10.1080/15623599.2016.1233087](https://doi.org/10.1080/15623599.2016.1233087).
- [25] L. Zhu and S.O. Cheung, "Power of incentivization in construction dispute avoidance", *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, vol. 12, no. 2, art. no. 03720001, 2020, doi: [10.1061/\(ASCE\)LA.1943-4170.0000368](https://doi.org/10.1061/(ASCE)LA.1943-4170.0000368).
- [26] J.L. Brockman, "Interpersonal conflict in construction: Cost, cause, and consequence", *Journal of Construction Engineering and Management*, vol. 140, no. 2, art. no. 04013050, 2014, doi: [10.1061/\(ASCE\)CO.1943-7862.0000805](https://doi.org/10.1061/(ASCE)CO.1943-7862.0000805).
- [27] D. Parikh, G.J. Joshi, and D.A. Patel, "Development of prediction models for claim cause analyses in highway projects", *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, vol. 11, no. 4, pp. 04519018, 2019, doi: [10.1061/\(ASCE\)LA.1943-4170.0000303](https://doi.org/10.1061/(ASCE)LA.1943-4170.0000303).
- [28] A.S.A. Saad, "Operational framework to settle contractual claims in construction projects", Master's thesis, Cape Peninsula University of Technology, Cape Town, 2017.
- [29] O. Ekhtator, "Investigating causes of disputes in building construction projects in Nigeria", *International Journal of Science, Environment and Technology*, vol. 5, no. 5, pp. 3516–3527, 2016.
- [30] D.T. Hai, "Assessment of contractors' claims on construction projects in Vietnam", *The Open Civil Engineering Journal*, vol. 13, pp. 218–228, 2019, doi: [10.2174/1874149501913010218](https://doi.org/10.2174/1874149501913010218).
- [31] E.K. Zaneldin, "Investigating the types, causes and severity of claims in construction projects in the UAE", *International Journal of Construction Management*, vol. 20, no. 5, pp. 385–401, 2020, doi: [10.1080/15623599.2018.1484863](https://doi.org/10.1080/15623599.2018.1484863).
- [32] M.M. Kumaraswamy, "Conflicts, claims and disputes in construction", *Engineering, Construction and Architectural Management*, vol. 4, no. 2, pp. 95–111, 1997, doi: [10.1108/eb021042](https://doi.org/10.1108/eb021042).
- [33] A. Enshassi, R.M. Choudhry, and S. El-Ghandour, "Contractors' perception towards causes of claims in construction projects", *International Journal of Construction Management*, vol. 9, no. 1, pp. 79-92, 2009, doi: [10.1080/15623599.2009.10773123](https://doi.org/10.1080/15623599.2009.10773123).
- [34] P. Love, P. Davis, J. Ellis, and S.O. Cheung, "Dispute causation: identification of pathogenic influences in construction", *Engineering, Construction and Architectural Management*, vol. 17, no. 4, pp. 404–423, 2010, doi: [10.1108/09699981011056592](https://doi.org/10.1108/09699981011056592).
- [35] G. Sibanyama, M. Muya, and C. Kaliba, "An overview of construction claims: A case study of the Zambian construction industry", *International Journal of Construction Management*, vol. 12, no. 1, pp. 65–81, 2012, doi: [10.1080/15623599.2012.10773185](https://doi.org/10.1080/15623599.2012.10773185).
- [36] D.R.I. Stamatiou, K.A. Kirytopoulos, S.T. Ponis, S. Gayialis, and I. Tatsiopoulou, "A process reference model for claims management in construction supply chains: the contractors' perspective", *International Journal of Construction Management*, vol. 19, no. 5, pp. 382-400, 2019, doi: [10.1080/15623599.2018.1452100](https://doi.org/10.1080/15623599.2018.1452100).
- [37] M. Parchami Jalal, E. Noorzai, and T. Yavari Roushan, "Root cause analysis of the most frequent claims in the building industry through the SCoP3E Ishikawa diagram", *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, vol. 11, no. 2, art. no. 04519004, 2019, doi: [10.1061/\(ASCE\)LA.1943-4170.0000289](https://doi.org/10.1061/(ASCE)LA.1943-4170.0000289).

- [39] L. Le-Hoai, C.N. Dang, S.B. Lee, and Y.D. Lee, "Benchmarking claim causes against contractors in emerging markets: empirical case study", *International Journal of Construction Management*, vol. 19, no. 4, pp. 307–316, 2019, doi: [10.1080/15623599.2018.1435156](https://doi.org/10.1080/15623599.2018.1435156).
- [40] N.A. Bakhary, H. Adnan, and A. Ibrahim, "A study of construction claim management problems in Malaysia", *Procedia Economics and Finance*, vol. 23, pp. 63–70, 2015, doi: [10.1016/S2212-5671\(15\)00327-5](https://doi.org/10.1016/S2212-5671(15)00327-5).
- [41] M.A. Hiyassat, F. Alkasagi, M. El-Mashaleh, and G.J. Sweis, "Risk allocation in public construction projects: the case of Jordan", *International Journal of Construction Management*, vol. 22, no. 8, pp. 1478–1488, 2022, doi: [10.1080/15623599.2020.1728605](https://doi.org/10.1080/15623599.2020.1728605).
- [42] N.B. Chaphalkar, K.C. Iyer, and S.K. Patil, "Prediction of outcome of construction dispute claims using multilayer perceptron neural network model", *International Journal of Project Management*, vol. 33, no. 8, pp. 1827–1835, 2015, doi: [10.1016/j.ijproman.2015.09.002](https://doi.org/10.1016/j.ijproman.2015.09.002).
- [43] S. Aryal and K. Dahal, "A review of causes and effects of dispute in the construction projects of Nepal", *Journal of Steel Structure and Construction*, vol. 4, no. 2, art. no. 144, 2018, doi: [10.4172/2472-0437.1000144](https://doi.org/10.4172/2472-0437.1000144).
- [44] A.S. Faridi and S.M. El-Sayegh, "Significant factors causing delay in the UAE construction industry", *Construction Management and Economics*, vol. 24, no. 11, pp. 1167–1176, 2006, doi: [10.1080/01446190600827033](https://doi.org/10.1080/01446190600827033).
- [45] R.-K. Akogbe, X. Feng, and J. Zhou, "Importance and ranking evaluation of delay factors for development construction projects in Benin", *KSCE Journal of Civil Engineering*, vol. 17, no. 6, pp. 1213–1222, 2013, doi: [10.1007/s12205-013-0446-2](https://doi.org/10.1007/s12205-013-0446-2).
- [46] Y. Vacanas and C. Danezis, "An overview of the risk of delay in Cyprus construction industry", *International Journal of Construction Management*, vol. 21, no. 4, pp. 369–381, 2021, doi: [10.1080/15623599.2018.1541703](https://doi.org/10.1080/15623599.2018.1541703).
- [47] M. Sami Ur Rehman, M.J. Thaheem, A.R. Nasir, and K.I.A. Khan, "Project schedule risk management through building information modelling", *International Journal of Construction Management*, vol. 22, no. 8, pp. 1489–1499, 2022, doi: [10.1080/15623599.2020.1728606](https://doi.org/10.1080/15623599.2020.1728606).
- [48] M.A. Hossain, D. Rayimbekov, A. Nadeem, and J.R. Kim, "Delay causes in Kazakhstan's construction projects and remedial measures", *International Journal of Construction Management*, vol. 22, no. 5, pp. 801–819, 2022, doi: [10.1080/15623599.2019.1647635](https://doi.org/10.1080/15623599.2019.1647635).
- [49] A. Shrivastava and H.K. Singla, "Analysis of interaction among the factors affecting delay in construction projects using interpretive structural modelling approach", *International Journal of Construction Management*, vol. 22, no. 8, pp. 1455–1463, 2022, doi: [10.1080/15623599.2020.1728486](https://doi.org/10.1080/15623599.2020.1728486).
- [50] S. Alshihri, K. Al-Gahtani, and A. Almohsen, "Risk factors that lead to time and cost overruns of building projects in Saudi Arabia", *Buildings*, vol. 12, no. 7, pp. 902, 2022, doi: [10.3390/buildings12070902](https://doi.org/10.3390/buildings12070902).
- [51] R.A. Waheeb and B.S. Andersen, "Causes of Problems in Post- Disaster Emergency Re-Construction Projects—Iraq as a Case Study", *Public Works Management & Policy*, vol. 27, no. 1, pp. 61–97, 2022, doi: [10.1177/1087724X21990034](https://doi.org/10.1177/1087724X21990034).
- [52] D.A. Kshaf, M.A. Mohamed, and K.M. El-Dash, "The major problems between main contractors and subcontractors in construction projects in Egypt", *Ain Shams Engineering Journal*, vol. 13, no. 6, pp. 101813, 2022, doi: [10.1016/j.asej.2022.101813](https://doi.org/10.1016/j.asej.2022.101813).
- [53] A. Kamal, M. Abas, D. Khan, R.W. Azfar, "Risk factors influencing the building projects in Pakistan: from perspective of contractors, clients and consultants", *International Journal of Construction Management*, vol. 22, no. 6, pp. 1141–1157, 2022, doi: [10.1080/15623599.2019.1683693](https://doi.org/10.1080/15623599.2019.1683693).
- [54] M. Gündüz, Y. Nielsen, and M. Özdemir, "Quantification of delay factors using the relative importance index method for construction projects in Turkey", *Journal of Management in Engineering*, vol. 29, no. 2, pp. 133–139, 2013, doi: [10.1061/\(ASCE\)ME.1943-5479.0000129](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000129).
- [55] H., Doloi, et al., "Analysing factors affecting delays in Indian construction projects", *International Journal of Project Management*, vol. 30, no. 4, pp. 479–489, 2012, doi: [10.1016/j.ijproman.2011.10.004](https://doi.org/10.1016/j.ijproman.2011.10.004).
- [56] I. Mahamid, A. Sawhney, K.C. Iyer, and S. Rentala, "Common risks affecting time overrun in road construction projects in Palestine: Contractors' perspective", *Australasian Journal of Construction Economics and Building*, vol. 13, no. 2, pp. 45–53, 2013, doi: [10.5130/ajceb.v13i2.3194](https://doi.org/10.5130/ajceb.v13i2.3194).

- [56] A. Arantes, P.F. da Silva, and L.M.D. Ferreira, "Delays in construction projects-causes and impacts", in *2015 International Conference on Industrial Engineering and Systems Management (IESM)*. IEEE, 2015, pp. 1105–1110, doi: [10.1109/IESM.2015.7380293](https://doi.org/10.1109/IESM.2015.7380293).
- [57] . E. Safapour, S. Kermanshachi, and I. Ramaji, "Selection of Best Practices that Enhance Phase-Based Cost and Schedule Performances in Complex Construction Projects", *Engineering Management Journal*, vol. 35, no. 1, pp. 84–99, 2022, doi: [10.1080/10429247.2022.2036068](https://doi.org/10.1080/10429247.2022.2036068).
- [58] R. Asadi, S. Wilkinson, and J.O.B. Rotimi, "Towards contracting strategy usage for rework in construction projects: a comprehensive review", *Construction Management and Economics*, vol. 39, no. 12, pp. 953–971, 2021, doi: [10.1080/01446193.2021.2004609](https://doi.org/10.1080/01446193.2021.2004609).
- [59] E. Safapour, S. Kermanshachi, P. Taneja, and A. Pamidimukkala, "Exploratory Analysis of Human-, Organizational-, and Project-Based Reworks: Challenges and Strategies", *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, vol. 14, no. 1, art. no. 04521045, 2022, doi: [10.1061/\(ASCE\)LA.1943-4170.0000524](https://doi.org/10.1061/(ASCE)LA.1943-4170.0000524).
- [60] O. Bagaya and J. Song, "Empirical study of factors influencing schedule delays of public construction projects in Burkina Faso", *Journal of Management in Engineering*, vol. 32, no. 5, art. no. 05016014, 2016, doi: [10.1061/\(ASCE\)ME.1943-5479.0000443](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000443).
- [61] D.T.N. Huy, P.N. Van, and N.T.T. Ha, "Education and computer skill enhancing for Vietnam laborers under industry 4.0 and evfta agreement", *Elementary Education Online*, vol. 20, no. 4, pp. 1033–1038, 2021.
- [62] T. Chang, X. Deng, B.G. Hwang, and X. Zhao, "Political risk paths in international construction projects: Case study from Chinese construction enterprises", *Advances in Civil Engineering*, vol. 2018, art. no. 6939828, 2018, doi: [10.1155/2018/6939828](https://doi.org/10.1155/2018/6939828).
- [63] F. Tshidavhu and N. Khatleli, "An assessment of the causes of schedule and cost overruns in South African megaprojects: A case of the critical energy sector projects of Medupi and Kusile", *Acta Structilia*, vol. 27, no. 1, pp. 119–143, 2020, doi: [10.18820/24150487/as27i1.5](https://doi.org/10.18820/24150487/as27i1.5).
- [64] E. Elmagdobi, N. Culic, D. Beljakovic, A. Milajic, and G. Pejicic, "Common causes of conflicts in construction projects-comparative analysis of projects in Libya and Serbia", *Arhiv za Tehnicke Nauke/Archives for Technical Sciences*, vol. 2, no. 15, pp. 33–40, 2016, doi: [10.7251/afts.2016.0815.033E](https://doi.org/10.7251/afts.2016.0815.033E).
- [65] M. Tafazzoli and P.P. Shrestha, "Investigating Causes of Delay in US Construction Projects", in *53<sup>rd</sup> ASC Annual Conference Proceedings*. Associated Schools of Construction, 2017.
- [66] A. Rauzana and W. Dharma, "Causes of delays in construction projects in the Province of Aceh, Indonesia", *PloS one*, 2022, vol. 17, no. 1, art. no. e0263337, doi: [10.1371/journal.pone.0263337](https://doi.org/10.1371/journal.pone.0263337).
- [67] Y. Zhang, T. Wang, and K.V. Yuen, "Construction site information decentralized management using blockchain and smart contracts", *Computer-Aided Civil and Infrastructure Engineering*, vol. 37, no. 11, pp. 1450–1467, 2022, doi: [10.1111/mice.12804](https://doi.org/10.1111/mice.12804).
- [68] A.V. Kotharkar, A.M. Ali, S. Manishankar, M. Arun, and M. Devi, "Major causes of delay in construction of highway projects", *AIP Conference Proceedings*, vol. 2393, no. 1, art. no. 020183, 2022, doi: [10.1063/5.0075048](https://doi.org/10.1063/5.0075048).
- [69] J. Tariq and S.S.S. Gardezi, "Study the delays and conflicts for construction projects and their mutual relationship: A review", *Ain Shams Engineering Journal*, vol. 14, no. 1, art. no. 101815, 2023, doi: [10.1016/j.asej.2022.101815](https://doi.org/10.1016/j.asej.2022.101815).
- [70] M. Noushad, A.V. Thomas, and K.P. Ramaswamy, "Evaluation of Dispute Prone Areas in Construction Projects", in *Proceedings of International Web Conference in Civil Engineering for a Sustainable Planet*, S.K. Nayar, et al., Eds. AIJR Books, 2021, pp. 62–68, doi: [10.21467/proceedings.112.8](https://doi.org/10.21467/proceedings.112.8).
- [71] S. Maiti and J.-H. Choi, "Investigation and implementation of conflict management strategies to minimize conflicts in the construction industry", *International Journal of Construction Management*, vol. 21, no. 4, pp. 337–352, 2021, doi: [10.1080/15623599.2018.1536964](https://doi.org/10.1080/15623599.2018.1536964).
- [72] G. Wu, C. Liu, X. Zhao, and J. Zuo, "Investigating the relationship between communication-conflict interaction and project success among construction project teams", *International Journal of Project Management*, vol. 35, no. 8, pp. 1466–1482, 2017, doi: [10.1016/j.ijproman.2017.08.006](https://doi.org/10.1016/j.ijproman.2017.08.006).

- [73] E. Cakmak and P.I. Cakmak, "An analysis of causes of disputes in the construction industry using analytical network process", *Procedia - Social and Behavioral Sciences*, vol. 109, pp. 183–187, 2014, doi: [10.1016/j.sbspro.2013.12.441](https://doi.org/10.1016/j.sbspro.2013.12.441).
- [74] J. Xue, et al., "Mapping the knowledge domain of stakeholder perspective studies in construction projects: A bibliometric approach", *International Journal of Project Management*, vol. 38, no. 6, pp. 313–326, 2020, doi: [10.1016/j.ijproman.2020.07.007](https://doi.org/10.1016/j.ijproman.2020.07.007).
- [75] G. Heravi and Z. Hajihosseini, "Risk allocation in public- private partnership infrastructure projects in developing countries: case study of the Tehran-Chalus toll road", *Journal of Infrastructure Systems*, vol. 18, no. 3, pp. 210–217, 2012, doi: [10.1061/\(ASCE\)IS.1943-555X.0000090](https://doi.org/10.1061/(ASCE)IS.1943-555X.0000090).
- [76] D. Nguyen and M. Garvin, "Risk allocation and management practices in highway PPP contracts: Pilot study of Virginia", in *Construction Research Congress 2016*, J.L. Perdomo-Rivera, et al., Eds. Reston, VA: ASCE, 2016, pp. 559–568, doi: [10.1061/9780784479827.057](https://doi.org/10.1061/9780784479827.057).
- [77] S.M. El-Sayegh and M.H. Mansour, "Risk assessment and allocation in highway construction projects in the UAE", *Journal of Management in Engineering*, vol. 31, no. 6, art. no. 04015004, 2015, doi: [10.1061/\(ASCE\)ME.1943-5479.0000365](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000365).
- [78] I.H. El-adaway, "Construction dispute mitigation through multi-agent based simulation and risk management modeling", PhD dissertation, Iowa State University, Ames, 2008.
- [79] I. Mahamid, A. Bruland, and N. Dmaldi, "Causes of delay in road construction projects", *Journal of Management in Engineering*, vol. 28, no. 3, pp. 300–310, 2012, doi: [10.1061/\(ASCE\)ME.1943-5479.0000096](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000096).
- [80] M.T. Al-Qershi and R. Kishore, "Claim causes and types in Indian construction industry-contractor's perspective", *American Journal of Civil Engineering and Architecture*, vol. 5, no. 5, pp. 196–203, 2017.
- [81] R.J. Long, "Why claims occur – The red flags", Long International. [Online]. Available: <https://www.long-intl.com/articles/why-claims-occur/>.
- [82] C.S. Goh, H. Abdul-Rahman, and Z. Abdul Samad, "Applying risk management workshop for a public construction project: Case study", *Journal of Construction Engineering and Management*, vol. 139, no. 5, pp. 572–580, 2013, doi: [10.1061/\(ASCE\)CO.1943-7862.0000599](https://doi.org/10.1061/(ASCE)CO.1943-7862.0000599).
- [83] I.L. Qureshi, A.M.D. Al Saadi, and I.A. Rahman, "Identification of delay factor in Oman construction industry", *International Journal of Sustainable Construction Engineering and Technology*, vol. 10, no. 1, 2019.
- [84] S. Azhar, M. Khalfan, and T. Maqsood, "Building information modeling (BIM): now and beyond", *Australasian Journal of Construction Economics and Building*, vol. 12, no. 4, pp. 15–28, 2012, doi: [10.5130/AJCEB.v12i4.3032](https://doi.org/10.5130/AJCEB.v12i4.3032).
- [85] R. Okereke, U. Muhammed, and E. Eze, "Potential Benefits of Implementing Building Information Modelling (BIM) in the Nigerian Construction Industry", *Journal of Technology Management and Business*, vol. 8, no. 2, pp. 1–15, 2021.
- [86] R. Samimpay and E. Saghatforoush, "Benefits of implementing building information modeling (BIM) in infrastructure projects", *Journal of Engineering, Project, and Production Management*, vol. 10, no. 2, pp. 123–140, 2020, doi: [10.2478/jepm-2020-0015](https://doi.org/10.2478/jepm-2020-0015).
- [87] C.B. Farnsworth, S. Beveridge, K.R. Miller, and J.P. Christofferson, "Application, advantages, and methods associated with using BIM in commercial construction", *International Journal of Construction Education and Research*, vol. 11, no. 3, pp. 218–236, 2015, doi: [10.1080/15578771.2013.865683](https://doi.org/10.1080/15578771.2013.865683).
- [88] M. Fargnoli and M. Lombardi, "Building information modelling (BIM) to enhance occupational safety in construction activities: Research trends emerging from one decade of studies", *Buildings*, vol. 10, no. 6, art. no. 98, 2020, doi: [10.3390/buildings10060098](https://doi.org/10.3390/buildings10060098).
- [89] A. Sanchez, K. Hampson, and S. Vaux, Eds. *Delivering value with BIM. A whole-of-life approach*. London: Routledge, 2016.
- [90] R. Crotty, *The impact of building information modelling: transforming construction*. New York: Routledge, 2013.

- [91] A. Mirzaei, F. Nasirzadeh, M.P. Jalal, and Y. Zamani, "4D-BIM dynamic time-space conflict detection and quantification system for building construction projects", *Journal of Construction Engineering and Management*, vol. 144, no. 7, art. no. 04018056, 2018, doi: [10.1061/\(ASCE\)CO.1943-7862.0001504](https://doi.org/10.1061/(ASCE)CO.1943-7862.0001504).
- [92] A. Charehzehi, C.S. Chai, A.M. Yusof, H.Y. Chong, and S.C. Loo, "Building information modeling in construction conflict management", *International Journal of Engineering Business Management*, vol. 9, art. no. 1847979017746257, 2017, doi: [10.1177/1847979017746257](https://doi.org/10.1177/1847979017746257).
- [93] Y. Zou, A. Kiviniemi, and S.W. Jones, "A review of risk management through BIM and BIM-related technologies", *Safety Science*, vol. 97, pp. 88–98, 2017, doi: [10.1016/j.ssci.2015.12.027](https://doi.org/10.1016/j.ssci.2015.12.027).
- [94] A.M. Eldeep, M.A. Farag, and L.M. Abd El-hafez, "Using BIM as a lean management tool in construction processes-A case study", *Ain Shams Engineering Journal*, vol. 13, no. 2, art. no. 101556, 2022, doi: [10.1016/j.asej.2021.07.009](https://doi.org/10.1016/j.asej.2021.07.009).
- [95] M.-H. Shin, J.-H. Jung, and H.-Y. Kim, "Quantitative and Qualitative Analysis of Applying Building Information Modeling (BIM) for Infrastructure Design Process", *Buildings*, vol. 12, no. 9, art. no. 1476, 2022, doi: [10.3390/buildings12091476](https://doi.org/10.3390/buildings12091476).
- [96] S.M. Paik, P. Leviakangas, and J. Choi, "Making most of BIM in design: Analysis of the importance of design coordination", *International Journal of Construction Management*, vol. 22, no. 12, pp. 2225–2233, 2022, doi: [10.1080/15623599.2020.1774837](https://doi.org/10.1080/15623599.2020.1774837).
- [97] K. Castañeda, O. Sanchez, R.F. Herrera, E. Pellicer, and H. Porras, "BIM-based traffic analysis and simulation at road intersection design", *Automation in Construction*, vol. 131, art. no. 103911, 2021, doi: [10.1016/j.autcon.2021.103911](https://doi.org/10.1016/j.autcon.2021.103911).
- [98] H.S. Ibrahim, N. Hashim, and K.A.A. Jamal, "The potential benefits of building information modelling (BIM) in construction industry", *IOP Conference Series: Earth and Environmental Science*, vol. 385, 2019, doi: [10.1088/1755-1315/385/1/012047](https://doi.org/10.1088/1755-1315/385/1/012047).
- [99] R. Chahrour, et al., "Cost-benefit analysis of BIM-enabled design clash detection and resolution", *Construction Management and Economics*, vol. 39, no. 1, pp. 55–72, 2021, doi: [10.1080/01446193.2020.1802768](https://doi.org/10.1080/01446193.2020.1802768).
- [100] B. Akhmetzhanova, A. Nadeem, M.A. Hossain, and J.R. Kim, "Clash Detection Using Building Information Modeling (BIM) Technology in the Republic of Kazakhstan", *Buildings*, vol. 12, no. 2, art. no. 102, 2022, doi: [10.3390/buildings12020102](https://doi.org/10.3390/buildings12020102).
- [101] J.H. Lee, M.J. Ostwald, S. Arasteh, and P. Oldfield, "BIM- Enabled Design Collaboration Processes in Remote Architectural Practice and Education in Australia", *Journal of Architectural Engineering*, vol. 29, no. 1, art. no. 05022012, 2023, doi: [10.1061/JAEIED.AEENG-1505](https://doi.org/10.1061/JAEIED.AEENG-1505).

Received: 2024-11-10, Revised: 2024-12-23